Tanami, Northern Territory
TEMPEST
Geophysical Survey

Acquisition and Processing Report

for

ABM Resources N.L.

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Authorised for release by :   …………………………..

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Survey flown: June - July 2012

by

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1. SURVEY OPERATIONS AND LOGISTICS

1.1 Introduction

Between the 21st June and the 10th July 2012, Fugro Airborne Surveys Pty. Ltd. (FAS) undertook an airborne TEMPEST electromagnetic and magnetic survey for ABM Resources N.L., over the Tanami Project area in the Northern Territory. The survey consisted of 3 areas. Total coverage of the survey area amounted to 4386 line kilometres flown in 18 flights. The survey was flown using a CASA 212 aircraft, registration VH-TEM owned and operated by FAS. This report summarises the procedures and equipment used by FAS in the acquisition, verification and processing of the airborne geophysical data.

1.2 Survey Base

The survey was based out of Ti Tree, Northern Territory. The survey aircraft was operated from Ti Tree Airport with the aircraft fuel available on site. A temporary office was set up at the Ti Tree Roadhouse, Ti Tree, where all survey operations were run and the post-flight data verification was performed.

1.3 Survey Personnel

The following personnel were involved in this project:

Project Supervision - Acquisition	Peter Johnson
- Processing	Denis Cowey
On-site Crew Leader	Ben Riggs
Pilot/s	Peter Hiskins, Elizabeth Derricks
System Operator/s	Ben Riggs
Engineer	James Kenny, John Remmington-Gurney
Field Data Processing	Mohamed Abubeker
Office Data Processing	Chao Zhou, Mohamed Abubeker

1.4 Area Map
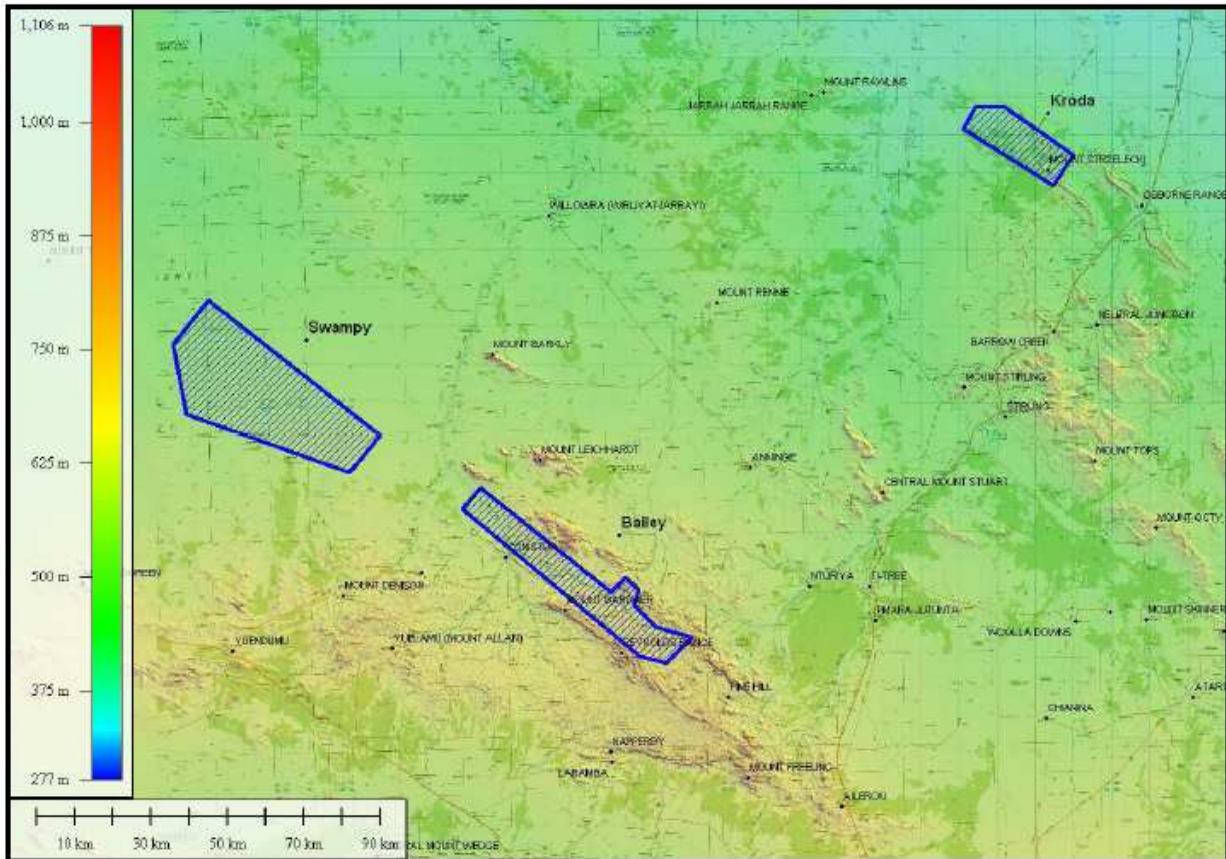
Tamani survey areas (Kroda, Swampy & Bailey)
GDA94 MGA 53

1.5 General Disclaimer

It is Fugro Airborne Survey's understanding that the data and report provided to the client is to be used for the purpose agreed between the parties. That purpose was a significant factor in determining the scope and level of the Services being offered to the Client. Should the purpose for which the data and report is used change, the data and report may no longer be valid or appropriate and any further use of, or reliance upon, the data and report in those circumstances by the Client without Fugro Airborne Survey's review and advice shall be at the Client's own or sole risk.

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2. SURVEY SPECIFICATIONS AND PARAMETERS

2.1 Area Co-ordinates

The survey areas were located within GDA94 MGA Zone 53S, Central Meridian = 135
(Note - Co-ordinates in GDA94/MGA Zone 53S)

Area 1 - Kroda			Area 3 - Bailey	
Easting	Northing		Easting	Northing
371814	7677358		229905	7572559
389926	7664857		234818	7577964
384585	7656846		268848	7550819
361197	7671714		272712	7554485
364129	7677336		276229	7551414
			274941	7547550
Area 2 - Swampy			280331	7541783
Easting	Northing		289901	7539030
200461	7581978		283362	7532194
157743	7597071		276387	7533919
154295	7615476			
163624	7626947			
208598	7591751			

2.2 Survey Area Parameters

Job Number	-	2319
Survey Company	-	Fugro Airborne Surveys Pty Ltd
Date Flown	-	21st June – 10th July 2012
Client	-	ABM Resources N.L.
EM System	-	25 Hz TEMPEST
Navigation	-	Real-time differential GPS
Datum	-	GDA94
Projection	-	MGA Zone 53S
Project Name	-	Tanami, N.T.
Area Names	-	Kroda, Swampy & Bailey.
Nominal Terrain Clearance	-	100 m
Traverse Line Spacing	-	400 m (Area 1 & 3)
		1000 m (Area 2)
Traverse Line Direction	-	034 – 214 degrees (Area 1)
		042 – 222 degrees (Area 2 & 3)
Traverse Line Numbers	-	10002 – 10143 (Area 1)
		20001 – 20058 (Area 2)
		30001 – 30169 (Area 3)
Tie Line Spacing	-	N/A (Area 1 & 2)
		4000 m (Area 3)
Tie Line Direction	-	N/A (Area 1 & 2)
		132 – 312 degrees (Area 3)
Tie Line Numbers	-	N/A (Area 1 & 2)
		39001 – 39005 (Area 3)
Line Kilometres Area 1 (Kroda)	-	1519 km
Line Kilometres Area 2 (Swampy)	-	1229 km
Line Kilometres Area 3 (Bailey)	-	1638 km
Total Survey Line Kilometres	-	4386 km

2.3 Job Safety Plan

A Job Safety Plan was prepared and implemented in accordance with the Fugro Airborne Surveys Occupational Safety & Health Management System.

3. AIRCRAFT EQUIPMENT AND SPECIFICATIONS

3.1 Aircraft

Manufacturer	-	CASA
Model	-	212
Registration	-	VH-TEM
Ownership	-	Fugro Airborne Surveys Pty Ltd

3.2 TEMPEST System Specifications

Specifications of the TEMPEST Airborne EM System (Lane et al., 2000) are:

- Base frequency - 25 Hz
- Transmitter area - 221 m^2
- Transmitter turns - 1
- Waveform - Square
- Duty cycle - 50%
- Transmitter pulse width - 10 ms
- Transmitter off-time - 10 ms
- Peak current - 280 A
- Peak moment - 61880 Am^2
- Average moment - 30940 Am^2
- Sample rate - 75 kHz on X and Z
- Sample interval - 13 microseconds
- Samples per half-cycle - 1500
- System bandwidth - 25 Hz to 37.5 kHz
- Flying height - 100 m (subject to safety considerations)
- EM sensor - Towed bird with 3 component dB/dt coils
- Tx-Rx horizontal separation - 120 m (nominal)
- Tx-Rx vertical separation - 35 m (nominal)
- Stacked data output interval - 200 ms (~12 m)
- Number of output windows - 15
- Window centre times - 13 µs to 16.2 ms
- Magnetometer - Stinger-mounted cesium vapour
- Magnetometer compensation - Fully digital
- Magnetometer output interval - 200 ms (~12 m)
- Magnetometer resolution - 0.001 nT
- Typical noise level - 1.0 nT
- GPS cycle rate - 1 second

3.2.1 EM Receiver and Logging Computer

The EM receiver computer was an EMFASDAS. The EM receiver computer executes a proprietary program for system control, timing, data acquisition and recording. Control, triggering and timing is provided to the TEMPEST transmitter and Digital Signal Processing (DSP) boards by the timing card, which ensures that all waveform generation and sampling is accomplished with high accuracy. The timing card is synchronised to the Global Positioning System (GPS) through the use of the Pulse Per Second (PPS) output from the system GPS card. Synchronisation is also provided to the magnetometer processor card for the purpose of accurate magnetic sampling with respect to the EM transmitter waveform.

The EM receiver computer displays information on the main screen during system calibrations and survey line acquisition to enable the airborne operator to assess the data quality and performance of the system.

3.2.2   TEMPEST Transmitter

The transmitted waveform is a square wave of alternating polarity, which is triggered directly from the EM receiver computer. The nominal transmitter base frequency was 25 Hz with a pulse width of 10ms (50 % duty cycle). Loop current waveform monitoring is provided by a current transformer located directly in the loop current path to allow for full logging of the waveform shape and amplitude, which is sampled by the EM receiver.

3.2.3   TEMPEST 3-Axis Towed Bird Assembly

The TEMPEST 3-axis towed bird assembly provides accurate low noise sampling of the X (horizontal in line), Y (horizontal transverse) and Z (vertical) components of the electromagnetic field. The receiver coils measure the time rate of change of the magnetic field (dB/dt). Signals from each axis are transferred to the aircraft through a tow cable specifically designed for its electrical and mechanical properties.

3.3   FASDAS Survey Computer

The Survey computer executes a proprietary program for acquisition and recording of location, magnetic and ancillary data. Data are presented both numerically and graphically in real time on the Video Graphics Array (VGA) Liquid Crystal Display (LCD) display, which provides an on-line display capability. The operator may alter the sensitivity of the displays on-line to assist in quality control. Selected EM data are transferred from the EM receiver computer to the SURVEY computer for quality control (QC) display.

3.3.1   Cesium Vapour Magnetometer Sensor

A cesium vapour magnetometer sensor is utilised on the aircraft and consists of the sensor head and cable, and the sensor electronics. The sensor head is housed at the end of a composite material tail stinger.

3.3.2   Magnetometer Processor Board

A FASDAS magnetometer processor board is used for de-coupling and processing the Larmor frequency output of the magnetometer sensor. The processor board interfaces with the survey computer, which initiates data sampling and transfer for precise sample intervals and also with the EM receiver computer to ensure that the magnetic samples remain synchronised with the EM system.

3.3.3   Fluxgate Magnetometer

A tail stinger mounted Bartington MAG-03MC three-axis fluxgate magnetometer is used to provide information on the attitude of the aircraft. This information is used for compensation of the measured magnetic total field.

3.3.4   GPS Receiver

A Novatel GPScard 951R is utilised for airborne positioning and navigation. Satellite range data are recorded for generating post processed differential solutions.

3.3.5   Differential GPS Demodulator

The OMNISTAR differential GPS service provides real time differential corrections.

3.4   Navigation System

A FASDAS Navigation Computer was used for real-time navigation. These computers load a pre-programmed flight plan from disk which contains boundary co-ordinates, line start and end co-ordinates, local co-ordinate system parameters, line spacing, and cross track definitions. The World Geodetic System 1984 (WGS84) latitude and longitude positional data received from the Novatel GPS card contained in the SURVEY computer is transformed to the local co-ordinate system for calculation of the cross track and distance to go values. This information, along with ground heading and ground speed, is displayed to the pilot numerically and graphically on a two line LCD display, and on an analogue Horizontal Strip Indicator (HSI). It is also presented on a LCD screen in conjunction with a pictorial representation of the survey area, survey lines, and ongoing flight path.

The Navigation computers are interlocked to the SURVEY computer for auto selection and verification of the line to be flown. The GPS information passed to the navigation computer is corrected using the received real time differential data from the OMNISTAR service, enabling the aircraft to fly as close to the intended track as possible.

3.5   Altimeter System

3.5.1   Radar Altimeter

Model:	Collins RL 50 radio altimeter system
Sample interval:	0.2 second
Accuracy:	+/- 1.5 % of indicated altitude.

The Collins radio altimeter is a high quality instrument whose output is factory calibrated. It is fitted with a test function which checks the calibration of a terrain clearance of 100 feet, and altitudes which are multiples of 100 feet. The aircraft radio altitude is recorded onto digital tape as well as displayed on the aircraft chart recorder. The recorded value is the average of the altimeters output during the previous second.

3.5.2   Laser Altimeter

Model:	Optech 501SB (WGT)
Sample interval:	0.2 second
Accuracy:	± 0.05m at survey altitude

3.5.3   Barometric Altimeter

Output of a Digiquartz 215A-101pressure transducer is used for calculating the barometric altitude of the aircraft. The atmospheric pressure is taken from a gimbal-mounted probe projecting 0.5 metres from the wing tip of the aircraft and fed to the transducer mounted in the aircraft wingtip.

3.6   Video Tracking System

The video file recorded by the digital video system is synchronised with the geophysical record by a digital fiducial display. It is also labelled with GPS latitude and longitude information and survey line number.

3.7   Data Recorded by the Airborne Acquisition Equipment

With the FASDAS acquisition system the raw EM data including fiducial, local time, X and Z axis sensor response, current monitor and bird auxiliary sensor output are recorded on the EM receiver computer as "*.raw" EM files. Logging to the files is continuous, however, a new *.raw EM file is created when the size of the previous one reaches 1GB.

The FASDAS Survey computer records a continuous MSD file which contains all other ancillary data including magnetic, altimeter, GPS and analogue channels.

4. GROUND DATA ACQUISITION EQUIPMENT AND SPECIFICATIONS

4.1 Magnetic Base Station

Two CF1 magnetometers were used to measure the daily variations of the Earth's magnetic field. The base stations were established in an area of low gradient, away from cultural influences. The base stations were run continuously throughout the survey flying period with a sampling interval of 1 and 5 seconds respectively, at a sensitivity of 0.01 nT. The base station data were closely examined after each day's production flying to determine if any data had been acquired during periods of out-of-specification diurnal variation. The base stations were located approximetly 80m apart at Ti Tree Airport.

4.2 GPS Base Station

A GPS base logging station was set up at Ti Tree Airport. The sensor was contained in the CF1 unit.

The GPS base system was comprised of a Novatel GPS PC card mounted in a portable computer. The computer is connected to a mains UPS backup, with a reserve capacity of approximately 100 minutes, to ensure continuous data logging in the event of mains power interruptions.

The GPS base station position was calculated by logging data continuously at the base position over a period of approximately 24 hours. These data were then statistically averaged to obtain the position of the base station using GrafNav software.

The calculated GPS base (1) position was (in WGS84):
    Lat: 22° 7' 52.94754" S
    Long: 133° 25' 18.07782" E
    Height: 572.333 m. (WGS84 Ellipsoidal Height)

5.   EM AND OTHER CALIBRATIONS AND MONITORING

At the beginning and end of each individual survey flight, the EM system is checked for background noise levels and performance. All of these checks are conducted at a nominal terrain clearance of 600 m (2000 ft) to eliminate ground response.

These checks include:-

5.1   Transmitter-off

These lines are recorded in straight and level flight with the system in standard survey geometry, with the transmitter turned off and bird response turned on to observe ambient noise and to check for noise in the receiver system (bird/coils → tow cable → winch → computer). *Note: FFFF is the flight number and PP is the attempt number.*

Pre-Flight Transmitter-off: **Line 900FFFFPP**
Post-Flight Transmitter-off: **Line 906FFFFPP**

5.2   Noise Additive

These lines are recorded in straight and level flight with the system in standard survey geometry, with the transmitter on and the bird response turned off at the tow cable winch. This is to check the noise contribution from the acquisition system and is used in deconvolution of survey line data. *Note: FFFF is the flight number and PP is the attempt number.*

Pre-Flight Noise Additive: **Line 901FFFFPP**
Post-Flight Transmitter-off: **Line 904FFFFPP**

5.3   Zero

These lines are recorded in straight and level flight with the system in standard survey configuration with transmitter and receiver turned on. This is used to determine the system's response in the absence of ground signal and is used to determine a standard waveform for deconvolution of survey lines. *Note: FFFF is the flight number and PP is the attempt number.*

Additionally, through all these calibrations the airborne operator can assess the system and ambient noise levels.

Pre-Flight Zero: **Line 902FFFFPP**
Post-Flight Zero: **Line 905FFFFPP**

5.4   Swoops

This line is recorded immediately after the pre-flight zero. During this manoeuvre the pilot conducts a series of 'swoop' manoeuvres (pitch up/pitch down) over approximately 30-40 seconds to vary the position of the towed sensor relative to the aircraft. The EM data are monitored by the airborne operator to confirm correct operation of the system during the manoeuvre. This data is used to determine coefficients used in the processing to compensate for such variations in the survey data. *Note: FFFF is the flight number and PP is the attempt number.*

Pre-Flight Swoop: **Line 903FFFFPP**

5.5   Dynamic Magnetometer Compensation

To limit aircraft manoeuvre effects on the magnetic data that can be of the same spatial wavelength as the signals from geological sources, compensation calibration lines are flown in a low magnetic gradient area close to the survey. This involves flying a series of tests on the survey line heading and approximately 15 degrees either side to accommodate small heading variations whilst flying survey lines. The data for each heading consists of a series of aircraft manoeuvres, including pitches, rolls and yaws. This is done to artificially create the most extreme possible attitude the aircraft may encounter whilst on

survey. Data from these lines are used to derive compensation coefficients for removing magnetic noise induced by the aircraft's attitude in the naturally occurring magnetic field.

Compensation data were acquired on the dates below.

21st June 2012

5.6   Parallax Checks

Due to the relative positions of the EM towed bird and the magnetometer instruments on the aircraft and to processing / recording time lags, raw readings from each vary in position. To correct for this and to align selected anomaly features on lines flown in opposite directions, magnetics, EM data and the altimeters are 'parallaxed' with respect to the position information. System parallax is checked occasionally or following any major changes in the aircraft system, which are likely to affect the parallax values.

Variable	Parallax Value
Magnetics	13.2 s
GPS	0 s
Radar Altimeter	0 s
Laser Altimeter	0 s
EM - X	- 4.4 s
EM – Z	- 3.0 s

5.7   Radar Altimeter Calibration

The radar altimeter is checked for accuracy and linearity every 12 months or when any change in a key system component requires this procedure to be carried out. This calibration allows the radar altimeter data to be compared and assessed with other height data (GPS and barometric) to confirm the accuracy of the radar altimeter over its operating range.

Absolute radar and barometric altimeter calibration was carried out over water at Mandurah, Western Australia, and was successful in calibrating the radar altimeter to information provided by the GPS and barometer instrument. Calibration factors were as expected. The calibration procedure also provides parallax information required for positional correction of the radar and GPS altimeters.

5.8   Heading Error Checks

Historically, heading error checks have been part of the aeromagnetic data acquisition procedure but they are no longer used. Fugro Airborne Surveys now calculates these effects using the aircraft magnetic compensation system and specially developed software. The precision to which these effects are now calculated and corrected for is far in excess of the manual methods used in the past.

6. DATA PROCESSING

6.1   Field Data Processing

6.1.1   Quality Control Specifications

6.1.1.1   Navigation Tolerance

The re-flight specifications applied for the duration of the survey were:

Electronic Navigation - absence of electronic navigation data (e.g. GPS base station fails).

Flight Path - where the flightpath deviates from the flightplan by more than 50 metres for more than 5 km. The line spacing measurements to be used in determining such reflights will be made from the field flight path recovery

Altitude - terrain clearance continuously exceeds the nominal terrain clearance by plus or minus 30 m over a distance of 5 km or more unless to do so would, in the sole opinion of the pilot, jeopardise the safety of the aircraft or the crew or the equipment or would be in contravention of the Civil Aviation Safety Authority regulation such as those pertaining to built up areas.

6.1.1.2   Magnetics Noise and Diurnal Tolerance

The re-flight specifications applied for the duration of the survey were:

Magnetic Diurnal - where the magnetometer base station data exceeds a 10 nT change in 10 minutes.

6.1.1.3   Electromagnetic Data

The quality control checks on the electromagnetic data were:

Noise - where RMS noise in the last channel of the EM data exceeds 0.1 fT over 3 km for B-field (assessed in a resistive region) or where FAS believes an important anomaly is rendered un-interpretable.

Sferics – where sferic activity renders a potential anomaly un-interpretable.

6.1.2   In-Field Data Processing

Following acquisition, multiple copies of the EM data are made onto DVDs or CDs. The EM, location, magnetic and ancillary data are then processed at the field base to the point that the quality of the data from each flight can be fully assessed. Copies of the raw and processed data are then transferred to Perth for final data processing. A more comprehensive statement of EM data processing is given in section 6.2.3.

6.2 Final Data Processing

6.2.1   Magnetics

Magnetic data were compensated for aircraft manoeuvre noise using coefficients derived from the appropriate compensation flight. Base station data is edited so that all significant spikes, level shifts and null data are eliminated.

A diurnal base value was then added.

Area	Base Value
Tanami	50200nT

A lag was applied to synchronise the magnetic data with the navigation data.

The International Geomagnetic Reference Field (IGRF) 2010 model (updated for secular variation) was removed from the levelled total field magnetics. An IGRF base value was then added to the data.

Area	Base Value	Updated Model
Tanami	49956nT	21/6/2012

Where appropriate the magnetic data was tie line levelled. A FAS proprietary microlevelling process was then applied in order to more subtly level the data.

Note: Magnetic data was only processed to finals and delivered for Area 2.

6.2.2   Derived Topography

Aircraft navigation whilst in survey mode is via real time differential GPS, obtained by combining broadcast differential corrections with on-board GPS measurements. Terrain clearance is measured with a laser altimeter.

The ground elevation, relative to the WGS84 spheroid used by GPS receiver units, is obtained by finding the difference between the terrain clearance (from the final processed and edited laser altimeter) and the aircraft GPS antenna altitude above the ellipsoid (GPS height derived from post-processing of the DGPS data using the field base station data), and taking into account that the laser altimeter is mounted 2.3 metres below the GPS antenna.

The digital elevation model derived from this survey can be expected to have an absolute accuracy of +/- several metres in areas of low to moderate topographic relief. Sources of error include uncertainty in the height of the GPS base station, variations in the laser altimeter characteristics over ground of varying surface characteristics (ie. false and non-returns are more prevalent over dense vegetation and water, respectively), and the finite footprint of the laser altimeter.

Following this, where appropriate, tie line and micro-levelling was applied in order to more subtly level the data. The algorithms are FAS proprietary operations used to remove the small across-line corrugations that may appear in the gridded data. The micro-levelling process attempts to de-corrugate the data without destroying the data's integrity. This is achieved by confining the changes to very small values and applying them as a correction to the along-line data.

An N-Value is then subtracted to correct the final data to the Australian Height Datum (AHD).

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, laser altitude and GPS altitude. The GPS altitude value is dependent on the number of available satellites, plus the accuracy of the averaged GPS base position. Although post-processing of GPS data will yield X and Y accuracies in the order of 0.5 metres, the accuracy of the altitude value is usually much less, but generally still within 1-2 metres. Further inaccuracies may be introduced during the interpolation and gridding process as only 1 out of every 5 points across-line is real data. Furthermore, along line obstructions may cause the pilot to veer laterally and so data interpolated between lines may vary significantly from real topography, and do not show artificial vertical obstructions.

Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.

6.2.3   Electromagnetic Data Processing

Details of the pre-processing applied to TEMPEST data can be found in Lane et al. (2000).

6.2.3.1   Standard EM Processing

Calibration
High altitude calibration data are used to characterise the system response in the absence of any ground response.

Cleaning and Stacking
Routines to suppress sferic noise, powerline noise, VLF noise, and coil motion noise (collectively termed "cleaning" and to stack the data are applied to the survey line data. Output from the stacking filter is drawn at 0.2 second intervals. The stacked data are saved to file as an internal data management practice.

Deconvolution and Binning
The survey height stacked data are deconvolved using the high altitude reference waveform. The effect of currents in the transmitter loop and airframe ("primary") are then removed, leaving a "pure" ground response. The deconvolved ground response data are then transformed to B-field response for a perfect 100% duty cycle square wave. Finally, the evenly spaced samples are binned into a number of windows.

Table of TEMPEST window information for 25Hz base frequency

Window #	Start sample	End sample	No of samples	start time (s)	End time (s)	centre time (s)	centre time (ms)
1	1	2	2	0.000007	0.000020	0.000013	0.013
2	3	4	2	0.000033	0.000047	0.000040	0.040
3	5	6	2	0.000060	0.000073	0.000067	0.067
4	7	10	4	0.000087	0.000127	0.000107	0.107
5	11	16	6	0.000140	0.000207	0.000173	0.173
6	17	26	10	0.000220	0.000340	0.000280	0.280
7	27	42	16	0.000353	0.000553	0.000453	0.453
8	43	66	24	0.000567	0.000873	0.000720	0.720
9	67	102	36	0.000887	0.001353	0.001120	1.120
10	103	158	56	0.001367	0.002100	0.001733	1.733
11	159	246	88	0.002113	0.003273	0.002693	2.693
12	247	384	138	0.003287	0.005113	0.004200	4.200
13	385	600	216	0.005127	0.007993	0.006560	6.560
14	601	930	330	0.008007	0.012393	0.010200	10.200
15	931	1500	570	0.012407	0.019993	0.016200	16.200

The data are reviewed after windowing. Any decisions involving re-flights due to AEM factors are made at this point.

Raw and Final EM Data
The "raw" or "uncorrected" EM amplitudes reflect, not only the variations in ground conductivity, but the variations in geometry of the various parts of the EM measurements (i.e. transmitter loop pitch, transmitter loop roll, transmitter loop terrain clearance, transmitter loop to receiver coil horizontal longitudinal separation, transmitter loop to receiver coil horizontal transverse separation, and transmitter loop to receiver coil vertical separation) during the survey. For example, the largest influence on the early time EM amplitude is the terrain clearance of the transmitter loop. The larger the terrain clearance, the smaller the amplitude. Later window times (larger window number) show diminished variations due to terrain clearance.

"Final" or "geometry-corrected" located data are produced for optimum presentation of the EM amplitude data in image format (e.g. window amplitude images, principal component analysis images derived from the window amplitudes (Green, 1998b)). Between "raw" and "final" states, the ground response data undergo an approximate correction to produce data from a nominated standard geometry. A dipole-image method (Green, 1998a) is used to adjust the data to the response that would be expected at a standard terrain clearance (100m), standard transmitter loop pitch and roll (zero degrees), and a standard transmitter loop to receiver coil geometry (120m behind and 35m below the aircraft). These variables have been set to their respective standard values in the "final" located data (whereas the "raw" located data file contains the variable field data). Zero parallax is applied to transmitter loop pitch, roll, terrain clearance, X component EM and Z component EM data prior to geometry correction. Over extremely conductive ground (e.g. > 100 S conductance), the estimates for transmitter loop to receiver coil separation determined from the primary field coupling factors may be in error at the metre scale due to uncertainty in the estimation of the primary field. This will influence the accuracy of very early time window amplitude information in the "geometry-corrected" located data. Receiver coil pitch has a significant effect on early time Z component response and late time X component response (Green and Lin, 1996). Receiver coil roll impacts early time Z component response.

Levelling

Limited range micro-levelling may be applied to the final window amplitudes for presentation purposes, principally for multi-flight surveys or when isolated re-flight lines are present.

6.2.3.2   Factors and Corrections

Geometric Factor

The geometric factor gives the ratio of the strength of the primary field coupling between the transmitter loop and the receiver coil at each observation relative to the coupling observed at high altitude during acquisition of reference waveform data. Variations in this factor indicate a change in the attitude and/or relative separation of the transmitter loop and the receiver coil.

Transmitter-Receiver Geometry

Transmitter to receiver geometry values for each observation is derived from the high altitude reference waveforms and knowledge of the system characteristics. These data are available in the located data (see section 6.2.6.1 for "standardised" values)

GPS Antenna, Laser Altimeter and Transmitter Loop Offset Corrections

The transmitter loop was mounted 0.1m above the GPS antenna on the aircraft. The GPS antenna is 3.3m above the belly of the aircraft. The laser altimeter sensor is mounted in the belly of the aircraft. Therefore a total of 3.05m (-0.25m + 3.3m) was added to the laser altimeter data to determine the transmitter loop height above the ground.

Transmitter Loop Pitch and Roll Correction

Measured vertical gyro aircraft pitch and roll attitude measurements are converted to transmitter loop pitch and roll by adding 0.45 degrees for pitch and 0.6 degrees for roll. Nose up is positive for pitch, and left wing up is positive for roll.

6.2.3.3   Primary Sources of EM Noise

A number of "monitor" values are calculated during processing to assist with interpretation. They generally represent quantities that have been removed as far as is practical from the data, but may still be present in trace amounts. These are more significant for interpretation of discrete conductors than for general mapping applications.

Sferic Monitor

Sferics are the electromagnetic signals associated with lightning activity. These signals travel large distances around the Earth. Background levels of sferics are recorded at all times from lightning activity in tropical areas of the world (eg tropical parts of Asia, South America and Africa). Additional higher amplitude signals are produced by "local" lightning activity (ie at distances of kilometres to hundreds of kilometres).

The sferic monitor is the sum of the absolute differences brought about by the sferic filter operations, summed over 0.2 second intervals, normalised by the receiver effective area. It is given in units of uV/sq.m/0.2s. Many sferics have a characteristic form that is well illustrated by figure 2 in Garner and Thiel (2000). The high frequency, initial part of a sferic event can be detected and filtered more easily than the later, low frequency portion. The sferic monitor indicates where at least the high frequency portion of a sferic has been successfully removed, but it is quite possible that lower frequency elements of the sferic event may have eluded detection, passing through to the window amplitude data. Thus, discrete anomalies coincident with sferic activity as indicated by the sferic monitor should be down-weighted relative to features clear of any sign of sferic activity.

Low Frequency Monitor
The Low Frequency Monitor (LFM) makes use of amplitudes at frequencies below the base frequency which are present in the streamed data to estimate the amplitude of coil motion (Earth magnetic field) noise at the base frequency in log10(pV/sqrt(Hz)/sq.m). The coil motion noise below the base frequency is rejected through the use of tapered stacking, but the coil motion noise at the base frequency itself is not easily removed. A sharp spike in the LFM can be an indicator of a coil motion event (eg the bird passing through extremely turbulent air). Note that the LFM will also respond to sferic events with an appreciable low frequency (sub-base frequency) component. This situation can be inferred when both the LFM and sferic monitors show a discrete kick.

Powerline Monitor
The powerline monitor gives the amplitude of the received signal at the powerline frequency (50 or 60 Hz) in log10 (pV/sqrt (Hz)/sq.m). Careful selection of the base frequency (such that the powerline frequency is an even harmonic of the base frequency) and tapered stacking combine to strongly attenuate powerline signals. When passing directly over a powerline, the rapid lateral variations in the strength and direction of the magnetic fields associated with the powerline can result in imperfect cancellation of the powerline response during stacking. Some powerline-related interference can manifest itself in a form that is similar to the response of a discrete conductor. The exact form of the monitor profile over a powerline depends on the line direction, powerline direction, powerline current, and receiver component, but the monitor will show a general increase in amplitude approaching the powerline.

Grids (or images) of the powerline monitor reveal the location of the transmission lines. Note that the X component (horizontal receiver coil axis parallel with the flight line direction) does not register any response from powerlines parallel to the flight line direction since the magnetic fields associated with powerlines only vary in a direction perpendicular to the powerline. Note also that the Z component (vertical receiver coil axis) shows a narrow low directly over the powerline where the magnetic fields are purely horizontal.

Very Low Frequency Monitors
Wide area VLF communication signals in the 15 to 25 kHz frequency band are monitored by the TEMPEST system. In the Australian region, signals at 18.2 kHz, 19.8 kHz, 21.4 kHz and 22.2 kHz are monitored as the amplitude of the received signal at these frequencies in log10(pV/sqrt(Hz)/sq.m). The strongest signal comes from North West Cape (19.8 kHz). The signal at 18.2 kHz is often observed to pulse in a regular sequence. These strong narrow band signals have some impact on the high frequency response of the system, but they are strongly attenuated by selection of the base frequency and tapered stacking. The VLF transmissions are strongest in amplitude, in the horizontal direction at right angles to the direction to the VLF transmitter. This directional dependence enables the VLF monitors to be used to indicate the receiver coil attitude.

6.2.3.4   Other Sources of EM Noise
Man-made periodic discharges
If an image of the Z component sferic monitor shows the presence of spatially coherent events, then pulsed cultural interference would be strongly suspected. Since sferic signals are much stronger in the horizontal plane than in the vertical plane, few sferics of significant amplitude are recorded in Z component data. In contrast, evidence of cultural interference is generally swamped by true sferics in X component sferic monitor images.

Electric fences are the most common source of pulsed cultural interference. Periodic discharges (eg every second or so) into a large wire loop (fence) produce very large spikes in raw data. These are attenuated to a large degree by the sferic filter, but a residual artefact can still be present in the processed data.

Coil motion / Earth field noise

A change in coupling between the receiver coil and the ambient magnetic field will induce a voltage in the receiver coil. This noise is referred to as coil motion or Earth field noise. Receiver coils in the towed bird are suspended in a fashion that attempts to keep this noise below the noise floor at frequencies equal to and above the base frequency of the system. Severe turbulence, however, can result in 'coil knock events' that introduce noise into the processed data.

Grounded metal objects

Grounded extensive metal objects such as pipelines and rail lines can qualify as conductors and may produce a response that is visible in processed data. Grounded metal objects produce a response similar to shallow, highly conductive, steeply dipping conductors. These objects can sometimes be identified from good quality topographic maps, from aerial photographs, by viewing the tracking video, from their unusual spatial distribution (ie often a series of linear segments) and in some circumstances from their effect on the powerline monitor. A powerline running close to a long metal object will induce a 50 Hz response in the object.

6.2.4   Conductivity Depth Images (CDI)

CDI conductivity sections for TEMPEST data were calculated using EMFlow and then modified to reflect the finite depth of investigation using an in-house routine, *Sigtime*.

The *Sigtime* routine removes many of the spurious conductive features that appear at depth as a result of fitting long time constant exponential decays to very small amplitude features in the late times. For each observation, the time when the response falls below a signal threshold amplitude is determined. This time is transformed into a diffusion depth with reference to the conductivity values determined for that observation. Anomalous conductivity values below this depth are replaced by background values or set to undefined, reflecting the uncertainty in their origin. The settings and options applied are indicated in the appropriate header files for *Sigtime* output. This procedure is different to that which would be obtained by filtering conductivity values using either a constant time or constant depth across the entire line.

The "final" Z component EM data were input into version 5.10 of EMFlow to calculate Conductivity Depth Images (CDI). Conductivity values were calculated at each point then run through *Sigtime.*

EMFlow was developed within the CRC-AMET through AMIRA research projects (Macnae et al, 1998, Macnae and Zonghou, 1998, Stolz and Macnae, 1998). The software has been commercialised by Encom Technology Pty Ltd. Examples of TEMPEST conductivity data can be seen in Lane et al. (2000), Lane et al. (1999), and Lane and Pracillio (2000).

Conductivity values were calculated to a depth of 500 m below surface at each point, using a depth increment of 5 m and a conductivity range of 0.01-100mS/m for areas1 and 3 and 0.1-200mS/m for area 2.

6.2.5   System Specifications for Modelling TEMPEST Data

Differences between the specifications for the acquisition system, and those of the virtual system for which processed results are given, must be kept in mind when forward modelling, transforming or inverting TEMPEST data.

Acquisition is carried out with a 50% duty cycle square transmitter current waveform and dB/dt sensors.

During processing, TEMPEST EM data are transformed to the response that would be obtained with a B-field sensor for a 100% duty cycle square waveform at the base frequency, involving a 1A change in current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter. Data are given in units of femtotesla (fT = 10^{-15} Tesla). It is this configuration, rather than the actual acquisition configuration, which must be specified when modelling TEMPEST data.

Window timing information is given above (see section 6.2.3).

6.2.5.1   Standard Height and Geometry

The "final" EM data have been standardised through an approximate transformation to a standard transmitter loop terrain clearance, transmitter loop pitch and roll of zero degrees, and a fixed transmitter loop to receiver coil geometry (roughly equal to the average "raw" geometry values). Transmitter loop pitch, transmitter loop roll and transmitter loop terrain clearance values for each observation have been modified to reflect the standard values. Hence, the "final" (fixed) geometry values should be used if modelling with the final X- and Z-component amplitude data - the following table summarises the values used to correct the transmitter height/pitch/roll/geometry to.

Table of values used to standardise transmitter loop height, pitch, roll and geometry

Variable	Standardised value
Transmitter loop pitch	0 degrees
Transmitter loop roll	0 degrees
Transmitter loop terrain clearance	100 metres
Transmitter loop – to – receiver coil geometry	120 m behind and 35 m below the aircraft

6.2.5.2   Parallax

The located data files utilise the following parallax values:-
- magnetics = 13.2 fiducials (69 observations from the zero parallax position),
- radar altimeter = 0 fiducials (0 observations from the zero parallax position),
- EM X-component = -4.4 fiducials (22 observation from the zero parallax position),
- EM Z-component = -3.0 fiducials (15 observations from the zero parallax position),

For the Tempest Airborne EM system, due to the asymmetry in the transmitter loop-receiver coil geometry with respect to flight direction, there is no single EM parallax value which will align the peak response for all conductivity distributions for lines flown in opposite directions.

The choice of EM parallax value depends on the intended usage, but with the predominance of broad, shallowly dipping conductors, and the client's desire to grid the data, parallax has been applied so that data are optimised for gridding. The 'optimum' depends on the conductor depth, the acquisition geometry and the delay time, and hence, the selected value will be a compromise.

(NB negative parallax values are defined in this case as shifting the indicated quantity forward along line to larger fiducial values. Location information remains in the zero parallax state)

6.2.6   Delivered Products

Appendix III contains a complete list of all data supplied digitally.

Digital ascii located data and a Geosoft GDB format were produced, containing the raw and final, X and Z EM data, conductivity and digital terrain data. Magnetic located data were only supplied for Area 2, Swampy.

Stacked CDI sections and CDI-multiplots (Z component) in Adobe PDF format.

Grids (in ER Mapper format) of all X and Z EM windows and digital elevation were produced. Magnetic grids were only supplied for Area 2, Swampy.

A flight path map was delivered in "png" image format.

Acquisition and processing report in hardcopy and digital format.

7. REFERENCES

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APPENDIX I – Weekly Acquisition Reports

System:	Tempest		
Aircraft:	VH-TEM		

	19446.2	Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation
Total Job kms: 4386.600 Kms	19546.2	Hrs - The hours the Periodic Inspection is actally due at start of the job

Plan Kms Remain: 0.000 Kms
% Complete: 100.000 %

Job Number: 2319
Contract Number: CT6892
Job Name: Tanami,NT
Area Names: kroda, Swampy & Bailey
Client: ABM Recources

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	FAS Scrub	Time Start	End	Engine Hours on M/R	Hours to Periodic Inspectio	Job Hrs to Date	Prod. to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc
18-June-2012 Julian Day 170 **Monday**									100.0							
Date 19-Jun Julian Day 171 **Tuesday**		PH,ED				10:33:00	12:48:00	2.3						0.50	MO	PH, ED ferry TEM from Perth to Kalgoorlie
														0.50	MO	BR & MA fly from Perth to Alice Springs
									97.7	2.3						
Date 20-Jun Julian Day 172 **Wednesday**		PH,ED				6:36:00	9:12:00	2.6						0.25	MO	PH,ED ferry TEM from Kalgoorlie to Warburton
		PH,ED				10:13:00	13:12:00	3.0						0.25	MO	PH,ED ferry TEM from Warburton to Ti Tree
														0.25	MO	GRJ flies from Brisbane to Alice Springs
														0.25	MO	BR, MA, GRJ drive from Alice Springs to Ti Tree
									92.1	7.9					Comment	Base Setup
Date 21-Jun Julian Day 173 **Thursday**	1	PH,ED	BR			9:44:00	13:26:00	3.7						0.50	SETUP	Reccie / Comp Box / PTW
														0.50	SETUP	Base Setup
									88.4	11.6						
Date 22-Jun Julian Day 174 **Friday**	2	PH,ED	BR	414.300	96.200	8:06:00	14:01:00	5.9						1.00	P & S	Scrubs due coil knocks and system issue
															Comment	GPS issues, temporary fix installed.
															Comment	scrubs due to system problem.
									82.5	17.5	414.300	96.200				
Date 23-Jun Julian Day 175 **Saturday**	3	PH,ED	BR	11.300	33.900	9:27:00	11:06:00	1.7							Comment	Scrubs due coil knocks / gusting wind conditions
													1.00	1.00	W	Flight terminated due to strong / gusting winds on-
									80.8	19.2	425.600	130.100				
Date 24-Jun Julian Day 176 **Sunday**	4	PH,ED	BR	11.300	78.800	7:42:00	9:38:00	1.9							Comment	Scrubs due coil knocks / gusting wind conditions
													1.00	1.00	W	No further flights possible due to winds
															Comment	Weekly Site Safety Meeting
								`	78.9	21.1	436.900	208.900				
Totals This Week: ▶				**436.900**	**208.900**	Week Hours:▶	**21.0**	▲: A/C Hrs to Next Service					**2.00**	**6.00**		

System:	Tempest	
Aircraft:	VH-TEM	

19446.2 Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation

Total Job kms: 4386.600 Kms

19546.2 Hrs - The hours the Periodic Inspection is actally due at start of the job

Plan Kms Remain: 0.000 Kms
% Complete: 100.000 %

Job Number: 2319
Contract Number: CT6892
Job Name: Tanami,NT
Area Names: kroda, Swampy & Bailey
Client: ABM Recources

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	FAS Scrub	Time Start	End	Engine Hours on M/R	Hours to Periodic Inspectio	Job Hrs to Date	Prod. to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc
25-June-2012														1.00	PDO	PDO
Julian Day 177																
Monday																
									78.9	21.1	436.900	208.900				
Date 26-Jun	5	PH,ED	BR		67.200	7:13:00	8:57:00	1.7							Comment	Scrubs due coil knocks
Julian Day 178													1.00	1.00	W	Flight terminated due to strong / gusting winds.
Tuesday																
									77.2	22.8	436.900	276.100				
Date 27-Jun	6	PH,ED	BR	678.300	21.700	8:42:00	15:00:00	6.3						1.00	P & S	Coil Knocks & Turbulence
Julian Day 179															Comment	James Kenny Arrives
Wednesday																
									70.9	29.1	1115.200	297.800				
Date 28-Jun	7	PH,ED	BR	710.300	30.100	7:11:00	13:25:00	6.2						0.50	P & S	Coil Knocks & Turbulence
Julian Day 180	8	PH,ED	BR	288.200		14:43:00	17:43:00	3.0						0.50	P	
Thursday																
									61.7	38.3	2113.700	327.900				
Date 29-Jun	9	PH,ED	BR		17.700	7:01:00	8:04:00	1.1						0.50	S	Bird Problems, flight cut short
Julian Day 181														0.50	E	Bird Problems
Friday																
									60.6	39.4	2113.700	345.600				
Date 30-Jun															Comment	Bird Problems / repairs
Julian Day 182														1.00	PDO	PDO
Saturday																
									60.6	39.4	2113.700	345.600				
Date 1-Jul	10	PH,ED	BR			8:46:00	9:53:00	1.1						0.50	E	Bird Test Flight
Julian Day 183														0.50	E	High winds. No further flights
Sunday																
							`		59.5	40.5	2113.700	345.600				

Totals This Week: ▶	1676.800	136.700	Week Hours:▶	19.4	▲: A/C Hrs to Next Service	1.00	7.00

System:	Tempest
Aircraft:	VH-TEM

19446.2 Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation

Total Job kms:	4386.600	Kms

19546.2 Hrs - The hours the Periodic Inspection is actally due at start of the job

Plan Kms Remain:	0.000	Kms
% Complete:	100.000	%

Job Number:	2319
Contract Number:	CT6892
Job Name:	Tanami,NT
Area Names:	kroda, Swampy & Bailey
Client:	ABM Recources

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspectio	Job Hrs to Date	Prod. to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc
02-July-2012	11	PH, ED	BR	558.000	34.000	6:50:00	12:42:00	5.9						1.00	P & S	Scrubs due turbulence / coil motion
Julian Day 184																
Monday																
									53.6	46.4	2671.700	379.600				
Date 3-Jul	12	PH,ED	BR	147.500	738.000	7:01:00	13:16:00	6.3						0.50	P & S	Scrubs due turbulence / coil motion
Julian Day 185													0.50	0.50	W	less than 150km accepted (0.5 standby)
															Comment	Client dropped by.
Tuesday																
									47.3	52.7	2819.200	1117.600				
Date 4-Jul	13	PH,ED	BR	40.500	572.800	6:57:00	13:20:00	6.4							Comment	Scrubs due turbulence / coil motion
Julian Day 186													1.00	1.00	W	short flight due wx. Less than 100km accepted
Wednesday																
									40.9	59.1	2859.700	1690.400				
Date 5-Jul	14	PH,ED	BR		47.800	6:45:00	8:24:00	1.7							Comment	Scrubs due turbulence / coil motion
Julian Day 187													1.00	1.00	W	short flight- turbulence. Less than 100km accepted
Thursday																
									39.2	60.8	2859.700	1738.200				
Date 6-Jul														1.00	PDO	PDO called due to strong winds
Julian Day 188																
Friday																
									39.2	60.8	2859.700	1738.200				
Date 7-Jul	15	PH,ED	BR	47.300	79.800	7:10:00	10:07:00	3.0							Comment	Scrubs due turbulence / coil motion
Julian Day 189													1.00	1.00	W	short flight - turbulence. Less than 100km
Saturday																
									36.2	63.8	2907.000	1818.000				
Date 8-Jul	16	PH,ED	BR	430.500	66.000	6:55:00	13:00:00	6.1						1.00	P & R & S	Scrubs due turbulence / coil motion
Julian Day 190																
Sunday																
								`	30.1	69.9	3337.500	1884.000				

Totals This Week: ▶ **1223.800**   **1538.400**   Week Hours:▶ **29.2**   ▲: A/C Hrs to Next Service   **3.50**   **7.00**

System:	Tempest	
Aircraft:	VH-TEM	

19446.2 Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation

Total Job kms:	4386.600 Kms

19546.2 Hrs - The hours the Periodic Inspection is actally due at start of the job

Plan Kms Remain:	0.000 Kms
% Complete:	100.000 %

Job Number:	2319
Contract Number:	CT6892
Job Name:	Tanami,NT
Area Names:	kroda, Swampy & Bailey
Client:	ABM Recources

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspectio	Job Hrs to Date	Prod. to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc
09-July-2012	17	PH,ED	BR	514.600	223.400	6:50:00	12:22:00	5.5						1.00	P & S	Scrubs due turbulence / coil motion
Julian Day 191															Comment	JK departs
Monday																
									24.6	75.4	3852.100	2107.400				
Date 10-Jul	18	PH,ED	BR	534.500	26.100	6:59:00	12:05:00	5.1						1.00	P & S	Scrubs due turbulence / coil motion
Julian Day 192															Comment	JRG arrives
Tuesday																
									19.5	80.5	4386.600	2133.500				
Date 11-Jul														1.00	SETUP	Packup
Julian Day 193																
Wednesday																
									19.5	80.5	4386.600	2133.500				
Date 12-Jul														1.00	MO	Aircraft and vehicle demobilise
Julian Day 194																
Thursday																
									19.5	80.5	4386.600	2133.500				
Date 13-Jul																
Julian Day 195																
Friday																
									19.5	80.5	4386.600	2133.500				
Date 14-Jul																
Julian Day 196																
Saturday																
									19.5	80.5	4386.600	2133.500				
Date 15-Jul																
Julian Day 197																
Sunday																
								`	19.5	80.5	4386.600	2133.500				

Totals This Week: ▶	**1049.100**	**249.500**	Week Hours:▶ **10.6**	▲: A/C Hrs to Next Service	**4.00**

APPENDIX II – Located Data Formats

Headers for final data files

FINAL EM

AREA 1

```
COMM FAS PROJECT NUMBER                                                   2319
COMM AREA NUMBER:                                                            1
COMM SURVEY COMPANY:                                      Fugro Airborne Surveys
COMM CLIENT:                                                   ABM Resources NL
COMM SURVEY TYPE:                                          25Hz TEMPEST Survey
COMM AREA NAME:                                                          Kroda
COMM STATE:                                                                 NT
COMM COUNTRY:                                                         Australia
COMM SURVEY FLOWN:                                                   July 2012
COMM LOCATED DATA CREATED:                                           July 2012
COMM
COMM DATUM:                                                             GDA94
COMM PROJECTION:                                                           MGA
COMM ZONE:                                                                  53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                              400 m
COMM TRAVERSE LINE DIRECTION:                                     34 - 214 deg
COMM NOMINAL TERRAIN CLEARANCE:                                          100 m
COMM FINAL LINE KILOMETRES:                                            1519 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                                     10002 - 10143
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                              CASA 212, VH-TEM
COMM
COMM MAGNETOMETER:                                  Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                             Stinger mounted
COMM RESOLUTION:                                                     0.001 nT
COMM RECORDING INTERVAL:                                               0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                    25Hz TEMPEST
COMM INSTALLATION:             Transmitter loop mounted on the aircraft
COMM                                      Receiver coils in a towed bird
COMM COIL ORIENTATION:                                                   X,Z
COMM RECORDING INTERVAL:                                               0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:        -120 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:          -35 m
COMM
COMM RADAR ALTIMETER:                                         Collins RL-50
COMM RECORDING INTERVAL:                                               0.2 s
COMM
COMM LASER ALTIMETER:                                          Optech 501SB
COMM RECORDING INTERVAL:                                               0.2 s
COMM
COMM NAVIGATION:                                  Real-time differential GPS
COMM RECORDING INTERVAL:                                               1.0 s
```

```
COMM
COMM ACQUISITION SYSTEM:                                          FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED              0.0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED              0.0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                               0.0 s
COMM
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN TIE LINE LEVELLED
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM    X-COMPONENT EM DATA                                    4.4 s
COMM    Z-COMPONENT EM DATA                                    3.0 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED          EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                         000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                             5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM -------------------------------------------------------------------
COMM DISCLAIMER
COMM -------------------------------------------------------------------
COMM It is Fugro Airborne Survey's understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
COMM altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
```

```
COMM satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
COMM the order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM -------------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START        END      CENTRE
COMM    1        0.007      0.020       0.013
COMM    2        0.033      0.047       0.040
COMM    3        0.060      0.073       0.067
COMM    4        0.087      0.127       0.107
COMM    5        0.140      0.207       0.173
COMM    6        0.220      0.340       0.280
COMM    7        0.353      0.553       0.453
COMM    8        0.567      0.873       0.720
COMM    9        0.887      1.353       1.120
COMM   10        1.367      2.100       1.733
COMM   11        2.113      3.273       2.693
COMM   12        3.287      5.113       4.200
COMM   13        5.127      7.993       6.560
COMM   14        8.007     12.393      10.200
COMM   15       12.407     19.993      16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM  Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                     UNITS           NULL              FORMAT
COMM Line                                      -99999999         I10
COMM Flight                                    -99               I4
COMM Fiducial                                  -999999.9         F8.1
COMM Project_FAS                               -9999             I6
COMM Date                                      -9999999          I9
COMM Time                      s               -9999.9           F8.1
COMM Bearing                   deg             -99               I4
COMM Latitude                  deg             -99.9999999       F12.7
COMM Longitude                 deg             -999.9999999      F13.7
COMM Easting                   m               -99999.99         F10.2
COMM Northing                  m               -999999.99        F11.2
COMM Tx_Elevation              m               -999.99           F8.2
```

```
COMM Lidar                         m                -999.99            F8.2
COMM DTM                           m                -999.99            F8.2
COMM Tx_Pitch                      deg              -999.99            F8.2
COMM Tx_Roll                       deg              -999.99            F8.2
COMM Tx_Clearance                  m                -999.99            F8.2
COMM HSep_Raw                      m                -999.99            F8.2
COMM VSep_Raw                      m                -999.99            F8.2
COMM Tx_Clearance_std              m                -999.99            F8.2
COMM HSep_std                      m                -999.99            F8.2
COMM VSep_std                      m                -999.99            F8.2
COMM EMX_nonhprg[1:15]             fT               -999.999999        F12.6
COMM EMX_hprg[1:15]                fT               -999.999999        F12.6
COMM X_Sferics                                      -9999.999          F10.3
COMM X_LowFreq                                      -9999.999          F10.3
COMM X_Powerline                                    -9999.999          F10.3
COMM X_VLF1                                         -9999.999          F10.3
COMM X_VLF2                                         -9999.999          F10.3
COMM X_VLF3                                         -9999.999          F10.3
COMM X_VLF4                                         -9999.999          F10.3
COMM X_Geofact                                      -9999.999          F10.3
COMM EMZ_nonhprg[1:15]             fT               -999.999999        F12.6
COMM EMZ_hprg[1:15]                fT               -999.999999        F12.6
COMM Z_Sferics                                      -9999.999          F10.3
COMM Z_LowFreq                                      -9999.999          F10.3
COMM Z_Powerline                                    -9999.999          F10.3
COMM Z_VLF1                                         -9999.999          F10.3
COMM Z_VLF2                                         -9999.999          F10.3
COMM Z_VLF3                                         -9999.999          F10.3
COMM Z_VLF4                                         -9999.999          F10.3
COMM Z_Geofact                                      -9999.999          F10.3
COMM COND_Z[1:100]                 mS/m             -9999.999          F10.3
COMM COND_Z_DEPTH[1:100]           m                -99999             I5
```

AREA 2

```
COMM FAS PROJECT NUMBER                                      2319
COMM AREA NUMBER:                                               2
COMM SURVEY COMPANY:                        Fugro Airborne Surveys
COMM CLIENT:                                    ABM Resources NL
COMM SURVEY TYPE:                            25Hz TEMPEST Survey
COMM AREA NAME:                                          Swampy
COMM STATE:                                                  NT
COMM COUNTRY:                                         Australia
COMM SURVEY FLOWN:                                   July 2012
COMM LOCATED DATA CREATED:                           July 2012
COMM
COMM DATUM:                                              GDA94
COMM PROJECTION:                                           MGA
COMM ZONE:                                                  53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                            1000 m
COMM TRAVERSE LINE DIRECTION:                    42 - 222 deg
COMM NOMINAL TERRAIN CLEARANCE:                        100 m
COMM FINAL LINE KILOMETRES:                           1229 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                    20001 - 20058
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                              CASA 212, VH-TEM
```

```
COMM
COMM MAGNETOMETER:                                    Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                              Stinger mounted
COMM RESOLUTION:                                                    0.001 nT
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                    25Hz TEMPEST
COMM INSTALLATION:                      Transmitter loop mounted on the aircraft
COMM                                            Receiver coils in a towed bird
COMM COIL ORIENTATION:                                                  X,Z
COMM RECORDING INTERVAL:                                              0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:         -120 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:          -35 m
COMM
COMM RADAR ALTIMETER:                                         Collins RL-50
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM LASER ALTIMETER:                                          Optech 501SB
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM NAVIGATION:                                   Real-time differential GPS
COMM RECORDING INTERVAL:                                              1.0 s
COMM
COMM ACQUISITION SYSTEM:                                            FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                     0.0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                     0.0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                      0.0 s
COMM
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN TIE LINE LEVELLED
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM     X-COMPONENT EM DATA                                         4.4 s
COMM     Z-COMPONENT EM DATA                                         3.0 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED              EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                             000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                                   5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM -----------------------------------------------------------------------
COMM DISCLAIMER
COMM -----------------------------------------------------------------------
COMM It is Fugro Airborne Survey's understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
```

```
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
COMM altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
COMM satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
COMM the order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM ----------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START        END       CENTRE
COMM    1        0.007       0.020       0.013
COMM    2        0.033       0.047       0.040
COMM    3        0.060       0.073       0.067
COMM    4        0.087       0.127       0.107
COMM    5        0.140       0.207       0.173
COMM    6        0.220       0.340       0.280
COMM    7        0.353       0.553       0.453
COMM    8        0.567       0.873       0.720
COMM    9        0.887       1.353       1.120
COMM   10        1.367       2.100       1.733
COMM   11        2.113       3.273       2.693
COMM   12        3.287       5.113       4.200
COMM   13        5.127       7.993       6.560
COMM   14        8.007      12.393      10.200
COMM   15       12.407      19.993      16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
```

```
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM  Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                      UNITS            NULL               FORMAT
COMM Line                                        -99999999          I10
COMM Flight                                      -99                I4
COMM Fiducial                                    -999999.9          F8.1
COMM Project_FAS                                 -9999              I6
COMM Date                                        -9999999           I9
COMM Time                       s                -9999.9            F8.1
COMM Bearing                    deg              -99                I4
COMM Latitude                   deg              -99.9999999        F12.7
COMM Longitude                  deg              -999.9999999       F13.7
COMM Easting                    m                -99999.99          F10.2
COMM Northing                   m                -999999.99         F11.2
COMM Tx_Elevation               m                -999.99            F8.2
COMM Lidar                      m                -999.99            F8.2
COMM DTM                        m                -999.99            F8.2
COMM Tx_Pitch                   deg              -999.99            F8.2
COMM Tx_Roll                    deg              -999.99            F8.2
COMM Tx_Clearance               m                -999.99            F8.2
COMM HSep_Raw                   m                -999.99            F8.2
COMM VSep_Raw                   m                -999.99            F8.2
COMM Tx_Clearance_std           m                -999.99            F8.2
COMM HSep_std                   m                -999.99            F8.2
COMM VSep_std                   m                -999.99            F8.2
COMM EMX_nonhprg[1:15]          fT               -999.999999        F12.6
COMM EMX_hprg[1:15]             fT               -999.999999        F12.6
COMM X_Sferics                                   -9999.999          F10.3
COMM X_LowFreq                                   -9999.999          F10.3
COMM X_Powerline                                 -9999.999          F10.3
COMM X_VLF1                                      -9999.999          F10.3
COMM X_VLF2                                      -9999.999          F10.3
COMM X_VLF3                                      -9999.999          F10.3
COMM X_VLF4                                      -9999.999          F10.3
COMM X_Geofact                                   -9999.999          F10.3
COMM EMZ_nonhprg[1:15]          fT               -999.999999        F12.6
COMM EMZ_hprg[1:15]             fT               -999.999999        F12.6
COMM Z_Sferics                                   -9999.999          F10.3
COMM Z_LowFreq                                   -9999.999          F10.3
COMM Z_Powerline                                 -9999.999          F10.3
COMM Z_VLF1                                      -9999.999          F10.3
COMM Z_VLF2                                      -9999.999          F10.3
COMM Z_VLF3                                      -9999.999          F10.3
COMM Z_VLF4                                      -9999.999          F10.3
COMM Z_Geofact                                   -9999.999          F10.3
COMM COND_Z[1:100]             mS/m              -9999.999          F10.3
COMM COND_Z_DEPTH[1:100]       m                 -99999             I5
```

AREA 2 – Magnetics data only

```
COMM FAS PROJECT NUMBER                                              2319
COMM AREA NUMBER:                                                       2
COMM SURVEY COMPANY:                                 Fugro Airborne Surveys
COMM CLIENT:                                              ABM Resources NL
COMM SURVEY TYPE:                                     25Hz TEMPEST Survey
COMM AREA NAME:                                                    Swampy
```

```
COMM STATE:                                                            NT
COMM COUNTRY:                                                   Australia
COMM SURVEY FLOWN:                                             July 2012
COMM LOCATED DATA CREATED:                               September 2012
COMM
COMM DATUM:                                                        GDA94
COMM PROJECTION:                                                     MGA
COMM ZONE:                                                            53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                      1000 m
COMM TRAVERSE LINE DIRECTION:                             42 - 222 deg
COMM NOMINAL TERRAIN CLEARANCE:                                   100 m
COMM FINAL LINE KILOMETRES:                                      1229 km
COMM
COMM LINE NUMBERING                                      L20001:L20058
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                          CASA 212, VH-TEM
COMM
COMM MAGNETOMETER:                              Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                      Stinger mounted
COMM RESOLUTION:                                                0.001 nT
COMM RECORDING INTERVAL:                                          0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                25Hz TEMPEST
COMM INSTALLATION:              Transmitter loop mounted on the aircraft
COMM                                     Receiver coils in a towed bird
COMM COIL ORIENTATION:                                              X,Z
COMM RECORDING INTERVAL:                                          0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:     -120 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:       -35 m
COMM
COMM RADAR ALTIMETER:                                      Collins RL-50
COMM RECORDING INTERVAL:                                          0.2 s
COMM
COMM LASER ALTIMETER:                                      Optech 501SB
COMM RECORDING INTERVAL:                                          0.2 s
COMM
COMM NAVIGATION:                            Real-time differential GPS
COMM RECORDING INTERVAL:                                          1.0 s
COMM
COMM ACQUISITION SYSTEM:                                        FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM MAGNETIC DATA
COMM DIURNAL CORRECTION APPLIED                    base value 52000 nT
COMM PARALLAX CORRECTION APPLIED                              13.2 s
COMM IGRF CORRECTION APPLIED                       base value 52172 nT
COMM IGRF MODEL 2010 extrapolated to                    2012/06/22
COMM DATA HAVE BEEN TIE LINE LEVELLED
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                 0 s
COMM
```

```
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN TIE LINE LEVELLED
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM     X-COMPONENT EM DATA                                   -4.4 s
COMM     Z-COMPONENT EM DATA                                     -4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED           EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                           000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                               5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM -----------------------------------------------------------------------
COMM DISCLAIMER
COMM -----------------------------------------------------------------------
COMM It is Fugro Airborne Survey's understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM -----------------------------------------------------------------------
```

```
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW        START        END        CENTRE
COMM    1          0.007       0.020        0.013
COMM    2          0.033       0.047        0.040
COMM    3          0.060       0.073        0.067
COMM    4          0.087       0.127        0.107
COMM    5          0.140       0.207        0.173
COMM    6          0.220       0.340        0.280
COMM    7          0.353       0.553        0.453
COMM    8          0.567       0.873        0.720
COMM    9          0.887       1.353        1.120
COMM   10          1.367       2.100        1.733
COMM   11          2.113       3.273        2.693
COMM   12          3.287       5.113        4.200
COMM   13          5.127       7.993        6.560
COMM   14          8.007      12.393       10.200
COMM   15         12.407      19.993       16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM  Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                    UNITS           NULL             FORMAT
COMM Line                                     -99999999        I10
COMM Flight                                   -99              I4
COMM Fiducial                                 -999999.9        F8.1
COMM Project_FAS                              -9999            I6
COMM Date                                     -9999999         I9
COMM Time                     s               -9999.9          F8.1
COMM Bearing                  deg             -99              I4
COMM Latitude                 deg             -99.9999999      F12.7
COMM Longitude                deg             -999.9999999     F13.7
COMM Easting                  m               -99999.99        F10.2
COMM Northing                 m               -999999.99       F11.2
COMM Diurnal                  nT              -99999.999       F11.3
COMM Mag                      nT              -99999.999       F11.3
```

AREA 3

```
COMM FAS PROJECT NUMBER                                        2319
COMM AREA NUMBER:                                                 3
COMM SURVEY COMPANY:                         Fugro Airborne Surveys
COMM CLIENT:                                      ABM Resources NL
COMM SURVEY TYPE:                            25Hz TEMPEST Survey
COMM AREA NAME:                                             Bailey
```

```
COMM STATE:                                                              NT
COMM COUNTRY:                                                     Australia
COMM SURVEY FLOWN:                                               July 2012
COMM LOCATED DATA CREATED:                                  September 2012
COMM
COMM DATUM:                                                         GDA94
COMM PROJECTION:                                                      MGA
COMM ZONE:                                                            53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                        400 m
COMM TRAVERSE LINE DIRECTION:                              42 - 222 deg
COMM TIE LINE SPACING:                                           4000 m
COMM TIE LINE DIRECTION:                                 132 - 312 deg
COMM NOMINAL TERRAIN CLEARANCE:                                   100 m
COMM FINAL LINE KILOMETRES:                                      1638 km
COMM
COMM LINE NUMBERING                                       L30001:L30169
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                        CASA 212, VH-TEM
COMM
COMM ELECTROMAGNETIC SYSTEM:                              25Hz TEMPEST
COMM INSTALLATION:             Transmitter loop mounted on the aircraft
COMM                                     Receiver coils in a towed bird
COMM COIL ORIENTATION:                                            X,Z
COMM RECORDING INTERVAL:                                         0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:     -120 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:      -35 m
COMM
COMM RADAR ALTIMETER:                                    Collins RL-50
COMM RECORDING INTERVAL:                                         0.2 s
COMM
COMM LASER ALTIMETER:                                      Optech 501SB
COMM RECORDING INTERVAL:                                         0.2 s
COMM
COMM NAVIGATION:                              Real-time differential GPS
COMM RECORDING INTERVAL:                                         1.0 s
COMM
COMM ACQUISITION SYSTEM:                                         FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                 0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                 0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                  0 s
COMM
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM     X-COMPONENT EM DATA                                   -4.4 s
COMM     Z-COMPONENT EM DATA                                     -4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
```

```
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED                    EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                                   000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                                       5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM ------------------------------------------------------------------------
COMM DISCLAIMER
COMM ------------------------------------------------------------------------
COMM It is Fugro Airborne Survey's understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
COMM altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
COMM satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
COMM the order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM ------------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START        END        CENTRE
COMM    1        0.007       0.020        0.013
COMM    2        0.033       0.047        0.040
COMM    3        0.060       0.073        0.067
```

```
COMM    4          0.087       0.127       0.107
COMM    5          0.140       0.207       0.173
COMM    6          0.220       0.340       0.280
COMM    7          0.353       0.553       0.453
COMM    8          0.567       0.873       0.720
COMM    9          0.887       1.353       1.120
COMM   10          1.367       2.100       1.733
COMM   11          2.113       3.273       2.693
COMM   12          3.287       5.113       4.200
COMM   13          5.127       7.993       6.560
COMM   14          8.007      12.393      10.200
COMM   15         12.407      19.993      16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM  Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                      UNITS           NULL              FORMAT
COMM Line                                       -99999999         I10
COMM Flight                                     -99               I4
COMM Fiducial                                   -999999.9         F8.1
COMM Project_FAS                                -9999             I6
COMM Date                                       -9999999          I9
COMM Time                       s               -9999.9           F8.1
COMM Bearing                    deg             -99               I4
COMM Latitude                   deg             -99.9999999       F12.7
COMM Longitude                  deg             -999.9999999      F13.7
COMM Easting                    m               -99999.99         F10.2
COMM Northing                   m               -999999.99        F11.2
COMM Tx_Elevation               m               -999.99           F8.2
COMM Lidar                      m               -999.99           F8.2
COMM DTM                        m               -999.99           F8.2
COMM Tx_Pitch                   deg             -999.99           F8.2
COMM Tx_Roll                    deg             -999.99           F8.2
COMM Tx_Clearance               m               -999.99           F8.2
COMM HSep_Raw                   m               -999.99           F8.2
COMM VSep_Raw                   m               -999.99           F8.2
COMM Tx_Clearance_std           m               -999.99           F8.2
COMM HSep_std                   m               -999.99           F8.2
COMM VSep_std                   m               -999.99           F8.2
COMM EMX_nonhprg[1:15]          fT              -999.999999       F12.6
COMM EMX_hprg[1:15]             fT              -999.999999       F12.6
COMM X_Sferics                                  -9999.999         F10.3
COMM X_LowFreq                                  -9999.999         F10.3
COMM X_Powerline                                -9999.999         F10.3
COMM X_VLF1                                     -9999.999         F10.3
COMM X_VLF2                                     -9999.999         F10.3
COMM X_VLF3                                     -9999.999         F10.3
COMM X_VLF4                                     -9999.999         F10.3
COMM X_Geofact                                  -9999.999         F10.3
COMM EMZ_nonhprg[1:15]          fT              -999.999999       F12.6
COMM EMZ_hprg[1:15]             fT              -999.999999       F12.6
COMM Z_Sferics                                  -9999.999         F10.3
COMM Z_LowFreq                                  -9999.999         F10.3
```

```
COMM Z_Powerline                                  -9999.999            F10.3
COMM Z_VLF1                                        -9999.999            F10.3
COMM Z_VLF2                                        -9999.999            F10.3
COMM Z_VLF3                                        -9999.999            F10.3
COMM Z_VLF4                                        -9999.999            F10.3
COMM Z_Geofact                                     -9999.999            F10.3
COMM COND_Z[1:100]              mS/m               -9999.999            F10.3
COMM COND_Z_DEPTH[1:100]       m                   -99999               I5
```

APPENDIX III – List of all Supplied Data and Products

Initial Raw Products (Gridded data in Georeferenced TIFF format)

- Raw CDI's for 25% of survey lines
- Raw EM Channels (X and Z) for 3 selected windows

Preliminary Gridded Products (delivered in ERMapper format GDA94 MGA53S)

- Digital Terrain Model
- 15 channels of X-component
- 15 channels of Z-component
- EM Time Constant for X-component
- EM Time Constant for Z-component

Final Located Data

2319_Final.des **–** Header file describing the contents of the located data.
2319_Final.asc – A flat ASCII files containing located magnetic, EM and digital terrain data
2319_Final.gdb – Geosoft database file containing located magnetic, EM and digital terrain data

Final Magnetics Located Data for Area 2

2319_2_Final_TMI.des **–** Header file describing the contents of the located data.
2319_2_Final_TMI.asc – A flat ASCII files containing located magnetic data.
2319_2_Final_TMI.gdb – Geosoft database file containing located magnetic data

Final Gridded Products (delivered in ERMapper format GDA94 MGA53S)

- Total Magnetic Intensity for Area 2
- First Vertical Derivative TMI for Area 2
- Digital Terrain Model
- 15 channels of X-component
- 15 channels of Z-component
- EM Time Constant for X-component
- EM Time Constant for Z-component

Final Digital Products

- Flight Path map
- Z-Component Conductivity Depth Image (CDI) Multiplots & Stacked sections

Final Acquisition and Processing Report

Delivered as hardcopy and digitally