Billabong Creek, NSW.

TEMPEST
Geophysical Survey

for

Bureau of Rural Sciences

Acquisition and Processing Report

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Authorised for release by : ……..

……..

Survey flown: September 2001

by

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FAS JOB# 904

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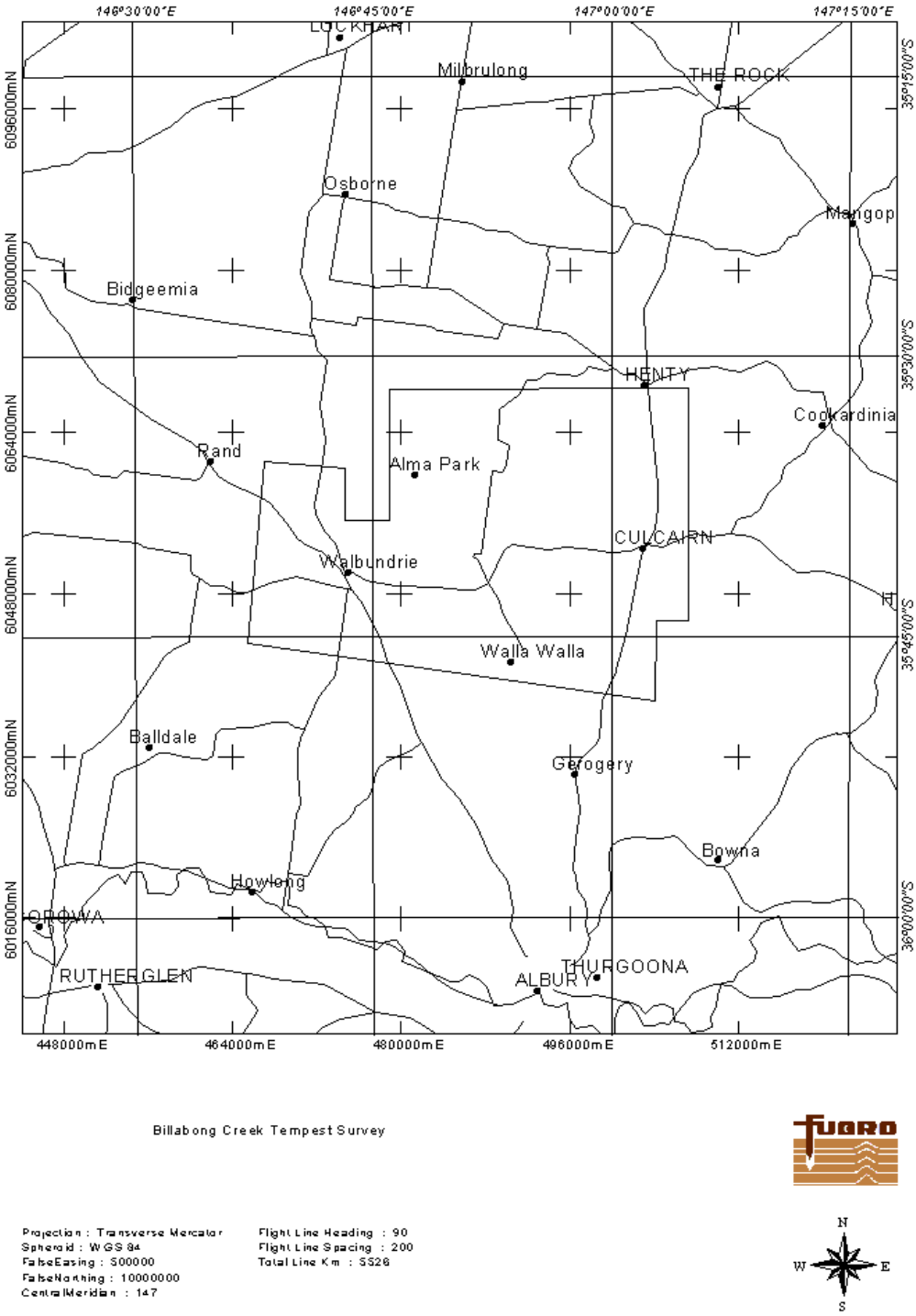
1 Introduction

This report summarises the acquisition and processing of data from the TEMPEST survey flown by Fugro Airborne Surveys (FAS) for the Billabong Creek project during September of 2001, for the Bureau of Rural Sciences. Electromagnetic, magnetic and elevation data were acquired over the area shown below.



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GDA94 co-ordinates for the Billabong Creek survey area

	Longitude	Latitude
1	147.081000	-35.529000
2	146.768000	-35.529000
3	146.768000	-35.647000
4	146.721000	-35.647000
5	146.721000	-35.600000
6	146.636000	-35.594000
7	146.618000	-35.756000
8	147.046000	-35.807000
9	147.047000	-35.736000
10	147.081000	-35.736000

2 Project Crew

The following personnel were employed for this project:

Field Operations

Processors	B.Adams / M.Zengerer
Airborne Operator	S.Miller / R.Rackham
Pilots	P.Hiskins / M.Harradence / M.Lester / E.Ikli

Base Operations

Project Manager	Davin Allen
Data Processing	Matthew Owers
Technical Supervisor	Daniel Sattel

3 Summary of Survey Parameters

3.1 Survey Area Parameters

AGSO Job Number	904
Fugro Job Number	1481_2
Survey Company	Fugro Airborne Surveys
Date Flown	31st August – 19th September 2001
Client	Bureau of Rural Sciences
Terrain Clearance	120 metres
EM System	25Hz TEMPEST
Total Line kilometres	5522 kilometres
Aircraft	CASA 212 (VH-TEM)
Traverse Line Spacing	200 metres
Traverse Line Direction	090 – 270 degrees
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

3.2 Flight Plans

The flight plans are given in Appendix I.

3.3 Standby Days

A total of 8.5 standby days were accrued.

DATE	REASON
August 31st, 2001	Diurnal
September 1st, 2001	Bad weather
September 2nd, 2001	Bad weather
September 3rd, 2001	0.5 days bad weather
September 4th, 2001	Bad weather
September 8th, 2001	Bad weather
September 9th, 2001	Bad weather
September 12th, 2001	Bad weather
September 13th, 2001	Bad weather

3.4 Job Safety Plan

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

4 Data Acquisition equipment and Specifications

The airborne data acquisition system utilised on this project consists of the following sub-systems:

4.1 Survey Aircraft

A CASA C212-200 Turbo Prop, registration VH-TEM, was used for this survey.

4.2 TEMPEST System Specifications

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

- Base frequency - 25Hz
- Transmitter area - 244m^2
- Transmitter turns - 1
- Waveform - Square
- Duty cycle - 50%
- Transmitter pulse width - 10 ms
- Transmitter off-time - 10 ms
- Peak current - 300 A
- Peak moment - 73,200 Am^2
- Average moment - 36,600 Am^2
- Sample rate - 75 kHz
- Sample interval - 13.33 microseconds
- Samples per half-cycle - 1500
- System bandwidth - 25 Hz to 37.5 kHz
- Flying height - 115m (nominal subject to safety considerations)
- EM sensor - Towed bird with 3 component dB/dt coils
- Tx-Rx horizontal separation - 120m (nominal)
- Tx-Rx vertical separation - 30m (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 - 0.001nT
- Typical noise level - 0.2nT
- GPS cycle rate - 1 second

4.2.1 EM Receiver and Logging Computer

The EM receiver computer is a Picodas PDAS-1000 data acquisition system. 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 DSP signal processing boards by the timing card, which ensures that all waveform generation and sampling is accomplished with high accuracy. The timing card is synchronised to GPS through the use of the 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.

4.2.2 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.

4.2.3 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.

4.3 PDAS 1000 Survey Computer

The SURVEY computer is a PICODAS PDAS 1000 data acquisition system. 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 VGA 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 QC display.

4.3.1 Cesium Vapour Magnetometer Sensor

A Scintrex CS-2 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.

4.3.2 Magnetometer Processor Board

A Picodas magnetometer processor board is used for de-coupling and processing the Larmor frequency output of the magnetometer sensor. The processor board interfaces with the PDAS 1000 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.

4.3.3 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.

4.3.4 GPS Receiver

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

4.3.5 Differential GPS Demodulator

The Racal Surveys' LANDSTAR differential GPS service provides real time differential corrections.

4.4 Navigation System

A Picodas PNAV 2001 Navigation Computer is used for real-time navigation. The PNAV computer loads 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 WGS-84 latitude and longitude positional data received from the Novatel GPScard 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 analog HSI indicator. 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 PNAV is interfaced to the SURVEY computer for auto selection and verification of the line to be flown. The GPS information passed to the PNAV 2001 navigation computer is corrected using the received real time differential data, enabling the aircraft to fly as close to the intended track as possible.

4.5 Altimeter System

4.5.1 Radar Altimeter

A Sperry RT220 radar altimeter is used for determining absolute altitude. The altimeter outputs a voltage proportional to height above terrain and has two scales for the indicated height: one scale covers altitudes up to 500ft (152m) while the second scale covers altitudes greater than 500ft. This signal is available to a dashboard analog indicator for the pilot, and to the PDAS 1000 computer for display and recording.

4.5.2 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.

4.5.3 Laser Altimeter

The Laser Altimeter used for this survey was an Optech 501SA LIDAR Rangefinder.

4.6 Video Tracking System

The video tape recorded by a PAL VHS colour video system is synchronised with the geophysical record by a digital fiducial display, which is recorded along with GPS latitude and longitude information and survey line number.

4.7 Data Recorded by the Airborne Acquisition Equipment

Raw EM data including fiducial, local time, X, Y, Z axis sensor response, current monitor and bird auxiliary sensor output are recorded on the EM receiver computer as "**G**" EM files.

The Survey computer records all other survey data including aeromagnetic and GPS data using as "**S**" Survey files, and "**R**" Rover files containing GPS raw range data for post processing.

5 Ground Data Acquisition Equipment

5.1 GPS Base Station System

The GPS base station consists of a Novatel GPS PC card mounted in a portable IBM 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. For this survey, the antenna for the GPS base station was located at the Wagga Wagga base.

The GPS base station position was determined by averaging non-differentially corrected position data, acquired at the GPS base station position, continuously over a period of 29 hours and 42 minutes.

145°
The calculated GPS base position was (in GDA 94):

	mean	standard deviations	
Longitude	147° 26' 15.63"	0.000027801960	(deg)
Latitude	-35° 07' 51.38"	0.000030814880	(deg)
Height	327.02	7.131782493938	(m) (Ellipsoidal)

This position was used as the GPS base station position for post-flight differential GPS processing of all survey data.

5.2 Base Magnetometer System

Two proton precession magnetometers were used as diurnal base stations. The units were located near the airport in an area where they were not affected by aircraft or motor vehicle movement.

The units were time checked prior to each survey flight commencement against the GPS receiver time in the aircraft, which is the time base for all acquired data.

6 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 1000 m (3000 ft) to eliminate ground response.

These checks include:-

6.1 Pre-Flight Barometer Calibration: Line C1511

A recording of the barometer output at a known elevation is carried out before take-off to assist with calibration and determination of drift during the flight. The barometer is used as a back-up to the GPS for aircraft altitude.

6.2 Pre-Flight Zero: Line C9001

This calibration is performed once the aircraft is established en route to the survey area. Background EM levels are recorded and assessed by the airborne operator to determine if: -

a. the system noise level is acceptable,
b. the response had not varied significantly from previous flights, and
c. the sferic level is acceptable.

These data are recorded for approximately 90 seconds. (See Appendix VII for tabulated results)

6.3 Pre-Flight Swoops: Line C9002

This manoeuvre is conducted immediately after the pre sortie zero. During this manoeuvre the relative position of the towed sensor is deliberately made to vary relative to the aircraft. The EM data are monitored by the airborne operator to confirm correct operation of the system during the manoeuvre.

6.4 Post-Flight Zero: Line C9003

This calibration is performed immediately following the completion of the survey sorties. Background EM levels are recorded to characterise any changes occurred in the system over the duration of the flight. These data are recorded for approximately 90 seconds. (See Appendix VII for tabulated results)

6.5 Post-Flight Barometer Calibration: Line C1611

A recording of the barometer output is repeated following landing at the end of the flight to assist with calibration and determination of drift during the flight.

6.6 Additive EM Measurements: Lines C9004, C9005, and C9007

A recording of the background signal through the X, Y and Z receiver coil inputs is carried out before and/or after acquisition of data for survey lines on each flight. These measurements may be made with the transmitter on (C9004, C9005) or with the transmitter off (C9007). The signal from the receiver coils is removed from the signal pathway by disconnecting the power to the bird at the winch inside the aircraft.

6.7 Electromagnetic Data Quality: Lines 92000

Data was recorded over a five kilometre long electromagnetic calibration line after every 1500 line kilometres of successful data acquisition, in order to demonstrate system repeatability. It was not required to disrupt a survey flight in order to fly the calibration line after exactly 1500 line kilometres of successful data acquisition. Accordingly, calibration lines were flown at the start or end of a flight.
Multiplots of CDI and EM data were made available to the client to demonstrate data repeatability (see Appendix VIII). The calibration line was located along the following cooordinates, and was approximately 5 kilometres long.

471340 E 6053730 N – 489475 E 6053845 N

6.8 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 6th September 2001

6.9 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. For this survey, the parallax check was carried out using the Dawesville W.A. data collected on the 2nd May 2001.

6.10 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 it's operating range.

Absolute radar and barometric altimeter calibration was carried out over water (over Port Phillip Bay on 12th May 2001) 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. See Table 1 in Appendix IX for calibration values.

6.11 Laser Altimeter Calibration

The laser altimeter was contracted on an "experimental" basis only. No calibrations were carried out for the laser altimeter. The instrument had continual "drop-outs" resulting in downward going spikes in the recorded data sequence.

6.12 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.

7 Data Processing

7.1 Field Data Processing

7.1.1 Quality Control Specifications

7.1.1.1 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).

Traverse Lines Separation - Actual flight line path deviates more than 40m off course for a distance of 1500m or more, or if a flight line intersects an adjacent flight line.

Altitude - Terrain clearance continuously exceeds the nominal terrain clearance by plus or minus 20m over a distance of 2km 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.

7.1.1.2 Magnetics Noise And Diurnal Tolerance

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

Noise - Where the total peak-to-peak noise of the magnetometer exceeds 1.0nT.

Magnetic Diurnal- The client was to be notified if the magnetic diurnal variations were greater than 10 nT in 5 minutes or less; or if the magnetic diurnal variation was greater than 2.0 nT when measured from any chord 1 minute long across the diurnal record.

7.1.1.3 Electromagnetic Data

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

High altitude – Where noise levels exceed a standard deviation of greater than 0.03fT for windows 1, 2 and 3 and less than 0.025fT in windows 4 to 15.

Noise - Where noise in the EM data exceeds 1fT or renders an important anomaly uninterpretable

Flights were performed over a five kilometre long electromagnetic calibration line after every 1500 line kilometres of successful data acquisition, in order to demonstrate system repeatability. It was not required to disrupt a survey flight in order to fly the calibration line after exactly 1500 line kilometres of successful data acquisition. Accordingly, calibration lines were generally flown at the start or end of a flight. A CDI plot is present in Appendix VIII.

7.1.2 In-Field Data Processing

Following acquisition, multiple copies of the EM data are made onto Exabyte tapes. 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 7.2.3.

7.2 *Final Data Processing*

7.2.1 Magnetics

Magnetic data are compensated for aircraft manoeuvre noise using coefficients derived from the appropriate compensation flight. The data are then corrected for diurnal variations. The IGRF (model 2000, date 2001.8) is removed, and first and second vertical derivatives calculated for quality checking purposes.

For this survey, tie lines were not flown, and therefore tie line levelling could not be carried out. Microlevelling was carried out, with minimal data manipulation. Parameters for microlevelling are as follows: length and width = 800metres, tolerance = 5 nT.

The total magnetic intensity (TMI) data were gridded to produce ermapper format grids. Grids of the first vertical derivative (1VD) of the TMI was also produced.

7.2.2 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. The aircraft's height above mean sea level was determined by differentially post-processing the synchronised DGPS data from the aircraft and GPS base station.Terrain clearance is measured with a radar altimeter.

The ground elevation, relative to the WGS84 spheroid used by GPS receiver units, is obtained by subtracting the terrain clearance from the aircraft altitude, noting the vertical separation between the GPS antenna and the radar altimeter, and applying suitable corrections for the separation between the two instruments.

Derived surface topography values with respect to mean sea level (referenced to the geoid) are obtained by correcting the spheroid values with geoid-spheroid separation values supplied by AUSLIG.

The digital terrain model (DTM) derived from this survey can be expected to have an absolute accuracy of +/- 5 metres in areas of low to moderate topographic relief. Sources of error include uncertainty in the location of the GPS base station, variations in the radar altimeter characteristics over ground of varying surface texture, and the finite footprint of the radar altimeter.

7.2.3 Electromagnetic Data Pre-processing

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

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

Routines to suppress sferic noise, powerline noise, VLF noise, coil motion noise and to stack the data are applied (termed "cleaning") to data from survey lines. 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.

The survey level 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 undergoes a review after windowing. Any decisions involving re-flights due to AEM factors are made at this point.

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.

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.

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.
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.

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.

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.

Average transmitter to receiver geometry values for each flight are derived from the high altitude reference waveforms and knowledge of the system characteristics. The geometry values are given in the table below. These values (for each flight) should be used when modelling the "raw" data.

Table of average transmitter loop to receiver coil geometry values for each flight

Flight No	Horizontal separation (m)	Vertical separation (m)
1	123.2	40.5
2	123.3	40.8
3	122.8	43.1
4	123.1	42.1
5	123.1	42.7
6	123.7	40.0
7	123.7	40.4
8	123.7	40.4
9	123.9	40.1
10	123.4	42.0
11	123.4	42.0
12	123.4	42.0

A correction of +0.1 m was added to the measured aircraft altitude to obtain transmitter loop altitude. This correction was derived from the transmitter loop to ground separation of +2.4 metres and GPS antenna to ground separation of +2.3 metres.

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.

The “raw” .“uncorrected” or “non height and geometry corrected” located data is one of two principal data products of the TEMPEST system.

The “raw” EM amplitudes reflect not only the variations in ground conductivity but the variations in geometry of the various parts of the EM measurements (ie 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.

A second, “final” or “height and geometry-corrected”, located data file is produced for optimum presentation of the EM amplitude data in image format (eg window amplitude images, principal component analysis images derived from the window amplitudes (Green,1998b). Between “raw” and “final” states, the ground response data undergoes 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 (115m), standard transmitter loop pitch and roll (zero degrees), and a standard transmitter loop to receiver coil geometry (120 m behind and 30 m 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 (eg > 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 "height and 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.

Limited range micro-levelling was applied to the final window amplitudes for presentation purposes, principally for multi-flight surveys and when isolated re-flight lines were present.

Due to the asymmetry in the transmitter loop - receiver coil geometry with respect to flight direction, there is no single parallax value which will align the peak response for all conductivity distributions for lines flown in opposite directions. The choice of parallax value depends on the intended usage. A parallax value of 0.2 secs (1 second = 10 fiducials for this survey) was applied to the X component data, 1.4 secs to the Z component data, and 0.4 secs to the radar altimeter data, all with respect to the location information. These values produce optimum derived topography images (in the case of the radar altimeter parallax), and generally align peak responses over horizontal or broad conductors for the X and Z component window amplitudes at early to mid times. Relative to the above "horizontal" parallax values, the X component EM data should be parallaxed by 1.6 secs and the Z component data by –0.6 secs for optimum alignment of peak response from thin steeply dipping conductors.

7.2.4 Conductivity Depth Images (CDI)

The "final" or "corrected" or "height and geometry-corrected" X component data were input to the program EMFlow to calculate Conductivity Depth Images (CDI). 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). Version 4.00 of EMFlow was used.

The table below specifies the system geometry for the data input to EMFlow and the specification of the system geometry used in EMFlow. Note that there is a +8m difference in the transmitter loop terrain clearance specification and the terrain clearance to which the input data were height corrected. This +8m difference was used because FAS has empirically found it to be the value to be used in EMFlow in order to optimally match CDI and borehole conductivity logs.

Variable	Input Data Geometry	Specified Geometry
Transmitter loop pitch	0 degrees	0 degrees
Transmitter loop roll	0 degrees	0 degrees
Transmitter loop terrain clearance	115 metres	123 metres
Transmitter loop–receiver coil horizontal spacing	123 metres behind aircraft	123 metres behind aircraft
Transmitter loop – receiver coil vertical spacing	41 metres below aircraft	41 metres below aircraft

The EMFlow descriptor file used in this project is included in Appendix X. Forty two time constants (Taus) ranging from 5µs to 50ms were used in the decomposition. In the decomposition, normalisation was completed by global maximum and a smoothing factor of 0.4 was applied. The data weights were 1.0 for all windows.

Conductivity values were calculated to a depth of 200m below surface at each point, using a depth increment of 5m. EMFlow allows only twenty different conductivities to be computed. In this case they were chosen to be logarithmically spaced between 1mS/m and 1000mS/m.

A routine developed by FAS, known as SIGTIME, was then applied to the conductivity data. 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 at late times. Anomalous conductivity values below the depth at which the response falls beneath believable levels, are set

undefined to reflect their uncertainty. The settings applied are indicated in the final CDI data header file in Appendix IV. The SIGTIME settings used were;

Signal threshold value	-	0.05 fT
Depth factor	-	0.65
Depth of last signal return factor	-	0.7
Depth of investigation factor	-	1.0
Background conductivity	-	1 mS/m

Conductivity values were set to undefined below the depth of last signal return.

7.2.5 Layered Earth Inversions (LEI)

The Algorithm and its Limitations

Layered earth inversions were used to derive the conductivity structure of the subsurface from X-component Tempest data. The algorithm developed by Fugro Airborne Surveys models the subsurface as horizontally layered and takes into account periodicity effects. The inversion routine makes use of a damped singular value decomposition (SVD) to minimise in a least-squares sense the Chi-square data misfit (Lines and Treitel, 1984). The implemented forward model algorithm is described in Ward and Hohmann (1987). Statistical data analysis has shown that, due to its limited bandwidth, the information content of airborne data is limited to 3-5 layers (Sattel, 1998; Sattel, 2001). The same starting model is used for all inversions: a conductive layer (“layer 2” at 0.1 S/m to represent saprolite) sandwiched between a resistive top alluvial layer (“layer 1” at 0.01 S/m) and a resistive basement (0.001 S/m).

The model parameters of the inversion with parameter weights shown in brackets were:
1. Log of layer 1 conductivity (1)
2. Log of layer 2 conductivity (1)
3. Log of halfspace conductivity (8)
4. Log of layer 1 thickness (1)
5. Log of layer 2 thickness (16)
6. DC offset (100)
7. EM system terrain clearance (50)

Higher weights reduce the impact of the corresponding parameters on the inversion. The inclusion of a DC offset parameter and the modelling of relative amplitudes (referenced to the latest channel) allowed to compensate for primary field uncertainties. No bounds were applied to the conductivies, but to prevent absurd thicknesses these were bound by twice the diffusion depth of the EM system used.

The inversion objective function was

$$X^2 = \sum_{i=1}^{15} \frac{[d_i - y_i]^2}{\sigma_i^2}$$

with d_i and y_i the observed and modelled EM data, respectively, and σ_i the following data weights:

1. 0.1012920
2. 0.1012920
3. 0.1012920
4. 0.0954987
5. 0.0974679
6. 0.0981478
7. 0.0954987
8. 0.0974679
9. 0.0795822
10. 0.0638077
11. 0.0407208
12. 0.0284529
13. 0.0194936
14. 0.0131426
15. 0.0100000

The inversion was terminated as soon as either the objective function had been minimised or 100 iterations had passed.

The inversion output includes:

1. EM system terrain clearance
2. Chi-squared data misfit
3. DC offset
4. Layer 1 conductivity
5. Layer 2 conductivity
6. Halfspace conductivity
7. Layer 1 thickness
8. Layer 2 thickness
9. Depth of penetration

Due to sometimes unreliable radar altimeter readings two different approaches were taken:

1) the raw EM data were modelled using the dynamic bird position with the LEI enabled to change the EM system terrain clearance in order to improve data fit. The transmitter loop was modelled to have zero pitch and roll and no height offset was applied to initialize the EM system terrain clearance with the radar derived value.
2) the final HPRG-corrected EM data were modelled. The HPRG-corrected data were corrected to the following HPRG values: Tx height: 115m, Tx-Rx horizontal separation: 120m, Tx-Rx vertical separation: 30m, Tx pitch and roll: 0 degrees.

The inversion was performed for every fifth data point (1.0 seconds) rather than at every data point.

Limitations of layered-earth inversions are:

1. *The starting model*. Results are fairly independent of the inversion-starting model for most conductivity scenarios, considering the level of vertical resolution, which is achievable with airborne EM data. Two scenarios, where inversion results are strongly influenced by the starting model are: (1) in very conductive terrain, where slow decays are indistinguishable from the primary field, and (2) when conductance equivalence occurs. Scenario (2) refers to the fact that EM data responds to conductance variations and in a subtler way to conductivity and thickness variations; to be able to resolve the latter a layer must exceed a minimum thickness, which is a function of conductivity.

The surveyed area was moderately conductive and the modelling was not affected by limitation 1.

2. 2-D and 3-D conductivity scenario. The value of 1-D inversions is uncertain in 2-D and 3-D situations, such as vertical contacts and spatially confined conductors. Edge effects are observed with AEM data at vertical contacts, which introduces artefacts in models inverted with a 1-D assumption, and are emphasised by the asymmetrical system configuration of fixed-wing towed-bird EM systems. Also, late-time decays are modelled with a power-law assumption, whereas 3-D conductors have exponential decays at late times. Nevertheless, Ellis (1995) has shown that for the AEM system geometry, 1-D models usually give reasonable results when compared to full 3-D computations.

***The layered-earth inversion results indicate that lateral conductivity changes in the survey area are predominantly smooth*.**

3. *Rugged topography*. This represents the biggest limitations due to the following: (1) the surface is not flat as modelled by the 1-D inversion; (2) the transmitter-receiver geometry deviates from its nominal geometry; (3) aircraft manoeuvres cause coil motion-induced noise.

Only small sections of EM data in the southeastern part of the surveyed area are affected by rugged topography.

4. *Other effects*. Ignoring current channelling effects, 1-D assumption models only the earth's inductive response. Also disregarded are effects from magnetic permeability and inducted polarisation

(IP). Models show that EM responses due to the magnetic permeability of the subsurface can be ignored for fixed-wing surveys (Sattel, 2000) and IP effects are only observed in very resistive environments (Smith and Klein, 1996).

7.2.6 Gridding

The line data for the magnetic and electromagnetic data had no filtering applied to it before the gridding, however, the unit conductivities had a median and a mean filter both with a length of 11 points applied before gridding.

The gridding method used for the magnetic and electromagnetic data was a 3rd order bicubic polynomial using gridding software developed within Fugro Airborne Surveys. The data was gridded using a grid cell size of approximately 1/5 the line spacing ie. 40m

No filtering to the grids was applied, except for the CDI and unit parameter grids which had a 5 by 5 median filtered applied followed by a 7 x 7 hanning filter.

7.2.7 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 7.2.3).

7.2.7.1 Standard Height and Geometry

If using data from the “raw” located data files, the average relative position of the receiver coils from the transmitter loop for each flight can be obtained from the table given above (section 7.2.3). Transmitter loop pitch, transmitter loop roll and transmitter loop terrain clearance values for each observation can be obtained from the located data file.

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 transmitter loop to receiver coil geometry equal to the average values given below. Transmitter loop pitch, transmitter loop roll and transmitter loop terrain clearance values for each observation have been modified to reflect the standard values.

The following table summarises the values used to correct the 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	120 metres
Transmitter loop – to – receiver coil geometry	123 metres behind and 41 metres below the aircraft

7.2.7.2 Parallax

The “raw” and “final” located data files utilise the following parallax values :-

- magnetics = 0.5 seconds (2.5 observations from the zero parallax position),
- radar altimeter = 0.4 seconds (2 observations from the zero parallax position),
- EM X-component = 0.2 seconds (1 observation from the zero parallax position),
- EM Z-component = 1.4 seconds (7 observations from the zero parallax position),

These EM parallax values are optimised for aligning the EM response amplitudes for *horizontal* or *broad shallow dipping conductors*, which account for the majority of responses in regolith-dominated terrains such as this.

For optimum gridded display of the response for *discrete vertical* or *narrow conductors*, the following EM parallax values are appropriate :-

- EM X-component = 1.8 seconds (9 observations from the zero parallax position, or 8 observations from the “horizontal” parallax position),
- EM Z-component = 0.8 seconds (4 observations from the zero parallax position, or -3 observations from the “horizontal” parallax position).

(NB Positive parallax values are defined in this case as shifting the indicated quantity back along line to smaller fiducial (or time) values. Location information remains in the zero parallax state.)

7.2.8 Delivered Products

Appendix V contains a complete list of data supplied digitally.

Separate digital located data files were produced for the EM “raw” and “final” data sets for both the X- and Z-components, and for magnetics and digital elevation. The header files for all data are found in Appendix IV.

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APPENDIX I - Flight Plans

```
JOB_Number  1481.2                                                          *
CLIENT      BRS                                                             *
AREA_NAME   Billabong Creek                                                 *
PLANNED_BY  katherine mckenna    22/08/2001 Initial Flight Plan             *
|                                                                           *
SPHEROID    22  W.G.S_1984 6378137.0 298.257223563 0.9996                   *
DELTAXYZ    0         0         0         0.000 0.000 0.000 0.000           *
HEMISPHERE  SOUTH                                                           *
UTM_ORIGIN  55   147   147                                                  *
BOUNDARY    1   507344  6068287 -35.529000 +147.081000 -353144.4 +1470451.6 34 *
BOUNDARY    2   478967  6068266 -35.529000 +146.768000 -353144.4 +1464604.8 34 *
BOUNDARY    3   478998  6055178 -35.647000 +146.768000 -353849.2 +1464604.8 34 *
BOUNDARY    4   474743  6055167 -35.647000 +146.721000 -353849.2 +1464315.6 34 *
BOUNDARY    5   474728  6060380 -35.600000 +146.721000 -353600.0 +1464315.6 34 *
BOUNDARY    6   467026  6061020 -35.594000 +146.636000 -353538.4 +1463809.6 34 *
BOUNDARY    7   465465  6043047 -35.756000 +146.618000 -354521.6 +1463704.8 34 *
BOUNDARY    8   504156  6037457 -35.807000 +147.046000 -354825.2 +1470245.6 34 *
BOUNDARY    9   504250  6045331 -35.736000 +147.047000 -354409.6 +1470249.2 34 *
BOUNDARY   10   507325  6045329 -35.736000 +147.081000 -354409.6 +1470451.6 34 *
SQUARE_KMS  1018.180                                                        *
|                                                                           *
NAVTYPE     NOVATEL                                                         *
NAVMODE     U.T.M                                                           *
PLAN_TYPE   Normal                                                          *
LINE_TYPE   S.LINE                                                          *
HEADING     090                                                             *
SPACING     200                                                             *
OVER_LINE   1                                                               *
OVERFLY     400                                                             *
MIN_LENGTH  5                                                               *
FIRST_LINE  10                                                              *
INCREMENT   10                                                              *
X_TRACK     100                                                             *
MASTER_PT   1   500000  6000000 -36.144718 +147.000000                      *
MASTER_NEW  1   486400  6053800 -35.659559 +146.849746                      *
KM_in_AREA  5178                                                            *
KM+OVERFLY  5526                                                            *
```

APPENDIX II – Daily Acquisition Reports

Processing Report - Flt 001

Job :1481_2
Date: :03 Sep
Area :Billabong Creek
Flight :01
Pilots :M.Harradence, P.Hiskins
Processing :B.Adams, M. Zengerer
Technical :S. Miller
Flying Conditions : wind = 5 kph, temp@takeoff = 14 degrees, cloud: overcast low

General:
12 lines flown plus one calibration line.
2147 to 2158 + 2075.
117.8 kms flown

E.M Data.
The zero stats are within spec.
Cultural effects are prominent in some of the lower line numbers, along with some slight coil knocks but otherwise the data is quite clean.
Filtering has been applied to data. Some enquiries will be made regarding residual deconvolution.
Minor spherics.

X-Track
Fine

Mag
Still processing.

GPS
Fine.

Processing Report - Flt 002

Job :1481_2
Date : 05 Sep
Area :Billabong Creek
Flight :02
Pilots :M.Harradence, P.Hiskins
Processing :B.Adams, M. Zengerer
Technical :S. Miller
Flying Conditions : wind = 0 kph, temp@takeoff = 15 degrees, cloud: scattered

General:
21 lines flown
2126 to 2146
653.2 kms flown

E.M Data.
Zero stats not entirely within spec – slightly out on window 11 in prezero X-component.
Cultural effects are prominent throughout the data, sferics were severe particularly in X-channel.
Filtering has been applied to data.

X-Track
Fine

Mag
Compbox still required.

GPS
52 second gap in base GPS data due to power failure.

Processing Report - Flt 003

Job **:1481_2**
Date **: 06 Sep**
Area **:Billabong Creek**
Flight **:03**
Pilots **:M.Harradence, P.Hiskins**
Processing **:B.Adams, M. Zengerer**
Technical **:S. Miller**
Flying Conditions **: wind = 0 kph, temp@takeoff = 4 degrees, cloud: nil**

General:
12 lines flown along with compbox.
2114 to 2125
491.5 kms flown

E.M Data.
Zero stats within spec.
Cultural effects are again prominent in data, one large powerline crossing through the entire area the likely culprit. Sferics were moderate today but appeared to be fairly effectively filtered.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 004

Job **:1481_2**
Date **: 07 Sep**
Area **:Billabong Creek**
Flight **:04**
Pilots **:M.Harradence, P.Hiskins**
Processing **:B.Adams, M. Zengerer**
Technical **:Ross R**
Flying Conditions **: wind = E/20, temp@takeoff = 10 degrees, cloud: overcast**

General:
10 lines flown along with testline 92041
2113 to 2104
423.2 kms flown

E.M Data.
Zero stats within spec.
Cultural effects are again prominent in data. Sferics in X and Z, sometimes associated with radio noise. X-component spectra abnormal.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 005

Job :1481_2
Date :10 Sep
Area :Billabong Creek
Flight :05
Pilots :M.Harradence, P.Hiskins
Processing :B.Adams, M. Zengerer
Technical :Ross Rackham
Flying Conditions : wind = N/10, temp@takeoff = 19 degrees, cloud: 6/8 4000ft

General:
18 lines flown, we have decided to scrub four of them.
2099 to 2086, will re-fly 2103-2100
588.4 effective kms flown

E.M Data.
Zero stats within spec.
Cultural effects are again prominent in data. Aircrew noticed “small spikes” in z-coil on the first 5 flights, which turned out at processing stage to be large glitches in the low frequency noise component of the z-channel, implying perhaps some z-coil motion, but for some reason the x-channel wasn’t affected.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 006

Job :1481_2
Date : 11 Sep
Area :Billabong Creek
Flight :06
Pilots :M.Harradence, P.Hiskins
Processing :B.Adams, M. Zengerer
Technical :Ross Rackham
Flying Conditions : wind = E/10, temp@takeoff = 11 degrees, cloud: overcast 6000ft

General:
19 lines flown
2085 to 2067
793.4 kms flown

E.M Data.
Zero stats are not within spec on post zero flight, no doubt due to high sferic activity, which increased as the day wore on. The X-spectra is also distorted again due to high sferic activity. Despite this the filtering process has removed most of the ill effects caused by the sferics.
Cultural effects are again prominent in data.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 007

Job **:1481_2**
Date **: 15 Sep**
Area **:Billabong Creek**
Flight **:07**
Pilots **:E. Ikli and M.Lester**
Processing **:B.Adams, M. Zengerer**
Technical **:Ross Rackham**
Flying Conditions **: wind = SW, temp@takeoff = 08 degrees, cloud: nill**

General:
17 lines flown including the calibration line and five reflights
2066 to 2055
709 kms flown

E.M Data.
A large spheric has landed itself in the middle of the pre-zero line placing the zero stats out of spec however when edited the stats are well within spec.
Both the X and Z spectum show pronounced peaks at 50Hz. This does not appear to have affected the data.
Cultural effects are again prominent in data.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 008

Job **:1481_2**
Date **: 15 Sep**
Area **:Billabong Creek**
Flight **:08**
Pilots **:E. Ikli and M.Harradence**
Processing **:B.Adams, M. Zengerer**
Technical **:Ross Rackham**
Flying Conditions **: wind = W at 5 knts, temp@takeoff = 25 degrees, cloud: nill**

General:
7 lines flown and two scrubbed.
2048 to 2054, 206.7 kms flown
Bird tow cable was found to be faulty resulting in unusable pre-survey calibrations. Data quality improves with time

E.M Data.
The poor data is due to a faulty bird tow cable which has resulted in unusable pre flight calibrations. Data was processed using only the post cleaned reference wave form for deconvolution. This appears to have been successful however the X-component still contains some cable spasms which resulted in scrubbing two lines.
The zero stats are well within spec for this flight. The reason for this becomes apparent when the pre-zero file is viewed. The pronounced peak seen in the X and Z spectum from flight 7 are not present.
Cultural effects are again prominent.

X-Track - Fine
Mag - Fine
GPS - Fine

Processing Report - Flt 009

Job **:1481_2**
Date **: 16 Sep**
Area **:Billabong Creek**
Flight **:09**

Pilots **:E. Ikli and M.Lester**
Processing **:B.Adams, M. Zengerer**
Technical **:Ross Rackham**
Flying Conditions **: wind = NW, temp@takeoff = 15 degrees, cloud: nil**

General:
21 lines flown
20270 to 20470
744.9 kms in total

E.M Data.
A large spheric lies in the middle of the post zero line. The zero stats are out of spec due to cable motion whilst flying pre zero cal line. This cable problem has effected the X-channel data but enough to cause significant problems (yet).
Both the X and Z spectra show pronounced peaks at 50Hz and at several later frequencies. This does not appear to have affected the data.
Cultural effects are again prominent in data.

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 010

Job **:1481_2**
Date **: 18 Sep**
Area **:Billabong Creek**
Flight **:10**
Pilots **:M.Harradence and M.Lester**
Processing **:B.Adams, M. Zengerer**
Technical **:Ross Rackham**
Flying Conditions **: wind = NW, temp@takeoff = 6.6 degrees, cloud: 3/8**

General:
25 lines flown plus the calibration line. Included 3 reflights
2025 to 2004, 2050 to 2052
766.8 kms in total
Bird cabel collapsed first thing and required fixing. Solved the problems seen in previous flights.

E.M Data.
The data was generally very good with only cultural influences causing any real problems.
Spherics were minor

X-Track
Fine

Mag
Fine

GPS
Fine

Processing Report - Flt 011

Job	**:1481_2**
Date	**: 19 Sep**
Area	**:Billabong Creek**
Flight	**:11**
Pilots	**:M.Harradence and M.Lester**
Processing	**:B.Adams, M. Zengerer**
Technical	**:Ross Rackham**
Flying Conditions	**: wind = N, temp@takeoff = 11.1 degrees, cloud: clear**

General:
4 lines flown
2003 to 2001, 2026
116.8 kms flown

E.M Data.
Pre Zero cal line unable to use due to massive glitch at beginning of line
Post Zero looks ok but for some reason won't process either
Survey lines have usual cultural noise but otherwise ok

X-Track
Fine

Mag
Fine

GPS
Fine

APPENDIX III - Flight Summary (Line Listing)

(Note: 1511 Pre-flight barometer calibration
1611 Post-flight barometer calibration
1700's Tie lines
1800's Magnetometer compensation lines
9001 Pre-flight high altitude reference calibration
9002 Pre-flight high altitude coupling calibration
9003 Post-flight high altitude reference calibration
9005 Pre-flight additive calibration
9007 Post-flight additive calibration

For direction, 1=east, 2=north, 3=west, 4=south)

Production Lines:

Line	Flight	Direction	Date	Start Fid	End Fid	Start Time	End Time
			(yyyymmdd)	(s)	(s)	(hh\mm\ss)	(hh\mm\ss)
21580	1	1	20010903	1	127	15:47:45	15:49:52
21570	1	3	20010903	128	222	15:52:04	15:53:39
21560	1	1	20010903	223	334	15:55:12	15:57:04
21550	1	3	20010903	335	434	16:00:13	16:01:53
21540	1	1	20010903	435	556	16:05:48	16:07:50
21530	1	3	20010903	557	687	16:11:08	16:13:19
21520	1	1	20010903	688	838	16:17:05	16:19:36
21510	1	3	20010903	839	1040	16:21:48	16:25:10
21500	1	1	20010903	1041	1234	16:27:21	16:30:35
21490	1	3	20010903	1235	1485	16:32:56	16:37:07
21480	1	1	20010903	1486	1732	16:38:56	16:43:03
21470	1	3	20010903	1733	1988	16:45:56	16:50:12
21460	2	1	20010905	527	799	13:19:23	13:23:56
21450	2	3	20010905	800	1109	13:26:58	13:32:08
21440	2	1	20010905	1110	1423	13:34:55	13:40:09
21430	2	3	20010905	1424	1770	13:43:39	13:49:26
21420	2	1	20010905	1771	2114	13:51:37	13:57:21
21410	2	3	20010905	2115	2504	14:00:56	14:07:26
21400	2	1	20010905	2505	2907	14:09:19	14:16:02
21390	2	3	20010905	2908	3339	14:19:32	14:26:44
21380	2	1	20010905	3340	3801	14:28:39	14:36:21
21370	2	3	20010905	3802	4387	14:39:32	14:49:18
21360	2	1	20010905	4388	4860	14:51:14	14:59:07
21350	2	3	20010905	4861	5373	15:02:11	15:10:44
21340	2	1	20010905	5374	5889	15:12:39	15:21:15
21330	2	3	20010905	5890	6436	15:23:59	15:33:06
21320	2	1	20010905	6437	6963	15:35:07	15:43:54
21310	2	3	20010905	6964	7572	15:46:29	15:56:38
21300	2	1	20010905	7573	8170	15:58:48	16:08:46
21290	2	3	20010905	8171	8796	16:11:01	16:21:27
21280	2	1	20010905	8797	9372	16:24:11	16:33:47
21270	2	3	20010905	9373	9994	16:36:03	16:46:25
21260	2	1	20010905	9995	10576	16:48:26	16:58:08
21250	3	3	20010906	1832	2407	10:03:39	10:13:15
21240	3	1	20010906	2408	3054	10:16:11	10:26:58
21230	3	3	20010906	3055	3635	10:28:50	10:38:31
21220	3	1	20010906	3636	4264	10:40:38	10:51:07
21210	3	3	20010906	4265	4850	10:52:59	11:02:45
21200	3	1	20010906	4851	5481	11:04:47	11:15:18
21190	3	3	20010906	5482	6096	11:17:49	11:28:04
21180	3	1	20010906	6097	6775	11:30:34	11:41:53

21170	3	3	20010906	6776	7403	11:44:07	11:54:35
21160	3	1	20010906	7404	8058	11:57:36	12:08:31
21150	3	3	20010906	8059	8692	12:10:45	12:21:19
21140	3	1	20010906	8693	9365	12:23:41	12:34:54
21130	4	3	20010907	611	1200	08:08:16	08:18:06
21120	4	1	20010907	1201	1987	08:20:09	08:33:16
21110	4	3	20010907	1988	2611	08:35:18	08:45:42
21100	4	1	20010907	2612	3364	08:48:19	09:00:52
21090	4	3	20010907	3365	3971	09:03:42	09:13:49
21080	4	1	20010907	3972	4727	09:16:50	09:29:26
21070	4	3	20010907	4728	5315	09:31:54	09:41:42
21060	4	1	20010907	5316	6031	09:44:22	09:56:18
21050	4	3	20010907	6032	6627	09:58:39	10:08:35
21040	4	1	20010907	6628	7330	10:11:52	10:23:35
21030	5	3	20010910	237	885	12:22:14	12:33:03
21020	5	1	20010910	886	1548	12:35:25	12:46:28
21010	5	3	20010910	1549	2185	12:48:34	12:59:11
21000	5	1	20010910	2186	2844	13:01:26	13:12:25
20990	5	3	20010910	2845	3486	13:14:36	13:25:18
20980	5	1	20010910	3487	4154	13:27:47	13:38:55
20970	5	3	20010910	4155	4843	13:41:20	13:52:49
20960	5	1	20010910	4844	5517	13:55:33	14:06:47
20950	5	3	20010910	5518	6162	14:09:06	14:19:51
20940	5	1	20010910	6163	6815	14:21:49	14:32:42
20930	5	3	20010910	6816	7460	14:34:58	14:45:43
20920	5	1	20010910	7461	8117	14:47:35	14:58:32
20910	5	3	20010910	8118	8770	15:00:31	15:11:24
20900	5	1	20010910	8771	9428	15:13:35	15:24:33
20890	5	3	20010910	9429	10069	15:26:33	15:37:14
20880	5	1	20010910	10070	10717	15:39:31	15:50:19
20870	5	3	20010910	10718	11360	15:52:27	16:03:10
20860	5	1	20010910	11361	11998	16:05:45	16:16:23
20850	6	3	20010911	239	835	07:34:35	07:44:32
20840	6	1	20010911	836	1654	07:47:03	08:00:42
20830	6	3	20010911	1655	2222	08:03:04	08:12:32
20820	6	1	20010911	2223	2983	08:15:22	08:28:03
20810	6	3	20010911	2984	3582	08:29:57	08:39:56
20800	6	1	20010911	3583	4321	08:42:11	08:54:30
20790	6	3	20010911	4322	4926	08:56:48	09:06:53
20780	6	1	20010911	4927	5685	09:09:55	09:22:34
20770	6	3	20010911	5686	6309	09:25:09	09:35:33
20760	6	1	20010911	6310	7009	09:37:55	09:49:35
20750	6	3	20010911	7010	7608	09:52:01	10:02:00
20740	6	1	20010911	7609	8302	10:04:11	10:15:45
20730	6	3	20010911	8303	8900	10:18:04	10:28:02
20720	6	1	20010911	8901	9584	10:30:28	10:41:52
20710	6	3	20010911	9585	10202	10:44:00	10:54:18
20700	6	1	20010911	10203	10879	10:57:08	11:08:25
20690	6	3	20010911	10880	11479	11:11:10	11:21:10
20680	6	1	20010911	11480	12143	11:27:11	11:38:15
20670	6	3	20010911	12144	12748	11:40:44	11:50:49
21131	7	3	20010915	506	1149	07:45:00	07:55:44
21000	7	1	20010915	1150	1821	07:57:47	08:08:59
21011	7	3	20010915	1822	2475	08:11:02	08:21:56
21021	7	1	20010915	2476	3135	08:23:51	08:34:51
21031	7	3	20010915	3136	3796	08:37:05	08:48:06
20660	7	1	20010915	3797	4436	08:51:13	09:01:53
20650	7	3	20010915	4437	5093	09:04:18	09:15:15
20640	7	1	20010915	5094	5730	09:17:48	09:28:25
20630	7	3	20010915	5731	6367	09:30:42	09:41:19
20620	7	1	20010915	6368	7026	09:43:16	09:54:15

20610	7	3	20010915	7027	7672	09:56:21	10:07:07
20600	7	1	20010915	7673	8320	10:08:53	10:19:41
20590	7	3	20010915	8321	8953	10:21:44	10:32:17
20580	7	1	20010915	8954	9623	10:34:38	10:45:48
20570	7	3	20010915	9624	10271	10:48:24	10:59:12
20560	7	1	20010915	10272	10874	11:09:16	11:19:19
20550	7	3	20010915	10875	11512	11:21:18	11:31:56
20540	8	1	20010915	445	1087	15:52:53	16:03:36
20530	8	3	20010915	1088	1736	16:05:40	16:16:29
20500	8	1	20010915	3049	3677	16:44:21	16:54:50
20490	8	3	20010915	3678	4312	16:56:51	17:07:26
20480	8	1	20010915	4313	4925	17:09:18	17:19:31
20470	9	3	20010916	525	1174	08:02:31	08:13:21
20460	9	1	20010916	1175	1799	08:15:46	08:26:11
20450	9	3	20010916	1800	2433	08:28:45	08:39:19
20440	9	1	20010916	2434	3083	08:41:45	08:52:35
20430	9	3	20010916	3084	3699	08:54:58	09:05:14
20420	9	1	20010916	3700	4330	09:07:29	09:18:00
20410	9	3	20010916	4331	4936	09:20:24	09:30:30
20400	9	1	20010916	4937	5554	09:32:34	09:42:52
20390	9	3	20010916	5555	6178	09:45:08	09:55:32
20380	9	1	20010916	6179	6794	09:57:56	10:08:12
20370	9	3	20010916	6795	7423	10:10:07	10:20:36
20360	9	1	20010916	7424	7860	10:25:19	10:32:36
20350	9	3	20010916	7861	8298	10:35:02	10:42:20
20340	9	1	20010916	8299	8732	10:44:28	10:51:42
20330	9	3	20010916	8733	9175	10:54:20	11:01:43
20320	9	1	20010916	9176	9609	11:03:40	11:10:54
20310	9	3	20010916	9610	10043	11:13:14	11:20:28
20300	9	1	20010916	10044	10470	11:25:24	11:32:31
20290	9	3	20010916	10471	10920	11:34:52	11:42:22
20280	9	1	20010916	10921	11351	11:45:26	11:52:37
20270	9	3	20010916	11352	11804	11:54:56	12:02:29
20501	10	1	20010918	388	1005	11:08:57	11:19:15
20510	10	3	20010918	1006	1629	11:21:46	11:32:10
20521	10	1	20010918	1630	2286	11:34:18	11:45:15
20250	10	3	20010918	2287	2749	11:49:10	11:56:53
20240	10	1	20010918	2750	3218	11:58:54	12:06:43
20230	10	3	20010918	3219	3657	12:09:00	12:16:19
20220	10	1	20010918	3658	4123	12:18:44	12:26:30
20210	10	3	20010918	4124	4570	12:28:55	12:36:22
20200	10	1	20010918	4571	5020	12:38:39	12:46:09
20190	10	3	20010918	5021	5464	12:48:04	12:55:28
20180	10	1	20010918	5465	5928	12:57:32	13:05:16
20170	10	3	20010918	5929	6391	13:07:44	13:15:27
20160	10	1	20010918	6392	6857	13:18:19	13:26:05
20150	10	3	20010918	6858	7294	13:28:23	13:35:40
20140	10	1	20010918	7295	7738	13:37:51	13:45:15
20130	10	3	20010918	7739	8168	13:47:24	13:54:34
20120	10	1	20010918	8169	8614	13:56:54	14:04:20
20110	10	3	20010918	8615	9066	14:06:16	14:13:48
20100	10	1	20010918	9067	9510	14:16:02	14:23:26
20090	10	3	20010918	9511	9943	14:25:42	14:32:55
20080	10	1	20010918	9944	10398	14:34:47	14:42:22
20070	10	3	20010918	10399	10834	14:44:26	14:51:42
20060	10	1	20010918	10835	11283	14:53:43	15:01:12
20050	10	3	20010918	11284	11725	15:03:08	15:10:30
20040	10	1	20010918	11726	12170	15:12:29	15:19:54
20030	11	3	20010919	238	648	07:08:47	07:15:38
20020	11	1	20010919	649	1137	07:18:09	07:26:18
20010	11	3	20010919	1138	1542	07:28:50	07:35:35

20260	11	1	20010919	1543	2034	07:37:40	07:46:01

Pre and Post Calibration Lines:

Line	Flight	Direction	Date	Start Fid	End Fid	Start Time	End Time
			(yyyymmdd)	(s)	(s)	(hh\mm\ss)	(hh\mm\ss)
15110	1	2	20010903	1	60	13:46:14	13:47:14
90040	1	1	20010903	1	90	15:17:54	15:19:24
90010	1	1	20010903	91	180	15:20:10	15:21:40
90020	1	1	20010903	181	230	15:22:18	15:23:08
90030	1	3	20010903	1989	2078	16:54:29	16:55:59
90050	1	3	20010903	2079	2168	16:56:38	16:58:08
90060	1	3	20010903	2169	2258	16:58:59	17:00:29
16110	1	2	20010903	1	60	17:32:54	17:33:54
15110	2	2	20010905	1	60	12:31:17	12:32:17
90041	2	3	20010905	292	381	12:56:48	12:58:18
90012	2	3	20010905	382	471	12:58:55	13:00:25
90020	2	3	20010905	472	526	13:00:52	13:01:47
90030	2	3	20010905	10577	10666	17:05:02	17:06:32
90050	2	3	20010905	10667	10756	17:07:17	17:08:47
90060	2	3	20010905	10757	10846	17:09:22	17:10:52
16110	2	2	20010905	1	60	17:39:45	17:40:45
90041	3	3	20010906	1550	1639	09:27:19	09:28:49
90010	3	3	20010906	1640	1729	09:30:20	09:31:50
90020	3	3	20010906	1751	1831	09:33:38	09:34:59
90030	3	1	20010906	9366	9455	12:42:51	12:44:21
90050	3	1	20010906	9456	9545	12:44:56	12:46:26
90060	3	1	20010906	9546	9635	12:47:09	12:48:39
16110	3	2	20010906	1	60	13:11:42	13:12:42
15110	4	2	20010907	1	60	06:40:29	06:41:29
90041	4	3	20010907	91	180	07:30:01	07:31:31
90010	4	3	20010907	181	270	07:32:25	07:33:55
90020	4	3	20010907	271	326	07:34:36	07:35:32
90030	4	1	20010907	7331	7420	10:27:08	10:28:38
90050	4	1	20010907	7421	7510	10:29:50	10:31:20
90060	4	1	20010907	7511	7600	10:32:25	10:33:55
16110	4	1	20010907	1	60	10:58:49	10:59:49
15110	5	1	20010910	1	66	10:39:41	10:40:47
90041	5	3	20010910	9	98	11:58:29	11:59:59
90010	5	3	20010910	99	188	12:01:02	12:02:32
90020	5	3	20010910	189	236	12:03:48	12:04:36
90030	5	1	20010910	11999	12088	16:21:06	16:22:36
90050	5	1	20010910	12089	12178	16:23:36	16:25:06
90060	5	1	20010910	12179	12268	16:26:26	16:27:56
16110	5	1	20010910	1	60	16:44:58	16:45:58
15110	6	1	20010911	1	60	06:39:50	06:40:50
90040	6	3	20010911	1	90	07:17:48	07:19:18
90010	6	3	20010911	91	180	07:20:36	07:22:06
90020	6	3	20010911	181	238	07:23:17	07:24:15
90030	6	1	20010911	12749	12838	11:56:10	11:57:40
90050	6	1	20010911	12839	12928	11:58:29	11:59:59
90060	6	1	20010911	12929	13018	12:01:10	12:02:40
16110	6	1	20010911	1	60	12:22:11	12:23:11
15110	7	3	20010915	1	60	06:31:37	06:32:37

90040	7	3	20010915	1	90	07:10:07	07:11:37
90010	7	3	20010915	91	180	07:13:00	07:14:30
90020	7	3	20010915	181	246	07:15:15	07:16:21
90030	7	3	20010915	11513	11602	11:37:14	11:38:44
90050	7	1	20010915	11603	11692	11:39:26	11:40:56
90060	7	1	20010915	11693	11782	11:41:59	11:43:29
16110	7	3	20010915	1	60	12:04:36	12:05:36
15110	8	1	20010915	1	60	15:01:23	15:02:23
90041	8	3	20010915	158	247	15:35:16	15:36:46
90012	8	3	20010915	248	337	15:37:51	15:39:21
90021	8	1	20010915	338	444	15:41:10	15:42:57
90030	8	1	20010915	4926	5015	17:25:16	17:26:46
90050	8	1	20010915	5016	5105	17:27:17	17:28:47
90060	8	1	20010915	5106	5195	17:29:35	17:31:05
16110	8	1	20010915	1	60	17:52:01	17:53:01
15110	9	1	20010916	1	60	06:36:11	06:37:11
90010	9	3	20010916	97	186	07:25:39	07:27:09
90020	9	3	20010916	187	254	07:27:59	07:29:07
90041	9	1	20010916	255	344	07:37:49	07:39:19
90011	9	3	20010916	345	434	07:50:58	07:52:28
90021	9	3	20010916	435	524	07:53:17	07:54:47
90030	9	1	20010916	11805	11894	12:08:47	12:10:17
90060	9	1	20010916	11895	11984	12:11:29	12:12:59
90050	9	1	20010916	11985	12074	12:13:58	12:15:28
16110	9	1	20010916	1	60	12:34:53	12:35:53
15110	10	1	20010918	1	60	06:23:29	06:24:29
90040	10	3	20010918	1	90	10:45:21	10:46:51
90010	10	3	20010918	91	180	10:47:32	10:49:02
90020	10	3	20010918	181	241	10:49:33	10:50:34
90031	10	1	20010918	12261	12350	15:26:53	15:28:23
90050	10	1	20010918	12351	12440	15:29:20	15:30:50
90060	10	1	20010918	12441	12530	15:31:46	15:33:16
16110	10	1	20010918	1	60	15:50:45	15:51:45
15110	11	1	20010919	1	60	06:14:37	06:15:37
90040	11	3	20010919	1	90	06:55:01	06:56:31
90010	11	3	20010919	91	180	06:57:27	06:58:57
90020	11	3	20010919	181	237	06:59:33	07:00:30
90030	11	1	20010919	2035	2124	07:52:35	07:54:05
90050	11	1	20010919	2125	2214	07:54:54	07:56:24
90060	11	1	20010919	2215	2304	07:57:30	07:59:00
16110	11	3	20010919	1	60	08:18:08	08:19:08
15110	12	3	20010919	1	60	15:01:48	15:02:48
90040	12	3	20010919	1394	1483	16:05:53	16:07:23
90010	12	3	20010919	1484	1574	16:08:16	16:09:47
90020	12	3	20010919	1575	1662	16:10:40	16:12:08
90050	12	1	20010919	2021	2110	16:42:18	16:43:48
90060	12	1	20010919	2111	2200	16:44:41	16:46:11
16110	12	1	20010919	1	87	17:09:27	17:10:54

Repeatability Calibration Lines:

Line	Flight	Direction	Date	Start Fid	End Fid	Start Time	End Time
			(yyyymmdd)	(s)	(s)	(hh\mm\ss)	(hh\mm\ss)
92010	1	3	20010903	231	345	15:35:45	15:37:40
92041	4	3	20010907	361	610	07:50:37	07:54:47
92070	7	3	20010915	247	505	07:31:09	07:35:28
92120	12	3	20010919	1663	1817	16:22:43	16:25:18

Compensation Calibration Lines:

Line	Flight	Direction	Date	Start Fid	End Fid	Start Time	End Time
			(yyyymmdd)	(s)	(s)	(hh\mm\ss)	(hh\mm\ss)
18110	3	2	20010906	1	358	08:50:08	08:56:06
18120	3	1	20010906	359	757	08:57:05	09:03:44
18130	3	4	20010906	758	1156	09:04:43	09:11:22
18140	3	3	20010906	1157	1546	09:12:26	09:18:56

APPENDIX IV - Data Formats (Post-Processed Files)

Headers for "raw" data files

```
BILLABONG CREEK TEMPEST SURVEY: RAW (UN-CORRECTED) EM LOCATED DATA


Survey Specifications:

   AGSO job number           904
   Fugro job number          1481.2
   Survey company            FUGRO AIRBORNE SURVEYS
   Survey aircraft           Casa-212 VH-TEM
   Date flown/compiled       September 2001
   Client name               Bureau of Rural Sciences
   Area name                 Billabong Creek, NSW
   Line kilometreage         5522 kilometres
   Traverse line spacing     200 metres
   Traverse line direction   090 - 270 degrees
   Terrain clearance         120 metres
   EM system                 25Hz TEMPEST
   Navigation                Real-time differential GPS
   Datum                     GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

   507344  6068287
   478967  6068266
   478998  6055178
   474743  6055167
   474728  6060380
   467026  6061020
   465465  6043047
   504156  6037457
   504250  6045331
   507325  6045329


Geometry Corrections:

   The EM data have NOT been corrected for transmitter height/pitch/roll
   nor transmitter-receiver geometry variations.

System Geometry:

   The nominal transmitter-receiver geometry is:

      transmitter terrain clearance = 120 metres
      distance behind the aircraft  = 123 metres
      distance below the aircraft   =  41 metres


Altimeter Corrections:

   The following corrections were added to the aircraft altitude:

      transmitter - rad alt separation = +2.4 metres
      GPS_antenna - rad alt separation = -2.3 metres


Parallax Values:

   For this data set, the following parallax values were applied:

      X-component EM data = 0.2 seconds
      Z-component EM data = 1.4 seconds
      radar altimeter     = 0.4 seconds
      magnetometer        = 0.5 seconds
```

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component, written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter	m	F12.2	-9999999
12	Tx loop roll	deg	F10.5	-9999999
13	Tx loop pitch	deg	F10.5	-9999999
14	Tx loop terrain clearance	m	F10.2	-9999999
15	Tx-Rx horizontal separation	m	F10.2	-9999999
16	Tx-Rx vertcial separation	m	F10.2	-9999999
17	Rx coil terrain clearance	m	F10.2	-9999999
18	Sferics	uV/sq.m/0.2s	F12.3	-9999999
19	18.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
20	19.8kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
21	21.4kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
22	22.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
23	Powerline	log10(pV/root.Hz/sq.m)	F10.3	-9999999
24	Low freq	log10(pV/root.Hz/sq.m)	F10.3	-9999999
25-39	15 EM windows	fT	15(F10.6)	-9999999
40	Geometric factor	N/A	F10.3	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: RAW MAGNETIC LOCATED DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have NOT been corrected for transmitter height/pitch/roll nor transmitter-receiver geometry variations.

System Geometry:

The nominal transmitter-receiver geometry is:

transmitter terrain clearance = 120 metres
distance behind the aircraft = 123 metres
distance below the aircraft = 41 metres

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres

Parallax Values:

For this data set, the following parallax values were applied:

X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter = 0.4 seconds
magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows area

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component,
written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter	m	F12.2	-9999999
12	Fluxgate: X-axis	nT	F12.3	-9999999
13	Fluxgate: Y-axis	nT	F12.3	-9999999
14	Fluxgate: Z-axis	nT	F12.3	-9999999
15	Un-compensated magnetics	nT	F12.3	-9999999
16	Raw compensated magnetics	nT	F12.3	-9999999
17	Magnetic diurnal	nT	F12.3	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: RAW ELEVATION LOCATED DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have NOT been corrected for transmitter height/pitch/roll nor transmitter-receiver geometry variations.

System Geometry:

The nominal transmitter-receiver geometry is:

transmitter terrain clearance = 120 metres
distance behind the aircraft = 123 metres
distance below the aircraft = 41 metres

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres

Parallax Values:

For this data set, the following parallax values were applied:

X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter = 0.4 seconds
magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component,
written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I10	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter	m	F12.2	-9999999
12	GPS time	sec	F12.1	-9999999
13	GPS height (GDA94 ellipsoid)	m	F12.2	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: FINAL (UN-CORRECTED) EM LOCATED DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have NOT been corrected for transmitter height/pitch/roll nor transmitter-receiver geometry variations.

System Geometry:

The nominal transmitter-receiver geometry is:

transmitter terrain clearance = 120 metres
distance behind the aircraft = 123 metres
distance below the aircraft = 41 metres

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres

Parallax Values:

For this data set, the following parallax values were applied:

X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter = 0.4 seconds
magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component,
written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter (raw)	m	F12.2	-9999999
12	Radar altimeter (edited)	m	F12.2	-9999999
13	Tx-loop roll	deg	F10.5	-9999999
14	Tx-loop pitch	deg	F10.5	-9999999
15	Tx-loop terrain clearance	m	F10.2	-9999999
16	Tx-Rx horizontal separation	m	F10.2	-9999999
17	Tx-Rx vertcial separation	m	F10.2	-9999999
18	Rx-coil terrain clearance	m	F10.2	-9999999
19	Sferics	uV/sq.m/0.2s	F12.3	-9999999
20	18.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
21	19.8kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
22	21.4kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
23	22.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
24	Powerline	log10(pV/root.Hz/sq.m)	F10.3	-9999999
25	Low freq	log10(pV/root.Hz/sq.m)	F10.3	-9999999
26-40	15 EM windows	fT	15(F10.6)	-9999999
41	Geometric factor	N/A	F10.3	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

Headers for "final" data files

```
BILLABONG CREEK TEMPEST SURVEY: FINAL (HEIGHT AND GEOMETRY) EM LOCATED DATA


Survey Specifications:

   AGSO job number           904
   Fugro job number          1481.2
   Survey company            FUGRO AIRBORNE SURVEYS
   Survey aircraft           Casa-212 VH-TEM
   Date flown/compiled       September 2001
   Client name               Bureau of Rural Sciences
   Area name                 Billabong Creek, NSW
   Line kilometreage         5522 kilometres
   Traverse line spacing     200 metres
   Traverse line direction   090 - 270 degrees
   Terrain clearance         120 metres
   EM system                 25Hz TEMPEST
   Navigation                Real-time differential GPS
   Datum                     GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

   507344  6068287
   478967  6068266
   478998  6055178
   474743  6055167
   474728  6060380
   467026  6061020
   465465  6043047
   504156  6037457
   504250  6045331
   507325  6045329

Geometry Corrections:

   The EM data have been corrected for transmitter height/pitch/roll
   and transmitter-receiver geometry variations.

System Geometry:

   The transmitter-receiver geometry has been corrected to be:

      transmitter terrain clearance = 120 metres
      distance behind the aircraft  = 123 metres
      distance below the aircraft   =  41 metres


Altimeter Corrections:

   The following corrections were added to the aircraft altitude:

      transmitter - rad alt separation = +2.4 metres
      GPS_antenna - rad alt separation = -2.3 metres


Parallax Values:

   While calculating the height/pitch/roll/geometry correction,
   the following parallax values were applied:

      X-component EM data = 0.0 seconds
      Z-component EM data = 0.0 seconds
      radar altimeter     = 0.0 seconds

   For this data set, the following parallax values were applied:

      X-component EM data = 0.2 seconds
      Z-component EM data = 1.4 seconds
      radar altimeter     = 0.4 seconds
```

magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component, written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter (raw)	m	F12.2	-9999999
12	Radar altimeter (edited)	m	F12.2	-9999999
13	Laser altimeter	m	F12.2	-9999999
14	Tx-loop roll	deg	F10.5	-9999999
15	Tx-loop pitch	deg	F10.5	-9999999
16	Tx-loop terrain clearance	m	F10.2	-9999999
17	Tx-Rx horizontal separation	m	F10.2	-9999999
18	Tx-Rx vertical separation	m	F10.2	-9999999
19	Rx-coil terrain clearance	m	F10.2	-9999999
20	Sferics	uV/sq.m/0.2s	F12.3	-9999999
21	18.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
22	19.8kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
23	21.4kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
24	22.2kHz	log10(pV/root.Hz/sq.m)	F10.3	-9999999
25	Powerline	log10(pV/root.Hz/sq.m)	F10.3	-9999999
26	Low freq	log10(pV/root.Hz/sq.m)	F10.3	-9999999
27-41	15 EM windows	fT	15(F10.6)	-9999999
42	Geometric factor	N/A	F10.0	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: FINAL MAGNETIC LOCATED DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have been corrected for transmitter height/pitch/roll and transmitter-receiver geometry variations.

System Geometry:

The transmitter-receiver geometry has been corrected to be:

transmitter terrain clearance = 120 metres
distance behind the aircraft = 123 metres
distance below the aircraft = 41 metres

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres

Parallax Values:

While calculating the height/pitch/roll/geometry correction, the following parallax values were applied:

X-component EM data = 0.0 seconds
Z-component EM data = 0.0 seconds
radar altimeter = 0.0 seconds

For this data set, the following parallax values were applied:

X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter = 0.4 seconds
magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component, written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter (raw)	m	F12.2	-9999999
12	Radar altimeter (edited)	m	F12.2	-9999999
13	Final unlevelled magnetics	nT	F12.3	-9999999
14	Final microlevelled magnetics	nT	F12.3	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: FINAL ELEVATION LOCATED DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have been corrected for transmitter height/pitch/roll and transmitter-receiver geometry variations.

System Geometry:

The transmitter-receiver geometry has been corrected to be:

transmitter terrain clearance = 120 metres
distance behind the aircraft = 123 metres
distance below the aircraft = 41 metres

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres

Parallax Values:

While calculating the height/pitch/roll/geometry correction, the following parallax values were applied:

X-component EM data = 0.0 seconds
Z-component EM data = 0.0 seconds
radar altimeter = 0.0 seconds

For this data set, the following parallax values were applied:

X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter = 0.4 seconds
magnetometer = 0.5 seconds

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for each component, written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-9999999
5	Date	ddmmyyyy	I10	-9999999
6	Direction	deg	I6	-9999999
7	Longitude (GDA94)	deg	F12.6	-9999999
8	Latitude (GDA94)	deg	F12.6	-9999999
9	Easting (GDA94)	m	F9.0	-9999999
10	Northing (GDA94)	m	F10.0	-9999999
11	Radar altimeter (raw)	m	F12.2	-9999999
12	Radar altimeter (edited)	m	F12.2	-9999999
13	Aircraft altitude (GDA94)	m	F12.2	-9999999
14	Derived topography (AHD)	m	F12.2	-9999999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: FINAL LOCATED CONDUCTIVITY DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometreage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Geometry Corrections:

The EM data have been corrected for transmitter height/pitch/roll and transmitter-receiver geometry variations.

System Geometry:

The transmitter-receiver geometry has been corrected to be:

```
transmitter terrain clearance = 120 metres
distance behind the aircraft  = 123 metres
distance below the aircraft   =  41 metres
```

Altimeter Corrections:

The following corrections were added to the aircraft altitude:

```
transmitter - rad alt separation = +2.4 metres
GPS_antenna - rad alt separation = -2.3 metres
```

Parallax Values:

While calculating the height/pitch/roll/geometry correction, the following parallax values were applied:

```
X-component EM data = 0.0 seconds
Z-component EM data = 0.0 seconds
radar altimeter     = 0.0 seconds
```

For this data set, the following parallax values were applied:

```
X-component EM data = 0.2 seconds
Z-component EM data = 1.4 seconds
radar altimeter     = 0.4 seconds
magnetometer        = 0.5 seconds
```

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580
Calibration lines 92010, 92041, 92070, 92120

Located Data Format:

One file of combined line data for the survey lines and one for the calibration lines written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I6	
2	Flight number	N/A	I4	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-99999
5	Date	ddmmyyyy	I9	-99999
6	Direction	deg	I4	-99
7	Longitude (GDA94)	deg	F11.6	-99999
8	Latitude (GDA94)	deg	F11.6	-99999
9	Easting (GDA94)	m	F9.1	-99999
10	Northing (GDA94)	m	F10.1	-99999
11	Radar altimeter (edited)	m	F6.1	-9999
12	Tx-loop terrain clearance	m	F6.1	-9999
13	Data misfit	percent	F8.3	-99999
14	Time of last signal return	ms	F6.1	-99999
15	Depth of last signal return	m	F8.1	-99999
16	Depth of investigation	m	F8.1	-99999
17-86	Interval conductivities: 5m step	mS/m	70(F8.1)	-99999
87-96	Interval conductivities: variable	mS/m	10(F7.1)	-99999
97	Depth to top (of unit)	m	F7.1	-99999
98	Depth to base (of unit)	m	F7.1	-99999
99	Elevation of top (of unit)	(AHD) m	F7.1	-99999
100	Elevation of base (of unit)	(AHD) m	F7.1	-99999
101	Average unit conductivity	mS/m	F7.1	-99999
102	Unit thickness	m	F7.1	-99999
103	Unit conductance	S	F8.3	-99999

Each field separated by a blank
Each record terminated by <CR><NL>

BILLABONG CREEK TEMPEST SURVEY: FINAL LOCATED LEI DATA

Survey Specifications:

AGSO job number	904
Fugro job number	1481.2
Survey company	FUGRO AIRBORNE SURVEYS
Survey aircraft	Casa-212 VH-TEM
Date flown/compiled	September 2001
Client name	Bureau of Rural Sciences
Area name	Billabong Creek, NSW
Line kilometerage	5522 kilometres
Traverse line spacing	200 metres
Traverse line direction	090 - 270 degrees
Terrain clearance	120 metres
EM system	25Hz TEMPEST
Navigation	Real-time differential GPS
Datum	GDA94 (Zone 55)

Survey Boundary (in GDA94 co-ordinates):

507344	6068287
478967	6068266
478998	6055178
474743	6055167
474728	6060380
467026	6061020
465465	6043047
504156	6037457
504250	6045331
507325	6045329

Electromagnetic System:

TEMPEST is a time-domain square-wave system transmitting at a base frequency of 25Hz with 3 orthogonal-axis receiver coils in a towed bird. Final EM output is recorded 5 times per second (~12 metres). The times (in milliseconds) for the 15 windows are:

Window	Start	End	Mean
1	0.007	0.020	0.013
2	0.033	0.047	0.040
3	0.060	0.073	0.067
4	0.087	0.127	0.107
5	0.140	0.207	0.173
6	0.220	0.340	0.280
7	0.353	0.553	0.453
8	0.567	0.873	0.720
9	0.887	1.353	1.120
10	1.367	2.100	1.733
11	2.113	3.273	2.693
12	3.287	5.113	4.200
13	5.127	7.993	6.560
14	8.007	12.393	10.200
15	12.407	19.993	16.200

Lines:

Traverse lines ..... 20010 - 21580

Located Data Format:

One file of combined line data for each component,
written in the following ascii format :-

Col	Variable	Units	Format	Undefined
1	Job number	N/A	I4	
2	Flight number	N/A	I3	
3	Line number	N/A	I6	
4	Fiducial	N/A	I8	-99
5	Date	N/A	ddmmyyyy	-99
6	Direction	deg	I3	-99
7	Longitude (GDA94)	deg	F10.6	-99
8	Latitude (GDA94)	deg	F10.6	-99
9	Easting (GDA94)	m	F8.1	-99
10	Northing (GDA94)	m	F9.1	-99
11	Radar altimeter (LEI output)	m	F6.1	-99
12	Layer 1 conductivity	mS/m	F6.1	-99
13	Layer 2 conductivity	mS/m	F6.1	-99
14	Half-space conductivity	mS/m	F6.1	-99
15	Layer 1 thickness	m	F5.1	-99
16	Layer 2 thickness	m	F5.1	-99
17	Depth of penetration	m	F6.0	-99
18	Chi-square data fit		F5.1	-99

Each field separated by a blank
Each record terminated by <CR><NL>

Undefined parameters are set to –99.
The depth of penetration is determined from the skin depth estimate for a base-frequency of 25 Hz, the cumulative conductance and a noise estimate of the data.
The Chi-square data fit is defined as

$$X^2 = \frac{1}{\sigma^2} \sum_{i=1}^{n} (y_i - d_i)^2$$

where σ is the standard deviation of the measured data y_i and d_i are the modelled data.

APPENDIX V – List of all Supplied Digital Data

List of ASCII located data files and document files

Located File	Description
904_job_report.doc	Acquisition and processing report (Word format)
904_RawEM.hdr	“raw” EM data header
904_RawEMX.asc	“raw” EM data, X-component, survey lines
904_RawEMZ.asc	“raw” EM data, Z-component, survey lines
904_RawMag.hdr	“raw” Mag data header
904_RawMag.asc	“raw” Mag data, survey lines
904_RawElev.hdr	“raw” Elevation data header
904_RawElev.asc	“raw” Elevation data, survey lines
904_FinalRawEM.hdr	“final” Uncorrected EM data header
904_FinalRawEMX.asc	“final” Uncorrected EM data, X-component, survey lines
904_FinalRawEMZ.asc	“final” Uncorrected EM data, Z-component, survey lines
904_RawEM.hdr	“final” Corrected EM data header
904_RawEMX.asc	“final” Corrected EM data, X-component, survey lines
904_RawEMZ.asc	“final” Corrected EM data, Z-component, survey lines
904_FinalMag.hdr	“final” Mag data header
904_FinalMag.asc	“final” Mag data, survey lines
904_FinalElev.hdr	“final” Elevation data header
904_FinalElev.asc	“final” Elevation data, survey lines
904_FinalCDI.hdr	“final” CDI and Unit Parameters data header
904_FinalCDI.asc	“final” CDI and Unit Parameters data, survey lines
904_FinalLEI.hdr	“final” Layered Earth Inversion data header
904_FinalLEI.out	“final” Layered Earth Inversion survey line data

List of gridded data files (in ER-mapper format)

Located File	Description
904_TMI	Total magnetic intensity [nanotesla]
904_TMI1vd	1st vertical derivative of total magnetic intensity [nT/m]
904_Topo	Derived topography [metres AHD]
904_cdi_interval_{depth from}_[depth to}	Interval Conductivities: (5m steps) 70 grids [mS/m]
904_cdi_interval_{depth from}_{depth to}	Interval Conductivities: (various steps) 10 grids [mS/m]
904_conductance	Unit Parameter: conductance of conductive unit [S]
904_depth_base	Unit Parameter: depth to base of conductive unit [m]
904_depth_top	Unit Parameter: depth to top of conductive unit [m]
904_elevation_base	Unit Parameter: elevation of base of conductive unit [m AHD]
904_elevation_top	Unit Parameter: elevation of top of conductive unit [m AHD]
904_thickness	Unit Parameter: thickness of conductive unit [m]
904_average_conductivity	Unit Parameter: mean conductivity of unit [mS/m]

APPENDIX VI – List of all Supplied Products

CD-ROMs containing located and gridded digital data, as set out in Appendix V.
Acquisition and processing report.

APPENDIX VII - Pre and Post Flight Zero Results

Table 1. Mean and standard deviation of processed data recorded at high altitude before and after each production survey flight.

Flight No.	Window No.	Pre X mean (aT)	Pre X std dev (aT)	Pre Z mean (aT)	Pre Z std dev (aT)	Post X mean (aT)	Post X std dev (aT)	Post Z mean (aT)	Post Z std dev (aT)
1	1	-4	23	-6	20	-6	18	-6	24
1	2	22	18	14	14	20	22	15	12
1	3	0	17	-3	10	-2	20	-3	8
1	4	6	15	2	9	4	13	2	6
1	5	10	14	5	8	8	12	5	5
1	6	8	14	3	8	6	11	3	5
1	7	8	13	3	7	6	11	3	5
1	8	7	12	3	7	6	9	3	5
1	9	7	13	3	6	6	8	3	5
1	10	7	15	3	7	6	12	3	6
1	11	6	19	3	7	5	16	3	6
1	12	5	14	2	6	4	13	2	4
1	13	4	12	2	5	4	7	2	3
1	14	3	9	1	3	3	8	2	2
1	15	3	8	2	3	4	8	2	4
2	1	-1	25	-3	21	-3	18	-6	23
2	2	25	22	16	24	22	21	15	24
2	3	3	24	0	19	1	14	-3	18
2	4	9	21	4	12	7	16	2	7
2	5	13	20	7	12	10	14	5	6
2	6	11	19	6	11	8	13	3	6
2	7	11	17	6	10	8	12	3	6
2	8	11	16	5	9	8	11	3	7
2	9	10	19	5	9	8	11	3	7
2	10	10	23	5	11	7	13	3	7
2	11	9	26	5	12	7	17	3	6
2	12	8	20	4	9	6	14	3	6
2	13	7	16	4	7	5	9	2	4
2	14	5	11	3	5	4	8	2	3
2	15	6	9	4	5	5	8	2	4
3	1	-3	21	-4	17	-4	18	-5	18
3	2	24	21	15	18	22	17	15	13
3	3	1	18	-1	14	0	17	-2	11
3	4	7	19	4	11	6	15	3	7
3	5	11	18	6	11	10	15	6	7
3	6	9	17	5	10	8	14	4	7
3	7	9	16	5	9	8	13	4	7
3	8	9	14	5	8	8	11	4	7
3	9	9	15	5	8	8	10	4	7
3	10	8	17	4	10	7	11	4	7
3	11	8	21	4	10	7	14	4	8
3	12	7	17	3	8	6	13	3	5
3	13	5	11	3	5	5	7	3	5
3	14	4	10	2	4	4	8	2	3
3	15	5	11	3	4	4	6	2	4
4	1	-3	23	-4	20	-6	21	-5	20
4	2	23	24	16	14	21	16	14	13
4	3	1	20	-1	12	-2	14	-3	10
4	4	7	18	4	9	4	13	2	6
4	5	10	18	6	9	8	12	5	6

4	6	8	17	5	9	6	11	3	6
4	7	9	15	5	8	6	10	3	6
4	8	8	14	5	8	6	10	3	6
4	9	8	13	5	7	6	10	3	6
4	10	8	17	5	9	5	12	3	7
4	11	7	21	4	12	5	16	3	7
4	12	6	15	4	7	5	12	2	7
4	13	5	11	3	6	4	9	2	5
4	14	4	10	2	5	3	7	1	4
4	15	5	10	3	6	4	8	1	4
5	1	-7	16	-5	16	-5	21	-4	18
5	2	20	13	14	16	21	14	16	14
5	3	-3	11	-2	12	-1	14	-1	11
5	4	4	11	3	8	5	13	4	10
5	5	7	11	5	8	8	11	6	9
5	6	5	10	4	8	6	11	5	9
5	7	6	9	4	7	6	11	5	8
5	8	5	9	4	6	6	10	5	7
5	9	5	8	4	6	6	11	5	7
5	10	5	10	3	7	6	15	4	8
5	11	5	15	3	9	5	16	4	8
5	12	4	10	3	7	5	13	4	7
5	13	3	7	2	4	4	8	3	5
5	14	2	7	1	4	3	7	3	4
5	15	3	7	2	4	3	8	3	5
6	1	-3	27	-3	16	-1	24	-6	14
6	2	23	21	17	20	24	21	15	14
6	3	1	15	0	12	3	20	-3	10
6	4	7	16	4	11	9	19	2	7
6	5	11	15	7	11	12	19	5	7
6	6	9	14	6	11	10	17	4	6
6	7	9	13	6	10	10	16	4	7
6	8	8	12	5	10	10	14	4	7
6	9	8	11	5	10	10	14	4	7
6	10	8	16	5	12	9	24	3	7
6	11	7	22	5	15	9	33	3	9
6	12	6	14	4	10	7	25	3	8
6	13	5	13	4	8	6	22	2	4
6	14	5	9	3	6	4	23	2	4
6	15	5	8	3	6	6	16	2	4
7	1	-3	29	-5	14	-4	19	-6	16
7	2	22	32	15	13	22	18	15	13
7	3	1	38	-2	10	0	18	-3	11
7	4	7	34	3	8	6	16	2	7
7	5	10	33	5	8	9	16	5	7
7	6	8	30	4	7	7	15	3	7
7	7	8	18	4	7	8	13	4	7
7	8	8	10	4	6	7	12	3	7
7	9	8	12	4	6	7	12	3	7
7	10	8	16	3	7	7	14	3	7
7	11	7	19	3	7	6	18	3	8
7	12	7	13	3	7	6	12	3	6
7	13	6	12	2	4	5	9	2	4
7	14	5	9	2	4	4	7	2	3
7	15	7	8	2	4	4	7	2	3
9	1	-3	38	-4	17	-2	26	-4	21
9	2	23	18	16	15	22	16	17	15
9	3	1	20	-1	12	1	15	-1	13
9	4	7	18	4	9	7	14	5	11
9	5	10	17	6	9	10	14	7	11
9	6	8	16	5	8	9	14	6	10

9	7	8	15	5	9	9	13	6	9
9	8	8	14	5	9	8	12	6	8
9	9	8	15	5	10	8	11	6	7
9	10	8	20	4	11	8	16	5	8
9	11	7	23	4	12	7	26	5	10
9	12	6	19	4	9	6	19	4	9
9	13	5	16	3	7	5	12	4	5
9	14	3	21	2	4	3	16	3	5
9	15	3	21	3	5	4	16	4	6
10	1	-5	15	-4	14	-5	22	-5	17
10	2	21	15	15	13	21	18	14	14
10	3	-1	14	-1	13	-1	15	-2	11
10	4	5	13	3	9	5	14	3	8
10	5	9	12	6	10	9	14	5	7
10	6	7	11	4	9	7	13	4	7
10	7	7	10	5	9	7	12	4	7
10	8	7	10	4	8	7	11	4	7
10	9	7	12	4	8	7	10	4	7
10	10	6	14	4	8	6	14	4	8
10	11	6	17	4	10	6	21	3	8
10	12	5	17	3	9	5	14	3	7
10	13	4	9	2	5	4	9	3	5
10	14	3	9	2	4	3	9	2	4
10	15	4	7	2	4	4	9	3	4
11	1					-4	18	-6	11
11	2					21	18	13	12
11	3					0	14	-3	10
11	4					6	14	1	6
11	5					9	13	4	6
11	6					7	13	3	6
11	7					7	11	3	6
11	8					7	10	2	6
11	9					7	10	3	7
11	10					7	13	2	7
11	11					6	15	2	7
11	12					5	13	2	5
11	13					4	8	1	4
11	14					4	9	1	2
11	15					4	9	1	3

APPENDIX VIII – CDI Sections of Repeatability Lines

Insert 1 CDI sections of repeat calibration lines

APPENDIX IX – Radar Altimeter Calibration

Table 1. Radar Altimeter Calibration Lookup Table

Millivolts	Meters	Millivolts	Meters	Millivolts	Meters	Millivolts	meters
201.21600	14.51	2098.32999	157.31	4792.79244	361.90	7443.56494	566.44
201.80266	14.56	2100.93054	157.51	4810.49693	363.25	7484.62263	569.59
207.64814	15.16	2134.79516	160.00	4853.15683	366.51	7491.82822	570.12
208.37590	15.21	2148.93951	161.02	4856.91832	366.78	7526.94293	572.81
210.22166	15.42	2181.53743	163.42	4887.11536	369.07	7542.64064	574.03
210.58341	15.45	2197.45359	164.58	4920.82615	371.65	7570.49354	576.19
210.64261	15.48	2225.30239	166.64	4920.94603	371.66	7598.36355	578.38
211.61422	15.55	2245.84103	168.16	4957.86516	374.49	7616.76206	579.86
213.99736	15.70	2265.70256	169.67	4978.80903	376.12	7648.16152	582.34
214.62511	15.74	2295.79700	171.97	4998.70687	377.63	7664.84695	583.64
216.21294	15.87	2310.28621	173.11	5028.92594	379.94	7690.14675	585.61
217.23279	15.98	2344.09713	175.73	5041.44140	380.88	7716.69470	587.70
217.59775	16.03	2363.99666	177.29	5069.50767	383.04	7731.90495	588.90
217.75399	16.05	2391.38556	179.40	5088.65805	384.53	7769.56337	591.91
218.03356	16.07	2425.15282	181.99	5108.10880	386.05	7778.48369	592.62
218.58811	16.09	2439.27786	183.05	5140.60976	388.58	7821.11376	595.99
219.22148	16.13	2482.65724	186.36	5143.68183	388.83	7827.69457	596.51
222.98081	16.32	2486.11113	186.62	5179.36018	391.58	7869.79287	599.78
224.75945	16.42	2530.89098	190.01	5199.91380	393.15	7874.16000	600.11
235.81984	17.23	2535.25499	190.33	5218.10093	394.53	7915.73091	603.35
238.38206	17.52	2575.37551	193.33	5255.76440	397.43	7916.02483	603.38
239.44201	17.61	2586.07668	194.13	5259.97776	397.75	7955.40029	606.48
239.81776	17.64	2615.32370	196.32	5296.07866	400.54	7959.57265	606.81
240.24608	17.70	2637.85449	198.02	5312.87456	401.84	7995.90122	609.63
254.25809	18.66	2655.97972	199.39	5344.96437	404.33	8002.26377	610.12
255.43600	18.75	2690.34425	201.99	5360.49109	405.52	8035.58252	612.65
255.29601	18.76	2696.24960	202.43	5398.42870	408.41	8045.30992	613.39
255.25189	18.77	2743.91315	206.02	5407.60590	409.10	8077.43383	615.86
267.26752	19.78	2797.04591	210.04	5454.41008	412.65	8088.59866	616.73
268.50686	19.88	2797.65712	210.09	5455.98764	412.76	8120.95529	619.30
277.79268	20.58	2849.00260	213.99	5506.14335	416.61	8130.17274	620.04
284.41188	21.03	2849.26288	214.01	5506.72210	416.66	8173.66325	623.52
290.06557	21.41	2894.68581	217.47	5552.57720	420.26	8173.93167	623.55
295.19114	21.75	2899.01931	217.80	5555.89771	420.52	8221.86116	627.32
298.25133	21.96	2940.65503	220.97	5598.92742	423.87	8233.30549	628.19
314.46817	23.10	2949.03112	221.60	5603.76987	424.24	8271.47617	631.13
323.17301	23.73	2989.36241	224.64	5647.38453	427.59	8291.48361	632.68
350.97093	25.79	2998.81580	225.34	5649.25323	427.73	8320.91532	634.96
357.73959	26.31	3037.05518	228.18	5692.19457	431.02	8344.24804	636.78
390.05088	28.75	3047.11279	228.92	5693.53346	431.13	8372.15686	639.00
404.54000	29.85	3082.10367	231.55	5731.81018	434.09	8392.54642	640.60
426.02800	31.48	3091.34982	232.25	5737.44897	434.52	8427.19426	643.30
457.42157	33.83	3123.84936	234.75	5772.27667	437.19	8438.24280	644.14
460.18440	34.03	3131.74725	235.35	5781.31908	437.88	8480.99377	647.41
504.71043	37.37	3163.79458	237.78	5814.67909	440.43	8483.45686	647.59
512.85962	37.98	3174.13602	238.54	5828.65833	441.51	8521.17920	650.47
554.78211	41.13	3206.23828	240.93	5866.00119	444.41	8532.96171	651.40
567.57907	42.10	3222.56146	242.15	5875.09291	445.13	8558.91861	653.43
609.86927	45.32	3253.31558	244.50	5920.60037	448.67	8579.17504	655.01
628.69420	46.76	3272.80440	245.99	5922.65249	448.82	8597.99417	656.46
668.78917	49.81	3304.53339	248.44	5965.78780	452.13	8627.01891	658.68
680.46410	50.70	3318.78557	249.53	5980.31932	453.22	8642.21450	659.82
725.09063	54.05	3357.61556	252.46	6008.93968	455.39	8674.63837	662.31
728.77447	54.30	3362.31707	252.80	6036.97849	457.56	8694.24482	663.85
760.05296	56.61	3408.31290	256.23	6058.80354	459.27	8724.27953	666.21
785.47264	58.49	3416.74675	256.86	6089.90059	461.72	8756.34163	668.75
799.24259	59.51	3459.99032	260.08	6116.18895	463.82	8773.21191	670.12
839.41478	62.51	3478.06196	261.43	6138.80610	465.60	8821.28471	673.90

843.97199	62.86	3511.97694	263.94	6177.09591	468.58	8821.25505	673.91
886.19326	66.01	3531.91696	265.44	6186.06753	469.25	8868.18320	677.58
895.25272	66.67	3564.82866	267.92	6229.02385	472.53	8887.51526	679.08
925.37927	68.89	3579.66560	269.05	6240.90809	473.42	8913.01134	681.08
942.38172	70.16	3616.20640	271.89	6268.85663	475.53	8953.41920	684.27
962.00867	71.62	3624.58308	272.55	6303.59736	478.18	8954.64814	684.39
994.84258	74.12	3665.53139	275.70	6307.53330	478.48	8995.06498	687.59
1005.43438	74.94	3670.72098	276.10	6342.88743	481.19	9013.21154	689.00
1049.11555	78.25	3714.78258	279.41	6362.18673	482.68	9038.17466	690.96
1055.35769	78.73	3716.67797	279.55	6380.16184	484.06	9067.34701	693.19
1087.90795	81.15	3760.73591	282.84	6416.49823	486.90	9084.55453	694.48
1106.95100	82.56	3765.14569	283.17	6422.97143	487.41	9112.49204	696.62
1127.68155	84.08	3802.88384	286.03	6464.62999	490.67	9131.71142	698.11
1147.80461	85.59	3813.50383	286.84	6467.99929	490.94	9151.57880	699.66
1175.15340	87.66	3844.58011	289.23	6513.04025	494.44	9181.55512	701.99
1189.56049	88.76	3857.38473	290.22	6514.84675	494.57	9186.69709	702.38
1225.20167	91.49	3885.56965	292.41	6558.96524	497.93	9219.56371	704.96
1230.51131	91.91	3896.03381	293.22	6568.20034	498.63	9232.47040	705.96
1272.97019	95.11	3933.05705	296.05	6604.29359	501.39	9254.63717	707.69
1273.04140	95.12	3936.20860	296.27	6619.21819	502.56	9281.26978	709.83
1310.41271	97.87	3972.00056	298.97	6648.94616	504.89	9293.45948	710.82
1310.95920	97.91	3991.36820	300.42	6669.07307	506.46	9327.48441	713.56
1346.71318	100.51	4009.34976	301.77	6695.07074	508.48	9333.81944	714.07
1347.90883	100.60	4044.39210	304.46	6721.51562	510.49	9372.51199	717.14
1386.83881	103.52	4048.44314	304.78	6742.27054	512.05	9376.37598	717.44
1388.25975	103.64	4084.98821	307.60	6773.61019	514.43	9417.48908	720.63
1427.12719	106.61	4094.98923	308.38	6794.05222	515.97	9422.64099	721.01
1431.35978	106.94	4121.00106	310.38	6816.46505	517.70	9461.80549	724.05
1467.28702	109.65	4142.02133	311.99	6850.80260	520.37	9471.04650	724.77
1474.79374	110.20	4159.80162	313.34	6854.20415	520.63	9503.79464	727.36
1509.95935	112.79	4187.44342	315.45	6894.22296	523.72	9520.46325	728.67
1518.87183	113.44	4202.41144	316.59	6905.29956	524.56	9543.55225	730.51
1550.12031	115.75	4231.89940	318.83	6936.44571	526.98	9568.47620	732.46
1566.35014	116.99	4254.89923	320.57	6960.49263	528.88	9583.00494	733.60
1591.47561	118.89	4275.52206	322.14	6980.20058	530.44	9613.65945	735.99
1630.59851	121.87	4315.07014	325.18	7012.11091	533.01	9622.50611	736.69
1635.10680	122.21	4321.92051	325.72	7024.64811	534.04	9653.42411	739.14
1679.43463	125.57	4369.21270	329.36	7058.65198	536.72	9661.67901	739.82
1702.89293	127.34	4375.88359	329.88	7073.01241	537.85	9691.04736	742.11
1724.43025	128.95	4415.43266	332.94	7106.37969	540.39	9703.17355	743.03
1772.12775	132.54	4434.83587	334.43	7120.36612	541.45	9730.92639	745.14
1776.01466	132.85	4460.26635	336.38	7154.71258	544.05	9749.34026	746.52
1819.39752	136.11	4490.48613	338.70	7165.85356	544.91	9770.16834	748.09
1836.50554	137.41	4501.78312	339.58	7198.40726	547.44	9798.06360	750.27
1863.90729	139.46	4540.61853	342.55	7210.06519	548.36	9810.26255	751.23
1893.60166	141.69	4547.13549	343.02	7242.51977	550.90	9849.69169	754.36
1909.15178	142.84	4578.97791	345.42	7254.74329	551.86	9860.11841	755.19
1946.51281	145.66	4603.74408	347.28	7291.29484	554.64	9904.96604	758.76
1954.53314	146.26	4619.04023	348.42	7304.04077	555.61	9912.90494	759.40
1995.22782	149.38	4655.34743	351.19	7342.06116	558.51	9959.69824	763.22
2001.16878	149.85	4670.39799	352.35	7353.54270	559.40	9959.75467	763.27
2032.44760	152.28	4704.90829	355.04	7392.85015	562.44	10011.1357	767.60
2048.76358	153.54	4729.89003	357.01	7401.19900	563.10		
2064.80958	154.79	4759.72408	359.33	7442.54796	566.35		

APPENDIX X – EMFLOW DESCRIPTION FILE

Emflow Description File:

```
FILE FORMAT VERSION
8
SYSTEM NAME
TEMPEST 25 Hz X component
VERSION
1.0
DEFINED BY
SBH
DATE DEFINED
2001aug
TIME SCALING
1500  0.02   [sec]
WAVEFORM TYPE
halfperiod
0.02   [sec]
WAVEFORM NORMALIZED BY
total field
_____________________________________________________________
  TxRx  TxRy  TxRz  TyRx  TyRy  TyRz  TzRx  TzRy  TzRz
     0     0     0     0     0     0    15     0     0
_____________________________________________________________
                         ++++++++
                         + TzRx +
                         ++++++++
_____________________________________________________________
TRANSMITTER CURRENT WAVEFORM
undefined
_____________________________________________________________
RECEIVER PRIMARY FIELD
calibrated
AMPLITUDE SCALING
1  1   []
4
        TIME      CURRENT        ERROR  [ppm]
           0            0            0
           1       26.785            0
        1499       26.785            0
        1500            0            0
_____________________________________________________________
RECEIVER SAMPLING
15
       START          END       WEIGHT
         0.5          1.5            1
         2.5          3.5            1
         4.5          5.5            1
         6.5          9.5            1
        10.5         15.5            1
        16.5         25.5            1
        26.5         41.5            1
        42.5         65.5            1
        66.5        101.5            1
       102.5        157.5            1
       158.5        245.5            1
       246.5        383.5            1
       384.5        599.5            1
       600.5        929.5            1
       930.5       1499.5            1
_____________________________________________________________
TRANSMITTER GEOMETRY
moving dipole
z
```

```
      0       0       1
XYZ POSITION:
      0       0       0
_____________________________________________________________
RECEIVER GEOMETRY
moving dipole
x
      1       0       0
XYZ POSITION:
   -123       0     -41
_____________________________________________________________
DATA FORMAT
Geosoft format (1 yes, 0 no)
     0
Sample file name (if available)
D:\1481_2\1481_2final_repeatsX.asc
Number of comment lines at the beginning of each data file
     0
Number of items in each data record
    39
POSITION (INDEX) OF CHANNELS IN EACH DATA RECORD
channel   ????  TxRx  TxRy  TxRz  TyRx  TyRy  TyRz  TzRx  TzRy  TzRz
     1     0     0     0     0     0     0     0    15     0     0
     2     0     0     0     0     0     0     0    16     0     0
     3     0     0     0     0     0     0     0    17     0     0
     4     0     0     0     0     0     0     0    18     0     0
     5     0     0     0     0     0     0     0    19     0     0
     6     0     0     0     0     0     0     0    20     0     0
     7     0     0     0     0     0     0     0    21     0     0
     8     0     0     0     0     0     0     0    22     0     0
     9     0     0     0     0     0     0     0    23     0     0
    10     0     0     0     0     0     0     0    24     0     0
    11     0     0     0     0     0     0     0    25     0     0
    12     0     0     0     0     0     0     0    26     0     0
    13     0     0     0     0     0     0     0    27     0     0
    14     0     0     0     0     0     0     0    28     0     0
    15     0     0     0     0     0     0     0    29     0     0
----------------------
line          1   1
FID           3   1
east          4   1
north         5   1
z_topo        11  1
altitude      12  1
Rx_pitch      0   0
Rx_roll       0   0
Rx_yaw        0   0
Tx_pitch      0   0
Tx_roll       0   0
Tx_yaw        0   0
TMI           0   2
z(ASL)        0   2
----------------------
```