Arnhem Land, NT

TEMPEST
Geophysical Survey

for

Cameco Australia Pty Ltd

Acquisition and Processing Report

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

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Survey flown: June - July 2004

by

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FAS JOB# 1662

1 Introduction

This report summarises the acquisition and processing of data from the TEMPEST survey flown by Fugro Airborne Surveys (FAS) in Arnhem Land over the Kukulak and Gunbatgarri areas during June and July of 2004, for Cameco Australia Pty Ltd.

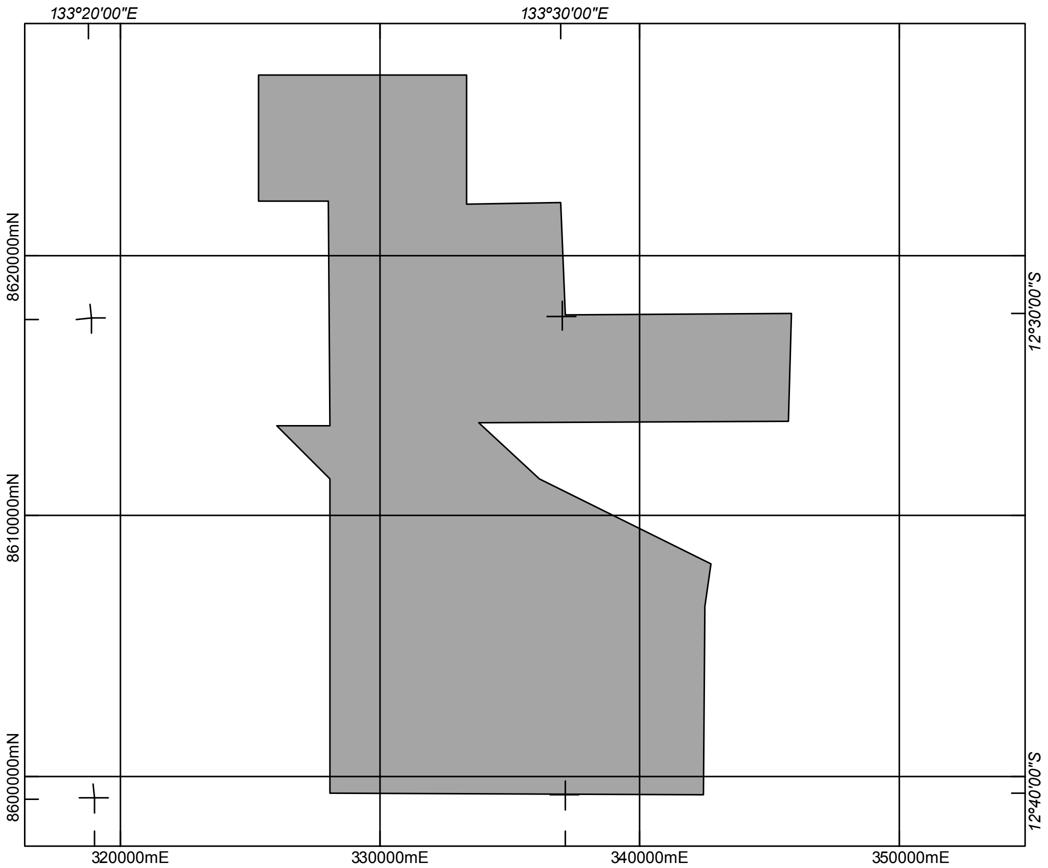
Electromagnetic and elevation data were acquired over the areas shown below. Boundary coordinates are in WGS84.

Kukulak Survey, Area 1:

	Eastings	Northings
1	342498	8606508
2	342429	8599285
3	328-91	8599301
4	326060	8611405
5	328066	8613450
6	328033	8613450
7	328033	8622100
8	325357	8622100
9	325357	8626946
10	333339	8626946
11	333339	8621972
12	336977	8622009
13	337110	8617739
14	345805	8617754
15	345719	8613600
16	333800	8613582
17	336108	8611405
18	342706	8608147

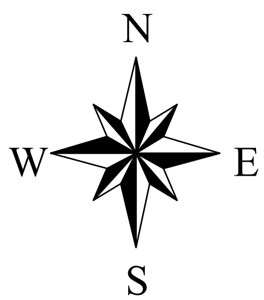
Gunbatgarri Survey, Area 2:

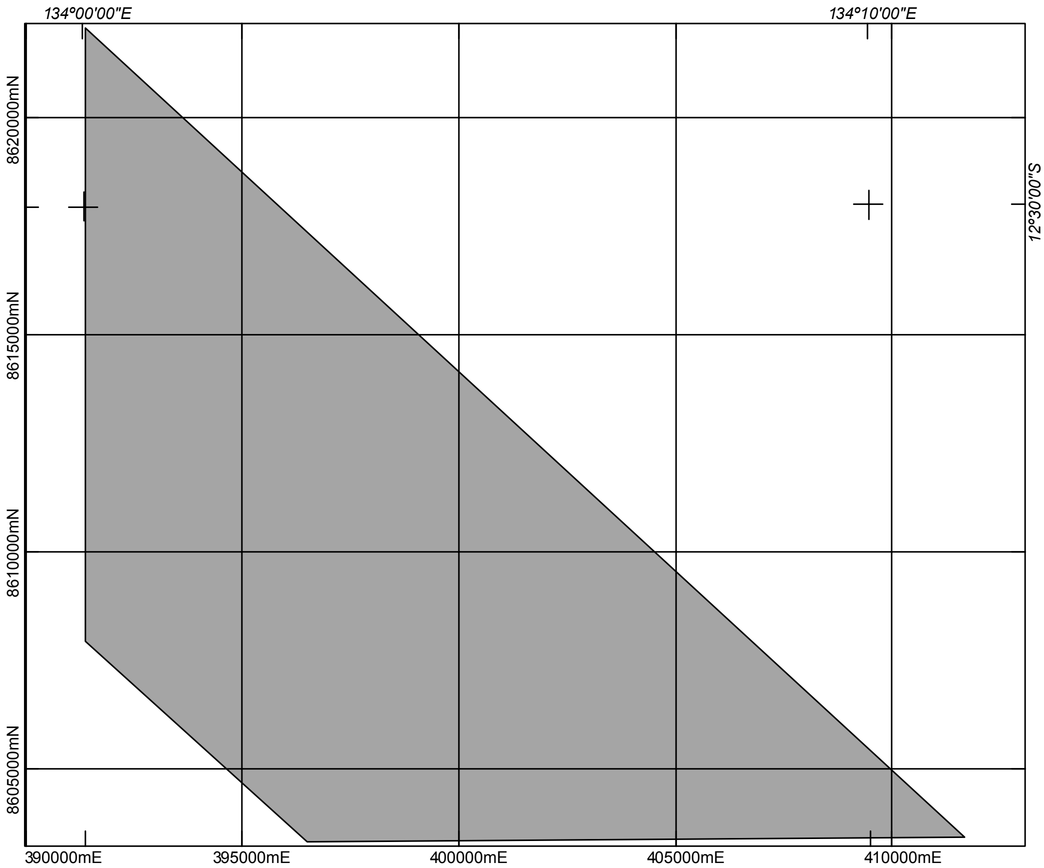
	Eastings	Northings
1	391367	8622082
2	422680	8603402
3	396500	8603300
4	391367	8607933



Cameco Australia Pty Ltd
Kukulak, Northern Territory
Tempest Geophysical Survey

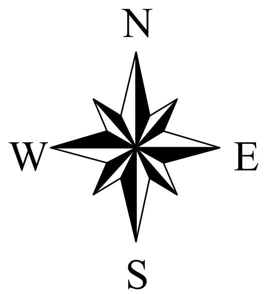
Datum: WGS84
Projection: MGA
Zone: 53





Cameco Australia Pty Ltd
Gunbatgarri, Northern Territory
TEMPEST Geophysical Survey

Datum: WGS84
Projection: MGA
Zone: 53



2 Project Crew

The following personnel were employed for this project:

Field Operations

Processor / Crew Leader	Denis Cowey / Matthew Lawrence
Airborne Operators & Techs	John Stewart / Luke Gallin
Pilots	Grant Hamilton / Mark Harradence

Base Operations

Project Manager	Davin Allen
Processing Manager	Andrea Tovey
Data Processing	Matthew Owers

3 Summary of Survey Parameters

3.1 Survey Area Parameters

Fugro Job Number	1662
Survey Company	Fugro Airborne Surveys
Date Flown	16th June 2004 to 1st July 2004
Client	Cameco Australia Pty Ltd
EM System	25Hz TEMPEST
Aircraft	Shorts Skyvan (VH-WGT)
Navigation	Real-time differential GPS
Datum	AGD66 (AMG, Zone 53)

Area (Name)	Line Spacing	Line Direction	Terrain Clearance	Line kilometres
Area 1 (Kukulak)	200 metres	090 – 270	120 metres	1785 kilometres
Area 2 (Gunbatgarri)	200 metres	133 – 313	120 metres	947 kilometres
Arnhem Repeat Lines			120 metres	114 kilometres
Total Line Kilometres				**2846 kilometres**

3.2 Flight Plans

The flight plans are given in Appendix I.

3.3 Standby Days

6.5 standby days were accrued during this survey due to strong winds and turbulence.

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 Shorts Skyvan, registration VH-WGT, 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 - 186m^2
- Transmitter turns - 1
- Waveform - Square
- Duty cycle - 50%
- Transmitter pulse width - 10 ms
- Transmitter off-time - 10 ms
- Peak current - 280 A
- Peak moment - 52,080 Am^2
- Average moment - 26,040 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 - 120 m (subject to safety considerations)
- EM sensor - Towed bird with 3 component dB/dt coils
- Tx-Rx horizontal separation - 120 m (nominal)
- Tx-Rx vertical separation - 35 m (nominal)
- Stacked data output interval - 200 ms (~12 m)
- Number of output windows - 15
- Window centre times - 13.3 μs to 16.2 ms
- Magnetometer - Stinger-mounted cesium vapour
- Magnetometer compensation - Fully digital
- Magnetometer output interval - 200 ms (~12 m)
- Magnetometer resolution - 0.001 nT
- Typical noise level - 0.2 nT
- 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.

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 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 GPS Receiver

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

4.3.2 Differential GPS Demodulator

The OMNISTAR 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

Model:	Sperry Stars AA-200 radio altimeter system
Sample interval:	1.0 second
Accuracy:	+/- 1.5 % of indicated altitude.

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

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.

4.6 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 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, there were two GPS base station locations.

For flights 1 to 3, the GPS antenna was located on the roof of room 2 at the Kakadu Lodge.
For flights 4 to 16, the GPS antenna was located on the roof of room 107 at the Aurora Kakadu Resort Hotel.

The GPS base station was positioned by collecting 36 hours of data at the aircraft and this was used to post correct the base GPS position using GrafNav software.

The calculated GPS base position was (in WGS 84):

Flights 1 to 3	Lat: 12° 39′ 52.86″ S Long: 132° 50′ 09.68″ E Height: 109.27 m
Flights 4 to 16	Lat: 12° 40′ 33.58″ S Long: 132° 28′ 47.11″ E Height: 90.42 m

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 600 m (2000 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 manoeuvre 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.

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.

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 Parallax Checks

Due to the relative positions of the EM towed bird 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, 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.

6.8 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 (14th November 2003, over Mandurah, WA) 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.

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:

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

<u>Traverse Lines Separation</u> - actual flight line path deviates more than 125% off course for a distance of 5 km or more, or if a flight line intersects an adjacent flight line. Where flight lines are more than 20 m off course over a continuous distance of 1500 m or more unless the deviation is required by civil aviation requirements.

<u>Altitude</u> - terrain clearance continuously exceeds the nominal terrain clearance by plus or minus 20 m over a distance of 2 km or more unless to do so would, in the sole opinion of the pilot, jeopardise the safety of the aircraft or the crew or the equipment or would be in contravention of the Civil Aviation Safety Authority regulation such as those pertaining to built up areas.

7.1.1.2 Electromagnetic Data

The quality control checks on the electromagnetic data were:

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

<u>Sferics</u> – where sferic activity renders a potential anomaly un-interpretable.

7.1.2 In-Field Data Processing

Following acquisition, multiple copies of the EM data are made onto DVDs. The EM, location 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 7.2.2.

7.2 Final Data Processing

7.2.1 Derived Topography

Aircraft navigation whilst in survey mode is via real time differential GPS, obtained by combining broadcast differential corrections with on-board GPS measurements. Terrain clearance is measured with a 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 laser altimeter, and applying suitable corrections for the separation between the two instruments (see section 7.2.2.2).

Derived surface topography, or digital elevation model (DEM), 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 elevation model derived from this survey can be expected to have an absolute accuracy of +/- several metres in areas of low to moderate topographic relief. Sources of error include uncertainty in the 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.

7.2.2 Electromagnetic Data Processing

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

7.2.2.1 Standard EM Processing

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

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

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

Table of TEMPEST window information for 25Hz base frequency

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

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

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

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

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

7.2.2.2 Factors and Corrections

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

Transmitter-Receiver Geometry
Transmitter to receiver geometry values for each observation are derived from the high altitude reference waveforms and knowledge of the system characteristics. These data are available in the located data (see section 7.2.4.1 for “standardised” values)

GPS Antenna and Transmitter Loop Corrections
The transmitter loop was mounted 0.25m below the GPS antenna on the aircraft. The GPS antenna is 3.3m above the belly of the aircraft. The radar altimeter sensor is mounted in the belly of the aircraft. Therefore a total of 3.05m (-0.25m + 3.3m) was added to the radar altimeter data to determine the transmitter loop height above the ground.

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

7.2.2.3 Primary Sources of EM Noise

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

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

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

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

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

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

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

7.2.2.4 Other Sources of EM Noise

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

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

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

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

7.2.3 Conductivity Depth Images (CDI)

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

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

The “uncorrected” data for each area were input into EMFlow (version 5.10) to calculate Conductivity Depth Images (CDI). Conductivity values were calculated to a depth of 960m below surface at each point, using a depth increment of 5m, then run through *Sigtime* before being made into the CDI products (stacked CDI sections and CDI-multiplots). This processing was completed for both X and Z component data.

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).

7.2.4 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 7.2.2.1).

7.2.4.1 Standard Height and Geometry

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

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

Variable	Standardised value
Transmitter loop roll	0 degrees
Transmitter loop pitch	0 degrees
Transmitter loop terrain clearance	120 metres
Transmitter–receiver geometry: distance behind aircraft distance below aircraft	120 metres 35 metres

7.2.4.2 Parallax

The located data files utilise the following parallax values :-

- radar altimeter = 0.6 fiducials (3 observations from the zero parallax position),
- EM X-component = 0.2 fiducials (1 observation from the zero parallax position),
- EM Z-component = 1.4 fiducials (7 observations from the zero parallax position),

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

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 fiducials (9 observations from the zero parallax position, or 8 observations from the “horizontal” parallax position),
- EM Z-component = 0.6 fiducials (3 observations from the zero parallax position, or -4 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 values. Location information remains in the zero parallax state.)

7.2.5 Other Products

Adaptive time constants
An “adaptive time constant” grid is calculated by fitting an exponential decay to the last few windows above a specified threshold. Thus, the calculation does not involve a fixed window range and ‘adapts’ to the nature of the decay at each observation. It summarises the latest time constants that are seen in the data (using a minimum of 2 windows and a maximum of 3 windows to define the time constant). The calculated time constants do not have any criteria applied to them as to how well the data fits an exponential decay model. This method of time constant calculation produces virtually continuous output, limited only by the requirement for at least 2 windows to be above a specified threshold. In resistive areas, this image highlights the long time constants associated with discrete conductors.

Time constant grids were produced for both X and Z component “final” EM data.

7.2.6 Delivered Products

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

Digital flat ascii located data files and Geosoft databases were produced containing uncorrected and corrected data for both the X- and Z-components. Magnetics were not supplied but digital elevation data were included. The header files can be found in Appendix III.

ER-Mapper grids of DTM and the 15 windows of EM (X and Z component) were supplied.

7.2.7 Comments on Data from this Survey

Too keep the final data consistent with that delivered in the 2003 Arnhem Land survey, the same processing parameters were used for this survey, ie. used the same ‘standard’ transmitter to reciever geometry and same standard flying height, when running the height-pitch-roll-geometry (HPRG) corrections.

As in the 2003 survey it was deemed advantageous to use the “raw” EM data (see section 7.2.2.1 for explanation) rather than the “final” EM data in Emflow, however, because experience has shown that the transmitter height/pitch/roll correction may *overcompensate* at times thereby producing results that correlate too well with topography. Appendix VI displays the contents of the Emflow *descriptor* (.dsc) files. The conductivity range chosen was 0.1mS/m to 100mS/m with a modified tau range of 0.002-10 ms (as in the 2003 CDI data).

The Sigtime parameters (see section 7.2.3) were set differently for the X and Z-component data (due to their differing coupling strengths): the *depth factor* being 1.5 for the X-component EM data and 0.8 for the Z-component EM data.

Based on the daily repeat line which was once again the same as that flown in 2002 and 2003, data quality was comparable between this SKYVAN system and the CASA system used in the 2003 survey. The X-component had slightly more early-time noise but late-time noise levels were vastly better due to less sferics at this time of year. Noise levels in the Z-component were almost identical. The difference in the X-component early-time data could be attributed to slight differences in the bird / coil suspension that was used for this survey. The CDIs of the test-lines showed similar responses over the flat-lying, weakly conductive bodies for both the X and Z components which was very encouraging.

References

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APPENDIX I - Flight Plans

```
JOB_Number  1662                                                                *
CLIENT      Cameco                                                              *
AREA_NAME   Kukulak                                                             *
PLANNED_BY  mjl                                                                 *
|                                                                               *
SPHEROID    22  W.G.S_1984 6378137.0 298.257223563 0.9996                       *
DELTAXYZ    0.0 0.0 0.0 0.0 0.0 0.0 0.0                                         *
HEMISPHERE  SOUTH                                                               *
UTM_ORIGIN  53   135   135                                                      *
BOUNDARY    1   342498  8606508 -12.601404 +133.550004 -123605.1 +1333300.0 12 *
BOUNDARY    2   342429  8599285 -12.666697 +133.549001 -124000.1 +1333256.4 12 *
BOUNDARY    3   328091  8599301 -12.665799 +133.417003 -123956.9 +1332501.2 12 *
BOUNDARY    4   328066  8611405 -12.556384 +133.417445 -123323.0 +1332502.8 12 *
BOUNDARY    5   326060  8613450 -12.537788 +133.399101 -123216.0 +1332356.8 12 *
BOUNDARY    6   328066  8613450 -12.537898 +133.417558 -123216.4 +1332503.2 12 *
BOUNDARY    7   328033  8622100 -12.459704 +133.417730 -122734.9 +1332503.8 12 *
BOUNDARY    8   325357  8622100 -12.459558 +133.393115 -122734.4 +1332335.2 12 *
BOUNDARY    9   325357  8626946 -12.415753 +133.393385 -122456.7 +1332336.2 12 *
BOUNDARY   10   333339  8626946 -12.416178 +133.466796 -122458.2 +1332800.5 12 *
BOUNDARY   11   333339  8621972 -12.461142 +133.466532 -122740.1 +1332759.5 12 *
BOUNDARY   12   336977  8622009 -12.460996 +133.499999 -122739.6 +1332960.0 12 *
BOUNDARY   13   337110  8617739 -12.499603 +133.501001 -122958.6 +1333003.6 12 *
BOUNDARY   14   345805  8617754 -12.499901 +133.581000 -122959.6 +1333451.6 12 *
BOUNDARY   15   345719  8613600 -12.537450 +133.580003 -123214.8 +1333448.0 12 *
BOUNDARY   16   333800  8613582 -12.537010 +133.470326 -123213.2 +1332813.2 12 *
BOUNDARY   17   336108  8611405 -12.556810 +133.491449 -123324.5 +1332929.2 12 *
BOUNDARY   18   342706  8608147 -12.586597 +133.552002 -123511.8 +1333307.2 12 *
SQUARE_KMS  332.635                                                             *
|                                                                               *
NAVTYPE     NOVATEL                                                             *
NAVMODE     U.T.M                                                               *
PLAN_TYPE   Normal                                                              *
LINE_TYPE   S.LINE    X.LINE    0         0                                     *
HEADING     90        180                                                       *
SPACING     200       2000      200       200                                   *
OVER_LINE   1         1                                                         *
OVERFLY     0         0                                                         *
MIN_LENGTH  8         8                                                         *
FIRST_LINE  10        10                                                        *
INCREMENT   10        10                                                        *
X_TRACK     100       100                                                       *
MASTER_PT   1   342498  8606508 -12.601404 +133.550004                          *
MASTER_NEW  0  Not implemented.                                                 *
KM_IN_AREA  1667      206                                                       *
KM+OVERFLY  1667      206                                                       *
```

```
JOB_Number  1662                                                                *
CLIENT      Cameco                                                              *
AREA_NAME   Gunbatgarri                                                         *
PLANNED_BY  mjl                                                                 *
|                                                                               *
SPHEROID    22  W.G.S_1984 6378137.0 298.257223563 0.9996                       *
DELTAXYZ    0.0 0.0 0.0 0.0 0.0 0.0 0.0                                         *
HEMISPHERE  SOUTH                                                               *
UTM_ORIGIN  53   135   135                                                      *
BOUNDARY    1   391367  8622082 -12.462651 +134.000386 -122745.5 +1340001.4 12 *
BOUNDARY    2   411680  8603402 -12.632184 +134.186756 -123755.9 +1341112.3 12 *
BOUNDARY    3   396500  8603300 -12.632644 +134.046989 -123757.5 +1340249.2 12 *
BOUNDARY    4   391367  8607933 -12.590581 +133.999893 -123526.1 +1335959.6 12 *
SQUARE_KMS  179.131                                                             *
|                                                                               *
NAVTYPE     NOVATEL                                                             *
NAVMODE     U.T.M                                                               *
PLAN_TYPE   Normal                                                              *
LINE_TYPE   S.LINE    X.LINE    0         0                                     *
HEADING     133       223                                                       *
SPACING     200       4000      200       200                                   *
OVER_LINE   1         1                                                         *
OVERFLY     0         0                                                         *
```

```
MIN_LENGTH  6        6                                                          *
FIRST_LINE  10       10                                                         *
INCREMENT   10       10                                                         *
X_TRACK     100      100                                                        *
MASTER_PT   1   391367  8622082 -12.462651 +134.000386                          *
MASTER_NEW  0  Not implemented.                                                 *
KM_IN_AREA  896      30                                                         *
KM+OVERFLY  896      30                                                         *
```

APPENDIX II – Weekly Operations Reports

Week Commencing:	**Monday 14-Jun-04**	Aircraft:	VH-WGT	Operators:	Stewart	Pilots:	Harradence\Hamilton
Job Number:	1662	Base:	Jabiru, NT	Data Proc:	Lawrence\Cowey	Techs:	Stewart\Gallin
Total km:	4139.0	Country:	Australia	Crew Leader:	Lawrence\Cowey	Client:	Cameco (Geoff Beckitt)
		Area Name:	Arhnem & Rudall	Accom:	Kakadu Resort	Contact #:	08 8979 0166 (Rm 107)

Date		Flight	Crew		Time		M/R	Oil		Fuel	This Flight		To Date		Standby	Comments
		Number	Plt(s)	Op	T/O	Land	Hrs	L	R	Added	Prod	Refly	Prod	Refly	(0, 0.5, 1)	
Monday	14-Jun-04															Weather:
																Remarks: Stewart and Lawrence arrived Darwin then drove to Jabiru
Julian	531															
Day	1				Hours Today		0.0				0.0	0.0	0.0	0.0		Safety Meeting:
Tuesday	15-Jun-04		MH				1.2									Weather: Fine, very windy from 9:30am onwards
																Remarks: Aircraft ferry Darwin-Jabiru. Base equipment setup.
Julian	532															
Day	2				Hours Today		1.2				0.0	0.0	0.0	0.0		Safety Meeting: Pre job safety / JSP meeting held
Wednesday	16-Jun-04	1	MH	JS			2.2				0.0				1.0	Weather: Strong easterly winds
																Remarks: Flight abandoned after the low level test-line due to strong turbulence
Julian	533															and coil knocks. Comp box flown.
Day	3				Hours Today		2.2				0.0	0.0	0.0	0.0		Safety Meeting:
Thursday	17-Jun-04	2	MH	JS			1.6				32.0				1.0	Weather: Easterly winds increasing early in morning.
																Remarks: Flight abandoned early due to strong turbulence and coil knocks in data
Julian	534															
Day	4				Hours Today		1.6				32.0	0.0	32.0	0.0		Safety Meeting:
Friday	18-Jun-04	3	MH	JS			2.3				161.0				0.5	Weather: Fine, easterly winds increasing throughout flight
																Remarks: Flight abandoned after 6 lines due to turbulence and coil knocks
Julian	535															
Day	5				Hours Today		2.3				161.0	0.0	193.0	0.0		Safety Meeting:
Saturday	19-Jun-04	4	MH	JS			2.9				251.0	25.0				Weather: Fine, light winds
																Remarks: Fulll production flight
Julian	536															
Day	6				Hours Today		2.9				251.0	25.0	444.0	25.0		Safety Meeting:
Sunday	20-Jun-04	5	MH	JS			3.1				234.0	15.0				Weather: Winds increasing throughout flt
																Remarks: Full production flt though last line scrubbed due to coil knocks
Julian	537															
Day	7				Hours Today		3.1				234.0	15.0	678.0	40.0		Safety Meeting:
Total Job Hours		13.3			Weekly Totals		13.3	0	0	0	678.0	40.0			2.5	
					Total Aircraft Hours		71668	Ltrs/Hr		0			Total Standby		2.5	
					Hours to Next Periodic		53.4	Running Avg			96.9	km/day	% Complete		16.4	%
					Anticipated Hours Next week						51.0	km/hr	km Remaining		3461.0	km

Week Commencing: **Monday 21-Jun-04**	Aircraft: VH-WGT	Operators: Stewart	Pilots: Harradence\Hamilton
Job Number: 1662	Base: Jabiru, NT	Data Proc: Lawrence\Cowey	Techs: Stewart\Gallin
Total km: 4139	Country: Australia	Crew Leader: Lawrence\Cowey	Client: Cameco (Geoff Beckitt)
	Area Name: Arhnem & Rudall	Accom: Kakadu Resort	Contact #: 08 8979 0166 (Rm 107)

Date		Flight	Crew		Time		M/R	Oil		Fuel	This Flight		To Date		Standby	Comments
		Number	Plt(s)	Op	T/O	Land	Hrs	L	R	Added	Prod	Refly	Prod	Refly	(0, 0.5, 1)	
Monday	21-Jun-04															Weather:
																Remarks: Pilot's 7th day off
Julian	538															
Day	8				Hours Today		0.0				0.0	0.0	678.0	40.0		Safety Meeting:
Tuesday	22-Jun-04	6	MH	JS			2.0				45.0	14.0			1.0	Weather: Fine, winds increasing throughout flight
																Remarks: Flight abandoned early due to turbulence and coil knocks.
Julian	539															Denis Cowey arrived in pm
Day	9				Hours Today		2.0				45.0	14.0	723.0	54.0		Safety Meeting:
Wednesday	23-Jun-04	7	MH	JS			1.8				43.0	27.0			1.0	Weather: Fine, winds increasing throughout flight
																Remarks: Flight abandoned early due to turbulence and coil knocks.
Julian	540															
Day	10				Hours Today		1.8				43.0	27.0	766.0	81.0		Safety Meeting:
Thursday	24-Jun-04	8	MH	JS			3.2				27.1	180.4				Weather:Fine, winds increasing throughout day
																Remarks: Majority of flight scrubbed due to bird noise
Julian	541															MattL leaves, GrantH, LukeG arrive.
Day	11				Hours Today		3.2				27.1	180.4	793.1	261.4		Safety Meeting:
Friday	25-Jun-04	9	MH	JS			2.6				113.3	18.2			0.5	Weather:Fine, winds increasing throughout day
			GH													Remarks: Flight abandoned after block2 lines completed so that response
Julian	542															of new bird GINA could be compared with old before flying any of block1.
Day	12				Hours Today		2.6				113.3	18.2	906.4	279.6		MarkH leaves.
Saturday	26-Jun-04	10	GH	JS			2.2				102.6	0.0			0.5	Weather:Fine, winds increasing throughout day
																Remarks: Flight abandoned early due to turbulence and coil knocks.
Julian	543															Finished Gunbatggi area, flew ties Kukulak
Day	13				Hours Today		2.2				102.6	0.0	1009.0	279.6		Safety Meeting:
Sunday	27-Jun-04	11	GH	JS			1.4				65.0	9.0			1.0	Weather:Fine, winds increasing throughout day
																Remarks: Flight abandoned early due to turbulence and coil knocks.
Julian	544															
Day	14				Hours Today		1.4				65.0	9.0	1074.0	288.6		Safety Meeting:
Total Job Hours		26.5	Weekly Totals				13.2	0	0	0	396.0	248.6			4.0	
			Total Aircraft Hours					Ltrs/Hr		0			Total Standby		6.5	
			Hours to Next Periodic					Running Avg			56.6 km/day		% Complete		25.9 %	
			Anticipated Hours Next week								30.0 km/hr		km Remaining		3065.0 km	

Week Commencing:	**Monday 28-Jun-04**	Aircraft:	VH-WGT	Operators:	Stewart	Pilots:	Harradence\Hamilton
Job Number:	1662	Base:	Jabiru, NT	Data Proc:	Lawrence\Cowey	Techs:	Stewart\Gallin
Total km:	4139	Country:	Australia	Crew Leader:	Lawrence\Cowey	Client:	Cameco (Geoff Beckitt)
		Area Name:	Arhnem & Rudall	Accom:	Kakadu Resort	Contact #:	08 8979 0166 (Rm 107)

Date		Flight	Crew		Time		M/R	Oil		Fuel	This Flight		To Date		Standby	Comments
		Number	Plt(s)	Op	T/O	Land	Hrs	L	R	Added	Prod	Refly	Prod	Refly	(0, 0.5, 1)	
Monday	28-Jun-04	12	GH	JS			3.1				375.6	17.7				Weather:Fine, winds increasing late morning
																Remarks:Full flight
Julian	545															
Day	15				Hours Today		3.1				375.6	17.7	1449.6	306.3		Safety Meeting:
Tuesday	29-Jun-04	13	GH	JS			3.2				321.3	16.9				Weather:Fine, winds increasing late morning
																Remarks:Full flight
Julian	546															
Day	16				Hours Today		3.2				321.3	16.9	1770.9	323.2		Safety Meeting:
Wednesday	30-Jun-04	14	GH	JS			3.5				385.5	0.0				Weather:Good
		15	GH	JS			2.0				190.2	14.5				Remarks:Flew 2 flights due to good weather.
Julian	547															
Day	17				Hours Today		5.5				575.7	14.5	2346.6	337.7		Safety Meeting:
Thursday	1-Jul-04	16	GH	JS			3.0				348.1	0.0				Weather: Fine, spherical activity increasing throughout day
																Remarks:Jabiru areas completed
Julian	548															Scott Miller arrives.
Day	18				Hours Today		3.0				348.1	0.0	2694.7	337.7		Safety Meeting:
Friday	2-Jul-04															Weather:
																Remarks:
Julian	549															
Day	19				Hours Today		0.0				0.0	0.0	2694.7	337.7		Safety Meeting:
Saturday	3-Jul-04															Weather:
																Remarks:
Julian	550															
Day	20				Hours Today		0.0				0.0	0.0	2694.7	337.7		Safety Meeting:
Sunday	4-Jul-04															Weather:
																Remarks:
Julian	551															
Day	21				Hours Today		0.0				0.0	0.0	2694.7	337.7		Safety Meeting:
Total Job Hours		41.3	Weekly Totals				14.8	0	0	0	1620.7	49.1			0.0	
			Total Aircraft Hours					Ltrs/Hr		0			Total Standby		6.5	
			Hours to Next Periodic					Running Avg			231.5 km/day		% Complete		65.1 %	
			Anticipated Hours Next week								109.5 km/hr		km Remaining		1444.3 km	

APPENDIX III – Data Formats (Post Processed Files)

Sample Headers for final data files

Kukulak_Tempest_final.hdr

```
COMM JOB NUMBER:                                                 1662
COMM AREA NUMBER:                                                   1
COMM SURVEY COMPMANY:                             Fugro Airborne Surveys
COMM CLIENT:                                    Cameco Australia Pty Ltd
COMM SURVEY TYPE:                                         25Hz TEMPEST
COMM AREA NAME:                                                Kukulak
COMM STATE:                                                         NT
COMM SURVEY FLOWN:                                           June 2004
COMM LOCATED DATA CREATED:                                   Sept 2004
COMM
COMM DATUM:                                                      AGD66
COMM PROJECTION:                                                   AMG
COMM ZONE:                                                          53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                      200 m
COMM TRAVERSE LINE DIRECTION:                              090-270 deg
COMM TIE      LINE SPACING:                                     2000 m
COMM TIE      LINE DIRECTION:                              000-180 deg
COMM NOMINAL TERRAIN CLEARANCE:                                  120 m
COMM FINAL LINE KILOMETRES:                                    1785 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                              10010 - 11380
COMM TIE      LINE NUMBERS:                       17020, 17050, 17080
COMM
COMM AREA BOUNDARY
COMM
COMM   342498  8606508
COMM   342429  8599285
COMM   328091  8599301
COMM   328066  8611405
COMM   326060  8613450
COMM   328066  8613450
COMM   328033  8622100
COMM   325357  8622100
COMM   325357  8626946
COMM   333339  8626946
COMM   333339  8621972
COMM   336977  8622009
COMM   337110  8617739
COMM   345805  8617754
COMM   345719  8613600
COMM   333800  8613582
COMM   336108  8611405
COMM   342706  8608147
COMM
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                    Shorts Skyvan, VH-WGT
COMM
COMM MAGNETOMETER:                         Cesium Vapour optical absorption
COMM INSTALLATION:                                             stinger
COMM RESOLUTION:                                               0.01 nT
COMM RECORDING INTERVAL:                                         0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                              25Hz TEMPEST
COMM INSTALLATION:                 Transmitter loop mounted on the aircraft
COMM                                         Receiver coils in a towed bird
COMM COIL ORIENTATION:                                         X and Z
COMM RECORDING INTERVAL:                                         0.2 s
COMM SYSTEM GEOMETRY:
COMM RECEIVER DISTANCE BEHIND THE TRANSMITTER:                   120 m
COMM RECEIVER DISTANCE BELOW THE TRANSMITTER:                     35 m
COMM
COMM RADAR ALTIMETER:                                 Sperry Stars AA200
COMM RECORDING INTERVAL:                                         0.2 s
COMM
```

```
COMM NAVIGATION:                                 Real-time differential GPS
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM ACQUISITION SYSTEM:                                          Fugro DAS
COMM
COMM DATA PROCESSING
COMM
COMM MAGNETIC DATA HAVE NOT BEEN SUPPLIED FOR THIS SURVEY
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS
COMM X-COMPONENT EM DATA                                              0.2 s
COMM Z-COMPONENT EM DATA                                              1.4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED (both components) EMFlow V5.1
COMM
COMM DIGITAL TERRAIN DATA
COMM PARALLAX CORRECTION APPLIED TO RADAR ALIMETER DATA               0.6 s
COMM PARALLAX CORRECTION APPLIED TO GPS ALIMETER DATA                 0.0 s
COMM DTM CALCULATED [DTM = GPS ALTITUDE - RADAR ALTITUDE]
COMM DATA HAVE BEEN MICROLEVELLED
COMM ----------------------------------------------------------------------
COMM The accuracy of the elevation calculation is directly dependent on
COMM the accuracy of the two input parameters, radar altitude and GPS
COMM altitude.  The radar altitude value may be erroneous in areas of heavy
COMM tree cover, where the altimeter reflects the distance to the tree
COMM canopy rather than the ground.  The GPS altitude value is primarily
COMM dependent on the number of available satellites. Although
COMM post-processing of GPS data will yield X and Y accuracies in the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the +/-5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM ----------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START       END      CENTRE
COMM    1        0.007      0.020      0.013
COMM    2        0.033      0.047      0.040
COMM    3        0.060      0.073      0.067
COMM    4        0.087      0.127      0.107
COMM    5        0.140      0.207      0.173
COMM    6        0.220      0.340      0.280
COMM    7        0.353      0.553      0.453
COMM    8        0.567      0.873      0.720
COMM    9        0.887      1.353      1.120
COMM   10        1.367      2.100      1.733
COMM   11        2.113      3.273      2.693
COMM   12        3.287      5.113      4.200
COMM   13        5.127      7.993      6.560
COMM   14        8.007     12.393     10.200
COMM   15       12.407     19.993     16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
```

```
Output field format : DOS  - Flat ascii
Number of fields    :  60

Field     Columns  Type Format  Channel                Description

    1     1 -   6  int  (i 6)   LINE                  [Line                                   ]
    2     7 -  10  int  (i 4)   FLIGHT                [Flight                                 ]
```

```
  3    11 -  18  real (f 8.1) FID                  [Fiducial                          (s)  ]
  4    19 -  27  int  (i 9)   EASTING              [Easting   AMG53                   (m)  ]
  5    28 -  37  int  (i10)   NORTHING             [Northing  AMG53                   (m)  ]
  6    38 -  50  real (f13.6) LATITUDE             [Latitude  AGD66                 (deg)  ]
  7    51 -  63  real (f13.6) LONGITUDE            [Longitude AGD66                 (deg)  ]
  8    64 -  71  real (f 8.2) TxHeight             [Final Tx Altitude                 (m)  ]
  9    72 -  79  real (f 8.2) TxRalt_final         [Final Tx Terrain Clearance        (m)  ]
 10    80 -  87  real (f 8.2) DTM                  [DTM                               (m)  ]
 11    88 -  97  real (f10.5) Pitch_Final          [Final Tx pitch                  (deg)  ]
 12    98 - 107  real (f10.5) Roll_Final           [Final Tx roll                   (deg)  ]
 13   108 - 115  real (f 8.2) HSep_Final           [Final Tx-Rx horizontal separation (m)  ]
 14   116 - 123  real (f 8.2) VSep_Final           [Final Tx-Rx vertical separation   (m)  ]
 15   124 - 135  real (f12.6) EMX_Final[1]         [Window X01 Final                 (fT)  ]
 16   136 - 147  real (f12.6) EMX_Final[2]         [Window X02 Final                 (fT)  ]
 17   148 - 159  real (f12.6) EMX_Final[3]         [Window X03 Final                 (fT)  ]
 18   160 - 171  real (f12.6) EMX_Final[4]         [Window X04 Final                 (fT)  ]
 19   172 - 183  real (f12.6) EMX_Final[5]         [Window X05 Final                 (fT)  ]
 20   184 - 195  real (f12.6) EMX_Final[6]         [Window X06 Final                 (fT)  ]
 21   196 - 207  real (f12.6) EMX_Final[7]         [Window X07 Final                 (fT)  ]
 22   208 - 219  real (f12.6) EMX_Final[8]         [Window X08 Final                 (fT)  ]
 23   220 - 231  real (f12.6) EMX_Final[9]         [Window X09 Final                 (fT)  ]
 24   232 - 243  real (f12.6) EMX_Final[10]        [Window X10 Final                 (fT)  ]
 25   244 - 255  real (f12.6) EMX_Final[11]        [Window X11 Final                 (fT)  ]
 26   256 - 267  real (f12.6) EMX_Final[12]        [Window X12 Final                 (fT)  ]
 27   268 - 279  real (f12.6) EMX_Final[13]        [Window X13 Final                 (fT)  ]
 28   280 - 291  real (f12.6) EMX_Final[14]        [Window X14 Final                 (fT)  ]
 29   292 - 303  real (f12.6) EMX_Final[15]        [Window X15 Final                 (fT)  ]
 30   304 - 313  real (f10.1) X_Sferics            [X_Sferics                              ]
 31   314 - 323  real (f10.3) X_Lowfreq            [X_Lowfreq                              ]
 32   324 - 333  real (f10.3) X_Powerline          [X_Powerline                            ]
 33   334 - 343  real (f10.3) X_kHz_182            [X_kHz_18.2                             ]
 34   344 - 353  real (f10.3) X_kHz_198            [X_kHz_19.8                             ]
 35   354 - 363  real (f10.3) X_kHz_214            [X_kHz_21.4                             ]
 36   364 - 373  real (f10.3) X_kHz_222            [X_kHz_22.2                             ]
 37   374 - 383  int  (i10)   X_Geofact            [X_Geometric factor                     ]
 38   384 - 395  real (f12.6) EMZ_Final[1]         [Window Z01 Final                 (fT)  ]
 39   396 - 407  real (f12.6) EMZ_Final[2]         [Window Z02 Final                 (fT)  ]
 40   408 - 419  real (f12.6) EMZ_Final[3]         [Window Z03 Final                 (fT)  ]
 41   420 - 431  real (f12.6) EMZ_Final[4]         [Window Z04 Final                 (fT)  ]
 42   432 - 443  real (f12.6) EMZ_Final[5]         [Window Z05 Final                 (fT)  ]
 43   444 - 455  real (f12.6) EMZ_Final[6]         [Window Z06 Final                 (fT)  ]
 44   456 - 467  real (f12.6) EMZ_Final[7]         [Window Z07 Final                 (fT)  ]
 45   468 - 479  real (f12.6) EMZ_Final[8]         [Window Z08 Final                 (fT)  ]
 46   480 - 491  real (f12.6) EMZ_Final[9]         [Window Z09 Final                 (fT)  ]
 47   492 - 503  real (f12.6) EMZ_Final[10]        [Window Z10 Final                 (fT)  ]
 48   504 - 515  real (f12.6) EMZ_Final[11]        [Window Z11 Final                 (fT)  ]
 49   516 - 527  real (f12.6) EMZ_Final[12]        [Window Z12 Final                 (fT)  ]
 50   528 - 539  real (f12.6) EMZ_Final[13]        [Window Z13 Final                 (fT)  ]
 51   540 - 551  real (f12.6) EMZ_Final[14]        [Window Z14 Final                 (fT)  ]
 52   552 - 563  real (f12.6) EMZ_Final[15]        [Window Z15 Final                 (fT)  ]
 53   564 - 573  real (f10.1) Z_Sferics            [Z_Sferics                              ]
 54   574 - 583  real (f10.3) Z_Lowfreq            [Z_Lowfreq                              ]
 55   584 - 593  real (f10.3) Z_Powerline          [Z_Powerline                            ]
 56   594 - 603  real (f10.3) Z_kHz_182            [Z_kHz_18.2                             ]
 57   604 - 613  real (f10.3) Z_kHz_198            [Z_kHz_19.8                             ]
 58   614 - 623  real (f10.3) Z_kHz_214            [Z_kHz_21.4                             ]
 59   624 - 633  real (f10.3) Z_kHz_222            [Z_kHz_22.2                             ]
 60   634 - 643  int  (i10)   Z_Geofact            [Z_Geometric factor                     ]
      644 - 645 <newline>
```

Total number of lines : 141

Flt	Line	Start X	Start Y	End X	End Y	Kms
10	17021	328267	8626934	328263	8599013	27.92
10	17050	334288	8599124	334269	8621934	22.81
10	17080	340269	8617933	340262	8598977	18.96
11	10370	327736	8619441	337020	8619444	9.28
11	10380	337126	8619243	327751	8619238	9.38
11	10390	327734	8619039	337090	8619035	9.36
11	10400	337126	8618844	327764	8618842	9.36
11	10410	327763	8618634	337102	8618641	9.34
11	10420	337108	8618445	327751	8618430	9.36
12	10430	327727	8618224	337054	8618240	9.33
12	10440	337172	8618042	327769	8618042	9.40
12	10450	327778	8617844	337071	8617842	9.29
12	10460	337539	8617638	327818	8617644	9.72
12	10470	327768	8617437	345804	8617441	18.04
12	10480	345836	8617250	327783	8617243	18.05
12	10490	327783	8617040	345799	8617037	18.02
12	10500	345859	8616845	327790	8616848	18.07
12	10510	327745	8616640	345809	8616646	18.06
12	10520	345805	8616441	327760	8616446	18.05
12	10530	327761	8616243	345806	8616242	18.05

12	10540	345801	8616063	327773	8616051	18.03
12	10550	327771	8615841	345793	8615845	18.02
12	10560	345824	8615639	327830	8615644	17.99
12	10570	327733	8615447	345778	8615439	18.05
12	10580	345819	8615242	327826	8615247	17.99
12	10590	327752	8615041	345775	8615041	18.02
12	10600	345782	8614843	327830	8614842	17.95
12	10610	327776	8614642	345758	8614641	17.98
12	10620	345747	8614450	327775	8614440	17.97
12	10630	327757	8614244	345764	8614239	18.01
12	10640	345750	8614050	327819	8614041	17.93
12	10650	327773	8613845	345723	8613837	17.95
13	10011	325086	8626635	333359	8626641	8.27
13	10020	333386	8626454	325094	8626443	8.29
13	10030	325073	8626179	333315	8626245	8.24
13	10040	333347	8626050	325115	8626047	8.23
13	10050	325059	8625839	333322	8625841	8.26
13	10060	333295	8625638	325080	8625642	8.22
13	10070	325069	8625443	333336	8625443	8.27
13	10080	333406	8625259	325101	8625239	8.31
13	10090	325063	8625047	333332	8625039	8.27
13	10100	333370	8624853	325125	8624843	8.25
13	10110	325068	8624642	333357	8624641	8.29
13	10120	333368	8624445	325114	8624445	8.25
13	10130	325063	8624236	333337	8624242	8.27
13	10140	333360	8624045	325096	8624048	8.26
13	10150	325063	8623841	333339	8623842	8.28
13	10160	333415	8623659	325113	8623643	8.30
13	10170	325090	8623436	333352	8623443	8.26
13	10180	333378	8623246	325102	8623243	8.28
13	10190	325088	8623036	333336	8623042	8.25
13	10200	333421	8622853	325063	8622841	8.36
13	10210	325030	8622646	333340	8622644	8.31
13	10220	333371	8622477	325111	8622437	8.26
13	10230	325064	8622243	333324	8622243	8.26
13	10240	333383	8622057	325086	8622042	8.30
13	10250	325785	8621836	336945	8621840	11.16
13	10270	327750	8621450	336964	8621445	9.21
13	10280	337027	8621253	327809	8621249	9.22
13	10290	327757	8621042	337012	8621042	9.26
13	10300	337048	8620853	327808	8620839	9.24
13	10310	327752	8620640	337029	8620644	9.28
13	10320	337048	8620444	327813	8620443	9.23
13	10330	327749	8620245	337011	8620243	9.26
13	10340	337063	8620049	327756	8620043	9.31
13	10350	327744	8619841	337040	8619840	9.30
13	10361	337104	8619651	327773	8619644	9.33
13	10670	327543	8613437	345711	8613442	18.17
13	10661	345769	8613642	327786	8613640	17.98
14	10261	336938	8621643	327796	8621643	9.14
14	10930	327781	8608241	342353	8608240	14.57
14	10920	341950	8608471	327807	8608445	14.14
14	10910	327755	8608638	341586	8608642	13.83
14	10900	341175	8608823	327779	8608842	13.40
14	10890	327759	8609036	340728	8609041	12.97
14	10880	340591	8609152	327837	8609243	12.75
14	10870	327764	8609432	339963	8609442	12.20
14	10860	339580	8609629	327819	8609641	11.76
14	10850	327757	8609839	339141	8609839	11.38
14	10840	338773	8610030	327836	8610040	10.94
14	10830	327765	8610227	338337	8610238	10.57
14	10820	338102	8610374	327805	8610443	10.30
14	10810	327783	8610636	337516	8610639	9.73
14	10800	337167	8610839	327838	8610858	9.33
14	10790	327739	8611038	336685	8611039	8.95
14	10780	336373	8611239	327715	8611241	8.66
14	10770	327516	8611438	335955	8611443	8.44
14	10760	335751	8611635	327327	8611641	8.42
14	10750	327102	8611836	335530	8611842	8.43
14	10740	335400	8612038	326959	8612041	8.44
14	10730	326703	8612240	335092	8612245	8.39
14	10720	334978	8612443	326548	8612442	8.43
14	10710	326316	8612643	334718	8612636	8.40
14	10700	334491	8612842	326160	8612842	8.33
14	10690	325972	8613036	334286	8613046	8.31
14	10680	334102	8613245	325770	8613251	8.33
14	10950	327763	8607844	342709	8607842	14.95
14	10940	342737	8608036	327791	8608042	14.95
14	10970	327790	8607436	342660	8607445	14.87
14	10960	342713	8607619	327789	8607642	14.92
14	10990	327771	8607043	342608	8607040	14.84
14	10980	342621	8607244	327786	8607243	14.84
14	11010	327804	8606639	342526	8606638	14.72
14	11000	342581	8606819	327814	8606845	14.77
15	11020	342563	8606443	327795	8606459	14.77

15	11040	342527	8606044	327836	8606043	14.69
15	11050	327774	8605839	342518	8605842	14.74
15	11060	342558	8605648	327785	8605641	14.77
15	11070	327788	8605437	342459	8605439	14.67
15	11080	342531	8605248	327795	8605240	14.74
15	11090	327768	8605027	342466	8605040	14.70
15	11100	342519	8604852	327795	8604841	14.72
15	11110	327753	8604643	342452	8604639	14.70
15	11120	342527	8604456	327845	8604440	14.68
15	11130	327780	8604243	342479	8604244	14.70
15	11140	342491	8604044	327790	8604041	14.70
15	11150	327804	8603841	342460	8603844	14.66
16	11030	327788	8606243	342526	8606238	14.74
16	11160	342531	8603648	327847	8603646	14.68
16	11170	327799	8603444	342483	8603440	14.68
16	11180	342476	8603242	327793	8603245	14.68
16	11190	327778	8603043	342497	8603044	14.72
16	11200	342475	8602845	327844	8602843	14.63
16	11210	327814	8602647	342450	8602644	14.64
16	11220	342466	8602481	327798	8602441	14.67
16	11230	327808	8602243	342454	8602243	14.65
16	11240	342498	8602056	327822	8602039	14.68
16	11250	327780	8601841	342483	8601842	14.70
16	11260	342489	8601674	327856	8601639	14.63
16	11270	327787	8601440	342481	8601441	14.69
16	11280	342463	8601229	327835	8601242	14.63
16	11290	327779	8601041	342458	8601043	14.68
16	11300	342472	8600831	327862	8600850	14.61
16	11310	327806	8600643	342417	8600641	14.61
16	11320	342490	8600438	327822	8600423	14.67
16	11330	327764	8600237	342467	8600240	14.70
16	11340	342483	8600039	327842	8600038	14.64
16	11350	327813	8599843	342462	8599840	14.65
16	11360	342505	8599644	327867	8599647	14.64
16	11370	327820	8599445	342422	8599438	14.60
16	11380	342495	8599244	327833	8599240	14.66

Total Kilometres : 1784.74

Kukulak_Tempest_uncor.hdr

```
COMM JOB NUMBER:                                                     1662
COMM AREA NUMBER:                                                       1
COMM SURVEY COMPMANY:                                 Fugro Airborne Surveys
COMM CLIENT:                                        Cameco Australia Pty Ltd
COMM SURVEY TYPE:                                             25Hz TEMPEST
COMM AREA NAME:                                                    Kukulak
COMM STATE:                                                             NT
COMM SURVEY FLOWN:                                               June 2004
COMM LOCATED DATA CREATED:                                       Sept 2004
COMM
COMM DATUM:                                                          AGD66
COMM PROJECTION:                                                       AMG
COMM ZONE:                                                              53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                          200 m
COMM TRAVERSE LINE DIRECTION:                                  090-270 deg
COMM TIE      LINE SPACING:                                         2000 m
COMM TIE      LINE DIRECTION:                                  000-180 deg
COMM NOMINAL TERRAIN CLEARANCE:                                      120 m
COMM FINAL LINE KILOMETRES:                                        1785 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                                  10010 - 11380
COMM TIE      LINE NUMBERS:                            17020, 17050, 17080
COMM
COMM AREA BOUNDARY
COMM
COMM   342498  8606508
COMM   342429  8599285
COMM   328091  8599301
COMM   328066  8611405
COMM   326060  8613450
COMM   328066  8613450
COMM   328033  8622100
COMM   325357  8622100
COMM   325357  8626946
COMM   333339  8626946
COMM   333339  8621972
COMM   336977  8622009
COMM   337110  8617739
COMM   345805  8617754
COMM   345719  8613600
COMM   333800  8613582
COMM   336108  8611405
COMM   342706  8608147
COMM
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                       Shorts Skyvan, VH-WGT
COMM
COMM MAGNETOMETER:                           Cesium Vapour optical absorption
COMM INSTALLATION:                                                  stinger
COMM RESOLUTION:                                                    0.01 nT
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                   25Hz TEMPEST
COMM INSTALLATION:                   Transmitter loop mounted on the aircraft
COMM                                          Receiver coils in a towed bird
COMM COIL ORIENTATION:                                              X and Z
COMM RECORDING INTERVAL:                                              0.2 s
COMM SYSTEM GEOMETRY:
COMM RECEIVER DISTANCE BEHIND THE TRANSMITTER:                        120 m
COMM RECEIVER DISTANCE BELOW THE TRANSMITTER:                          35 m
COMM
COMM RADAR ALTIMETER:                                    Sperry Stars AA200
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM NAVIGATION:                                Real-time differential GPS
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM ACQUISITION SYSTEM:                                         Fugro DAS
COMM
COMM DATA PROCESSING
COMM
COMM MAGNETIC DATA HAVE NOT BEEN SUPPLIED FOR THIS SURVEY
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS
```

```
COMM X-COMPONENT EM DATA                                             0.2 s
COMM Z-COMPONENT EM DATA                                             1.4 s
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED (both components) EMFlow V5.1
COMM
COMM DIGITAL TERRAIN DATA
COMM PARALLAX CORRECTION APPLIED TO RADAR ALIMETER DATA              0.6 s
COMM PARALLAX CORRECTION APPLIED TO GPS ALIMETER DATA                0.0 s
COMM DTM CALCULATED [DTM = GPS ALTITUDE - RADAR ALTITUDE]
COMM DATA HAVE BEEN MICROLEVELLED
COMM ----------------------------------------------------------------------
COMM The accuracy of the elevation calculation is directly dependent on
COMM the accuracy of the two input parameters, radar altitude and GPS
COMM altitude.  The radar altitude value may be erroneous in areas of heavy
COMM tree cover, where the altimeter reflects the distance to the tree
COMM canopy rather than the ground.  The GPS altitude value is primarily
COMM dependent on the number of available satellites. Although
COMM post-processing of GPS data will yield X and Y accuracies in the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the +/-5 metre range.  Further inaccuracies
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COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
```

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Output field format : DOS  - Flat ascii
Number of fields    : 252

Field     Columns  Type Format  Channel                Description

    1      1 -   6  int  (i 6)   LINE                  [Line                                  ]
    2      7 -  10  int  (i 4)   FLIGHT                [Flight                                ]
    3     11 -  18  real (f 8.1) FID                   [Fiducial                         (s)  ]
    4     19 -  27  int  (i 9)   EASTING               [Easting   AMG53                  (m)  ]
    5     28 -  37  int  (i10)   NORTHING              [Northing  AMG53                  (m)  ]
    6     38 -  50  real (f13.6) LATITUDE              [Latitude  AGD66                (deg)  ]
    7     51 -  63  real (f13.6) LONGITUDE             [Longitude AGD66                (deg)  ]
    8     64 -  71  real (f 8.2) TxHeight_Raw          [Raw Tx Altitude  (AHD)           (m)  ]
    9     72 -  79  real (f 8.2) TxRalt_Raw            [Raw Tx Terrain Clearance         (m)  ]
   10     80 -  87  real (f 8.2) DTM                   [DTM                              (m)  ]
   11     88 -  97  real (f10.5) Pitch_Raw             [Raw Tx pitch                   (deg)  ]
   12     98 - 107  real (f10.5) Roll_Raw              [Raw Tx roll                    (deg)  ]
   13    108 - 115  real (f 8.2) HSep_Raw              [Raw Tx-Rx horizontal separation  (m)  ]
   14    116 - 123  real (f 8.2) VSep_Raw              [Raw Tx-Rx vertical separation    (m)  ]
   15    124 - 135  real (f12.6) EMX_Raw[1]            [Window X01 Raw                  (fT)  ]
   16    136 - 147  real (f12.6) EMX_Raw[2]            [Window X02 Raw                  (fT)  ]
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 17   148 - 159  real (f12.6) EMX_Raw[3]        [Window X03 Raw                     (fT)  ]
 18   160 - 171  real (f12.6) EMX_Raw[4]        [Window X04 Raw                     (fT)  ]
 19   172 - 183  real (f12.6) EMX_Raw[5]        [Window X05 Raw                     (fT)  ]
 20   184 - 195  real (f12.6) EMX_Raw[6]        [Window X06 Raw                     (fT)  ]
 21   196 - 207  real (f12.6) EMX_Raw[7]        [Window X07 Raw                     (fT)  ]
 22   208 - 219  real (f12.6) EMX_Raw[8]        [Window X08 Raw                     (fT)  ]
 23   220 - 231  real (f12.6) EMX_Raw[9]        [Window X09 Raw                     (fT)  ]
 24   232 - 243  real (f12.6) EMX_Raw[10]       [Window X10 Raw                     (fT)  ]
 25   244 - 255  real (f12.6) EMX_Raw[11]       [Window X11 Raw                     (fT)  ]
 26   256 - 267  real (f12.6) EMX_Raw[12]       [Window X12 Raw                     (fT)  ]
 27   268 - 279  real (f12.6) EMX_Raw[13]       [Window X13 Raw                     (fT)  ]
 28   280 - 291  real (f12.6) EMX_Raw[14]       [Window X14 Raw                     (fT)  ]
 29   292 - 303  real (f12.6) EMX_Raw[15]       [Window X15 Raw                     (fT)  ]
 30   304 - 313  real (f10.1) X_Sferics         [X_Sferics                                ]
 31   314 - 323  real (f10.3) X_Lowfreq         [X_Lowfreq                                ]
 32   324 - 333  real (f10.3) X_Powerline       [X_Powerline                              ]
 33   334 - 343  real (f10.3) X_kHz_182         [X_kHz_18.2                               ]
 34   344 - 353  real (f10.3) X_kHz_198         [X_kHz_19.8                               ]
 35   354 - 363  real (f10.3) X_kHz_214         [X_kHz_21.4                               ]
 36   364 - 373  real (f10.3) X_kHz_222         [X_kHz_22.2                               ]
 37   374 - 383  real (f10.3) X_Geofact         [X_Geometric factor raw                   ]
 38   384 - 395  real (f12.6) EMZ_Raw[1]        [Window Z01 Raw                     (fT)  ]
 39   396 - 407  real (f12.6) EMZ_Raw[2]        [Window Z02 Raw                     (fT)  ]
 40   408 - 419  real (f12.6) EMZ_Raw[3]        [Window Z03 Raw                     (fT)  ]
 41   420 - 431  real (f12.6) EMZ_Raw[4]        [Window Z04 Raw                     (fT)  ]
 42   432 - 443  real (f12.6) EMZ_Raw[5]        [Window Z05 Raw                     (fT)  ]
 43   444 - 455  real (f12.6) EMZ_Raw[6]        [Window Z06 Raw                     (fT)  ]
 44   456 - 467  real (f12.6) EMZ_Raw[7]        [Window Z07 Raw                     (fT)  ]
 45   468 - 479  real (f12.6) EMZ_Raw[8]        [Window Z08 Raw                     (fT)  ]
 46   480 - 491  real (f12.6) EMZ_Raw[9]        [Window Z09 Raw                     (fT)  ]
 47   492 - 503  real (f12.6) EMZ_Raw[10]       [Window Z10 Raw                     (fT)  ]
 48   504 - 515  real (f12.6) EMZ_Raw[11]       [Window Z11 Raw                     (fT)  ]
 49   516 - 527  real (f12.6) EMZ_Raw[12]       [Window Z12 Raw                     (fT)  ]
 50   528 - 539  real (f12.6) EMZ_Raw[13]       [Window Z13 Raw                     (fT)  ]
 51   540 - 551  real (f12.6) EMZ_Raw[14]       [Window Z14 Raw                     (fT)  ]
 52   552 - 563  real (f12.6) EMZ_Raw[15]       [Window Z15 Raw                     (fT)  ]
 53   564 - 573  real (f10.1) Z_Sferics         [Z_Sferics                                ]
 54   574 - 583  real (f10.3) Z_Lowfreq         [Z_Lowfreq                                ]
 55   584 - 593  real (f10.3) Z_Powerline       [Z_Powerline                              ]
 56   594 - 603  real (f10.3) Z_kHz_182         [Z_kHz_18.2                               ]
 57   604 - 613  real (f10.3) Z_kHz_198         [Z_kHz_19.8                               ]
 58   614 - 623  real (f10.3) Z_kHz_214         [Z_kHz_21.4                               ]
 59   624 - 633  real (f10.3) Z_kHz_222         [Z_kHz_22.2                               ]
 60   634 - 643  real (f10.3) Z_Geofact         [Z_Geometric factor raw                   ]
 61   644 - 653  real (f10.3) CNDX[1]           [Conductivity_X01   0- 5 m        (mS/m)  ]
 62   654 - 663  real (f10.3) CNDX[2]           [Conductivity_X02   5- 10 m       (mS/m)  ]
 63   664 - 673  real (f10.3) CNDX[3]           [Conductivity_X03  10- 15 m       (mS/m)  ]
 64   674 - 683  real (f10.3) CNDX[4]           [Conductivity_X04  15- 20 m       (mS/m)  ]
 65   684 - 693  real (f10.3) CNDX[5]           [Conductivity_X05  20- 25 m       (mS/m)  ]
 66   694 - 703  real (f10.3) CNDX[6]           [Conductivity_X06  25- 30 m       (mS/m)  ]
 67   704 - 713  real (f10.3) CNDX[7]           [Conductivity_X07  30- 35 m       (mS/m)  ]
 68   714 - 723  real (f10.3) CNDX[8]           [Conductivity_X08  35- 40 m       (mS/m)  ]
 69   724 - 733  real (f10.3) CNDX[9]           [Conductivity_X09  40- 45 m       (mS/m)  ]
 70   734 - 743  real (f10.3) CNDX[10]          [Conductivity_X10  45- 50 m       (mS/m)  ]
 71   744 - 753  real (f10.3) CNDX[11]          [Conductivity_X11  50- 55 m       (mS/m)  ]
 72   754 - 763  real (f10.3) CNDX[12]          [Conductivity_X12  55- 60 m       (mS/m)  ]
 73   764 - 773  real (f10.3) CNDX[13]          [Conductivity_X13  60- 65 m       (mS/m)  ]
 74   774 - 783  real (f10.3) CNDX[14]          [Conductivity_X14  65- 70 m       (mS/m)  ]
 75   784 - 793  real (f10.3) CNDX[15]          [Conductivity_X15  70- 75 m       (mS/m)  ]
 76   794 - 803  real (f10.3) CNDX[16]          [Conductivity_X16  75- 80 m       (mS/m)  ]
 77   804 - 813  real (f10.3) CNDX[17]          [Conductivity_X17  80- 85 m       (mS/m)  ]
 78   814 - 823  real (f10.3) CNDX[18]          [Conductivity_X18  85- 90 m       (mS/m)  ]
 79   824 - 833  real (f10.3) CNDX[19]          [Conductivity_X19  90- 95 m       (mS/m)  ]
 80   834 - 843  real (f10.3) CNDX[20]          [Conductivity_X20  95-100 m       (mS/m)  ]
 81   844 - 853  real (f10.3) CNDX[21]          [Conductivity_X21 100-105 m       (mS/m)  ]
 82   854 - 863  real (f10.3) CNDX[22]          [Conductivity_X22 105-110 m       (mS/m)  ]
 83   864 - 873  real (f10.3) CNDX[23]          [Conductivity_X23 110-115 m       (mS/m)  ]
 84   874 - 883  real (f10.3) CNDX[24]          [Conductivity_X24 115-120 m       (mS/m)  ]
 85   884 - 893  real (f10.3) CNDX[25]          [Conductivity_X25 120-125 m       (mS/m)  ]
 86   894 - 903  real (f10.3) CNDX[26]          [Conductivity_X26 125-130 m       (mS/m)  ]
 87   904 - 913  real (f10.3) CNDX[27]          [Conductivity_X27 130-135 m       (mS/m)  ]
 88   914 - 923  real (f10.3) CNDX[28]          [Conductivity_X28 135-140 m       (mS/m)  ]
 89   924 - 933  real (f10.3) CNDX[29]          [Conductivity_X29 140-145 m       (mS/m)  ]
 90   934 - 943  real (f10.3) CNDX[30]          [Conductivity_X30 145-150 m       (mS/m)  ]
 91   944 - 953  real (f10.3) CNDX[31]          [Conductivity_X31 150-155 m       (mS/m)  ]
 92   954 - 963  real (f10.3) CNDX[32]          [Conductivity_X32 155-160 m       (mS/m)  ]
 93   964 - 973  real (f10.3) CNDX[33]          [Conductivity_X33 160-165 m       (mS/m)  ]
 94   974 - 983  real (f10.3) CNDX[34]          [Conductivity_X34 165-170 m       (mS/m)  ]
 95   984 - 993  real (f10.3) CNDX[35]          [Conductivity_X35 170-175 m       (mS/m)  ]
 96   994 -1003  real (f10.3) CNDX[36]          [Conductivity_X36 175-180 m       (mS/m)  ]
 97  1004 -1013  real (f10.3) CNDX[37]          [Conductivity_X37 180-185 m       (mS/m)  ]
 98  1014 -1023  real (f10.3) CNDX[38]          [Conductivity_X38 185-190 m       (mS/m)  ]
 99  1024 -1033  real (f10.3) CNDX[39]          [Conductivity_X39 190-195 m       (mS/m)  ]
100  1034 -1043  real (f10.3) CNDX[40]          [Conductivity_X40 195-200 m       (mS/m)  ]
101  1044 -1053  real (f10.3) CNDX[41]          [Conductivity_X41 200-205 m       (mS/m)  ]
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102  1054 -1063  real (f10.3) CNDX[42]          [Conductivity_X42 205-210 m      (mS/m)  ]
103  1064 -1073  real (f10.3) CNDX[43]          [Conductivity_X43 210-215 m      (mS/m)  ]
104  1074 -1083  real (f10.3) CNDX[44]          [Conductivity_X44 215-220 m      (mS/m)  ]
105  1084 -1093  real (f10.3) CNDX[45]          [Conductivity_X45 220-225 m      (mS/m)  ]
106  1094 -1103  real (f10.3) CNDX[46]          [Conductivity_X46 225-230 m      (mS/m)  ]
107  1104 -1113  real (f10.3) CNDX[47]          [Conductivity_X47 230-235 m      (mS/m)  ]
108  1114 -1123  real (f10.3) CNDX[48]          [Conductivity_X48 235-240 m      (mS/m)  ]
109  1124 -1133  real (f10.3) CNDX[49]          [Conductivity_X49 240-245 m      (mS/m)  ]
110  1134 -1143  real (f10.3) CNDX[50]          [Conductivity_X50 245-250 m      (mS/m)  ]
111  1144 -1153  real (f10.3) CNDX[51]          [Conductivity_X51 250-255 m      (mS/m)  ]
112  1154 -1163  real (f10.3) CNDX[52]          [Conductivity_X52 255-260 m      (mS/m)  ]
113  1164 -1173  real (f10.3) CNDX[53]          [Conductivity_X53 260-265 m      (mS/m)  ]
114  1174 -1183  real (f10.3) CNDX[54]          [Conductivity_X54 265-270 m      (mS/m)  ]
115  1184 -1193  real (f10.3) CNDX[55]          [Conductivity_X55 270-275 m      (mS/m)  ]
116  1194 -1203  real (f10.3) CNDX[56]          [Conductivity_X56 275-280 m      (mS/m)  ]
117  1204 -1213  real (f10.3) CNDX[57]          [Conductivity_X57 280-285 m      (mS/m)  ]
118  1214 -1223  real (f10.3) CNDX[58]          [Conductivity_X58 285-290 m      (mS/m)  ]
119  1224 -1233  real (f10.3) CNDX[59]          [Conductivity_X59 290-295 m      (mS/m)  ]
120  1234 -1243  real (f10.3) CNDX[60]          [Conductivity_X60 295-300 m      (mS/m)  ]
121  1244 -1253  real (f10.3) CNDX[61]          [Conductivity_X61 300-305 m      (mS/m)  ]
122  1254 -1263  real (f10.3) CNDX[62]          [Conductivity_X62 305-310 m      (mS/m)  ]
123  1264 -1273  real (f10.3) CNDX[63]          [Conductivity_X63 310-315 m      (mS/m)  ]
124  1274 -1283  real (f10.3) CNDX[64]          [Conductivity_X64 315-320 m      (mS/m)  ]
125  1284 -1293  real (f10.3) CNDX[65]          [Conductivity_X65 320-325 m      (mS/m)  ]
126  1294 -1303  real (f10.3) CNDX[66]          [Conductivity_X66 325-330 m      (mS/m)  ]
127  1304 -1313  real (f10.3) CNDX[67]          [Conductivity_X67 330-335 m      (mS/m)  ]
128  1314 -1323  real (f10.3) CNDX[68]          [Conductivity_X68 335-340 m      (mS/m)  ]
129  1324 -1333  real (f10.3) CNDX[69]          [Conductivity_X69 340-345 m      (mS/m)  ]
130  1334 -1343  real (f10.3) CNDX[70]          [Conductivity_X70 345-350 m      (mS/m)  ]
131  1344 -1353  real (f10.3) CNDX[71]          [Conductivity_X71 350-355 m      (mS/m)  ]
132  1354 -1363  real (f10.3) CNDX[72]          [Conductivity_X72 355-360 m      (mS/m)  ]
133  1364 -1373  real (f10.3) CNDX[73]          [Conductivity_X73 360-365 m      (mS/m)  ]
134  1374 -1383  real (f10.3) CNDX[74]          [Conductivity_X74 365-370 m      (mS/m)  ]
135  1384 -1393  real (f10.3) CNDX[75]          [Conductivity_X75 370-375 m      (mS/m)  ]
136  1394 -1403  real (f10.3) CNDX[76]          [Conductivity_X76 375-380 m      (mS/m)  ]
137  1404 -1413  real (f10.3) CNDX[77]          [Conductivity_X77 380-385 m      (mS/m)  ]
138  1414 -1423  real (f10.3) CNDX[78]          [Conductivity_X78 385-390 m      (mS/m)  ]
139  1424 -1433  real (f10.3) CNDX[79]          [Conductivity_X79 390-395 m      (mS/m)  ]
140  1434 -1443  real (f10.3) CNDX[80]          [Conductivity_X80 395-400 m      (mS/m)  ]
141  1444 -1453  real (f10.3) CNDX[81]          [Conductivity_X81 400-405 m      (mS/m)  ]
142  1454 -1463  real (f10.3) CNDX[82]          [Conductivity_X82 405-410 m      (mS/m)  ]
143  1464 -1473  real (f10.3) CNDX[83]          [Conductivity_X83 410-415 m      (mS/m)  ]
144  1474 -1483  real (f10.3) CNDX[84]          [Conductivity_X84 415-420 m      (mS/m)  ]
145  1484 -1493  real (f10.3) CNDX[85]          [Conductivity_X85 420-425 m      (mS/m)  ]
146  1494 -1503  real (f10.3) CNDX[86]          [Conductivity_X86 425-430 m      (mS/m)  ]
147  1504 -1513  real (f10.3) CNDX[87]          [Conductivity_X87 430-435 m      (mS/m)  ]
148  1514 -1523  real (f10.3) CNDX[88]          [Conductivity_X88 435-440 m      (mS/m)  ]
149  1524 -1533  real (f10.3) CNDX[89]          [Conductivity_X89 440-445 m      (mS/m)  ]
150  1534 -1543  real (f10.3) CNDX[90]          [Conductivity_X90 445-450 m      (mS/m)  ]
151  1544 -1553  real (f10.3) CNDX[91]          [Conductivity_X91 450-455 m      (mS/m)  ]
152  1554 -1563  real (f10.3) CNDX[92]          [Conductivity_X92 455-460 m      (mS/m)  ]
153  1564 -1573  real (f10.3) CNDX[93]          [Conductivity_X93 460-465 m      (mS/m)  ]
154  1574 -1583  real (f10.3) CNDX[94]          [Conductivity_X94 465-470 m      (mS/m)  ]
155  1584 -1593  real (f10.3) CNDX[95]          [Conductivity_X95 470-475 m      (mS/m)  ]
156  1594 -1603  real (f10.3) CNDX[96]          [Conductivity_X96 475-480 m      (mS/m)  ]
157  1604 -1613  real (f10.3) CNDX[97]          [Conductivity_X97 480-485 m      (mS/m)  ]
158  1614 -1623  real (f10.3) CNDX[98]          [Conductivity_X98 485-490 m      (mS/m)  ]
159  1624 -1633  real (f10.3) CNDX[99]          [Conductivity_X99 490-495 m      (mS/m)  ]
160  1634 -1643  real (f10.3) CNDX[100]         [Conductivity_X100 495-500 m     (mS/m)  ]
161  1644 -1653  real (f10.3) CNDX[101]         [Conductivity_X101 500-505 m     (mS/m)  ]
162  1654 -1663  real (f10.3) CNDX[102]         [Conductivity_X102 550-510 m     (mS/m)  ]
163  1664 -1673  real (f10.3) CNDX[103]         [Conductivity_X103 510-515 m     (mS/m)  ]
164  1674 -1683  real (f10.3) CNDX[104]         [Conductivity_X104 515-520 m     (mS/m)  ]
165  1684 -1693  real (f10.3) CNDX[105]         [Conductivity_X105 520-525 m     (mS/m)  ]
166  1694 -1703  real (f10.3) CNDX[106]         [Conductivity_X106 525-530 m     (mS/m)  ]
167  1704 -1713  real (f10.3) CNDX[107]         [Conductivity_X107 530-535 m     (mS/m)  ]
168  1714 -1723  real (f10.3) CNDX[108]         [Conductivity_X108 535-540 m     (mS/m)  ]
169  1724 -1733  real (f10.3) CNDX[109]         [Conductivity_X109 540-545 m     (mS/m)  ]
170  1734 -1743  real (f10.3) CNDX[110]         [Conductivity_X110 545-550 m     (mS/m)  ]
171  1744 -1753  real (f10.3) CNDX[111]         [Conductivity_X111 550-555 m     (mS/m)  ]
172  1754 -1763  real (f10.3) CNDX[112]         [Conductivity_X112 555-560 m     (mS/m)  ]
173  1764 -1773  real (f10.3) CNDX[113]         [Conductivity_X113 560-565 m     (mS/m)  ]
174  1774 -1783  real (f10.3) CNDX[114]         [Conductivity_X114 565-570 m     (mS/m)  ]
175  1784 -1793  real (f10.3) CNDX[115]         [Conductivity_X115 570-575 m     (mS/m)  ]
176  1794 -1803  real (f10.3) CNDX[116]         [Conductivity_X116 575-580 m     (mS/m)  ]
177  1804 -1813  real (f10.3) CNDX[117]         [Conductivity_X117 580-585 m     (mS/m)  ]
178  1814 -1823  real (f10.3) CNDX[118]         [Conductivity_X118 585-590 m     (mS/m)  ]
179  1824 -1833  real (f10.3) CNDX[119]         [Conductivity_X119 590-595 m     (mS/m)  ]
180  1834 -1843  real (f10.3) CNDX[120]         [Conductivity_X120 595-600 m     (mS/m)  ]
181  1844 -1853  real (f10.3) CNDX[121]         [Conductivity_X121 600-605 m     (mS/m)  ]
182  1854 -1863  real (f10.3) CNDX[122]         [Conductivity_X122 605-610 m     (mS/m)  ]
183  1864 -1873  real (f10.3) CNDX[123]         [Conductivity_X123 610-615 m     (mS/m)  ]
184  1874 -1883  real (f10.3) CNDX[124]         [Conductivity_X124 615-620 m     (mS/m)  ]
185  1884 -1893  real (f10.3) CNDX[125]         [Conductivity_X125 620-625 m     (mS/m)  ]
186  1894 -1903  real (f10.3) CNDX[126]         [Conductivity_X126 625-630 m     (mS/m)  ]
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 187  1904 -1913  real (f10.3) CNDX[127]            [Conductivity_X127 630-635 m     (mS/m)   ]
 188  1914 -1923  real (f10.3) CNDX[128]            [Conductivity_X128 635-640 m     (mS/m)   ]
 189  1924 -1933  real (f10.3) CNDX[129]            [Conductivity_X129 640-645 m     (mS/m)   ]
 190  1934 -1943  real (f10.3) CNDX[130]            [Conductivity_X130 645-650 m     (mS/m)   ]
 191  1944 -1953  real (f10.3) CNDX[131]            [Conductivity_X131 650-655 m     (mS/m)   ]
 192  1954 -1963  real (f10.3) CNDX[132]            [Conductivity_X132 655-660 m     (mS/m)   ]
 193  1964 -1973  real (f10.3) CNDX[133]            [Conductivity_X133 660-665 m     (mS/m)   ]
 194  1974 -1983  real (f10.3) CNDX[134]            [Conductivity_X134 665-670 m     (mS/m)   ]
 195  1984 -1993  real (f10.3) CNDX[135]            [Conductivity_X135 670-675 m     (mS/m)   ]
 196  1994 -2003  real (f10.3) CNDX[136]            [Conductivity_X136 675-680 m     (mS/m)   ]
 197  2004 -2013  real (f10.3) CNDX[137]            [Conductivity_X137 680-685 m     (mS/m)   ]
 198  2014 -2023  real (f10.3) CNDX[138]            [Conductivity_X138 685-690 m     (mS/m)   ]
 199  2024 -2033  real (f10.3) CNDX[139]            [Conductivity_X139 690-695 m     (mS/m)   ]
 200  2034 -2043  real (f10.3) CNDX[140]            [Conductivity_X140 695-700 m     (mS/m)   ]
 201  2044 -2053  real (f10.3) CNDX[141]            [Conductivity_X141 700-705 m     (mS/m)   ]
 202  2054 -2063  real (f10.3) CNDX[142]            [Conductivity_X142 705-710 m     (mS/m)   ]
 203  2064 -2073  real (f10.3) CNDX[143]            [Conductivity_X143 710-715 m     (mS/m)   ]
 204  2074 -2083  real (f10.3) CNDX[144]            [Conductivity_X144 715-720 m     (mS/m)   ]
 205  2084 -2093  real (f10.3) CNDX[145]            [Conductivity_X145 720-725 m     (mS/m)   ]
 206  2094 -2103  real (f10.3) CNDX[146]            [Conductivity_X146 725-730 m     (mS/m)   ]
 207  2104 -2113  real (f10.3) CNDX[147]            [Conductivity_X147 730-735 m     (mS/m)   ]
 208  2114 -2123  real (f10.3) CNDX[148]            [Conductivity_X148 735-740 m     (mS/m)   ]
 209  2124 -2133  real (f10.3) CNDX[149]            [Conductivity_X149 740-745 m     (mS/m)   ]
 210  2134 -2143  real (f10.3) CNDX[150]            [Conductivity_X150 745-750 m     (mS/m)   ]
 211  2144 -2153  real (f10.3) CNDX[151]            [Conductivity_X151 750-755 m     (mS/m)   ]
 212  2154 -2163  real (f10.3) CNDX[152]            [Conductivity_X152 755-760 m     (mS/m)   ]
 213  2164 -2173  real (f10.3) CNDX[153]            [Conductivity_X153 760-765 m     (mS/m)   ]
 214  2174 -2183  real (f10.3) CNDX[154]            [Conductivity_X154 765-770 m     (mS/m)   ]
 215  2184 -2193  real (f10.3) CNDX[155]            [Conductivity_X155 770-775 m     (mS/m)   ]
 216  2194 -2203  real (f10.3) CNDX[156]            [Conductivity_X156 775-780 m     (mS/m)   ]
 217  2204 -2213  real (f10.3) CNDX[157]            [Conductivity_X157 780-785 m     (mS/m)   ]
 218  2214 -2223  real (f10.3) CNDX[158]            [Conductivity_X158 785-790 m     (mS/m)   ]
 219  2224 -2233  real (f10.3) CNDX[159]            [Conductivity_X159 790-795 m     (mS/m)   ]
 220  2234 -2243  real (f10.3) CNDX[160]            [Conductivity_X160 795-800 m     (mS/m)   ]
 221  2244 -2253  real (f10.3) CNDX[161]            [Conductivity_X161 800-805 m     (mS/m)   ]
 222  2254 -2263  real (f10.3) CNDX[162]            [Conductivity_X162 805-810 m     (mS/m)   ]
 223  2264 -2273  real (f10.3) CNDX[163]            [Conductivity_X163 810-815 m     (mS/m)   ]
 224  2274 -2283  real (f10.3) CNDX[164]            [Conductivity_X164 815-820 m     (mS/m)   ]
 225  2284 -2293  real (f10.3) CNDX[165]            [Conductivity_X165 820-825 m     (mS/m)   ]
 226  2294 -2303  real (f10.3) CNDX[166]            [Conductivity_X166 825-830 m     (mS/m)   ]
 227  2304 -2313  real (f10.3) CNDX[167]            [Conductivity_X167 830-835 m     (mS/m)   ]
 228  2314 -2323  real (f10.3) CNDX[168]            [Conductivity_X168 835-840 m     (mS/m)   ]
 229  2324 -2333  real (f10.3) CNDX[169]            [Conductivity_X169 840-845 m     (mS/m)   ]
 230  2334 -2343  real (f10.3) CNDX[170]            [Conductivity_X170 845-850 m     (mS/m)   ]
 231  2344 -2353  real (f10.3) CNDX[171]            [Conductivity_X171 850-855 m     (mS/m)   ]
 232  2354 -2363  real (f10.3) CNDX[172]            [Conductivity_X172 855-860 m     (mS/m)   ]
 233  2364 -2373  real (f10.3) CNDX[173]            [Conductivity_X173 860-865 m     (mS/m)   ]
 234  2374 -2383  real (f10.3) CNDX[174]            [Conductivity_X174 865-870 m     (mS/m)   ]
 235  2384 -2393  real (f10.3) CNDX[175]            [Conductivity_X175 870-875 m     (mS/m)   ]
 236  2394 -2403  real (f10.3) CNDX[176]            [Conductivity_X176 875-880 m     (mS/m)   ]
 237  2404 -2413  real (f10.3) CNDX[177]            [Conductivity_X177 880-885 m     (mS/m)   ]
 238  2414 -2423  real (f10.3) CNDX[178]            [Conductivity_X178 885-890 m     (mS/m)   ]
 239  2424 -2433  real (f10.3) CNDX[179]            [Conductivity_X179 890-895 m     (mS/m)   ]
 240  2434 -2443  real (f10.3) CNDX[180]            [Conductivity_X180 895-900 m     (mS/m)   ]
 241  2444 -2453  real (f10.3) CNDX[181]            [Conductivity_X181 900-905 m     (mS/m)   ]
 242  2454 -2463  real (f10.3) CNDX[182]            [Conductivity_X182 905-910 m     (mS/m)   ]
 243  2464 -2473  real (f10.3) CNDX[183]            [Conductivity_X183 910-915 m     (mS/m)   ]
 244  2474 -2483  real (f10.3) CNDX[184]            [Conductivity_X184 915-920 m     (mS/m)   ]
 245  2484 -2493  real (f10.3) CNDX[185]            [Conductivity_X185 920-925 m     (mS/m)   ]
 246  2494 -2503  real (f10.3) CNDX[186]            [Conductivity_X186 925-930 m     (mS/m)   ]
 247  2504 -2513  real (f10.3) CNDX[187]            [Conductivity_X187 930-935 m     (mS/m)   ]
 248  2514 -2523  real (f10.3) CNDX[188]            [Conductivity_X188 935-940 m     (mS/m)   ]
 249  2524 -2533  real (f10.3) CNDX[189]            [Conductivity_X189 940-945 m     (mS/m)   ]
 250  2534 -2543  real (f10.3) CNDX[190]            [Conductivity_X190 945-950 m     (mS/m)   ]
 251  2544 -2553  real (f10.3) CNDX[191]            [Conductivity_X191 950-955 m     (mS/m)   ]
 252  2554 -2563  real (f10.3) CNDX[192]            [Conductivity_X192 955-960 m     (mS/m)   ]
      2564 -2565 <newline>
```

Total number of lines : 141

Flt	Line	Start X	Start Y	End X	End Y	Kms
10	17021	328267	8626934	328263	8599013	27.92
10	17050	334288	8599124	334269	8621934	22.81
10	17080	340269	8617933	340262	8598977	18.96
11	10370	327736	8619441	337020	8619444	9.28
11	10380	337126	8619243	327751	8619238	9.38
11	10390	327734	8619039	337090	8619035	9.36
11	10400	337126	8618844	327764	8618842	9.36
11	10410	327763	8618634	337102	8618641	9.34
11	10420	337108	8618445	327751	8618430	9.36
12	10430	327727	8618224	337054	8618240	9.33
12	10440	337172	8618042	327769	8618042	9.40
12	10450	327778	8617844	337071	8617842	9.29

12	10460	337539	8617638	327818	8617644	9.72
12	10470	327768	8617437	345804	8617441	18.04
12	10480	345836	8617250	327783	8617243	18.05
12	10490	327783	8617040	345799	8617037	18.02
12	10500	345859	8616845	327790	8616848	18.07
12	10510	327745	8616640	345809	8616646	18.06
12	10520	345805	8616441	327760	8616446	18.05
12	10530	327761	8616243	345806	8616242	18.05
12	10540	345801	8616063	327773	8616051	18.03
12	10550	327771	8615841	345793	8615845	18.02
12	10560	345824	8615639	327830	8615644	17.99
12	10570	327733	8615447	345778	8615439	18.05
12	10580	345819	8615242	327826	8615247	17.99
12	10590	327752	8615041	345775	8615041	18.02
12	10600	345782	8614843	327830	8614842	17.95
12	10610	327776	8614642	345758	8614641	17.98
12	10620	345747	8614450	327775	8614440	17.97
12	10630	327757	8614244	345764	8614239	18.01
12	10640	345750	8614050	327819	8614041	17.93
12	10650	327773	8613845	345723	8613837	17.95
13	10011	325086	8626635	333359	8626641	8.27
13	10020	333386	8626454	325094	8626443	8.29
13	10030	325073	8626179	333315	8626245	8.24
13	10040	333347	8626050	325115	8626047	8.23
13	10050	325059	8625839	333322	8625841	8.26
13	10060	333295	8625638	325080	8625642	8.22
13	10070	325069	8625443	333336	8625443	8.27
13	10080	333406	8625259	325101	8625239	8.31
13	10090	325063	8625047	333332	8625039	8.27
13	10100	333370	8624853	325125	8624843	8.25
13	10110	325068	8624642	333357	8624641	8.29
13	10120	333368	8624445	325114	8624445	8.25
13	10130	325063	8624236	333337	8624242	8.27
13	10140	333360	8624045	325096	8624048	8.26
13	10150	325063	8623841	333339	8623842	8.28
13	10160	333415	8623659	325113	8623643	8.30
13	10170	325090	8623436	333352	8623443	8.26
13	10180	333378	8623246	325102	8623243	8.28
13	10190	325088	8623036	333336	8623042	8.25
13	10200	333421	8622853	325063	8622841	8.36
13	10210	325030	8622646	333340	8622644	8.31
13	10220	333371	8622477	325111	8622437	8.26
13	10230	325064	8622243	333324	8622243	8.26
13	10240	333383	8622057	325086	8622042	8.30
13	10250	325785	8621836	336945	8621840	11.16
13	10270	327750	8621450	336964	8621445	9.21
13	10280	337027	8621253	327809	8621249	9.22
13	10290	327757	8621042	337012	8621042	9.26
13	10300	337048	8620853	327808	8620839	9.24
13	10310	327752	8620640	337029	8620644	9.28
13	10320	337048	8620444	327813	8620443	9.23
13	10330	327749	8620245	337011	8620243	9.26
13	10340	337063	8620049	327756	8620043	9.31
13	10350	327744	8619841	337040	8619840	9.30
13	10361	337104	8619651	327773	8619644	9.33
13	10670	327543	8613437	345711	8613442	18.17
13	10661	345769	8613642	327786	8613640	17.98
14	10261	336938	8621643	327796	8621643	9.14
14	10930	327781	8608241	342353	8608240	14.57
14	10920	341950	8608471	327807	8608445	14.14
14	10910	327755	8608638	341586	8608642	13.83
14	10900	341175	8608823	327779	8608842	13.40
14	10890	327759	8609036	340728	8609041	12.97
14	10880	340591	8609152	327837	8609243	12.75
14	10870	327764	8609432	339963	8609442	12.20
14	10860	339580	8609629	327819	8609641	11.76
14	10850	327757	8609839	339141	8609839	11.38
14	10840	338773	8610030	327836	8610040	10.94
14	10830	327765	8610227	338337	8610238	10.57
14	10820	338102	8610374	327805	8610443	10.30
14	10810	327783	8610636	337516	8610639	9.73
14	10800	337167	8610839	327838	8610858	9.33
14	10790	327739	8611038	336685	8611039	8.95
14	10780	336373	8611239	327715	8611241	8.66
14	10770	327516	8611438	335955	8611443	8.44
14	10760	335751	8611635	327327	8611641	8.42
14	10750	327102	8611836	335530	8611842	8.43
14	10740	335400	8612038	326959	8612041	8.44
14	10730	326703	8612240	335092	8612245	8.39
14	10720	334978	8612443	326548	8612442	8.43
14	10710	326316	8612643	334718	8612636	8.40
14	10700	334491	8612842	326160	8612842	8.33
14	10690	325972	8613036	334286	8613046	8.31
14	10680	334102	8613245	325770	8613251	8.33
14	10950	327763	8607844	342709	8607842	14.95

14	10940	342737	8608036	327791	8608042	14.95
14	10970	327790	8607436	342660	8607445	14.87
14	10960	342713	8607619	327789	8607642	14.92
14	10990	327771	8607043	342608	8607040	14.84
14	10980	342621	8607244	327786	8607243	14.84
14	11010	327804	8606639	342526	8606638	14.72
14	11000	342581	8606819	327814	8606845	14.77
15	11020	342563	8606443	327795	8606459	14.77
15	11040	342527	8606044	327836	8606043	14.69
15	11050	327774	8605839	342518	8605842	14.74
15	11060	342558	8605648	327785	8605641	14.77
15	11070	327788	8605437	342459	8605439	14.67
15	11080	342531	8605248	327795	8605240	14.74
15	11090	327768	8605027	342466	8605040	14.70
15	11100	342519	8604852	327795	8604841	14.72
15	11110	327753	8604643	342452	8604639	14.70
15	11120	342527	8604456	327845	8604440	14.68
15	11130	327780	8604243	342479	8604244	14.70
15	11140	342491	8604044	327790	8604041	14.70
15	11150	327804	8603841	342460	8603844	14.66
16	11030	327788	8606243	342526	8606238	14.74
16	11160	342531	8603648	327847	8603646	14.68
16	11170	327799	8603444	342483	8603440	14.68
16	11180	342476	8603242	327793	8603245	14.68
16	11190	327778	8603043	342497	8603044	14.72
16	11200	342475	8602845	327844	8602843	14.63
16	11210	327814	8602647	342450	8602644	14.64
16	11220	342466	8602481	327798	8602441	14.67
16	11230	327808	8602243	342454	8602243	14.65
16	11240	342498	8602056	327822	8602039	14.68
16	11250	327780	8601841	342483	8601842	14.70
16	11260	342489	8601674	327856	8601639	14.63
16	11270	327787	8601440	342481	8601441	14.69
16	11280	342463	8601229	327835	8601242	14.63
16	11290	327779	8601041	342458	8601043	14.68
16	11300	342472	8600831	327862	8600850	14.61
16	11310	327806	8600643	342417	8600641	14.61
16	11320	342490	8600438	327822	8600423	14.67
16	11330	327764	8600237	342467	8600240	14.70
16	11340	342483	8600039	327842	8600038	14.64
16	11350	327813	8599843	342462	8599840	14.65
16	11360	342505	8599644	327867	8599647	14.64
16	11370	327820	8599445	342422	8599438	14.60
16	11380	342495	8599244	327833	8599240	14.66

Total Kilometres : 1784.74

APPENDIX IV – List of all Supplied Digital Data

List of ASCII located data files and document files

Located File	Description
<area_name>_Tempest_final.asc	ASCII located corrected EM, CDI and ancillary data
<area_name>_Tempest_final.hdr	ASCII located corrected EM, CDI and ancillary header
<area_name>_Tempest_final.i3	ASCII located corrected data Geosoft import template
<area_name>_Tempest_final.gdb	Corrected EMX and EMZ, CDI and ancillary data Profile Analyst database
<area_name>_Tempest_uncor.asc	ASCII located uncorrected EM data
<area_name>_Tempest_uncor.hdr	ASCII located uncorrected EM data header
<area_name>_Tempest_uncor.i3	ASCII located uncorrected EM data Geosoft import template
<area_name>_Tempest_uncor.gdb	Uncorrected EMX and EMZ data Profile Analyst database

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

Grid Name	Description
<area>_emx	X-component EM (all 15 windows as multi-layered grid)
<area>_emx.ers	X-component EM header
<area>_emz	Z-component EM (all 15 windows as multi-layered grid)
<area>_emz.ers	Z-component EM header
<area>_tconX	X-component Time Constant (in milliseconds)
<area>_tconX.ers	X-component Time Constant header
<area>_tconZ	Z-component Time Constant (in milliseconds)
<area>_tconZ.ers	Z-component Time Constant header
Dtm	Derived topography
Dtm.ers	Derived topography header

APPENDIX V – List of all Supplied Products

As detailed in appendix IV:

1 CD-ROM containing
- final ER-mapper grids
- corrected and uncorrected EM, CDI and ancillary data in Profile Analyst database
- final ASCII located data, headers and import templates
- image files (.png) of stacked and multiplot-style CDI sections
- digital copy of acquisition and processing report

Hardcopy of acquisition and processing report.

APPENDIX VI – EMflow Description Files

X-Component Descriptor File: 1662x.dsc

```
FILE FORMAT VERSION
9
SYSTEM NAME
TEMPEST 25 Hz X component
VERSION
1.0
DEFINED BY
MCO
DATE DEFINED
20040727
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       28.452            0
        1499       28.452            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:
   -120       0     -35
_________________________________________________________
DATA FORMAT
Geosoft format (1 yes, 0 no)
     0
Sample file name (if available)
D:\J1544_testlines\emfemflowX.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
----------------------
```

Z-Component Descriptor File: 1662z.dsc

```
FILE FORMAT VERSION
9
SYSTEM NAME
TEMPEST 25 Hz Z component
VERSION
1.0
DEFINED BY
MCO
DATE DEFINED
20040728
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     0     0    15
_________________________________________________________
                         ++++++++
                         + TzRz +
                         ++++++++
```

```
________________________________________________________
TRANSMITTER CURRENT WAVEFORM
undefined
________________________________________________________
RECEIVER PRIMARY FIELD
calibrated
AMPLITUDE SCALING
1  1   [---]
4
        TIME      CURRENT        ERROR  [ppm]
           0            0            0
           1       28.452            0
        1499       28.452            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:
   -120       0     -35
________________________________________________________
DATA FORMAT
Geosoft format (1 yes, 0 no)
     0
Sample file name (if available)
E:\J1544_23\emflow\emflowZ.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     0     0    15
     2     0     0     0     0     0     0     0     0     0    16
     3     0     0     0     0     0     0     0     0     0    17
     4     0     0     0     0     0     0     0     0     0    18
     5     0     0     0     0     0     0     0     0     0    19
     6     0     0     0     0     0     0     0     0     0    20
     7     0     0     0     0     0     0     0     0     0    21
     8     0     0     0     0     0     0     0     0     0    22
     9     0     0     0     0     0     0     0     0     0    23
    10     0     0     0     0     0     0     0     0     0    24
    11     0     0     0     0     0     0     0     0     0    25
    12     0     0     0     0     0     0     0     0     0    26
    13     0     0     0     0     0     0     0     0     0    27
    14     0     0     0     0     0     0     0     0     0    28
    15     0     0     0     0     0     0     0     0     0    29
----------------------
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
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```