

TESLA

AIRBORNE
GEOSCIENCE

OPERATIONS REPORT

AMADEUS CENTRAL AIRBORNE MAGNETIC AND RADIOMETRIC SURVEY



TESLA AIRBORNE GEOSCIENCE PTY LTD

OCTOBER 2000



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1. INTRODUCTION

This report provides details of the Amadeus Central airborne geophysical survey flown in the Northern Territory during 2000. The survey was commissioned by the Northern Territory Department of Mines and Energy and flown by Tesla Airborne Geoscience Pty Ltd.

2. SURVEY DETAILS

2.1 Project Identification

Area Name:	Amadeus Central
Contractor:	Tesla Airborne Geoscience Pty Ltd
Tesla Job No.:	TA2687

2.2 Survey Location

The survey location is shown in Figure 1. Since the survey was contained within two UTM zones, the survey was flown as two areas. Area 1 being that part of the survey contained in UTM Zone 52, and Area 2 being that part of the survey contained in UTM Zone 53. Final flight paths are provided in ERMapper format in the "Flight_Path" directory of this final report CDROM. Figures 2 and 3 are maps of the flight path at a reduced scale.

Survey boundary coordinates are:

-24° 30'	130° 30'
-24° 30'	133° 30'
-25° 30'	133° 30'
-25° 30'	131° 22'
-25° 16'	131° 22'
-25° 16'	131° 10'
-25° 00'	131° 10'
-25° 00'	130° 30' (WGS84)

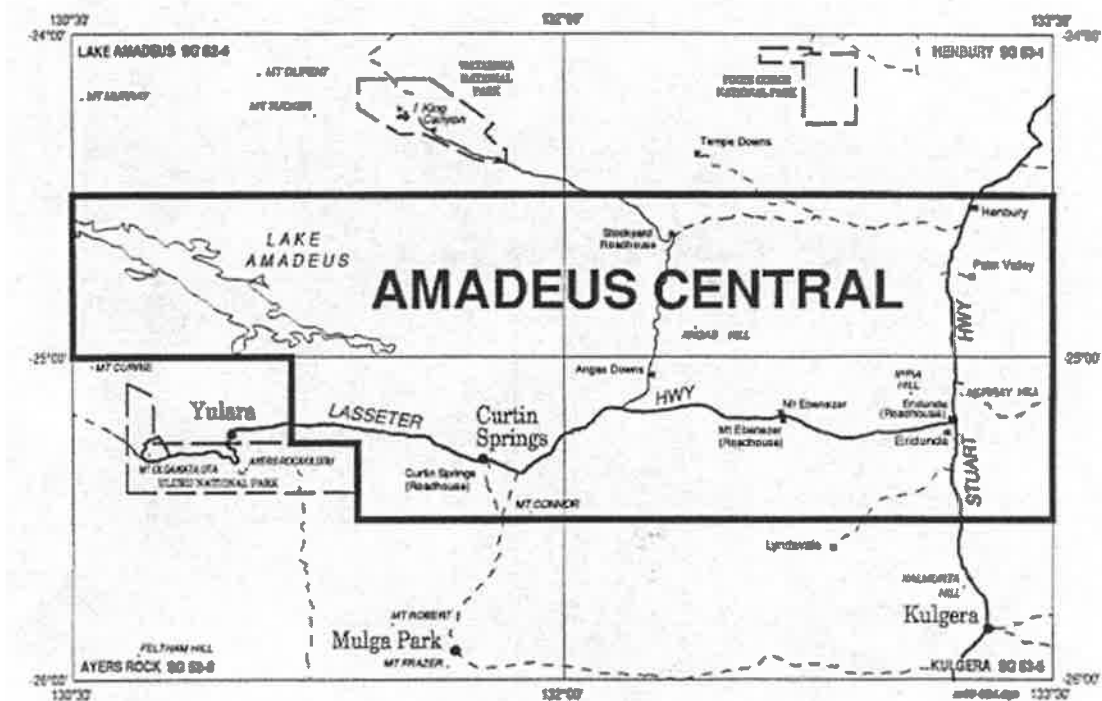
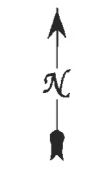
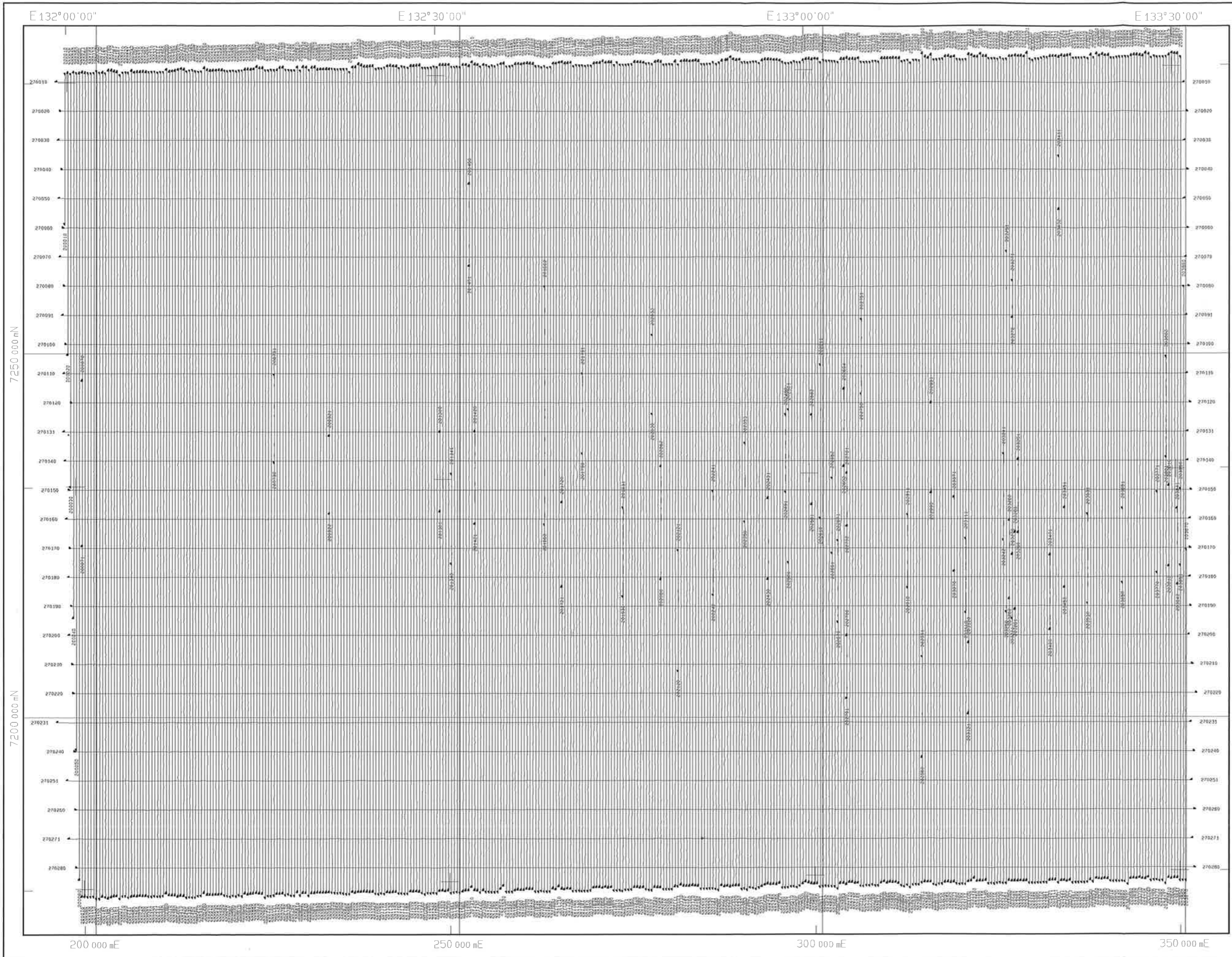


FIGURE 1 – SURVEY LOCATION



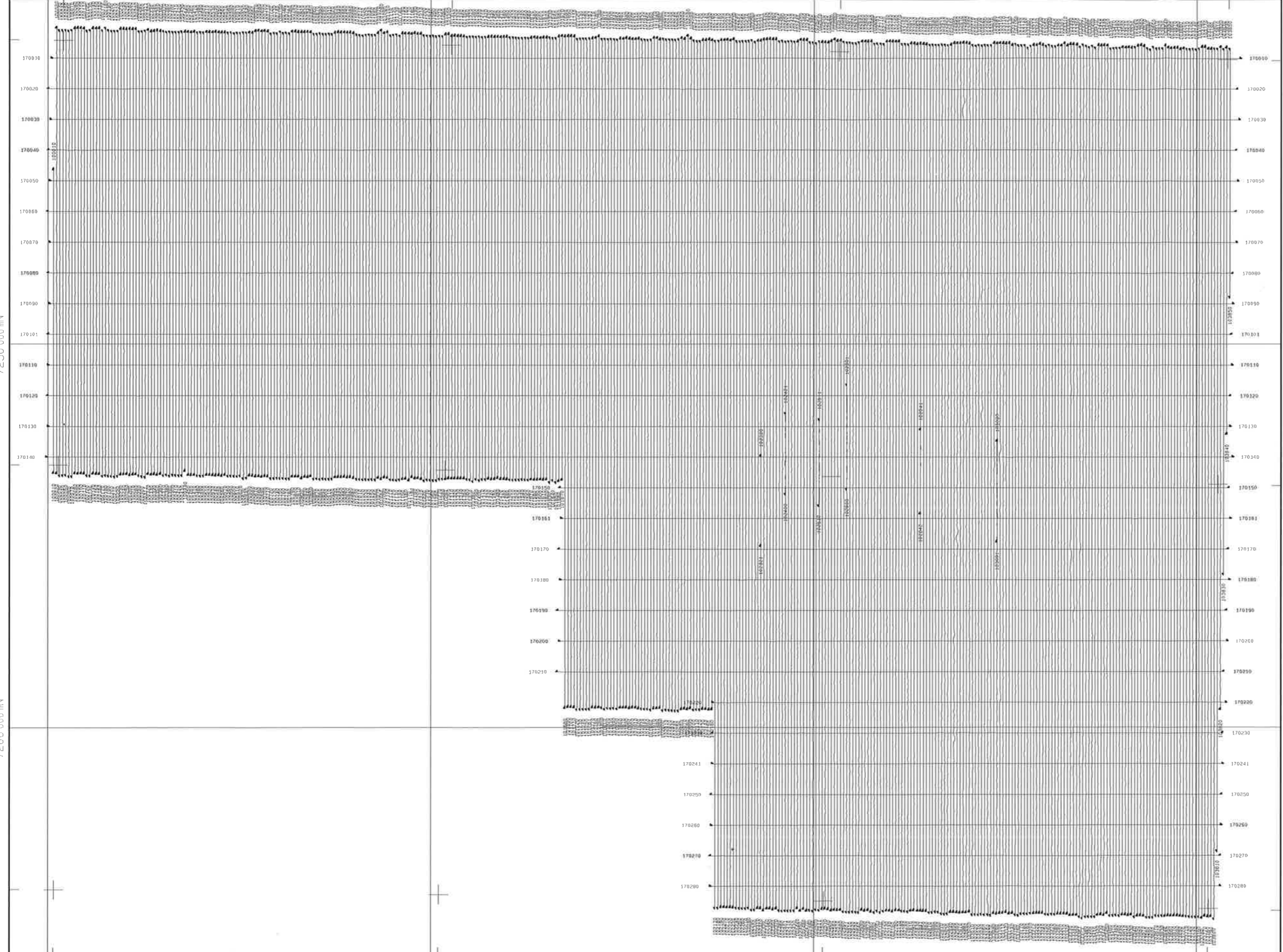
GDA 94
MGA 53

NORTHERN TERRITORY DEPARTMENT OF MINES AND ENERGY		
Amadeus Central Airborne Geophysical Survey Area 2 (Yulara) Flight Path Zone 53		
DATE: 10/00	BY: Telsa-10	PLAN NO.
SCALE: 1: 500 000	REF: TA2687	Figure 3

E 130°30'00" E 131°00'00" E 131°30'00" E 132°00'00"

7250 000 mN

7200 000 mN



650 000 mE 700 000 mE 750 000 mE 800 000 mE

S 24°30'00"

S 25°00'00"

S 25°00'00"



GDA 94
MGA 52

NORTHERN TERRITORY DEPARTMENT OF MINES AND ENERGY		
Amadeus Central Airborne Geophysical Survey Area 1 (Erdunda) Flight Path Zone 52		
DATE: 10/00	BY: Tesla-10	PLAN NO.
SCALE: 1: 500 000	REF: TA2687	Figure 2

2.3 Specifications

Traverse kilometres	77,105
Traverse direction	000-180
Traverse spacing	400 m
Number of traverses	828
Tie-line kilometres	7,577
Tie-line direction	090-270
Tie-line spacing	4,000 m
Number of tie lines	56
Survey height	80m
Sample Intervals:	
Magnetics (aircraft)	10Hz (approx. 7m)
Radiometrics	1Hz (approx. 70m)
GPS positions	1Hz
Radar altimeter	10Hz
Temperature, pressure & humidity	1Hz
Magnetics (base stations)	0.5Hz
Crystal size	33.6Lt

3. PROJECT PERSONNEL

PROJECT SUPERVISION	Rod Pullin – data acquisition Andrea Wieman – data processing
SURVEY PILOTS	Mark Lester Darien Sherman Mark Rooney Gavin Langmaid Paul Stent Ken Alonso
SURVEY OPERATORS	Ian Norcock Tom Jenkins Paul McCarron Grant Couston
DATA PROCESSING	Sheryl Murphy Andrea Wieman Joe Kita
NTDME CONTACT	Kerry Slater

4. ACQUISITION

4.1 Aircraft and Equipment

4.1.1 VH-MOK

Model	Cessna 210R
<i>Acquisition System</i>	
Model	Tesla TAG3
Software Version	3.66
<i>Total Field Magnetometer</i>	
Sensor	Scintrex CS-2
Mounting	Tail Stinger
Sensitivity	0.001 nT
<i>Vector Magnetometer</i>	
Model	Billingsley TFM100-1E
<i>Compensator</i>	
Model	RMS Instruments Automatic Aeromagnetic Digital Compensator (AADCII)
<i>Gamma-ray Spectrometer</i>	
Model	Exploranium GR820
<i>Crystals</i>	
Detectors	Eight all-viewing NaI crystals Total volume: 33.6 litres
<i>Radar Altimeter</i>	
Model	Collins Alt-55B
<i>Humidity and Temperature Transmitter</i>	
Model	Vaisala HMD 50Y
<i>Barometer</i>	
Model	Vaisala PTB 200A
Serial Number	S2920020
<i>GPS Receiver</i>	
Model	Novatel 951R
Real-time Corrections	Fugro Surveys OmniSTAR link

4.1.2 Base Stations

GPS Receiver

Model

Marconi Allstar OEM CMT-1200

BASE GPS RECORD:

Erlunda

Job No:	TA2687	Crew Leader:	I. Norcock
Client:	N.T. D.M.E.	Date:	21 st May 2000
Area:	Amadeus Central	Julian:	142
Aircraft:	VH-MOK	Completed by:	I. Norcock
Calculated Base Station	<i>Latitude</i>	25° 11' 53.0405" S	
Co-ordinates	<i>Longitude</i>	133° 12' 00.2588" E	
	<i>Height</i>	430.063 metres	
Ellipsoid	WGS84		
Method of Position Determination:	Differentially processed against averaged, real-time corrected aircraft position		
Duration of Sample	3.0 hours		
Sample Interval:	1 second		
Differential Correction Method:	Real-time: Fugro OmniSTAR		
	Post-flight: Waypoint Consulting Inc. Grafnav V6.01		
Location of GPS Antenna:	Mounted on roof above room 47 of the Desert Oaks Motel, Erlunda		

BASE GPS RECORD:

Yulara

Job No:	TA2687	Crew Leader:	T. Jenkins
Client:	N.T. D.M.E.	Date:	7 th July 2000
Area:	Amadeus Central	Julian:	189
Aircraft:	VH-MOK	Completed by:	T. Jenkins
Calculated Base Station	<i>Latitude</i>	25° 14' 06.8140" S	
Co-ordinates	<i>Longitude</i>	130° 59' 21.5412" E	
	<i>Height</i>	527.957 metres	
Ellipsoid	WGS84		
Method of Position Determination:	Averaging		
Duration of Sample	5 days		
Sample Interval:	1 second		
Differential Correction Method:	Real-time: Fugro OmniSTAR		
	Post-flight: Waypoint Consulting Inc. Grafnav V6.01		
Location of GPS Antenna:	Attached to office caravan at site 217, Ayers Rock Camping Ground, Yulara		

Magnetometers
Models

Scintrex Envimag

BASE MAGNETOMETER RECORDS

Erlunda

Job No:	TA2687	Aircraft:	VH-MOK
Client:	N.T D.M.E	Date:	17 th May 2000
Area:	Amadeus Central	Julian:	138
Crew Leader:	I. Norcock	Completed by:	I. Norcock

Magnetometer A

Magnetometer Type:	Scintrex Envi-mag
Serial Number:	9403068
Location:	Erlunda Airstrip
Cycle Rate:	2.0 seconds
Sensor Height:	2 metres

Area Gradient

2m North	54558.9
2m South	54558.9
2m East	54561.7
2m West	54557.0
Central	54556.6

Magnetometer B

Magnetometer Type:	Scintrex Envi-mag
Serial Number:	9411107
Location:	Erlunda Airstrip
Cycle Rate:	2.0 seconds
Sensor Height:	2 metres

Area Gradient

2m North	54575.7
2m South	54575.7
2m East	54577.4
2m West	54576.7
Central	54576.3

BASE MAGNETOMETER RECORDS

Yulara

Job No:	TA2687	Aircraft:	VH-MOK
Client:	N.T D.M.E	Date:	7 th July 2000
Area:	Amadeus Central	Julian:	189
Crew Leader:	T. Jenkins	Completed by:	G. Couston

Magnetometer A

Magnetometer Type:	Scintrex Envi-mag
Serial Number:	9403068
Location:	Yulara Airstrip
Cycle Rate:	2.0 seconds
Sensor Height:	2 metres

Area Gradient

2m North	54704.7
2m South	54700.9
2m East	54702.5
2m West	54703.6
Central	54703.1

Magnetometer B

Magnetometer Type:	Scintrex Envi-mag
Serial Number:	9411107
Location:	Yulara Airstrip
Cycle Rate:	2.0 seconds
Sensor Height:	2 metres

Area Gradient

2m North	54697.0
2m South	54695.8
2m East	54693.5
2m West	54695.7
Central	54695.7

4.2 Survey Operations

Bases	Erlunda, NT Yulara, NT
Acquisition Commencement	May 16, 2000
Acquisition Completion	August 12, 2000
Average Production	1,568 km/day

A full daily operations report is provided as a Microsoft Excel spreadsheet under the "Operations" directory of this final report CDROM. Survey flight logs are also provided as an Excel spreadsheet in this directory.

4.3 Recorded Parameters

All acquired data are recorded digitally.

The following parameters are recorded at 10 Hz:

<i>Parameter</i>	<i>Resolution</i>	<i>units</i>
Local time	0.1	s
Fiducial number (time after midnight, local)	1.0	unit
Terrain clearance (radar altimeter)	0.01	m
Uncompensated Total Magnetic Intensity (TMI)	0.001	nT
Fluxgates X, Y & Z	0.01	nT
Fluxgate Total Field	0.01	nT
Uncompensated TMI 4 th difference	0.001	nT
Compensated TMI	0.001	nT

The following parameters are recorded at 1 Hz:

<i>Parameter</i>	<i>Resolution</i>	<i>units</i>
GPS time	1.0	s
Latitude	0.0000001	°
Longitude	0.0000001	°
GPS height	0.01	m
Outside air temperature	1.0	°C
Barometric pressure	0.01	hPa
Barometric altitude	0.01	m
Relative humidity	0.001	%
Full 256-channel gamma-ray spectrum	1.0	cps
Spectrometer livetime	0.001	s
Resolution	0.1	%
Number of satellites	1.0	
Position dilution of precision (PDOP)	0.1	
HDOP	0.1	

4.4 Calibrations and System Checks

4.4.1 Radiometric Calibrations

Pre-survey radiometric calibrations for the aircraft were completed. Results are summarised in Table 1.

		VH-MOK
Aircraft Background	TC	107.00
	K	25.38
	U	3.64
	Th	8.69
Cosmic Background	TC	0.831
	K	0.052
	U	0.034
	Th	0.029
Height Attenuation	TC	0.0073
	K	0.0093
	U	0.0064
	Th	0.0075
Stripping	α	0.2572
	β	0.4334
	γ	0.8280
	a	0.0524
	b	0.0000
	c	0.0000
Air/Ground	Dose	24.45
	K	81.97
	U	9.69
	Th	5.02

TABLE 1 – COEFFICIENTS SUMMARY

4.4.2 Magnetic Compensation

Magnetic compensation sequences were flown at 10,000 feet above sea level. Resulting coefficients were used for real-time magnetic compensation.

4.4.3 Low-level Test Lines

The Erldunda low level test line was located along a fence line orientated in an east-west direction, approximately ten kilometres north of Erldunda Roadhouse. The Yulara low level test line was located along a road orientated in an east-west direction, approximately five kilometres south-east of Ayer's Rock. The test lines were flown at survey height. The start and end points were visually definable positions captured as GPS waypoints for ease of orientation and reference purposes.

The start and end point coordinates are:

Erldunda

Start	(WGS84)	25° 08.41055' S	133° 10.55842' E
End	(WGS84)	25° 10.29298' S	133° 05.11628' E

Yulara

Start	(WGS84)	25° 22.78782' S	131° 08.45739' E
End	(WGS84)	25° 17.73434' S	131° 13.01347' E

Resulting statistics and Th graph are given in the "Calibrations" directory of this CDROM.

4.4.4 Radiometric Button Checks

Crystal stabilisation using Thorium was undertaken prior to each day's acquisition. Radiometric counts were recorded with Thorium samples beneath the aircraft and also with samples removed to determine background radiation.

Calibration statistics and Th graph for these calibrations are given in the "Calibrations" directory of this CDROM.

5. PROCESSING

5.1 Hardware and Software

All data processing was carried out by Tesla10 Pty Ltd in its Perth, WA office.

Hardware	UNIX workstations PCs HP Designjet 650C Plotter HP Designjet 755 Plotter Exabyte 8mm tape drive Compact Disc writer Iomega ZIP drives
Software	Tesla10 Pty Ltd in-house software ERMapper 5.2 and 5.5

5.2 GPS Positioning

5.2.1 Spheroids, Datums and Zones

The acquired GPS positions (latitude, longitude and altitude) were differentially post-processed in the field. These coordinates were then converted to easting and northing grid positions referencing GDA94 in MGA zones 52 and 53.

The 1 Hz position data was linearly interpolated to coordinate all 0.1 Hz data.

5.2.2 Quality Control

In addition to Tesla's 'normal' quality control, "100-hourly" reports were produced. These are in the form of ERMapper vector files (.erv) and are provided in the "Quality_Control" directory of this final report CDROM.

- flight path
- ground speed

5.3 Magnetics

5.3.1 Quality Control

In addition to Tesla's 'normal' quality control, "100-hourly" reports were produced. These are in the form of ERMapper vector files (.erv) and are provided in the "Quality_Control" directory of this final report CDROM.

- high-pass magnetic noise
- diurnal variation
- radar altimeter

This visual aspect of quality control was aided by the determination of statistics (max., min., mean and s.d.) for all parameters for every line.

System spikes were removed from the magnetic data but cultural responses were retained.

5.3.2 Parallax Correction

System parallax adjustments were performed by interpolating the position data to fit the magnetic data. An adjustment of four fiducials was applied.

5.3.3 Diurnal Correction

The magnetic data were corrected for diurnal variations. The correction formula was:

diurnal corrected TMI = compensated TMI *minus* diurnal *plus* mean diurnal value

5.3.4 IGRF Correction

The International Geophysical Reference Field (IGRF) was removed from the data using the 2000 model extrapolated to the survey date. The correction formula was:

final corrected TMI = diurnal corrected TMI *minus* local IGRF *plus* Base_Value

5.3.5 Levelling

Tie line levelling and further micro-levelling produced the final levelled magnetics data.

5.3.6 Gridding

A bi-cubic spline algorithm was used to produce gridded data of 100 metre cell size.

5.3.7 Enhancements

First vertical derivative profiles were calculated on the TMI line data.

The TMI gridded data was reduced to the pole. A first vertical derivative grid was produced from the gridded TMI data. This FVD grid was then enhanced by an Automatic Gain Control process.

5.4 Radiometrics

5.4.1 Quality Control

256 channel spectral plots for all flights and source tests were produced. All data were checked for peak stability and count variation.

Statistics for all channels were calculated and checked. Profiles were produced where required. The data were subsequently checked (images, profiles and statistics) after each stage of processing to ensure continued data integrity.

5.4.2 Calibrations and Coefficients

See Section 4.4.

5.4.3 256-Channel Pre-processing

The raw spectra were firstly smoothed using Tesla10's MAXNF technique. This is based on MNF theory. The 256 channel data were then pre-processed to obtain data for Radon gas background removal.

Raw count rates used for final processing were extracted by summing the 256 channel data over the IAEA windows centred on the peak locations, to the nearest channel. The IAEA windows are:

Total Count	0.40 to 2.81 MeV
Potassium	1.37 to 1.57 MeV
Uranium (Bi^{214})	1.66 to 1.86 MeV
Thorium (Tl^{208})	2.41 to 2.81 MeV
Cosmic	>3.0 MeV

5.4.4 Final Processing

Filters were applied to height, temperature, pressure, altitude and the cosmic count.

Cosmic, aircraft and Radon backgrounds were removed.

The Potassium, Uranium and Thorium count rates were corrected for Compton scattering (stripped). The coefficients themselves were corrected to the STP corrected height using theoretical linear corrections for the three primary stripping coefficients.

Corrections to the terrain clearance were made using STP corrected heights and the absorption factors appropriate to the exponentially decreasing count rates with height.

The airborne gamma-ray counts were converted to the equivalent ground radioelement concentrations and the data were then tie line levelled and micro-levelled where required. A minimum curvature algorithm was used to produce gridded data of 100 metre cell size.

5.5 Digital Elevation Model

5.5.1 Processing

The form of the calculation used was:

$$\text{Digital Terrain} = \text{GPS altitude} - \text{Radar Altimeter}$$

where,

GPS Altitude is flying height above ellipsoid (WGS84)

Radar Altimeter is flying height above ground

Tie line levelling and further micro-levelling produced the final levelled terrain model.

5.5.2 Australian Height Datum

The terrain surface was subsequently referenced to the AUSLIG 1998 N-values to produce a DTM corrected to the Australian Height Datum.

6. FINAL PRODUCTS

6.1 Final Located Data

Final located data was produced in ASEG GDF2 format. Three products were produced:

- 0.1 second magnetics & digital terrain
- 1.0 second radiometrics (ROI windows)
- 1.0 second 256-channel radiometrics

6.2 Final Gridded Data

Final gridded data was produced in ERMapper format. The grids supplied are:

- Total Magnetic Intensity (TMI)
- TMI Reduced to the Pole (RTP)
- 1st Vertical Derivative of TMI (1VD)
- Automatic Gain Control of 1VD TMI (AGC 1VD)
- Total Count (provided as Doserate, nG/h) (TC)
- Potassium (%) (K)
- Uranium (ppm) (U)
- Thorium (ppm) (Th)
- Digital Elevation Model (DTM)