Project 200380
West Arnhem Land
Northern Territory
GT-1A
Airborne Gravity Survey

for

Geoscience Australia

Acquisition and Processing Report

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Survey flown August-September, 2003

by

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FAS Job No. 1608 - CMG Job No. 2003-2

FIGURES

TABLES

1.0 Introduction

This report summarises the acquisition and processing of data from the GT-1A airborne gravity survey flown by Fugro Airborne Surveys Pty Ltd (FAS) and Canadian Micro Gravity Pty Ltd (CMG).

The survey acquired GT-1A airborne gravimetric data at 2000 metre line spacing, and approximately 20000 metre tie lines spacing over the area depicted in Figure 1.

The total line kilometres acquired (including and excluding 4 km lead-ins and lead-outs respectively) was:

	Include leads	*Exclude leads*
Survey Traverses	4062.9 km	3672.7 km
Survey Tie Lines	501.1 km	441.0 km

In addition, a repeat line was flown 5 times. The total repeat line kilometres acquired (including and excluding approx. 5 km lead-ins and lead-outs respectively) was:

	Include leads	*Exclude leads*
Repeat Lines	104.2 km	54.3 km

In addition two lines were flown to coincide with detailed ground gravity traverses. The total line kilometres (including and excluding 4 km lead-ins and lead-outs respectively) for these lines was:

	Include leads	*Exclude leads*
Cameco Traverses	57.3 km	41.3 km

Line kilometres for the complete job therefore total:

Include leads	*Exclude leads*
4725.5 km	4209.3 km

The GT-1A gravimeter (Berzhitzky et. al., 2002) was developed by JSC STC Gravimetric Technology of Moscow, Russia (GT) with funding assistance from, firstly, World Geoscience Corporation, and subsequently from Fugro Airborne Surveys. CMG has an exclusive marketing arrangement with GT and supplies the system worldwide.

The GT-1A is a small, lightweight "INS-GPS" system that is operated independently from any other equipment carried by a fixed wing survey aircraft.

The GT-1A is differentiated from existing, commercially available total field gravimeters by :-

- Its small size and weight and low power requirement;
- Its ease of operation, with no on-board operator required;
- A vertically constrained accelerometer which minimises cross-coupling, allowing measurements during turns and thus providing short lead-ins for survey lines;
- Dual dynamic ranges of +/- 500 Gals and +/- 250 Gals, respectively, allowing high quality data to be collected even in moderate turbulence;
- Monitoring of variations in the geometry of the gravimeter and the GPS antenna;
- Advanced data processing routines that remove the effects of changes in the system geometry.

It is the system's ability to operate in a broad range of conditions with high levels of productivity that makes the GT-1A unique.

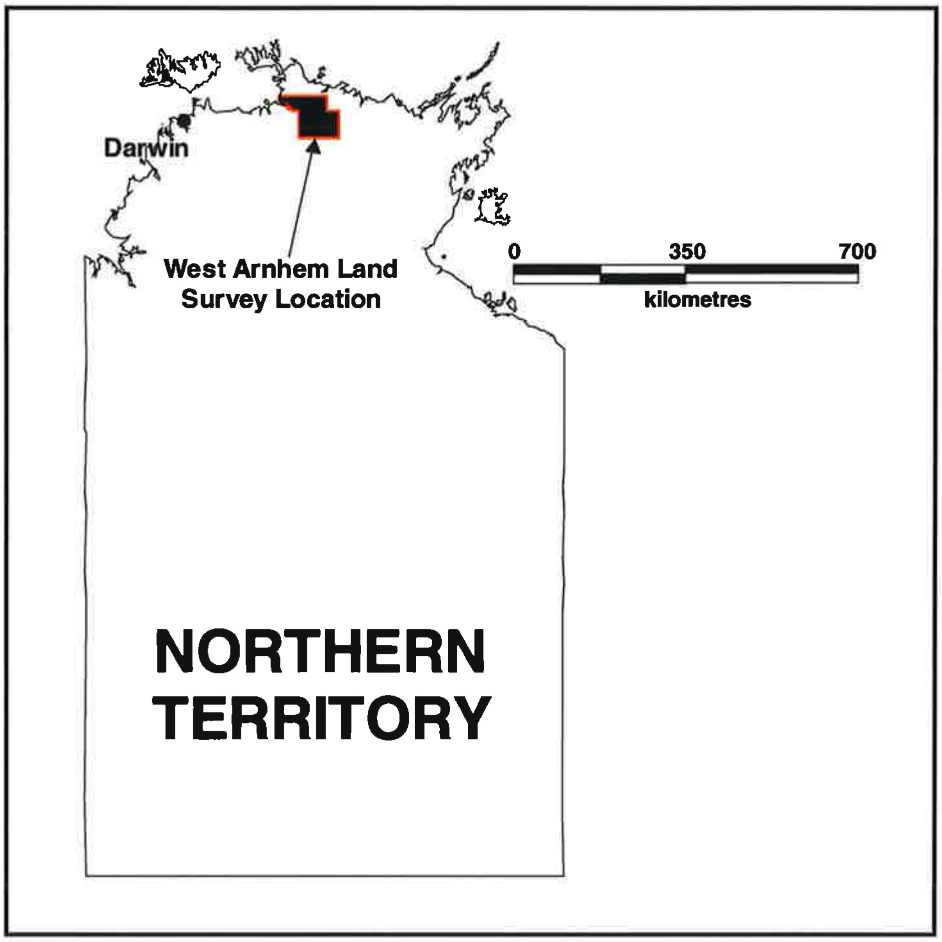


Figure 1: Location of Survey Area

2.0 Project Crew

The following personnel were employed on this project:

Field Operations

Crew Leader/Mag operator	Wayne Hewison (FAS)
Pilot	Jamie Day (FAS)
GT-1A Operator	Andy Gabell (CMG)
GT-1A Data Processor	Helen Tuckett (CMG)

Base Operations

Project Manager	Rod Pullin (FAS)
Data Processing	Helen Tuckett (CMG)
	Andy Gabell (CMG)

3.0 Summary of Survey Parameters

3.1. Survey Area Parameters

Traverse line spacing	2,000 m
Traverse line direction	090 – 270 degrees
Tie line spacing	~20,000 m
Tie line direction	000 – 180 degrees
Total Line km	4169.7 km (excluding lead in/lead out)
Flying height	655 metres above sea level (constant barometric altitude)

3.2. Flight Plan

The flight plan for the survey is in Appendix I.

3.3. Job Safety Plan

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

Part of this plan required the ground crew to monitor the aircraft movement during acquisition flights using the Omnistar Flight Following System. Logs are included in Appendix II.

3.4. Daily Activity Report

A report of daily activity covering the dates 27th August 2003 to 15th September 2003 may be found in Appendix III. The report covers production figures, flight duration and times, and estimates of wind speed and direction for each flight. Metadata for the survey appears in Appendix IV.

4.0 Airborne Data Acquisition Equipment and Specifications

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

4.1. Survey Aircraft

An Aerocommander Shrike 500 S, registration VH-EXS was used for this survey.

4.2. GT-1A Mobile Gravimeter System

Appendix V provides the Equipment log used by CMG for this survey.

Specifications of the GT-1A Mobile Gravimeter are:

Measurement range	9.76 to 9.84 m/s^2
Dynamic range	
a) fine channel	± 0.25 g
b) coarse channel	± 0.5 g
Drift over 24 hours	< 5 mGal
Drift over 24 hours (corrected)	< 0.03 mGal
Measurement error (RMS) for 12 hours (static mode)	
a) fine channel	0.2 to 0.3 mGal
b) coarse channel	0.3 o 0.5 mGal
Scale factor measurement accuracy	10^{-4}
Ultimate angles:	
a) roll	±45°
b) pitch	±45°
Latitude measurement range	75° S to 75° N
Operating ambient temperature	+5°C to +50° C
Permissable vibration level over frequency range 5 - 35 Hz	0.2 g
Power consumption	
a) operating mode	150 W
b) stand-by economy mode (temp. control)	50 W
c) stand-by mode	145 W
Weight	110 kg
Dimensions	Ø 600 x 920 mm H
Service life	30,000 hours

Gravimetric anomaly evaluation error (RMS) under the following conditions:

- vertical accelerations up to 0.5 g;

- proper gravimeter and GPS antennae installation on the aircraft and at the base station;
- use of dual frequency GPS receivers with a data acquisition rate of at least 2 Hz;
- visibility of more than 6 satellites;
- PDOP not more than 2.5;
- GPS base line length less than 50 km:

a) over bandwidth of 0.01 Hz	0.6 mGal
b) over bandwidth of 0.0125 Hz	1.0 mGal

System readiness time:

a) from cold start	48 hrs
b) from stand-by economy mode	10hrs
c) from stand-by mode	2hrs

4.2.1. GT-1A Control and Display Unit (CDU) and Logging Computer

The GT-1A CDU is a rugged computer with IBM PC architecture.

The CDU executes a proprietary program for system control, data acquisition and recording. Control commands are provided to the GT-1A microprocessor via menu commands.

The CDU displays information on the main screen during system operation. The operator initiates data recording prior to take-off. An LED, connected to the CDU, is mounted in the cockpit and indicates whether the data being collected are within acceptable limits, or not. Once data acquisition and recording are initiated the system runs automatically until manually interrupted - it is therefore not necessary for an operator to accompany the instrument during a flight.

4.2.2. Uninterruptable Power Supply (UPS)

Ground power (240 V AC) is supplied to the gravimeter via the UPS, which also acts as a transformer and coverts AC power to 27 V DC. The UPS also provides backup power from internally mounted gel-cell batteries for up to 15 minutes in the case of a power failure.

4.2.3. Power distribution Board

The power distribution board accepts power that originates either from the 240 V AC supply (converted to DC in the UPS) or from the aircraft bus via a connection to the Picodas 1000A power console. The power is then reticulated to the GT-1A gravimeter, the CDU, and the dual frequency GPS receiver.

4.2.4. Dual Frequency GPS

The gravimeter measures total accelerations - a combination of inertial and gravity accelerations. In order to separate gravity accelerations from the total, an Ashtech Z-Surveyor dual frequency GPS was initially used to record raw GPS data at a frequency of 2 HZ. This receiver was replaced on 3/9/03 with an Ashtech ZXTreme Dual Frequency GPS (see section 5.1 for further details).

The GPS data were post-processed, and the vertical (inertial) acceleration calculated, allowing the gravity acceleration to be derived once the data are integrated with accelerometer data from the gravimeter.

The GPS data were recorded on an internal PCMCIA format disk, however data are also provided to the gravimeter microprocessor in real time for system timing and synchronisation, and to assist with real-time control of the inertially stabilised platform in which the gravity sensing element is housed. This GPS is completely independent from the GPS system used for aircraft navigation.

4.3. Navigation and Ancillary Data System

4.3.1. PDAS 1000 Survey Computer

The SURVEY computer is a PICODAS PDAS 1000 data acquisition system based on IBM PC architecture.

The SURVEY computer executes a proprietary survey program for data acquisition and recording. Data is 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 displayed on-line to assist in quality control.

4.3.2. PDAS 1000A Interface

A PDAS 1000A power console is used in conjunction with the PDAS 1000 survey computer. The console contains power supplies for providing regulated power to instruments such as the cesium and fluxgate magnetometers, humidity, temperature, and barometric pressure transducers. It also provides interconnection to all analogue signals.

4.3.3. GPS Receiver

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

4.3.4. Differential GPS Demodulator

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

4.3.5. Picodas PNAV 2001 Navigation Computer

The 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 interlocked 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.

4.3.6. Radar Altimeter

A King KRA-405 radar altimeter is used for determining absolute altitude. The altimeter outputs a voltage proportional to height above terrain and has a single scale for the indicated height. This signal is available to a dashboard analog indicator for the pilot, and to the PDAS 1000 computer for display and recording.

4.3.7. Barometric Altimeter

Output of a Digiquartz pressure 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.

4.4. Data Recorded by the GT-1A Mobile Gravimeter System

Raw gravimeter data are recorded on the CDU as "**G**-" and "**S**-" Files.

Raw GPS data are recorded on a PCMCIA format disk, internal to the Ashtech dual frequency GPS receiver.

See Appendix VI for details of data formats of the GT-1A and GPS files.

5.0 Ground Data Acquisition Equipment

The ground data acquisition equipment used on this project consisted of the following systems:

5.1. GPS Base Stations

The primary GPS base station initially consisted of an Ashtech Z-Surveyor dual frequency GPS receiver, powered by 12 V battery. The backup base station was initially a Trimble 4000SSi Dual Frequency GPS, powered by a 12 V battery. Both antennae for the GPS base stations were located in a clear area within the bounds of the Jabiru airport.

However, a number of difficulties were encountered with both the rover and primary base GPS receivers. As a hardware fault was suspected, two new Ashtech ZXTreme Dual Frequency GPS receivers were shipped to the survey base, arriving on 2/9/03. On 3/9/03 one of the ZXTreme receivers was installed in the aircraft as the rover, and the second was installed as the primary base. The Z-Surveyor receiver that had been used as the rover was installed as the backup base.

The second Z-Surveyor (the original primary base) was returned to the supplier for fault diagnosis, while the Trimble was not used again.

Two faults were identified by the supplier. First the PCMCIA format data cards used in the Ashtechs were found to be the incorrect type. This resulted in difficulty downloading the data directly from the cards after insertion into a PCMCIA slot in the processing computer. As a precaution, all GPS data were therefore downloaded with the cards still inserted in the receiver - a much slower process. However, while some problems were still encountered, it at least proved possible to recover the data.

The second problem identified was a short in the GPS data cable. While this also resulted in intermittent data download problems, the major impact was encountered after re-formatting the data cards. On most occasions the short caused a loss of information in the receiver memory, necessitating the receivers to be initialised the next day, with all parameters needing to be reset.

The primary GPS base station antenna position was calibrated by submitting data recorded between 20.16.00 (2003-08-30) and 01:41:59 (2003-08-31) to the AUSPOS online GPS Processing Service offered by the National Mapping Division (formerly AUSLIG) of Geoscience Australia.

See Appendix XV for reports of AUSPOS GPS processing.

The calculated base GPS antenna position was:

Geodetic, GRS80 Ellipsoid, GDA94

Latitude	-12° 39' 30.8467"
Longitude	132° 53' 41.1623"
Height	82.996m
Height above Geoid	27.940m

The RMS for the data recorded on 2003-08-30 was 0.0052m, and for the data recorded on 2003-08-31 it was 0.0059m.

6.0 Gravimeter Calibrations And Monitoring

6.1. GT-1A Reference Measurements

At the beginning and end of each survey flight, the aircraft was parked at the same, marked, location (the "reference location") and a gravimeter reference measurement of at least 15 minutes duration was recorded. The position of the Gravity Sensing Element (GSE) when the aircraft is parked at the reference location, is referred to as "the reference point".

The calculated position of the aircraft GPS antenna when parked at the reference location was:

Geodetic, GRS80 Ellipsoid, GDA94

Latitude	-12° 39' 33.9028"
Longitude	132° 53' 34.3098"
Height	81.896m
Height above Geoid	26.850m

The RMS for these data recorded on 2003-08-29 was 0.0096m.

The GPS antenna was located 0.88m above the Gravity Sensing Element (GSE), which was, in turn, located 1.02m above the tarmac.

This position was marked with a metal spike driven into the tarmac to allow the reference point to be tied in to the Fundamental Gravity Network at a later time. Appendix VII provides additional details of the reference point.

The pre- and post-flight reference data are used by program Gravigal to correct for in-flight gravimeter drift. There is no need to correct for drift between flights, as the relative free air anomaly is assumed to be equal to zero at the reference point by the post processing software. Thus the instrument is effectively reset for each flight.

The reference data also give an indication of the stability of the instrument over the period of the survey. These data are presented in Appendix VIII.

Note: Temperatures during the day rose as high as 38°C. The aircraft was parked on the airport tarmac in the sun. Although the doors were left open to promote air circulation, temperatures inside the cabin were likely to have significantly exceeded 50°C, the upper limit specified for operation of the GT-1A. While the gravimeter itself did not indicate overheating, from 6/9/03 onwards an audible, high temperature warning was active on the CDU each afternoon. On most days the CDU was simply rebooted and the warning ceased, and the gravimeter's key parameters all stayed within specifications. However on 8/9/03 one parameter (kdr - the Fibre Optic Gyro, or FOG, drift) exceeded specifications. The flight was undertaken, and acceptable data resulted. However, as the parameter did not return to within specified limits following the flight, the gravimeter's auto-calibration procedure was run that evening. Flights 1 to 8 and Flights 9 to 14 were therefore acquired with different calibration settings. The large variation is ambient temperature is likely to have affected the drift rate of the instrument. In future operations air will be circulated through the aircraft cabin to alleviate this problem.

6.2. Conversion from Relative to Absolute Gravity

The observed gravity reading at the ground 1.02m below the GT-1A sensor's reference position, is 978300.066mGal (9783000.66μms^{-2}). The ground reading needs to be corrected for the 1.02m difference in vertical position between the tarmac and the reference point. The free air correction of 0.30764mGal/m (3.0764μms^{-2}/m) was used to estimate the adjustment required. The corrected value for the 1.02m offset is therefore 978299.752mGal (9782997.52 μms^{-2}). This value has been tied to the Fundamental Gravity Network, and is therefore the absolute observed gravity value for the reference point.

The GT-1A data processing stream produces free air gravity anomalies relative to the reference point. It uses the Helmert equation for calculation of normal gravity, and a free air correction of 0.30764mGal/m (3.0764μms^{-2}/m).

The relative free air anomalies in the survey area were corrected to absolute free air anomalies, relative to the ellipsoid, by subtraction of 61.143mGal (611.43μms^{-2}) from each value. Appendix IX contains a more detailed consideration of conversion from relative to absolute gravity.

6.3. Repeat Line 9999

The southern 20 kms of Tie Line 9003 was identified as the location for the repeat line in order to help establish the repeatability of the complete acquisition and processing system. The repeat line was flown, on average, every third flight, in total, 5 repeat lines were flown during the duration of the survey. The repeat line data was processed in the same manner as the survey lines. This aspect of the survey is dealt with in section 7.2.2.7.

7.0 Data Processing

7.1 Field Data Processing Equipment

Two laptop computers were used in the field processing centre for the purpose of data retrieval from the aircraft, quality control checks on the acquired data and in-field data processing. Software consisted of the commercial products GrafNav and Geosoft in addition to proprietary CMG software. Section 7.2.3 covers the data processing software in more detail.

7.2. Field Data Processing - Quality Control

7.2.1 Navigation Tolerance

Due to the wide line spacing and broad spatial resolution of the GT-1A gravimeter the off-line navigation tolerance is not the most critical element of the survey. In fact, because it helps keep aircraft accelerations to a minimum it is usually preferable to allow the autopilot to control all aircraft manoeuvres, even if it means straying off-line.

Fill-in flight lines or tie lines were required where they are more than 10% of the line spacing (200 m) off course over a continuous distance of 1,000 m or more, and where the deviation can be considered significant enough to affect the final data quality. No lines were rejected using this criterion.

The most critical aspect of a gravity survey is maintenance of altitude. The mean GPS altitude was 712.00m (range 694.82m to 738.71m), with a standard deviation for the entire survey of 7.07m.

7.2.2. Gravimeter Data

The data processing sequence to produce the relative free air gravity anomaly is shown in Figure 2.

The processing sequence produces a large number of parameters. The parameters listed in the following sections are the most reliable indicators of data quality, and were examined on a daily basis as the data from each flight were processed. Where the value of a parameter exceeded its nominal value a symbol was plotted on a flight plan at the correct geographical location. All out-of specification parameters were placed on the same plot. The plot was then examined to determine whether such readings occurred on line, or outside the survey boundary. Where the occurrence was outside the survey boundary, the value was ignored. Where the occurrence occurred on line, this was noted, but unless multiple parameters were out of specification the data were not rejected.

The files and parameters checked were as follows:

7.2.2.1. C-File (GPS position file output from GrafNav)

Parameters examined, and their nominal specifications were:

- SVs > 6 — The number of satellites used in processing the current epoch
- PDOP < 2.5 — The position dilution of precision.
- RMS < 1.0 — L1 Root Mean Square

7.2.2.2. Phase_L1.dat (Differential velocity files output from GTQC12)

Parameters examined, and their nominal specifications were:

- RMS Velocity < 0.05 — Root Mean Square of Velocity Differential Solution.
- Type = 1 — Differential Phase Velocity Solution Flag, Type = 1 indicates an acceptable solution.

7.2.2.3. E-File (INS file output from GTQC12)

Parameters examined, and their nominal specifications were:

- Alpha 1 < 0.0011636 radians — Estimate of gyro platform x axis misalignment errors
- Alpha 2 < 0.0011636 radians — Estimate of gyro platform y axis misalignment errors

7.2.2.4. Acc-G-File (Gravimeter data file output from GTQC20)

Parameters examined were:

- Fine channel saturations No saturations=0, Saturations=1
- Coarse channel saturations — No saturations=0, Saturations=1

Acceptable gravity data can still be recovered on a line where the gravimeter's dynamic range has been exceeded. However the quality of the resulting output depends on both the number of times the instrument has saturated, and the distribution of the saturations along line.

In the West Arnhem Land survey the number of fine channel saturations along line were generally sufficient to render the fine channel data no better than the coarse channel data. So much coarse channel data needed to be substituted where the fine channel had saturated that the resultant data was equivalent to coarse channel data on most flights. The fine channel data were therefore not used.

The number of coarse channel saturations was the most common reason for scrubbing a line.

7.2.2.5. RMS errors of gravity anomaly calculations (from Program Gravigal)

Both the peak-to-peak and RMS residual errors are calculated by CMG's proprietary program Gravigal when the gravity anomaly is modelled. For a single line if less than 10% of the data exhibits peak-to-peak errors of more than 6,000 mGal*sec, and an RMS error of less than 1500 mGal*sec, then the result is considered to be acceptable. This is one of the more definitive tests of data quality.

The West Arnhem Land data has lines with RMS errors ranging from 386.14 to 3087.00 mGal*sec. However only three lines, 1015.0, 1041.0 and 1043.0 had RMS errors exceeding 1000 mGal*sec. (Note: this excludes segments of two lines affected by bush fires where the resultant errors were much higher).

Even lines with a significant number of coarse channel saturations did not necessarily result in large RMS residual errors. This indicates that acceptable gravity anomalies may still be recovered from data with a large number of saturations. However while the gravity anomaly can be recovered, the greater the number of saturations, the more likely it is that the data have been "over-smoothed" by the Kalman filter.

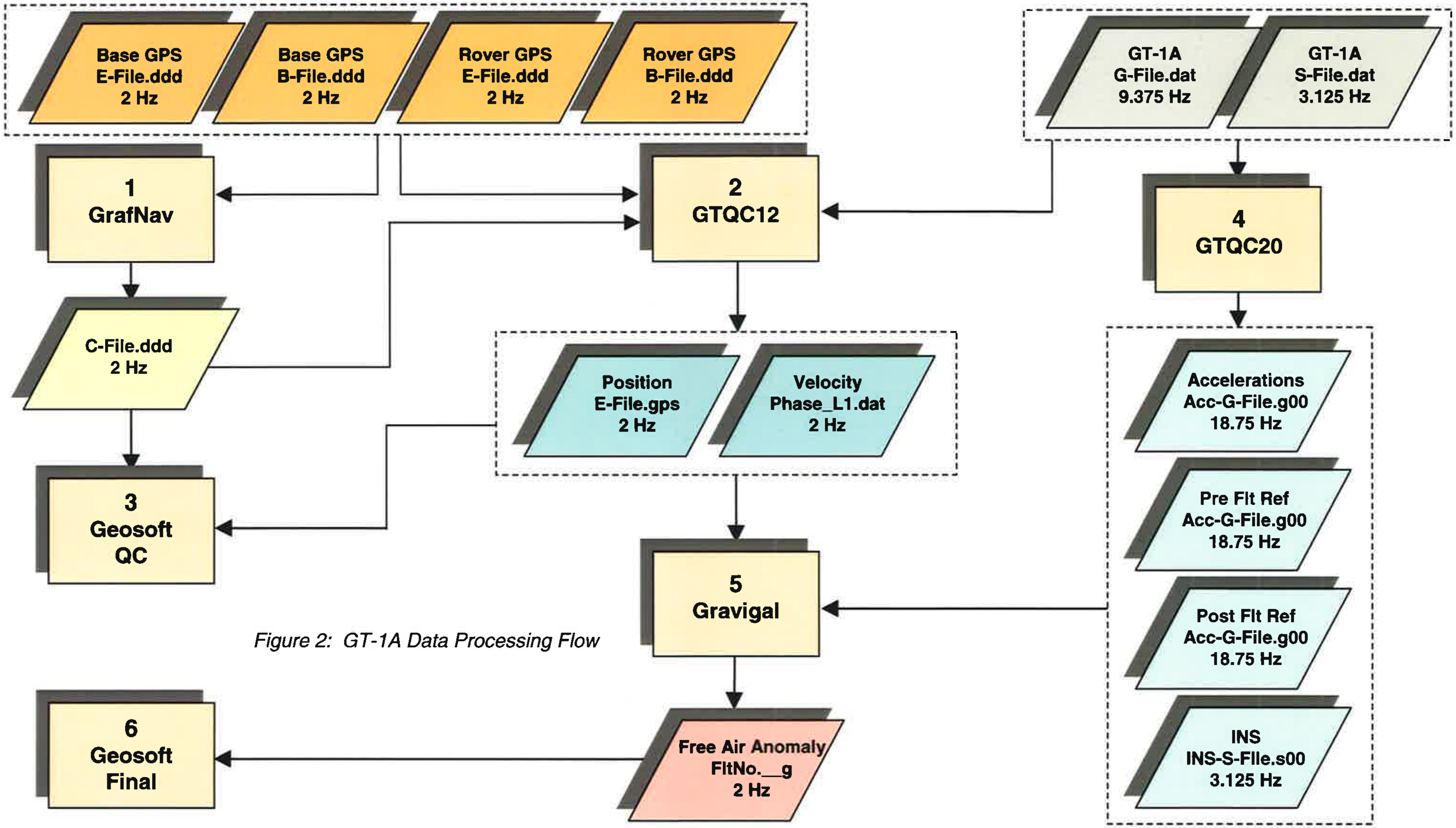


Figure 2: GT-1A Data Processing Flow

7.2.2.6. QC Estimates of Raw Channel Cross-over Errors

The final QC test was examination of the raw data cross-over value. The data were corrected only for intra-flight drift using reference measurements. The cross-over values were generated, on a daily basis, using Geosoft. Only 107 second data were analysed for cross-over errors.

The errors were estimated in the field by calculating the standard deviation of each cross-over, then calculating the mean of these standard deviations for each line. The average standard deviation for each accepted line for Flights 1 to 8 ranged between 0.34 and 1.64 mGal. The average of the line averages for these flights was 0.94 mGal. The cross-over errors for flights 9 to 14 (following instrument recalibration) were generally higher, with an average of all lines of 2.24mGal.

Section 7.3.4 discusses cross-over error analysis in more detail.

7.2.2.7. Procedure to Accept or Scrub Lines

As this project was limited by the number of flying hours available, the QC strategy was consequently slightly different from normal. The QC checks described in sections 7.2.2.1 to 7.2.2.7 were used to decide whether a line should be accepted or placed on a list of possible scrubs.

For Flights 1 to 8 the RMS error from Gravigal, the number of coarse channel saturations and the raw cross-over errors were all given equal weight in ranking the quality of the data. The repeat line rms errors were also examined to provide an idea of the instrument stability.

For Flights 9 to 14 less weight was given to the raw cross-over errors, given that the instrument had been re-calibrated, and there was some uncertainty regarding the effect of this.

Once data had been acquired on every line re-flights were started, with the worst lines being re-flown first. Ultimately the factor that weighed most heavily was the number of coarse channel saturations, given that too many coarse channel saturations results in "over-smoothing" of the data. Accepted lines all had less than 40 coarse channels saturations.

Appendix X contains a summary of the QC parameter values for the entire survey. Intersection statistics are provided in Appendix XI.

7.2.2.8. QC Estimate of Errors for Repeat Line 9999

The repeat line was processed in the same manner as survey flight lines, with the same QC parameters being checked. The Repeat line QC summary appears in Appendix XII.

These lines were trimmed to exclude everything except the middle 10 km of the line, they were resampled (and re-oriented if necessary) so that all data samples coincided as closely as possible.

For QC purposes, the errors of (only) the 107 second filtered data were then estimated using the following method. Line 9999.0 was used as the "reference" line. The mean of this line was subtracted from each reading along the line. Each subsequent line also had its own mean subtracted from each reading. The difference between each "normalised" reading on Line 9999.0 and the line to which it was being compared was calculated. The standard deviation of the differences was calculated, and multiplied by $1/\sqrt{2}$. The results appear in Table 1 below.

Table 1: QC Repeat Line 9999 Error estimate (mGal)

9999.0	9999.1	9999.2	9999.3	9999.4
0.000	0.348	0.723	0.494	0.164

7.3. Final Data Processing

Figure 2 shows the gravity data processing sequence. In-field QC produces in-flight drift-corrected relative free air Δg from program Gravigal. This stage of processing was iterated a number of times in the office to refine calculation of the free air gravity anomaly. The filter length (107 second, 80 seconds or 60 seconds) is set in the Gravigal program.

The data were then imported to Geosoft Oasis Montaj for further processing.

7.3.1 Program Gravigal

This program models the free air gravity anomaly, and includes the following corrections:

a) Static correction based on pre-flight and post-flight reference measurements to remove drift within each flight;
b) Eotvos correction = $-v_x^2 * \cos\Phi / ((r+h)\cos\Phi - 2 * 0.00007292115 * \cos\Phi * v_x - v_y^2 / (r+h)$, where Φ is the latitude of the aircraft, vx and vy are the velocities of the aircraft in the x (north) and y (east) directions, r is the Earth's radius at the latitude Φ, and h is the altitude of the aircraft above the WGS84 ellipsoid;
c) Subtraction of Theoretical Gravity. The Russian processing software uses the "Helmert" system for gravity reduction. Theoretical, or normal, gravity = $g_n = [9.78030 * ((1 + 0.005302 * \sin^2\Phi) - (0.000007 * \sin^2 2\Phi)) - 0.00014] * 100{,}000]$, where Φ is the latitude of the aircraft in radians, and the result is in milligals;
d) Free air correction, again using a formula accepted in Russia, $g_{fa} = 0.30764$ h, where h is height of the aircraft in metres and the result is in milligals;
e) Note that the Gravigal software assumes that the free air anomaly at the reference point is zero - the data produced for survey lines are therefore Free Air anomalies relative to this Reference Point, and with respect to the ellipsoid.

7.3.2 Geosoft

The reference equations specified for the contract were the 1967 International Gravity Formula, and a free air correction using the full formula expressed as a vertical gradient (see Appendix XIII for details of the specified formulae). This required the free air data output from Gravigal to be converted back to observed gravity, then re-calculation of the free air anomaly using the specified set of equations.

The following processes were applied in the Geosoft environment:

f) Earth tide correction using a modified Geosoft GX;
g) Levelling correction, based on cross-over values;
h) Proprietary 2D noise reduction filter;
i) Conversion of the free air anomaly data to gravity units ($\mu m/sec^2$)
j) Conversion to absolute free air anomalies by adding an offset of 611.43 $\mu m/sec^2$ - determined by a gravity measurement at the reference point;
k) Derivation of the equivalent of "observed gravity" by reversal of the free air correction, $g_{ob} = g_{fa} + g_n - 0.30764*h$, where h is height of the aircraft in metres. Note that this step uses the Helmert equations as detailed above;
l) Calculation of the height of each reading relative to the geoid by subtraction of the NValue for each point from the GPS height;
m) Calculation of the absolute free air anomaly using the following equations:
  - $g_n = 9{,}780{,}318.456 * (1 + 0.005\,278\,895 * \sin^2\Phi + 0.000\,023\,462 * \sin^4\Phi)$ where the result is in gravity units;
  - $g_{fa} = (3.08768 - 0.00440 * \sin^2\Phi) * h - 0.000\,001\,442 * h^2$ where the result is in gravity units.

n) Subtraction of minor noise from the free air anomaly (standard deviation ~ 0.07$\mu m/sec^2$ - the noise is introduced by the unfiltered height term in the free air correction formula);
o) Back calculation of observed gravity;
p) Calculation of the "normalised" Bouguer correction $GC_{bN} = 0.4191$ * ground elevation (in metres). Note the density is set to one. A high resolution Digital Elevation Model (supplied by Geoscience Australia) was used in this process;

q) Filtering of the normalised Bouguer correction - this was done in two steps - a 1D filter matching the Gravigal Kalman filter length (107, 80 or 60 seconds), and a 2D noise removal algorithm as originally applied to the gravity data. This process was undertaken to "match" the frequency content of the free air anomaly data, and the Bouguer correction;

r) Calculation of the Bullard (earth curvature) correction using the formula:
   - g_{BULL} = ((1.464 * (Terrain height/1000)) - (0.3533 * (Terrain height/1,000)^2) + (0.000045 * (Terrain / 1,000)^3)) * 10 (the result being in gravity units), and subsequent application of the same filtering process described in q) above;

s) Calculation of a normalised terrain correction (this was done using a terrain correction supplied by Intrepid Geophysics under contract to Canadian Micro Gravity, as the Geosoft program does not allow terrain corrections to be calculated for measurement positions located above the terrain height), and subsequent application of the same filtering process described in q);

t) Calculation of Bouguer corrections for densities of 2.54g/cm^3 and 2.67g/cm^3 by multiplying the normalised Bouguer correction by 2.54 and 2.67, respectively;

u) Calculation of terrain corrections for densities of 2.54g/cm^3 and 2.67g/cm^3 by multiplying the normalised terrain correction by 2.54 and 2.67, respectively;

v) Calculation of the simple Bouguer anomaly (g_{Bsim}) for densities 2.54 and 2.67 using the formula $g_{Bsim} = g_{fa}$ - Bouguer correction - Bullard correction;

w) Calculation of the complete Bouguer anomaly (g_{Bcom}) for densities 2.54 and 2.67 using the formula $g_{Bcom} = g_{Bsim}$ + terrain correction.

Modification of the standard earth tide correction (as used for ground gravity surveys) was necessary because this correction was applied to the airborne data after drift corrections had been applied - in other words in a different order to that used for ground gravity surveys. Where the earth tide correction was linear, or almost linear, the GT-1A drift correction would already account for earth tide effects. However if the earth tide correction was non-linear, then the non-linear component was not accounted for by the drift correction, and a correction was applied.

Appendix IX discusses in more detail the conversion of data from the relative free air anomalies using the Helmert equations to absolute data in the IGSN71 framework.

The 107 second, 80 second and 60 second Final Absolute Free Air Anomaly and Final Absolute Complete Bouguer Anomaly grids are shown in Figures 3 to 8.

7.3.3 60 and 80 Second Filtered Data

The 60 and 80 second data were processed exactly the same way as the 107 second filtered data. However, the 2D noise removal algorithm works well only when the line spacing is significantly closer than the half-width of the filtered data. The 60 second data, with a half-width of 2.1 km, matches the line spacing too closely for the algorithm to work well, and artifacts perpendicular to the line direction are introduced. Based on this, and other data collected with the GT-1A, the minimum filter length should generally be 80 seconds. In the case where a line spacing of 1 km or less is used, shorter filter lengths may produce acceptable data.

7.3.4 Final Estimate of RMS Errors for Repeat Line 9999

In addition to using the repeat line in the field a second method was used to estimate noise in the office. This method is outlined in Green and Lane (2003), and should be a more robust estimate of noise. In addition to a noise estimate for each line, an overall noise estimate for all lines is produced. Note that the same data were used to calculate the results shown in Tables 1 and 2 - only the method to estimate rms errors is different.

Table 2: Final Repeat Line 9999 Error estimate (mGal) - Method II

9999.0	9999.1	9999.2	9999.3	9999.4	Overall
0.166	0.550	0.898	0.332	0.377	0.526

The results presented in Table 2 are considered to be the best estimates of the noise present in the repeat lines.

7.3.5 Estimate of RMS Errors of Cross-overs

Cross-over errors for the survey data were again analysed in the office.

Both raw cross-over errors, and cross-over errors following removal of DC offsets and slopes (first-order levelling), and cross-over errors following full levelling and noise removal were examined.

The latter two are likely to be a better indicators of data quality, because there are a number of factors that can produce offsets and slopes (possibly including recalibration of the instrument, changes in the GPS satellite constellation during the survey, and GPS multipath). These can be adequately corrected by the levelling process, and will therefore have no effect on the final data quality.

Cross-over noise was estimated using the following method:

- Calculation of the standard deviation of all cross-over differences;
- Multiplication of this number by $1/\sqrt{2}$ (to distribute the error between the line and the tie line);
- The average of the RMS error of cross-overs for each line were also calculated.

This method is a more robust estimate of noise than the method applied in the field.

The RMS error of raw data for individual lines calculated using this method ranged from 5.48 to 42.23 $\mu msec^{-2}$. The RMS error for all cross-overs was 21.70 $\mu msec^{-2}$ and the average of the RMS error for all lines was 13.81 $\mu msec^{-2}$.

For data that had zero and first order levelling applied, the RMS error for individual lines ranged from zero to 26.40 $\mu msec^{-2}$. The RMS error for all cross-overs was10.3 $\mu msec^{-2}$, and the average of the RMS error for all lines was 9.8 $\mu msec^{-2}$.

For final data the RMS error for individual lines ranged from 0.76 to 9.75 $\mu msec^{-2}$. The RMS error for all cross-overs was 3.67 $\mu msec^{-2}$, and the average of the RMS error for all lines was 2.64 $\mu msec^{-2}$. See Appendix XI for further details.

7.3.6 Cameco Lines

In addition to the survey and repeat lines, data were acquired over two short lines where Cameco had detailed ground traverses. The "Cameco" data were processed using the same methods applied to the survey lines.

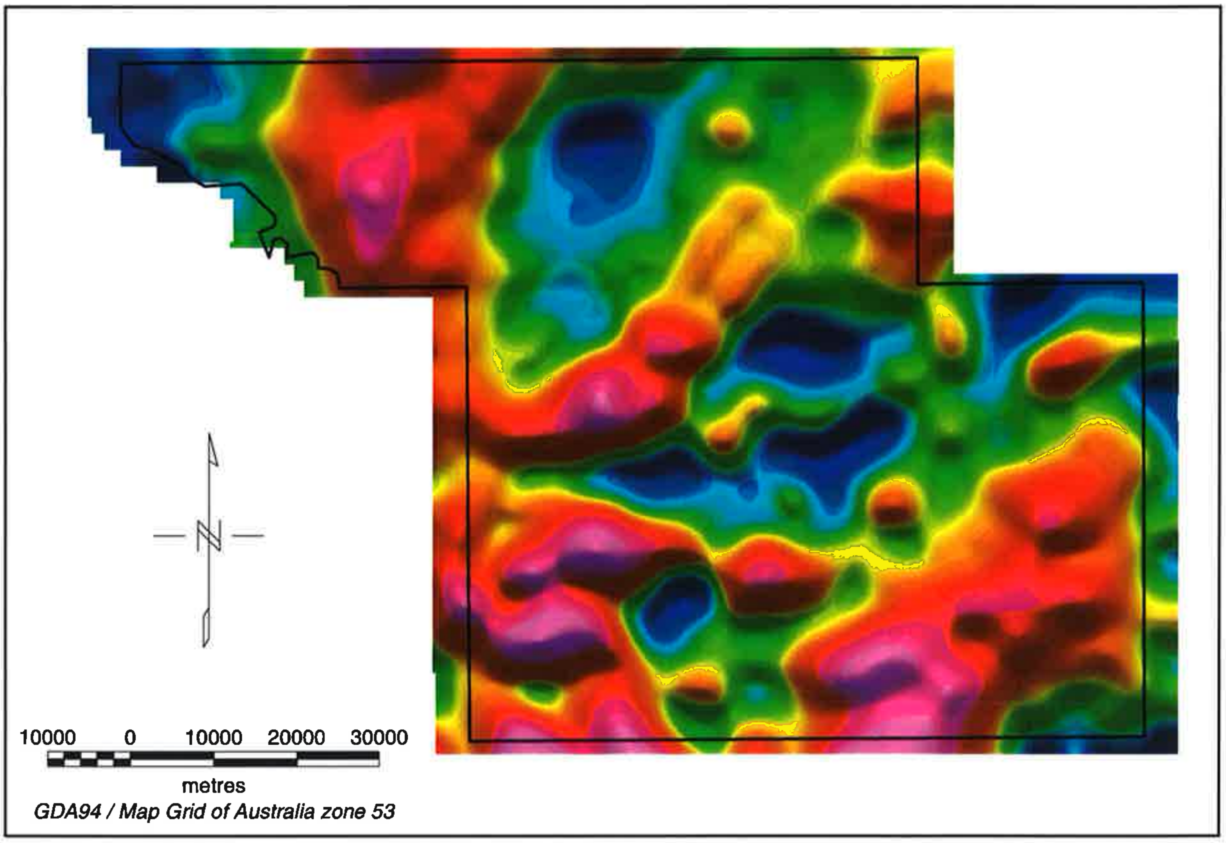


Figure 3: Final Absolute Free Air Anomaly - 107 second (3.7 km) filter
(Map shading - inclination = 45°, declination = 0°)

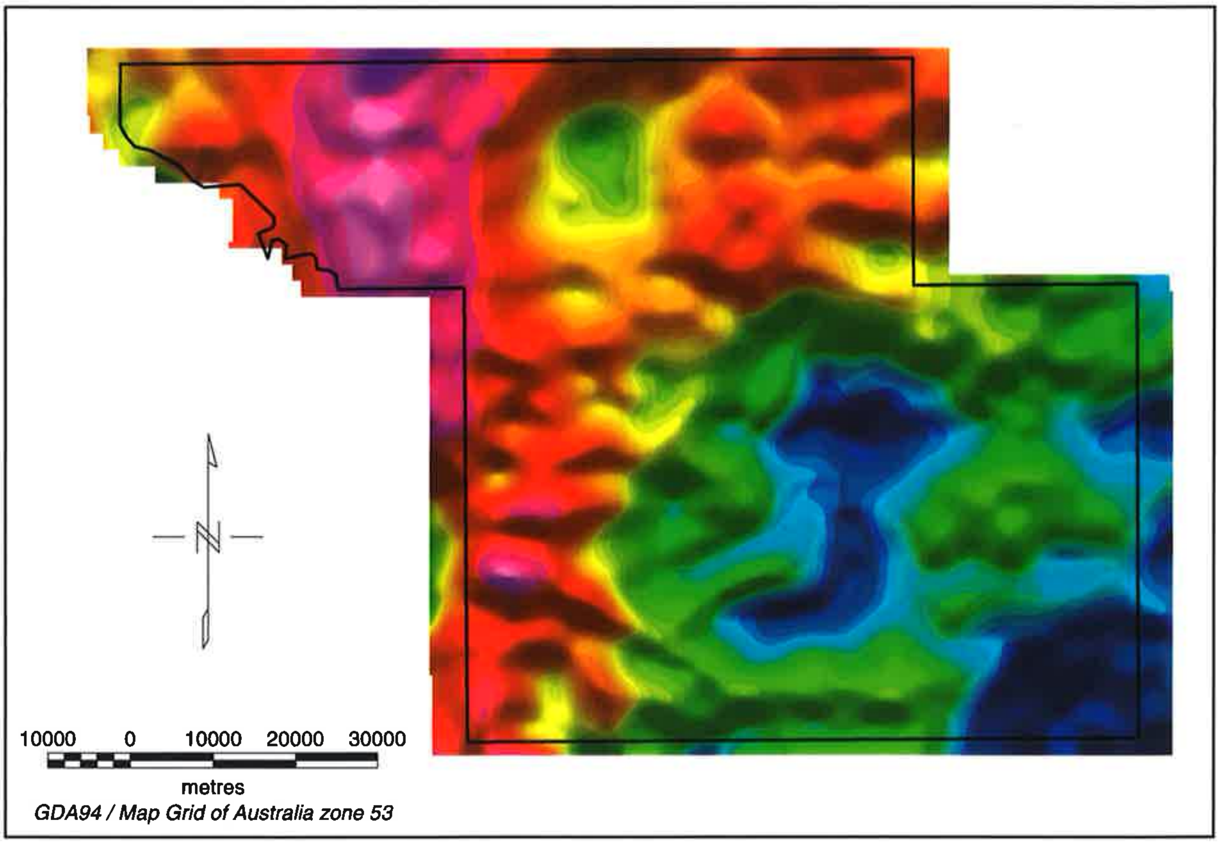


Figure 4: Final Absolute Complete Bouger Anomaly (Density=2.67) - 107 second (3.7 km) filter
(Map shading - inclination = 45°, declination = 0°)

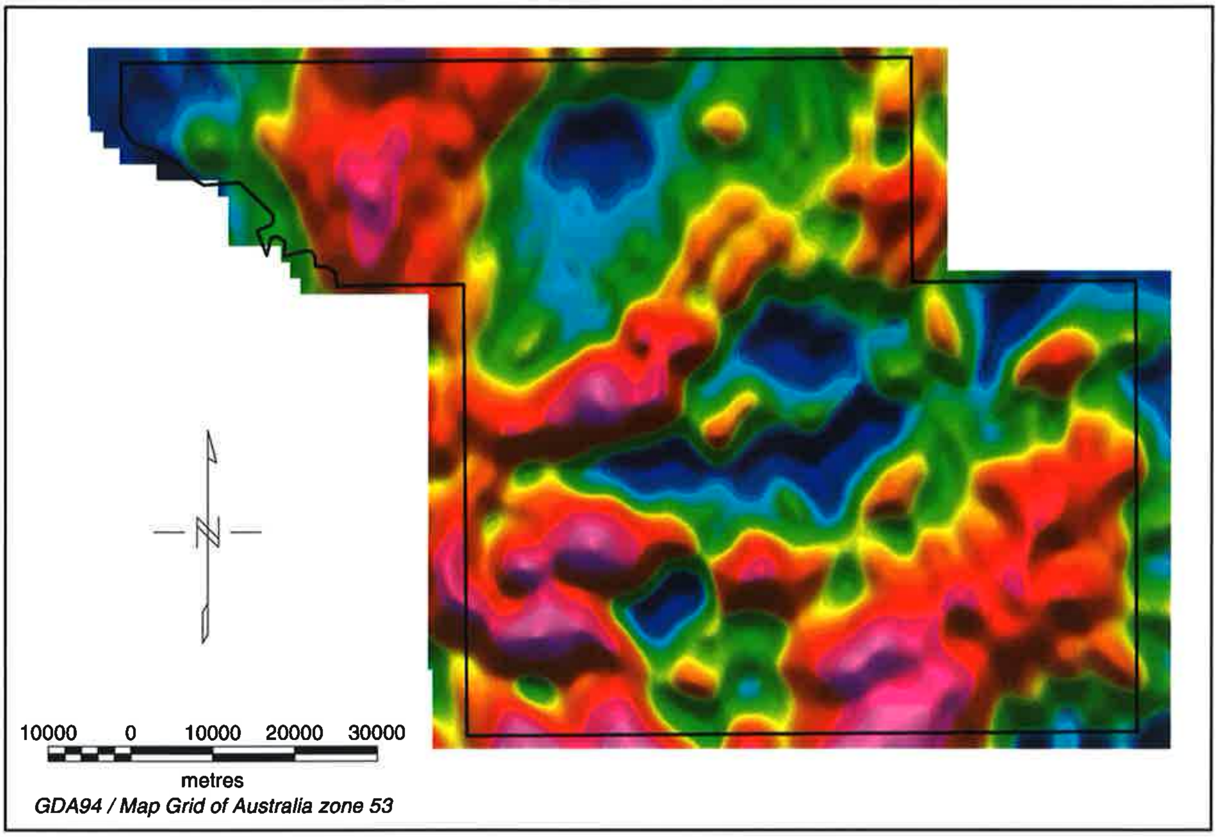


Figure 5: Final Absolute Free Air Anomaly - 80 second (2.8 km) filter
(Map shading – inclination = 45°, declination = 0°)

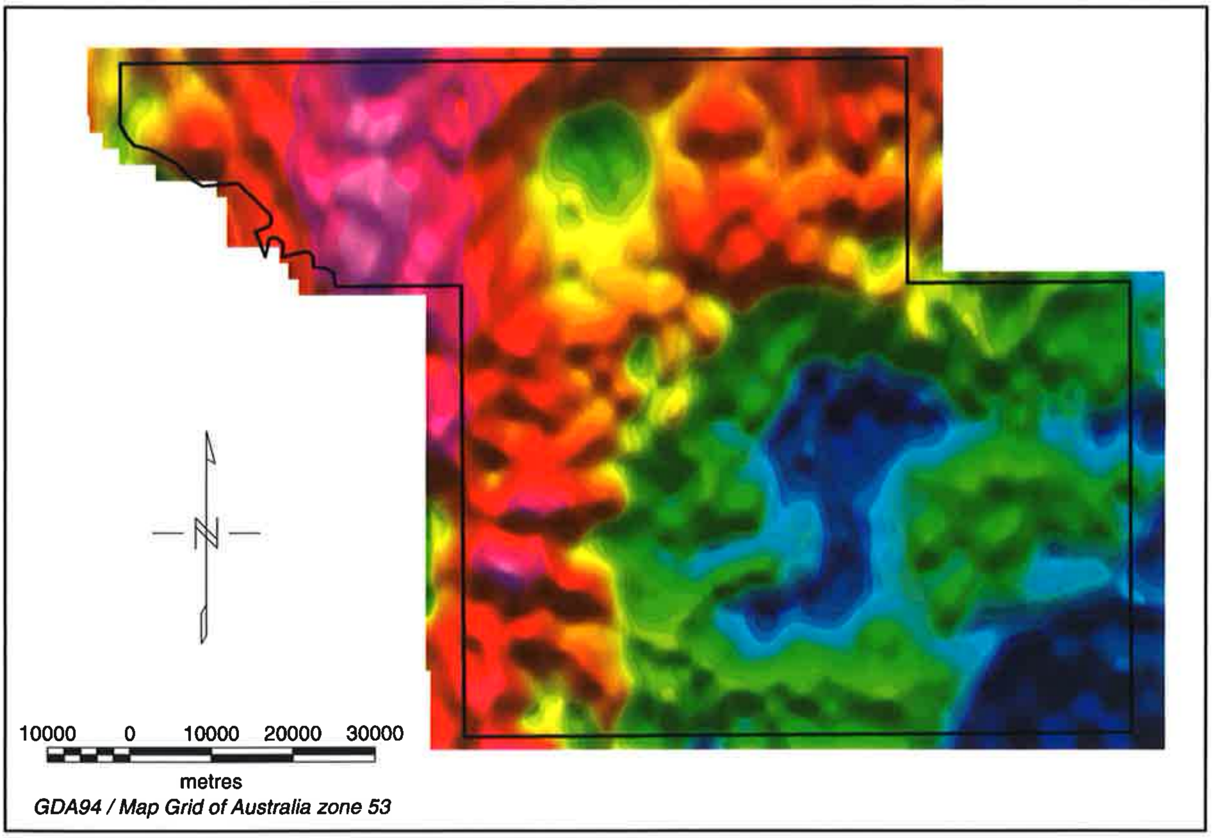


Figure 6: Final Absolute Complete Bouger Anomaly (Density=2.67) - 80 second (2.8 km) filter
(Map shading – inclination = 45°, declination = 0°)

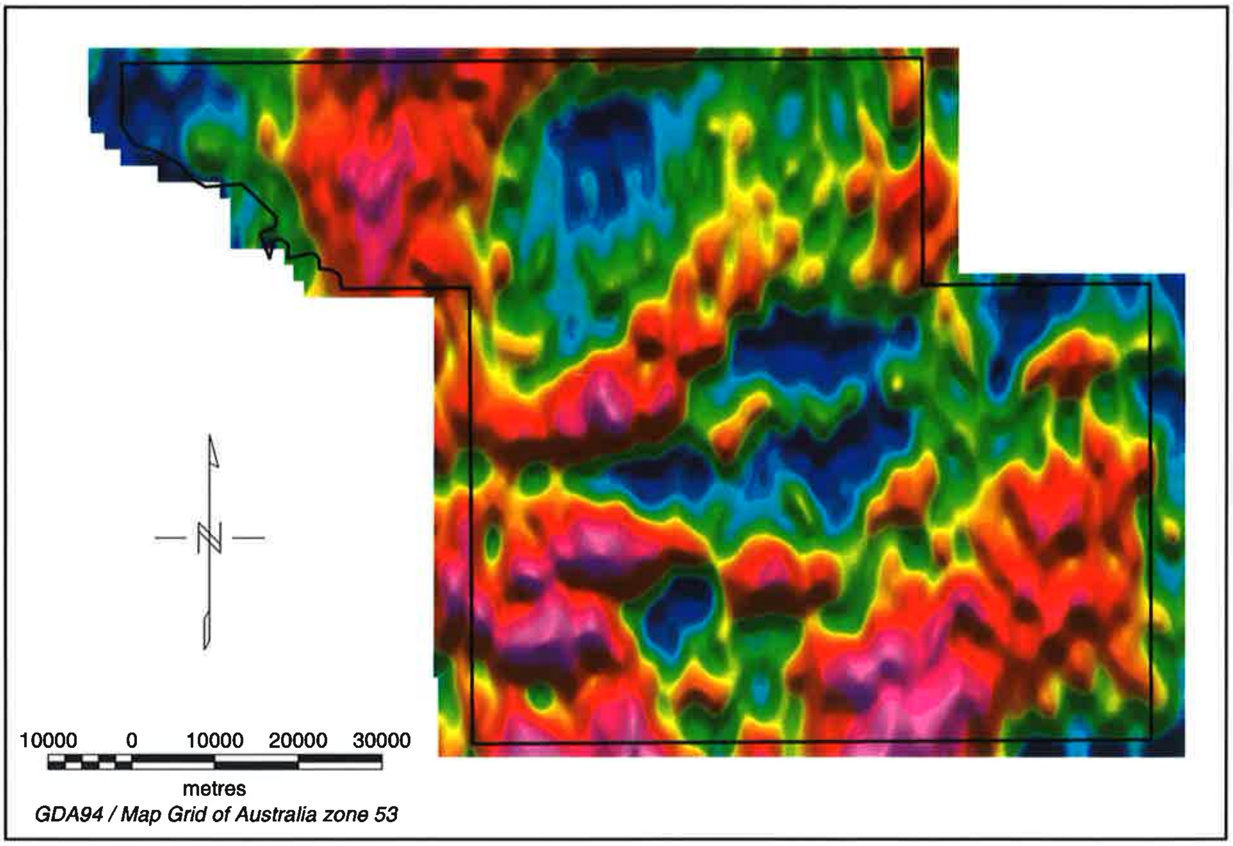


Figure 7: Final Absolute Free Air Anomaly - 60 second (2.1 km) filter
(Map shading – inclination = 45°, declination = 0°)

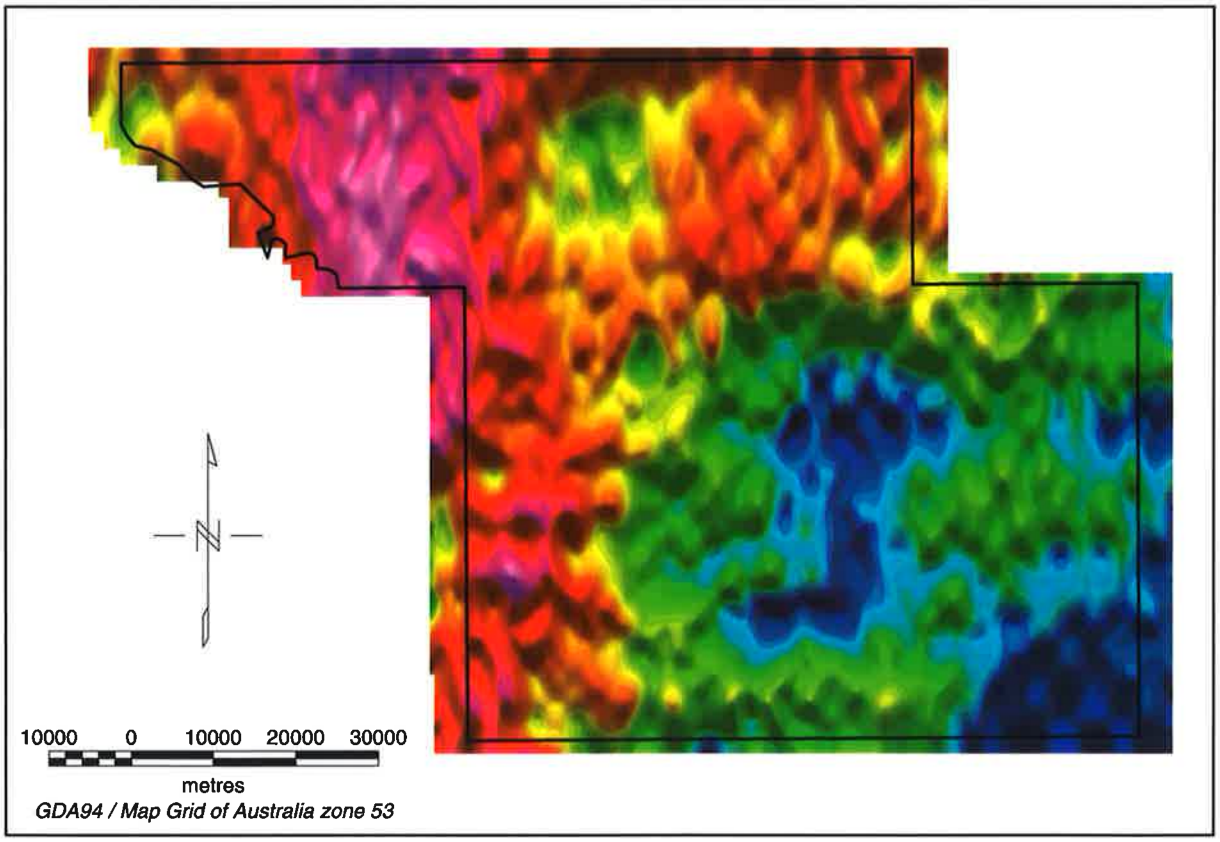


Figure 8: Final Absolute Complete Bouger Anomaly (Density=2.67) - 60 second (2.1 km) filter
(Map shading – inclination = 45°, declination = 0°)

7.3.7 Final Delivered Products

Final data are provided as ASCII line data files, ERMapper grids and Geosoft binary grids on CDROM.

The formats of the ASCII line data files are described in Appendix XIV.

Details of the final line data files delivered are shown in Table 3 below.

Table 3: Description of Final Line Data Files

Line Data File Name	Data Type	Description
FinalData107.xyz	ASCII	Final Survey Line Data - 107 second (3.7 km) filter
FinalData080.xyz	ASCII	Final Survey Line Data - 80 second (2.8 km) filter
FinalData060.xyz	ASCII	Final Survey Line Data - 60 second (2.1 km) filter
CamecoData.xyz	ASCII	Final Cameco Line Data - 107, 80 & 60 second filters
RepeatLine.xyz	ASCII	Repeat Line Data - 107 second (3.7 km) filter

Details of the final grids delivered are shown in Table 4 below.

Table 4: Description of Final Grid Files

Fig. No.	Grid Name	Units	Cell Size	Grid Type	Description
3	FAabs107.ers FAabs107 FAabs107.grd	 μms^{-2}** μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Free Air Anomaly - 107 second (3.7 km) filter
4	BA107com267.ers BA107com267 BA107com267.grd	 μms^{-2} μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Complete Bouger Anomaly (Density=2.67) - 107 second (3.7 km) filter
5	FAabs80.ers FAabs80 FAabs80.grd	 μms^{-2} μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Free Air Anomaly - 80 second (2.8 km) filter
6	BA80com267.ers BA80com267 BA80com267.grd	 μms^{-2} μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Complete Bouger Anomaly (Density=2.67) - 80 second (2.8 km) filter
7	FAabs60.ers FAabs60 FAabs60.grd	 μms^{-2} μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Free Air Anomaly - 60 second (2.1 km) filter
8	BA60com267.ers BA60com267 BA60com267.grd	 μms^{-2} μms^{-2}	 400m 400m	ERMapper Header ERMapper Grid Geosoft Binary Grid	Final Absolute Complete Bouger Anomaly (Density=2.67) - 60 second (2.1 km) filter

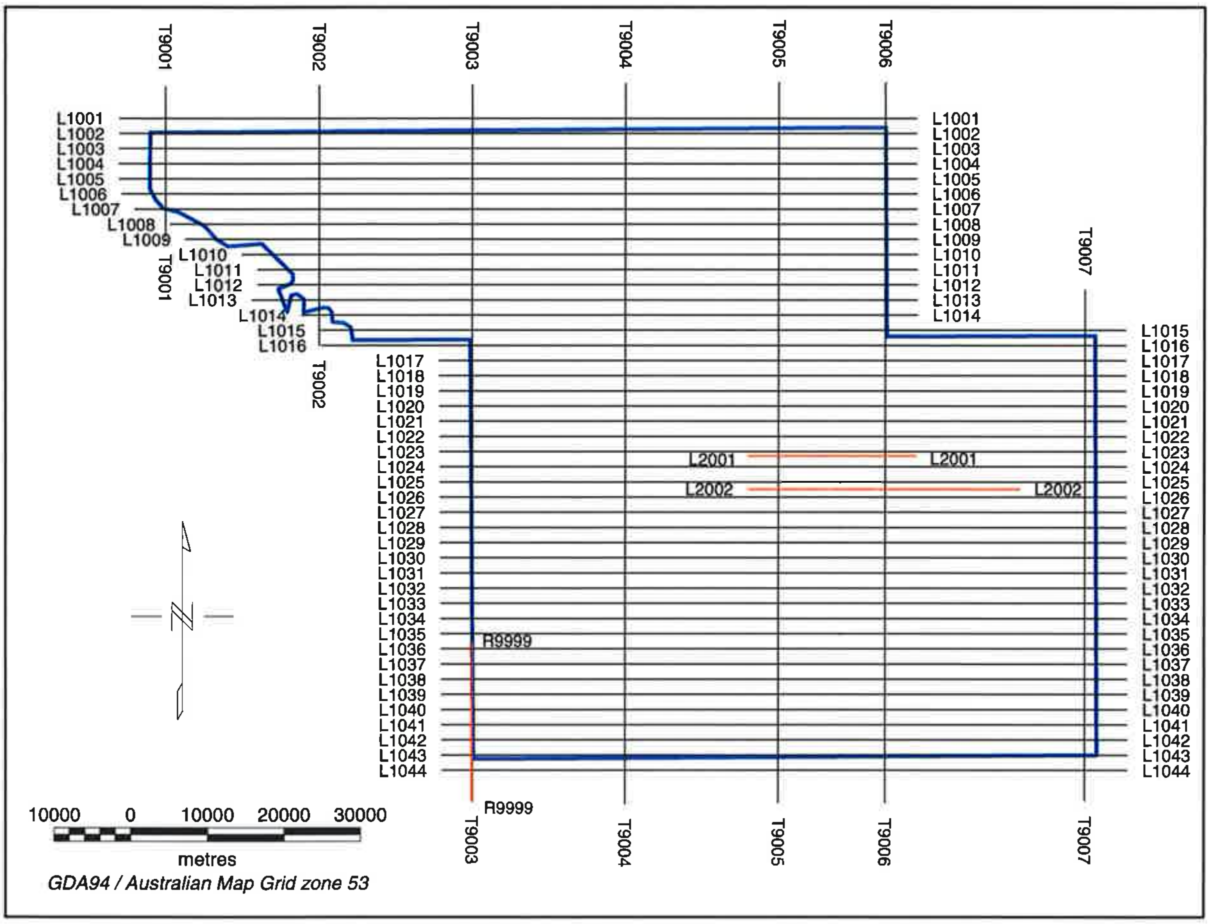
** Where 1 μms^{-2} = 0.1 mGal

References

Berzhitzky, V. N., Bolotin, Y. V., Golovan, A. A., Ilyin, V. N., Parusnikov, N. V., Smoller, Y. L., and Yurist, S. S, 2002. GT-1A Inertial Gravimeter System - Results of Flight Tests. Report by Z A O Scientific and Technological Enterprise Gravimetric Technologies and Lomonosov Moscow State University Faculty of Mechanics and Mathematics.

Green, A., and Lane, R., 2003. Estimating Noise Levels in AEM Data. Extended Abstract, ASEG 16th Geophysical Conference and Exhibition, February 2003, Adelaide.

Appendix I - Flight Planned Lines



Note: Line R9999 (Red) is the location of the repeat line.
Lines L2001 and L2002 are the Cameco traverses.

Appendix II - Omnistar Flight Following Logs

Omnistar Flight Following Log - 30th August 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	29/08/2003	10:00:56 pm	11° 46' 50.99" S	132° 52' 00.84" E	250 °	280 Km/Hour	none
10002100	29/08/2003	10:29:55 pm	11° 54' 07.99" S	132° 33' 11.88" E	235 °	280 Km/Hour	none
10002100	29/08/2003	10:50:16 pm	11° 59' 12.01" S	133° 08' 48.84" E	090 °	240 Km/Hour	none
10002100	29/08/2003	11:26:16 pm	12° 44' 28.00" S	133° 44' 08.88" E	180 °	250 Km/Hour	none
10002100	29/08/2003	11:59:25 pm	12° 40' 50.02" S	132° 53' 52.08" E	015 °	250 Km/Hour	none

Omnistar Flight Following Log - 31st August 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	30/08/2003	10:04:05 pm	12° 24' 50.00" S	133° 29' 51.00" E	000 °	240 Km/Hour	none
10002100	30/08/2003	10:32:55 pm	12° 02' 30.98" S	133° 16' 22.08" E	270 °	250 Km/Hour	none
10002100	30/08/2003	11:02:15 pm	12° 00' 10.01" S	132° 47' 30.12" E	090 °	240 Km/Hour	none
10002100	30/08/2003	11:37:55 pm	12° 03' 34.99" S	133° 09' 56.88" E	270 °	240 Km/Hour	none
10002100	30/08/2003	11:54:55 pm	12° 03' 16.99" S	132° 34' 13.08" E	270 °	250 Km/Hour	none
10002100	31/08/2003	12:26:15 am	12° 02' 01.00" S	133° 36' 45.00" E	120 °	220 Km/Hour	none
10002100	31/08/2003	12:58:05 am	12° 09' 55.01" S	132° 34' 50.88" E	145 °	270 Km/Hour	none

Omnistar Flight Following Log - 1st September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	01/09/2003	08:20:35 am	12° 43' 36.01" S	133° 49' 14.88" E	255 °	270 Km/Hour	none
10002100	01/09/2003	08:22:45 am	12° 43' 53.00" S	133° 44' 33.00" E	270 °	250 Km/Hour	Panic BDF
10002100	01/09/2003	08:24:15 am	12° 43' 54.01" S	133° 40' 01.92" E	270 °	250 Km/Hour	none
10002100	01/09/2003	08:25:55 am	12° 43' 50.02" S	133° 35' 24.00" E	270 °	250 Km/Hour	none
10002100	01/09/2003	08:28:25 am	12° 43' 50.02" S	133° 30' 42.84" E	270 °	260 Km/Hour	none
10002100	01/09/2003	08:30:05 am	12° 43' 50.02" S	133° 26' 34.08" E	270 °	270 Km/Hour	Panic BDF
10002100	01/09/2003	08:32:15 am	12° 43' 45.01" S	133° 21' 18.00" E	270 °	250 Km/Hour	Panic BDF
10002100	01/09/2003	08:34:15 am	12° 43' 44.00" S	133° 16' 50.88" E	270 °	240 Km/Hour	none
10002100	01/09/2003	08:36:25 am	12° 43' 43.00" S	133° 11' 53.88" E	270 °	260 Km/Hour	none
10002100	01/09/2003	08:38:15 am	12° 43' 41.02" S	133° 07' 46.92" E	270 °	250 Km/Hour	none
10002100	01/09/2003	08:40:45 am	12° 43' 36.98" S	133° 03' 06.12" E	270 °	250 Km/Hour	none

Omnistar Flight Following Log - 2nd September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	01/09/2003	10:04:05 pm	12° 04' 39.00" S	133° 08' 49.92" E	270 °	260 Km/Hour	none
10002100	01/09/2003	10:25:35 pm	12° 07' 41.02" S	132° 43' 59.88" E	090 °	230 Km/Hour	none
10002100	01/09/2003	11:02:05 pm	12° 05' 44.02" S	133° 08' 45.96" E	270 °	270 Km/Hour	none
10002100	01/09/2003	11:54:55 pm	12° 21' 07.99" S	133° 21' 01.08" E	240 °	310 Km/Hour	none

Omnistar Flight Following Log - 3rd September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	02/09/2003	09:59:05 pm	12° 00' 24.01" S	133° 23' 02.04" E	090 °	230 Km/Hour	none
10002100	02/09/2003	10:25:35 pm	12° 02' 20.00" S	132° 48' 11.88" E	270 °	260 Km/Hour	none
10002100	02/09/2003	11:03:16 pm	12° 02' 22.99" S	133° 34' 40.08" E	160 °	220 Km/Hour	none
10002100	02/09/2003	11:32:45 pm	12° 39' 29.02" S	132° 53' 47.04" E	275 °	020 Km/Hour	none

Omnistar Flight Following Log - 4th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	03/09/2003	10:02:55 pm	12° 10' 10.99" S	133° 30' 11.88" E	270 °	270 Km/Hour	none
10002100	03/09/2003	10:20:25 pm	12° 09' 56.02" S	132° 53' 45.96" E	270 °	240 Km/Hour	none
10002100	03/09/2003	11:05:06 pm	12° 11' 07.01" S	133° 04' 36.12" E	270 °	250 Km/Hour	none
10002100	03/09/2003	11:42:35 pm	12° 14' 35.99" S	133° 33' 12.96" E	090 °	250 Km/Hour	none
10002100	04/09/2003	12:22:45 am	12° 23' 48.01" S	132° 47' 39.12" E	155 °	280 Km/Hour	none

Omnistar Flight Following Log - 8th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	07/09/2003	10:11:15 pm	12° 36' 43.99" S	133° 50' 21.12" E	300 °	240 Km/Hour	none
10002100	07/09/2003	10:48:06 pm	12° 38' 21.01" S	133° 20' 24.00" E	090 °	250 Km/Hour	none
10002100	07/09/2003	11:29:05 pm	12° 34' 53.00" S	132° 53' 57.12" E	270 °	250 Km/Hour	none
10002100	08/09/2003	12:22:05 am	12° 37' 59.99" S	132° 53' 11.04" E	260 °	230 Km/Hour	none

Omnistar Flight Following Log - 9th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	08/09/2003	10:02:05 pm	12° 25' 14.99" S	133° 22' 09.84" E	180 °	240 Km/Hour	none
10002100	08/09/2003	10:32:26 pm	12° 15' 38.99" S	133° 29' 54.96" E	000 °	250 Km/Hour	none
10002100	08/09/2003	11:07:05 pm	12° 05' 21.01" S	132° 49' 23.16" E	215 °	250 Km/Hour	none
10002100	08/09/2003	11:16:56 pm	12° 15' 24.01" S	132° 56' 54.96" E	090 °	240 Km/Hour	none
10002100	08/09/2003	11:16:56 pm	12° 15' 24.01" S	132° 56' 54.96" E	090 °	240 Km/Hour	none

Omnistar Flight Following Log - 10th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	09/09/2003	09:59:45 pm	12° 19' 23.99" S	133° 50' 26.88" E	245 °	240 Km/Hour	none
10002100	09/09/2003	10:26:25 pm	12° 17' 44.02" S	132° 55' 12.00" E	075 °	220 Km/Hour	none
10002100	09/09/2003	11:06:15 pm	12° 20' 57.98" S	133° 16' 36.84" E	270 °	250 Km/Hour	none
10002100	09/09/2003	11:30:05 pm	12° 28' 32.02" S	133° 15' 05.04" E	090 °	250 Km/Hour	none
10002100	09/09/2003	11:56:56 pm	12° 31' 52.00" S	133° 28' 28.92" E	270 °	250 Km/Hour	none

Omnistar Flight Following Log - 11th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	10/09/2003	10:07:55 pm	12° 23' 02.00" S	133° 07' 01.92" E	090 °	250 Km/Hour	none
10002100	10/09/2003	10:41:56 pm	12° 26' 24.00" S	133° 16' 49.80" E	270 °	260 Km/Hour	none

Omnistar Flight Following Log - 12th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	11/09/2003	10:00:55 pm	12° 15' 54.00" S	133° 44' 17.16" E	000 °	250 Km/Hour	none
10002100	11/09/2003	10:33:05 pm	12° 14' 13.99" S	132° 46' 55.92" E	090 °	240 Km/Hour	none
10002100	11/09/2003	11:04:55 pm	12° 18' 56.02" S	133° 47' 31.92" E	270 °	260 Km/Hour	none
10002100	11/09/2003	11:13:45 pm	12° 18' 47.02" S	133° 19' 45.12" E	270 °	260 Km/Hour	none

Omnistar Flight Following Log - 13th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	12/09/2003	10:02:35 pm	12° 33' 04.00" S	133° 47' 36.96" E	270 °	250 Km/Hour	none
10002100	12/09/2003	10:24:25 pm	12° 32' 46.00" S	132° 59' 26.16" E	270 °	250 Km/Hour	none
10002100	12/09/2003	11:05:25 pm	12° 33' 58.00" S	133° 14' 47.04" E	270 °	250 Km/Hour	none
10002100	12/09/2003	11:32:05 pm	12° 37' 19.99" S	133° 32' 04.92" E	090 °	250 Km/Hour	none
10002100	12/09/2003	11:59:05 pm	12° 45' 52.99" S	133° 16' 19.92" E	265 °	250 Km/Hour	none

Omnistar Flight Following Log - 15th September 2003

ID	GPS Date	GPS Time	Latitude	Longitude	Brg	Speed	Alerts
10002100	14/09/2003	10:02:35 pm	12° 24' 27.00" S	132° 54' 02.88" E	040 °	270 Km/Hour	none
10002100	14/09/2003	10:33:45 pm	12° 25' 53.00" S	133° 30' 38.16" E	270 °	260 Km/Hour	none
10002100	14/09/2003	11:04:16 pm	12° 44' 57.01" S	133° 39' 06.12" E	270 °	250 Km/Hour	none
10002100	14/09/2003	11:36:36 pm	12° 45' 56.02" S	133° 16' 45.84" E	090 °	250 Km/Hour	none
10002100	14/09/2003	11:58:55 pm	12° 43' 00.98" S	133° 24' 54.00" E	275 °	270 Km/Hour	none

Appendix III - Summary of Daily Activity

Flight No.	Date	AM/PM	Wind Spd/Dir	QNH	Flight Start Time (Local)	Flight End Time (Local)	Total Flight Hours Flown	Kms/Hour	Repeat Line Kms	Cameco Line Kms	Survey Kms Flown	Survey Kms Scrub	Survey Kms Accepted
-	27-Aug-03	Aircraft VH-EXS and pilot (Jamie Day) mobilised Kununurra to Jabiru.											
-	28-Aug-03	Crew (Wayne Hewison, Andy Gabell, Helen Tuckett) mobilised Darwin to Jabiru. Gravimeter restart & calibration due to loss of AC ground power at airport for 3 hours during previous night.											
-	29-Aug-03	Gravimeter warming up after restart and calibration. Battery backup ground power organised. Contacted all local Aviation operators, local police and all other relevant parties regarding flight operations. Set up GPS Bases.											
1	30-Aug-03	AM	15kt/084	1015	6:44	9:28	2.73	157.64	20.84	0.00	409.51	156.75	252.76
2	30-Aug-03	PM	-	1010	15:59	17:06	1.12	159.75	0.00	0.00	178.92	178.92	0.00
3	31-Aug-03	AM	10kt/050	1014	6:25	10:37	4.20	167.62	0.00	0.00	704.00	614.53	89.47
4	01-Sep-03	PM	15kt/078	1010	17:03	18:29	1.43	139.70	20.84	0.00	178.94	0.00	178.94
5	02-Sep-03	AM	25kt/130	1015	6:27	9:34	3.12	155.97	0.00	0.00	486.61	88.12	398.49
6	03-Sep-03	AM	30kt/130	1015	6:40	8:55	2.25	138.61	0.00	0.00	311.88	58.00	253.88
7	04-Sep-03	AM	30kt/135	1016	6:35	9:55	3.33	164.74	0.00	0.00	548.60	105.14	443.46
-	05-Sep-03	PDO - Pilot Day Off											
-	06-Sep-03	Aircraft magneto found unserviceable during Pre-flight check. Mobilisation of aircraft engineer from Perth arranged.											
-	07-Sep-03	Aircraft engineer arrived pm, magneto changed.											
8	08-Sep-03	AM	7kt/120	1014	6:42	9:48	3.10	179.95	20.84	0.00	537.00	179.01	357.99
9	09-Sep-03	AM	12kt/050	1014	6:29	9:40	3.18	169.03	0.00	0.00	537.53	89.60	447.93
10	10-Sep-03	AM	10kt/150	1014	6:30	9:37	3.12	178.95	20.84	0.00	537.49	179.08	358.42
11	11-Sep-03	AM	12kt/120	1013	6:25	9:09	2.73	196.85	0.00	0.00	537.41	89.57	447.84
12	12-Sep-03	AM	-	1013	6:25	8:58	2.55	172.40	0.00	0.00	439.63	0.00	439.63
13	13-Sep-03	AM	-	1012	6:32	10:31	3.98	140.18	20.84	0.00	537.06	89.45	447.61
-	14-Sep-03	PDO - Pilot Day Off											
14	15-Sep-03	AM	15kt/270	1011	6:28	9:38	3.17	141.18	0.00	57.30	447.55	0.00	447.55
-	15-Sep-03	Aircraft VH-EXS and pilot (Jamie Day) demobilised from Jabiru AM. Crew (Wayne Hewison, Andy Gabell, Helen Tuckett) demobilised from Jabiru PM.											
Total Survey Kilometres			**4563.96**		**Summary Hrs, Kms**		**40.01**	**162.37**	**104.21**	**57.30**	**6392.12**	**1828.17**	**4563.96**
Total Accepted Kms			**4725.46**		**Kilometres to go**		**0.00**						
Total Hours			**40.00**		**Hours to go**		**-0.01**						
Total Kms/Hour rate			**114.10**		**Kms/Hour rate to go**		**0.00**						

Appendix IV - Metadata

Name:	**Project 200380** **West Arnhem Land, Northern Territory** **GT-1A Airborne Gravity Survey**
Start Date:	**27 August 2003**
End Date:	**15 September 2003**
Operators:	**Geoscience Australia** **Northern Territory Geological Survey** **Cameco Australia** **Rio Tinto**
Contractor:	**Fugro Airborne Surveys Pty Ltd** **Canadian Micro Gravity Pty Ltd**
Processors:	**Canadian Micro Gravity Pty Ltd**
Software:	**GPS Processing - GrafNav** **Gravity Processing - GTQC, Gravigal and Geosoft**
Vessel Type:	**Aircraft (fixed wing) VH-EXS, Aerocommander Shrike 500 S**
Geodetic Datum:	**GDA94**
Projection:	**MGA53**
Accuracy:	**10cm or better**
Location Method:	**Post Processed Dual Frequency GPS**
Traverse Spacing:	**2000 metres**
Tie Spacing:	**20000 metres (approx.)**
Traverse Direction:	**090/270 degrees**
Tie Direction:	**000/180 degrees**
Traverse kilometres:	**3672.7**
Tie kilometres:	**441.0**
Total kilometres:	**4113.7**
Height above ground level:	**Constant barometric height 655m above sea level**
West longitude	**132.62 Degrees**
East longitude:	**133.75 Degrees**
North latitude:	**-12.00 Degrees**
South latitude:	**-12.75 Degrees**
Accuracy Gravity:	**5 micrometers per second squared (estimated)**
Gravity Datum:	**IGSN71**
Terrain Correction Computation Method:	**Intrepid Terrain Correction**
Fundamental Gravity Network Ties:	**Jabiru Isogal station 2003 4401** **Pine Creek Isogal station 2003 4402** **Fugro Jabiru Base station 2003 4403**
Equipment Details:	**Gravimetric Technology GT-1A mobile gravimeter s/n:00001** **Ashtech Z-Xtreme and Z-Surveyor Dual Frequency GPS receivers**
Crew:	**Wayne Hewison (FAS) - Crew Leader/Mag operator** **Jamie Day (FAS) - Pilot** **Andy Gabell (CMG) - GT-1A Operator** **Helen Tuckett (CMG) - GT-1A Data Processor**
Any Other Information:	**Approximate Spatial Resolutions (filter half-widths using mean velocity of 69 metres/second)** **107 seconds ≈ 3.7 km** **80 seconds ≈ 2.8 km** **60 seconds ≈ 2.1 km**

Appendix V - Equipment Log

Equipment Model/Description	Function	Manufacturer	Part Number	Serial Number	Country	Faulted	Comments
Z-Surveyor Dual Frequency GPS	Rover GPS	Ashtech	800203-01 E	UZ01453	USA	02/09/03	Hired from SAGEM. Returned to SAGEM 04/7/03 - with suspect hardware fault.
Z-Surveyor Dual Frequency GPS	Base GPS	Ashtech	800203-01 J	UZ01010	USA	-	Hired from SAGEM. Base #1 (Primary) 30/08/03 to 02/09/03. Base #2 (Backup) 03/09/03 to 15/09/03
Trimble 4000SSi Dual Frequency GPS	Base GPS	TrimbleNavigation	24840-11	3605A14279	USA	-	Supplied by Fugro Ground Surveys. Base #2 (Backup) 30/08/03 to 03/09/03.
Trimble L1/L2 Antenna	Base GPS	TrimbleNavigation	22020-00	220046058	USA	-	Supplied by Fugro Ground Surveys. Base #2 (Backup) 30/08/03 to 03/09/03.
Toshiba Satellite Pro 490 XCDT Laptop	Base GPS Logging	Toshiba Corporation	-	58012681	JAPAN		Supplied by Fugro Airborne Surveys. Base #2 (Backup) Logging 30/08/03 to 03/09/03.
ZXTreme Dual Frequency GPS	Rover GPS	Ashtech	800889 Rev.B	ZE120021105	USA	-	Hired from SAGEM. Arrived on site 02/09/03 & used in aircraft from 03/09/03 to 15/09/03.
ZXTreme PDL 450-470 Dual Frequency GPS	Base GPS	Ashtech	800889-02 Rev.B	ZE220021105	USA	-	Hired from SAGEM. Arrived 02/09/03 & used as Base #1 (Primary) 03/09/03 to 15/09/03.
GT-1A Gravimeter	Gravity Data	Gravimetric Technologies	-	0001	RUSSIA	-	Supplied by Canadian Micro Gravity.
Control Display Unit IBM Compatable Industrial Computer	Gravimeter Logging	-	-	AANW3A8P017	-	-	Supplied by Canadian Micro Gravity.
Gravimeter UPS	Power supply	Gravimetric Technologies	-	-	RUSSIA	-	Supplied by Canadian Micro Gravity.
Gravimeter Power Distribution Unit	Power distribution	Gravimetric Technologies	-	-	RUSSIA	-	Supplied by Canadian Micro Gravity.
Toshiba TE2000 Laptop	Data Processing	Toshiba Corporation		4201 9279V	JAPAN	-	Supplied by Fugro Airborne Surveys.

Appendix VI - In-Flight, Intermediate and GPS Data File Formats

GT-1A Gravimetric Sensing Element (GSE) and Accelerometer data file (G-File)

G*(ddhhmm)*.dat — *dd* = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of first record (00-59)

The G-File sample frequency is 9.375Hz.
Each record in the data file contains 18 variables, comma delimited.
Row 1 - Contains date, time, flight, measurement number and Tgg information.
Row 2 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**$TAGRV**	Text	Instrument Identifier
2	**Top**	seconds	Time from initialisation of the gravimeter
3	**Tgps**	hhmmss.ss	Greenwich time received from GPS
4	**Tsynh**	seconds	Time interval (s) from the beginning of the Greenwich second (defined by the sync pulse received from GPS) up to the end of the mentioned interval
5	**Wz**	m/s^2	Average value of the z component of apparent acceleration of the fine channel along the z axis of the azimuth-free coordinate system at the time interval [ti -δτ, ti] (δτ = 16/300 s). A first order aperiodic filter with a time constant of 2 sec is applied
6	**oWz**	m/s^2	Average value of the z component of apparent acceleration of the fine channel along the z axis of the azimuth-free coordinate system averaged over the previous time interval (δτ=16/300 s). A first order aperiodic filter with a time constant of 2 sec is applied
7	**Wzh**	m/s^2	Average value of the z component of apparent acceleration of the coarse channel along the z axis of the azimuth-free coordinate system at the time interval [ti -δτ, ti] (δτ = 16/300 s). A first order aperiodic filter with a time constant of 2 sec is applied
8	**oWzh**	m/s^2	Average value of the z component of apparent acceleration of the coarse channel along the z axis of the azimuth-free coordinate system averaged over the previous time interval (δτ=16/300 s). A first order aperiodic filter with a time constant of 2 sec is applied
9	**Wxa**	m/s^2	Average value of the x component of apparent acceleration along the x axis of the azimuth-free coordinate system at the time interval (δτ=16/300 s)
10	**oWxa**	m/s^2	Average value of the x component of apparent acceleration along the x axis of the azimuth-free coordinate system averaged over the previous time interval [ti -δτ, ti] (δτ = 16/300 s)
11	**Way**	m/s^2	Average value of the y component of apparent acceleration along the y axis of the azimuth-free coordinate system at the time interval (δτ=16/300 s)
12	**oWya**	m/s^2	Average value of the y component of apparent acceleration along the y axis of the azimuth-free coordinate system averaged over the previous time interval [ti -δτ, ti] (δτ = 16/300 s)
13	**Text**		Increments in normalised temperature: External
14	**Tkpl**		Increments in normalised temperature: Gyro-platform
15	**Tkwz**		Increments in normalised temperature: Gravimetric Sensing Element
16	**Tkoe**		Increments in normalized temperature: Gravimetric Sensing Element resistor
17	**Nh**		Number of 1/300s measurements of Wz > 0.25 g (N1 or fine) and Wzh > 0.5g (N2 or coarse) for the previous interval of 1/9 sec. Nh = N1 + (N2 x1000)
18	***Chksum**	-	Asterisk symbol and checksum of 2 characters

GT1-A Gyro Vertical (GV) data file (S-File)

S(*ddhhmm*).dat *dd* = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of first record (00-59)

The S-File sample frequency is 3.125Hz.
Each record in the data file contains 18 variables, comma delimited.
Row 1 - Contains date, time, flight, measurement number and Tgg information.
Row 2 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**$TAINS**	Text	Instrument Identifier
2	**Top**	seconds	Time from initialization of the gravimeter
3	**Tgps**	hhmmss.ss	Greenwich time received from GPS
4	**Tsynh**	seconds	Time interval (s) from the beginning of the Greenwich second (defined by the sync pulse received from GPS) up to the end of the mentioned interval
5	**vxa**	1/s	Values of the normalised projections of the relative angular velocity at current Greenwich time (ti)
6	**vya**	1/s	Values of the normalized projections of the relative angular velocity at current Greenwich time (ti)
7	**qN**	1/s	The value of the North component of absolute angular velocity
8	**Aghk**	radians	The value of the azimuth-free co-ordinate system heading; calculated clockwise
9	**C**	radians	The value of the azimuth angle between the instrument and the azimuth-free co-ordinate systems; calculated clockwise
10	**dvxa**	1/s	Value of the corresponding normalised damping signals
11	**dvya**	1/s	Value of the corresponding normalised damping signals
12	**tdp**	$1/s^2$	Value of the corresponding damping algorithm estimations
13	**tdq**	$1/s^2$	Value of the corresponding damping algorithm estimations
14	**Dux**	radians	Value of the x rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Dux values correspond to aircraft (pitch) nose up.
15	**Duy**	radians	Value of the y rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Duy values correspond to aircraft (roll) left wing up.
16	**Duz**	radians	Value of the z rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Duz values correspond to aircraft rotating (yaw) anti-clockwise.
17	**SY**		Equipment status and data readiness in hex-format
18	***Chksum**	-	Asterisk symbol and checksum of 2 characters

Variable SY bit descriptions:

Bit	Physical Meaning
0	Tilt about X axis > 10^{o}
1	Tilt about Y axis > 10^{o}
2	GSE is out of norm
3	Exceeding GSE noise
4	Gyro drift is out of norm
5	Servo system X is out of norm
6	Servo system Y is out of norm
7	Servo system Z is out of norm

Bit	Physical Meaning
8	FOG drift is out of norm
9	Malfunction of angle sensor data receiver board
10	Invalidity of GPS information
11	No GPS sync pulse
12	No reception from GPS
13	Malfunction of accelerometer signal receiver board
14	Equipment unreadiness
15	Emergency situation

GT1-A Header file (H-File)

H(*ddhhmm*).tit

dd = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of first record (00-59)

The header file includes service information on flight and constants entered.
Parameter values are recorded in terms of radians, metres, minutes, seconds and deg°min'sec.sec" for angles.

Parameter	Unit	Description
F =	deg°min'sec.sec"	Geographical latitude of the starting point (reference point)
L =	deg°min'sec.sec"	Geographical longitude of the starting point (reference point) Normally set to zero
H =	metres	Altitude of the starting point above the reference ellipsoid
G =	m/s^2	Gravity force acceleration at the starting point. If data is not available, G = 9.810000 m/s^2 is recorded
D =	dd:mm:yyyy	Date of flight
VarGPS =	-	Normally set to zero
Fcheb =	-	Normally set to zero
Xant	metres	X coordinate (lateral axis of the aircraft) of the GPS antenna
Yant	metres	Y coordinate (longitudinal axis of the aircraft) of the GPS antenna
Zant	metres	Z coordinate (vertical axis of the aircraft) of the GPS antenna
Kwx	-	Correction to the scale factor of accelerometer X
Kwy	-	Correction to the scale factor of accelerometer Y
Kwzm	-	Correction to the GSE scale factor, small range
Kwzb	-	Correction to the GSE scale factor, large range
Kp	-	Correction to the scale factor of gyro X
Kq	-	Correction to the scale factor of gyro Y
Kr	-	Correction to the FOG scale factor
dp	-	Gyro drift along X axis
dq	-	Gyro drift along Y axis
dr	-	FOG (Fibre Optic Gyro) drift along Z axis
dWx	-	Zero drift of accelerometer X
dWy	-	Zero drift of accelerometer Y
Awx	min'sec.sec"	Nonalignment of accelerometer X
Awy	min'sec.sec"	Nonalignment of accelerometer Y
Ay	min'sec.sec"	Non-orthogonality of gyro axes
Betz	sec.sec"	Non-alignment of GSE (Gravimetric Sensing Element) about X axis
Gamz	sec.sec"	Non-alignment of GSE (Gravimetric Sensing Element) about Y axis
dDUx	deg°min'sec.sec"	Zero signal of angular-data transmitter X
dDUy	deg°min'sec.sec"	Zero signal of angular-data transmitter Y
dDUz	deg°min'sec.sec"	Zero signal of angular-data transmitter Z
Kwxq	-	Scale factor of GSE root-mean-square correction
Kwyq	-	Scale factor of GSE root-mean-square correction

Post Processed GT1-A Gravimetric Sensing Element (GSE) and Accelerometer data file (Acc-G-File)

Acc-G*(ddhhmm)*.g00 *dd* = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of the first record (00-59)

The G-File is input to Program GTQC20, which provides rudimentary QC checks of the file contents, discards some "unwanted" variables, renames the remaining variables, and "unpacks" the data such that each record contains a set of observations for a single time interval, rather than the two time intervals per record in the G-File. The Acc-G-File is output from Program GTQC20. *Note*: Gra2 variable initially contains the same data as Gra3. During the processing sequence the "Fine channel" data are adjusted by substitution of "Coarse channel" data where the Fine channel has saturated. This "repaired" version of the Fine channel data is written to the Gra2 variable.

The Acc-G-File sample frequency is 18.75Hz – twice the sample frequency of the G-File.

Each record in the data file contains these 9 variables, space delimited.
Row 1 - Contains the data headings.
Row 2 - Contain null.
Row 3 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**nRecord**	Integer	Record number
2	**Gra1**	m/s^2	Fine channel Gravimeter data (Wz or oWz from G-File)
3	**Gra2**	m/s^2	Coarse channel Gravimeter data (Wzh or oWzh from G-File)
4	**Gra3**	m/s^2	Coarse channel Gravimeter data (Wzh or oWzh from G-File)
5	**Acc1**	m/s^2	X component acceleration (Wxa or oWxa from G-File)
6	**Acc2**	m/s^2	Y component acceleration (Way or oWya from G-File)
7	**Temp**	degrees	Increments in normalized temperature: Gravimetric Sensing Element resistor (Tkoe from G-File)
8	**nSat**	Integer	Number Saturations > 0.25g (N1 or fine Ch.) and > 0.5g (N2 or coarse Ch.) NSat = N1 + (N2 x1000) (Nh from G-File)
9	**Time**	seconds	GPS Time in second since start of day (Tsynh from G-File)

Post Processed GT1-A Gyro Vertical (GV) data file (Ins-S-File)

Ins-S*(ddhhmm)*.s00

dd = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of the first record (00-59)

The S-File is input to Program GTQC20, which provides rudimentary QC checks of the file contents, discards some "unwanted" variables and renames the remaining variables. The Ins-S-File is output from Program GTQC20.

The Ins-S-File sample frequency is 3.125Hz.

Each record in the data file contains 6 variables, space delimited.
Rows 1 & 3 - Contain the data headings.
Rows 2 & 4 - Contain null.
Row 5 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**DTime[sec]**	seconds	GPS time since start of day
2	**Kpl[deg]**	degrees	Platform heading
3	**Dux[deg]**	degrees	Value of the x rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Dux values correspond to aircraft (pitch) nose up.
4	**Duy[deg]**	degrees	Value of the y rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Duy values correspond to aircraft (roll) left wing up.
5	**Duz[deg]**	degrees	Value of the z rotation angle of the internal gimbal window, external gimbal window and the gravimeter body relative to the base, respectively. Positive Duz values correspond to aircraft rotating (yaw) anti-clockwise.
6	**C[deg]**	degrees	Increments is normalised temperature

Ashtech Rover Binary Measurement file (B-File)

B*(nnnnsyy).ddd*
nnnn = 4 character Rover name (eg. rexs)
s = session character (a-z)
yy = last 2 digits of current calendar year
ddd = day of the year of first record (001-366)

The B-File is a raw binary measurement file, downloaded from a GPS receiver, containing collected pseudo-range, optional carrier phase, and doppler measurement data. It contains computed positions for every epoch, plus health flags indicating the confidence of the measurements.

The B-File sample frequency is 2Hz.

Ashtech Rover Binary Ephemeris file (E-File)

E*(nnnnsyy).ddd*
nnnn = 4 character Rover name (eg. rexs)
s = session character (a-z)
yy = last 2 digits of current calendar year
ddd = day of the year of first record (001-366)

The E-File is a binary file, downloaded from a GPS receiver, containing the GPS satellite ephemeris data. It gives orbit parameters and satellite clock corrections and is used to compute the satellite's position.

Ashtech Base Binary Measurement file (B-File)

B*(nnnnsyy).ddd*
nnnn = 4 character Base name (eg. base)
s = session character (a-z)
yy = last 2 digits of current calendar year
ddd = day of the year of first record (001-366)

The B-File is a raw binary measurement file, downloaded from a GPS receiver, containing collected pseudo-range, optional carrier phase, and doppler measurement data. It contains computed positions for every epoch, plus health flags indicating the confidence of the measurements.

The B-File sample frequency is 2Hz.

Ashtech Base Binary Ephemeris file (E-File)

E*(nnnnsyy).ddd*
nnnn = 4 character Base name (eg. base)
s = session character (a-z)
yy = last 2 digits of current calendar year
ddd = day of the year of first record (001-366)

The E-File is a binary file, downloaded from a GPS receiver, containing the GPS satellite ephemeris data. It gives orbit parameters and satellite clock corrections and is used to compute the satellite's position.

Trimble Base Binary Data file (Dat-File)

***(nnnsss)*.dat** *nnn* = 3 character Base name (eg. bs2)
sss = session/flight number (eg. 001)

The Dat-File is a raw binary data file, downloaded from a GPS receiver, containing collected pseudo-range, optional carrier phase, and doppler measurement data. It contains computed positions for every epoch, plus health flags indicating the confidence of the measurements.

The Dat-File sample frequency is 2Hz.

Trimble Base Binary Ephemeris file (Eph-File)

***(nnnsss)*.eph** *nnn* = 3 character Base name (eg. bs2)
sss = session/flight number (eg. 001)

The Eph-File is a binary file, downloaded from a GPS receiver, containing the GPS satellite ephemeris data. It gives orbit parameters and satellite clock corrections and is used to compute the satellite's position.

Trimble Base Binary Ionospheric file (Ion-File)

***(nnnsss)*.ion** *nnn* = 3 character Base name (eg. bs2)
sss = session/flight number (eg. 001)

The Ion-File is a binary file, downloaded from a GPS receiver, containing ionospheric parameters.

Trimble Base ASCII Message file (Mes-File)

***(nnnsss)*.mes** *nnn* = 3 character Base name (eg. bs2)
sss = session/flight number (eg. 001)

The Mes-File is an ASCII file, downloaded from a GPS receiver, containing site and session parameters.

Post Processed Rover GPS Position file (C-File)

C(*nnnnsyy*).*ddd* *nnnn* = 4 character Rover name (eg. rexs)
s = session character (a-z)
yy = last 2 digits of current calendar year
ddd = day of the year of first record (001-366)

The C-File is ASCII file containing a chronological listing of time, site, number of satellites, PDOP, and position from every epoch. This file lists the Rover's position in WGS-84 coordinates. Each line in the ASCII C-File is a record for a single epoch.

The C-File sample frequency is 2Hz.

Each record in the data file contains 15 variables, space delimited.
Rows 1 to 4 - Contain processing information.
Row 5 - Contains the data variable headings.
Row 6 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**SITE**	Text	Rover site name
2	**MM/DD/YY**	mm/dd/yy	Date of the current epoch
3	**HH:MM:SS**	hh:mm:ss.ss	GPS time of the current epoch
4	**SVs**	Integer	The number of satellites used in processing the current epoch
5	**PDOP**	Real	The position dilution of precision
6	**S**	S or N	South or North Latitude
7	**LATITUDE**	deg.deg	The WGS-84 geodetic Latitude coordinate of the Rover
8	**E**	E or W	East or West Longitude
9	**LONGITUDE**	deg.deg	The WGS-84 geodetic Longitude coordinate of the Rover
10	**HI**	m	The Ellipsoidal Height of the Rover antenna
11	**RMS**	m	L1 Root Mean Square
12	**FLAG**	Integer	Quality Number where 1 is best and 6 is worse
13	**V_EAST**	m/s	The eastward velocity of the Rover
14	**V_NORTH**	m/s	The northward velocity of the Rover
15	**V_UP**	m/s	The upward velocity of the Rover

Processed Velocity Solutions data files (L1-File)

Phase_L1.dat Velocity solutions use carrier phase on L1.

The L1-File is an ASCII file containing a chronological listing of time, position and velocity information.

The L1-File sample frequency is 2Hz.

Each record in the data file contains 11 variables, space delimited.
Row 1 - Contains the start and end time parameters.
Row 2 - Contains the data variable headings.
Row 3 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**(1)Time**	seconds	GPS Time in seconds from the beginning of the day
2	**Phi**	radians	Latitude - Code Differential Solution
3	**Lambda**	radians	Longitude - Code Differential Solution
4	**Height**	m	Altitude - Code Differential Solution
5	**RmsPos**	m	Root Mean Square of Position - Code Differential Solution
6	**V_E**	m/s	Velocity East - Differential Carrier Phases (L1 or iono-free) are used for velocity solution
7	**V_N**	m/s	Velocity North - Differential Carrier Phases (L1 or iono-free) are used for velocity solution
8	**V_UP**	m/s	Velocity Vertical - Differential Carrier Phases (L1 or iono-free) are used for velocity solution
9	**RmsVel**	m/s	Root Mean Square of Velocity Differential Solution
10	**SVS**	Integer	Number of Satellites used in solution
11	**Type**	Integer	Differential Phase Velocity Solution Flag 1 = Solution Good 0 = Solution Sufficient -1 = Solution Bad

Processed INS and integrated Position data file (E-File)

E*(ddhhmm)*.ins *dd* = month day date of first record (01-31)
hh = hour of first record (00-23)
mm = minute of first record (00-59)

The E-File is an ASCII file containing a chronological listing of time, INS platform parameters, position from integrated GPS/INS data and eotvos correction information.

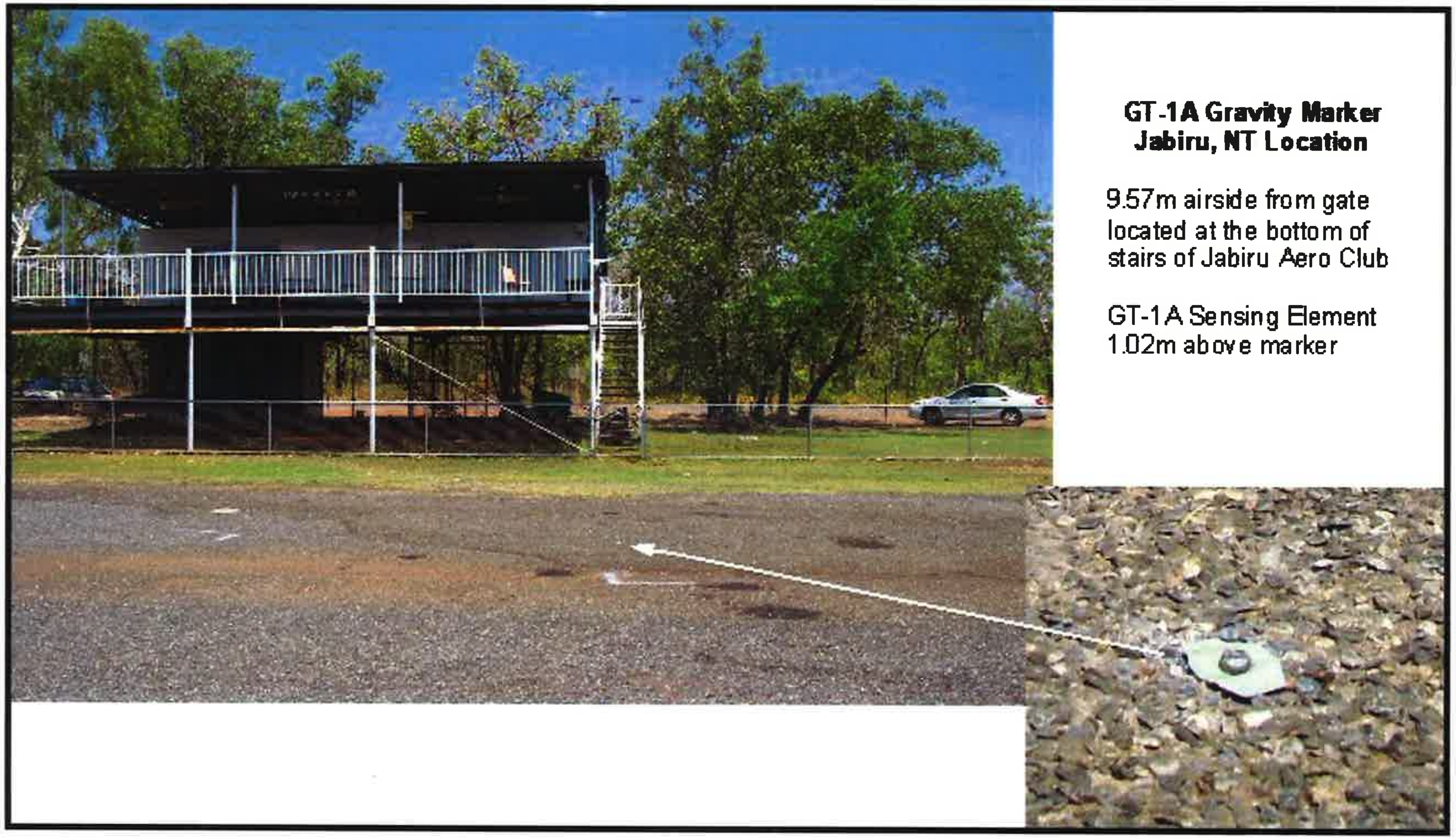
The E-File sample frequency is 2Hz.

Each record in the data file contains 15 variables, space delimited.
Rows 1 to 4 - Contain parameter information.
Row 5 - Contains the data variable headings.
Row 6 - Start of data.
The sequence, variable name, units and description of each variable are presented in the following table.

N	Variable	Units	Description
1	**t[sec]**	seconds	GPS Time in seconds from the beginning of the day
2	**FLAG**	Integer	Set to 0
3	**Vxa[m/s]**	m/s	Projection of horizontal velocity on gyro platform x axis
4	**Vya[m/s]**	m/s	Projection of horizontal velocity on gyro platform y axis
5	**Wxa[m/s^2]**	m/s^2	Projection of specific force on gyro platform x axis
6	**Wya[m/s^2]**	m/s^2	Projection of specific force on gyro platform y axis
7	**Phi[rad]**	radians	Latitude - INS/GPS integration
8	**Lambda[rad]**	radians	Longitude - INS/GPS integration
9	**Eps[rad]**	radians	Azimuth angle of gyro platform
10	**Alpha1[rad]**	radians	Estimate of gyro platform x axis misalignment errors
11	**Alpha2[rad]**	radians	Estimate of gyro platform y axis misalignment errors
12	**G-G(0)[m/s^2]**	m/s^2	Difference between regular components of gravity force on flight line and at aerodrome reference point - corrected for antenna displacement
13	**V^2/R[m/s^2]**	m/s^2	Eotvos correction term
14	**2uVecos(Phi) [m/s^2]**	m/s^2	Eotvos correction term
15	**h_gps[m]**	m	GPS height

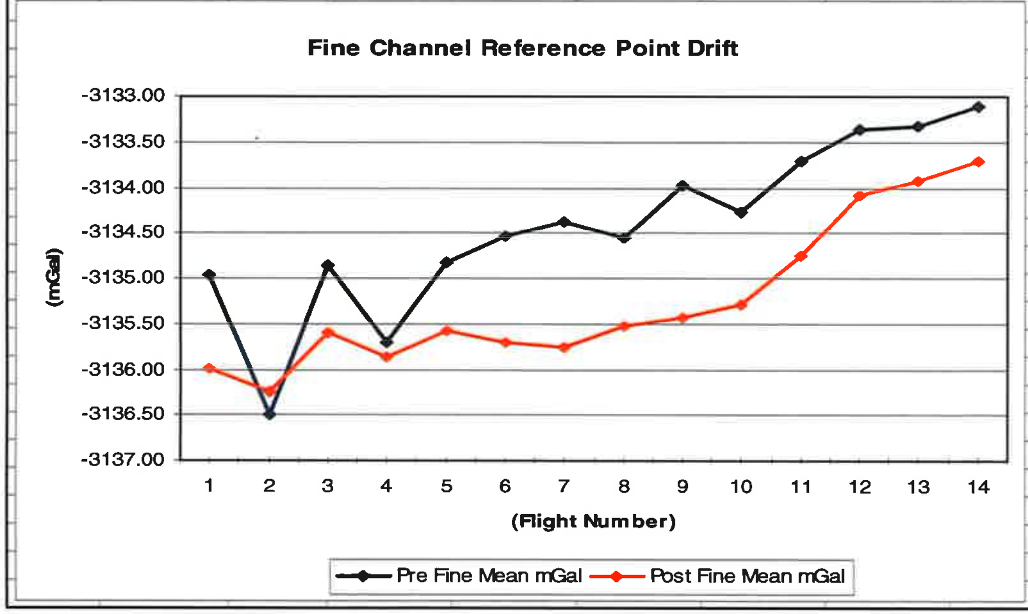
Appendix VII - Gravity Reference Point Position

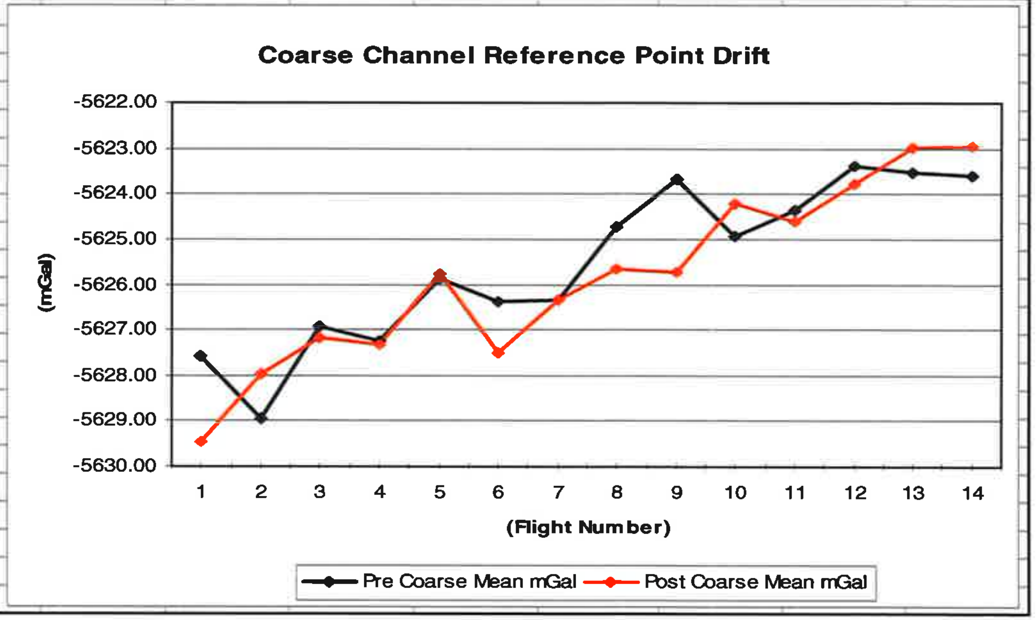
The GT-1A Reference Position has been integrated into the Australian Fundamental Gravity Network. This station is identified as 20034403 and has an Observed Gravity value of 978300.066 mGals at ground level. The Observed Gravity value for the GT-1A Reference Point (1.02m above the ground) is 978299.752 mGals.



Appendix VIII - Reference Measurements Statistics

Flt No.	Date	AM/PM	Pre Fine Mean mGal	Pre Fine Drift mGal/h	Pre Fine RMS mGal	Post Fine Mean mGal	Post Fine Drift mGal/h	Post Fine RMS mGal	Pre Coarse Mean mGal	Pre Coarse Drift mGal/h	Pre Coarse RMS mGal	Post Coarse Mean mGal	Post Coarse Drift mGal/h	Post Coarse RMS mGal	Fine Ch Flt Drift (mGal/h)	Coarse Ch Flt Drift (mGal/h)
1	30-Aug-03	AM	-3134.97	1.1093	0.3423	-3135.99	-1.0298	12.0841	-5627.57	1.2400	0.5474	-5629.45	-3.4231	12.0968	-0.2399	-0.4428
2	30-Aug-03	PM	-3136.50	0.7355	7.4433	-3136.25	0.1995	9.2377	-5628.94	-2.3255	7.4482	-5627.99	-3.5975	9.2512	0.1218	0.4756
3	31-Aug-03	AM	-3134.85	0.7576	16.4895	-3135.59	-0.9238	25.2040	-5626.93	-0.1373	16.4936	-5627.16	-3.5258	25.2083	-0.1428	-0.0457
4	01-Sep-03	PM	-3135.69	-0.3927	6.4359	-3135.87	-0.5240	0.6203	-5627.24	-0.6618	6.4448	-5627.32	-3.5866	0.7727	-0.0656	-0.0274
5	02-Sep-03	AM	-3134.82	1.4823	6.2799	-3135.57	-1.8826	11.8760	-5625.88	2.0373	6.2893	-5625.77	-6.8373	11.8965	-0.1926	-0.0288
6	03-Sep-03	AM	-3134.52	0.3939	11.3183	-3135.70	-0.4761	11.8651	-5626.37	1.3480	11.3255	-5627.52	-1.1613	11.8731	-0.3280	-0.3180
7	04-Sep-03	AM	-3134.36	1.3736	11.1688	-3135.75	-0.3341	9.2633	-5626.36	-0.0728	11.1746	-5626.33	-2.9005	9.2808	-0.3201	0.0070
8	08-Sep-03	AM	-3134.54	1.5285	0.7513	-3135.53	-2.5733	10.7947	-5624.73	1.1104	0.7950	-5625.66	-5.7244	10.8124	-0.2270	-0.2138
9	09-Sep-03	AM	-3133.98	0.4554	10.9505	-3135.44	0.3684	6.7724	-5623.66	2.1145	10.9607	-5625.72	-3.2285	6.7854	-0.3401	-0.4808
10	10-Sep-03	AM	-3134.26	0.7754	18.4432	-3135.28	0.2365	1.8348	-5624.95	0.9586	18.4443	-5624.20	-4.7807	1.9109	-0.2507	0.1836
11	11-Sep-03	AM	-3133.70	-0.3519	0.5038	-3134.75	0.0652	10.0733	-5624.34	2.0958	0.6072	-5624.62	-0.1883	10.0810	-0.2811	-0.0749
12	12-Sep-03	AM	-3133.36	-0.3312	3.0130	-3134.08	-0.9405	2.6371	-5623.36	0.2585	3.0320	-5623.77	1.0862	2.6674	-0.2023	-0.1127
13	13-Sep-03	AM	-3133.33	-0.1329	15.7483	-3133.92	-1.8930	5.5778	-5623.51	-1.4561	15.7523	-5622.97	-0.2120	5.5851	-0.1167	0.1077
14	15-Sep-03	AM	-3133.11	0.1941	0.2279	-3133.70	1.8908	20.5662	-5623.60	0.2988	0.3885	-5622.96	-5.1976	20.5727	-0.1509	0.1629





Appendix IX - Conversion from Relative to Absolute Gravity

Conversion of relative free air gravity to absolute gravity for the West Arnhem Land GT-1A Airborne Gravity Survey

Richard Lane (Geoscience Australia)
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10-December-2003

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Summary

The GT1-A airborne gravity system returns relative free air gravity data using a system of formulae different to that used by Geoscience Australia. The initial task was to convert relative free air gravity data to free air gravity data. The next task was to back out the corrections applied in the GT1-A data processing stream to produce absolute gravity tied to the Australian absolute gravity network. Having obtained absolute gravity, corrections consistent with those used with data in the Australian nation gravity database can be applied.

A ground gravity reading tied to the Australian absolute gravity network was available at ground level, 1.02 m below the reference position of the Gravity Sensing Element (GSE) in the GT1-A instrument.

This document describes a method to estimate absolute gravity at the instrument reference position, to recover the offset required to convert relative free air gravity to free air gravity, and to convert free air gravity derived using a system of formulae within the GT1-A data processing stream to absolute gravity.

Method

Free air gravity data are the result of removing theoretical gravity values and free air corrections from absolute gravity values (see for example Equation 7.14 of Blakely (1996)).

$$g_{fa,i} = g_a - g_{t,i} - g_{fac,i} \qquad \text{(Equation 1)}$$

where g_{fa} is free air data, g_a is absolute gravity, g_t is theoretical gravity, g_{fac} is the free air correction and i refers to the i^{th} system of gravity reduction formulae (i.e. a system of formulae for theoretical gravity, free air corrections, Bouguer corrections, etc).

An offset is removed from free air data from the GT-1A airborne gravity system during processing to produce relative free air gravity. This processing utilised a system of gravity reduction formulae, numbered here as system 1.

$$g'_{fa,1} = g_{fa,1} - DC \qquad \text{(Equation 2)}$$

where g'_{fa} is relative free air data and DC is a constant offset.

The offset is chosen during processing of the GT1-A data such that the relative free air value at the reference point ("ref") is zero.

$$g'_{fa,1}(ref) = g_{fa,1}(ref) - DC = 0 \qquad \text{(Equation 3)}$$

We can derive the following expression at the reference point,

$$\begin{aligned} g_a(ref) &= g_{fa,i}(ref) + g_{t,i}(ref) + g_{fac,i}(ref) \\ &= DC + g_{t,1}(ref) + g_{fac,1}(ref) \end{aligned} \qquad \text{(Equation 4)}$$

For two points, p1 and p2, at the same horizontal location but at different heights, h1 and h2, we can define a quantity $\delta g_a(p1,p2)$ as the difference in absolute gravity for the two points.

$$\delta g_a(p1, p2) = g_a(p1) - g_a(p2) \qquad \text{(Equation 5)}$$

Absolute gravity is known at an observation point ("obs") at the same horizontal location as the reference point.

$$\begin{aligned}\delta g_a(ref,obs) &= g_a(ref) - g_a(obs) \\ &= [g_{fa,i}(ref) - g_{fa,i}(obs)] + \\ &\quad [g_{t,i}(ref) - g_{t,i}(obs)] + \\ &\quad [g_{fac,i}(ref) - g_{fac,i}(obs)]\end{aligned} \qquad \text{(Equation 6)}$$

Because the observation and reference points are at the same horizontal location, they have the same theoretical gravity value.

$$g_{t,i}(ref) - g_{t,i}(obs) = 0 \qquad \text{(Equation 7)}$$

The difference in free air data values for the two points is equal to the difference between free air gravity at the observation point upward continued to the reference point, UC($g_{fa,i}$,obs,ref), and free air gravity at the observation point.

$$g_{fa,i}(ref) - g_{fa,i}(obs) = UC(g_{fa,i}, obs, ref) - g_{fa,i}(obs) \qquad \text{(Equation 8)}$$

Ideally, the observation and reference points would be one and the same point, and the difference in Equation 8 would be zero. Unfortunately, this is not the case. To compound the problem, the vertical gradient of free air gravity at this location is not known, making the upward continuation operation problematic. Provided the difference in height between the reference and observation locations was small, local topographic relief was low, and there were no strong local gradients in the complete Bouguer anomaly, it would be reasonable to assume that this vertical gradient was small relative to the vertical gradient in theoretical gravity (i.e. the gradient used in the free air correction).

$$\left|UC(g_{fa,i}, obs, ref) - g_{fa,i}(obs)\right| << \left|g_{fac,i}(ref) - g_{fac,i}(obs)\right| \qquad \text{(Equation 9)}$$

Equations 7 and 9 enable an estimate for the difference in absolute gravity between the reference and observation points to be obtained.

$$\begin{aligned}\delta g_a(ref,obs) &= g_a(ref) - g_a(obs) \\ &\approx g_{fac,i}(ref) - g_{fac,i}(obs)\end{aligned} \qquad \text{(Equation 10)}$$

Rearranging terms in Equation 10, we arrive at an approximate expression for the absolute gravity at the reference point.

$$g_a(ref) \approx g_a(obs) + g_{fac,i}(ref) - g_{fac,i}(obs) \qquad \text{(Equation 11)}$$

Equations 4 and 11 provide an expression for the offset.

$$\begin{aligned}DC &= g_a(ref) - g_{t,1}(ref) - g_{fac,1}(ref) \\ &\approx g_a(obs) + g_{fac,i}(ref) - g_{fac,i}(obs) - g_{t,1}(ref) - g_{fac,1}(ref)\end{aligned} \qquad \text{(Equation 12)}$$

If all calculations are performed using the formulae of system 1, Equation 12 can be simplified.

$$DC \approx g_a(obs) - g_{fac,1}(obs) - g_{t,1}(ref) \quad \text{(Equation 13)}$$

The terms on the right hand side of Equation 13 are all known. Hence, DC can be estimated.

Having calculated the offset, we can use Equation 2 to obtain free air data from the relative free air data, and Equation 1 to get absolute gravity from the free air data, all within the framework of system 1.

$$g_{fa,1} = g'_{fa,1} + DC \quad \text{(Equation 14)}$$

$$g_a = g_{fa,1} + g_{t,1} + g_{fac,1} \quad \text{(Equation 15)}$$

Having obtained absolute gravity at all points in the survey, we can calculate free air and Bouguer gravity values etc in any other system of formulae of our choice, such as that normally used by Geoscience Australia.

Results

The formulae for theoretical gravity (in μms^{-2}) and the free air correction (in μms^{-2}) as a function of latitude (φ, in radians) and ellipsoid height (h, in m) used in the GT1-A data processing stream (system 1) are given below.

$$g_{t,1} = 9780300 \cdot \left[1 + 0.0053020 \cdot \sin^2 \varphi - 0.0000070 \cdot \sin^2 2\varphi\right] - 140$$

(Equation 16)

$$g_{fac,1} = -3.0764 \cdot h \quad \text{(Equation 17)}$$

For the observation point, g_a(obs) was 9783000.66 μms^{-2}, WGS84 ellipsoid latitude was -12° 39' 33.9028" and the ellipsoid height was 80.876 m. The reference point was 1.02 m above the observation point.

Using Equations 13, 16 and 17, the offset (i.e. DC) applied to the free air gravity to obtain relative free air gravity was estimated to be 611.43 μms^{-2}. This offset is also the value for the free air anomaly that is estimated at the reference point using the formula in system 1 (i.e. $g_{fa,1}$(ref)). The absolute gravity estimated using Equation 15 for the reference point (i.e. g_a(ref)) is 9782997.52 μms^{-2}.

References

Blakely, R.J., 1996, Potential theory in gravity and magnetic applications: Cambridge University Press.

Appendix X - Survey QC Parameters

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	Flown Kms	Scrub Kms	Total Kms	GPS Time (seconds since start of day)		C-File Satellites >/=6		C-File PDOP <2.5		C-File RMS <1.0		L1-File RMSVel <0.05	
										Start	End	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1001	0	E	L	1	30-Aug-03	AM	103.93		103.93	80961.0	82510.5	8	9	1.8	2.2	0.018	0.066	0.0004	0.0152
1002	0	E	S	3	31-Aug-03	AM	103.94	103.94	103.94	Rover GPS Failure			-	-	-	-	-	-	-
1002	1	E	L	6	03-Sep-03	AM	103.94		103.94	77407.5	79004.5	8	9	1.2	2.0	0.027	0.045	0.0006	0.0171
1003	0	E	S	3	31-Aug-03	AM	103.96	103.96	103.96	Rover GPS Failure			-	-	-	-	-	-	-
1003	1	E	P/L	6	03-Sep-03	AM	103.96	58.00	103.96	81042.0	81801.5	7	8	1.8	2.4	0.019	0.060	0.0004	0.0310
1003	2	W	P/L	9	09-Sep-03	AM	58.00		103.96	81660.5	82554.0	6	7	1.9	2.7	0.003	0.044	0.0002	0.0140
1004	0	W	S	3	31-Aug-03	AM	103.98	103.98	103.98	Rover GPS Failure			-	-	-	-	-	-	-
1004	1	W	L	6	03-Sep-03	AM	103.98		103.98	79343.5	80759.0	8	9	1.8	2.6	0.017	0.041	0.0003	0.0232
1005	0	W	S	3	31-Aug-03	AM	104.00	104.00	104.00	Rover GPS Failure			-	-	-	-	-	-	-
1005	1	E	L	7	04-Sep-03	AM	104.00		104.00	76945.5	78520.5	8	9	1.2	1.9	0.011	0.039	0.0004	0.0095
1006	0	W	S	3	31-Aug-03	AM	103.67	103.67	103.67	Rover GPS Failure			-	-	-	-	-	-	-
1006	1	W	L	5	02-Sep-03	AM	103.67		103.67	78540.5	79976.0	7	9	1.4	2.8	0.016	0.039	0.0007	0.0194
1007	0	W	L	5	02-Sep-03	AM	102.02		102.02	82018.5	83395.5	7	8	1.8	2.4	0.013	0.051	0.0002	0.0235
1008	0	E	L	5	02-Sep-03	AM	97.40		97.40	76690.5	78249.5	8	9	1.2	1.8	0.013	0.027	0.0006	0.0211
1009	0	E	L	5	02-Sep-03	AM	95.41		95.41	80308.5	81790.5	8	9	1.8	2.2	0.027	0.045	0.0007	0.0273
1010	0	E	S	5	02-Sep-03	AM	88.12	88.12	88.12	83798.5	85096.5	6	8	1.7	2.6	0.010	0.089	0.0002	0.0331
1010	1	W	L	12	12-Sep-03	AM	88.12		88.12	79232.0	80475.5	7	8	1.8	2.3	0.009	0.034	0.0003	0.0104
1011	0	W	L	7	04-Sep-03	AM	86.09		86.09	78938.5	80191.5	8	9	1.8	2.6	0.017	0.043	0.0007	0.0122
1012	0	W	L	7	04-Sep-03	AM	86.10		86.10	81986.0	83238.5	6	8	1.8	2.7	0.012	0.049	0.0002	0.0176
1013	0	W	L	7	04-Sep-03	AM	86.88		86.88	85726.0	86991.5	9	10	1.0	1.4	0.016	0.098	0.0009	0.0216
1014	0	E	L	7	04-Sep-03	AM	80.39		80.39	80506.5	81739.0	8	8	1.9	2.2	0.012	0.049	0.0004	0.0275
1015	0	E	S	7	04-Sep-03	AM	105.14	105.14	105.14	83644.5	85222.5	6	9	1.6	2.5	0.032	0.119	0.0002	0.0297
1015	1	E	L	12	12-Sep-03	AM	105.14		105.14	80832.5	82361.5	6	8	1.8	2.7	0.012	0.059	0.0001	0.0111
1016	0	E	L	9	09-Sep-03	AM	105.00		105.00	83220.5	84766.5	8	9	1.6	2.1	0.012	0.058	0.0008	0.0313
1017	0	E	L	10	10-Sep-03	AM	89.62		89.62	77405.5	78701.5	8	9	1.9	2.8	0.012	0.031	0.0006	0.0111
1018	0	E	L	10	10-Sep-03	AM	89.61		89.61	80504.0	81806.0	7	8	1.8	2.4	0.015	0.066	0.0003	0.0173
1019	0	W	S	9	09-Sep-03	AM	89.60	89.60	89.60	84984.0	86269.5	9	10	1.2	1.7	0.025	0.067	0.0014	0.0215
1019	1	W	L	12	12-Sep-03	AM	89.60		89.60	82595.0	83876.0	8	9	1.5	1.8	0.014	0.044	0.0002	0.0249

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	L1-File Type=1	E-File Alpha1 <0.0011636		E-File Alpha2 <0.0011636		Fine Ch Satur-ations	Coarse Ch Satur-ations	Gravigal RMS Residuals <1500
								Min	Max	Min	Max			
1001	0	E	L	1	30-Aug-03	AM	1	-0.0001382	0.0000524	-0.0003218	-0.0000440	146	3	628.53
1002	0	E	S	3	31-Aug-03	AM	-	-	-	-	-	-	-	-
1002	1	E	L	6	03-Sep-03	AM	1	-0.0000541	0.0000924	-0.0001053	0.0000141	3195	16	509.31
1003	0	E	S	3	31-Aug-03	AM	-	-	-	-	-	-	-	-
1003	1	E	P/L	6	03-Sep-03	AM	1	-0.0000427	0.0000010	-0.0001174	0.0000422	75	5	655.26
1003	2	W	P/L	9	09-Sep-03	AM	1	-0.0000442	0.0000323	-0.0001208	0.0002176	0	0	576.11
1004	0	W	S	3	31-Aug-03	AM	-	-	-	-	-	-	-	-
1004	1	W	L	6	03-Sep-03	AM	1	0.0000051	0.0000538	0.0000610	0.0001384	2832	2	814.24
1005	0	W	S	3	31-Aug-03	AM	-	-	-	-	-	-	-	-
1005	1	E	L	7	04-Sep-03	AM	1	-0.0000125	0.0001772	-0.0000638	0.0000670	0	0	386.14
1006	0	W	S	3	31-Aug-03	AM	-	-	-	-	-	-	-	-
1006	1	W	L	5	02-Sep-03	AM	1	-0.0000677	-0.0000301	-0.0000148	0.0000650	18	0	759.59
1007	0	W	L	5	02-Sep-03	AM	1	-0.0001473	0.0000630	-0.0000078	0.0001095	16	2	783.80
1008	0	E	L	5	02-Sep-03	AM	1	-0.0000858	0.0001318	-0.0000226	0.0000819	280	3	540.64
1009	0	E	L	5	02-Sep-03	AM	1	-0.0000983	0.0001640	-0.0001100	-0.0000149	221	5	691.50
1010	0	E	S	5	02-Sep-03	AM	1	-0.0000523	0.0003279	-0.0002198	0.0000450	1638	306	597.45
1010	1	W	L	12	12-Sep-03	AM	1	-0.0001333	0.0001115	-0.0003181	-0.0000868	0	0	602.58
1011	0	W	L	7	04-Sep-03	AM	1	-0.0000806	0.0000146	-0.0000234	0.0000011	0	0	547.07
1012	0	W	L	7	04-Sep-03	AM	1	-0.0001609	0.0003098	-0.0000642	0.0000902	21	0	631.80
1013	0	W	L	7	04-Sep-03	AM	1	0.0000603	0.0003373	-0.0000260	0.0000493	193	8	902.93
1014	0	E	L	7	04-Sep-03	AM	1	-0.0001688	0.0000393	-0.0000529	0.0000183	35	0	692.13
1015	0	E	S	7	04-Sep-03	AM	1	-0.0002371	0.0001094	-0.0000613	0.0001032	1443	267	1390.90
1015	1	E	L	12	12-Sep-03	AM	1	-0.0000896	0.0001248	-0.0000282	0.0006115	0	0	448.14
1016	0	E	L	9	09-Sep-03	AM	1	-0.0001658	0.0001618	-0.0001474	0.0001036	740	22	724.59
1017	0	E	L	10	10-Sep-03	AM	1	-0.0000266	0.0000708	-0.0001638	0.0000351	13	0	645.09
1018	0	E	L	10	10-Sep-03	AM	1	-0.0000217	0.0000143	-0.0003192	0.0001018	28	3	678.47
1019	0	W	S	9	09-Sep-03	AM	1	-0.0002878	0.0000756	0.0000175	0.0001382	989	69	838.43
1019	1	W	L	12	12-Sep-03	AM	1	-0.0001288	0.0000533	-0.0007353	0.0006036	460	15	924.46

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	Flown Kms	Scrub Kms	Total Kms	GPS Time (seconds since start of day)		C-File Satellites >/=6		C-File PDOP <2.5		C-File RMS <1.0		L1-File RMSVel <0.05	
										Start	End	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1020	0	W	L	10	10-Sep-03	AM	89.60		89.60	78954.5	80226.5	8	8	1.9	2.0	0.013	0.035	0.0003	0.0209
1021	0	W	L	10	10-Sep-03	AM	89.59		89.59	82024.0	83301.5	6	8	1.8	2.6	0.027	0.086	0.0005	0.0200
1022	0	E	L	11	11-Sep-03	AM	89.58		89.58	75996.5	77282.0	8	9	1.3	2.2	0.011	0.028	0.0007	0.0139
1023	0	E	L	11	11-Sep-03	AM	89.58		89.58	78983.0	80255.5	8	8	1.8	2.2	0.007	0.031	0.0003	0.0191
1024	0	E	S	11	11-Sep-03	AM	89.57	89.57	89.57	81941.5	83205.5	7	8	1.8	2.0	0.012	0.040	0.0004	0.0239
1024	1	E	L	14	15-Sep-03	AM	89.57		89.57	79083.5	80314.5	7	8	1.7	2.6	0.007	0.042	0.0003	0.0131
1025	0	W	L	11	11-Sep-03	AM	89.57		89.57	77525.0	78795.0	8	9	1.8	2.7	0.008	0.028	0.0004	0.0112
1026	0	W	L	11	11-Sep-03	AM	89.56		89.56	80496.5	81762.5	6	8	1.7	2.7	0.002	0.022	0.0001	0.0179
1027	0	W	L	11	11-Sep-03	AM	89.55		89.55	83453.5	84705.0	9	9	1.5	1.6	0.010	0.056	0.0009	0.0198
1028	0	E	S	10	10-Sep-03	AM	89.55	89.55	89.55	83669.0	84993.0	8	9	1.3	1.8	0.035	0.121	0.0007	0.0266
1028	1	W	L	14	15-Sep-03	AM	89.55		89.55	77519.0	78799.0	8	9	2.0	2.2	0.009	0.029	0.0004	0.0109
1029	0	E	L	13	13-Sep-03	AM	89.54		89.54	77416.0	78687.0	8	9	1.8	2.8	0.006	0.028	0.0005	0.1210
1030	0	E	L	13	13-Sep-03	AM	89.54		89.54	80455.5	81754.0	6	7	1.9	2.9	0.005	0.032	0.0002	0.0350
1031	0	W	S	10	10-Sep-03	AM	89.53	89.53	89.53	85224.5	86490.0	9	10	1.0	1.3	0.015	0.072	0.0011	0.0226
1031	1	E	L	14	15-Sep-03	AM	89.53		89.53	75986.0	77240.0	8	8	2.1	3.0	0.011	0.031	0.0004	0.0098
1032	0	W	L	13	13-Sep-03	AM	89.52		89.52	78984.0	80229.5	7	8	1.7	2.6	0.004	0.026	0.0003	0.0121
1033	0	W	S	8	08-Sep-03	AM	89.52	89.52	89.52	85901.0	87178.5	9	10	1.3	1.4	0.017	0.099	0.0010	0.0213
1033	1	W	L	13	13-Sep-03	AM	89.52		89.52	81986.5	83268.0	8	9	1.6	1.8	0.011	0.052	0.0003	0.0187
1034	0	W	L	8	08-Sep-03	AM	89.51		89.51	82761.0	84052.5	7	9	1.6	2.0	0.048	0.073	0.0004	0.0269
1035	0	W	L	8	08-Sep-03	AM	89.50		89.50	79554.0	80847.0	8	8	1.8	2.2	0.012	0.048	0.0004	0.0180
1036	0	E	S	8	08-Sep-03	AM	89.50	89.50	89.50	84361.5	85630.5	8	9	1.6	2.0	0.012	0.141	0.0011	0.0281
1036	1	E	L	13	13-Sep-03	AM	89.50		89.50	83483.0	84762.5	9	10	1.3	1.6	0.022	0.061	0.0014	0.0225
1037	0	E	L	8	08-Sep-03	AM	89.49		89.49	81165.5	82442.5	6	8	1.8	2.7	0.011	0.050	0.0000	0.0289
1038	0	E	L	8	08-Sep-03	AM	89.48		89.48	78017.0	79279.5	8	9	1.8	2.7	0.014	0.034	0.0004	0.0144
1039	0	E	L	4	01-Sep-03	PM	89.48		89.48	28078.0	29425.5	9	11	1.4	2.0	0.048	0.103	0.0013	0.0167
1040	0	W	L	3	31-Aug-03	AM	89.47		89.47	75866.0	77190.5	8	9	1.3	1.6	0.009	0.049	0.0009	0.0136
1041	0	E	S	2	30-Aug-03	PM	89.47	89.47	89.47	25589.0	26891.5	8	9	1.9	2.3	0.007	0.039	0.0010	0.0230
1041	1	E	L	12	12-Sep-03	AM	89.47		89.47	75748.5	77031.5	8	9	1.4	2.2	0.011	0.037	0.0007	0.0125

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	L1-File Type=1	E-File Alpha1 <0.0011636		E-File Alpha2 <0.0011636		Fine Ch Satur-ations	Coarse Ch Satur-ations	Gravigal RMS Residuals <1500
								Min	Max	Min	Max			
1020	0	W	L	10	10-Sep-03	AM	1	-0.0000282	0.0000039	-0.0002303	0.0002208	46	2	713.62
1021	0	W	L	10	10-Sep-03	AM	1	-0.0000374	0.0000031	-0.0004834	0.0003511	219	3	807.83
1022	0	E	L	11	11-Sep-03	AM	1	-0.0001922	-0.0000762	-0.0000773	-0.0000227	11	0	655.84
1023	0	E	L	11	11-Sep-03	AM	1	-0.0002727	0.0000797	-0.0000428	0.0000691	160	2	695.55
1024	0	E	S	11	11-Sep-03	AM	1	-0.0000088	0.0002364	-0.0000311	0.0000626	562	34	848.50
1024	1	E	L	14	15-Sep-03	AM	1	-0.0003021	0.0001591	-0.0000009	0.0000504	0	0	648.50
1025	0	W	L	11	11-Sep-03	AM	1	-0.0001166	0.0001273	-0.0000186	0.0000610	3	0	627.08
1026	0	W	L	11	11-Sep-03	AM	1	-0.0003715	0.0002807	-0.0000767	0.0000534	71	3	931.89
1027	0	W	L	11	11-Sep-03	AM	1	-0.0000043	0.0001630	-0.0000539	0.0000139	622	38	932.98
1028	0	E	S	10	10-Sep-03	AM	1	-0.0000591	0.0000153	-0.0002325	0.0003893	760	31	791.02
1028	1	W	L	14	15-Sep-03	AM	1	-0.0004081	0.0003250	-0.0000279	0.0000265	0	0	676.53
1029	0	E	L	13	13-Sep-03	AM	1	0.0000179	0.0001999	-0.0000298	0.0000530	18	0	604.37
1030	0	E	L	13	13-Sep-03	AM	1	-0.0000693	0.0002545	-0.0000572	0.0000585	66	0	731.21
1031	0	W	S	10	10-Sep-03	AM	1	0.0000319	0.0000522	-0.0003178	0.0003690	1157	104	968.14
1031	1	E	L	14	15-Sep-03	AM	1	-0.0004542	0.0000349	-0.0000427	0.0000048	0	0	645.58
1032	0	W	L	13	13-Sep-03	AM	1	-0.0001291	0.0003293	-0.0000504	0.0000361	7	0	767.55
1033	0	W	S	8	08-Sep-03	AM	1	-0.0006556	0.0004176	-0.0003706	0.0003578	784	53	934.32
1033	1	W	L	13	13-Sep-03	AM	1	-0.0004083	0.0003461	-0.0000591	0.0000909	355	15	963.86
1034	0	W	L	8	08-Sep-03	AM	1	-0.0006969	0.0004395	-0.0003438	0.0003380	498	19	916.75
1035	0	W	L	8	08-Sep-03	AM	1	-0.0006433	0.0003076	-0.0002745	0.0002309	19	0	733.24
1036	0	E	S	8	08-Sep-03	AM	1	-0.0003207	0.0005004	-0.0002625	0.0003498	641	58	790.79
1036	1	E	L	13	13-Sep-03	AM	1	-0.0004407	0.0002027	-0.0001097	0.0000547	622	26	779.94
1037	0	E	L	8	08-Sep-03	AM	1	-0.0003133	0.0006034	-0.0002079	0.0003684	390	12	884.19
1038	0	E	L	8	08-Sep-03	AM	1	0.0001690	0.0004354	0.0000619	0.0002517	13	0	630.60
1039	0	E	L	4	01-Sep-03	PM	1	0.0000218	0.0000616	0.0000469	0.0000832	673	33	899.72
1040	0	W	L	3	31-Aug-03	AM	1	-0.0001480	-0.0000616	-0.0000022	0.0000275	10	0	426.32
1041	0	E	S	2	30-Aug-03	PM	1	-0.0000068	0.0000496	-0.0000400	-0.0000189	1173	86	3087.00
1041	1	E	L	12	12-Sep-03	AM	1	-0.0000237	-0.0000104	0.0000265	0.0002482	4	0	577.54

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	Flown Kms	Scrub Kms	Total Kms	GPS Time (seconds since start of day)		C-File Satellites >/=6		C-File PDOP <2.5		C-File RMS <1.0		L1-File RMSVel <0.05	
										Start	End	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1042	0	W	L	4	01-Sep-03	PM	89.46		89.46	29721.5	30994.5	9	10	1.4	1.6	0.027	0.131	0.0014	0.0255
1043	0	W	S	2	30-Aug-03	PM	89.45	89.45	89.45	24048.5	25345.0	9	9	2.0	2.2	0.013	0.039	0.0009	0.0221
1043	1	W	L	14	15-Sep-03	AM	89.45		89.45	82492.5	83766.5	9	9	1.5	1.7	0.026	0.045	0.0008	0.0175
1044	0	W	S	1	30-Aug-03	AM	89.45	89.45	89.45	84527.0	85837.5	6	8	1.7	2.7	0.039	0.080	0.0001	0.0298
1044	1	W	S	13	13-Sep-03	AM	89.45	89.45	89.45	85131.0	86400.5	9	9	1.3	1.4	0.024	0.068	0.0015	0.0221
1044	2	E	L	14	15-Sep-03	AM	89.45		89.45	84019.5	85264.0	9	10	1.3	1.4	0.026	0.066	0.0008	0.0307
9001	0	N	T	1	30-Aug-03	AM	20.14		20.14	80103.0	80410.5	8	8	2.1	2.2	0.016	0.040	0.0004	0.0096
9002	0	S	T	1	30-Aug-03	AM	34.28		34.28	79149.0	79655.0	8	9	1.3	1.9	0.014	0.037	0.0009	0.0100
9003	0	N	T	1	30-Aug-03	AM	94.42		94.42	77122.0	78507.0	8	9	1.2	1.8	0.015	0.049	0.0006	0.0235
9004	0	N	T	9	09-Sep-03	AM	94.96		94.96	76355.0	77733.0	8	9	1.3	2.2	0.010	0.028	0.0004	0.0104
9005	0	S	T	9	09-Sep-03	AM	94.98		94.98	78231.0	79591.5	8	9	1.9	2.7	0.007	0.027	0.0005	0.0109
9006	0	N	S	3	31-Aug-03	AM	94.98	94.98	94.98	Rover GPS Failure									
9006	1	N	T	9	09-Sep-03	AM	94.98		94.98	79928.5	81262.0	7	8	1.7	2.4	0.012	0.037	0.0007	0.0143
9007	0	S	S	1	30-Aug-03	AM	67.31	67.31	67.31	83044.5	84008.0	7	8	1.8	2.4	0.015	0.054	0.0008	0.0251
9007	1	N	T	12	12-Sep-03	AM	67.31		67.31	77888.5	78857.0	8	9	1.9	2.7	0.012	0.030	0.0006	0.0121
CAMECO LINES																			
2001	0	E	CL	14	15-Sep-03	AM	21.95		21.95	81410.0	81712.0	7	8	1.8	2.2	0.015	0.032	0.0008	0.0102
2002	0	E	S	13	13-Sep-03	AM	-		35.35	Off Line	-	-	-	-	-	-	-	-	-
2002	1	W	CL	14	15-Sep-03	AM	35.35		35.35	80685.0	81181.0	7	7	2.3	2.3	0.009	0.033	0.0006	0.0097

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	L1-File Type=1	E-File Alpha1 <0.0011636		E-File Alpha2 <0.0011636		Fine Ch Satur-ations	Coarse Ch Satur-ations	Gravigal RMS Residuals <1500
								Min	Max	Min	Max			
1042	0	W	L	4	01-Sep-03	PM	1	-0.0000070	0.0001311	-0.0000092	0.0000659	288	9	986.50
1043	0	W	S	2	30-Aug-03	PM	1	-0.0001975	-0.0000304	-0.0001865	-0.0000805	730	44	1595.00
1043	1	W	L	14	15-Sep-03	AM	1	-0.0001629	0.0002906	-0.0000004	0.0000839	72	0	612.87
1044	0	W	S	1	30-Aug-03	AM	1	-0.0000953	0.0003045	-0.0001187	0.0002998	1019	54	984.82
1044	1	W	S	13	13-Sep-03	AM	1	-0.0003527	0.0003391	-0.0000721	0.0000948	1055	122	799.37
1044	2	E	L	14	15-Sep-03	AM	1	-0.0002267	0.0003415	-0.0000253	0.0000264	416	23	823.36
9001	0	N	T	1	30-Aug-03	AM	1	-0.0002361	-0.0001792	-0.0002657	-0.0002431	0	0	780.02
9002	0	S	T	1	30-Aug-03	AM	1	-0.0000200	0.0000665	-0.0000356	0.0001566	0	0	412.05
9003	0	N	T	1	30-Aug-03	AM	1	-0.0000640	0.0000905	-0.0001657	0.0000828	37	0	679.37
9004	0	N	T	9	09-Sep-03	AM	1	-0.0000256	0.0001471	-0.0000339	0.0001109	0	0	777.31
9005	0	S	T	9	09-Sep-03	AM	1	-0.0000653	0.0001038	-0.0002138	0.0000870	3	2	620.47
9006	0	N	S	3	31-Aug-03	AM	-	-		-		-	-	-
9006	1	N	T	9	09-Sep-03	AM	1	-0.0000189	0.0002232	0.0025090	0.0002628	24	0	602.01
9007	0	S	S	1	30-Aug-03	AM	1	-0.0000864	0.0000923	-0.0000235	0.0004641	798	41	928.45
9007	1	N	T	12	12-Sep-03	AM	1	-0.0001317	0.0000624	-0.0000014	0.0002709	6	0	704.03
CAMECO LINES														
2001	0	E	CL	14	15-Sep-03	AM	1	0.0000723	0.0000847	0.0000121	0.0000236	2	0	608.66
2002	0	E	S	13	13-Sep-03	AM	-	-	-	-	-	-	-	-
2002	1	W	CL	14	15-Sep-03	AM	1	-0.0003824	0.0000408	-0.0000172	-0.0000011	0	0	596.35

Appendix XI - Intersection Statistics (Raw and Final)

Raw Data Cross-Over Errors - micrometres per second per second

Line	LZ	Tie	TZ	Diff.	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1001	72.19	T9001	64.20	7.99		T9001	64.20	L1001	72.19	-7.99	
L1001	166.15	T9002	156.57	9.58		T9001	66.59	L1002.1	60.79	5.80	
L1001	221.70	T9003	223.39	-1.69		T9001	61.63	L1003.1	51.42	10.21	
L1001	186.74	T9004	192.96	-6.22		T9001	44.32	L1004.1	34.08	10.24	
L1001	152.08	T9005	142.00	10.08		T9001	31.36	L1005.1	49.20	-17.84	
L1001	160.68	T9006.1	142.57	18.11	**6.23**	T9001	38.17	L1006.1	21.34	16.83	**9.47**
L1002.1	60.79	T9001	66.59	-5.80		T9002	156.57	L1001	166.15	-9.58	
L1002.1	164.75	T9002	168.07	-3.32		T9002	168.07	L1002.1	164.75	3.32	
L1002.1	218.80	T9003	224.16	-5.36		T9002	186.44	L1003.1	178.69	7.75	
L1002.1	170.82	T9004	167.78	3.04		T9002	192.87	L1004.1	184.26	8.60	
L1002.1	114.91	T9005	146.70	-31.79		T9002	193.66	L1005.1	192.03	1.63	
L1002.1	161.39	T9006.1	162.73	-1.34	**8.74**	T9002	204.26	L1006.1	186.47	17.78	
L1003.1	51.42	T9001	61.63	-10.21		T9002	218.39	L1007	221.19	-2.80	
L1003.1	178.69	T9002	186.44	-7.75		T9002	217.38	L1008	211.10	6.28	
L1003.2	147.10	T9004	130.79	16.31		T9002	205.87	L1009	220.50	-14.64	
L1003.2	148.06	T9005	141.40	6.67		T9002	196.78	L1010.1	182.69	14.10	
L1003.2	198.39	T9006.1	175.59	22.80	**10.25**	T9002	188.38	L1011	179.47	8.91	
L1004.1	34.08	T9001	44.32	-10.24		T9002	175.62	L1012	164.78	10.84	
L1004.1	184.26	T9002	192.87	-8.60		T9002	157.13	L1013	160.94	-3.81	**6.61**
L1004.1	238.72	T9003	224.83	13.89		T9003	223.39	L1001	221.70	1.69	
L1004.1	128.10	T9004	99.83	28.27		T9003	224.16	L1002.1	218.80	5.36	
L1004.1	136.93	T9005	128.06	8.87		T9003	224.83	L1004.1	238.72	-13.89	
L1004.1	195.42	T9006.1	179.15	16.28	**10.60**	T9003	219.66	L1005.1	218.97	0.70	
L1005.1	49.20	T9001	31.36	17.84		T9003	212.24	L1006.1	201.10	11.14	
L1005.1	192.03	T9002	193.66	-1.63		T9003	202.96	L1007	226.35	-23.39	
L1005.1	218.97	T9003	219.66	-0.70		T9003	196.47	L1008	193.97	2.50	
L1005.1	76.81	T9004	78.01	-1.20		T9003	187.65	L1009	184.25	3.41	
L1005.1	128.90	T9005	125.30	3.59		T9003	177.16	L1010.1	178.84	-1.68	
L1005.1	165.06	T9006.1	173.12	-8.06	**6.20**	T9003	171.16	L1011	186.21	-15.05	
L1006.1	21.34	T9001	38.17	-16.83		T9003	169.09	L1012	180.05	-10.96	
L1006.1	186.47	T9002	204.26	-17.78		T9003	173.52	L1013	185.10	-11.58	
L1006.1	201.10	T9003	212.24	-11.14		T9003	182.00	L1014	172.98	9.02	
L1006.1	62.75	T9004	55.53	7.22		T9003	178.60	L1015.1	162.52	16.08	
L1006.1	136.19	T9005	138.51	-2.32		T9003	165.68	L1016	195.37	-29.69	
L1006.1	181.38	T9006.1	157.45	23.94	**11.43**	T9003	164.50	L1017	185.87	-21.37	
L1007	221.19	T9002	218.39	2.80		T9003	171.70	L1018	190.62	-18.91	
L1007	226.35	T9003	202.96	23.39		T9003	174.20	L1019.1	174.95	-0.75	
L1007	62.06	T9004	47.81	14.25		T9003	171.62	L1020	205.32	-33.69	
L1007	160.80	T9005	148.63	12.18		T9003	179.37	L1021	207.25	-27.89	
L1007	171.39	T9006.1	139.74	31.65	**7.81**	T9003	195.24	L1022	203.03	-7.79	
L1008	211.10	T9002	217.38	-6.28		T9003	200.16	L1023	179.83	20.32	
L1008	193.97	T9003	196.47	-2.50		T9003	186.49	L1024.1	206.31	-19.82	
L1008	35.88	T9004	56.75	-20.87		T9003	165.75	L1025	186.96	-21.21	
L1008	142.17	T9005	144.82	-2.65		T9003	152.93	L1026	191.23	-38.31	
L1008	171.44	T9006.1	145.60	25.83	**11.98**	T9003	155.95	L1027	261.66	-105.71	
L1009	220.50	T9002	205.87	14.64		T9003	172.19	L1028.1	232.54	-60.34	
L1009	184.25	T9003	187.65	-3.41		T9003	190.71	L1029	193.78	-3.07	
L1009	78.14	T9004	66.15	11.99		T9003	206.83	L1030	255.28	-48.45	
L1009	155.92	T9005	143.57	12.36		T9003	209.19	L1031.1	239.38	-30.19	
L1009	202.32	T9006.1	184.59	17.73	**5.79**	T9003	198.82	L1032	293.00	-94.18	
L1010.1	182.69	T9002	196.78	-14.10		T9003	204.28	L1033.1	265.00	-60.72	
L1010.1	178.84	T9003	177.16	1.68		T9003	248.79	L1034	251.60	-2.80	
L1010.1	54.29	T9004	72.85	-18.56		T9003	289.39	L1035	352.54	-63.16	
L1010.1	117.68	T9005	152.17	-34.49		T9003	264.96	L1036.1	304.12	-39.16	
L1010.1	213.87	T9006.1	221.09	-7.22	**9.56**	T9003	198.35	L1037	175.09	23.26	

Line	LZ	Tie	TZ	Diff.	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1011	179.47	T9002	188.38	-8.91		T9003	158.81	L1038	167.06	-8.25	
L1011	186.21	T9003	171.16	15.05		T9003	148.17	L1039	167.91	-19.74	
L1011	90.55	T9004	81.66	8.89		T9003	145.40	L1040	137.66	7.74	
L1011	153.81	T9005	154.90	-1.09		T9003	148.59	L1041.1	149.20	-0.61	
L1011	197.73	T9006.1	223.10	-25.37	**11.20**	T9003	153.18	L1042	141.97	11.21	
L1012	164.78	T9002	175.62	-10.84		T9003	149.42	L1043.1	189.97	-40.55	
L1012	180.05	T9003	169.09	10.96		T9003	145.33	L1044.2	135.10	10.24	**20.16**
L1012	100.05	T9004	101.01	-0.96		T9004	192.96	L1001	186.74	6.22	
L1012	155.76	T9005	154.29	1.47		T9004	167.78	L1002.1	170.82	-3.04	
L1012	204.85	T9006.1	204.81	0.04	**5.48**	T9004	130.79	L1003.2	147.10	-16.31	
L1013	160.94	T9002	157.13	3.81		T9004	99.83	L1004.1	128.10	-28.27	
L1013	185.10	T9003	173.52	11.58		T9004	78.01	L1005.1	76.81	1.20	
L1013	118.74	T9004	126.86	-8.12		T9004	55.53	L1006.1	62.75	-7.22	
L1013	172.64	T9005	157.60	15.04		T9004	47.81	L1007	62.06	-14.25	
L1013	192.87	T9006.1	193.96	-1.09	**6.63**	T9004	56.75	L1008	35.88	20.87	
L1014	172.98	T9003	182.00	-9.02		T9004	66.15	L1009	78.14	-11.99	
L1014	121.36	T9004	134.90	-13.54		T9004	72.85	L1010.1	54.29	18.56	
L1014	169.90	T9005	157.66	12.24		T9004	81.66	L1011	90.55	-8.89	
L1014	202.43	T9006.1	186.72	15.70	**10.44**	T9004	101.01	L1012	100.05	0.96	
L1015.1	162.52	T9003	178.60	-16.08		T9004	126.86	L1013	118.74	8.12	
L1015.1	107.33	T9004	125.83	-18.50		T9004	134.90	L1014	121.36	13.54	
L1015.1	143.48	T9005	148.29	-4.81		T9004	125.83	L1015.1	107.33	18.50	
L1015.1	172.71	T9006.1	169.80	2.91		T9004	128.29	L1016	149.64	-21.35	
L1015.1	48.63	T9007.1	33.00	15.63	**9.94**	T9004	160.36	L1017	142.73	17.63	
L1016	195.37	T9003	165.68	29.69		T9004	200.09	L1018	239.69	-39.60	
L1016	149.64	T9004	128.29	21.35		T9004	224.52	L1019.1	213.41	11.10	
L1016	139.48	T9005	135.34	4.14		T9004	238.02	L1020	272.55	-34.53	
L1016	162.64	T9006.1	150.18	12.46		T9004	240.74	L1021	332.91	-92.16	
L1016	81.91	T9007.1	30.28	51.64	**12.90**	T9004	247.76	L1022	240.18	7.58	
L1017	185.87	T9003	164.50	21.37		T9004	262.34	L1023	290.71	-28.37	
L1017	142.73	T9004	160.36	-17.63		T9004	250.39	L1024.1	271.16	-20.77	
L1017	88.93	T9005	101.46	-12.52		T9004	186.15	L1025	153.51	32.65	
L1017	140.48	T9006.1	130.29	10.19		T9004	98.35	L1026	102.47	-4.12	
L1017	72.78	T9007.1	47.48	25.30	**13.81**	T9004	47.18	L1027	75.76	-28.57	
L1018	190.62	T9003	171.70	18.91		T9004	58.65	L1028.1	118.79	-60.14	
L1018	239.69	T9004	200.09	39.60		T9004	112.50	L1029	103.41	9.09	
L1018	45.69	T9005	45.07	0.62		T9004	197.40	L1030	261.29	-63.90	
L1018	123.67	T9006.1	111.30	12.37		T9004	269.32	L1031.1	278.31	-8.99	
L1018	131.75	T9007.1	97.21	34.55	**11.31**	T9004	282.72	L1032	300.19	-17.47	
L1019.1	174.95	T9003	174.20	0.75		T9004	238.34	L1033.1	334.55	-96.21	
L1019.1	213.41	T9004	224.52	-11.10		T9004	173.71	L1034	207.95	-34.24	
L1019.1	18.85	T9005	6.74	12.12		T9004	117.63	L1035	118.90	-1.26	
L1019.1	108.77	T9006.1	104.35	4.41		T9004	93.37	L1036.1	72.06	21.31	
L1019.1	134.82	T9007.1	135.55	-0.73	**5.97**	T9004	128.16	L1037	141.22	-13.06	
L1020	205.32	T9003	171.62	33.69		T9004	179.86	L1038	186.79	-6.92	
L1020	272.55	T9004	238.02	34.53		T9004	197.03	L1039	200.87	-3.84	
L1020	26.78	T9005	9.19	17.58		T9004	198.10	L1040	171.62	26.48	
L1020	127.42	T9006.1	118.76	8.66		T9004	224.77	L1041.1	182.41	42.35	
L1020	119.47	T9007.1	113.62	5.84	**9.57**	T9004	272.35	L1042	269.53	2.83	
L1021	207.25	T9003	179.37	27.89		T9004	300.04	L1043.1	318.11	-18.07	
L1021	332.91	T9004	240.74	92.16		T9004	307.91	L1044.2	301.89	6.02	**20.59**
L1021	70.13	T9005	37.90	32.23		T9005	142.00	L1001	152.08	-10.08	
L1021	171.47	T9006.1	135.39	36.09		T9005	146.70	L1002.1	114.91	31.79	
L1021	94.27	T9007.1	60.07	34.21	**18.96**	T9005	141.40	L1003.2	148.06	-6.67	
L1022	203.03	T9003	195.24	7.79		T9005	128.06	L1004.1	136.93	-8.87	
L1022	240.18	T9004	247.76	-7.58		T9005	125.30	L1005.1	128.90	-3.59	
L1022	42.28	T9005	82.39	-40.11		T9005	138.51	L1006.1	136.19	2.32	
L1022	119.65	T9006.1	128.06	-8.41		T9005	148.63	L1007	160.80	-12.18	
L1022	73.62	T9007.1	47.02	26.60	**17.36**	T9005	144.82	L1008	142.17	2.65	

Line	LZ	Tie	TZ	Diff.	Line rms
L1023	179.83	T9003	200.16	-20.32	
L1023	290.71	T9004	262.34	28.37	
L1023	114.34	T9005	123.28	-8.93	
L1023	87.70	T9006.1	104.83	-17.13	
L1023	142.76	T9007.1	79.55	63.21	**25.44**
L1024.1	206.31	T9003	186.49	19.82	
L1024.1	271.16	T9004	250.39	20.77	
L1024.1	113.77	T9005	119.60	-5.83	
L1024.1	107.06	T9006.1	98.04	9.02	
L1024.1	163.52	T9007.1	109.09	54.43	**15.71**
L1025	186.96	T9003	165.75	21.21	
L1025	153.51	T9004	186.15	-32.65	
L1025	89.09	T9005	64.66	24.42	
L1025	118.45	T9006.1	111.26	7.20	
L1025	197.41	T9007.1	129.47	67.94	**25.56**
L1026	191.23	T9003	152.93	38.31	
L1026	102.47	T9004	98.35	4.12	
L1026	47.13	T9005	16.32	30.82	
L1026	180.67	T9006.1	117.05	63.63	
L1026	239.42	T9007.1	150.47	88.95	**22.90**
L1027	261.66	T9003	155.95	105.71	
L1027	75.76	T9004	47.18	28.57	
L1027	-0.83	T9005	46.21	-47.04	
L1027	149.09	T9006.1	126.25	22.85	
L1027	168.79	T9007.1	154.11	14.68	**38.45**
L1028.1	232.54	T9003	172.19	60.34	
L1028.1	118.79	T9004	58.65	60.14	
L1028.1	113.89	T9005	113.15	0.75	
L1028.1	165.20	T9006.1	150.88	14.33	
L1028.1	178.39	T9007.1	140.83	37.56	**18.98**
L1029	193.78	T9003	190.71	3.07	
L1029	103.41	T9004	112.50	-9.09	
L1029	117.50	T9005	129.50	-12.00	
L1029	175.51	T9006.1	163.92	11.59	
L1029	174.08	T9007.1	127.83	46.24	**16.55**
L1030	255.28	T9003	206.83	48.45	
L1030	261.29	T9004	197.40	63.90	
L1030	136.64	T9005	105.41	31.23	
L1030	171.35	T9006.1	148.56	22.79	
L1030	154.85	T9007.1	130.49	24.36	**12.46**
L1031.1	239.38	T9003	209.19	30.19	
L1031.1	278.31	T9004	269.32	8.99	
L1031.1	126.38	T9005	123.08	3.30	
L1031.1	122.80	T9006.1	128.31	-5.51	
L1031.1	146.36	T9007.1	144.20	2.17	**9.56**
L1032	293.00	T9003	198.82	94.18	
L1032	300.19	T9004	282.72	17.47	
L1032	266.07	T9005	188.45	77.62	
L1032	273.73	T9006.1	135.24	138.50	
L1032	322.45	T9007.1	148.71	173.74	**42.23**
L1033.1	265.00	T9003	204.28	60.72	
L1033.1	334.55	T9004	238.34	96.21	
L1033.1	307.34	T9005	230.24	77.10	
L1033.1	280.49	T9006.1	160.66	119.83	
L1033.1	238.56	T9007.1	143.78	94.78	**15.71**
L1034	251.60	T9003	248.79	2.80	
L1034	207.95	T9004	173.71	34.24	
L1034	204.67	T9005	212.72	-8.05	
L1034	205.69	T9006.1	192.12	13.57	
L1034	159.22	T9007.1	147.63	11.59	**11.05**

Tie	TZ	Line	LZ	Diff	Line rms
T9005	143.57	L1009	155.92	-12.36	
T9005	152.17	L1010.1	117.68	34.49	
T9005	154.90	L1011	153.81	1.09	
T9005	154.29	L1012	155.76	-1.47	
T9005	157.60	L1013	172.64	-15.04	
T9005	157.66	L1014	169.90	-12.24	
T9005	148.29	L1015.1	143.48	4.81	
T9005	135.34	L1016	139.48	-4.14	
T9005	101.46	L1017	88.93	12.52	
T9005	45.07	L1018	45.69	-0.62	
T9005	6.74	L1019.1	18.85	-12.12	
T9005	9.19	L1020	26.78	-17.58	
T9005	37.90	L1021	70.13	-32.23	
T9005	82.39	L1022	42.28	40.11	
T9005	123.28	L1023	114.34	8.93	
T9005	119.60	L1024.1	113.77	5.83	
T9005	64.66	L1025	89.09	-24.42	
T9005	16.32	L1026	47.13	-30.82	
T9005	46.21	L1027	-0.83	47.04	
T9005	113.15	L1028.1	113.89	-0.75	
T9005	129.50	L1029	117.50	12.00	
T9005	105.41	L1030	136.64	-31.23	
T9005	123.08	L1031.1	126.38	-3.30	
T9005	188.45	L1032	266.07	-77.62	
T9005	230.24	L1033.1	307.34	-77.10	
T9005	212.72	L1034	204.67	8.05	
T9005	170.48	L1035	192.75	-22.27	
T9005	139.34	L1036.1	200.58	-61.24	
T9005	144.49	L1037	170.84	-26.35	
T9005	185.59	L1038	132.63	52.96	
T9005	209.01	L1039	235.84	-26.83	
T9005	176.00	L1040	139.45	36.55	
T9005	149.52	L1041.1	126.43	23.08	
T9005	164.85	L1042	187.31	-22.46	
T9005	170.41	L1043.1	185.86	-15.45	
T9005	146.89	L1044.2	135.13	11.77	**19.72**
T9006.1	142.57	L1001	160.68	-18.11	
T9006.1	162.73	L1002.1	161.39	1.34	
T9006.1	175.59	L1003.2	198.39	-22.80	
T9006.1	179.15	L1004.1	195.42	-16.28	
T9006.1	173.12	L1005.1	165.06	8.06	
T9006.1	157.45	L1006.1	181.38	-23.94	
T9006.1	139.74	L1007	171.39	-31.65	
T9006.1	145.60	L1008	171.44	-25.83	
T9006.1	184.59	L1009	202.32	-17.73	
T9006.1	221.09	L1010.1	213.87	7.22	
T9006.1	223.10	L1011	197.73	25.37	
T9006.1	204.81	L1012	204.85	-0.04	
T9006.1	193.96	L1013	192.87	1.09	
T9006.1	186.72	L1014	202.43	-15.70	
T9006.1	169.80	L1015.1	172.71	-2.91	
T9006.1	150.18	L1016	162.64	-12.46	
T9006.1	130.29	L1017	140.48	-10.19	
T9006.1	111.30	L1018	123.67	-12.37	
T9006.1	104.35	L1019.1	108.77	-4.41	
T9006.1	118.76	L1020	127.42	-8.66	
T9006.1	135.39	L1021	171.47	-36.09	
T9006.1	128.06	L1022	119.65	8.41	
T9006.1	104.83	L1023	87.70	17.13	
T9006.1	98.04	L1024.1	107.06	-9.02	

Line	LZ	Tie	TZ	Diff.	Line rms
L1035	352.54	T9003	289.39	63.16	
L1035	118.90	T9004	117.63	1.26	
L1035	192.75	T9005	170.48	22.27	
L1035	225.82	T9006.1	217.14	8.68	
L1035	159.94	T9007.1	157.32	2.62	**18.19**
L1036.1	304.12	T9003	264.96	39.16	
L1036.1	72.06	T9004	93.37	-21.31	
L1036.1	200.58	T9005	139.34	61.24	
L1036.1	273.96	T9006.1	235.26	38.70	
L1036.1	191.94	T9007.1	153.21	38.73	**21.90**
L1037	175.09	T9003	198.35	-23.26	
L1037	141.22	T9004	128.16	13.06	
L1037	170.84	T9005	144.49	26.35	
L1037	291.52	T9006.1	264.22	27.30	
L1037	164.50	T9007.1	141.97	22.53	**14.95**
L1038	167.06	T9003	158.81	8.25	
L1038	186.79	T9004	179.86	6.92	
L1038	132.63	T9005	185.59	-52.96	
L1038	277.39	T9006.1	293.64	-16.26	
L1038	155.46	T9007.1	147.23	8.23	**18.82**
L1039	167.91	T9003	148.17	19.74	
L1039	200.87	T9004	197.03	3.84	
L1039	235.84	T9005	209.01	26.83	
L1039	283.03	T9006.1	291.50	-8.47	
L1039	162.94	T9007.1	154.37	8.57	**9.74**
L1040	137.66	T9003	145.40	-7.74	
L1040	171.62	T9004	198.10	-26.48	
L1040	139.45	T9005	176.00	-36.55	
L1040	245.78	T9006.1	271.26	-25.48	
L1040	140.20	T9007.1	142.03	-1.84	**10.16**
L1041.1	149.20	T9003	148.59	0.61	
L1041.1	182.41	T9004	224.77	-42.35	
L1041.1	126.43	T9005	149.52	-23.08	
L1041.1	261.70	T9006.1	274.19	-12.49	
L1041.1	115.43	T9007.1	122.81	-7.38	**11.74**
L1042	141.97	T9003	153.18	-11.21	
L1042	269.53	T9004	272.35	-2.83	
L1042	187.31	T9005	164.85	22.46	
L1042	320.99	T9006.1	300.17	20.82	
L1042	122.29	T9007.1	105.68	16.61	**10.76**
L1043.1	189.97	T9003	149.42	40.55	
L1043.1	318.11	T9004	300.04	18.07	
L1043.1	185.86	T9005	170.41	15.45	
L1043.1	342.37	T9006.1	318.24	24.12	
L1043.1	115.08	T9007.1	80.38	34.70	**7.61**
L1044.2	135.10	T9003	145.33	-10.24	
L1044.2	301.89	T9004	307.91	-6.02	
L1044.2	135.13	T9005	146.89	-11.77	
L1044.2	282.77	T9006.1	309.02	-26.26	
L1044.2	50.86	T9007.1	51.20	-0.34	**6.82**
				21.70	**13.81**
				rms all	average line rms

Tie	TZ	Line	LZ	Diff	Line rms
T9006.1	111.26	L1025	118.45	-7.20	
T9006.1	117.05	L1026	180.67	-63.63	
T9006.1	126.25	L1027	149.09	-22.85	
T9006.1	150.88	L1028.1	165.20	-14.33	
T9006.1	163.92	L1029	175.51	-11.59	
T9006.1	148.56	L1030	171.35	-22.79	
T9006.1	128.31	L1031.1	122.80	5.51	
T9006.1	135.24	L1032	273.73	-138.50	
T9006.1	160.66	L1033.1	280.49	-119.83	
T9006.1	192.12	L1034	205.69	-13.57	
T9006.1	217.14	L1035	225.82	-8.68	
T9006.1	235.26	L1036.1	273.96	-38.70	
T9006.1	264.22	L1037	291.52	-27.30	
T9006.1	293.64	L1038	277.39	16.26	
T9006.1	291.50	L1039	283.03	8.47	
T9006.1	271.26	L1040	245.78	25.48	
T9006.1	274.19	L1041.1	261.70	12.49	
T9006.1	300.17	L1042	320.99	-20.82	
T9006.1	318.24	L1043.1	342.37	-24.12	
T9006.1	309.02	L1044.2	282.77	26.26	**22.12**
T9007.1	33.00	L1015.1	48.63	-15.63	
T9007.1	30.28	L1016	81.91	-51.64	
T9007.1	47.48	L1017	72.78	-25.30	
T9007.1	97.21	L1018	131.75	-34.55	
T9007.1	135.55	L1019.1	134.82	0.73	
T9007.1	113.62	L1020	119.47	-5.84	
T9007.1	60.07	L1021	94.27	-34.21	
T9007.1	47.02	L1022	73.62	-26.60	
T9007.1	79.55	L1023	142.76	-63.21	
T9007.1	109.09	L1024.1	163.52	-54.43	
T9007.1	129.47	L1025	197.41	-67.94	
T9007.1	150.47	L1026	239.42	-88.95	
T9007.1	154.11	L1027	168.79	-14.68	
T9007.1	140.83	L1028.1	178.39	-37.56	
T9007.1	127.83	L1029	174.08	-46.24	
T9007.1	130.49	L1030	154.85	-24.36	
T9007.1	144.20	L1031.1	146.36	-2.17	
T9007.1	148.71	L1032	322.45	-173.74	
T9007.1	143.78	L1033.1	238.56	-94.78	
T9007.1	147.63	L1034	159.22	-11.59	
T9007.1	157.32	L1035	159.94	-2.62	
T9007.1	153.21	L1036.1	191.94	-38.73	
T9007.1	141.97	L1037	164.50	-22.53	
T9007.1	147.23	L1038	155.46	-8.23	
T9007.1	154.37	L1039	162.94	-8.57	
T9007.1	142.03	L1040	140.20	1.84	
T9007.1	122.81	L1041.1	115.43	7.38	
T9007.1	105.68	L1042	122.29	-16.61	
T9007.1	80.38	L1043.1	115.08	-34.70	
T9007.1	51.20	L1044.2	50.86	0.34	**26.42**
				21.70	**13.81**
				rms all	average line rms

Final Data Cross-Over Errors - micrometres per second per second

Line	LZ	Tie	TZ	Diff	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1001	358.72	T9001	349.26	9.47		T9001	349.26	L1001	358.72	-9.47	
L1001	437.79	T9002	439.13	-1.33		T9001	350.46	L1002.1	350.88	-0.42	
L1001	508.40	T9003	510.45	-2.06		T9001	344.32	L1003.1	340.36	3.97	
L1001	492.06	T9004	481.68	10.38		T9001	325.81	L1004.1	325.59	0.21	
L1001	433.55	T9005	422.07	11.48		T9001	311.67	L1005.1	316.22	-4.55	
L1001	434.62	T9006.1	434.56	0.06	4.52	T9001	317.24	L1006.1	317.92	-0.68	2.14
L1002.1	350.88	T9001	350.46	0.42		T9002	439.13	L1001	437.79	1.33	
L1002.1	453.33	T9002	450.16	3.16		T9002	450.16	L1002.1	453.33	-3.16	
L1002.1	517.89	T9003	511.90	5.99		T9002	468.04	L1003.1	465.88	2.17	
L1002.1	453.47	T9004	456.73	-3.26		T9002	473.98	L1004.1	472.15	1.83	
L1002.1	426.19	T9005	427.14	-0.95		T9002	474.30	L1005.1	476.75	-2.44	
L1002.1	454.64	T9006.1	454.94	-0.30	2.31	T9002	484.43	L1006.1	485.83	-1.39	
L1003.1	340.36	T9001	344.32	-3.97		T9002	498.10	L1007	495.39	2.71	
L1003.1	465.88	T9002	468.04	-2.17		T9002	496.62	L1008	495.50	1.11	
L1003.2	419.81	T9004	419.98	-0.18		T9002	484.65	L1009	486.12	-1.46	
L1003.2	418.14	T9005	422.21	-4.08		T9002	475.11	L1010.1	475.84	-0.73	
L1003.2	468.07	T9006.1	468.03	0.05	1.40	T9002	466.27	L1011	465.63	0.64	
L1004.1	325.59	T9001	325.81	-0.21		T9002	453.07	L1012	451.72	1.35	
L1004.1	472.15	T9002	473.98	-1.83		T9002	434.13	L1013	434.38	-0.24	1.31
L1004.1	513.55	T9003	513.96	-0.42		T9003	510.45	L1001	508.40	2.06	
L1004.1	391.47	T9004	389.25	2.23		T9003	511.90	L1002.1	517.89	-5.99	
L1004.1	410.48	T9005	409.25	1.23		T9003	513.96	L1004.1	513.55	0.42	
L1004.1	472.11	T9006.1	471.81	0.30	0.99	T9003	509.50	L1005.1	509.51	-0.01	
L1005.1	316.22	T9001	311.67	4.55		T9003	502.80	L1006.1	502.45	0.35	
L1005.1	476.75	T9002	474.30	2.44		T9003	494.21	L1007	494.75	-0.53	
L1005.1	509.51	T9003	509.50	0.01		T9003	488.39	L1008	487.76	0.63	
L1005.1	365.35	T9004	367.67	-2.32		T9003	480.28	L1009	479.92	0.36	
L1005.1	409.99	T9005	406.86	3.13		T9003	470.49	L1010.1	470.77	-0.28	
L1005.1	465.21	T9006.1	466.01	-0.80	1.85	T9003	465.21	L1011	464.42	0.79	
L1006.1	317.92	T9001	317.24	0.68		T9003	463.83	L1012	464.38	-0.54	
L1006.1	485.83	T9002	484.43	1.39		T9003	468.93	L1013	470.34	-1.41	
L1006.1	502.45	T9003	502.80	-0.35		T9003	478.11	L1014	476.22	1.90	
L1006.1	345.85	T9004	345.44	0.42		T9003	475.39	L1015.1	473.44	1.96	
L1006.1	419.48	T9005	420.45	-0.96		T9003	463.19	L1016	465.90	-2.72	
L1006.1	448.02	T9006.1	450.58	-2.55	0.99	T9003	462.69	L1017	463.95	-1.26	
L1007	495.39	T9002	498.10	-2.71		T9003	470.59	L1018	468.77	1.82	
L1007	494.75	T9003	494.21	0.53		T9003	473.80	L1019.1	471.62	2.18	
L1007	340.41	T9004	337.94	2.47		T9003	471.86	L1020	473.40	-1.54	
L1007	427.55	T9005	430.92	-3.38		T9003	480.29	L1021	482.13	-1.84	
L1007	434.26	T9006.1	433.11	1.14	1.79	T9003	496.84	L1022	494.91	1.93	
L1008	495.50	T9002	496.62	-1.11		T9003	502.45	L1023	500.47	1.97	
L1008	487.76	T9003	488.39	-0.63		T9003	489.45	L1024.1	489.90	-0.45	
L1008	346.33	T9004	347.10	-0.76		T9003	469.40	L1025	470.44	-1.03	
L1008	428.83	T9005	427.49	1.33		T9003	457.26	L1026	458.60	-1.34	
L1008	443.73	T9006.1	439.21	4.52	1.66	T9003	460.97	L1027	460.84	0.13	
L1009	486.12	T9002	484.65	1.46		T9003	477.92	L1028.1	477.32	0.59	
L1009	479.92	T9003	480.28	-0.36		T9003	497.12	L1029	498.00	-0.88	
L1009	355.52	T9004	356.71	-1.19		T9003	513.92	L1030	513.17	0.75	
L1009	429.08	T9005	426.62	2.46		T9003	516.94	L1031.1	512.62	4.32	
L1009	477.87	T9006.1	478.45	-0.58	1.09	T9003	507.22	L1032	506.18	1.04	
L1010.1	475.84	T9002	475.11	0.73		T9003	513.33	L1033.1	520.06	-6.74	
L1010.1	470.77	T9003	470.49	0.28		T9003	558.53	L1034	561.29	-2.76	
L1010.1	362.96	T9004	363.62	-0.66		T9003	599.78	L1035	589.74	10.04	
L1010.1	433.55	T9005	435.60	-2.05		T9003	576.04	L1036.1	571.21	4.83	
L1010.1	510.41	T9006.1	515.22	-4.81	1.58	T9003	510.12	L1037	517.76	-7.64	

Line	LZ	Tie	TZ	Diff	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1011	465.63	T9002	466.27	-0.64		T9003	471.27	L1038	473.36	-2.09	
L1011	464.42	T9003	465.21	-0.79		T9003	461.33	L1039	457.68	3.66	
L1011	374.25	T9004	372.64	1.61		T9003	459.23	L1040	459.43	-0.20	
L1011	438.08	T9005	438.74	-0.65		T9003	463.08	L1041.1	464.25	-1.17	
L1011	516.47	T9006.1	517.48	-1.01	**0.76**	T9003	468.33	L1042	466.64	1.69	
L1012	451.72	T9002	453.07	-1.35		T9003	465.22	L1043.1	466.66	-1.43	
L1012	464.38	T9003	463.83	0.54		T9003	461.80	L1044.2	466.10	-4.29	**2.14**
L1012	394.24	T9004	392.18	2.06		T9004	481.68	L1001	492.06	-10.38	
L1012	440.42	T9005	438.52	1.91		T9004	456.73	L1002.1	453.47	3.26	
L1012	502.93	T9006.1	499.47	3.46	**1.28**	T9004	419.98	L1003.2	419.81	0.18	
L1013	434.38	T9002	434.13	0.24		T9004	389.25	L1004.1	391.47	-2.23	
L1013	470.34	T9003	468.93	1.41		T9004	367.67	L1005.1	365.35	2.32	
L1013	415.92	T9004	418.24	-2.32		T9004	345.44	L1006.1	345.85	-0.42	
L1013	441.64	T9005	442.24	-0.60		T9004	337.94	L1007	340.41	-2.47	
L1013	489.02	T9006.1	488.91	0.11	**0.97**	T9004	347.10	L1008	346.33	0.76	
L1014	476.22	T9003	478.11	-1.90		T9004	356.71	L1009	355.52	1.19	
L1014	423.14	T9004	426.48	-3.33		T9004	363.62	L1010.1	362.96	0.66	
L1014	441.51	T9005	442.71	-1.21		T9004	372.64	L1011	374.25	-1.61	
L1014	479.08	T9006.1	481.96	-2.88	**0.68**	T9004	392.18	L1012	394.24	-2.06	
L1015.1	473.44	T9003	475.39	-1.96		T9004	418.24	L1013	415.92	2.32	
L1015.1	418.91	T9004	417.60	1.31		T9004	426.48	L1014	423.14	3.33	
L1015.1	436.47	T9005	433.78	2.69		T9004	417.60	L1015.1	418.91	-1.31	
L1015.1	465.75	T9006.1	465.33	0.42		T9004	420.25	L1016	424.03	-3.78	
L1015.1	329.19	T9007.1	359.19	-29.99	**9.75**	T9004	452.52	L1017	452.17	0.36	
L1016	465.90	T9003	463.19	2.72		T9004	492.45	L1018	489.26	3.19	
L1016	424.03	T9004	420.25	3.78		T9004	517.07	L1019.1	517.63	-0.56	
L1016	420.27	T9005	421.26	-0.99		T9004	530.76	L1020	529.28	1.48	
L1016	446.95	T9006.1	446.01	0.93		T9004	533.68	L1021	534.04	-0.36	
L1016	354.38	T9007.1	355.80	-1.42	**1.60**	T9004	540.92	L1022	545.83	-4.91	
L1017	463.95	T9003	462.69	1.26		T9004	555.73	L1023	556.46	-0.73	
L1017	452.17	T9004	452.52	-0.36		T9004	544.01	L1024.1	538.72	5.29	
L1017	382.76	T9005	387.83	-5.08		T9004	480.01	L1025	476.99	3.02	
L1017	425.03	T9006.1	426.42	-1.39		T9004	392.44	L1026	396.55	-4.11	
L1017	383.15	T9007.1	372.33	10.82	**4.20**	T9004	341.50	L1027	344.66	-3.16	
L1018	468.77	T9003	470.59	-1.82		T9004	353.17	L1028.1	351.28	1.89	
L1018	489.26	T9004	492.45	-3.19		T9004	407.21	L1029	409.80	-2.60	
L1018	334.98	T9005	331.89	3.09		T9004	492.30	L1030	495.16	-2.86	
L1018	407.61	T9006.1	407.72	-0.11		T9004	564.41	L1031.1	559.39	5.02	
L1018	422.74	T9007.1	421.40	1.35	**1.76**	T9004	578.01	L1032	575.23	2.78	
L1019.1	471.62	T9003	473.80	-2.18		T9004	533.86	L1033.1	536.21	-2.35	
L1019.1	517.63	T9004	517.07	0.56		T9004	469.48	L1034	467.42	2.06	
L1019.1	297.32	T9005	294.01	3.31		T9004	413.63	L1035	412.21	1.43	
L1019.1	404.55	T9006.1	401.05	3.50		T9004	389.61	L1036.1	397.08	-7.47	
L1019.1	449.94	T9007.1	459.05	-9.11	**3.68**	T9004	424.63	L1037	426.07	-1.44	
L1020	473.40	T9003	471.86	1.54		T9004	476.56	L1038	468.54	8.02	
L1020	529.28	T9004	530.76	-1.48		T9004	493.94	L1039	491.51	2.43	
L1020	295.14	T9005	296.89	-1.75		T9004	495.21	L1040	501.42	-6.22	
L1020	417.12	T9006.1	415.74	1.38		T9004	522.07	L1041.1	524.52	-2.45	
L1020	432.73	T9007.1	436.50	-3.77	**1.60**	T9004	569.85	L1042	560.91	8.94	
L1021	482.13	T9003	480.29	1.84		T9004	597.72	L1043.1	595.56	2.15	
L1021	534.04	T9004	533.68	0.36		T9004	605.77	L1044.2	624.98	-19.21	**3.34**
L1021	326.43	T9005	326.04	0.39		T9005	422.07	L1001	433.55	-11.48	
L1021	428.99	T9006.1	432.63	-3.65		T9005	427.14	L1002.1	426.19	0.95	
L1021	389.94	T9007.1	382.26	7.68	**2.90**	T9005	422.21	L1003.2	418.14	4.08	
L1022	494.91	T9003	496.84	-1.93		T9005	409.25	L1004.1	410.48	-1.23	
L1022	545.83	T9004	540.92	4.91		T9005	406.86	L1005.1	409.99	-3.13	
L1022	374.72	T9005	370.95	3.77		T9005	420.45	L1006.1	419.48	0.96	
L1022	422.61	T9006.1	425.57	-2.95		T9005	430.92	L1007	427.55	3.38	
L1022	373.15	T9007.1	368.56	4.58	**2.69**	T9005	427.49	L1008	428.83	-1.33	

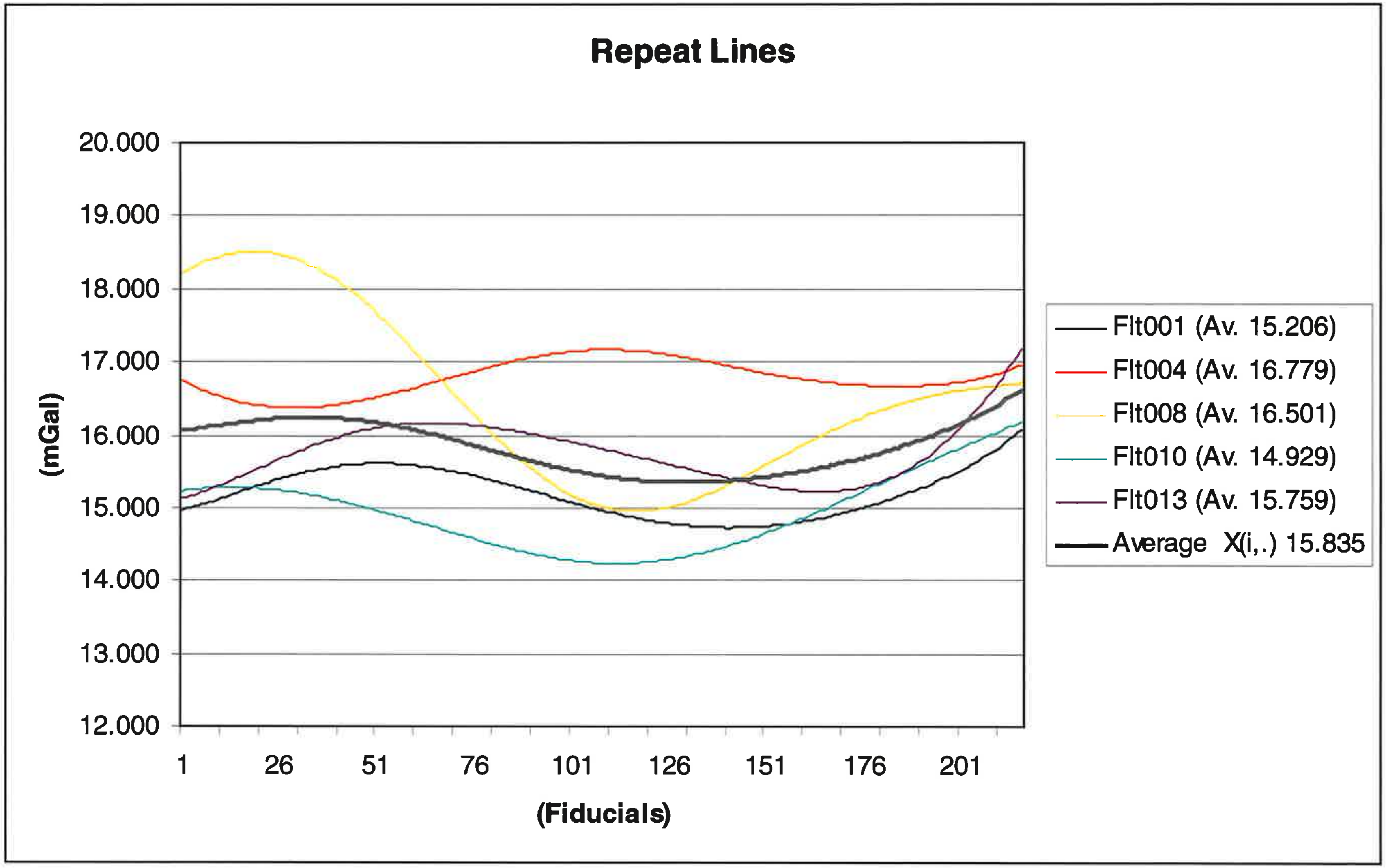
Line	LZ	Tie	TZ	Diff	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1023	500.47	T9003	502.45	-1.97		T9005	426.62	L1009	429.08	-2.46	
L1023	556.46	T9004	555.73	0.73		T9005	435.60	L1010.1	433.55	2.05	
L1023	411.21	T9005	412.26	-1.05		T9005	438.74	L1011	438.08	0.65	
L1023	406.43	T9006.1	402.59	3.84		T9005	438.52	L1012	440.42	-1.91	
L1023	394.37	T9007.1	400.41	-6.04	**2.57**	T9005	442.24	L1013	441.64	0.60	
L1024.1	489.90	T9003	489.45	0.45		T9005	442.71	L1014	441.51	1.21	
L1024.1	538.72	T9004	544.01	-5.29		T9005	433.78	L1015.1	436.47	-2.69	
L1024.1	401.92	T9005	408.99	-7.07		T9005	421.26	L1016	420.27	0.99	
L1024.1	398.79	T9006.1	396.06	2.72		T9005	387.83	L1017	382.76	5.08	
L1024.1	427.76	T9007.1	429.29	-1.52	**2.85**	T9005	331.89	L1018	334.98	-3.09	
L1025	470.44	T9003	469.40	1.03		T9005	294.01	L1019.1	297.32	-3.31	
L1025	476.99	T9004	480.01	-3.02		T9005	296.89	L1020	295.14	1.75	
L1025	351.66	T9005	354.47	-2.80		T9005	326.04	L1021	326.43	-0.39	
L1025	404.24	T9006.1	409.53	-5.29		T9005	370.95	L1022	374.72	-3.77	
L1025	452.65	T9007.1	449.02	3.63	**2.52**	T9005	412.26	L1023	411.21	1.05	
L1026	458.60	T9003	457.26	1.34		T9005	408.99	L1024.1	401.92	7.07	
L1026	396.55	T9004	392.44	4.11		T9005	354.47	L1025	351.66	2.80	
L1026	317.93	T9005	306.53	11.40		T9005	306.53	L1026	317.93	-11.40	
L1026	414.45	T9006.1	415.57	-1.12		T9005	336.81	L1027	342.79	-5.97	
L1026	468.40	T9007.1	469.36	-0.97	**3.66**	T9005	404.12	L1028.1	391.70	12.42	
L1027	460.84	T9003	460.97	-0.13		T9005	420.84	L1029	411.84	9.00	
L1027	344.66	T9004	341.50	3.16		T9005	397.11	L1030	405.90	-8.79	
L1027	342.79	T9005	336.81	5.97		T9005	415.14	L1031.1	423.57	-8.44	
L1027	430.01	T9006.1	425.02	4.99		T9005	480.86	L1032	476.23	4.64	
L1027	469.59	T9007.1	472.37	-2.79	**2.58**	T9005	523.02	L1033.1	516.40	6.62	
L1028.1	477.32	T9003	477.92	-0.59		T9005	505.89	L1034	506.95	-1.06	
L1028.1	351.28	T9004	353.17	-1.89		T9005	464.04	L1035	464.78	-0.74	
L1028.1	391.70	T9005	404.12	-12.42		T9005	433.32	L1036.1	434.31	-1.00	
L1028.1	450.00	T9006.1	449.89	0.11		T9005	438.88	L1037	444.87	-5.99	
L1028.1	458.08	T9007.1	458.46	-0.38	**3.75**	T9005	480.40	L1038	479.04	1.36	
L1029	498.00	T9003	497.12	0.88		T9005	504.23	L1039	493.18	11.05	
L1029	409.80	T9004	407.21	2.60		T9005	471.66	L1040	476.07	-4.41	
L1029	411.84	T9005	420.84	-9.00		T9005	445.59	L1041.1	455.54	-9.95	
L1029	458.19	T9006.1	463.16	-4.97		T9005	461.33	L1042	452.84	8.49	
L1029	447.38	T9007.1	444.84	2.55	**3.66**	T9005	467.30	L1043.1	461.44	5.86	
L1030	513.17	T9003	513.92	-0.75		T9005	444.21	L1044.2	472.43	-28.22	**4.94**
L1030	495.16	T9004	492.30	2.86		T9006.1	434.56	L1001	434.62	-0.06	
L1030	405.90	T9005	397.11	8.79		T9006.1	454.94	L1002.1	454.64	0.30	
L1030	447.51	T9006.1	448.03	-0.52		T9006.1	468.03	L1003.2	468.07	-0.05	
L1030	448.47	T9007.1	446.87	1.60	**2.74**	T9006.1	471.81	L1004.1	472.11	-0.30	
L1031.1	512.62	T9003	516.94	-4.32		T9006.1	466.01	L1005.1	465.21	0.80	
L1031.1	559.39	T9004	564.41	-5.02		T9006.1	450.58	L1006.1	448.02	2.55	
L1031.1	423.57	T9005	415.14	8.44		T9006.1	433.11	L1007	434.26	-1.14	
L1031.1	432.37	T9006.1	428.01	4.37		T9006.1	439.21	L1008	443.73	-4.52	
L1031.1	457.34	T9007.1	459.93	-2.59	**4.19**	T9006.1	478.45	L1009	477.87	0.58	
L1032	506.18	T9003	507.22	-1.04		T9006.1	515.22	L1010.1	510.41	4.81	
L1032	575.23	T9004	578.01	-2.78		T9006.1	517.48	L1011	516.47	1.01	
L1032	476.23	T9005	480.86	-4.64		T9006.1	499.47	L1012	502.93	-3.46	
L1032	436.15	T9006.1	435.17	0.98		T9006.1	488.91	L1013	489.02	-0.11	
L1032	461.43	T9007.1	463.81	-2.38	**1.48**	T9006.1	481.96	L1014	479.08	2.88	
L1033.1	520.06	T9003	513.33	6.74		T9006.1	465.33	L1015.1	465.75	-0.42	
L1033.1	536.21	T9004	533.86	2.35		T9006.1	446.01	L1016	446.95	-0.93	
L1033.1	516.40	T9005	523.02	-6.62		T9006.1	426.42	L1017	425.03	1.39	
L1033.1	461.04	T9006.1	460.82	0.23		T9006.1	407.72	L1018	407.61	0.11	
L1033.1	460.81	T9007.1	458.25	2.56	**3.46**	T9006.1	401.05	L1019.1	404.55	-3.50	
L1034	561.29	T9003	558.53	2.76		T9006.1	415.74	L1020	417.12	-1.38	
L1034	467.42	T9004	469.48	-2.06		T9006.1	432.63	L1021	428.99	3.65	
L1034	506.95	T9005	505.89	1.06		T9006.1	425.57	L1022	422.61	2.95	
L1034	491.24	T9006.1	492.52	-1.28		T9006.1	402.59	L1023	406.43	-3.84	
L1034	463.66	T9007.1	461.49	2.17	**1.50**	T9006.1	396.06	L1024.1	398.79	-2.72	

Line	LZ	Tie	TZ	Diff	Line rms	Tie	TZ	Line	LZ	Diff	Line rms
L1035	589.74	T9003	599.78	-10.04		T9006.1	409.53	L1025	404.24	5.29	
L1035	412.21	T9004	413.63	-1.43		T9006.1	415.57	L1026	414.45	1.12	
L1035	464.78	T9005	464.04	0.74		T9006.1	425.02	L1027	430.01	-4.99	
L1035	515.51	T9006.1	517.78	-2.27		T9006.1	449.89	L1028.1	450.00	-0.11	
L1035	467.22	T9007.1	470.57	-3.35	**2.88**	T9006.1	463.16	L1029	458.19	4.97	
L1036.1	571.21	T9003	576.04	-4.83		T9006.1	448.03	L1030	447.51	0.52	
L1036.1	397.08	T9004	389.61	7.47		T9006.1	428.01	L1031.1	432.37	-4.37	
L1036.1	434.31	T9005	433.32	1.00		T9006.1	435.17	L1032	436.15	-0.98	
L1036.1	539.33	T9006.1	536.16	3.17		T9006.1	460.82	L1033.1	461.04	-0.23	
L1036.1	463.93	T9007.1	465.86	-1.93	**3.34**	T9006.1	492.52	L1034	491.24	1.28	
L1037	517.76	T9003	510.12	7.64		T9006.1	517.78	L1035	515.51	2.27	
L1037	426.07	T9004	424.63	1.44		T9006.1	536.16	L1036.1	539.33	-3.17	
L1037	444.87	T9005	438.88	5.99		T9006.1	565.39	L1037	568.26	-2.87	
L1037	568.26	T9006.1	565.39	2.87		T9006.1	595.09	L1038	589.73	5.36	
L1037	458.46	T9007.1	454.04	4.41	**1.74**	T9006.1	593.23	L1039	590.11	3.12	
L1038	473.36	T9003	471.27	2.09		T9006.1	573.29	L1040	578.72	-5.43	
L1038	468.54	T9004	476.56	-8.02		T9006.1	576.51	L1041.1	579.97	-3.46	
L1038	479.04	T9005	480.40	-1.36		T9006.1	602.78	L1042	596.36	6.42	
L1038	589.73	T9006.1	595.09	-5.36		T9006.1	621.13	L1043.1	616.06	5.08	
L1038	459.11	T9007.1	458.71	0.40	**2.95**	T9006.1	612.20	L1044.2	636.90	-24.70	**3.43**
L1039	457.68	T9003	461.33	-3.66		T9007.1	359.19	L1015.1	329.19	29.99	
L1039	491.51	T9004	493.94	-2.43		T9007.1	355.80	L1016	354.38	1.42	
L1039	493.18	T9005	504.23	-11.05		T9007.1	372.33	L1017	383.15	-10.82	
L1039	590.11	T9006.1	593.23	-3.12		T9007.1	421.40	L1018	422.74	-1.35	
L1039	461.10	T9007.1	465.26	-4.16	**2.48**	T9007.1	459.05	L1019.1	449.94	9.11	
L1040	459.43	T9003	459.23	0.20		T9007.1	436.50	L1020	432.73	3.77	
L1040	501.42	T9004	495.21	6.22		T9007.1	382.26	L1021	389.94	-7.68	
L1040	476.07	T9005	471.66	4.41		T9007.1	368.56	L1022	373.15	-4.58	
L1040	578.72	T9006.1	573.29	5.43		T9007.1	400.41	L1023	394.37	6.04	
L1040	452.50	T9007.1	452.33	0.17	**2.05**	T9007.1	429.29	L1024.1	427.76	1.52	
L1041.1	464.25	T9003	463.08	1.17		T9007.1	449.02	L1025	452.65	-3.63	
L1041.1	524.52	T9004	522.07	2.45		T9007.1	469.36	L1026	468.40	0.97	
L1041.1	455.54	T9005	445.59	9.95		T9007.1	472.37	L1027	469.59	2.79	
L1041.1	579.97	T9006.1	576.51	3.46		T9007.1	458.46	L1028.1	458.08	0.38	
L1041.1	434.61	T9007.1	432.53	2.08	**2.49**	T9007.1	444.84	L1029	447.38	-2.55	
L1042	466.64	T9003	468.33	-1.69		T9007.1	446.87	L1030	448.47	-1.60	
L1042	560.91	T9004	569.85	-8.94		T9007.1	459.93	L1031.1	457.34	2.59	
L1042	452.84	T9005	461.33	-8.49		T9007.1	463.81	L1032	461.43	2.38	
L1042	596.36	T9006.1	602.78	-6.42		T9007.1	458.25	L1033.1	460.81	-2.56	
L1042	412.95	T9007.1	414.82	-1.88	**2.48**	T9007.1	461.49	L1034	463.66	-2.17	
L1043.1	466.66	T9003	465.22	1.43		T9007.1	470.57	L1035	467.22	3.35	
L1043.1	595.56	T9004	597.72	-2.15		T9007.1	465.86	L1036.1	463.93	1.93	
L1043.1	461.44	T9005	467.30	-5.86		T9007.1	454.04	L1037	458.46	-4.41	
L1043.1	616.06	T9006.1	621.13	-5.08		T9007.1	458.71	L1038	459.11	-0.40	
L1043.1	388.46	T9007.1	388.93	-0.46	**2.17**	T9007.1	465.26	L1039	461.10	4.16	
L1044.2	466.10	T9003	461.80	4.29		T9007.1	452.33	L1040	452.50	-0.17	
L1044.2	624.98	T9004	605.77	19.21		T9007.1	432.53	L1041.1	434.61	-2.08	
L1044.2	472.43	T9005	444.21	28.22		T9007.1	414.82	L1042	412.95	1.88	
L1044.2	636.90	T9006.1	612.20	24.70		T9007.1	388.93	L1043.1	388.46	0.46	
L1044.2	360.11	T9007.1	359.17	0.94	**8.64**	T9007.1	359.17	L1044.2	360.11	-0.94	**4.78**
				3.67	**2.64**					**3.66**	**2.64**
				rms all	average line rms					rms all	average line rms

Appendix XII - Repeat Line QC Parameters

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	Flown Kms	Scrub Kms	Total Kms	GPS Time (seconds since start of day)		C-File Satellites >/=6		C-File PDOP <2.5		C-File RMS <1.0		L1-File RMSVel <0.05	
										Start	End	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
9999	0	N	R	1	30-Aug-03	AM	20.842	-	20.842	77122.0	77418.5	9	9	1.6	1.6	0.026	0.049	0.0013	0.0150
9999	1	N	R	4	01-Sep-03	PM	20.842	-	20.842	31720.5	32008.0	9	9	1.3	1.3	0.015	0.041	0.0016	0.0238
9999	2	S	R	8	08-Sep-03	AM	20.842	-	20.842	77022.0	77360.0	8	9	1.4	1.8	0.005	0.014	0.0007	0.0099
9999	3	S	R	10	10-Sep-03	AM	20.842	-	20.842	76064.0	76353.0	9	9	1.3	1.3	0.006	0.014	0.0010	0.0134
9999	4	S	R	13	13-Sep-03	AM	20.842	-	20.842	76248.5	76538.0	8	9	2.0	2.1	0.003	0.012	0.0011	0.0202

Line No.	Ver. No.	Dir.	Line Type	Flt No.	Date	Am / Pm	L1-File Type=1	E-File Alpha1 <0.0011636		E-File Alpha2 <0.0011636		Fine Ch Satur-ations	Coarse Ch Satur-ations	Gravigal RMS Residuals <1500
								Min	Max	Min	Max			
9999	0	N	R	1	30-Aug-03	AM	1	-0.00006400	-0.00003130	-0.00016570	-0.00014570	13	0	679.37
9999	1	N	R	4	01-Sep-03	PM	1	0.00007670	0.00010680	-0.00000430	0.00001470	53	0	987.29
9999	2	S	R	8	08-Sep-03	AM	1	0.00006860	0.00014730	0.00007030	0.00014700	0	0	519.36
9999	3	S	R	10	10-Sep-03	AM	1	0.00005130	0.00006950	-0.00002380	-0.00001290	7	0	666.65
9999	4	S	R	13	13-Sep-03	AM	1	0.00011600	0.00012320	0.00009010	0.00011870	1	0	833.54


Repeat Lines
20.000
19.000
18.000
17.000
16.000
15.000
14.000
13.000
12.000
(mGal)
1
26
51
76
101
126
151
176
201
(Fiducials)
Flt001 (Av. 15.206)
Flt004 (Av. 16.779)
Flt008 (Av. 16.501)
Flt010 (Av. 14.929)
Flt013 (Av. 15.759)
Average X(i,.) 15.835

Appendix XIII - Geoscience Australia Formulae

Gravity formulae used in Geoscience Australia's Oracle Gravity Database and as specified in recent ground gravity contracts.

Gravity Data Processing

Processing of the gravity data must:

(a) correct for instrument drift and earth tide effects;
(b) apply loop and network adjustments and tie data to the Australian Fundamental Gravity datum;
(c) use the formulae and constants as specified below;

Calculations must include:

(i) normal gravity based on the 1967 international gravity formula:

$$Gn = 9{,}780{,}318.456*(1 + 0.005\ 278\ 895*\sin^2\phi + 0.000\ 023\ 462*\sin^4\phi)$$

where ϕ represents latitude in radians;

(ii) free air correction using the full formula expressed as a vertical gradient. For IGSN71(GRS67) the formula is as follows (Robbins, 1981) and (Flis, Butt, Hawke, 1998):

$$\delta g_h / \delta h = -2g_o/a[1 + f + m + (-3f + (5m)/2)\sin^2\phi] + (6g_o/a^2)*h$$

where g_o = equatorial gravity on the ellipsoid = 9,780,318.456 μms^{-2}
f = flattening coefficient = 1/298.25
a = semi–major axis radius of the ellipsoid = 6,378,160 m
m = centrifugal force at equator/g_o = 0.003 449 801 4
ϕ = latitude
h = height of meter above ellipsoid

This can be expressed as:

Free Air Correction = $(3.08768 - 0.00440\sin^2\phi)*h - 0.000001442*h^2$ μms^{-2} per metre;

(iii) Bouguer anomaly correction of 0.4191*density*ground_elevation μms^{-2} to produce Simple Bouguer values. (ground_elevation in metres).

REFERENCES

1. Robbins, S.L., 1981, Re–examination of the values used as constraints in calculating rock density from borehole gravity data: *Geophysics*, **46**, 208–210.
2. Flis, M.F., Butt, A.L., Hawke, P.J., 1998, Mapping the range front with gravity – are the corrections up to it? *Exploration Geophysics*, **29**, 378–383.

Appendix XIV - Final ASCII Data Files Formats

The Final Line Data (107, 80 and 60 seconds) are presented as three ASCII files, one file for each filter length.

The Final Data sample frequency is 2Hz.

Each record in the data file contains 39 variables, space delimited.
Row 1 - Contains the data variable headings.
Row 2 - Start of data.
The sequence, variable name, format, units, datum and description of each variable are presented in the following table.

N	Variable	Format	Units	Datum	Description
1	**Proj**	I8	Integer	-	Project Number - 200380
2	**Flt**	I3	Integer	-	Flight Number
3	**Line**	I8	Integer	-	Line Number
4	**Fid**	I5	Integer	-	Fiducial
5	**Date**	I12	yyyymmdd	-	Date
6	**Brg**	I3	Degrees	East of North	Bearing, Line Direction - 0, 90, 180 & 270 degrees
7	**Long**	F10.6	Deg.deg	GDA94	Final Longitude
8	**Lat**	F10.6	Deg.deg	GDA94	Final Latitude
9	**LatRad**	F20.17	Radians.radians	GDA94	Final Latitude
10	**East**	F8.1	Metres	GDA94, MGA53	Final Easting
11	**North**	F9.1	Metres	GDA94, MGA53	Final Northing
12	**GPSHt**	F6.2	Metres	-	GPS Height above WGS84 Ellipsoid
13	**GPSTime**	F7.1	Seconds	-	GPS time, seconds since start of GPS day
14	**CSats**	I5	Integer	-	Coarse Channel Saturation = 1, No Saturation = 0
15	**FSats**	I5	Integer	-	Fine Channel Saturation = 1, No Saturation = 0
16	**RawFA???_gu**	F11.3	μms^{-2}** (gravity units)	WGS84 Ellipsoid, Helmert System	Raw Relative Free Air Anomaly, unlevelled
17	**TieLvAdj_gu**	F11.3	μms^{-2} (gravity units)	-	Tie Line Levelling Adjustment
18	**TieLvFA???_gu**	F13.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Tie Line Levelled Relative Free Air Anomaly
19	**NoiseAdj_gu**	F11.3	μms^{-2} (gravity units)	-	Noise Adjustment

20	**RelFA???_gu**	F11.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Final Relative Free Air Anomaly
21	**DCHelmert_gu**	F12.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	DC Adjustment to Absolute Gravity
22	**AbsFA???HelEllips_gu**	F20.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Absolute Free Air Anomaly
23	**Terrain**	F8.3	Metres	AHD71	Terrain Height
24	**NValue**	F9.3	Metres	-	N-Value AusGeoid98
25	**AHD71Ht**	F8.2	Metres	AHD71	Height above Geoid
26	**ObsFilt_gu**	F13.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Observed Gravity, filtered height term
27	**Obs_gu**	F13.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Observed Gravity, unfiltered height term
28	**FA???GRS67AHDFilt_gu**	F20.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Free Air Anomaly
29	**NormBCorrFilt_gu**	F16.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Bouguer Correction, filtered to match gravity
30	**BullardCorrFilt_gu**	F18.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bullard (Earth Curvature) Correction, filtered to match gravity
31	**B???Corr254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.54
32	**B???Corr267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.67
33	**NormTerr???CorrFilt_gu**	F22.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Terrain Correction, filtered to match gravity
34	**Terr???Corr254_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.54
35	**Terr???Corr267_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.67
36	**BA???sim254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.54
37	**BA???sim267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.67
38	**BA???com254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.54
39	**BA???com267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.67

??? = Filter Length 060, 080, 107

** Where 1 µms^{-2} = 0.1 mGal

The Cameco Line Data (107, 80 and 60 seconds) are presented as one ASCII file.

The Cameco Data sample frequency is 2Hz.

Each record in the data file contains 84 variables, space delimited.
Row 1 - Contains the data variable headings.
Row 2 - Start of data.
The sequence, variable name, format, units, datum and description of each variable are presented in the following table.

N	Variable	Format	Units	Datum	Description
1	**Proj**	I8	Integer	-	Project Number - 200380
2	**Flt**	I3	Integer	-	Flight Number
3	**Line**	I8	Integer	-	Line Number
4	**Fid**	I5	Integer	-	Fiducial
5	**Date**	I12	yyyymmdd	-	Date
6	**Brg**	I3	Degrees	East of North	Bearing, Line Direction - 0, 90, 180 & 270 degrees
7	**Long**	F10.6	Deg.deg	GDA94	Final Longitude
8	**Lat**	F10.6	Deg.deg	GDA94	Final Latitude
9	**LatRad**	F20.17	Radians.radians	GDA94	Final Latitude
10	**East**	F8.1	Metres	GDA94, MGA53	Final Easting
11	**North**	F9.1	Metres	GDA94, MGA53	Final Northing
12	**GPSHt**	F6.2	Metres	-	GPS Height above WGS84 Ellipsoid
13	**GPSTime**	F7.1	Seconds	-	GPS time, seconds since start of GPS day
14	**CSats**	I5	Integer	-	Coarse Channel Saturation = 1, No Saturation = 0
15	**FSats**	I5	Integer	-	Fine Channel Saturation = 1, No Saturation = 0
16	**RawFA107_gu**	F11.3	μms^{-2}** (gravity units)	WGS84 Ellipsoid, Helmert System	Raw Relative Free Air Anomaly, unlevelled
17	**TieLvAdj107_gu**	F14.3	μms^{-2} (gravity units)	-	Tie Line Levelling Adjustment
18	**TieLvFA107_gu**	F13.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Tie Line Levelled Relative Free Air Anomaly
19	**NoiseAdj107_gu**	F14.3	μms^{-2} (gravity units)	-	Noise Adjustment

20	**RelFA107_gu**	F11.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Final Relative Free Air Anomaly
21	**DCHelmert_gu**	F12.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	DC Adjustment to Absolute Gravity
22	**AbsFA107HelEllips_gu**	F20.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Absolute Free Air Anomaly
23	**Terrain**	F8.3	Metres	AHD71	Terrain height
24	**NValue**	F9.3	Metres	-	N-Value AusGeoid98
25	**AHD71Ht**	F8.2	Metres	AHD71	Height above Geoid
26	**Obs107_gu**	F13.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Observed Gravity, unfiltered height term
27	**FA107GRS67AHD_gu**	F16.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Free Air Anomaly
28	**NormBCorr107_gu**	F15.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Bouguer Correction, filtered to match gravity
29	**BullardCorr107_gu**	F17.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Bullard (Earth Curvature) Correction, filtered to match gravity
30	**B107Corr254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.54
31	**B107Corr267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.67
32	**NormTerr107Corr_gu**	F18.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Terrain Correction, filtered to match gravity
33	**Terr107Corr254_gu**	F17.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.54
34	**Terr107Corr267_gu**	F17.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.67
35	**BA107sim254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.54
36	**BA107sim267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.67
37	**BA107com254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.54
38	**BA107com267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.67
39	**RawFA080_gu**	F11.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Raw Relative Free Air Anomaly, unlevelled
40	**TieLvAdj080_gu**	F14.3	μms^{-2} (gravity units)	-	Tie Line Levelling Adjustment
41	**TieLvFA080_gu**	F13.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Tie Line Levelled Relative Free Air Anomaly
42	**NoiseAdj080_gu**	F14.3	μms^{-2} (gravity units)	-	Noise Adjustment
43	**RelFA080_gu**	F11.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Final Relative Free Air Anomaly
44	**DCHelmert_gu**	F12.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	DC Adjustment to Absolute Gravity
45	**AbsFA080HelEllips_gu**	F20.3	μms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Absolute Free Air Anomaly
46	**Terrain**	F8.3	Metres	AHD71	Terrain height
47	**NValue**	F9.3	Metres	-	N-Value AusGeoid98

48	**AHD71Ht**	F8.2	Metres	AHD71	Height above Geoid
49	**Obs080_gu**	F13.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Observed Gravity, unfiltered height term
50	**FA080GRS67AHD_gu**	F16.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Free Air Anomaly
51	**NormBCorr080_gu**	F15.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Bouguer Correction, filtered to match gravity
52	**BullardCorr080_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bullard (Earth Curvature) Correction, filtered to match gravity
53	**B080Corr254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.54
54	**B080Corr267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density =2.67
55	**NormTerr080Corr_gu**	F18.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Terrain Correction, filtered to match gravity
56	**Terr080Corr254_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.54
57	**Terr080Corr267_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.67
58	**BA080sim254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.54
59	**BA080sim267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.67
60	**BA080com254_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.54
61	**BA080com267_gu**	F14.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.67
62	**RawFA060_gu**	F11.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Raw Relative Free Air Anomaly, Unlevelled
63	**TieLvAdj060_gu**	F14.3	µms^{-2} (gravity units)	-	Tie Line Levelling Adjustment
64	**TieLvFA060_gu**	F13.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Tie Line Levelled Relative Free Air Anomaly
65	**NoiseAdj060_gu**	F14.3	µms^{-2} (gravity units)	-	Noise Adjustment
66	**RelFA060_gu**	F11.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Final Relative Free Air Anomaly
67	**DCHelmert_gu**	F12.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	DC Adjustment to Absolute Gravity
68	**AbsFA060HelEllips_gu**	F20.3	µms^{-2} (gravity units)	WGS84 Ellipsoid, Helmert System	Absolute Free Air Anomaly
69	**Terrain**	F8.3	Metres	AHD71	Terrain height
70	**NValue**	F9.3	Metres	-	N-Value AusGeoid98
71	**AHD71Ht**	F8.2	Metres	AHD71	Height above Geoid
72	**Obs060_gu**	F13.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Observed Gravity - unfiltered height term
73	**FA060GRS67AHD_gu**	F16.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Free Air Anomaly
74	**NormBCorr060_gu**	F15.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Bouguer Correction, filtered to match gravity
75	**BullardCorr060_gu**	F17.3	µms^{-2} (gravity units)	IGSN71 System, AHD71	Bullard (Earth Curvature) Correction, filtered to match gravity

76	**B060Corr254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.54
77	**B060Corr267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Bouguer Correction, Density = 2.67
78	**NormTerr060Corr_gu**	F18.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Normalised Terrain Correction, filtered to match gravity
79	**Terr060Corr254_gu**	F17.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.54
80	**Terr060Corr267_gu**	F17.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Terrain Correction, Density = 2.67
81	**BA060sim254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.54
82	**BA060sim267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Simple Bouguer Anomaly, Density = 2.67
83	**BA060com254_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.54
84	**BA060com267_gu**	F14.3	μms^{-2} (gravity units)	IGSN71 System, AHD71	Final Absolute Complete Bouguer Anomaly, Density = 2.67

** Where 1 μms^{-2} = 0.1 mGal

The Repeat Line Data (107 seconds) are presented as one ASCII file.

The Repeat Data sample frequency is 2Hz.

Each record in the data file contains 15 variables, space delimited.
Row 1 - Contains the data variable headings.
Row 2 - Start of data.
The sequence, variable name, format, units, datum and description of each variable are presented in the following table.

N	Variable	Format	Units	Datum	Description
1	**Proj**	I8	Integer	-	Project Number - 200380
2	**Flt**	I3	Integer	-	Flight Number
3	**Line**	I8	Integer	-	Line Number
4	**Fid**	I5	Integer	-	Fiducial
5	**Date**	I12	yyyymmdd	-	Date
6	**Brg**	I3	Degrees	East of North	Bearing, Line Direction - 0, 90, 180 & 270 degrees
7	**Long**	F10.6	Deg.deg	GDA94	Final Longitude
8	**Lat**	F10.6	Deg.deg	GDA94	Final Latitude
9	**East**	F8.1	Metres	GDA94, MGA53	Final Easting
10	**North**	F9.1	Metres	GDA94, MGA53	Final Northing
11	**GPSHt**	F6.2	Metres	-	GPS Height above WGS84 Ellipsoid
12	**GPSTime**	F7.1	Seconds	-	GPS time, seconds since start of GPS day
13	**CSats**	I5	Integer	-	Coarse Channel Saturation = 1, No Saturation = 0
14	**FSats**	I5	Integer	-	Fine Channel Saturation = 1, No Saturation = 0
15	**RawFA107_gu**	F11.3	μms^{-2}** (gravity units)	WGS84 Ellipsoid, Helmert System	Raw Relative Free Air Anomaly, unlevelled

Appendix XV - AUSPOS GPS Processing Reports

AUSPOS Online GPS Processing Report - Job number: #100719 (Base GPS Position)

Space Geodesy Analysis Centre
The National Mapping Division (NMD), Geoscience Australia
October 15, 2003

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service. The AUSPOS Online GPS Processing Service uses International GPS Service (IGS) products (final, rapid, ultra-rapid depending on availability) including Precise Orbits, Earth Orientation, Coordinate Solutions (IGS-SSC) to compute precise coordinates in ITRF anywhere on Earth. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is attached to this report. Please direct email correspondence to geodesy@auslig.gov.au

AUSPOS Project Manager

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The National Mapping Division Home Page: www.auslig.gov.au

Job number: #100719; User: htuckett@aol.com AUSPOS version 1.01.24

1 User and IGS GPS Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antennna Reference Point (ARP).

User File	Antenna Type	Antenna Height (m)	Start Time	End Time
Base2422.03o	DEFAULT(NONE)	0.0000	2003-08-30 20:16:00	2003-08-31 01:41:59

2 Processing Summary

Date	IGS Data	User Data	Orbit Type
2003-08-30	jab1 darw alic	Base	IGS Final
2003-08-31	darw alic tow2	Base	IGS Final

3 Computed Coordinates, GDA94

For Australian users Geocentric Datum of Australia (GDA94, ITRF92@1994.0) coordinates are provided. GDA94 coordinates are determined from ITRF coordinates by an Geoscience Australia (GA) derived coordinate transformation process. GA transformation parameters between ITRF and GDA94 are re-computed weekly, incorporating the latest available tectonic motions (determined from the GA GPS network). GA recommends that users within Australia use GDA94 coordinates. All coordinates refer to the Ground Mark. For general/technical information on GDA94 see www.auslig.gov.au/geodesy/datums/gda.htm and www.anzlic.org.au/icsm/gdatm/

3.1 Cartesian, GDA94

	X(m)	Y(m)	Z(m)	
darw	-4091358.735	4684606.864	-1408580.651	GDA94
alic	-4052051.766	4212836.205	-2545106.028	GDA94
jab1	-4236442.746	4559929.725	-1388624.828	GDA94
Base	-4236517.443	4559870.793	-1388594.160	GDA94
tow2	-5054582.663	3275504.564	-2091539.889	GDA94

3.2 Geodetic, GRS80 Ellipsoid, GDA94

The height above the Geoid is computed using the GPS Ellipsoidal height and subtracting a Geoid-Ellipsoid separation. Geoid-Ellipsoidal separations are computed using a bilinear interpolation of the AUSGeoid98 grid. The height above the Geoid is only provided for sites within the AUSGeoid98 extents. For information on AUSGeoid98 see www.auslig.gov.au/geodesy/ausgeoid/geoid.htm

	Latitude(DMS)	Longitude(DMS)	Ellipsoidal Height(m)	Above-Geoid Height(m)	
darw	-12-50 -37.3586	131 7 57.8477	125.208	74.597	GDA94
alic	-23-40 -12.4461	133 53 7.8478	603.351	587.674	GDA94
jab1	-12-39 -31.8751	132 53 38.0195	82.235	27.183	GDA94
Base	-12-39 -30.8467	132 53 41.1623	82.996	27.940	GDA94
tow2	-19-16 -9.4282	147 3 20.4654	88.218	30.129	GDA94

3.3 MGA Grid, GRS80 Ellipsoid, GDA94

	East(M)	North(M)	Zone	Ellipsoidal Height(m)	Above-Geoid Height(m)	
darw	731469.104	8579189.651	52	125.208	74.597	GDA94
alic	386352.396	7381850.767	53	603.351	587.674	GDA94
jab1	271256.226	8599668.193	53	82.235	27.183	GDA94
Base	271350.826	8599700.566	53	82.996	27.940	GDA94
tow2	505851.330	7869375.316	55	88.218	30.129	GDA94

4 Computed Coordinates, ITRF2000

All computed coordinates are based on the IGS realisation of the ITRF2000 reference frame, provided by the IGS cumulative solution. All the given ITRF2000 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

4.1 Cartesian, ITRF2000

	X(m)	Y(m)	Z(m)	ITRF2000 @
darw	-4091359.041	4684606.667	-1408580.100	2003/08/31
alic	-4052052.113	4212836.093	-2545105.502	2003/08/31
jab1	-4236443.042	4559929.518	-1388624.276	2003/08/30
Base	-4236517.739	4559870.586	-1388593.608	2003/08/31
Base	0.033 m	0.028 m	0.004 m	RMS
tow2	-5054582.916	3275504.366	-2091539.371	2003/08/31

4.2 Geodetic, GRS80 Ellipsoid, ITRF2000

The height above the Geoid is computed using the GPS Ellipsoidal height and subtracting a Geoid-Ellipsoid separation. Geoid-Ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM96 geoid. More information on the EGM96 geoid can be found at www.nima.mil/GandG/wgsegm/egm96.html

	Latitude(DMS)	Longitude(DMS)	Ellipsoidal	Above-Geoid

			Height(m)	Height(m)
darw	-12-50 -37.3408	131 7 57.8597	125.136	74.986
alic	-23-40 -12.4283	133 53 7.8594	603.286	587.969
jab1	-12-39 -31.8572	132 53 38.0314	82.163	27.826
Base	-12-39 -30.8289	132 53 41.1742	82.924	28.583
Base	0.004 m	0.043 m	0.006 m	RMS
tow2	-19-16 -9.4112	147 3 20.4758	88.146	30.099

5 Solution Information

To validate your solution you should check the :-

i. Antenna Reference Point (ARP) to Ground Mark records;
ii. Apriori Coordinate Updates (valid range is 0.000 - 15.000 m);
iii. Coordinate Precision (valid range is 0.001 - 0.025 m);
iv. Root Mean Square (RMS) (valid range is 0.0005 - 0.0250 m); and
v. % Observations Deleted (valid range is 0 - 25) %;

5.1 ARP to Ground Mark, per day

All heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP). The Antenna Offsets refer to the vertical distance from the ARP to the L1 phase centre.

	Height(m)	Antenna Offsets(m)			
Station	Up	East	North	Up	yyyy/mm/dd
Base	0.0000	0.0000	0.0000	0.0000	2003/08/30
Base	0.0000	0.0000	0.0000	0.0000	2003/08/31

5.2 Apriori Coordinate Updates - Cartesian, per day

	dX(m)	dY(m)	dZ(m)	yyyy/mm/dd
Base	-0.003	0.010	0.004	2003/08/30
Base	-0.010	0.006	0.032	2003/08/31

5.3 Coordinate Precision - Cartesian, per day

1 Sigma	sX(m)	sY(m)	sZ(m)	yyyy/mm/dd
Base	0.008	0.008	0.003	2003/08/30
Base	0.012	0.021	0.009	2003/08/31

5.4 Coordinate Value - Cartesian, ITRF2000, per day

	X(m)	Y(m)	Z(m)	ITRF2000 @
Base	-4236517.721	4559870.591	-1388593.608	2003/08/30
Base	-4236517.782	4559870.547	-1388593.614	2003/08/31

5.5 Geodetic, GRS80 Ellipsoid, ITRF2000, per day

	Latitude(DMS)	Longitude(DMS)	Ellipsoidal Height(m)	
Base	-12-39 -30.8289	132 53 41.1736	82.915	2003/08/30
Base	-12-39 -30.8290	132 53 41.1761	82.926	2003/08/31

5.6 RMS, Observations, Deletions per day

Data	RMS (m)	# Observations	% Obs. Deleted	Date
darw	0.0056	4293	0 %	2003-08-30
alic	0.0050	3532	0 %	2003-08-30
jab1	0.0048	4237	4 %	2003-08-30
Base	0.0052	12062	1 %	2003-08-30
darw	0.0068	1297	0 %	2003-08-31
tow2	0.0047	935	0 %	2003-08-31
alic	0.0057	1006	2 %	2003-08-31
Base	0.0059	3238	0 %	2003-08-31

AUSPOS Online GPS Processing Report - Job number: #101098 (Reference Position)

Space Geodesy Analysis Centre
The National Mapping Division (NMD), Geoscience Australia
November 28, 2003

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service. The AUSPOS Online GPS Processing Service uses International GPS Service (IGS) products (final, rapid, ultra-rapid depending on availability) including Precise Orbits, Earth Orientation, Coordinate Solutions (IGS-SSC) to compute precise coordinates in ITRF anywhere on Earth. The Service is designed to process only dual frequency GPS phase data.
The AUSPOS Online GPS Processing Service is a free service and you are encouraged to use it for your projects. However, you may not charge others for this service. Geoscience Australia does not warrant that this service a) is error free; b) meets the customer's requirements. Geoscience Australia shall not be liable to the customer in respect of any loss, damage or injury (including consequential loss, damage or injury) however caused, which may arise directly or indirectly in respect of this service.

An overview of the GPS processing strategy is attached to this report. Please direct email correspondence to geodesy@auslig.gov.au

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Job number: #101098; User: htuckett@aol.com AUSPOS version 1.01.24

1 User and IGS GPS Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antennna Reference Point (ARP).

User File	Antenna Type	Antenna Height (m)	Start Time	End Time
Rexs2411.03o	DEFAULT(NONE)	0.8800	2003-08-29 19:59:00	2003-08-29 21:12:00

2 Processing Summary

Date	IGS Data	User Data	Orbit Type
2003-08-29	jab1 darw alic	Rexs	IGS Final

3 Computed Coordinates, GDA94

For Australian users Geocentric Datum of Australia (GDA94, ITRF92@1994.0) coordinates are provided. GDA94 coordinates are determined from ITRF coordinates by an Geoscience Australia (GA) derived coordinate transformation process. GA transformation parameters between ITRF and GDA94 are re-computed weekly, incorporating the latest available tectonic motions (determined from the GA GPS network). GA recommends that users within Australia use GDA94 coordinates. All coordinates refer to the Ground Mark. For general/technical information on GDA94 see www.auslig.gov.au/geodesy/datums/gda.htm and www.anzlic.org.au/icsm/gdatm/

3.1 Cartesian, GDA94

	X(m)	Y(m)	Z(m)	
darw	-4091358.735	4684606.864	-1408580.651	GDA94
alic	-4052051.766	4212836.205	-2545106.028	GDA94
jab1	-4236442.745	4559929.725	-1388624.828	GDA94
Rexs	-4236351.215	4559995.670	-1388685.551	GDA94

3.2 Geodetic, GRS80 Ellipsoid, GDA94

The height above the Geoid is computed using the GPS Ellipsoidal height and subtracting a Geoid-Ellipsoid separation. Geoid-Ellipsoidal separations are computed using a bilinear interpolation of the AUSGeoid98 grid. The height above the Geoid is only provided for sites within the AUSGeoid98 extents. For information on AUSGeoid98 see www.auslig.gov.au/geodesy/ausgeoid/geoid.htm

	Latitude(DMS)	Longitude(DMS)	Ellipsoidal Height(m)	Above-Geoid Height(m)	
darw	-12-50 -37.3586	131 7 57.8477	125.208	74.597	GDA94
alic	-23-40 -12.4461	133 53 7.8478	603.351	587.674	GDA94
jab1	-12-39 -31.8751	132 53 38.0195	82.235	27.183	GDA94
Rexs	-12-39 -33.9028	132 53 34.3098	81.896	26.850	GDA94

3.3 MGA Grid, GRS80 Ellipsoid, GDA94

	East(M)	North(M)	Zone	Ellipsoidal Height(m)	Above-Geoid Height(m)	
darw	731469.105	8579189.651	52	125.208	74.597	GDA94
alic	386352.396	7381850.768	53	603.351	587.674	GDA94
jab1	271256.225	8599668.192	53	82.235	27.183	GDA94
Rexs	271144.763	8599604.966	53	81.896	26.850	GDA94

4 Computed Coordinates, ITRF2000

All computed coordinates are based on the IGS realisation of the ITRF2000 reference frame, provided by the IGS cumulative solution. All the given ITRF2000 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

4.1 Cartesian, ITRF2000

	X(m)	Y(m)	Z(m)	ITRF2000 @
darw	-4091359.041	4684606.667	-1408580.100	2003/08/29
alic	-4052052.113	4212836.093	-2545105.502	2003/08/29
jab1	-4236443.041	4559929.518	-1388624.277	2003/08/29
Rexs	-4236351.511	4559995.463	-1388684.999	2003/08/29

4.2 Geodetic, GRS80 Ellipsoid, ITRF2000

The height above the Geoid is computed using the GPS Ellipsoidal height and subtracting a Geoid-Ellipsoid separation. Geoid-Ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM96 geoid. More information on the EGM96 geoid can be found at www.nima.mil/GandG/wgsegm/egm96.html

	Latitude(DMS)	Longitude(DMS)	Ellipsoidal	Above-Geoid

			Height(m)	Height(m)
darw	-12-50 -37.3408	131 7 57.8597	125.136	74.986
alic	-23-40 -12.4283	133 53 7.8594	603.286	587.969
jab1	-12-39 -31.8573	132 53 38.0314	82.162	27.825
Rexs	-12-39 -33.8849	132 53 34.3217	81.823	27.491

5 Solution Information

To validate your solution you should check the :-

i. Antenna Reference Point (ARP) to Ground Mark records;
ii. Apriori Coordinate Updates (valid range is 0.000 - 15.000 m);
iii. Coordinate Precision (valid range is 0.001 - 0.025 m);
iv. Root Mean Square (RMS) (valid range is 0.0005 - 0.0250 m); and
v. % Observations Deleted (valid range is 0 - 25) %;

5.1 ARP to Ground Mark, per day

All heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP). The Antenna Offsets refer to the vertical distance from the ARP to the L1 phase centre.

	Height(m)	Antenna Offsets(m)			
Station	Up	East	North	Up	yyyy/mm/dd
Rexs	0.8800	0.0000	0.0000	0.0000	2003/08/29

5.2 Apriori Coordinate Updates - Cartesian, per day

	dX(m)	dY(m)	dZ(m)	yyyy/mm/dd
Rexs	0.062	0.056	0.045	2003/08/29

5.3 Coordinate Precision - Cartesian, per day

1 Sigma	sX(m)	sY(m)	sZ(m)	yyyy/mm/dd
Rexs	0.093	0.029	0.029	2003/08/29

5.4 RMS, Observations, Deletions per day

Data	RMS (m)	# Observations	% Obs. Deleted	Date
darw	0.0098	1402	0 %	2003-08-29
alic	0.0093	1149	0 %	2003-08-29
jab1	0.0095	1448	0 %	2003-08-29
Rexs	0.0096	3999	0 %	2003-08-29

A GPS Computation Standards

A.1 Measurement Modelling

Observable	Ionosphere corrected L1 double difference carrier phase, Psuedo-range only used for receiver clock estimation, Elevation cut-off 15°, Sampling rate 30 seconds, Weighting 1.0cm for double di®erence, elevation dependent 1/sin(E).
Troposphere	Hopfield, Niell mapping function
Preprocessing	Receiver clocks estimated using pseudo-range information
Satellite center of mass correction	Block II x,y,z: 0.2794, 0.0000, 1.0259 m Block IIA x,y,z: 0.2794, 0.0000, 1.2053 m
Satellite Antenna Phase centre calibration	Not applied
Ground Antenna phase centre calibrations	Elevation-dependent phase centre corrections are applied according to the model IGS01, the NGS antenna calibrations are used when the antenna used is not a recognised IGS type. The corrections are given relative to the Dorne Margolin T antenna.
Atmospheric Drag	Jachhia Model
Centre of Mass Correction / Attitude	Nil

A.2 Orbit Modelling

Earth' s Gravitational (Static) Potential Model	EGM96 - degree and order 12
Solid Earth Tides (Dynamic) Potential	Love Model
Ocean Tide (Dynamic) Potential	'Christodoulidis
Third Body Perturbations	Sun, Moon and Planets Values for physical constants - AU, Moon/Earth mass ratio, GM(moon, sun and planets) from JPL DE403 Planetary Ephemeris.
Direct Solar Radiation Pressure	Rock

A.3 Station Position Modelling and Reference Frame

Precession	IAU76/IERS96
Nutation	IAU80/IERS96 (including epsilon and psi corrections)
Sine terms added to accumulated precession and nutation in Right Ascension	As in IERS TN 21, p. 21
Geodesic Nutation	As in IERS TN 21, P. 37
Polar Motion	IGS Earth Orientation Parameters (Ultra-rapid, Rapid, Final) - apriori
Earth Rotation (UT1)	IGS Earth Orientation Parameters (Ultra-rapid, Rapid, Final) - apriori
Daily and Sub-daily tidal corrections to X, Y and UT1	Applied (IERS2000)
Plate Motion	IGS Cumulative SSC
Planetary and Lunar Ephemeris	JPL DE403
Station Displacement - Solid Earth Tide Loading	Williamson and Diamante (1972) + Wahr (1980) for the frequency dependent elastic response of the Earth's fluid interior.
Station Displacement - Ocean Tide Loading	not applied
Station Displacement - Pole Tide	applied
Station Displacement - Atmosphere Loading	not applied
Reference Frame	IGS Cumulative SSC