TECHNICAL REPORT 8
Antarctic Geodesy
Casey 2001

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1. Introduction

In October 2001, Gary Johnston traveled to Australia's Antarctic base at Casey to carry out maintenance work on the GPS and ancillary equipment at that site which forms part of the Australian Regional GPS Network (ARGN). In addition he accurately measured the relationship between the ARGN monument and the three reference marks to check for any possible local movement since the site was established in December 1993. These measurements also provide a reliable base measurement for future monitoring. A GPS connection and difference in height by optical levelling between the ARGN monument and the tide gauge benchmark was also completed. This report documents the methods and results of these surveys.

2. ARGN Reference Mark Survey at AUS100 (CAS1)

Ex AUSLIG surveyor John Hyslop last completed the reference mark survey in 1993. This survey was at the time of establishment of AUS100 and the placement of the reference marks (RMs). Figure 2.1 shows the general layout of the RMs and the existing stations used for network orientation.

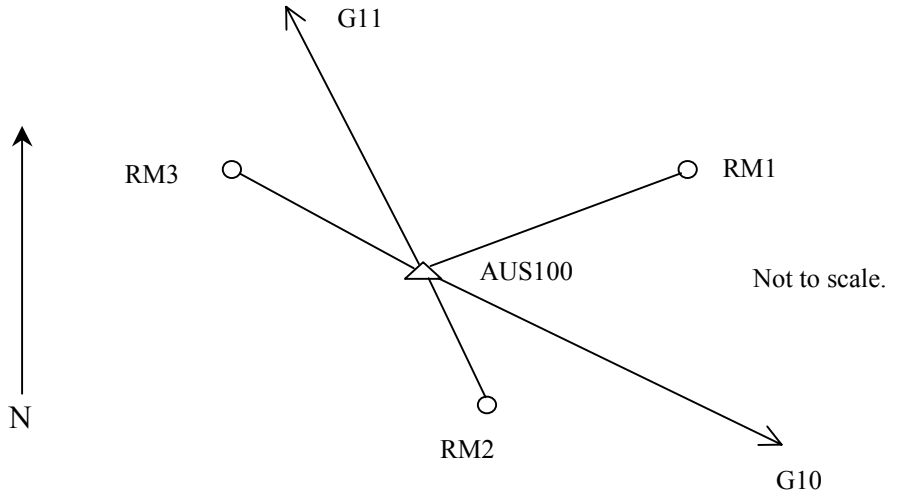

Figure 2.1 Network layout at AUS100 Casey

For this survey the coordinates of AUS100 and G10 were taken from the most recent adjustment of the Australian Antarctic Geodetic Network (known as ANT2001 – see www.auslig.gov.au/geodesy/antarc/antmarks.htm) and used as datum. The coordinates listed in Table 2.1 for G11 are based on a distance derived from the ANT2001 adjustment and an azimuth determined from this survey. As such they should only be used for computing azimuth between AUS100 and G11. The distance between AUS100 and G10 was not observed.

Site	Latitude				Longitude				Ellipsoidal Height	Lat Std Dev	Long Std Dev	Ellip HT Std Dev
AUS100	S	66	17	0.09240	E	110	31	10.94090	22.4630	0.0000	0.0000	0.0000
G10	S	66	17	17.22477	E	110	32	46.59485	43.4301	0.0000	0.0000	0.0000
G11	S	66	16	53.62757	E	110	30	59.80580	34.7600	0.0016	0.0023	0.0009
RM1	S	66	16	59.91304	E	110	31	11.91100	21.6930	0.0001	0.0002	0.0001
RM2	S	66	17	0.36752	E	110	31	11.55989	21.3644	0.0001	0.0001	0.0001
RM3	S	66	16	59.91039	E	110	31	10.36703	23.1406	0.0001	0.0002	0.0001

Table 2.1 Coordinate results for AUS100 and its RM's in terms of ITRF2000@2000.0. Standard deviations are one sigma and in units of meters.

The survey was completed using the Leica TC2003 total station and is estimated to have a relative accuracy of less them 1mm as reflected by the coordinate standard deviation in Table 2.1. The heighting results listed in Table 2.2 have been derived using the total station levelling technique detailed in section 5.

Site	Reduced Level
RM1	40.1168
RM2	39.7884
RM3	41.5642
AUS100	40.8868

Table 2.2. Orthometric height values for AUS100 and its RM's based on the levelling tabulated in section 4 of this report

2.1 Survey Comparisons

The following provides a comparison of the 2001 survey and the establishment survey of 1993.

Levelling

Table 3 shows a comparison between observed survey mark height differences from 2001 to 1993.

AUS100… . to:..	Height Difference (m) (AUSLIG 2001)	Height Difference (m) (AUSLIG 1993)	Difference (m)
RM1	0.770	0.7710	**-0.0010**
RM2	1.0984	1.098	**0.0004**
RM3	-0.6774	-0.680	**0.0026**

Table 2.3. Comparison of height differences between the 1993 and 2001 surveys.

Horizontal Survey

The tables below outlines the observed Easting and Northing differences from the 2001 and 1993 surveys.

EASTINGS

Aus100…. to:..	Difference Easting (m) (2001)	Difference Easting (m) (1993)	Difference (m)
RM1	12.0517	12.0514	**0.0003**
RM2	7.7823	7.7840	**-0.0017**
RM3	-7.1977	-7.1984	**0.0007**

Table 2. 4. Differences in Eastings between the 1993 and 2001 surveys.

NORTHINGS

AUS100… . to:..	Difference Northing (m) (2001)	Difference Northing (m) (1993)	Difference (m)
RM1	5.6462	5.6397	**0.0065**
RM2	-8.4591	-8.4645	**0.0054**
RM3	5.5805	5.5841	**-0.0036**

Table 2.5. Differences in Northings between the 1993 and 2001 surveys.

Table 6 compares the radial distance from AUS100 to each of the RM's from both the 2001 and 1993 surveys.

HORIZ DISTANCE

...Aus100 …. to:..	Distance (m) (2001)	Distance (m) (1993)	Difference (m)
RM1	13.314	13.311	0.0030
RM2	11.4989	11.504	-0.0051
RM3	9.1113	9.114	-0.0027

Table 2.6. Comparison of radial distances between the two surveys.

2.2 Discussion

Given the use of different techniques and equipment and the relatively small change in height (approximately 2.8 mm) between 1993 and 2001, no local vertical movement of the AUS100 mark can be reliably inferred.

The reduced horizontal data indicates a significant shift in Northing from the 1993 to the 2001 survey. Although this trend could indicate movement of the RMs, it is difficult to infer any definitive movement given the unknown nature and quality of the 1993 survey.

In summary, the comparison of the data from the surveys highlights no confirmed movement of the AUS100 survey monument. To ensure long term monitoring of this site, it is important to continue to use equipment and techniques that provide a known high level of accuracy.

3. Modifications to the Backup GPS equipment at the ARGN site

The backup receiver at Casey is an Ashtech Z12. Prior to this visit the receiver was unable to communicate with the LINUX PC on site, therefore restricting its practical use as a backup receiver for the ARGN. The receiver itself was operating normally upon arrival at the base with a full set of satellites locked and tracking although the internal memory was full.

The following hardware components were replaced in an attempt to reactivate the PC to Receiver communications.

- Ashtech Z12
- Stallion board
- Ashtech download cable
- Download cable to Stallion board size converter

These modifications did not have any immediate positive effect, however the communication channel did eventually open allowing data download. The reason for this delay is not satisfactorily understood at this stage, and is believed to be an incompatibility between the hardware present and the software / firmware / OS in use.

The controller SIM inside the GPS Power Controller (GPC) was also replaced in an attempt to rectify a problem with accessing the receiver through this unit. Again this did not have the positive effect expected. (Rather the status quo was maintained.)

At the time of departure from Casey the Ashtech Receiver was correctly operating with the PC, however the GPC was still unable to adequately communicate to the Receiver.

4. GPS Observations at the Casey Tide Gauge Benchmark

Historically HBM3 has been referred to as the tide gauge benchmark (TGBM) at Casey. This mark has been disturbed and is no longer suitable for this purpose. Not more then two metres away from HBM3 a new mark was placed by surveyor John Hyslop in 1993 to measure timed water measurements. This mark consists of a stainless steel bolt in rock with an aluminium tag inscribed with AUS299. This mark was centre punched and used for the GPS observations for this season. It is recommended that this mark be considered the TGBM for future works. It has been connected vertically to a variety of other marks in the vicinity as detailed in section four of this report.

Figure 4.1. GPS antenna over the TGBM (AUS299)

Three sessions were observed as detailed in Table 4.1. The antenna was removed between sessions two and three to allow a level connection, thus explaining the change of antenna height.

Date	DOY	Start	Finish	Antenna	Slope Height to BGP
11/10/01	284	4:34:00	22:02:30	ASH700936E	1.398m
12/10/01	285	2:44:30	7:48:30	ASH700936E	1.398m
12/10/01	285	9:48:30	14:44:00	ASH700936E	1.400m

Table 4.1 GPS Observation summary at TGBM AUS299.

Station	Parameter	Value	RMS Error
CAS1 (AUS100)	X	-901776.1611	0.0001
	Y	2409383.3967	0.0001
	Z	-5816748.4406	0.0001
	Ellipsoidal Height	22.4629	0.0001
	Latitude	- 66° 17’ 0 .092397”	0.0001
	Longitude	110° 31’ 10.940900”	0.0001
	EGM96 N value	-15.540	
AUS299	X	-902593.9998	0.0002
	Y	2409650.8824	0.0002
	Z	-5816469.9570	0.0004
	Height	-16.3722	0.0004
	Latitude	- 66° 16’ 40.595824”	0.0002
	Longitude	110° 32’ 4.823697”	0.0002
	EGM96 N value	-15.550	

Table 4.2. GPS results for the TGBM AUS299 at Casey in terms of ITRF2000@2000.0

Station	Component	RMS (mm)	DOY 294	DOY295 0	DOY295 1
AUS299	N	1.2	-0.7	1.1	1.1
	E	1.4	-0.6	0.5	1.8
	U	0.8	0.5	0.0	-1.0

Table 4.3. Repeatability of the AUS299 coordinates with daily corrections listed in mm.

Year	2001
GPS ellipsoidal difference	38.8351
Derived orthometric	38.8251
Orthometric by levelling	38.8272

Table 4.4 Comparison of Height differences. Derived orthometric value based on EGM96 N values listed in Table 4.2.

5. Levelling at Casey Station

A levelling run was undertaken from the AUS100 RM3 mark to the new TGBM AUS299, connecting to a number of existing survey marks in the vicinity if the

station. The total station height traversing technique was utilised for this project (Rüeger, 19981). A Leica TC2003 was used with Leica precision prisms on a braced prism pole. The long snow covered areas between the new Casey station and the old Casey station, particularly through the Tamar Valley, resulted in lengths of lines longer then would be normally suitable. However the placement of addition change points was not possible.

While these long lines have impeded the accuracy of this survey, it is clear that this technique is the most effective method of orthometric height transfer through this area. The location of rock outcrops suitable for change points is not conducive to normal spirit levelling because of the steep nature of the valley.

Table 5.1 lists the observed benchmarks, including the backward and forward estimates of height differences, and the associated difference. While the stainless steel bolt is a very useful marking style for the majority of applications it does however have a slightly uneven surface and is prone to a sloping head depending on the angle at which the bolt was originally placed. These factors coupled with the pointed end of the prism pole results in slightly different height estimate on a number of these marks. This difference is compensated on the following leg allowing a more reasonable run misclose.

Line	Forward	Backward	Mean
AUS100 RM3 – BM05	-3.0079	-3.0084	-3.0081
BM05 – AUS396	-11.6639	-11.6658	-11.6648
AUS396 – AUS394	2.4926	2.4966	2.4946
AUS394 – AUS395	-10.0444	-10.0444	-10.0444
AUS395 – HBM1	-12.1630	-12.1640	-12.1635
HBM1 – AUS299 TGBM	-5.1185	-5.1184	-5.1184
AUS299 – HBM2	3.4640	3.4653	3.4646
AUS299 – HBM3	-0.0796	-0.0788	-0.0792
AUS299 – HBM4	0.3723	0.3720	0.3721
AUS299 – Brass Pin TG area	0.2178	0.2178	0.2178

Table 5.1. Height differences from Total Station height traversing.

Station	Height
AUS100 Rm3	41.5642
BM05	38.5561
AUS396	26.8913
AUS394	29.3859
AUS395	19.3415
HBM1*	7.1780
AUS299 TGBM	2.0596
HBM2	5.5242
HBM3 * (disturbed)	1.9804
HBM4	2.4317
Brass Pin TG area*	2.2774

Table 5.2. Heights resulting from 2001 levelling.

***Notes**. Height from HBM1 adopted from King (2000)*

HBM3 has been disturbed and is now leaning.
The high point has been levelled.
Brass Pin in TG area may be WHF1 from King (2000).

6. Summary

This survey was carried at during the changeover on the Voyage 2 round trip. The assistance of Voyage management and Casey expeditioners is greatly appreciated.

A suitable level of accuracy has been achieved with the reference mark survey to form the foundation for future local surveys for monument stability studies. Similarly, the optical levelling connection from the ARGN site to the tide gauge benchmark, provides a reliable connection between the measurement of sea level at the tide gauge and the ellipsoidal height at the ARGN monument. This too provides a suitable basis for future monitoring.

References

King, Matt (2000) "*Report on Temperature Corrections for Levelling Observations made at Australia's Antarctic Bases*", Internal Report Prepared for: Mapping Officer, Australian Antarctic Division, June 2000, Revised: November 2000.

Rüeger, J.M., 1981 *"Practical results of EDM-Height Traversing",* The Australian Surveyor, 30[6]: 363-372.