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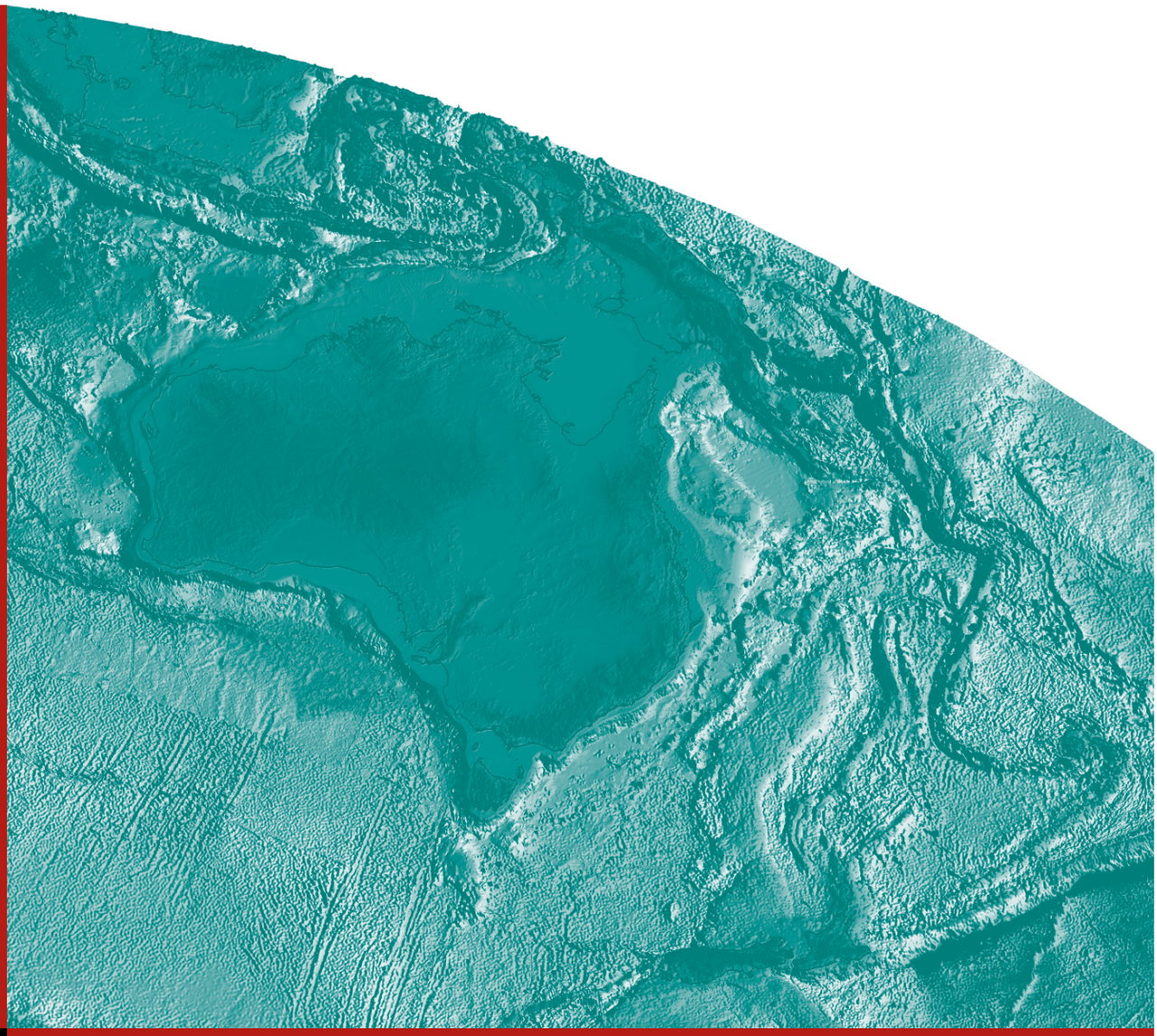

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

Determination of GDA94 coordinates for six CORSnet-NSW stations using the October 2010 GPS data set

Geoscience Australia
Record 2010/48

by

G. Hu, J. Dawson

Australian Government
Geoscience Australia

Department of Resources, Energy and Tourism
Minister for Resources and Energy: The Hon. Martin Ferguson, AM MP
Secretary: Drew Clarke

Geoscience Australia
Chief Executive Officer: Dr Chris Pigram

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Name of NATA approved facility:

Geoscience Australia – National Geospatial Reference Systems Project
Corner Jerrabomberra Ave and Hindmarsh Drive
Symonston ACT 2609 Australia
Telephone: (02) 6249 9111 Facsimile: (02) 6249 9969
Email: geodesy@ga.gov.au

Client Detail:

Dr Volker Janssen
Survey Infrastructure & Geodesy, Land and Property Management Authority, NSW
346 Panorama Avenue, Bathurst NSW 2795
Telephone: (02) 6332 8426 Facsimile: (02) 6332 8479
Email: Volker.Janssen@lpma.nsw.gov.au
Date of request: 27 October 2010

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Abbreviations:

AFN	Australian Fiducial Network
ARGN	Australian Regional GNSS Network
CORS	Continuously Operating Reference Stations
GDA94	Geocentric Datum Australia 1994
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
IGS	International GNSS Service
ITRF	International Terrestrial Reference Frame
ITRF92	International Terrestrial Reference Frame 1992
ITRF2005	International Terrestrial Reference Frame 2005

Introduction:

An application dated 27th October 2010 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from the Land and Property Management Authority, NSW for verification of GDA94 position on their CORSnet monuments. This report documents the processing and analysis of GPS data observed by the CORSnet-NSW GPS stations during a 7-day period from 17 October to 23 October 2010 (day of year 290 to 296) for 6 stations (GFTN, GLIN, MACK, TAMW, TNTR and WLGT) to satisfy the position verification requirements.

Measurand:

Station position, at the time of measurement and stated instrumentation, of a GPS monument with respect to the Geocentric Datum of Australia (GDA94) referred to the GRS80 ellipsoid being in the ITRF92 reference frame at the epoch 1994.0.

Measurand Traceability:

Measurement traceability was ensured by comparing the computed solution against the recognised value standard for position of the Australian Fiducial Network stations. Additionally, the computed solution was checked against the ITRF based solutions computed by the IGS and the individual global analysis centres of the IGS. The validity and traceability of the entire GPS system was ensured via its link to the global Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) observing networks through the ITRF. The validity and traceability of our internal computation processes were ensured by undertaking standard benchmark analysis prior to this analysis.

Measurand Uncertainty:

Position uncertainties were calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, *k*, of 2.

Type A uncertainty sources were evaluated by adopting an *a priori* sigma of **0.001** metre for the precision (1 sigma) of the L1-frequency, one-way, phase observation, at zenith. The corresponding uncertainties of all parameters were determined, by standard error propagation theory, in the least-squares estimation process used in the GPS analysis. Since the formal (internal) precision estimates of GPS solutions are well known to be optimistic, a factor of **10** (i.e. variance scale factor of 100) was subsequently applied to the variance-covariance matrix of the computed GDA94 coordinates.

Type B uncertainty sources, which in practice contribute to position uncertainty, cannot be estimated from the statistical analysis of short-period (i.e. 7-day) observations; these include environmental effects, such as long-period station loading (deformation) processes. Table 1 shows the major **Type B** uncertainty sources for GPS analysis.

Table 1. **Type B** uncertainty sources (95% C.L.) for position, determined from GPS, and the total uncertainty, assuming the normal distribution of the uncertainty sources, high degrees of freedom and a coverage factor, *k*, of 2.

Uncertainty Source	**Position Uncertainty Horizontal (mm)**	**Position Uncertainty Vertical (mm)**
Satellite orbits	5	10
Station deformation	5	15
Antenna phase centre	3	3
Monument stability	5	10
Reference Frame (ITRF)	3	5
Reference Frame (GDA94)	30	50
Total	**32**	**54**

GPS Data:

GPS RINEX data was supplied for 6 CORSnet-NSW stations spanning a 7-day period from 17 October to 23 October 2010 (day of year 290 to 296). Four character names of the stations are GFTN, GLIN, MACK, TAMW, TNTR and WLGT. Figure 1 shows the distribution of these stations. Table 2 lists the GPS receiver and antenna type at each site. An antenna height of 0.000m to the Antenna Reference Point (ARP) has been adopted for all CORSnet-NSW stations except for TAMW which has an antenna height of 0.300 m. The ARP is the reference point as defined by IGS and the RINEX specifications.

Figure 1 also shows the extended regional network of IGS, ARGN and AFN network sites used in the GPS data processing. Table 3 lists the GPS receiver and antenna type used in the GPS data processing for each of the IGS, ARGN and AFN network sites. Table 4 lists the GPS antenna heights used in the GPS data processing for all sites.

GPS Data Irregularities:

No irregularities were identified in the GPS data supplied in RINEX format from the CORSnet-NSW stations.

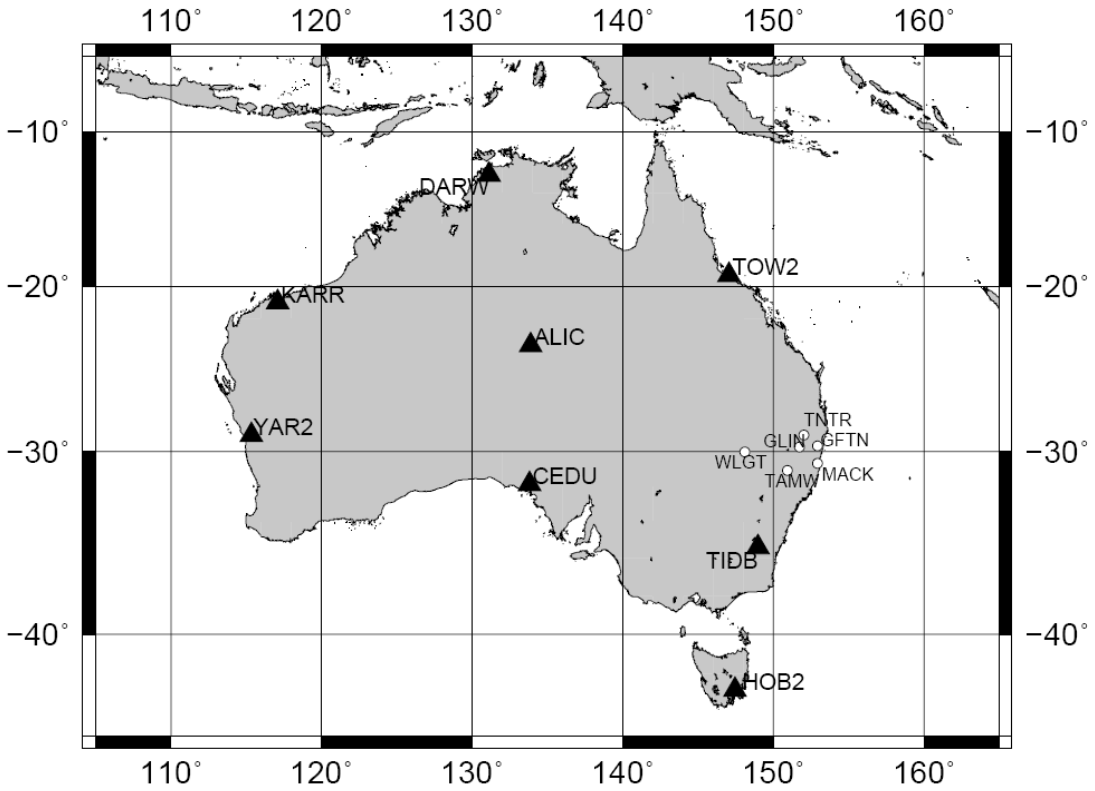

Figure 1: AFN/ARGN/IGS (black triangles), and CORSnet-NSW (circles) stations used in GPS data processing.

Table 2: CORSnet-NSW receiver and antenna types.

CORSnet-NSW base station	4-char. ID	GPS receiver type	GPS antenna SERIAL NUMBER	IGS antenna type AND DOME TYPE
Grafton	GFTN	LEICA GRX1200+GNSS	12356-019	LEIAR10 NONE
Glen Innes	GLIN	LEICA GRX1200+GNSS	13110049	LEIAR10 NONE
Macksville	MACK	LEICA GRX1200+GNSS	09250086	LEIAX1203+GNSS NONE
Tamworth	TAMW	LEICA GRX1200+GNSS	09250096	LEIAX1203+GNSS NONE
Tenterfield	TNTR	LEICA GRX1200+GNSS	13110027	LEIAR10 NONE
Walgett	WLGT	LEICA GRX1200+GNSS	12356-021	LEIAR10 NONE

Table 3: GPS receiver and antenna types for the AFN sites.

GPS Network	4-char. ID	GPS receiver type	GPS antenna SERIAL NUMBER	IGS antenna type AND DOME TYPE
IGS, ARGN,AFN	ALIC	LEICA GRX1200GGPRO	318	AOAD/M_T NONE
IGS, ARGN,AFN	CEDU	ASHTECH UZ-12	194	AOAD/M_T AUST
IGS, ARGN,AFN	DARW	LEICA GRX1200GGPRO	133	ASH700936D_M NONE
IGS, ARGN,AFN	HOB2	LEICA GRX1200GGPRO	203	AOAD/M_T NONE
IGS, ARGN,AFN	KARR	ASHTECH UZ-12	320	AOAD/M_T AUST
IGS, ARGN,AFN	TIDB	ASHTECH Z-XII3	205	AOAD/M_T JPLA
IGS, ARGN,AFN	TOW2	LEICA GRX1200GGPRO	326	AOAD/M_T AUST
IGS, ARGN,AFN	YAR2	ASHTECH UZ-12	371	AOAD/M_T JPLA

Table 4: GPS antenna heights to ARP used in GPS processing and site DOMES numbers ((bold site IDs for CORSnet-NSW stations, and others for AFN stations).

Site 4-char. ID	DOMES number	ANTENNA HEIGHT TO ARP (M)	site 4-char. ID	DOMES number	ANTENNA HEIGHT TO ARP (M)
GFTN	–	**0.0000**	CEDU	50138M001	0.0060
GLIN	–	**0.0000**	DARW	50134M001	0.0025
MACK	–	**0.0000**	HOB2	50116M004	0.0000
TAMW	–	**0.3000**	KARR	50139M001	0.0020
TNTR	-	**0.0000**	TIDB	50103M108	0.0614
WLGT	-	**0.0000**	TOW2	50140M001	0.0035
ALIC	50137M001	0.0070	YAR2	50107M004	0.0814

Method:

Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position Issue 1.6.

In summary, daily solutions of the CORSnet-NSW and AFN/ARGN/IGS/other site data were processed using Bernese GPS Processing Software version 5.0. The Bernese GPS Software conforms to the IERS2003 conventions. IGS final GPS satellite ephemerides and earth orientation parameters were used in the computations. The double difference carrier phase observables at 30-second epoch intervals were used for GPS data processing. Other measurement modelling and parameter estimation included:

- Receiver clock corrections.
- Absolute antenna elevation-dependent phase centre variation corrections.
- Solid earth tide displacements.
- Ocean loading displacements.
- Elevation cutoff of 10° for all observations.
- QIF integer ambiguity resolution strategy.
- Elevation dependent observation weighting.
- Troposphere zenith delays estimated at 1-hour intervals for all stations.
- Minimum constraint condition for daily network solution in terms of the ITRF2005 using subset of the IGS05 reference stations.

Daily solutions were combined to provide a weekly solution. This solution was transformed to GDA94 using a seven parameter transformation.

Results:

Table 5 lists the Root Mean Square (RMS) of the daily station coordinate values. Table 6 lists the GDA94 station coordinates resulting from the combination together with the position recognised-value standard GDA94 coordinates held fixed in the adjustment.

Table 5: Root Mean Square (RMS) of daily CORSnet-NSW and minimally constrained AFN/ARGN/IGS (bold station names) station coordinates.

Station	North (mm)	East (mm)	Up (mm)	Station	North (mm)	East (mm)	Up (mm)
ALIC	1.0	1.0	3.5	**YAR2**	1.4	0.7	2.5
CEDU	1.0	0.8	3.5	GFTN	0.9	0.9	3.1
DARW	1.2	2.3	3.0	GLIN	0.6	1.1	3.4
HOB2	1.5	1.0	2.0	MACK	0.8	1.2	7.5
KARR	0.6	0.9	4.1	TAMW	0.8	1.6	5.4
TIDB	0.7	0.7	4.3	TNTR	0.7	1.1	3.5
TOW2	1.0	1.6	3.2	WLGT	0.8	0.9	2.8

Table 6: Computed Geocentric Datum of Australia (GDA94) geodetic coordinates and their uncertainty for the CORSnet-NSW stations. The uncertainties are calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

Station	Longitude (DMS east)			Std (M)	Latitude (DMS south)			Std (M)	Ellipsoidal height (M)	Std (M)
GFTN	152	55	58.43930	0.0315	29	41	34.93218	0.0315	59.2010	0.0544
GLIN	151	45	5.98259	0.0315	29	44	36.80305	0.0315	1205.6877	0.0544
MACK	152	55	6.16504	0.0315	30	42	37.59543	0.0315	43.4343	0.0544
TAMW	150	55	51.28579	0.0315	31	05	34.29322	0.0315	439.6447	0.0544
TNTR	152	01	11.70396	0.0315	29	03	17.19617	0.0315	901.1751	0.0544
WLGT	148	07	0.97568	0.0315	30	01	24.21841	0.0315	170.3193	0.0544

END OF REPORT