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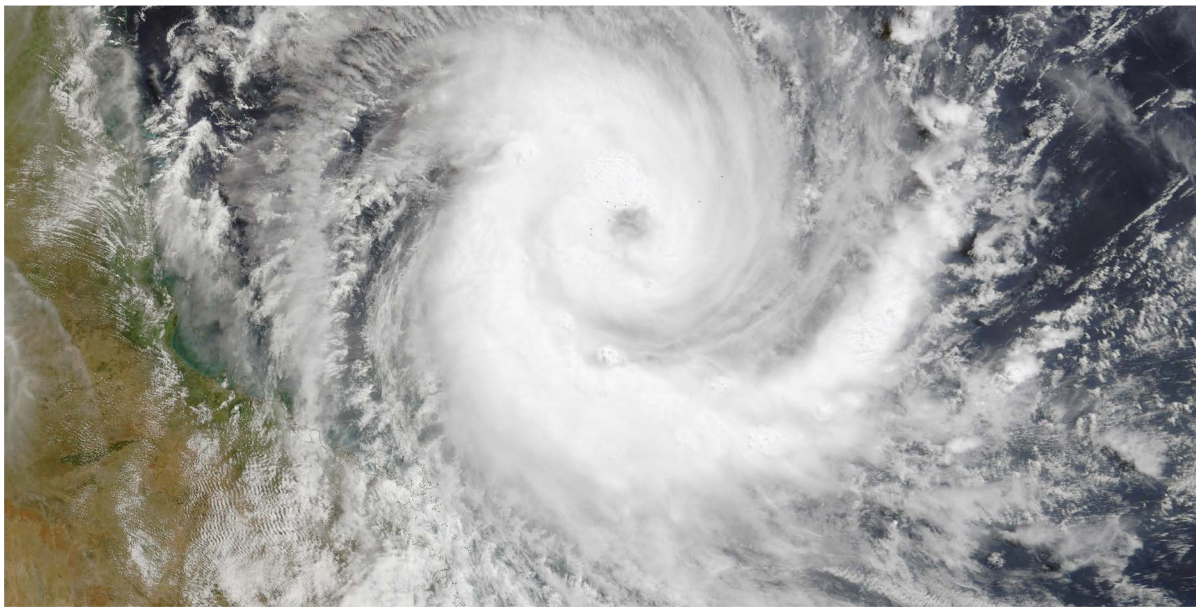

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Determination of GDA94 coordinates for fifteen CORSnet-NSW stations using the October 2012 GPS data sets

G. Hu, J. Dawson

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Contents

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Expiry of this Report

5 years after authorisation date.

Abbreviations

AFN	Australian Fiducial Network
ARGN	Australian Regional GNSS Network
CORS	Continuously Operating Reference Station(s)
GDA94	Geocentric Datum Australia 1994
GNSS	Global Navigation Satellite System(s)
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
IGS	International GNSS Service
ITRF	International Terrestrial Reference Frame
ITRF92	International Terrestrial Reference Frame 1992
ITRF2008	International Terrestrial Reference Frame 2008

Introduction

An application dated 05 November 2012 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from the Land and Property Information (LPI), NSW Department of Finance & Services, for verification of GDA94 position on their owned or managed station monument. This report documents the processing and analysis of GPS data observed by the LPI during a 7-day period from 14 October to 20 October 2012 (day of year 288 to 294) for the station GUNN and from 21 October to 27 October 2012 (day of year 295 to 301) for the other fourteen stations 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)
Antenna phase centre	3	10
Monument stability	1	1
Other sources including un-modelled crustal loading, satellite orbit variations, atmosphere, tectonics, signal multi-path	6	10

GPS Data

GPS RINEX data was supplied for spanning a 7-day period from 14 October to 20 October 2012 (day of year 288 to 294) for the station GUNN, and from 21 October to 27 October 2012 (day of year 295 to 301) for the other fourteen stations of CORSnet-NSW. 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 the above CORSnet-NSW stations. The ARP is the reference point as defined by IGS and the RINEX specifications.

Figure 2 shows the extended regional network of IGS, ARGN and AFN network sites used in the GPS data processing. Table 2 lists the GPS receiver and antenna type used in the GPS data processing for each of the AFN network sites. Table 3 lists the GPS antenna heights used in the GPS data processing for the AFN and the CORSnet-NSW stations.

GPS Data Irregularities

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

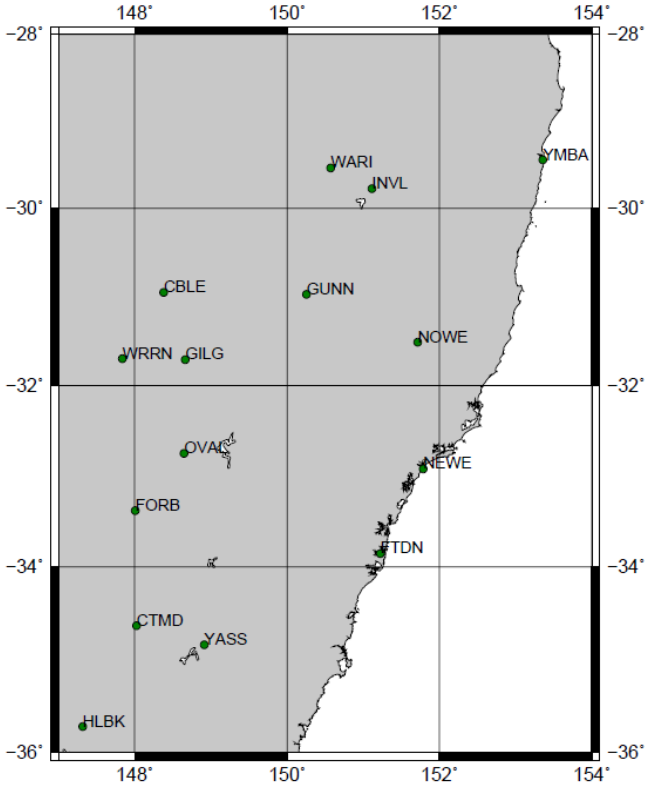

Figure 1: *CORSnet-NSW stations used in GPS data processing.*

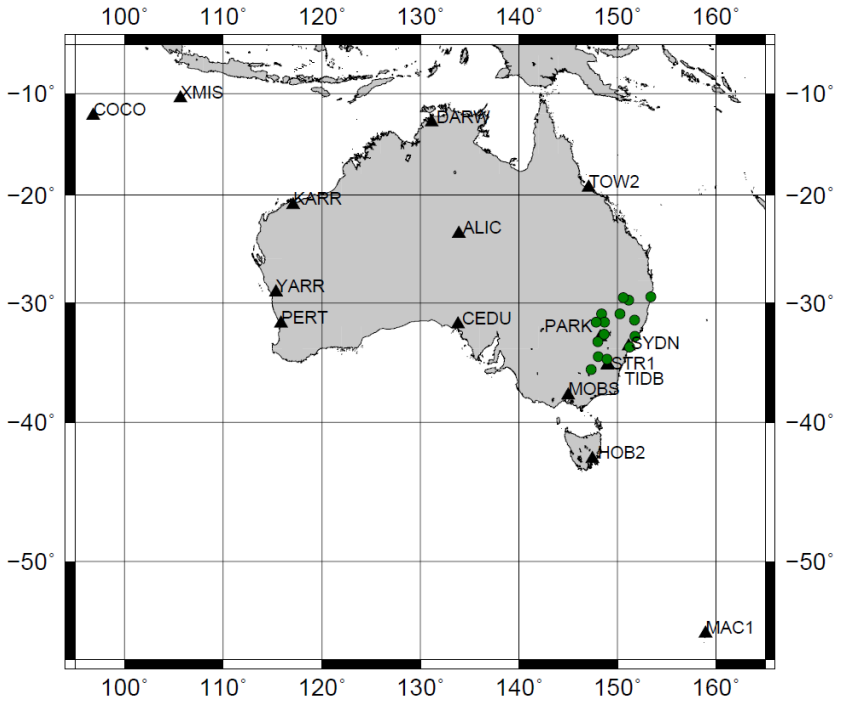

Figure 2: *AFN/ARGN/IGS stations (black triangles) used in GPS data processing.*

Table 2: *GPS receiver and antenna types for the CORSnet-NSW stations and the AFN/ARGN/IGS sites.*

Station	GPS receiver type	GPS antenna serial number	IGS antenna type and dome type
CBLE	TRIMBLE NETR9	0712118514	TRM57971.00 NONE
CTMB	LEICA GRX1200+GNSS	13194-010	LEIAR10 NONE
FORB	LEICA GRX1200+GNSS	13110-045	LEIAR10 NONE
FTDN	TRIMBLE NETR9	1441109201	TRM57971.00 NONE
GILG	TRIMBLE NETR9	0712118768	TRM57971.00 NONE
GUNN	TRIMBLE NETR9	0712118808	TRM57971.00 NONE
HLBK	TRIMBLE NETR9	0712118140	TRM57971.00 NONE
INVL	TRIMBLE NETR9	5109354041	TRM59800.00 SCIS
NEWE	LEICA GRX1200+GNSS	725070	LEIAR25.R4 LEIT
NOWE	LEICA GRX1200+GNSS	13194-015	LEIAR10 NONE
OVAL	TRIMBLE NETR9	0712118813	TRM57971.00 NONE
WARI	TRIMBLE NETR9	0412118503	TRM57971.00 NONE
WRRN	TRIMBLE NETR9	0712118773	TRM57971.00 NONE
YASS	TRIMBLE NETR9	1312118069	TRM57971.00 NONE
YMBA	TRIMBLE NETR9	0712118428	TRM57971.00 NONE
ALIC	LEICA GRX1200GGPRO	09370001	LEIAR25.R3 NONE
CEDU	TRIMBLE NETR8	194	AOAD/M_T AUST
COCO	TRIMBLE NETR8	202	AOAD/M_T NONE
DARW	GRX1200GGPRO	CR13354	ASH700936D_M NONE
HOB2	LEICA GRX1200GGPRO	203	AOAD/M_T NONE
KARR	TRIMBLE NETR8	4938353444	TRM59800.00 NONE
MAC1	LEICA GRX1200+GNSS	308	AOAD/M_T AUST
MOBS	LEICA GRX1200GGPRO	CR20020709	ASH701945C_M NONE
PARK	JPS E_GGD	CR620011902	ASH701945C_M NONE
PERT	TRIMBLE NETR9	5220354498	TRM59800.00 NONE
STR1	LEICA GRX1200GGPRO	CR620023911	ASH701945C_M NONE
SYDN	JPS E_GGD	CR519994908	ASH701945C_M NONE
TIDB	ASHTECH UZ-12	205	AOAD/M_T JPLA
TOW2	LEICA GRX1200GGPRO	09310016	LEIAR25.R3 NONE
XMIS	LEICA GRX1200GGPRO	CR6200503003	ASH701945C_M NONE
YARR	LEICA GRX1200PRO	103314	LEIAT504 NONE

Table 3: *GPS antenna heights to ARP used in GPS processing for the CORSnet-NSW stations and minimally constrained AFN (bold station names) stations.*

Station	Domes number	Antenna height to ARP (m)	Station	Domes number	Antenna height to ARP (m)
CBLE	AUM000280	0.0000	**ALIC**	50137M001	0.0015
CTMB	AUM000277	0.0000	**CEDU**	50138M001	0.0060
FORB	AUM000259	0.0000	**COCO**	50127M001	0.0040
FTDN	AUM000263	0.0000	**DARW**	50134M001	0.0025
GILG	AUM000279	0.0000	**HOB2**	50116M004	0.0000
GUNN	AUM000271	0.0000	**KARR**	50139M001	0.0010
HLBK	AUM000278	0.0000	**MAC1**	50135M001	0.0280
INVL	AUM000269	0.0000	**MOBS**	50182M001	0.0000
NEWE	AUM000268	0.0000	**PARK**	50108M001	0.0000
NOWE	AUM000272	0.0000	**PERT**	50133M001	0.0595
OVAL	AUM000274	0.0000	**STR1**	50119M002	0.0040
WARI	AUM000270	0.0000	**SYDN**	50124M003	0.0300
WRRN	AUM000276	0.0000	**TIDB**	50103M108	0.0614
YASS	AUM000275	0.0000	**TOW2**	50140M001	0.0033
YMBA	AUM000273	0.0000	**XMIS**	50183M001	0.0000
			YARR	50107M006	0.0045

Method

Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position Issue 1.15.

In summary, daily solutions of the CORSnet-NSW stations 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 tide 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 ITRF2008 using subset of the IGS08 reference stations.

This solution was transformed to GDA94 using the transformation approach detailed in: ITRF to GDA94 coordinate transformation, John Dawson and Alex Woods, *Journal of Applied Geodesy* **4** (2010), no. 4, pp. 189-199, available online at http://www.reference-global.com/loi/jag.

Results

Table 4 lists the Root Mean Square (RMS) of the daily station coordinate values. Table 5 lists the station coordinates resulting from the combination of the daily ITRF solutions and their subsequent transformation to GDA94.

Table 4: *Root Mean Square (RMS) of daily CORSnet-NSW stations 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)
CBLE	0.8	0.6	2.7	**ALIC**	0.7	0.5	3.4
CTMB	1.3	1.6	3.3	**CEDU**	0.5	0.7	1.9
FORB	0.6	0.7	4.8	**COCO**	0.9	2.8	7.0
FTDN	1.1	0.7	3.4	**DARW**	2.5	2.2	7.2
GILG	1.2	0.8	2.5	**HOB2**	1.8	0.8	4.8
GUNN	0.6	1.2	3.2	**KARR**	1.0	1.4	3.2
HLBK	1.1	0.9	3.5	**MAC1**	1.2	1.2	3.2
INVL	1.2	0.6	3.6	**MOBS**	0.6	0.6	2.9
NEWE	1.0	0.8	5.3	**PARK**	0.8	0.6	2.2
NOWE	1.0	1.0	2.1	**PERT**	0.6	0.6	4.2
OVAL	1.1	0.7	3.4	**STR1**	0.8	0.6	2.6
WARI	1.3	0.8	2.7	**SYDN**	0.8	0.7	2.0
WRRN	0.9	0.8	4.1	**TIDB**	1.2	1.7	5.0
YASS	1.4	0.8	3.5	**TOW2**	1.0	1.6	3.8
YMBA	0.7	0.7	3.7	**XMIS**	1.3	2.2	6.5
				YARR	0.5	0.9	3.6

Table 5: *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) Uncertainty (m)			Latitude (DMS south) Uncertainty (m)			Ellipsoidal height (m) Uncertainty (m)
CBLE	148	22	41.60975	30	57	12.77014	209.3348
			±0.008			±0.008	±0.019
CTMD	148	1	32.32745	34	38	21.49779	356.1974
			±0.008			±0.008	±0.019
FORB	148	0	25.08225	33	23	6.97485	269.7987
			±0.007			±0.008	±0.018
FTDN	151	13	30.88392	33	51	18.23318	27.9328
			±0.008			±0.008	±0.019
GILG	148	39	44.85861	31	42	39.55957	319.4753
			±0.008			±0.008	±0.019
GUNN	150	15	22.60270	30	58	41.42984	303.8404
			±0.007			±0.008	±0.018
HLBK	147	19	2.62946	35	43	27.77883	284.6243
			±0.008			±0.008	±0.019
INVL	151	6	51.81565	29	46	35.14380	627.2180
			±0.008			±0.008	±0.019
NEWE	151	47	19.47753	32	55	26.31541	30.1870
			±0.008			±0.008	±0.019
NOWE	151	42	58.59018	31	30	48.81441	886.7099
			±0.008			±0.008	±0.019
OVAL	148	38	45.77720	32	45	13.86721	409.4799
			±0.008			±0.008	±0.019
WARI	150	34	27.12041	29	32	26.11472	372.1191
			±0.008			±0.008	±0.019
WRRN	147	50	11.18998	31	42	2.93994	229.1439
			±0.008			±0.008	±0.019
YASS	148	54	47.68461	34	50	41.68031	522.7317
			±0.008			±0.008	±0.019
YMBA	153	21	28.41362	29	26	50.80009	43.6514
			±0.008			±0.008	±0.019

END OF REPORT