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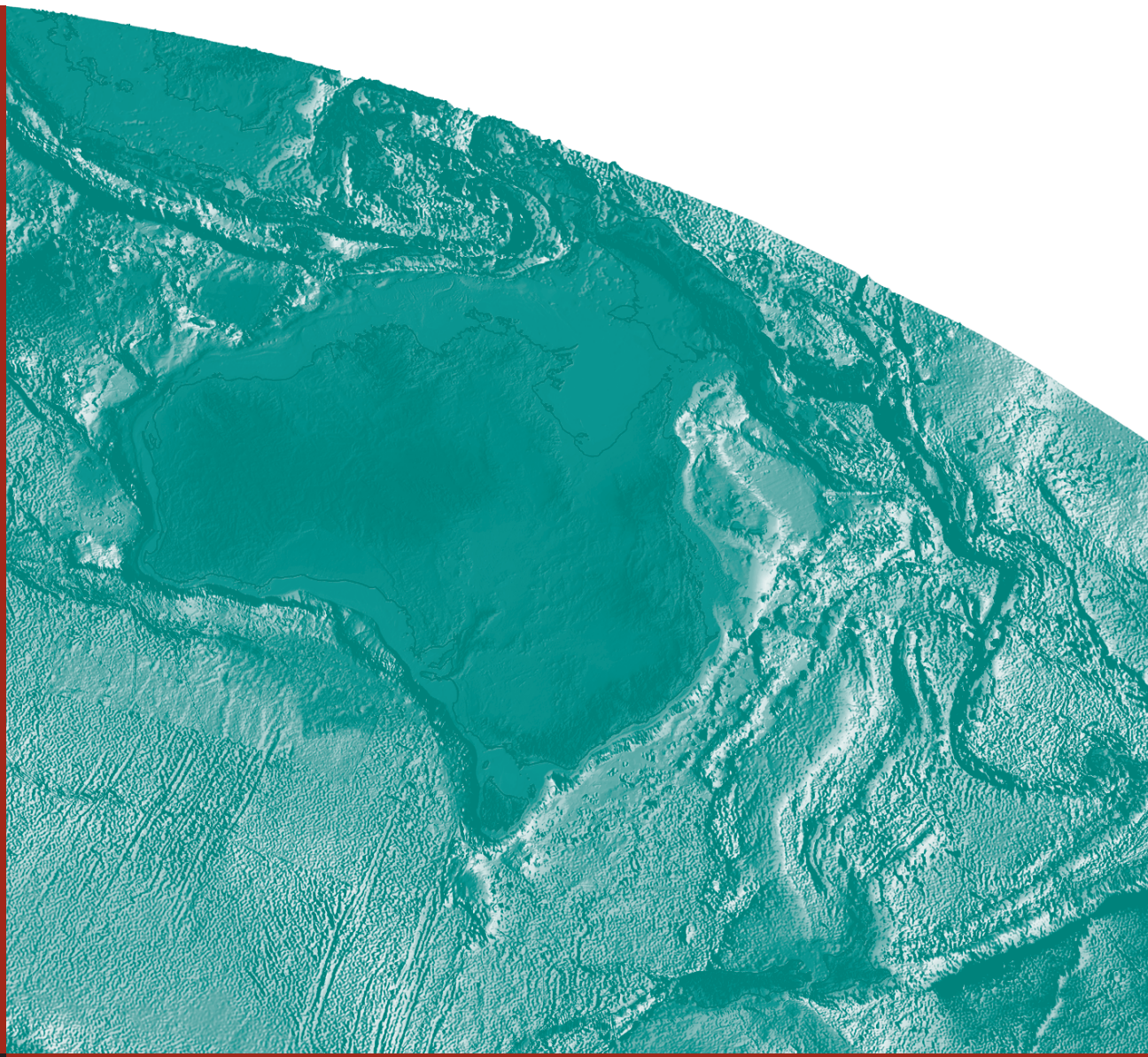

Determination of GDA94 coordinates for three stations of Position Partners using the November 2011 GPS data set

GEOSCIENCE AUSTRALIA
RECORD 2012/45

by

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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
ITRF2008	International Terrestrial Reference Frame 2008

Introduction:

An application dated 12 December 2011 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from the Position Partners PTY LTD for verification of GDA94 position on their owned or managed station monuments. This report documents the processing and analysis of GPS data observed by the Position Partners PTY LTD during a 7-day period from 20 to 26 November 2011 (day of year 324 to 330) for three stations (5KAD, 5LON and 5REG) 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 three stations of the Position Partners PTY LTD spanning a 7-day period from 20 to 26 November 2011 (day of year 324 to 330). Four character names of the stations are 5KAD, 5LON and 5REG. Figure 1 shows the distribution of these stations. Table 2 lists the GPS receiver and antenna type at each site. The GPS receiver and antenna types, and GPS antenna heights to the Antenna Reference Point (ARP) as supplied in the amended station files dated 27 April 2012 submitted with the application for verification of position have been adopted for the GPS data processing. The ARP is the reference point as defined by IGS and the RINEX specifications.

Figure 2 shows the 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 AFN network sites. Table 4 lists the GPS antenna heights used in the GPS data processing for the AFN and the Position Partners PTY LTD sites.

GPS Data Irregularities:

The GPS data set received on 27 April 2012 is regular.

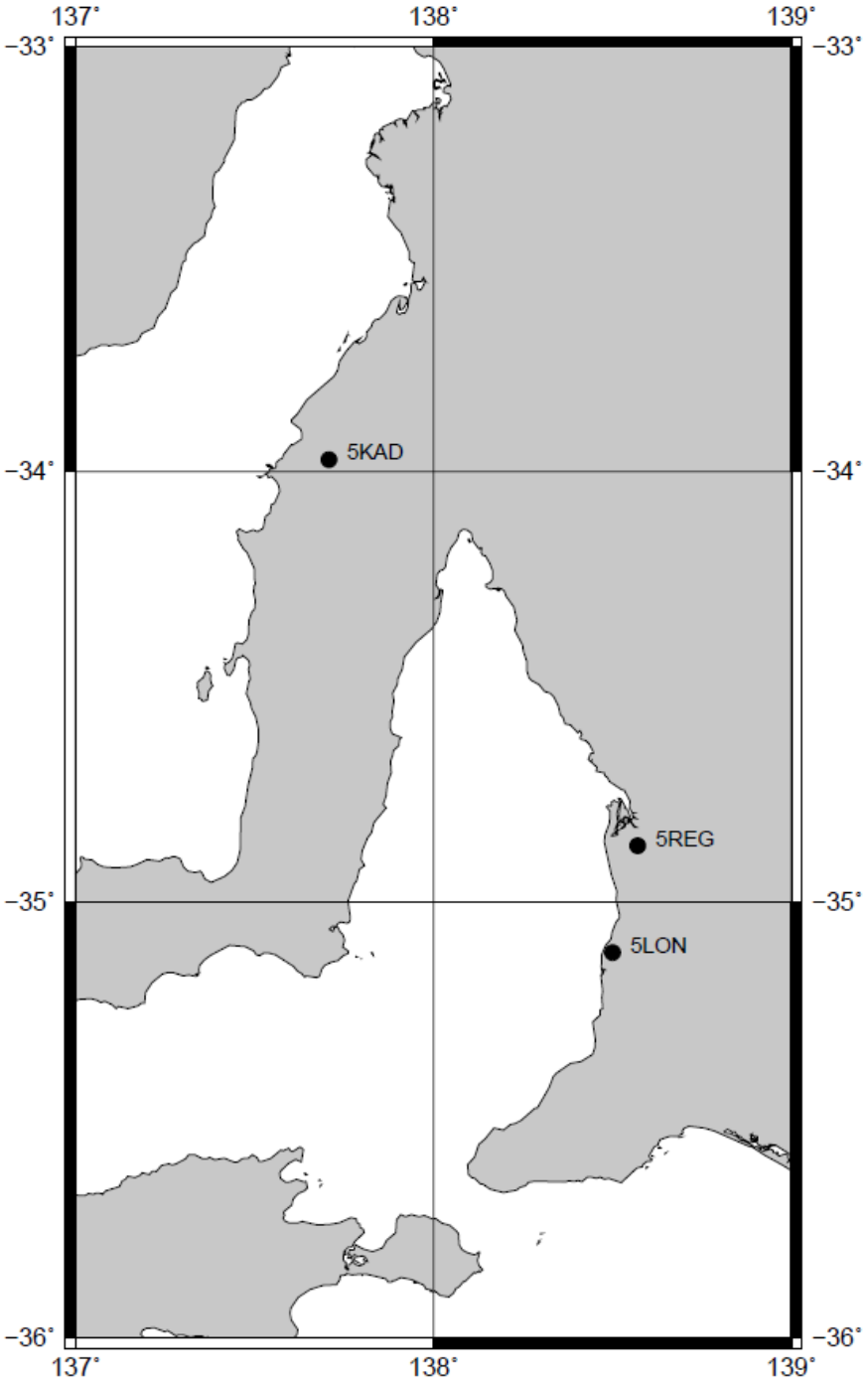

Figure 1: Position Partners PTY LTD stations used in GPS data processing.

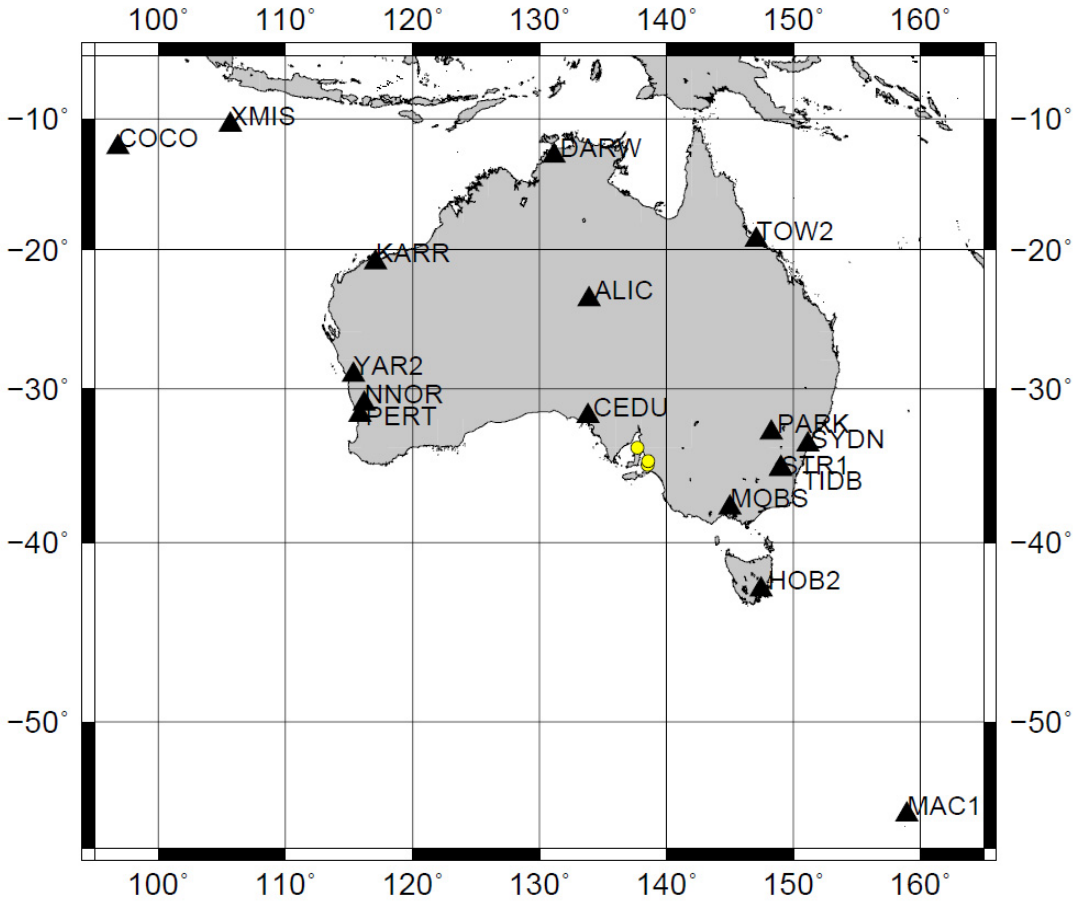

Figure 2: Position Partners PTY LTD stations (circles) and AFN (black triangles) stations used in GPS data processing.

Table 2: GPS receiver and antenna types for stations of the Position Partners PTY LTD.

Station name	4-char. ID	GPS receiver type	GPS antenna serial number	IGS antenna type and dome type
Kadina	5KAD	TPS NET-G3A	383-2180	TPSCR.G3 TPSH
Lonsdale	5LON	TPS NET-G3	383-2815	TPSCR.G3 TPSH
Regency Park	5REG	TPS NET-G3	383-2184	TPSCR.G3 TPSH

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
AFN	ALIC	LEICA GRX1200GGPRO	09370001	LEIAR25.R3 NONE
AFN	CEDU	TRIMBLE NETR8	194	AOAD/M_T AUST
AFN	COCO	TRIMBLE NETR8	202	AOAD/M_T NONE
AFN	DARW	GRX1200GGPRO	CR13354	ASH700936D_M NONE
AFN	HOB2	LEICA GRX1200GGPRO	203	AOAD/M_T NONE
AFN	KARR	TRIMBLE NETR8	4938353444	TRM59800.00 NONE
AFN	MAC1	LEICA GRX1200+GNSS	308	AOAD/M_T AUST
AFN	MOBS	LEICA GRX1200GGPRO	CR20020709	ASH701945C_M NONE
AFN	NNOR	ASHTECH Z-XII3	CR620021402	ASH701945C_M NONE
AFN	PARK	JPS E_GGD	CR620011902	ASH701945C_M NONE
AFN	PERT	ASHTECH UZ-12	CR620023901	ASH701945C_M NONE
AFN	STR1	LEICA GRX1200GGPRO	CR620023911	ASH701945C_M NONE
AFN	SYDN	JPS E_GGD	CR519994908	ASH701945C_M NONE
AFN	TIDB	ASHTECH UZ-12	205	AOAD/M_T JPLA
AFN	TOW2	LEICA GRX1200GGPRO	326	LEIAR25.R3 NONE
AFN	XMIS	LEICA GRX1200GGPRO	CR6200503003	ASH701945C_M NONE
AFN	YAR2	ASHTECH UZ-12	371	AOAD/M_T JPLA

Table 4: GPS antenna heights to ARP used in GPS processing for Position Partners PTY LTD stations and minimally constrained AFN (bold station names) stations.

Station 4-char. ID	Domes number	Antenna height to ARP (M)	Station 4-char. ID	Domes number	Antenna height to ARP (M)
5KAD	-	0.0845	**MOBS**	50182M001	0.0000
5LON	-	0.0845	**NNOR**	50181M001	0.0655
5REG	-	0.0845	**PARK**	50108M001	0.0000
ALIC	50137M001	0.0015	**PERT**	50133M001	0.0595
CEDU	50138M001	0.0060	**STR1**	50119M002	0.0040
COCO	50127M001	0.0040	**SYDN**	50124M003	0.0300
DARW	50134M001	0.0025	**TIDB**	50103M108	0.0614
HOB2	50116M004	0.0000	**TOW2**	50140M001	0.0033
KARR	50139M001	0.0010	**XMIS**	50183M001	0.0000
MAC1	50135M001	0.0280	**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 1.13.

In summary, daily solutions of the Position Partners PTY LTD 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 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 www.reference-global.com/loi/jag.

Results:

Table 5 lists the Root Mean Square (RMS) of the daily station coordinate values. Table 6 lists the station coordinates resulting from the combination of the daily ITRF solutions and their subsequent transformation to GDA94.

Table 5: Root Mean Square (RMS) of daily Position Partners PTY LTD station and minimally constrained AFN (bold station names) station coordinates.

Station	North (mm)	East (mm)	Up (mm)	Station	North (mm)	East (mm)	Up (mm)
5KAD	1.1	1.3	4.3	**MOBS**	1.3	1.3	6.1
5LON	0.9	1.8	3.1	**NNOR**	1.3	3.7	3.9
5REG	1.5	1.5	4.1	**PARK**	0.8	1.4	5.0
ALIC	0.7	2.0	5.4	**PERT**	1.2	3.5	4.6
CEDU	1.0	1.8	4.2	**STR1**	0.9	2.4	5.0
COCO	1.7	3.6	3.5	**SYDN**	1.0	1.6	6.4
DARW	2.0	1.8	8.5	**TIDB**	0.9	1.7	4.7
HOB2	1.6	2.7	7.6	**TOW2**	1.5	2.6	3.3
KARR	1.5	2.7	5.9	**XMIS**	0.8	3.3	4.8
MAC1	3.7	2.2	5.5	**YAR2**	1.3	3.1	4.6

Table 6: Computed Geocentric Datum of Australia (GDA94) geodetic coordinates and their uncertainty for the Position Partners PTY LTD 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. The uncertainties are 0.0315 m, 0.0315 m and 0.0544 m for east, north and vertical components respectively for all stations.

Station	Longitude (DMS east)			Latitude (DMS south)			Ellipsoidal height (M)
5KAD	137	42	29.49678	33	58	17.54877	47.0340
5LON	138	30	2.94457	35	06	58.73529	95.5551
5REG	138	34	16.64867	34	52	9.13306	12.8471

END OF REPORT