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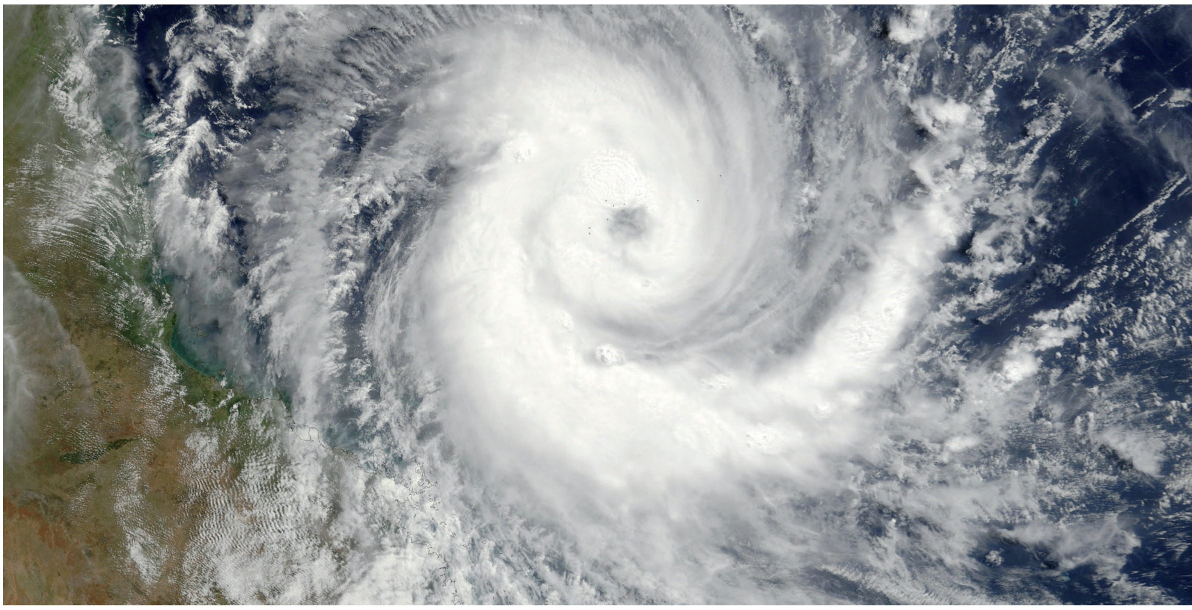

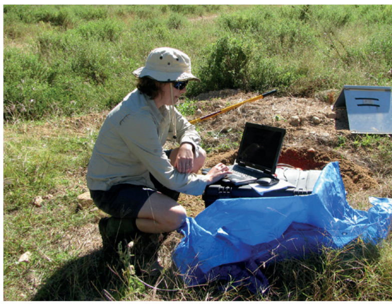

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Determination of GDA94 coordinates for station CCMB at the Clermont Coal Mine of Rio Tinto Coal Australia (RTCA) in central Queensland using the October and November 2012 GPS data sets

G. Hu and J. Dawson

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by

G. Hu, J. Dawson

Australian Government
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NATA

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Contents

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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 01 November 2012 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from the Clermont Coal Mine of Rio Tinto Coal Australia (RTCA) 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 Clermont Coal Mine during a 7-day period from 28 October to 03 November 2012 (day of year 302 to 308) for the station CCMB 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 the station CCMB at the Clermont Coal Mine of Rio Tinto Coal Australia (RTCA) spanning a 7-day period from 28 October to 03 November 2012 (day of year 302 to 308). Figure 1 shows the location of the station. Table 2 lists the GPS receiver and antenna type at the 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 22 November 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.

The AFN network sites used in the GPS data processing are plotted in Figure 1. 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 site CCMB.

GPS Data Irregularities:

The GPS data set received on 22 November 2012 is regular.

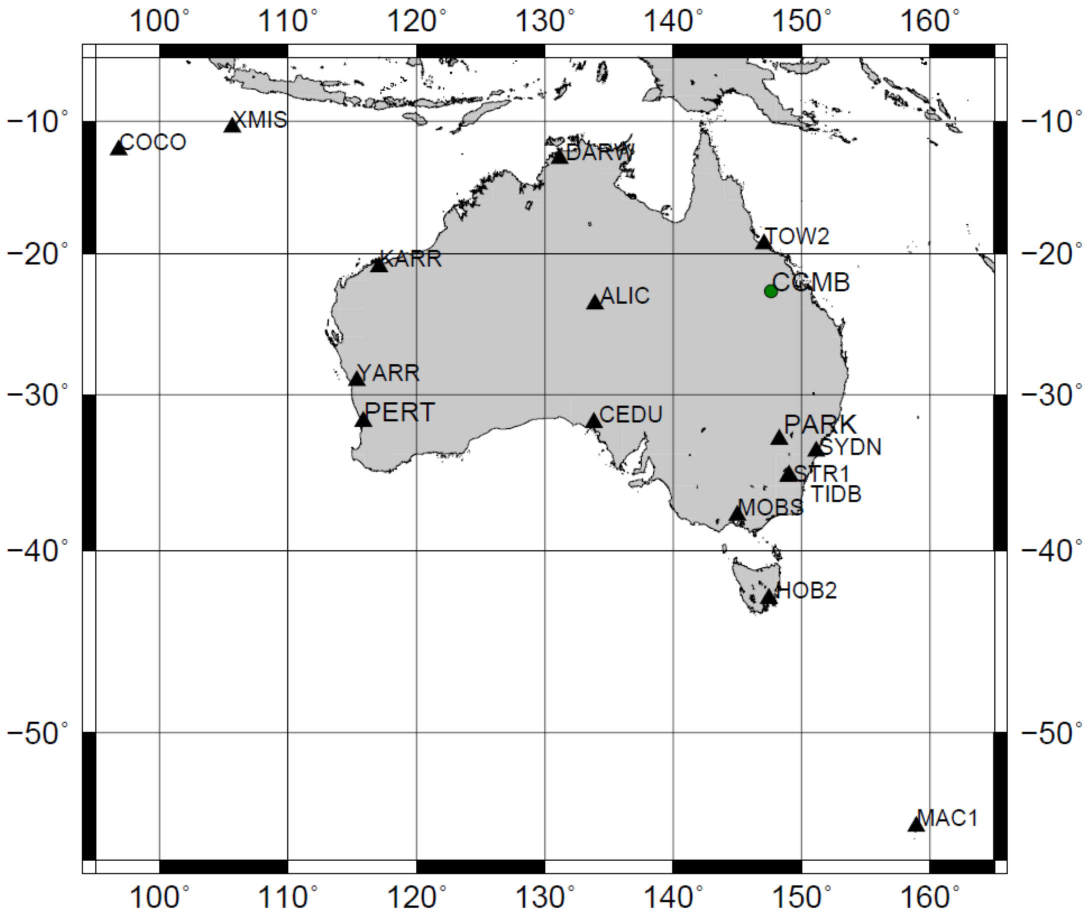

Figure 1: Station CCMB (circle) at the Clermont Coal Mine of Rio Tinto Coal Australia (RTCA) and AFN (black triangles) stations used in GPS data processing.

Table 2: GPS receiver and antenna types for the station CCMB and the AFN sites.

4-char. ID	GPS receiver type	GPS antenna serial number	IGS antenna type and dome type	
CCMB	**LEICA GRX1200GGPRO**	**07520021**	**LEIAX1202GG**	**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 station CCMB 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)
CCMB	-	0.0000	**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	**YARR**	50107M006	0.0045
MOBS	50182M001	0.0000			

Method:

Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position Issue 1.14.

In summary, daily solutions of the station CCMB 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 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 station CCMB and minimally constrained AFN (bold station names) station coordinates.

Station	North (mm)	East (mm)	Up (mm)	Station	North (mm)	East (mm)	Up (mm)
CCMB	1.0	1.8	6.1	**PARK**	1.1	0.6	2.3
ALIC	0.8	0.8	3.8	**PERT**	0.7	1.1	3.9
CEDU	0.5	0.7	2.1	**STR1**	0.8	1.2	2.4
COCO	1.9	1.7	4.9	**SYDN**	0.7	0.6	2.4
DARW	0.9	0.7	6.1	**TIDB**	0.6	1.2	2.3
HOB2	1.1	0.8	4.1	**TOW2**	1.4	1.4	4.7
KARR	0.7	0.9	2.8	**XMIS**	1.9	1.3	4.8
MAC1	0.6	0.9	2.6	**YARR**	0.5	0.8	2.9
MOBS	0.8	0.7	2.0				

Table 5: Computed Geocentric Datum of Australia (GDA94) geodetic coordinates and their uncertainty for the station CCMB. 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 0.032 m, 0.032 m and 0.054 m for east, north and vertical components respectively for all stations.

Station	Longitude (DMS east)	Latitude (DMS south)	Ellipsoidal height (M)
CCMB	147 37 21.74643	22 43 35.09958	339.0411

END OF REPORT