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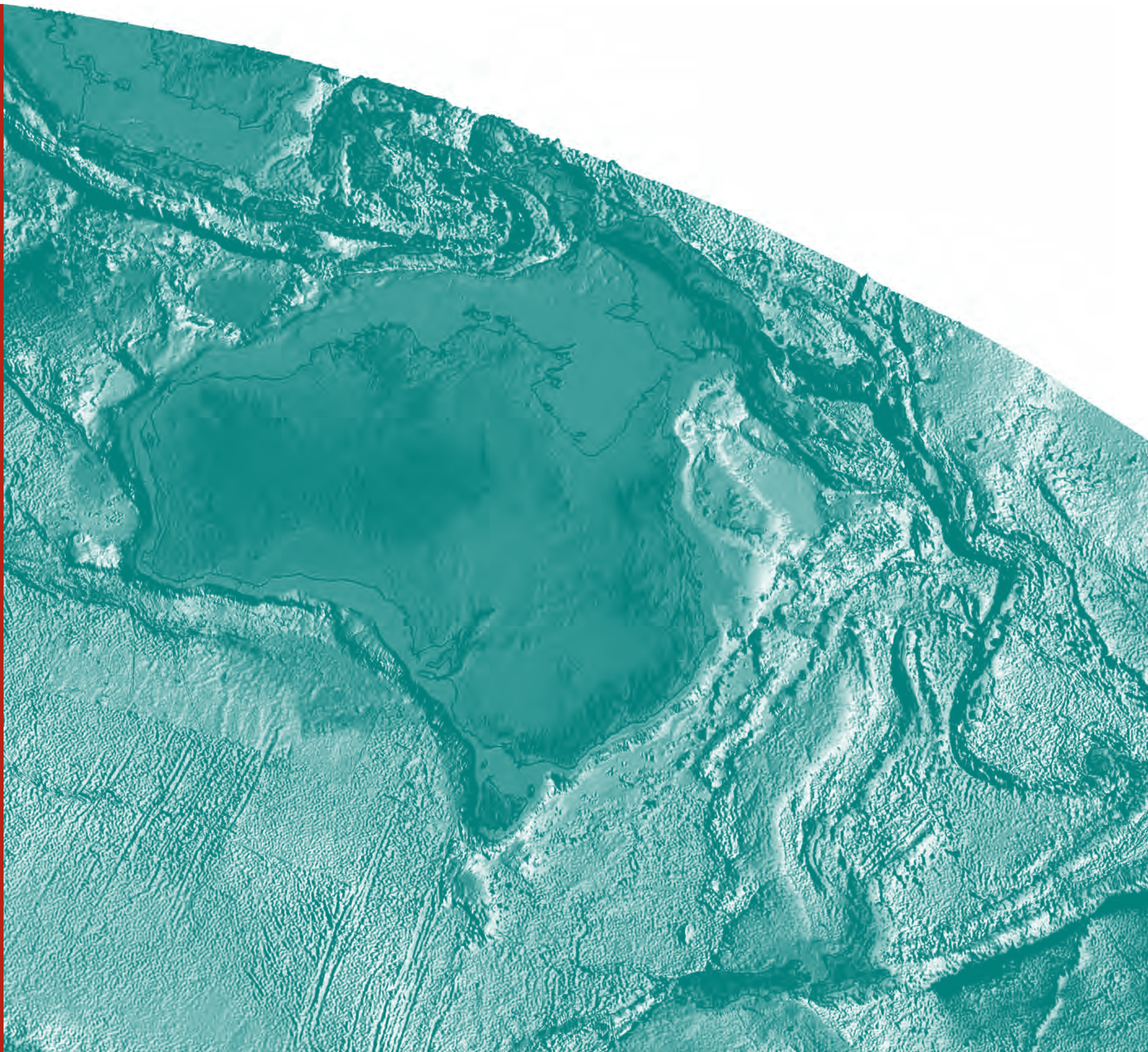

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

# Determination of GDA94 coordinates for two CORSnet-NSW stations using the November 2010 GPS data set

Geoscience Australia
Record 2011/05

by

G. Hu, J. Dawson

This report is accredited for compliance with ISO/IEC 17025:2005 and issued in accordance with NATA accreditation requirements.

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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 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 18th November 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 7th November to 13th November 2010 (day of year 311 to 317) for two stations (i.e. CNDO and GFTH) 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 two CORSnet-NSW stations (i.e. CNDO and GFTH) spanning a 7-day period from 7$^{th}$ November to 13$^{th}$ November 2010 (day of year 311 to 317). Figure 1 shows the distribution of these stations. Table 2 lists the GPS receiver and antenna type at each site. The antenna offset between station mark and Antenna Reference Point (ARP) is 0.002 m for CNDO and 0.000 m for GFTH. 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.

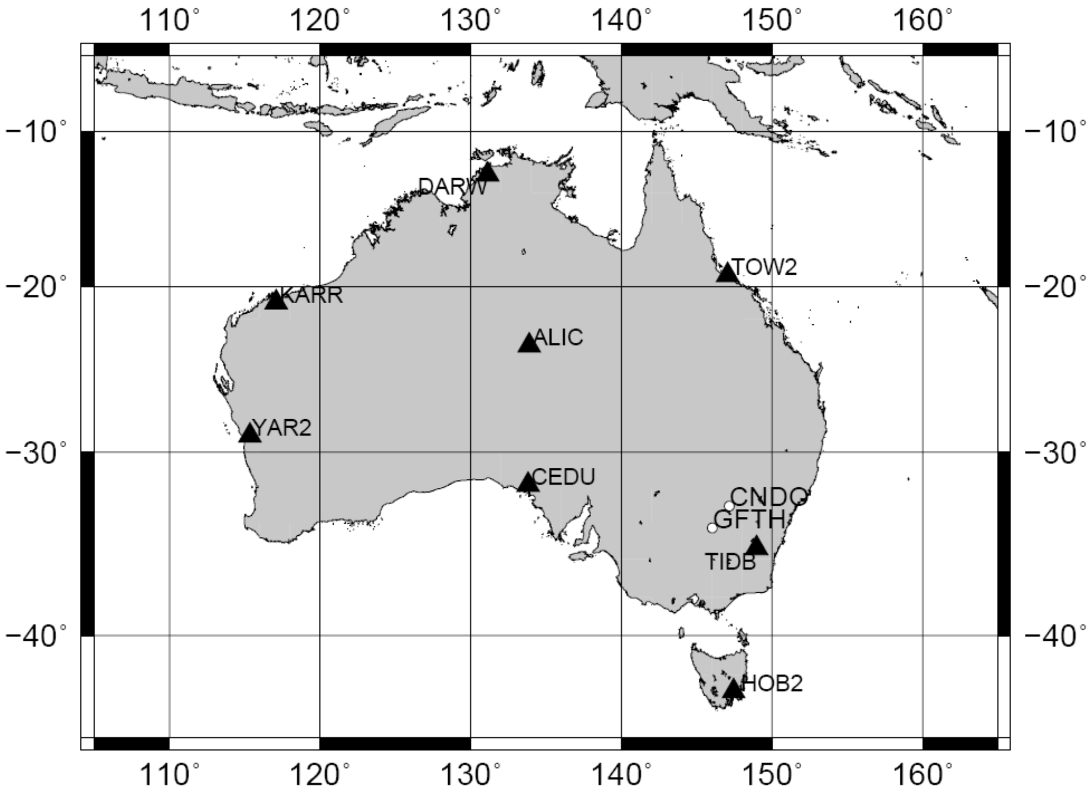


**Figure 1:** AFN/ARGN/IGS (black triangles), and CORSnet-NSW (circles) stations used in GPS data processing.

**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 |
|---|---|---|---|---|
| Condobolin | CNDO | LEICA GRX1200+GNSS | 13110-012 | LEIAR10 NONE |
| Griffith | GFTH | LEICA GRX1200+GNSS | 13110-025 | 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) |
|---|---|---|---|---|---|
| **CNDO** | – | **0.0020** | HOB2 | 50116M004 | 0.0000 |
| **GFTH** | – | **0.0000** | KARR | 50139M001 | 0.0020 |
| ALIC | 50137M001 | 0.0070 | TIDB | 50103M108 | 0.0614 |
| CEDU | 50138M001 | 0.0060 | TOW2 | 50140M001 | 0.0035 |
| DARW | 50134M001 | 0.0025 | 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 1.7.

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** | 1.3 | 1.7 | 5.9 | **TIDB** | 1.1 | 1.6 | 5.2 |
| **CEDU** | 1.4 | 2.0 | 3.2 | **TOW2** | 1.5 | 2.0 | 7.9 |
| **DARW** | 1.8 | 2.2 | 6.9 | **YAR2** | 1.3 | 1.4 | 6.4 |
| **HOB2** | 2.0 | 1.5 | 5.9 | CNDO | 0.7 | 1.0 | 5.6 |
| **KARR** | 1.4 | 1.4 | 4.2 | GFTH | 0.8 | 1.1 | 3.6 |

**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)<br>Std (M) | Latitude (DMS south)<br>Std (M) | Ellipsoidal height (M)<br>Std (M) |
|---|---|---|---|
| CNDO | 147 09 3.61478<br>0.0315 | 33 05 6.58755<br>0.0315 | 229.7451<br>0.0544 |
| GFTH | 146 02 12.43755<br>0.0315 | 34 17 10.73012<br>0.0315 | 161.6706<br>0.0544 |

**END OF REPORT**