Geocentric Datum of Australia 2020 Interim Release Note

Version 1.01

Intergovernmental Committee on Surveying and Mapping (ICSM)

Permanent Committee on Geodesy (PCG)

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Document History

DATE	VERSION	AMENDMENTS
02 March 2017	1.0	Initial version
03 March 2017	1.01	Corrected labelling in header of ITRF to GDA2020 transformation

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IMPORTANT

The publication is an 'interim' release note.

The update to the Recognized-value standard of measurement of position (RVS), and hence the national datum from GDA94 to GDA2020, will occur in late March. Until then, GDA94 remains the national datum.

When the RVS is changed, the gazettal will appear in the GDA Technical Manual. The GDA Technical Manual will also include recommendations on how to transform between historical Australian geodetic datums (AGD66 and AGD84) and GDA2020.

1 Introduction

1.1 Purpose of the Interim Release Note

The purpose of the Geocentric Datum of Australia 2020 (GDA2020) Interim Release Note is to aid the uptake of the parameters in EPSG registry and provide time for software developers to update and test their software before GDA2020 is officially released.

1.2 The Geocentric Datum of Australia

1.2.1 Terminology

Table 1.1 GDA terminology

Datum Name	Geographic Coordinate Set	Grid Coordinates
GDA2020	GDA2020	MGA2020

1.2.2 Definition

Table 1.2 GDA definition

Reference Frame	Epoch	Ellipsoid	Semi-major axis (m)	Inverse Flattening
ITRF2014	2020.0	GRS80	6378137	298.257222101

1.2.3 Legal Traceability of Position

The National Measurement Institute (NMI) administers the National Measurement Act 1960 and has the authority to appoint legal metrology authorities to verify reference standards of measurement. Geoscience Australia is appointed as a Verifying Authority for Position. As a Verifying Authority of Position, Geoscience Australia can issue certificates of

verification under Regulation 13 of the National Measurement Regulations 1999. These are commonly referred to as Regulation 13 Certificates.

Regulation 13 Certificates provide coordinates and their least uncertainty with respect to the Recognized-value standard of measurement of position (RVS) in Australia, which is the Australian Fiducial Network (AFN). The AFN will soon be updated (Geoscience Australia is in discussion with NMI) and will include 109 stations from the Australian Regional GNSS Network (ARGN) and AuScope network which are:

- operated by Geoscience Australia or similar agency;
- located on the Australian Tectonic Plate, within Australia's jurisdiction and on a high quality survey monument; and
- have plate motion model residuals less than 1 mm / yr.

The computed International Terrestrial Reference Frame 2014 (ITRF2014) coordinates and velocities were projected forward to the epoch of January 1, 2020 using the Plate Motion model (Section 2.3) to define GDA2020. GDA2020 will be determined with respect to the RVS with crustal velocities and uncertainties. These velocities enable coordinates to be mapped to any epoch.

More information on Regulation 13 Certificates including the application process can be found on the Geoscience Australia website (http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/regulation-13-certificates).

1.2.4 GDA2020 extent

The extent of the Geocentric Datum of Australia 2020 includes all the areas contained within Australia's marine jurisdiction (within 200 nautical miles of Australia) and its external territories, and the areas of Australia's continental shelf beyond 200 nautical miles as confirmed by the United Nations Commission on the Limits of the Continental Shelf. The areas include Cocos (Keeling) Islands, Christmas Island, Norfolk Island and Macquarie Island but excludes Heard-McDonald Islands and the Australian Antarctic Territory (AAT) as shown in Figure 1.

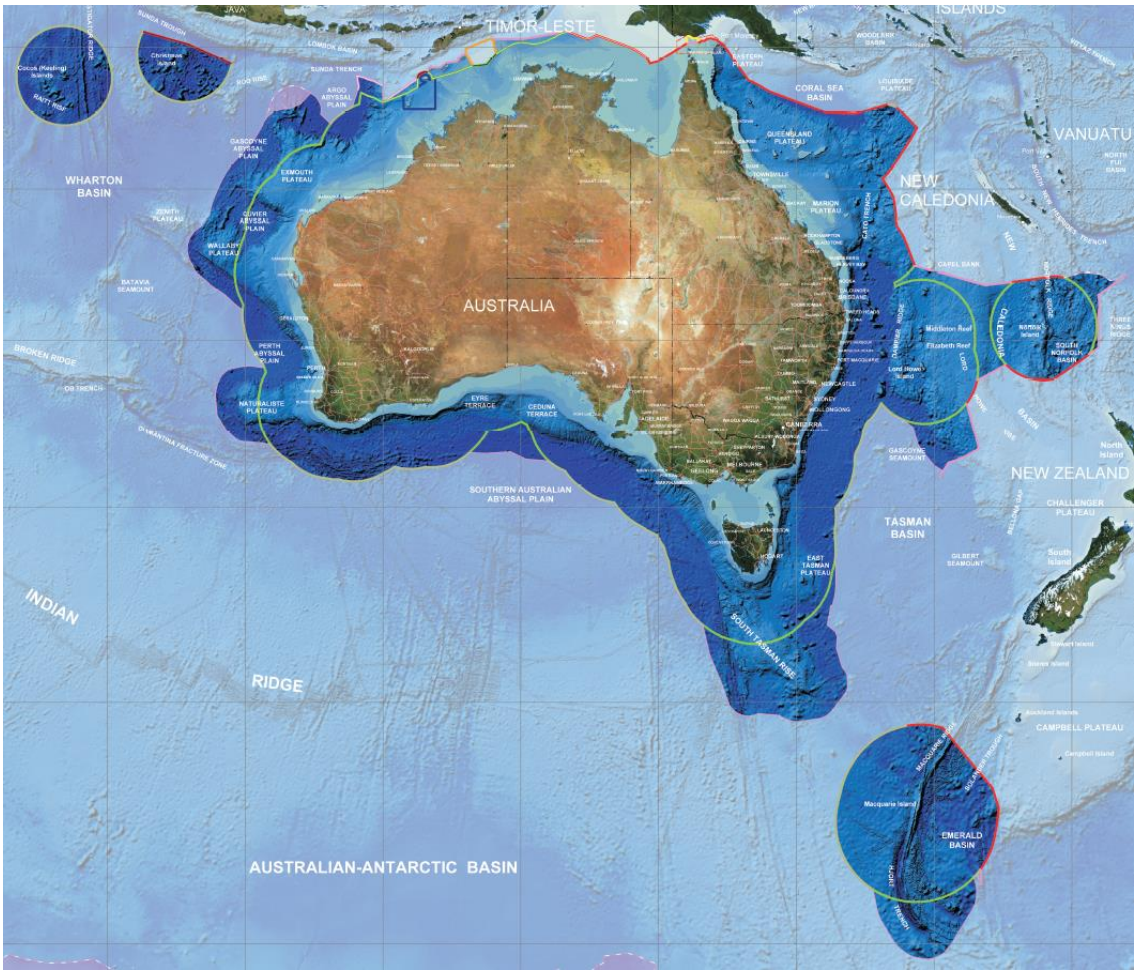

Figure 1.1 The area shown in dark blue is the GDA2020 extent. The colours of the lines represent different types of jurisdictional boundaries or proposed jurisdictional boundaries. For more information on the type of boundary, please refer to http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_70362

2 Transformations

A similarity transformation can be used to transform coordinates from one geodetic reference frame to another (e.g. GDA94 to GDA2020). The 14-parameter similarity transformation is the 7-parameter transformation (3 translations $t_x\ t_y\ t_z$, 3 rotations $r_x\ r_y\ r_z$ and scale s_c) with an additional 7 parameters used to describe the rates of change of the translation $\dot{t}_x\ \dot{t}_y\ \dot{t}_z$, rotation $\dot{r}_x\ \dot{r}_y\ \dot{r}_z$ and scale $\dot{s}_c$ in time. This allows for transformation between datums with data sets at any given epoch t where t_0 is the reference epoch. The translations and their rates are expressed in m and m / yr, respectively. The rotation and their rates are expressed in radians and radians / yr, respectively. The scale is unit-less and the scale rate is expressed in yr^{-1}. Parameters $X'\ Y'\ Z'$ are the transformed $X\ Y\ Z$ coordinates.

$$\begin{pmatrix} X'_{GDA2020} \\ Y'_{GDA2020} \\ Z'_{GDA2020} \end{pmatrix} = \begin{pmatrix} t_x + \dot{t}_x(t-t_0) \\ t_y + \dot{t}_y(t-t_0) \\ t_z + \dot{t}_z(t-t_0) \end{pmatrix} + \left(1 + s_c + \dot{s}_c(t-t_0)\right)$$
$$\begin{pmatrix} 1 & r_z + \dot{r}_z(t-t_0) & -r_y - \dot{r}_y(t-t_0) \\ -r_z - \dot{r}_z(t-t_0) & 1 & r_x + \dot{r}_x(t-t_0) \\ r_y + \dot{r}_y(t-t_0) & -r_x - \dot{r}_x(t-t_0) & 1 \end{pmatrix} \begin{pmatrix} X_{GDA94} \\ Y_{GDA94} \\ Z_{GDA94} \end{pmatrix}$$

2.1 Rotation matrix sign convention

There are two different ways of applying the sign conventions for the rotations. In both cases a positive rotation is an anti-clockwise rotation, when viewed along the positive axis towards the origin but:

1. The International Earth Rotation Service (IERS) assumes the rotations to be of the points around the cartesian axes, while;

2. The method historically used in Australia assumes the rotations to be of the cartesian axes around the points.

Although these two conventions exist, to enforce the property that all rotations describe anticlockwise rotation as positive when viewed along the axis towards the origin, the rotation of the coordinate axes around the points should be a skew-symmetric matrix with the opposite sign to the rotation of the point/s around the coordinate axis.

The transformation parameters in this Interim Release Note and GDA Technical Manual also adhere to the Australian convention. Due to the potential confusion, it is advisable to ensure that the conventions used in software are well understood and tested against the sample data supplied in Section 2.4 of this document.

2.2 GDA94 to GDA2020 transformation parameters

The 7-parameter similarity transformation was computed using stations common to both the GDA94 RVS and the GDA2020 RVS, except for Cocos Island (COCO), Christmas Island (XMIS) and Macquarie Island (MAC1), which were removed from the computation due to earthquake deformation.

The parameters to transform from GDA2020 to GDA94 can be computed by multiplying the values in Table 2.1 by -1.

Table 2.1 Transformation parameters for GDA94 to GDA2020 along with the one-sigma uncertainties (1σ). Units are in mm for the translation, parts-per-billion (ppb) for scale, and milli-arc-seconds (mas) for rotations.

	t_x	t_y	t_z	s_c	r_x	r_y	r_z
	61.55	-10.87	-40.19	-9.994	-39.4924	-32.7221	-32.8979
±	0.7	0.6	0.7	0.10	0.011	0.010	0.011

2.3 Plate Motion Model (ITRF2014 to GDA2020)

The plate motion model enables the conversion of coordinates from ITRF2014 to GDA2020 and vice versa. The model was derived using 109 ARGN and AuScope stations, which were used to realise the RVS.

The station coordinates and velocities were used to compute a conventional Euler plate model. This 3-parameter model can be expressed as a 14-parameter transformation with only rates of change rotation components (see Table 2.2).

Table 2.2 Transformation parameters for ITRF2014 to GDA2020 along with their one sigma uncertainties (1σ). Units are in mm and mm / yr for the translation and their rates, respectively, parts-per-billion (ppb) and ppb / yr for scale and its rate, respectively, and milli-arc-seconds (mas) and mas / yr for rotations and their rates, respectively.

	$t_x, \dot{t}_x$	$t_y, \dot{t}_y$	$t_z, \dot{t}_z$	$s_c, \dot{s}_c$	$r_x, \dot{r}_x$	$r_y, \dot{r}_y$	$r_z, \dot{r}_z$
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
±	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rates	0.00	0.00	0.00	0.00	1.50379	1.18346	1.20716
±	0.00	0.00	0.00	0.00	0.00417	0.00401	0.00370

2.4 Sample data

2.4.1 GDA94 to GDA2020 (7–parameter transformation)

GDA94 coordinates of Alice Springs (ALIC)

Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height (m)
-23° 40’ 12.44601876”	133° 53’ 07.847844”	603.3466

Latitude (DD)	Longitude (DD)	Ellipsoidal Height (m)
-23.67012389	133.88551329	603.3466

X	Y	Z
-4052051.7643	4212836.2017	-2545106.0245

GDA2020 coordinates of Alice Springs (ALIC)

Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height (m)
-23° 40’ 12.39650”	133° 53’ 07.87779”	603.2489

Latitude (DD)	Longitude (DD)	Ellipsoidal Height (m)
-23.67011014	133.8855216	603.2489

X	Y	Z
-4052052.7379	4212835.9897	-2545104.5898

Difference (GDA2020 – GDA94)

	Latitude	Longitude	Height (m)
Alice Springs (ALIC)	0.04952"	0.02995"	-0.0977

	N (m)	E (m)	U (m)
Alice Springs (ALIC)	1.5236	0.8487	-0.0977

2.4.2 ITRF2014 to GDA2020 (3–parameter transformation)

ITRF2014 at 2018.0 coordinates of Alice Springs (ALIC)

X	Y	Z
-4052052.6588	4212835.9938	-2545104.6946

GDA2020 coordinates of Alice Springs (ALIC)

X	Y	Z
-4052052.7373	4212835.9835	-2545104.5867

Difference (GDA2020 – ITRF2014 at 2018)

	X	Y	Z
Alice Springs (ALIC)	-0.0785	-0.0103	0.1079

2.4.3 Transformation from / to older datums

To transform between historical Australian geodetic datums (AGD66 and AGD84) and GDA2020, it is recommended that you first transform to GDA94 and then transform to GDA2020.

There is no intention to release official AGD66 and AGD84 to GDA2020 transformation parameters. The GDA Technical Manual will describe a two-stage process to transform between AGD66 and AGD84 to GDA94 and then GDA94 to GDA2020.