Geodetic Coordinate Systems In Australia

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Introduction

Geophysical and geological fieldwork in Australia usually requires a geographic infrastructure for the collation and best use of the data. Geophysicists may have come across potentially confusing acronyms and names in relation to positioning and mapping, including: Clarke spheroid, ANG, AGD, WGS84, AMG, UTM and AHD. What do they all mean? In addition Australia is currently working to introduce a new geodetic reference frame which is directly compatible with satellite positioning. To provide readers with a background to this change, a brief explanation and history of co-ordinate systems in Australia is presented, together with definitions, and a description of the steps currently being taken to make the integration of geographic data across Australia simpler and more effective.

In the past and today, large sums of money were and are being spent to collect geographically related data across Australia; which was recorded in a variety of ways. However modern computer techniques have now made it possible to efficiently collect large volumes of data quickly. This information can, however be worthless if it cannot be correctly archived, related in position to earlier data, and cross referenced for future use.

Geographical co-ordinate systems are fundamentally used to pinpoint the location of data, making it possible to compare data collected independently or at different epochs. Unfortunately there have been m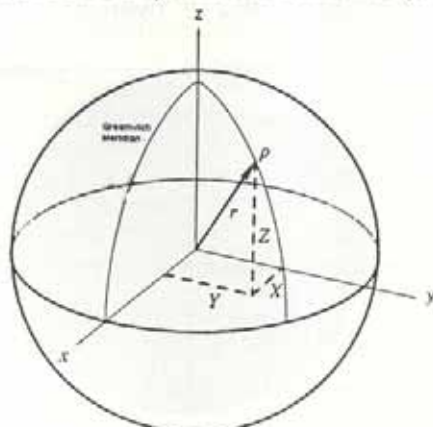any different reference systems used in the past for recording geographically related data, making the final integration a difficult task; and the individual data sets less usable.

Explanation of terms

Reference System

Most space-based positioning techniques provide coordinates in terms of an earth-centred reference system. This is a 3-dimensional Cartesian co-ordinate system which may be used to uniquely identify any location relative to the earth's centre of mass, as shown in Figure 1. The accuracy with which such a reference system can be defined has improved remarkably in recent years, and although refinement continues, any further development is unlikely to affect the average user.

- The origin is the earth's centre of mass.

- The positive arm of the Z axis passes along the instantaneous axis of rotation of the earth, towards the northern hemisphere.

- The positive arm of the X axis passes through the Greenwich meridian and is at right angles to the Z axis

- The positive arm of the Y axis is at right angles to both the Z and X axes so that they form a right handed system.

- Rotations about the axes are defined as positive if they are anti-clockwise when viewed from the positive end of the axis, looking towards the origin.

- X Y and Z do not correspond to latitude, longitude and height.

Ellipsoid

The earth's shape is best represented by an equipotential surface known as the geoid. However this surface is not regular and is best represented by an ellipsoid (also referred to as a spheroid). An ellipsoid is a 3-dimensional figure, formed by rotating an ellipse, which closely represents the shape of the earth. Its size and shape is usually defined by the semi major axis (the a radius), and the semi-minor axis (the b radius) as shown in Figure 2. The flattening (f) is the relationship between the semi-major and semi-minor axes of the ellipsoid:
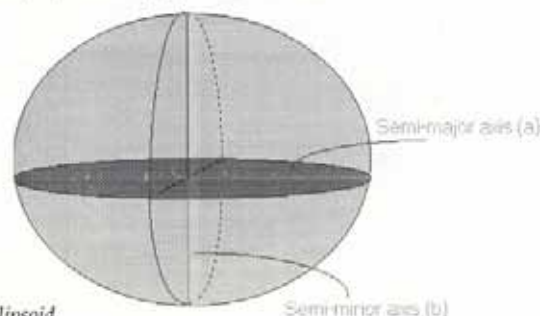
$$b/a = 1 - f \qquad (1)$$

$$b = a(1-f) \qquad (2)$$

Figure 1 - Earth-centred reference system

Figure 2 - Ellipsoid

Geodetic Datums

An ellipsoid may be chosen to best fit the whole earth, or only a region of it. The set of parameters that describe the relationship between a particular ellipsoid and a global geodetic reference system is called a geodetic datum (Figure 3).
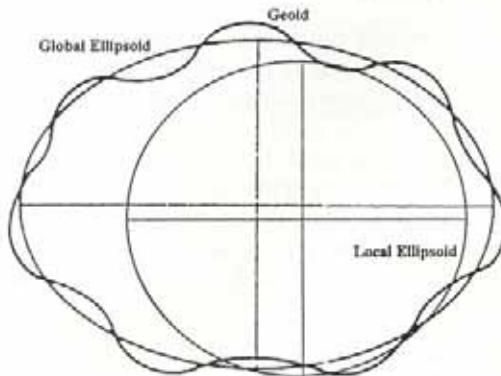

Figure 3 - Relationship between local and global datums

A geodetic datum is usually defined by a set of at least three parameters:

- The ellipsoid semi-major axis
- The ellipsoid flattening
- The offset of the local ellipsoid origin, with respect to the earth's centre, in terms of the X, Y and Z axes.

This is usually achieved with:

- The position of an origin station, and an orientation (azimuth and deflections of the vertical), or
- The position of a number of origin stations.
- Ideally the centre of the ellipsoid should coincide with the centre of the earth's mass and the axis of the ellipsoid should be parallel with the conventional terrestrial reference system (CTRS). However, in the past, this was rarely achieved or even intended. Datums were usually chosen to provide a best geometric fit to the area of interest, meaning that the centre of the ellipsoid did not coincide with the earth's centre.
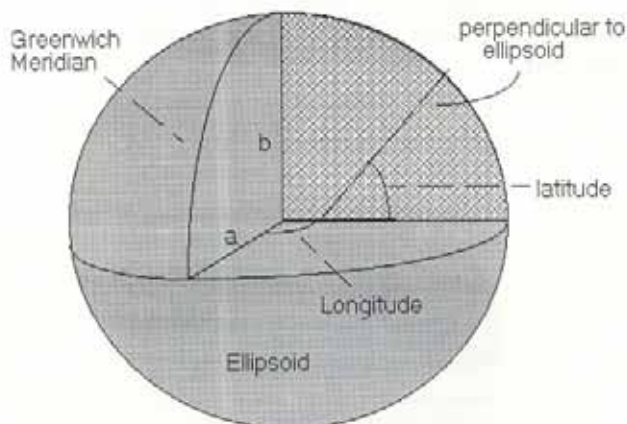

Figure 4 - Geographical Coordinates

Geographical Co-ordinates

Once a datum has been established positions may be expressed in terms of latitude, longitude and ellipsoidal height with respect to the chosen ellipsoid (Figure 4). It is therefore possible for a position on the earth's surface to have different geographic coordinates (latitude, longitude and ellipsoidal height) depending on which datum is being used.

Where available, Cartesian coordinates for a reference system (X Y Z) may be converted to latitude, longitude and ellipsoidal height. This conversion is a simple mathematical process and can be found in standard Geodesy textbooks such as Geophysical Geodesy by Kurt Lambeck. Note that the height is relative to the ellipsoid and may differ from the conventionally adopted mean sea level height by many metres (see the later section on heights).

Grid Coordinates

Working with latitudes and longitudes on an ellipsoid is sometimes too complex, so these positions are often converted to grid coordinates (eastings and northings). These grid coordinates are a 2-dimensional projection of latitude and longitude onto a flat surface. There is is a relatively simple mathematical conversion between latitudes and longitudes and eastings and northings; it does not involve a change of datums.

There are many types of projections, each with its own advantages and disadvantages, but one commonly used in Australia is the Transverse Mercator projection, as illustrated in Figure 5.

This projection is obtained by mathematically fitting a tangential cylinder about the ellipsoid and projecting each position, as seen from the centre of the ellipsoid, onto the cylinder, which can then be opened into a flat surface. To minimise distortions these projections are divided into zones, each zone centred on the meridian which is in contact with the cylinder. Therefore to uniquely define a position, it is imperative that the zone number is supplied with grid coordinates.

When this projection is used with internationally adopted zone designations and other parameters, it is known as the Universal Transverse Mercator projection (UTM). The Universal Transverse Mercator projection has the following characteristics:

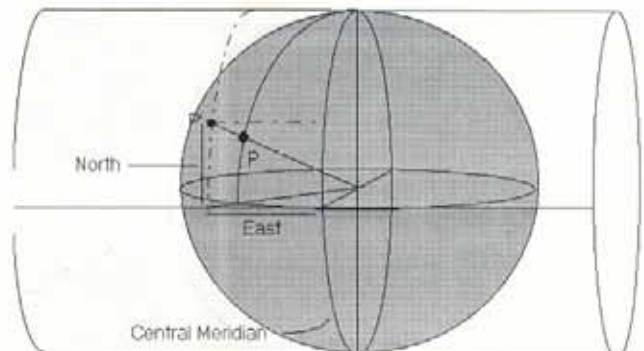- Zones are 6^0 wide, with a $\frac{1}{2}^0$ overlap.

Figure 5 - Transverse Mercator projection

- Coordinates are in metres, north and east of the origin (or false origin).

- A central meridian scale factor of 0.9996 is used to minimise the distortion at the zone edges.

- The origin for each zone is the intersection of the equator and the central meridian.

- In the southern hemisphere a false origin is used so that all coordinates are positive. This false origin is 10,000,000 metres south, and 500,000 metres west, of the zone origin.

The central north-south grid line of each zone (the central meridian) has an easting value of 500,000 metres and plots on the projection as a straight line, while other north-south grid lines plot as lines which converge towards the pole. Lines of constant latitude plot as curved lines bending about the central meridian.

Latitudes and longitudes are converted to UTM grid coordinates (and reverse) using Redfearn's formulae and the adopted ellipsoid parameters.

Summary of relationships

A position may be represented as Cartesian coordinates (X Y Z) which are relative to a 3-dimensional reference system. Once a suitable ellipsoid has been chosen and positioned relative to the reference system (a datum), these coordinates may be converted to latitude, longitude and ellipsoidal height. These geographical coordinates may in turn be converted to grid coordinates (easting, northing and zone) on a chosen projection. If different datums or projections are used, different geographic and grid coordinates will be obtained for the same site.

Coordinate systems used in Australia

Clarke 1858 ellipsoid

In Australia prior to 1966, there were some twenty different datums using four different ellipsoids. The ellipsoid used for most national mapping coverage was the Clarke 1858 ellipsoid, which is described by the semi-major axis and the flattening:

semi-major axis (a) = 20 926 348 Clarke feet

Flattening (f)   =   1/294.26

A Clarke foot is known to be 0.3047 9726 5425 metres, hence the semi-major axis converts to 6 378 293.645 metres. However most surveys were computed from baselines measured in British feet, where a British foot of 1926 is 0.3047 9947. This means that latitudes and longitudes computed from these baselines are actually in terms of an ellipsoid described by:

semi-major axis (a) = 20 926 348 British feet

   =   6 975 449.333 yards

   =   6 378 339.78 metres

Flattening (f)   =   1/294.26

Although the Clarke 1858 ellipsoid was used, the different origins used meant that there were actually a number of different datums. The most important origins used include:

Sydney Observatory:-
  S33°51'41.10"   E151°12'17.85"

Perth Observatory 1899: -
  S31°57'09.63"   E115°50'26.10"

Darwin Origin Pillar: -
  S12°28'08.452"   E130°50'19.802"

A comparison of coordinates, based on the Sydney and Perth origins would show on average a difference of about 10 seconds in longitude (about 300 metres). This is mainly due to the difference between the deflection of the vertical at these two sites.

Some 1:250,000 scale maps were based only on astronomical observations with an accuracy of the order of 100 metres or more, or by a mixture of astro and conventional surveying. A comparison of map coordinates based on different origins of this kind could give differences of hundreds of metres due to errors from: the astronomical observation, the deflections of the vertical, the surveying techniques used to transfer the astronomic position and the map compilation process.

The Australian National Grid

When latitudes and longitudes in terms of the Clarke 1858 ellipsoid were converted to Transverse Mercator grid coordinates they were known as Australian National Grid coordinates (ANG). The parameters used with the ANG were:

Ellipsoid	=	Clarke 1858
Central scale factor	=	1.0 exactly
False Easting	=	400 000 yards
False Northing	=	4 915 813.467 yards
Zone Width	=	5 degrees

Initial Central meridian =   116 degrees East longitude.

With these parameters the ANG northing became negative in Tasmania. Therefore, to maintain positive coordinates, 1,000,000 yards was usually added to the ANG northings in the Tasmanian region.

Because they are a direct conversion of the Clarke 1858 latitudes and longitudes, these grid coordinates have the same problems caused by the different origins used. These ANG coordinates are often referred to as Clarke coordinates because of the ellipsoid used.

The Australian Geodetic Datum

The Australian Geodetic Datum (AGD) was developed as a unique datum for Australia. It was proclaimed in the Australian Commonwealth Gazette of 6 October 1966 and included the parameters of the local ellipsoid known as the Australian National Spheroid (ANS) and the position of the origin point, Johnston Geodetic Station :

Latitude   S 25°56' 54.5515"

Longitude   E133° 12' 30.0771"

Ellipsoidal height   571.2 metres

Australian National Spheroid

Semi-major axis (a)   6 378 160.0 metres

Flattening (f)   1/298.25

Australian Geodetic Datum 1966

The adjustment of the Australian geodetic survey network was completed in March 1966 using the Australian Geodetic Datum.

The set of geographic coordinates (latitudes and longitudes) produced by this adjustment was known as the Australian Geodetic Datum 1966 co-ordinate set (AGD66) and was rapidly adopted by state and federal authorities.

The grid coordinates derived from a Universal Transverse Mercator projection of the AGD66 coordinates, therefore using the Australian National Spheroid, is known as the Australian Map Grid 1966 (AMG66) co-ordinate set.

Australian Geodetic Datum 1984

In 1982 a new national adjustment, referred to as the Geodetic Model of Australia 1982 (GMA82), was performed using all the data previously included in the 1966 adjustment, as well as additional, modern conventional and space-based observations. The datum used for this readjustment was identical to that used in 1966, but because of the improved observations and adjustment techniques these two co-ordinate sets differ by about 2 metres in south east Australia, and up to about 5 metres in the north west. This difference is not regular and it is not able to be modelled over the whole of Australia. The difference between AGD66 and AGD84 was not noticeable on maps at 1:250,000 and 1:100,000 scale which continued to be based on the AGD66 coordinate set.

The latitudes and longitudes resulting from this adjustment were accepted by the National Mapping Council (NMC) in 1984 and are now known as the Australian Geodetic Datum 1984 co-ordinate set (AGD84). When converted to Universal Transverse Mercator grid co-ordinates, projected from the Australian National Spheroid, the coordinate set is known as the Australian Map Grid 1984 (AMG84).

Western Australia, South Australia and Queensland mapping authorities chose to immediately adopt AGD84, while the other states continued to use AGD66. This has resulted in a mixture of coordinate sets with relatively small, but potentially confusing differences.

The World Geodetic System

From time to time the International Association of Geodesy adopts a geocentric reference system which is a best fit for the whole earth, based on the latest information. The reference system adopted in 1980 is known as the Geodetic Reference System 1980 (GRS80) and was used by the US Defense Mapping Agency

(DMA) as the basis for the World Geodetic System 1984 (WGS84). It is this system that is used for positions from the Global Positioning System (GPS). Because WGS84 is earth-centred, and AGD is offset from the earth's centre of mass, positions in these two systems differ by about 200 metres and about 5 seconds of latitude and longitude.

Previous versions of global reference systems (WGS72) were used in the early days of GPS, and the Transit Doppler positioning system which was in use prior to GPS used still other global reference systems (e.g. NWL9D and NSWC9Z2). Although slightly different, these systems all differ from the AGD by about 200 metres.

Transformation between co-ordinate systems

By the late 1980s GPS was becoming a popular means of positioning for both experts and non-experts. Although many GPS receievers and software give the option to convert the WGS84 positions to a local datum, some users are not aware of the need to do so, or are confused by the various methods available.

Geophysicists using data acquired using GPS positioning may wish to consider requesting both WGS84 and AMG coordinates in their digital located data files from contractors.

It should be noted that a transformation is required to move from one datum to another (e.g. WGS84 to AGD84). Changing from one coordinate type to another on the same datum (e.g. AGD66 to AMG66) is a mathematical conversion, not a transformation.

There are three common methods of transforming between co-ordinate systems:

- Apply a "block shift" in latitude longitude and height, or easting and northing, determined from one or more sites which have coordinates in both systems. This block shift may be determined from a single common site, or be interpolated from a number of common sites. The accuracy of this method is dependant on the accuracy of the coordinates in both systems and how representative they. This method is the best available when dealing with pre-1966 coordinates. It is also frequently used with the AGD66 co-ordinate set, when working over large areas.

- Molodensky's formulae were publshed by the US DMA in its report on the World Geodetic System 1984. These formulae are effectively a form of origin shift which also incorporates the differences in the two ellipsoids used. Included in DMA's report are parameters for use with the Molodensky formulae to transform from AGD66 and AGD84 to WGS84. However because these parameters are based on a average shift derived from Transit Doppler positions, the resulting transformation has an accuracy of about 5 metres horizontally and 10 to 20 metres vertically.

- Provided the two co-ordinate systems each have a consistent scale, orientation and origin

(homogeneous), sites which have positions known in both systems can be used to compute parameters for a 3-dimensional similarity transformation (three origin shifts, three rotations and a scale change). Such parameters are available to transform between AGD84 and WGS84 across Australia (the Higgins parameters of 1987) and also between AGD66 and WGS84 within NSW. Coordinates transformed with these parameters have an estimated accuracy of a couple of metres.

The Australian Height Datum (1971)

On 5 May 1971 the Division of National carried out a simultaneous adjustment of 97,230 kilometres of two-way optical levelling throughout Australia. Mean sea level for the period 1966-1969 from thirty tide gauges around the Australian continent was held fixed at zero height and the resulting computed surface, with minor modifications in two metropolitan areas, was termed the Australian Height Datum (AHD). At its 29th meeting in May 1971 the National Mapping Council adopted the AHD as the datum to which all vertical control for mapping was to be referred. This height datum continues to be used as the reference for all heights in Australia

Heighting by GPS

Mean sea level, on which the AHD is based, is a very close approximation of the equipotential surface known as the geoid. However this surface differs substantially from the WGS84 ellipsoid to which GPS heights refer (from -35 metres in south west Australia to +70 metres in northern Queensland). The difference between these two surfaces is known as the geoid-ellipsoid separation or N value, and is relative to a specific ellipsoid. Extreme care must be taken to ensure that the N value used is in terms of the correct datum.

$$H = h - N \qquad (3)$$

Where H = height above the geoid (the MSL or AHD value)

h = height above the ellipsoid (the height obtained from GPS)

N = Geoid-ellipsoid separation (N value)

More accurate results can be obtained from GPS by using differential techniques. Equation (3) then becomes:

$$\text{Diff } H = \text{diff } h - \text{diff } N \qquad (4)$$
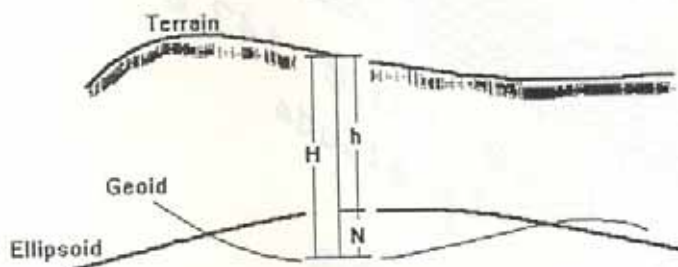

Figure 6 - The geoid-ellipsoid separation

If the geoid is above the ellipsoid, N is positive. If the geoid is below the ellipsoid, N is negative

There are a number of ways of determining the N value:

(1) Use astro-geodetic observations. This method is slow and expensive and is no longer used.

(2) Compare AHD and ellipsoidal heights at surrounding sites and then interpolate. This needs good absolute ellipsoidal heights and well determined MSL values and assumes that both are error free.

(3) Compute from a global geopotential model (e.g. OSU91). A geopotential model is a set of coefficients used with spherical harmonics to represent the geoid surface over the entire earth. They are generally derived from terrestrial gravity and satellite altimeter data and are available in some GPS software packages. They have an absolute accuracy of the order of a metre.

(4) Compute using a global geopotential model, refined with local gravity observations. This requires sophisticated software and observed local gravity data. The absolute accuracy may be well under 1 metre and the relative accuracy may be of the order of a few parts per million (mm per kilometre).

(5) Interpolate from a grid of N values generated by any of the above methods. This is fast and can be automated. The accuracy depends on the grid size and the nature of the geoid in the area.

AUSLIG has computed a grid of accurate N values for the Australian region, using method (4) above. This grid, which is known AUSGEOID93 (see Figure 7), is the second in a series of national geoids. Others will be produced as improved data and models become available. AUSLIG has also developed an interpolation software package known as Winter, for use with the AUSGEOID93 data set.

AUSGEOID93 consists of a 10' by 10' grid (approximately 20 km) of geoid ellipsoid separations in terms of the WGS84 ellipsoid. These values, which are suitable for use with the Global Positioning System (GPS), were computed using:

- The OSU91 global geopotential coefficients, produced by Professor Richard Rapp, Ohio State University, USA.

- The 1980 Australian Gravity data base from the Australian Geological Survey Organisation.

- Techniques and software developed by Dr A.H.W. Kearsley, Associate Professor University of NSW. This software was converted and enhanced by AUSLIG, to run on a Personal Computer.

The major advantage of the AUSGEOID93 data lies in its relative accuracy which has been estimated as between 2 and 5 parts per million (2-5 mm per km) by Dr Kearsley in 1988. Subsequent tests have supported this estimate. In fact using these N values in conjunction with GPS observations has frequently achieved 3rd order optical levelling results at a fraction of the cost and time. GPS results stored as latitude longitude and

ellipsoidal height may be reduced to the AHD using AUSGEOID93 or its future upgrades.

The Geocentric Datum of Australia

Space Geodesy methods have developed significantly in the last twenty five years using reference points external to the terrestrial system. Before these space geodesy techniques were available, reference frames were defined by regional geodetic systems of continental or national coverage whose origins did not necessarily coincide with each other or the centre of mass of the earth.

The reference frame used for satellite systems is earth centred and to optimise the potential benefits, most users needs to work in the same (geocentric) system. A geocentric datum uses the geocentre, the earth's centre of mass, as the origin of the reference frame together with appropriate scale and orientation parameters. In Australia the Australian National Spheroid was selected as a local best fit geometric figure across Australia and was not specifically related to the centre of mass or consequently directly compatible with the dynamic reference frame of artificial satellites.

In October 1984 the National Mapping Council, recognising the need for Australia to eventually convert to a geocentric datum, resolved to adopt the AGD84 co-ordinate set as the first step in that process. It noted that a universal reference figure for the earth had not yet emerged and again the Australian National Spheroid was used as the reference ellipsoid to establish the AGD84 co-ordinate set as the new basis for the geodetic infrastructure of Australia. Some states moved to the new co-ordinate set whilst others remained on AGD66.

In 1987 the Intergovernmental Committee on Surveying and Mapping had recognised the increasing use being made of satellite positioning systems and the ongoing development of global reference frames. It recommended that Australia adopt a Geocentric datum for surveying and mapping by the year 2000 and resolved that members could use their discretion in the timing of the conversion process.

In 1991 the Intergovernmental Committee on Surveying and Mapping (as successor to the National Mapping Council) set up a Geodesy working group. One of the problems to be addressed was the diverging use of datums and different co-ordinate sets being used across Australia AGD66, AGD84, WGS72, WGS84. At the time NSW were also requiring to move from AGD66 to a new coordinate system more accurate than AGD84.
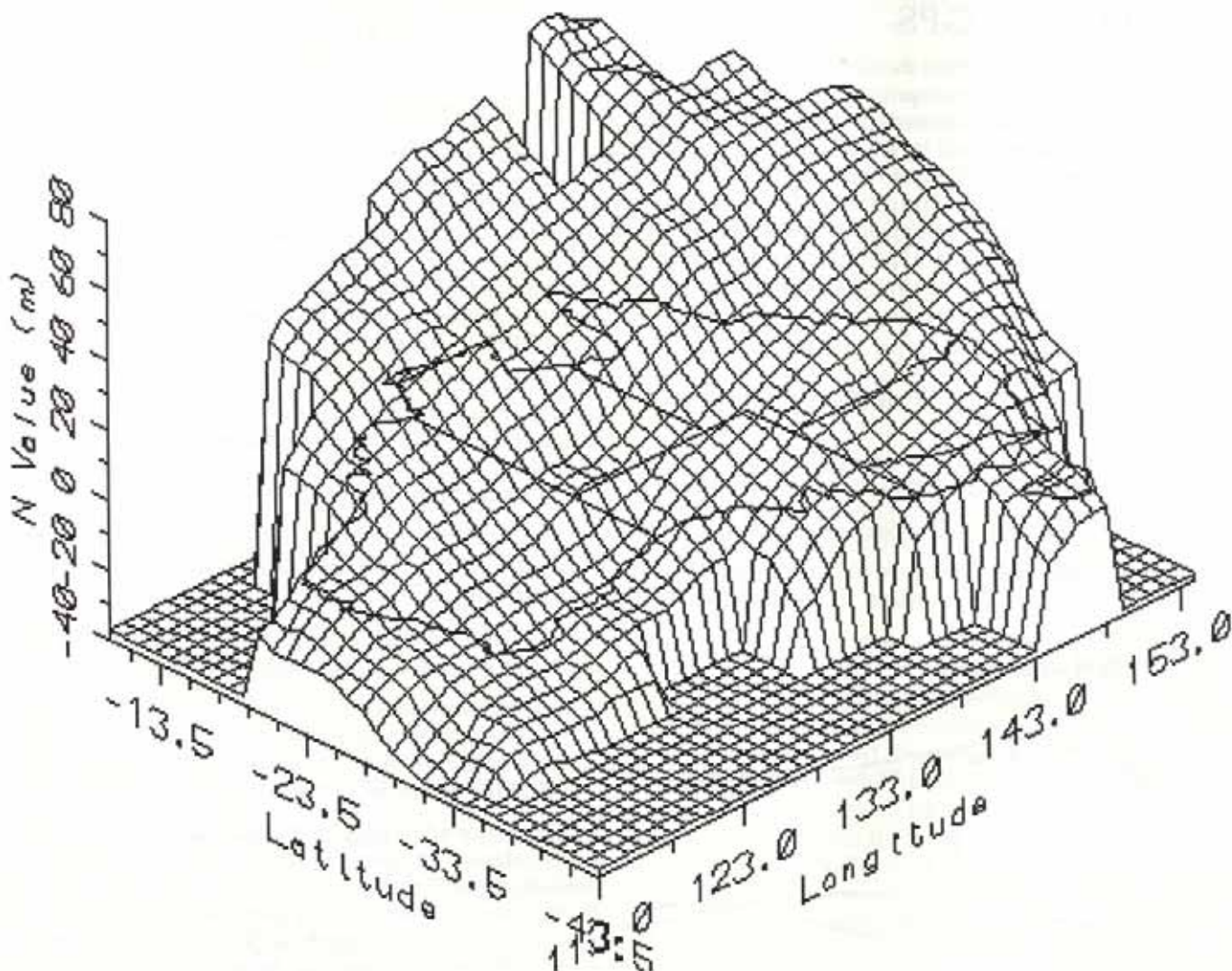

Figure 7 - The Geoid relative to WGS84 - AUSGEOID 93

The Global use of Geocentric Coordinates

The arguments for and against the adoption of a geocentric datum for national applications have been documented by Karl Breteger in the Australian Surveyor in 1991 but the world is seen to be inevitably moving to geocentric datums.

A global geocentric datum is already supported by a growing number of world wide organisations. America, Europe and some Asian countries have already moved to a geocentric datum. The UN Regional Cartographic Conference for the Asia -Pacific has passed a resolution for all countries in the region to use a geocentric datum for surveying and mapping This will eventually provide a world wide benefit by having the same reference system for all geographic information applications.

In 1990 the International Surveying body, FIG, recommended that its members promote and support the adoption and use of a global geocentric reference system proposed by the International Association of Geodesy (ITRF). In 1991 the fifty six member maritime nations of the International Hydrographic Organisation resolved that all future navigation charts would be based on the world geodetic system, and the Hydrographer RAN is progressively converting all paper and electronic charts in Australian waters to the WGS84 datum. The Australian Defence mapping agency RASVY, is also now converting all topographic information to a geocentric datum in line with an overall decision by Department of Defence. The International aviation organisation ICAO have now decided that all aviation charts will be in terms of a geocentric datum from 1997.

The introduction and application of the national geocentric datum to state land information administration is the responsibility of the individual state agencies.

The Australian Fiducial Network

The Australian Fiducial Network (AFN) of permanent, on line, GPS stations (Figure 8) is being established by the Australian Surveying and Land Information Group (AUSLIG). It will provide the national framework and the link to global reference

Figure 8 - The Australian Fiducial Network (AFN): permanent, on-line regional GPS station

frames. Each station will consists of a Rogue GPS receiver observing 30 second epoch data for precision Geodesy and a second receiver which gathers one second data for national integrity monitoring purposes. The network has been extended to a regional network to meet integrity monitoring requirements of other federal departments.

From a geodetic network viewpoint, the AFN has been densified within Australia with the GPS survey of a nominal 500 Km network, the Australian National Network (ANN), by the Intergovernmental Committee on Surveying and Mapping. This network includes connections to the array of high precision tides gauges operated by the National Tidal Facility to investigate sea level rise.

The AFN and ANN geodetic positions are currently being computed in the ITRF92 system. These coordinates will be within one metre of the WGS84 positions and will be known as the Geocentric Datum of Australia (GDA). The UTM projection of these coordinates will be known as the Map Grid of Australia coordinate set (MGA). The reference for heights will not change - it will remain as the Australian Height Datum. Fixed values of these sites will be used by state jurisdictions when they needed to enhance and readjust their networks using GPS. This will ultimately bring all state and federal networks on to the one datum to provide the maximum benefit to the Australian geographic information user community.

This co-ordinated dataset will then be held fixed for non scientific applications whilst the scientific movement of the Australian Plate will be monitored by periodic recomputation of the position of the AFN sites. The Australian plate can be expected to generally move about 2 metres in 20 years with little internal differential movement.

Real time differential GPS systems (DGPS) are available for navigation applications, and for accurate survey purposes GPS is used in a differential mode with post processing. For both these applications the correct coordinates of the base station and the reference frame in use needs to be known for computation of the unknown positions. Data from the AFN permanent receivers or from ANN sites will enable computations to be undertaken directly in terms of the Geocentric Datum of Australia

Current status of the AFN

The Antarctic sites in the regional network were set up last summer with permanent GPS trackers at Davis, Mawson and Casey together with the Macquarie Island. Data from these sites is trickled back to Canberra every 15 minutes by satellite. The Darwin AFN is now operational from a site at Manton Dam and data is also available from other sites at Ceduna, Karratha and Alice Springs. Cocos, Townsville and Wellington NZ will come on line in the near future. AUSLIG is discussing the future of civilian access to data from GPS trackers owned and operated by the USA at Tidbinbilla and Yaragadee W.A. and the possibility of replacing them with Australian units. An Australian receiver has been installed at Mt Pleasant in Hobart which will replace the current American owned GPS at that site, after a suitable change over period.

GPS observational data from all these sites can be obtained from AUSLIG for post processing, together with data from an integrity base station operating at The AUSLIG building in Canberra. Martin Hendy is the prime contact (telephone 06-2014346). Prior notice for data from these sites would be helpful in the present testing phase. GPS data from selected sites will be also be made available to the International scientific community principally through the IGS network.

Summary

Australia has used a number of different datums and coordinate sets:

- Pre-1966: the Clarke 1858 ellipsoid with a variety of origins, which as UTM grid coordinates were known as the Australian National Grid (ANG).

- 1966: The Australian Geodetic Datum adopted and the AGD66 geographic and AMG66 UTM coordinates used.

- 1971: Australian Height Datum (AHD) instituted.

- 1984: The AGD84 geographic and AMG84 UTM coordinates adopted by some authorities.

- Late 1980s: GPS becomes popular and positions in terms of WGS84 become available.

Australia is moving to a geocentric datum compatible with GPS and it is anticipated that the Intergovernmental committee on Surveying and Mapping will release geocentric coordinates of the national GPS sites later in 1994. These will be held as fixed values for general usage; whilst the movement of the continent will be monitored by permanent GPS receivers located at the Australian Fiducial network sites. The new geocentric coordinates of the Australian National Network will vary from the AGD values currently in use by about 200 metres

The AFN and the national integrity monitoring network will provide the national basis for legal traceability in Australia without the need to pursue legal responsibility into international law.

Information, software, formulae and references on co-ordinate systems, transformations, GPS and the AFN are available as a free service from the AUSLIG computer Bulletin Board System, which may be accessed using a PC and modem (06-2014375, 06-2014378).

AUSLIG