The current ellipsoid of choice in Australia (and indeed for the International Terrestrial Reference Frame - ITRF) is the Geodetic Reference System 1980 (GRS80), a geocentric ellipsoid designed to approximate the Earth on a global scale.

### Projections & Transformations

In practice, it is often required to express positions on a flat surface in the form of grid coordinates, i.e. in a 2-dimensional Cartesian coordinate system such as Cartesian and polar coordinates. This is achieved by map projections according to a recognised set of mathematical rules, resulting in an ordered system of projected coordinates (lines of constant longitude) and parallels (lines of constant latitude).

The most commonly used projection in Australia is the Universal Transverse Mercator (UTM) projection, which utilises a zone width of 6° and ensures that the scale is very close to unity across the entire zone. When applied to GDA94 coordinates in Australia, the resulting projected coordinates are known as the Map Grid of Australia 1994 (MGA94). As new data is received, it is incorporated into increased amounts of data and improved processing techniques, new and better transformation parameters are published. While this may seem unimportant between their initial availability and eventual adoption in software, it is important for users to apply the latest set of transformation parameters in order to achieve the highest possible quality of output coordinates.

### Drivers for datum modernisation

Datum modernisation is required in order to accommodate the increasingly accurate and timely data available from modern positioning technologies and GNSS CORS, to be able to be applied to future epochs. Datum modernisation is to supply all users with the most complete yet most straightforward datum parameters that can define a locally consistent set of coordinates, such that their positioning device can be accurately and associated spatial data to an acceptable level of accuracy.

It is important to emphasise that geodetic control underpins all spatial data, including applications such as mapping, surveying, construction and mining, agriculture, environmental management, transport, insurance, emergency services, communication and research. A geocentric datum uses the Earth’s centre of mass as its origin and is therefore compatible with GNSS-based positioning, a solid foundation provided by geodetic control, so they actually fit together and can facilitate meaningful results. The modernisation in Australia include:

- Including up-to-date geodetic observations and increased precision
- Replacing ITRF92
- Providing seamless coordinates across state borders
- Accounting for tectonic plate motion
- Accounting for tectonic plate rotation
- Introducing a truly 3D datum defined by ellipsoidal height

### Plate-fixed datums

A plate-fixed datum is attached to the tectonic plate and therefore also known as a static datum. It is ‘frozen’ at a certain instant in time. This has been achieved by adopting a set of station coordinates, essentially preventing the coordinates from changing over time due to (normal) tectonic plate motion.

However, as the time difference between the reference epoch and the current epoch increases, the plate-fixed datum deviates more and more from the true position of the plate (the earth-fixed or AUSGeoid98). Consequently, it needs to be updated at frequent intervals. GDA94 and GDA2020 are examples of plate-fixed datums.

#### GDA94

GDA94 was defined in the then state-of-the-art global reference frame, the International Terrestrial Reference Frame 1992 (ITRF92) at epoch 1994.0. An absolute definition was justified by the relatively uniform drift of the Australian continent at around 7 mm/year to the north-east. Tectonic plate motion is normalised to the difference between ITRF coordinates and GDA94 coordinates to increase over time, amounting to a few millimetres per year. This is generally not an issue for differential GNSS applications, however the lack of a real-time mass-market applications is causing this offset to introduce errors for the layperson.

#### GDA2020

GDA2020 is a much more homogeneous plate-fixed datum, deviating a national least squares network adjustment that rigorously propagates uncertainty. GDA2020, which is the current state-of-the-art global ITRF2014 reference frame at epoch 2020.0. The coordinates are extrapolated into the future to 1 January 2020 in order to extend the lifespan of the datum. GDA2020 is realised by gazetteing an exactly defined physicaldatum and ‘open data’ is only possible if these datasets across these areas are built on a robust and reliable datum.

### Height Datum modernisation

The Geodetic Datum of Australia 1994 (GDA94) is our national datum since its adoption in 2000. Significant improvements in positioning technology in the recent past have revealed that it is no longer capable of providing the required quality of datum for modern-day positioning applications. Consequently, Federal and State and Territory Governments have worked towards modernising Australia’s datum for the future. The improvements on the map of these changes coming into effect.

The Geodetic Datum of Australia 2020 (GDA2020) is a new, much improved Australian national datum that will replace GDA94 by January 2020. It is to be used in conjunction with the Australian Height Datum (AHD). By 2020, GDA2020 will be complemented (and possibly one day replaced) by the time-dependent, earth-fixed Australian Terrestrial Reference Frame (ATRF). To explain that properly, however, we must go much deeper.

### Coordinate systems & datums

A coordinate reference system is a methodology to define the specific location of entities or features. Usually, we use an ellipsoid to approximate the shape of the Earth. Positions on the ellipsoid are usually expressed in Cartesian coordinates (X, Y, Z) or curvilinear geographic coordinates (ρ, φ, λ, h) with ellipsoidal height.

Since a coordinate system is an idealised abstraction, it can only be accessed in practice through its physical materialisation (or realisation) called a reference frame or datum. The datum effectively defines the origin and orientation of the coordinate system at a certain instant in time (epoch), generally by adopting a set of station coordinates.

Nowadays this is usually provided by a network of Global Navigation Satellite System (GNSS) Continuously Operating Reference Stations (CORS). Over time, different techniques with varying levels of sophistication have been adopted to approximate the shape of the Earth’s surface, resulting in the adoption of many different datums. A geocentric datum uses the Earth’s centre of mass as its origin and is therefore compatible with GNSS-based positioning.