# Map grid systems in use in Australia and implications for map reading and GPS

## Latitude and longitude (Geographic coordinates)

Latitude and longitude are imaginary lines traced on the surface of the earth for the purpose of locating a specific place. The lines of latitude run east and west, and are parallel to each other. For convenience, the earth was divided into 360 degrees of latitude. The "zero" of latitude starts at the equator and is measured as 90 degrees north to the North Pole and 90 degrees south to the South Pole. Each degree represents 60 nautical miles on the earth's surface (1 nautical mile is 1852 m). The lines of longitude run north and south and are not parallel to each other. Each degree of longitude is 60 nautical miles apart at the equator and all come together at the North Pole and the South Pole. There are 360 degrees of longitude - 180 degrees to the east and west of Greenwich, UK, an arbitrary starting point used by all mapmakers.

## Universal Transverse Mercator (Cartesian coordinates)

Maps are flat but the Earth's surface is curved. The Universal Transverse Mercator (UTM) is a way of allowing the Earth's curved surface to be "projected" (mapped) on a "flat" surface such as a map. On a UTM map, it is the latitude and longitude that are curved, and the "grid" lines are straight and at 90 degrees to one another.

In the UTM system, lines parallel to the equator are called "northings" and lines parallel to the lines of longitude are called "eastings". The UTM system is not used in polar regions (it is not suitable) and so is only used from 80 degrees south of the equator to 84 degrees north of the equator.

To improve accuracy on UTM maps, the Earth was divided into "zones" of longitude and latitude (see below) with each zone covering 6 degrees of longitude and 8 degrees of latitude. Each zone has its own "central meridian" (easting). Australia is covered by zones 49 to 56 (eastings) and zones G to L (northings), with most of Queensland being in zones 55/56 and J/K. UTM eastings are measured as metres to the east of the central meridian in each zone. Zones become narrower towards the poles. The maximum size of any zone is therefore about 667 km "wide" (east-west) at the equator and 890 km "tall" (north-south). The UTM system has its "zero" northing on the Equator. The letters "I" and "O" were not used for zones to avoid confusion with the numbers "1" and "0".

The distance from the equator to the poles was originally defined as 10 000 000 m. To avoid having "negative" northings (for those of us in the Southern hemisphere) or "negative" eastings, an arbitrary 500 000 was added to the central meridian of each zone and 10 000 000 to the "zero" (central) northing for Southern hemisphere coordinates (only). This makes every UTM grid coordinate in the World always positive. It also means that if you are 1 m south of the equator you will have a UTM northing of "9 999 999" but if you move 1 m north of the equator your UTM northing will be just "1"!
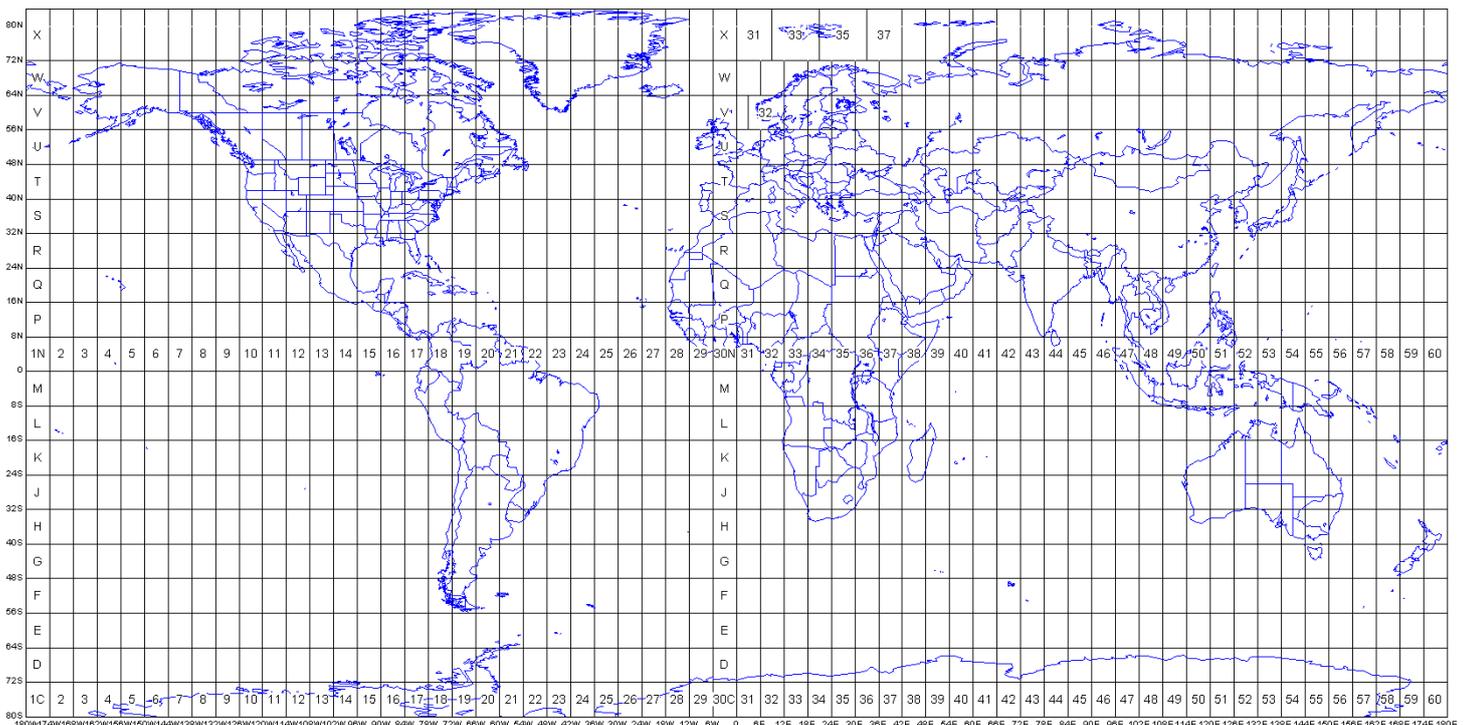
## Map grid coordinates

Most of us are familiar with 6 or 8 digit "map coordinates". A 6-digit coordinate gives a reference to within 100 m and an 8-digit coordinate to within 10 m. A "10-digit" coordinate would give a reference to within 1 meter.

In the southern hemisphere, the number for any of our "northings" will be a value between 1 110 000 (80 degrees South of the Equator) and 9 999 999 (1 m south of the Equator). The number for eastings anywhere in the world will be a value between 166 000 and 833 500 (500 000 $\pm$ 667 000/2).

For example, the turnoff from Samford Rd into BP park therefore has the full reference of (including its zones) 56 J 489 153E, 6 971 779N. The "6 digit" (nearest 100 m) grid reference corresponding to this would be 892 718.

The first Australian map grid system was introduced in 1966 and was called Australian Map Grid 66 or AMG66. There were some errors in AMG66 so that in 1984, a new AMG was developed and called AMG84. The maximum difference between AMG66 and AMG84 was only a few metres so for most practical purposes they are identical. These are both UTM systems. The "datums" associated with these were called the Australian Geodetic Datum (hence AGD66 and AGD84).

Most "topographic" maps we use at present are based on either AMG66 or AMG84.

In 1984, a new grid system was adopted "world wide" and this was called WGS84 (World Geodetic System 1984). This new coordinate system considered the earth to be a sphere and used the very centre of the earth as its "central point". The earlier AMG66 and AMG84 datums considered the earth to be a spheriod (squashed sphere) and the centre of the spheriod was not the centre of the Earth.

In the early 1990s, a new technology called "Global Positioning System" (GPS) started to be used by civilians. A GPS is a small device that can continuously receive radio signals from special orbiting satellites. By measuring the time delay from the various satellites to the GPS receiver it can "triangulate" the actual location of the GPS.

To make it easier to use GPS "seamlessly" between countries, the world needed a single "universal" grid system rather than every country having its own system (such as AMG66 and 84). This new grid system (a further variation on UTM) was called the World Geodetic System 1984 or WGS84.

Most GPS units are set up to read out in the WGS84 system (but many also give grid coordinates in other grid systems as well as latitude and longitude), and most "digital" maps now being stored in GPS units use the WGS84 grid reference system. WGS84 has therefore become the world standard for grid references and is the only "common system" accepted around the world (apart from latitude and longitude).

For this reason, a new Australian grid system was adopted in 1994 based on the WGS84 and is called the Map Grid of Australia 94 or MGA94 (the associated datum is called GDA94). Satellite coordinates from a GPS using WGS84 will give the *same values* as map coordinates based on MGA94 (GDA94). MGA94 is effectively the same as WGS84.

If a GPS is set up to give locations WGS84, then it will give full coordinates, which are to the nearest meter. It will also show the zones.

Most new Australian maps now being issued (or updated and reissued) are based on MGA94.

Grid lines on "new" maps do not line up with grid lines on "old" maps. To convert grid coordinates from either AMG66 or AMG84 ("old" maps) to MGA94 ("new" maps), you must add 120 m to the "old" Easting and 180 m to the "old" northing. To convert satellite readings in WGS84 back to "old" coordinates so they can be plotted on "old" maps, you would need to do the reverse.

| "Old" grid coordinate | "New" grid coordinate |
|---|---|
| AMG66 or 84 | MGA94 |
| 602 765 → | 603 767 |
| 6024 7658 → | 6036 7676 |