GPS Newsletter – General

A One Page Newsletter On System 500 GPS, Vol. 01 No. 19.

Ellipsoidal and Orthometric Heights and Geoid Models

One of the less well understood topics of surveying with GPS (or other survey instruments) is **heighting** and different height types.

What is the difference between an **ellipsoidal height** and an **orthometric height**? What is a **geoid model**, how is it used and what does it do?

This newsletters explains ellipsoidal heights – the next newsletter will describe orthometric heights and geoid models.

WGS84 Ellipsoidal Heights

An ellipsoidal height is the height of a point above the ellipsoid. In other words, it is the perpendicular distance from the surface of the ellipsoid to the point.

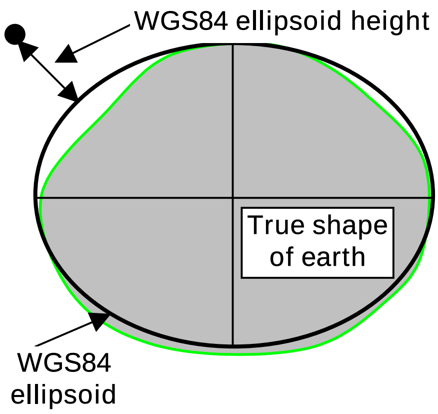
But why do we need to have an ellipsoid at all? The earth is not shaped like an ellipsoid – in reality, the earth is actually shaped like a pear. Why does GPS use the **WGS84 ellipsoid** to approximate the true shape of the earth?

Remember that the fundamental co-ordinates of points derived using GPS are **Cartesian** co-ordinates based on the World Geodetic System 84 **WGS84**. The origin of this co-ordinate system is approximately at the centre of the earth.

As explained in newsletter Vol. 00, No. 20, a point could be measured with GPS and be found to have Cartesian co-ordinates 4211089.525m, 742528.701m, 4717247.902m in WGS84. But these co-ordinates are virtually useless to a surveyor – is this point on the physical surface of the earth, in the air or where?

In order to make these Cartesian co-ordinates more useful and understandable, they can easily be converted to Geodetic co-ordinates (latitude, longitude and **ellipsoidal** height). And remember, it is an ellipsoid that is required to convert between Cartesian and Geodetic co-ordinates. Because WGS84 is a **global** co-ordinate system, an ellipsoid is chosen which is the best overall fit to our pear shaped earth – the **WGS84 ellipsoid**.

So now the position of our point can be described as 48°N, 10°E and ellipsoidal height of 500m. And now we have it – our point has a **WGS84 ellipsoidal height** of **500m**. This means our point is 500m above the surface of the **WGS84** ellipsoid.

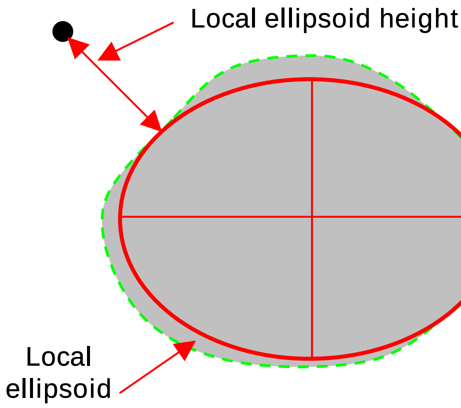


Local Ellipsoidal Heights

But of course, most countries do not use the WGS84 ellipsoid as the local ellipsoid for that country – **Switzerland** uses the **Bessel** ellipsoid and **UK** uses the **Airy** ellipsoid. This is because these ellipsoids fit better to the true shape of the earth in these parts of the world.

So now converting our point to **local geodetic** co-ordinates (including any transformation that may be required) results in co-ordinates of 48°00’0.82316”N, 9°59’49.66165”E and a **local ellipsoidal height** of **1468.783m**. This means our point is 1468.783m above the surface of the **local** ellipsoid.

In the diagram below, the local ellipsoid is shown to fit the true shape of the earth better for where our point is located.



But even the local ellipsoidal height is still not so useful to surveyors. Surveyors usually need to know the height of surveyed points above the true shape of the earth – **orthometric heights**, not the heights of points above a convenient mathematical shape. As already mentioned, the true shape of the earth is pear shaped. No ellipsoid could ever accurately represent the true shape of the earth.

Somehow we need to be able to convert between ellipsoidal heights (either local or WGS84 ellipsoidal heights) and orthometric heights. This can be achieved by using **geoid models**. Orthometric heights and geoid models are described next week.

Remember…

- An ellipsoidal height gives the height of a point above the ellipsoid.
- It is possible to have both **WGS84 ellipsoidal heights** and **local ellipsoidal heights.**

Leica Geosystems