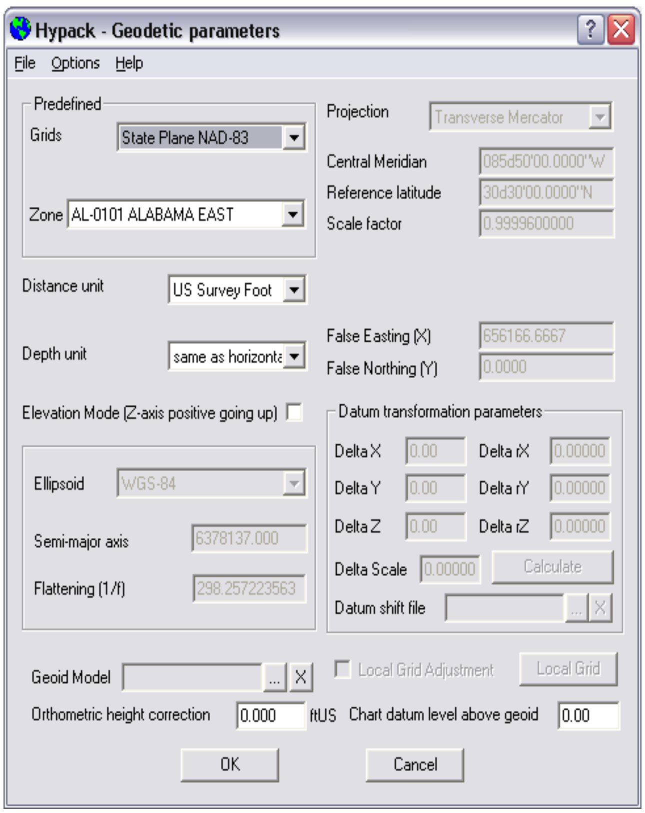
What is the difference between WGS84 and NAD83?

By Mircea Neacsu

A number of users have inquired about the apparent confusion between NAD83 and WGS84 in HYPACK®. Part of the criticism is justified because when HYPACK® for Windows was designed (back in 1995) there wasn't a heck of a difference between the two. The good news is that, for 90% of our users, this difference should still not be a cause of concern today.

WGS84 or GRS80



The first thing many users notice is that our definition of NAD-83 uses WGS84 as ellipsoid while the standard definition uses GRS-80 ellipsoid. Here are, for reference, the defining parameters for the two ellipsoids:

	Semi-major axis	Inverse of flattening
WGS84	6378137	298.257223563
GRS80	6378137	298.257222101

There is small difference between the flattening of the two ellipsoids but before fretting too much about it, let's calculate how different are the minor semi-axis (the North to South axis) of the two ellipsoids:

$$b_{WGS84} = 6356752.31425$$

$$b_{GRS80} = 6356752.31414$$

Wow! About 0.1mm. Even the most pedantic surveyor will not have much to complain about.

FACT: For all practical applications WGS84 ellipsoid and GRS80 ellipsoid are identical.

WGS84 – which WGS84?

You might have read about WGS84 ellipsoid and WGS84 datum. What is the difference between the two?

In general, a datum represents an ellipsoid and the position of its center. While the definition of WGS84 ellipsoid hasn't changed, the location of its center has changed slightly because it is intended to coincide with the center of mass of the Earth. As more and more precise measurements become available the datum changes. To denote the different flavors of the same datum (called *realizations*), it is customary to add a year or some other number to distinguish between them.

The original WGS 84 realization essentially agrees with NAD83 (1986). Subsequent WGS84 realizations, however, approximate certain ITRS realizations. Because GPS satellites broadcast the predicted WGS84 orbits, people who use this broadcast information for positioning points automatically obtain coordinates that are consistent with WGS84.

The US Department of Defense (DoD) established the original WGS84 reference frame in 1987 using Doppler observations from the Navy Navigation Satellite System (NNSS) or TRANSIT. In 1994, DoD introduced a realization of WGS 84 that is based completely on GPS observations, instead of Doppler observations. This new realization is officially known as WGS84 (G730) where the letter G stands for "GPS" and "730" denotes the GPS week number (starting at 0h UTC, 2 January 1994) when NIMA started expressing their derived GPS orbits in this frame. Another WGS84 realization, called WGS84 (G873), is also based completely on GPS observations. Again, the letter G reflects this fact, and "873" refers to the GPS week number starting at 0h UTC, 29 September 1996.

The current WGS84 realization is called WGS84(G1150).

NAD83 – WHICH NAD83?

Well, the same story applies to the NAD83 datum except that the purpose is slightly different: while WGS84 intends to track the center of mass of the Earth, the NAD83 datum intends to track the movement of the North American plate. Not surprisingly the two datums that were identical back in the 1980s have diverged to a point where now there are about 3-4 feet of difference between the two.

Though the years, the different realizations of NAD83 were NAD83(1986), NAD83(HARN), NAD83(CORS94). The latest realization of NAD83 datum is called NAD83(CORS96).

The relative shift between the WGS84 datum and NAD83 datum has been modeled by a 14-parameter datum transformation....

I can hear you saying “WHAT!? ... I had enough trouble with the 7-parameter datum transformation! What's this story about a 14-parameter transformation?”. It turns out this is really a 7-parameter transformation, but the 7 parameters are changing in time. The second set of parameters represents the speed of change over time. For reference here are the 14 parameters:

Parameter	Value at reference time 1997	Speed of change (per year)	Value for 2009
DX	0.9956 m	0.0007 m	1.004 m
DY	-1.9013 m	-0.0007 m	-1.910 m
DZ	-0.5215 m	0.0005 m	-0.515 m
RX	0.025915 “	0.000067 “	0.02672 “
RY	0.009426 “	-0.000757 “	0.00034 “
RZ	0.011599 “	-0.000051 “	0.01099 “
scale factor	0.00062 ppm	-0.00018 ppm	-0.0015 ppm

SHOULD I CARE ABOUT ALL THIS?

Chances are that you shouldn't care more than you care about the relativistic effect on GPS clocks. (It's nice to know about it in case you need to impress a nerdy boss, but it has no practical application whatsoever.)

If you are involved with such a precise project where the 3-4 feet of difference between WGS84 and NAD83 are important, you are probably using an RTK GPS system, hence you have to set-up a base station. Now, what coordinates are you going to enter in your base station? If you enter NAD83 coordinates (the common case), the coordinates coming out of your rover and recorded in HYPACK® are going to be also NAD83 coordinates.

FACT: The coordinate system set in the base station dictates the coordinates of the rover.

So the only times you should worry about the diverging datums are the following:

- You are surveying the base station yourself.
- You are using RTK data from an external provider you should ask on what datum they are working.