THE GLOBAL WGS 84 COORDINATE SYSTEM

3.1 Definition of the WGS 84 coordinate system

The World Geodetic System - 1984 (WGS 84) coordinate system is a Conventional Terrestrial System (CTS), realized by modifying the Navy Navigation Satellite System (NNSS), or TRANSIT, Doppler Reference Frame (NSWC 9Z-2) in origin and scale, and rotating it to bring its reference meridian into coincidence with the Bureau International de l'Heure (BIH)- defined zero meridian.

Origin and axes of the WGS 84 coordinate system are defined as following:

Origin = Earth's centre of mass

Z-Axis = The direction of the Conventional Terrestrial Pole (CTP) for polar motion, as defined by BIH on the basis of the coordinates adopted for the BIH stations.

X-Axis = Intersection of the WGS 84 reference meridian plane and the plane of the CTP's equator, the reference meridian being the zero meridian defined by the BIH on the basis of the coordinates adopted for the BIH stations.

Y-Axis = Completes a right-handed, Earth Centered, Earth Fixed (ECEF) orthogonal coordinate system, measured in the plane of the CTP equator, 90° East of the x-axis. An illustration of the WGS 84 coordinate system origin and axes, which serve also as the geometric centre and the X, Y, and Z axes of the WGS 84 Ellipsoid, is given in Fig. 3-1.

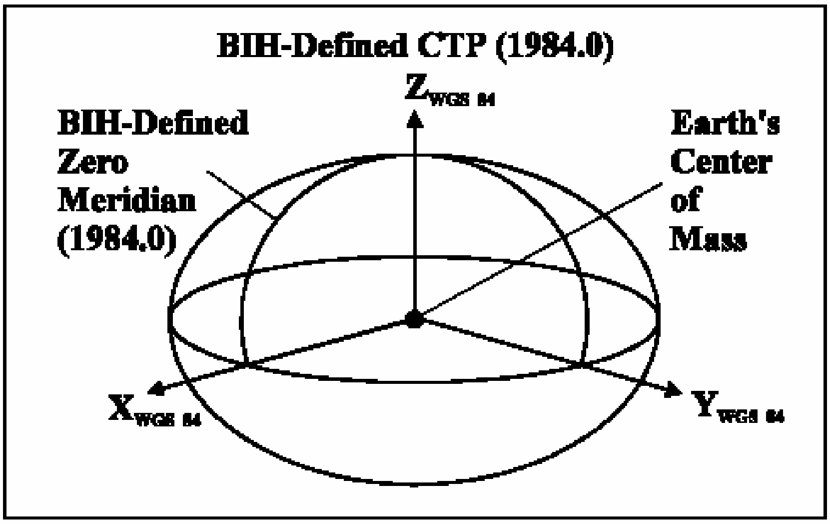


Fig. 3-1. The WGS 84 coordinate system definition

WGS 84 is an earth-fixed global reference frame, including an earth model. It is defined by a set of primary and secondary parameters.
The **primary** parameters are given in Tab. 3-1 and define the shape of an earth ellipsoid, its angular velocity, and the earth-mass which is included in the ellipsoid of reference.

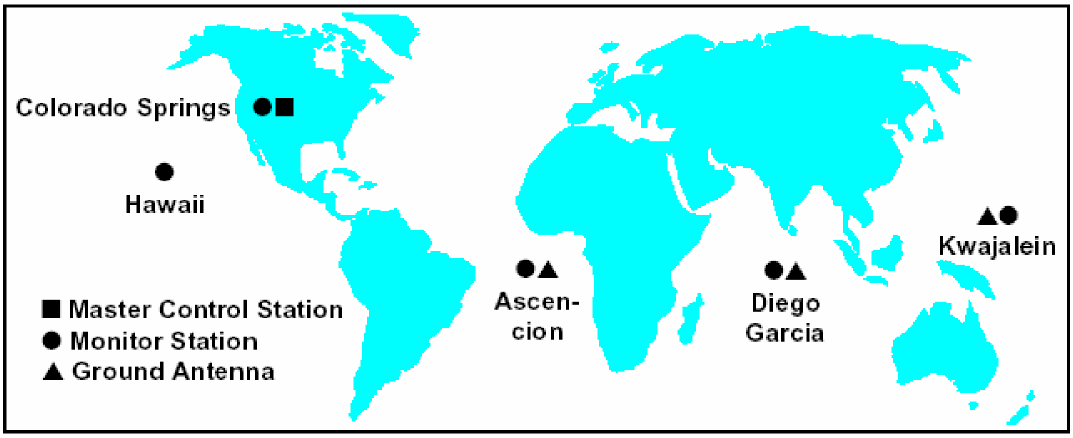
PARAMETER	*NAME*	*WGS 84*
Semimajor axis	a	6378137 m
Flattening	f	1/298.257223563
Angular velocity	ω	7.292115×10^{-5} rad s^{-1}
Geocentric gravitational constant (Mass of earth's atmosphere included)	GM	398600.5 km^3 s^{-2}
Normalized 2nd degree zonal harmonic coefficient of the gravitational potential	$\overline{C}_{20}$	$-484.16685 \times 10^{-6}$

Tab. 3-1. Primary parameters of WGS 84

The **secondary** parameters define a detailed Earth Gravity Field Model (EGM) of the degree and order n=m=180.
The WGS 84 EGM through n=m=180 is to be used when calculating WGS84 geoid heights, WGS 84 gravity disturbance components, and WGS 84 1° x 1° mean gravity anomalies via spherical harmonic expansions. Expansions to this degree and order (n=m=180) are needed to accurately model variations in the earth's gravitational field on or near the earth's surface. The WGS 84 EGM through n=m=41 is more appropriate for satellite orbit calculation (e.g. GPS navigation satellites) and prediction purposes.

3.2 Realization of the WGS 84 coordinate system

The origin and the orientation of coordinate axes in WGS 84 are defined by the X, Y, Z coordinates of the five GPS monitoring stations (see Fig. 3-2).



Realization of Origin and Orientation of WGS84

Historically the coordinates of the GPS tracking sites have been determined by the use of Doppler measurements to the TRANSIT satellite navigation system. Long observation periods of data have been processed in order to derive precise station coordinates.

The use of TRANSIT Doppler measurements in WGS 84 is a good example of the practical realization of a reference system. It should be pointed out once again that errors can propagate in the procedures used to realize reference frames.

Accuracy of WGS 84 coordinates

The accuracy (one sigma) of WGS 84 coordinates directly determined in WGS 84 by GPS Satellite Point Positioning, their respective precise ephemerides and ground-based satellite tracking data acquired in static mode, in terms of geodetic latitude ϕ, geodetic longitude λ, and geodetic height h are:

Horizontal $\sigma\phi = \sigma\lambda = \pm$ 1m (1σ)

Vertical $\sigma h = \pm$ 1 ... 2 m (1σ)

These errors incorporate not only the observational error but the errors associated with placing the origin of the WGS 84 coordinate system at the earth's centre of mass and determining the correct scale. These absolute values should not be confused with the centimeter-precision of GPS differential positioning. Historically, at the time of establishing WGS 84, only Satellite Doppler measurements with corresponding accuracy were available to determine the ground control segment of WGS 84.

The WGS 84 coordinates of a non-satellite derived local geodetic network station will be less accurate than the WGS 84 coordinates of a GPS station. This is due to the distortions and surveying errors present in local geodetic datum networks, the lack (in general) of a sufficient number of properly placed GPS stations collocated with local geodetic networks for use in determining the transformation parameters, and the uncertainty introduced by the datum transformation.

The accuracy of + 1 m in the definition of WGS 84 is sufficient for nearly all air navigation applications. Additional considerations may be necessary, if for example, satellite based landing systems down to CAT III are to be used in future. Precision CAT III needs a vertical accuracy of 0.6 m (horizontal: 6.0 m), which cannot be supplied by WGS 84 according to its accuracy definition, but for instance by ITRF.