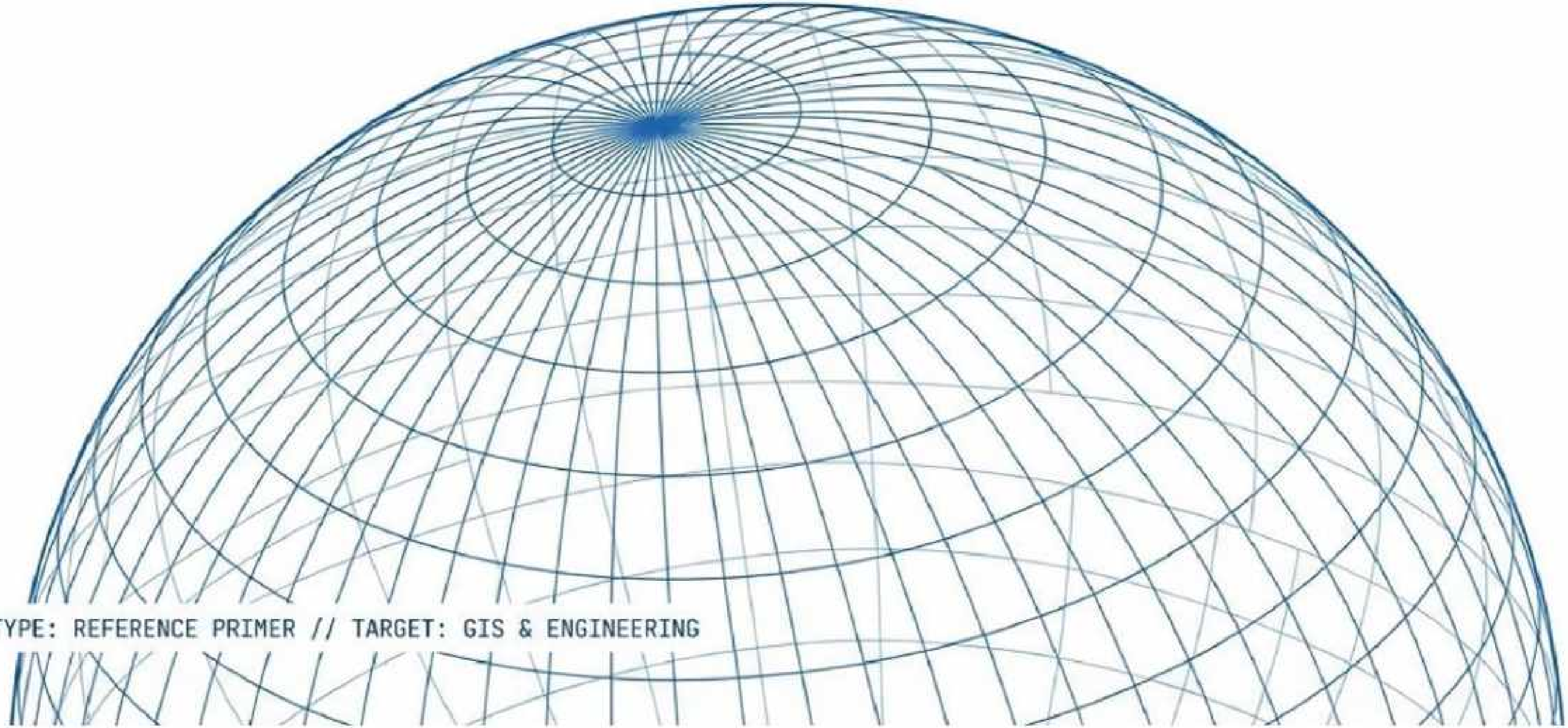
WGS 84: The World Geodetic System 1984.

A technical analysis of the global reference frame for GPS and Geodesy.

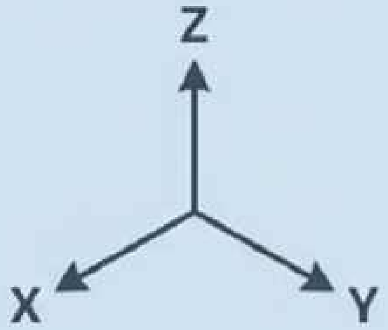


DOCUMENT TYPE: REFERENCE PRIMER // TARGET: GIS & ENGINEERING

Defining the Standard

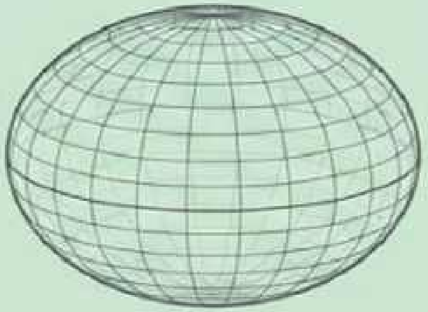
WGS 84 is a global geodetic system used as the standard reference for the Global Positioning System (GPS). It is a composite system defined by three pillars:

The Framework



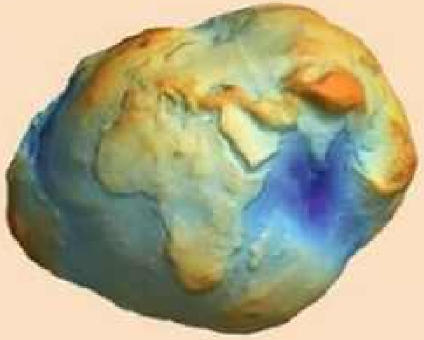
A **Coordinate System** for locating points.

The Ideal Shape



A **Reference Ellipsoid** (Modeled on IAG GRS 80).

The Physical Reality

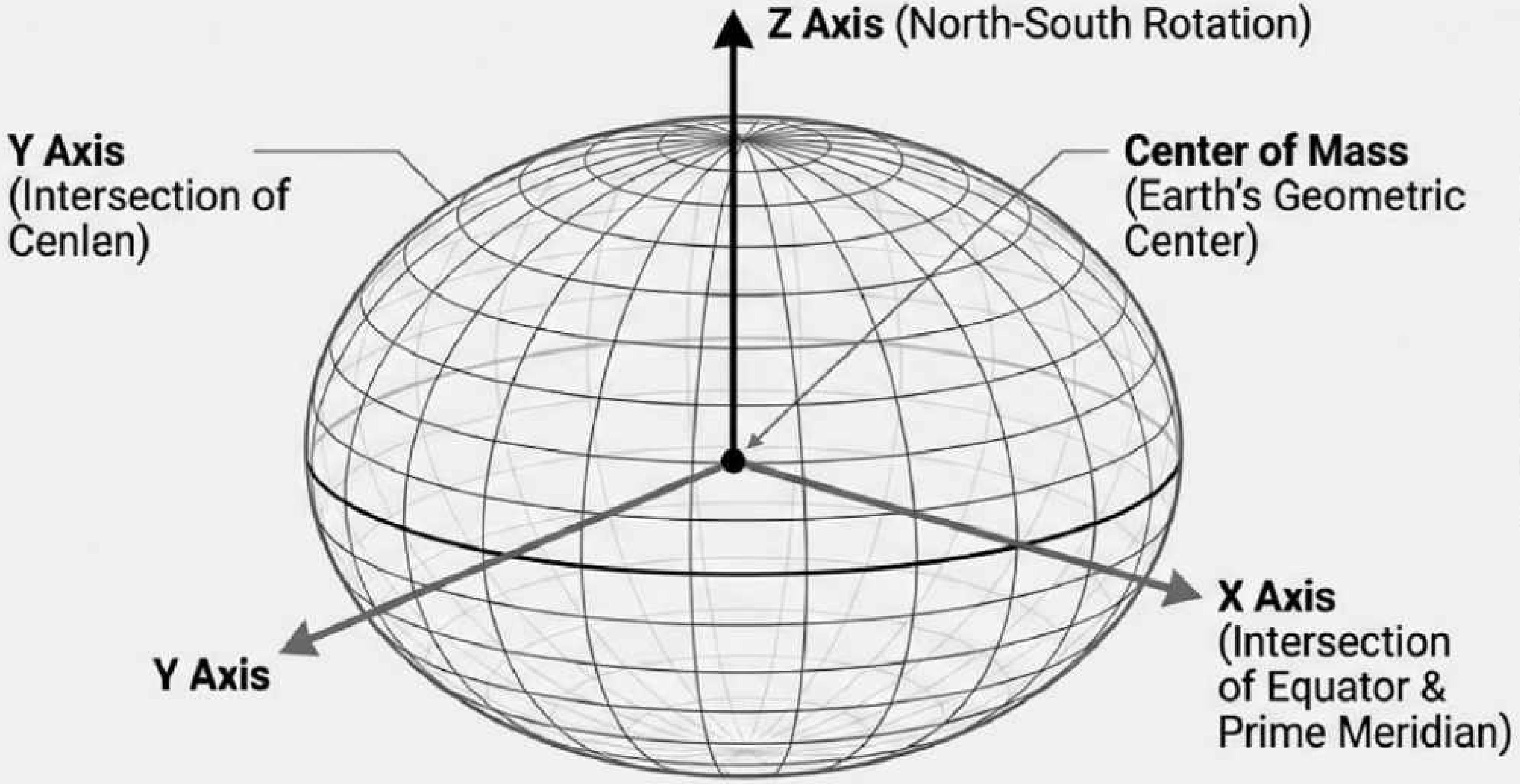


A **Geoid Model** (EGM96 / EGM2008).

Key Insight

The system models the Earth as an 'ellipsoid of revolution'—a solid volume slightly flattened at the poles.

Geometric Orientation



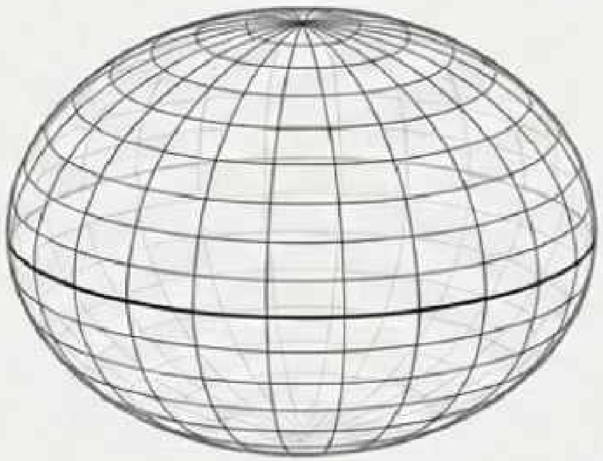
The system uses a Cartesian approach where the Z-axis aligns with the poles. The math aims to represent the real shape of the globe as closely as possible, despite surface irregularities.

Application: At any point, the difference between the theoretical ellipsoid and the real surface determines altitude.

Datum vs. Projection

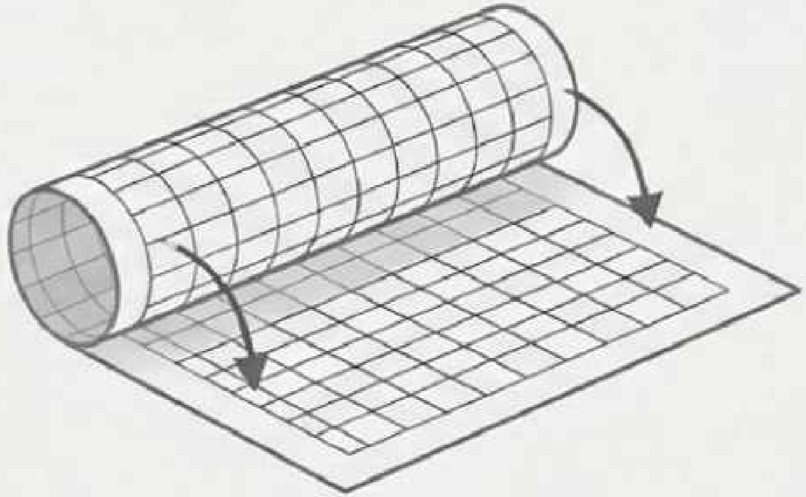
A geodetic system must not be confused with a map projection.

WGS 84 (Datum)



Defines the 3D physical model of the Earth (The Geoid). It is the container for the data.

UTM (Projection)



A method for flattening the 3D model onto a 2D plane for paper or screen navigation.

Note: Most navigation projections (Marine/Aerial) are established ON TOP OF the WGS 84 reference.

Evolution and Identification

```
<coda bade="() {
EPSG:4326
}
</endext mapl>
```

2D Coordinate Reference

Used for Latitude / Longitude

```
<coda tape="() {
EPSG:4979
}
</endext mapl>
```

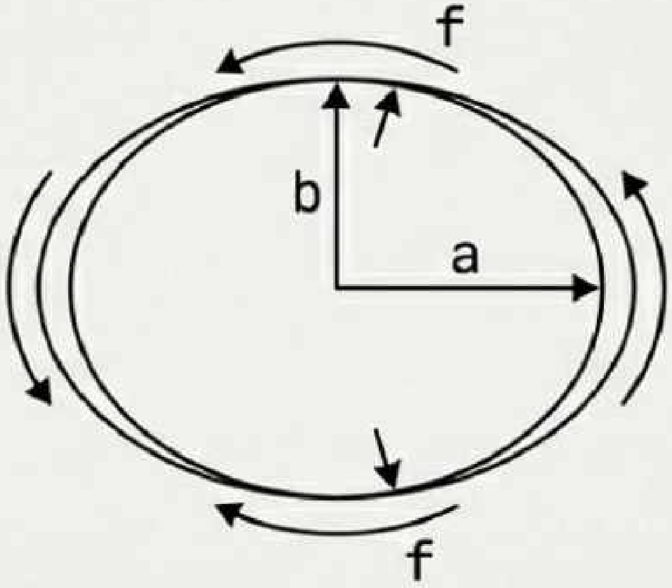
3D Coordinate Reference

Used for X, Y, Z (includes Altitude)

WGS 60 → **WGS 64** → **WGS 72** (TRANSIT System) → **WGS 84**

Primary Parameters

Parameter	Description	Value
Semi-major axis (a)	Radius at the Equator	`6,378,137.0 m`
Flattening (f)	Compression at the Poles	`1 / 298.257223563`



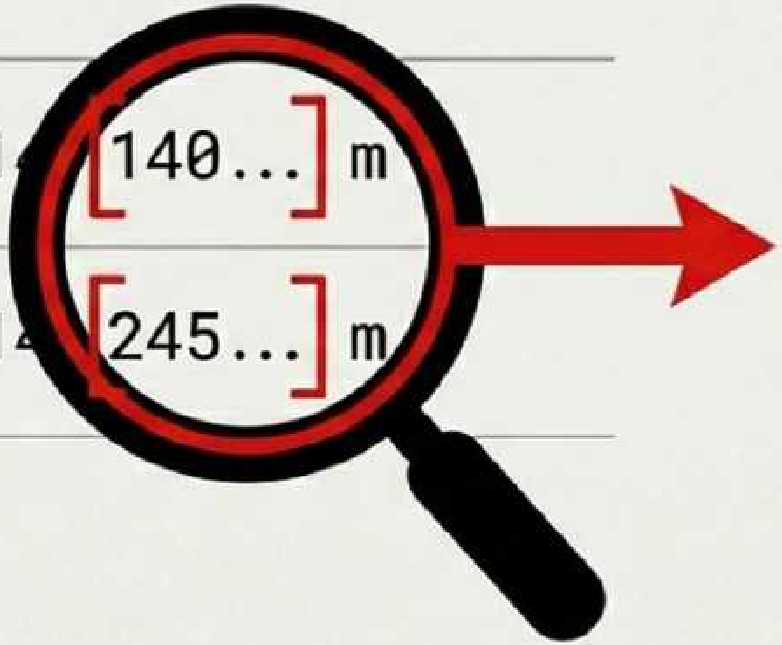
These values define the Ellipsoid of Revolution. The semi-major axis is identical to the GRS 80 standard, but the flattening factor contains a critical divergence.

The GRS 80 Divergence

WGS 84 vs. IAG GRS 80

Semi-minor axis (b)

GRS 80 (b) :	~ 6,356,752.314[140...] m
WGS 84 (b) :	~ 6,356,752.314[245...] m

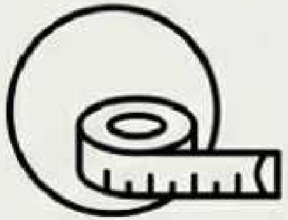


+ 0.1 mm Difference

The WGS 84 reference ellipsoid differs slightly from the IAG GRS 80 ellipsoid in its flattening value. This implies slight modifications in calculated values.

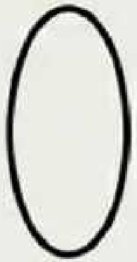
Derived Physics

Based on the primary parameters, the following physical characteristics are calculated:



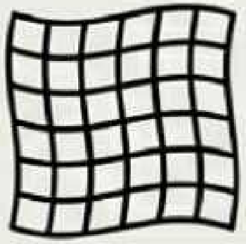
Equatorial Circumference

~ 40,075,017 km



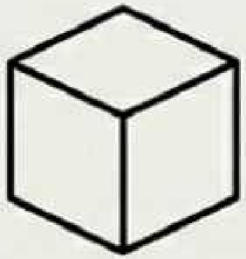
Meridian Length

~ 40,007,863 km



Surface Area (S)

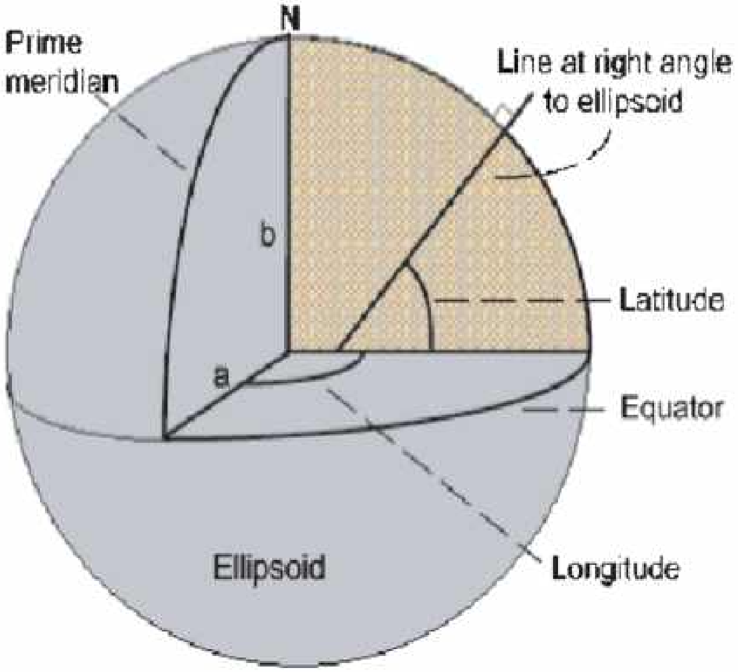
~ 510,065,622 km^2



Volume (V)

~ 1.083 billion km^3

Mass: ~ 6 * 10^24 kg (assuming mean density of 5.5).



Besides being a map/chart datum WGS 84 (World Geodetic System of 1984) also defines the shape and size of the ellipsoid of revolution (an oblate spheroid) that is considered to be the best representation of the Earth:

Flattening = f = Semi-major axis = equatorial radius = a =	1/298.257223563 (≈ 3.35 ‰) 6 378 137.0 m

From these two numbers it is possible to calculate:

Semi-minor axis = polar radius = b = (1−f)a =	6 356 752.3142 m
Difference between equatorial and polar radius = a−b =	21 384.6858 m
Axis ratio = b/a = 1−f =	0.996 647 189 335
First eccentricity squared = $e^2 = 1-(b/a)^2 = (2-f)f$ = First eccentricity = e =	0.006 694 379 990 14 0.081 819 190 842 622
Mean radius of the Earth = (2a+b)/3 =	6 371 008.7714 m
Surface area of the Earth = $A = 2\pi a^2+\pi(b^2/e)\ln[(1+e)/(1-e)]$ = Radius of sphere of equal surface area = $\frac{1}{2}\sqrt{(A/\pi)}$ =	510 065 621.724 km^2 6 371 007.1809 m
Volume of the Earth = $V = 4\pi a^2b/3$ = Radius of sphere of equal volume = $(\frac{3}{4}V/\pi)^{1/3} = (a^2b)^{1/3}$ =	1 083 207 319 801 km^3 6 371 000.7900 m
Maximum circumference of the Earth = circumference of the Earth at the equator = circumference of parallel of latitude at 0° latitude = 2πa = Radius of sphere of equal circumference = a (see above)	40 075.017 km
Minimum circumference of the Earth = circumference of the Earth through the poles = 4 × (distance from a pole to the equator) = Radius of sphere of equal circumference = 40 007 863 m/2π =	40 007.863 km 6 367 449.1458 m
Difference between maximum and minimum circumference =	67.154 km
Radius of curvature at the poles = $a/(1-e^2)^{1/2}$ = Radius of curvature in a meridian plane at the equator = $a(1-e^2)$ =	6 399 593.6258 m 6 335 439.3273 m
Difference between max. and min. radius of curvature =	64 154.2985 m
Latitude halfway between one of the poles and the equator =	45.14432° 45° 08.659′ 45° 08′ 39.5″ (1 min. of lat. = 1852.24 m) (1 min. of long. = 1314.13 m)

The Defining Formulas

Flattening

$$f = (a - b)/a$$

First Eccentricity

$$e = \sqrt{(a^2 - b^2)/a^2}$$

Second Eccentricity

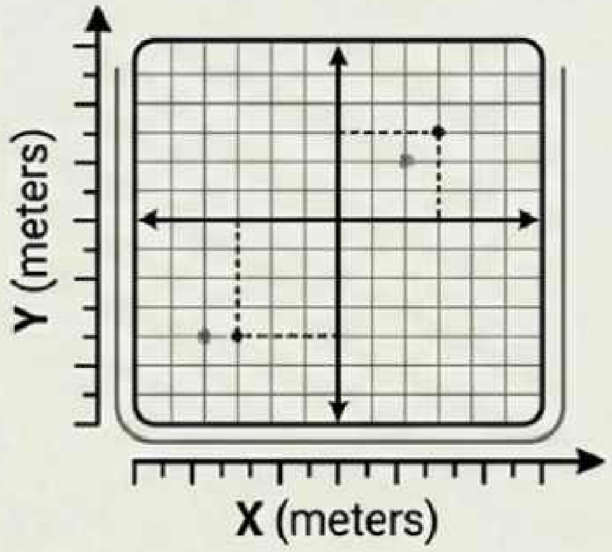
$$e' = \sqrt{(a^2 - b^2)/b^2}$$

First Eccentricity (e) for WGS 84 ≈ 0.081 819 190 842 622

The Language of Location

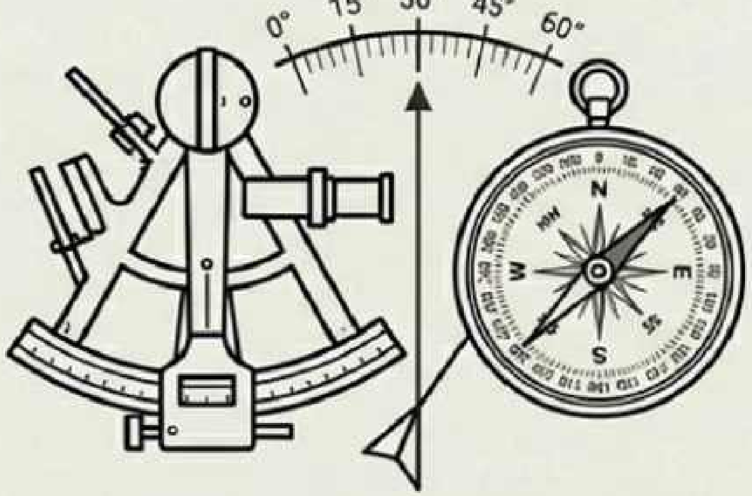
Coordinates are expressed in two primary unit categories.

Cartesian Units (Projected)



Universal Transverse Mercator (UTM).
Formats: Standard or NATO specifications.

Geographic Degrees (Ellipsoidal)



Angular measurements directly on the ellipsoid.
Variations: Decimal Degrees, DMS, Radians.

Cartesian Examples (UTM)

Format	Coordinate Data
Standard 36S	East (X) = 186 070 m | North (Y) = 9 781 387 m
UTM NATO	Long Zone: 36 | Hemisphere: S | East (X) = 86 070 m | North (Y) = 81 387 m

Geographic Examples: Degrees

Decimal Degrees (DDD)

Lat: -1.974651 (S)

Degree Decimal Minutes (DMM) [Google Maps Standard]

Lat: -1° 58.479060 (S) / Long: 30° 10.696293' (E)

Sexagesimal DMS

1° 58' 28.7436" S, 30° 10' 41.7776" E

Specialized Geographic Units

Grades >

Lat 2.19405667 (S) / Long 33.53141283 (E)

Decimal Hours >

Lat 0.1316434000 (S)

Hours Minutes Seconds >

Lat 0 h 7 min 53.916240 s (S)

Radians >

Lat 0.0344641615 (S) / Long 0.5267102011 (E)

Degree Seconds >

Lat 7108.74360 (S)

While Decimal Degrees are the web standard, WGS 84 supports conversion across time-based and angular-based scientific notations.

The Universal Standard

WGS 84 bridges the gap between theoretical geodesy and practical navigation. By defining the Earth's shape with sub-millimeter precision—distinguishing itself from GRS 80—it enables the global interoperability of GPS data.

References & Sources

- NGA: DoD World Geodetic System 1984 (NIMA)
- Didier Bouteloup: Les coordonnées géographiques
- IGN: Modèles d'ellipsoïdes utilisés en France
- Yellowstone Research Coordination Network: Lat/Lon Conversion

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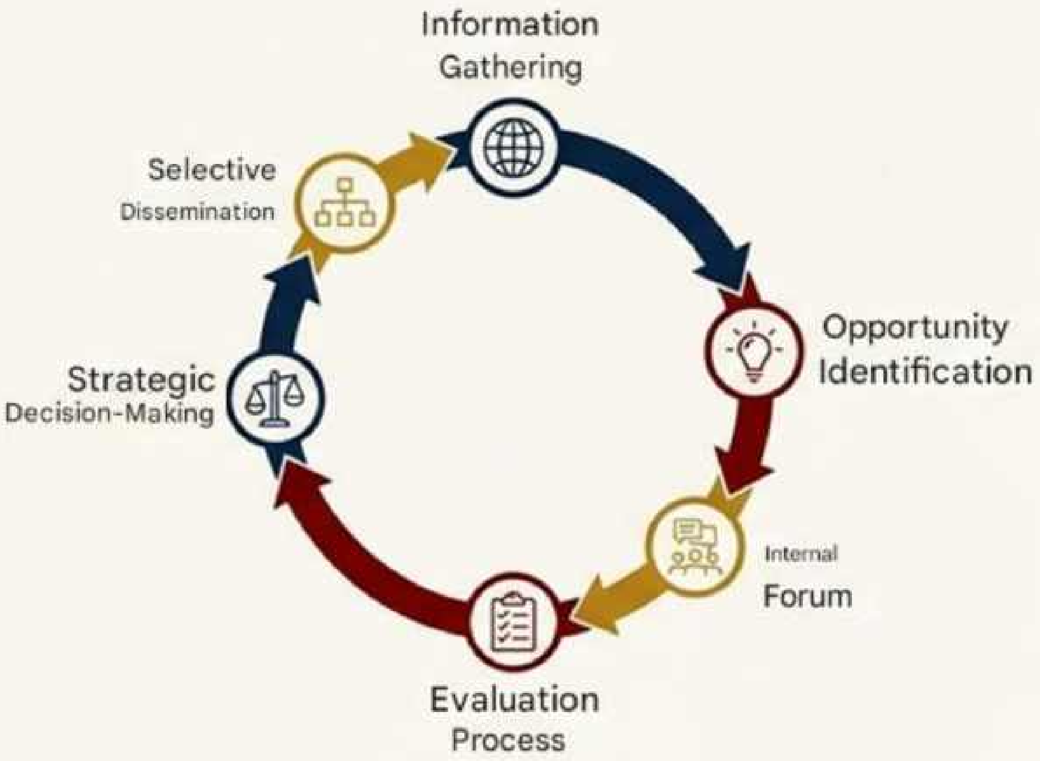
Proactive Economic Intelligence



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