Coordinate Systems

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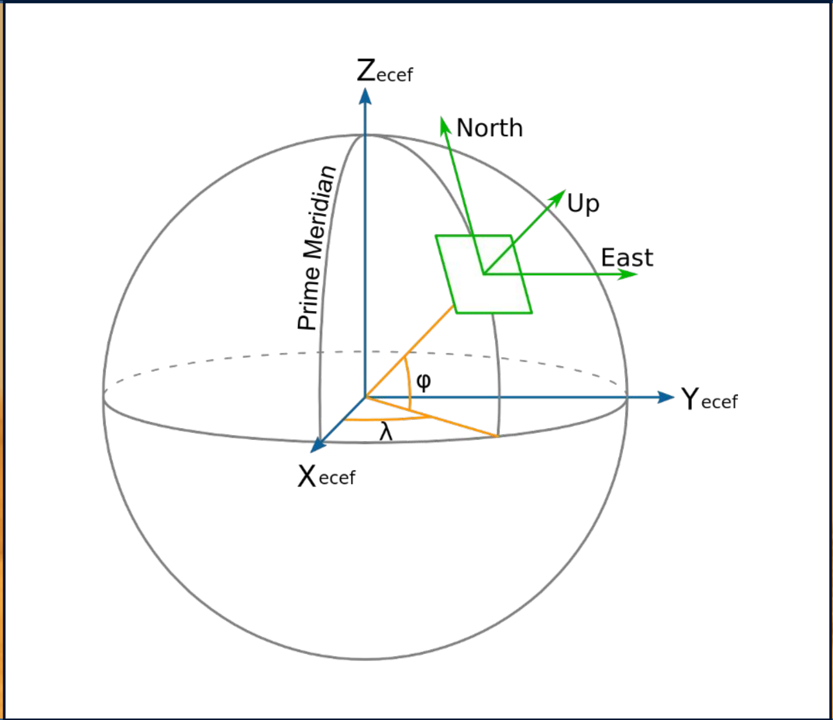
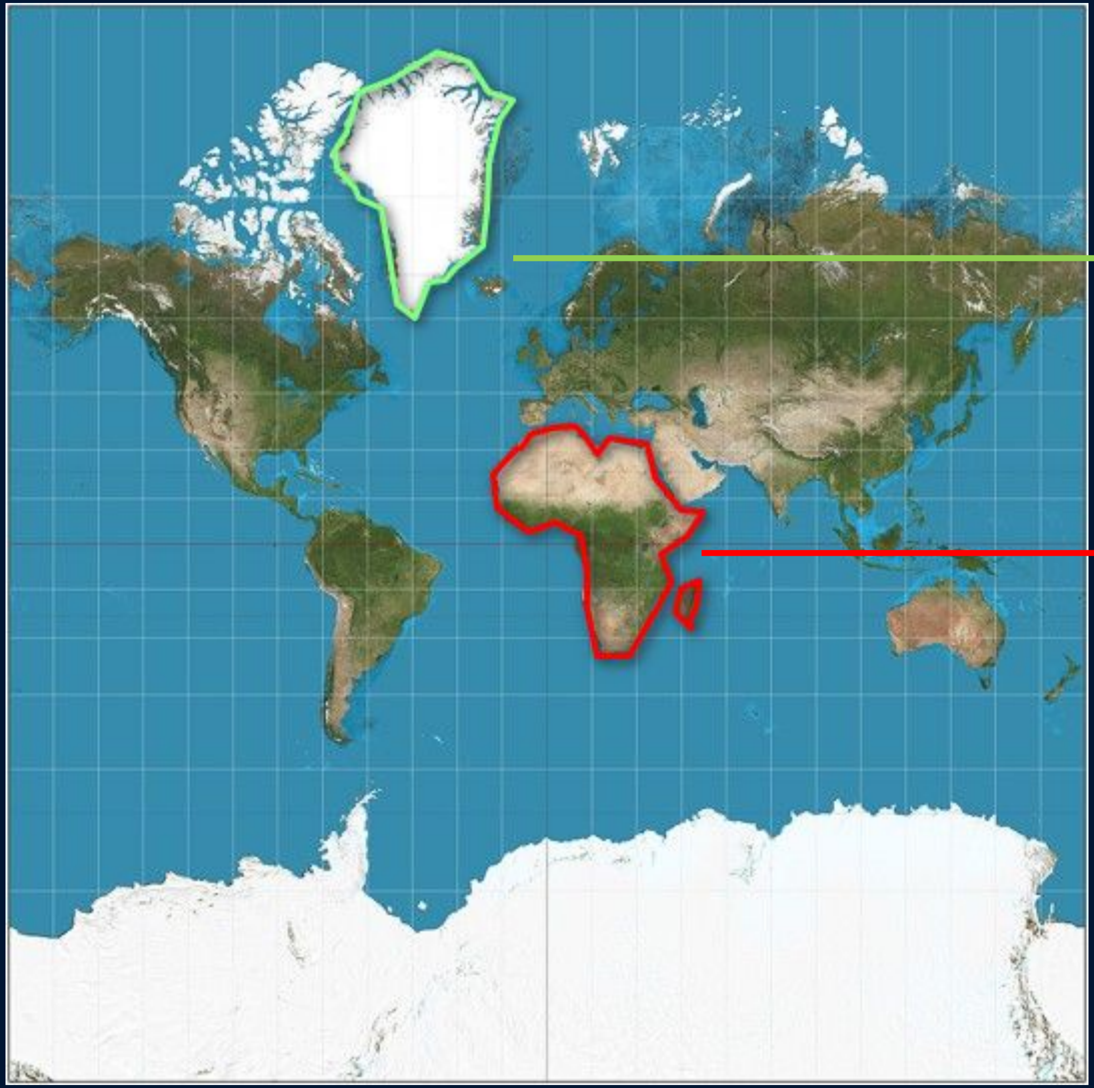
BRGTC



Coordinate System

2020.06.09 by Frank Li

Which area is larger?



Africa VS Greenland

2,166,086 m^2

30,221,532 m^2

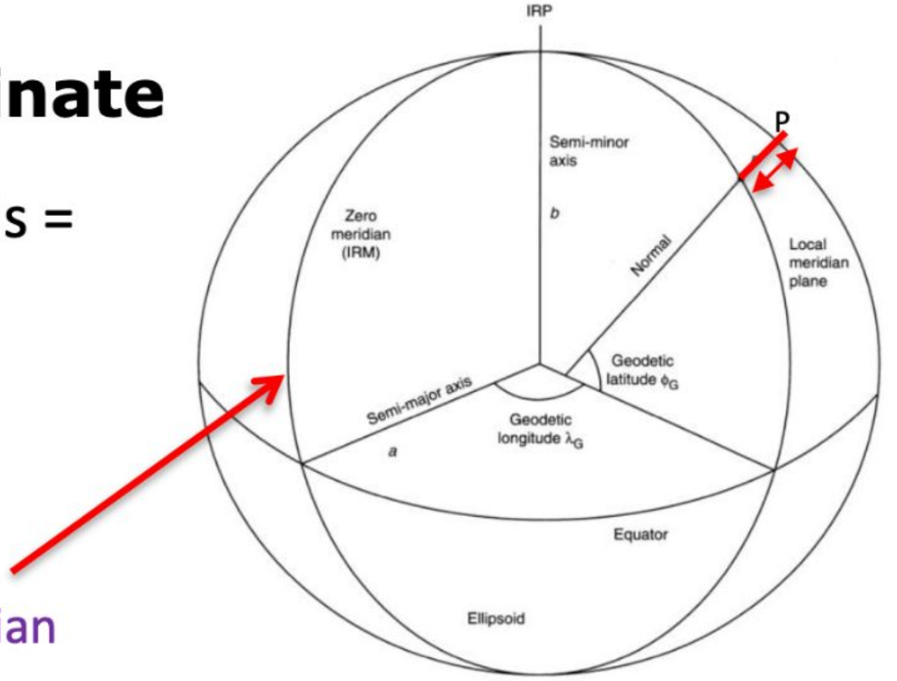
The Fact:
Africa ≈ 14 x Greenland

Geodetic and Cartesian Coordinate

Position related to ellipsoid

- *Geodetic latitude* Φ_P
- *Geodetic longitude* λ_P
- *Ellipsoidal height* h_p

Different reference ellipsoids = different coordinates



Prime Meridian

Fig. 8.7 *Geodetic coordinates* Schofield and Breach (2007) p289

System lies at the centre of an ellipsoid

- *Z-axis* is the IERS spin axis
- *X-axis* is in the direction of the Int. Ref. Meridian
- *Y-axis* is perpendicular to both of these.

Point P coordinates X_P, Y_P and Z_P

Geocentric coordinate system with origin at centre of ellipsoid- near the centre of the Earth.

Large coordinate numbers! e.g. 3867231.453, -83661.262, 5054440.211

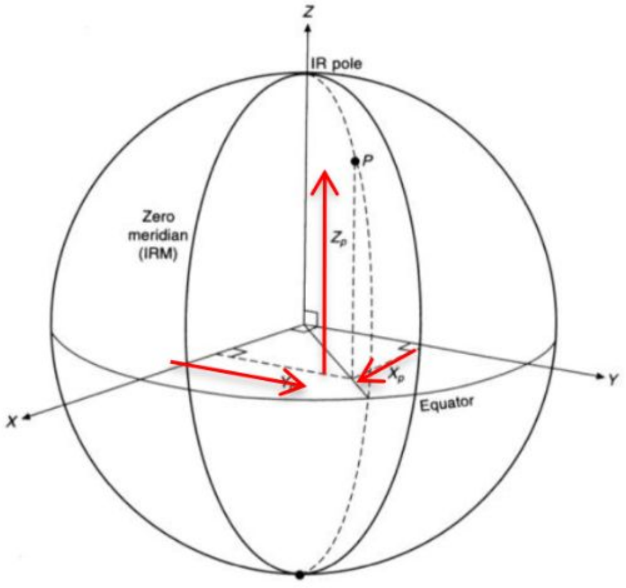
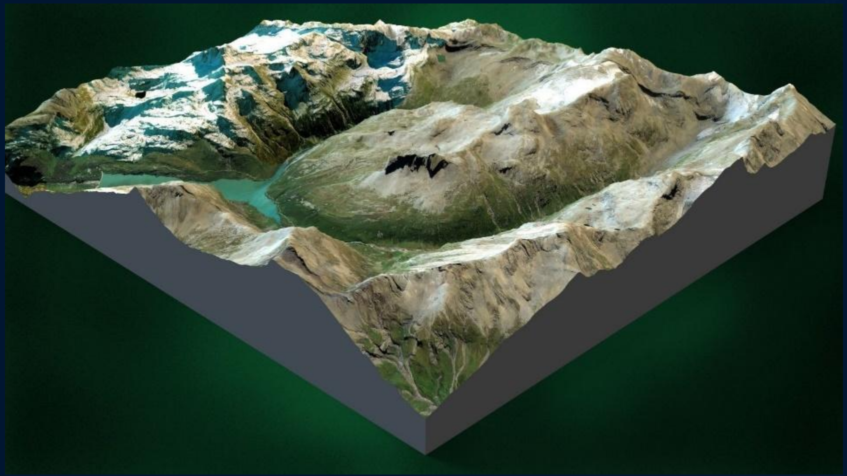


Fig. 8.8 *Geocentric cartesian coordinates* Schofield and Breach (2007) p290

But coordinates can be converted from geodetic to cartesian on the **same** ellipsoid using exact and reversible formulae

How to describe the earth?

So, how to describe the Earth?



Earth Surface Models

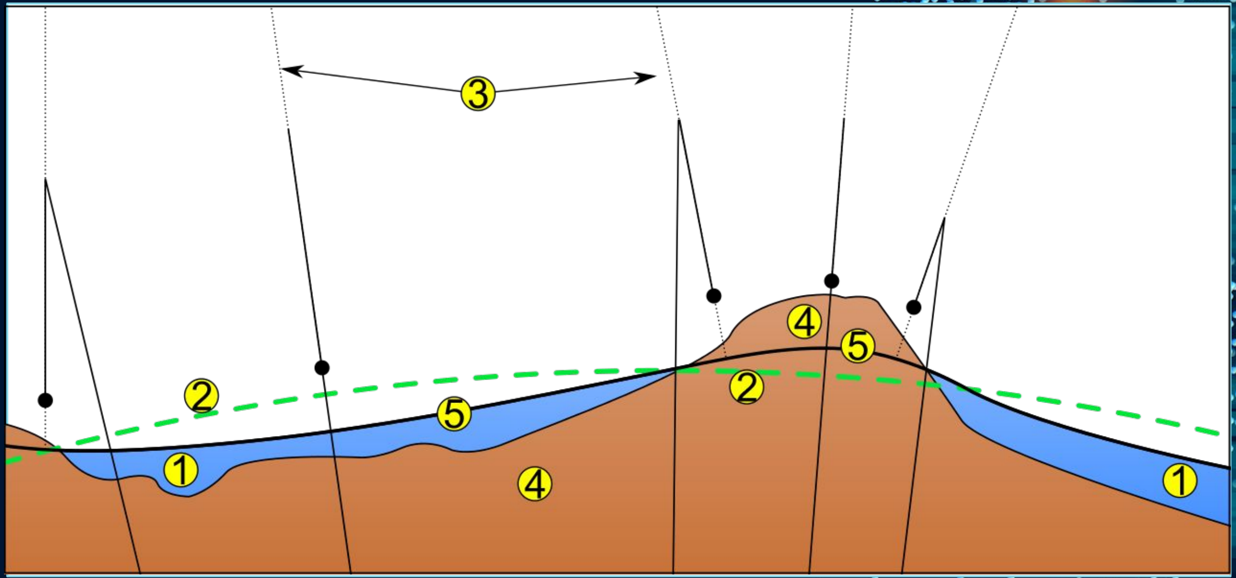
- Geoidal Surface (大地水准面)

The geoid is the shape that the ocean surface would take under the influence of the gravity and rotation of Earth alone. The geoid surface is irregular, but is considerably smoother than Earth's physical surface.

The distance from the ground point to the geoid is called absolute elevation or altitude.

是一个假想的由地球自由静止的海水平面，扩展延伸而形成的闭合曲面。但是由于重力分布的不同，大地水准面和完美椭球体有一定出入。

地面点到大地水准面的铅锤距离，称为绝对高程（正高）或者海拔。



4. Continent
5. Geoid

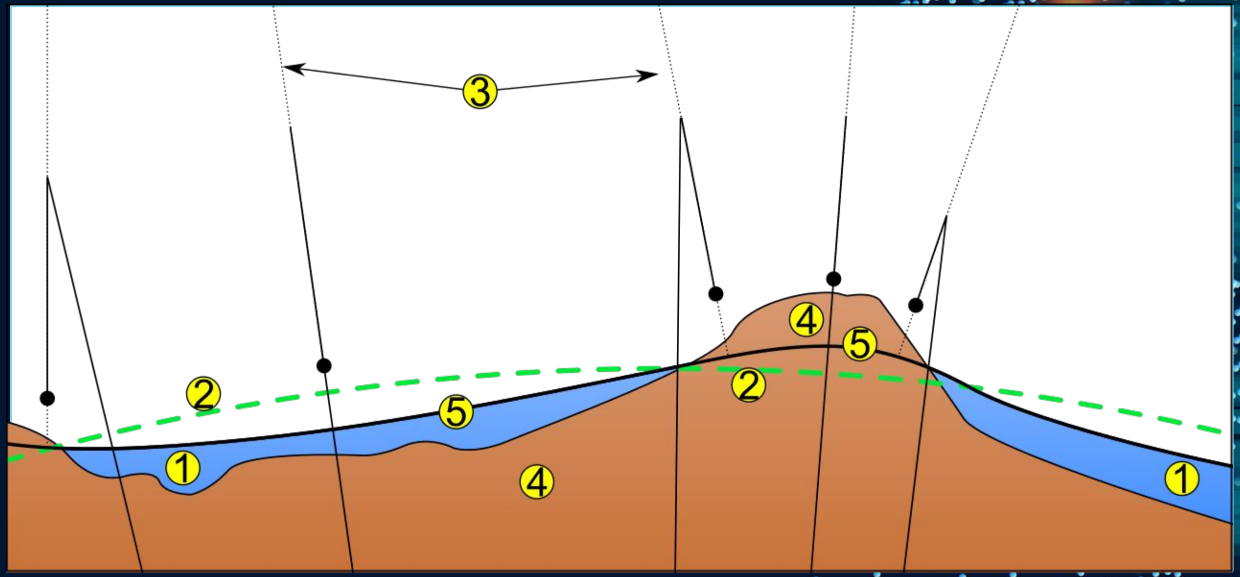
Earth Surface Models

- Quasi-Geoid (似大地水准面)

Surface parallel to the telluroid that is transferred to the mean sea level. The geoid and quasi-geoid are approximately the same surface over the oceans. However, the separation between the quasi-geoid and geoid can reach close to the meter level in mountainous areas.

似大地水准面是从地面点沿正常重力线量取正常高所得端点构成的封闭曲面，它与大地水准面不完全吻合。

地面点沿铅垂线到似大地水准面的距离称为正常高。



1. Ocean
2. Reference ellipsoid
3. Local plumb line
4. Continent
5. Geoid

Earth Surface Models

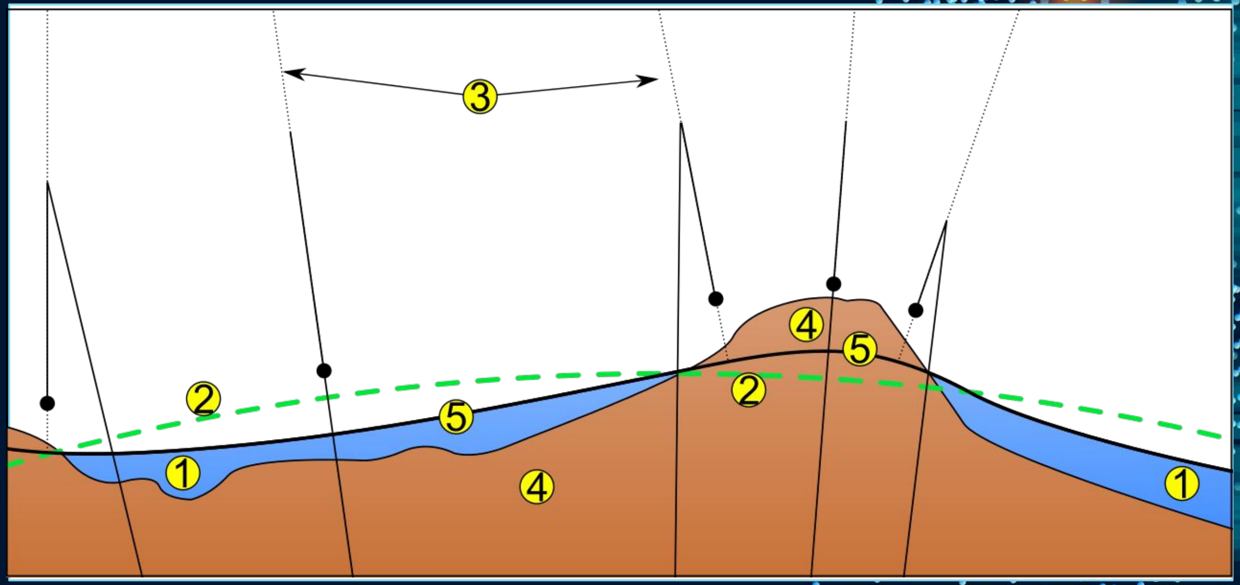
- Reference Ellipsoid（参考椭球面）

The reference ellipsoid is a mathematical idealized representation of the physical Earth.

Elevation of a point above the reference ellipsoid. The distance is measured along the ellipsoidal normal.

参考椭球面是处理大地测量成果而采用的与地球大小、形状接近并进行定位的椭球体表面。

地面点到参考椭球面的法线距离，称为大地高。



1. Ocean
2. Reference ellipsoid
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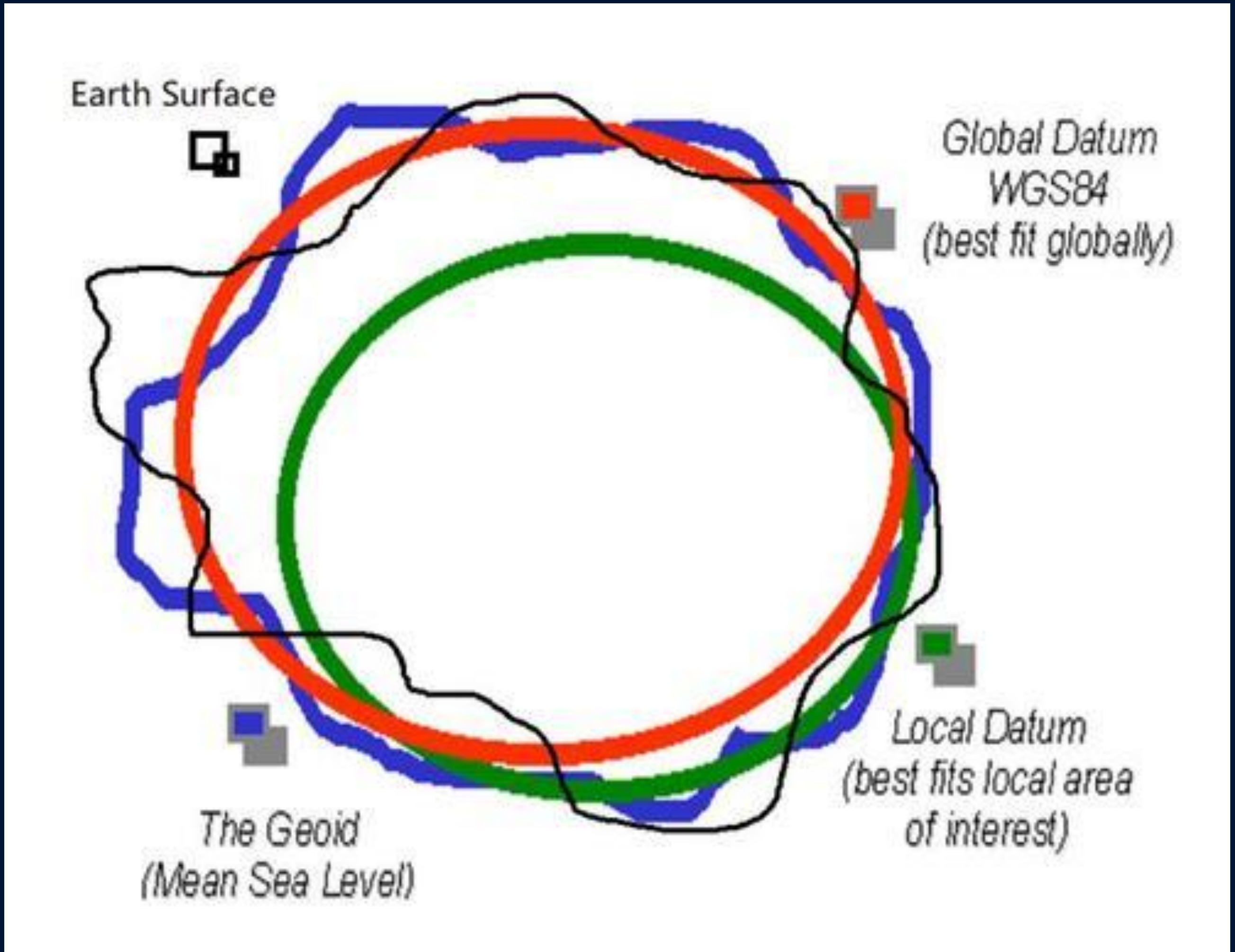
Earth Surface Models



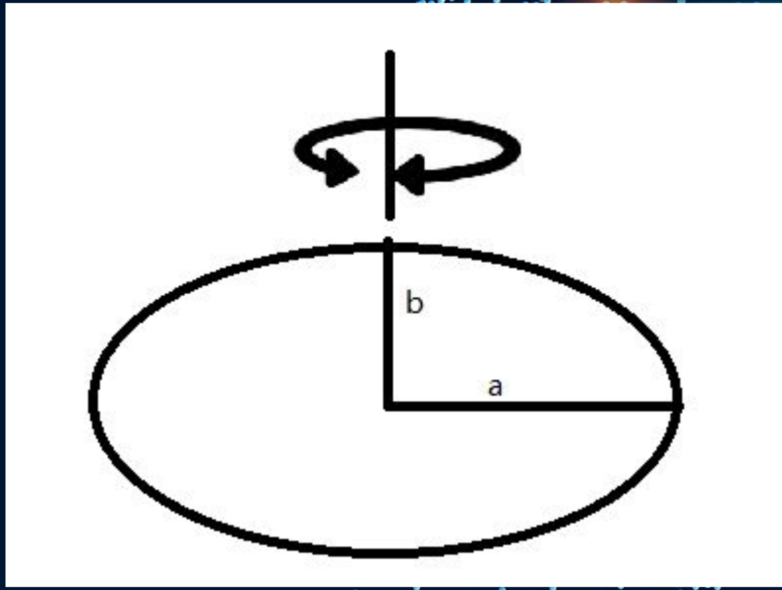
WGS84 + Geoid File = Mean Sea Level

The Ellipsoid Model

Scientists use a regular model, the ellipsoid model, to describe the earth.

a = Equatorial radius (6378.1370 km)

b = Polar radius (6356.7523 km)

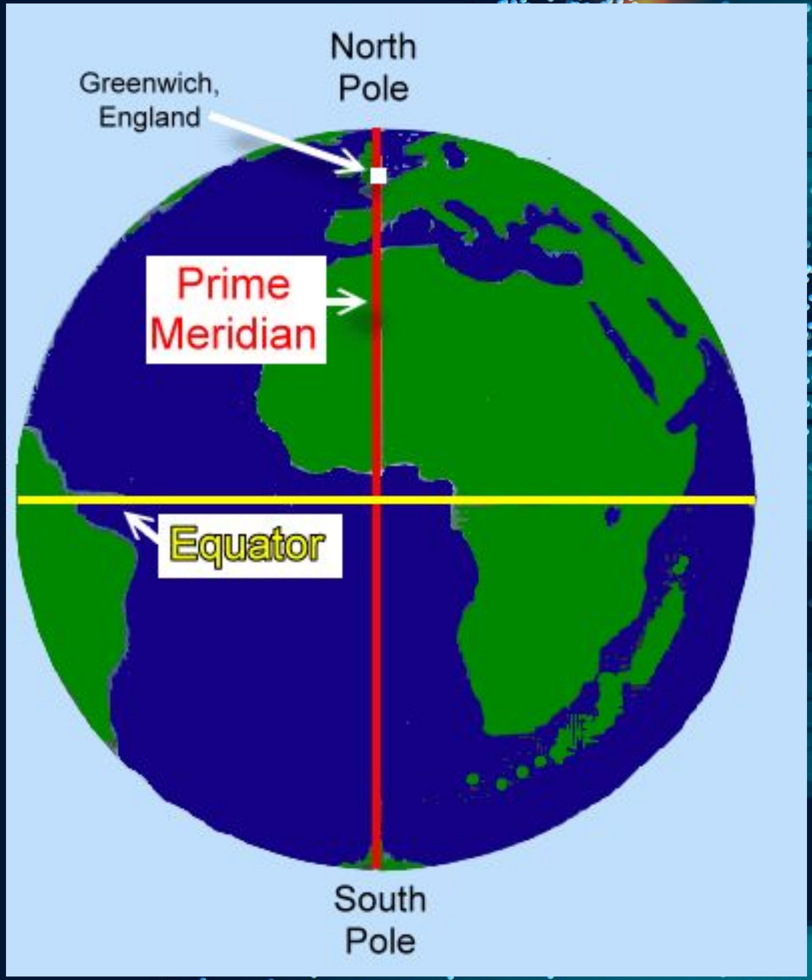


Prime Meridian & Equator

The **Equator** and **Prime Meridian** are circles that stretch all the way around the earth.

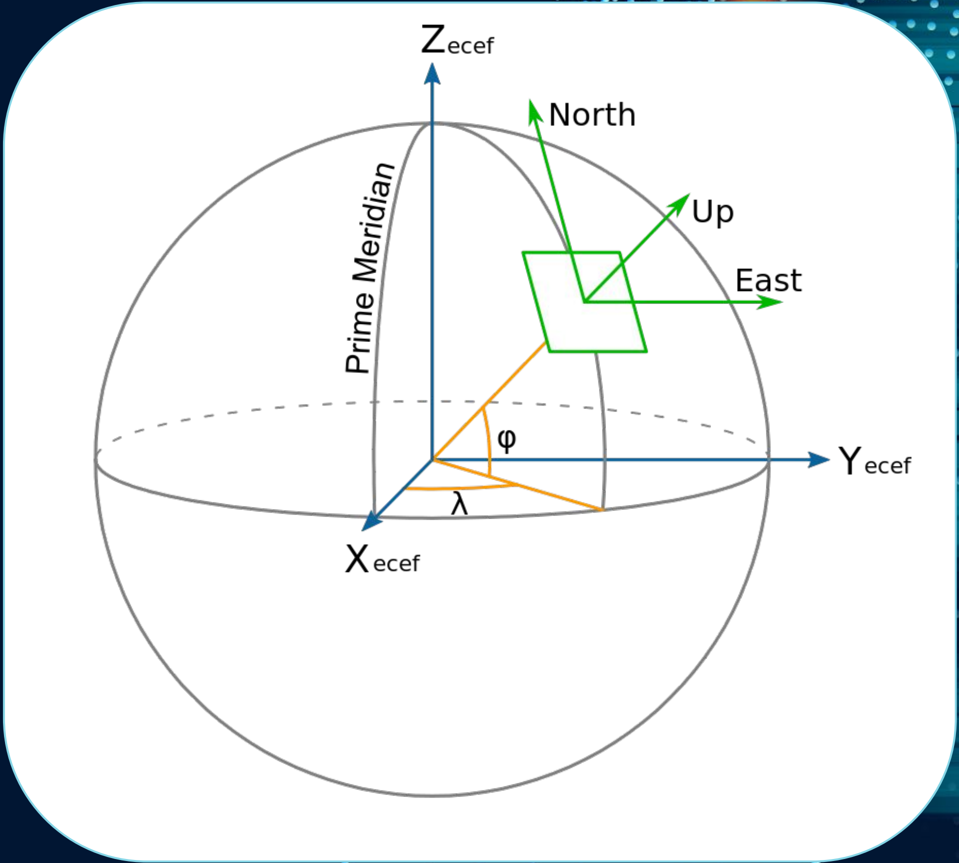
The **Equator** separates the Northern and Southern Hemisphere. The Equator is at 0° latitude.

The **Prime Meridian** separates the Eastern and Western Hemisphere. The Prime Meridian runs through Greenwich, England and is at 0° longitude.



Coordinate System

- **Geocentric Coordinate System (地心坐标系)**
- **Geodetic Coordinate System (地理坐标系)**
- **Projected Coordinate System （投影坐标系)**

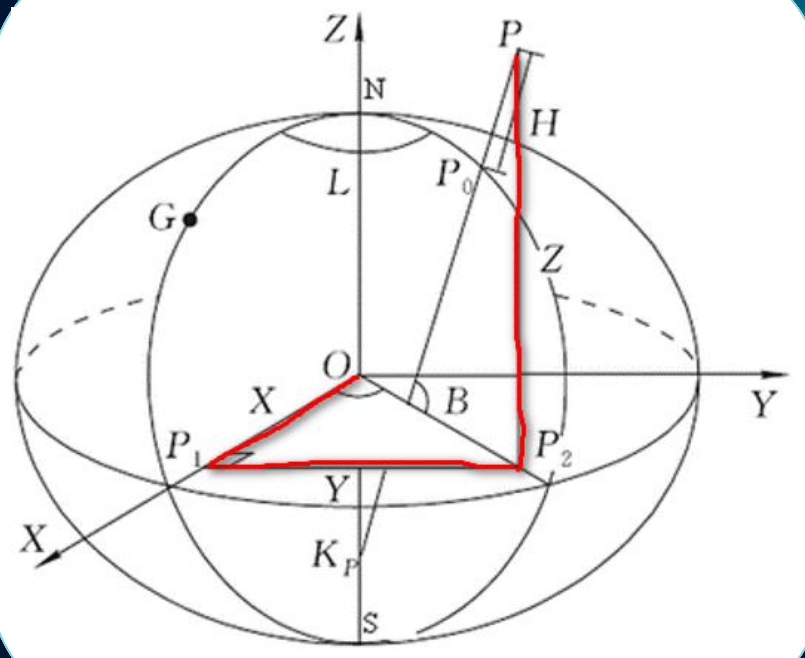


Geocentric Coordinate System

X, Y, Z

The geocentric coordinate system is not a planar coordinate system based on a map projection. It is a geographic coordinate system in which the earth is modeled as a sphere or spheroid in a right-handed XYZ (3D Cartesian) system measured from the center of the earth.

The X-axis points to the prime meridian, the Y-axis points 90° away in the equatorial plane, and the Z-axis points in the direction of the North Pole.



Geodetic Coordinate System

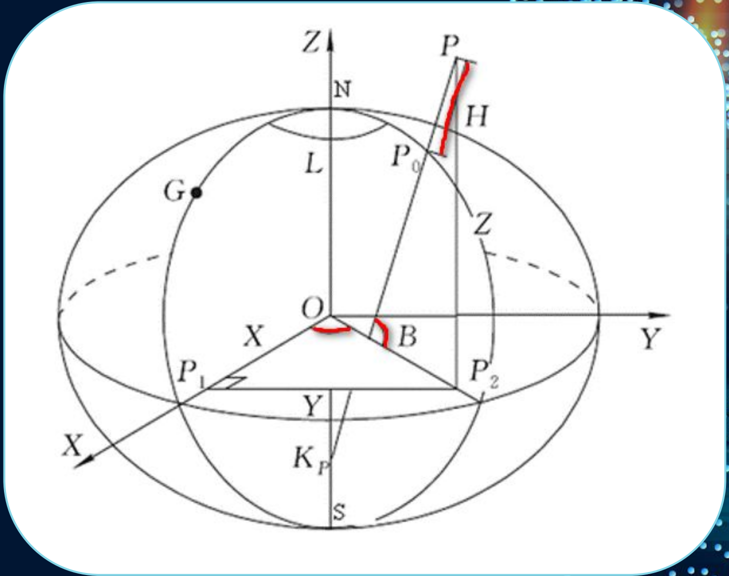
Latitude, Longitude, Altitude (B, L, H)

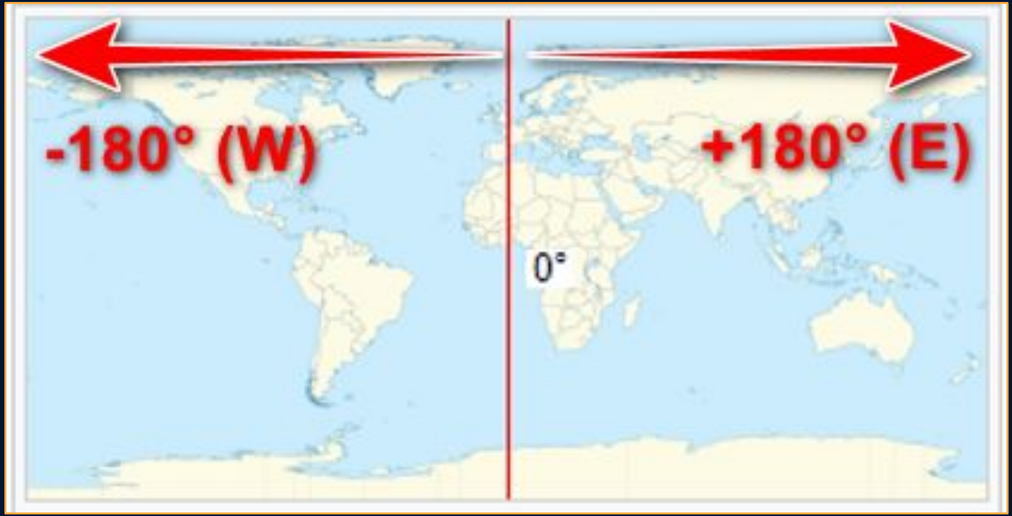
2 * Π * 6378000 / (360 * 60 * 60) ≈ 30m

1” ≈ 30m

1’ ≈ 1.8Km

1° ≈ 108Km

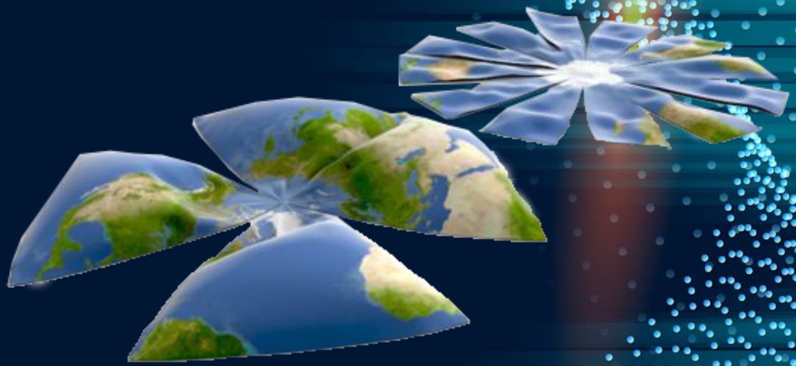


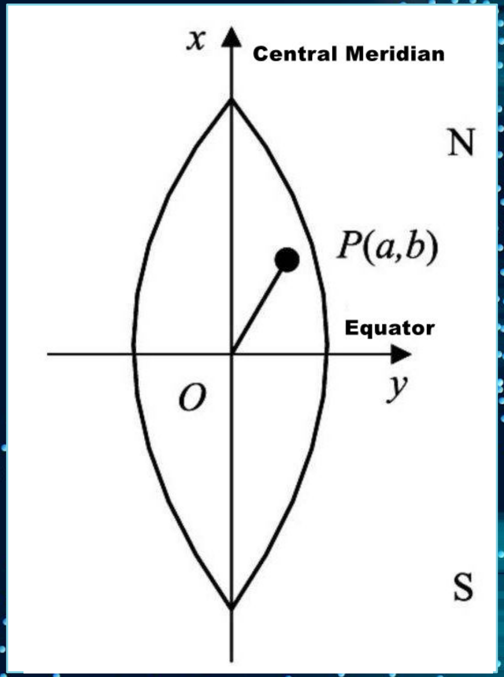


Projected Coordinate System

x, y, z or N, E, H

The earth's surface—and your GCS—are round, but your map—and your computer screen—are flat. That's a problem. You can't draw the round earth on a flat surface without deforming it. Imagine peeling an orange and trying to lay the peel flat on a table. You can get close, but only if you start tearing the peel apart. This is where map projections come in. They tell you how to distort the earth—how to tear and stretch that orange peel—so the parts that are most important to your map get the least distorted and are displayed best on the flat surface of the map.





Projection Zone

In order to reduce projection distortion, the earth is separated in to different parts.

There are two types of projection zone: 3° or 6°.

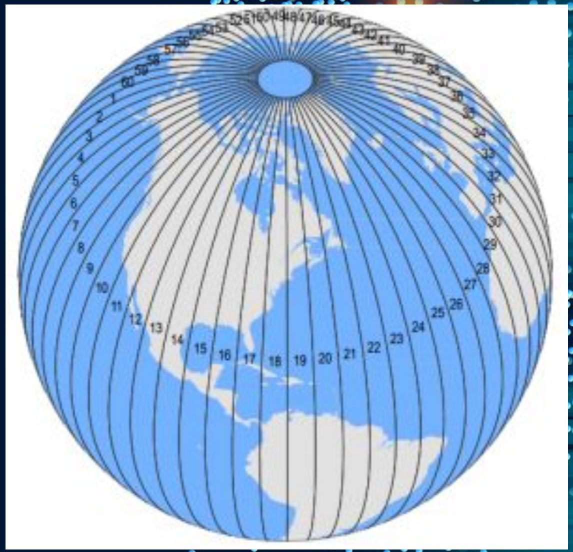
Predefined Projections

Country: UTM

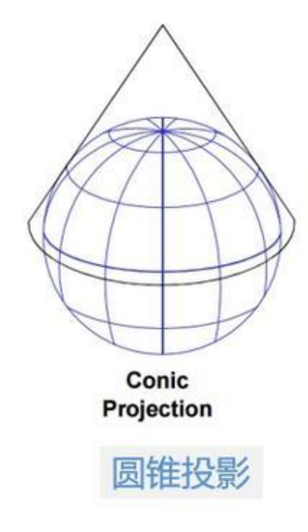
Search

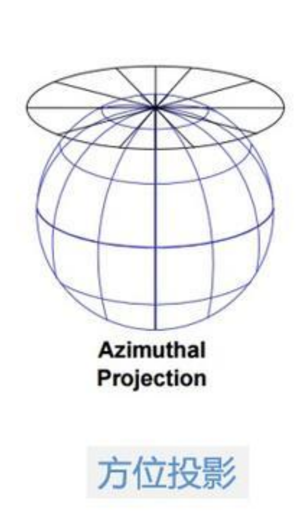
No.	Coordinate System	Ellipsoid Name
1	WGS 84/UTM zone 01N 174-180W	WGS 84
2	WGS 84/UTM zone 02N 168-174W	WGS 84
3	WGS 84/UTM zone 03N 162-168W	WGS 84
4	WGS 84/UTM zone 04N 156-162W	WGS 84
5	WGS 84/UTM zone 05N 150-156W	WGS 84
6	WGS 84/UTM zone 06N 144-150W	WGS 84
7	WGS 84/UTM zone 07N 138-144W	WGS 84
8	WGS 84/UTM zone 08N 132-138W	WGS 84
9	WGS 84/UTM zone 09N 126-132W	WGS 84
10	WGS 84/UTM zone 10N 120-126W	WGS 84
11	WGS 84/UTM zone 11N 114-120W	WGS 84
12	WGS 84/UTM zone 12N 108-114W	WGS 84
13	WGS 84/UTM zone 13N 102-108W	WGS 84
14	WGS 84/UTM zone 14N 96-102W	WGS 84
15	WGS 84/UTM zone 15N 90-96W	WGS 84

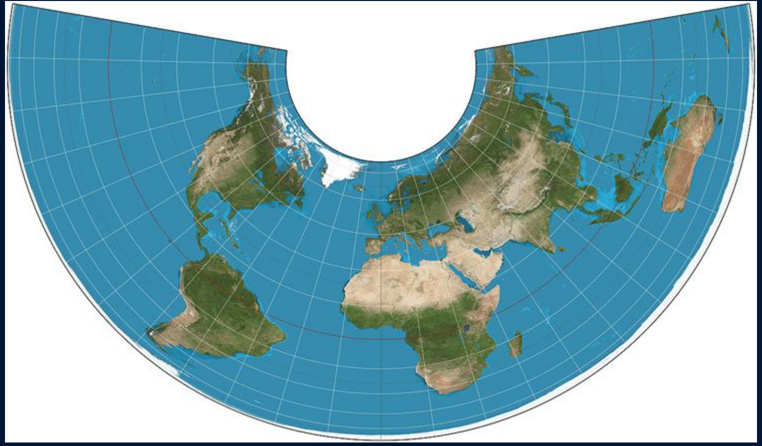
OK | Details

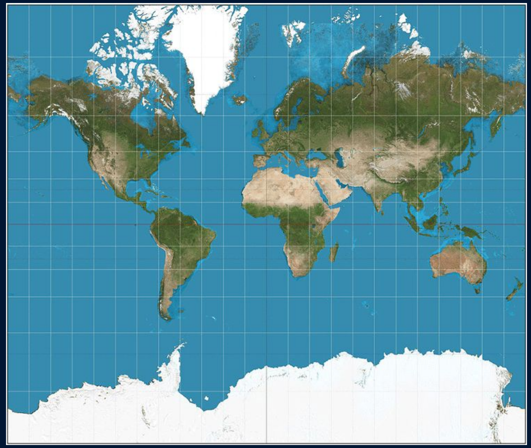


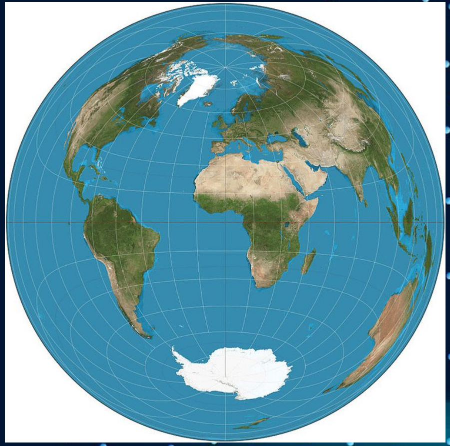
Types of Map Projections





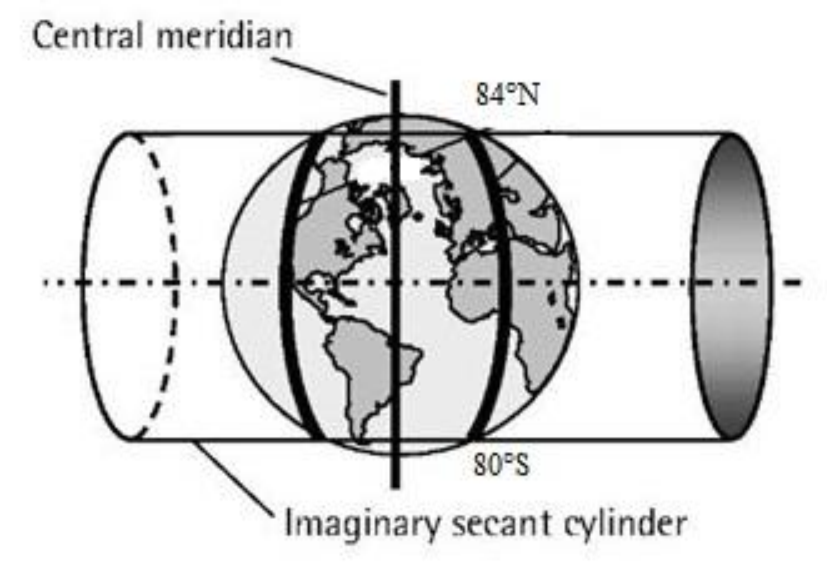






Classic Projections: UTM

The transverse Mercator projection rotates the cylinder 90 degrees. The UTM uses 60 zones that are 6 degrees wide, with standard central meridians. Within these zones the UTM projection has very little distortion. UTM coordinates can be extended into a neighboring zone for seamless operations, but the farther away from the 6 degree zone you move, the greater the distortion.



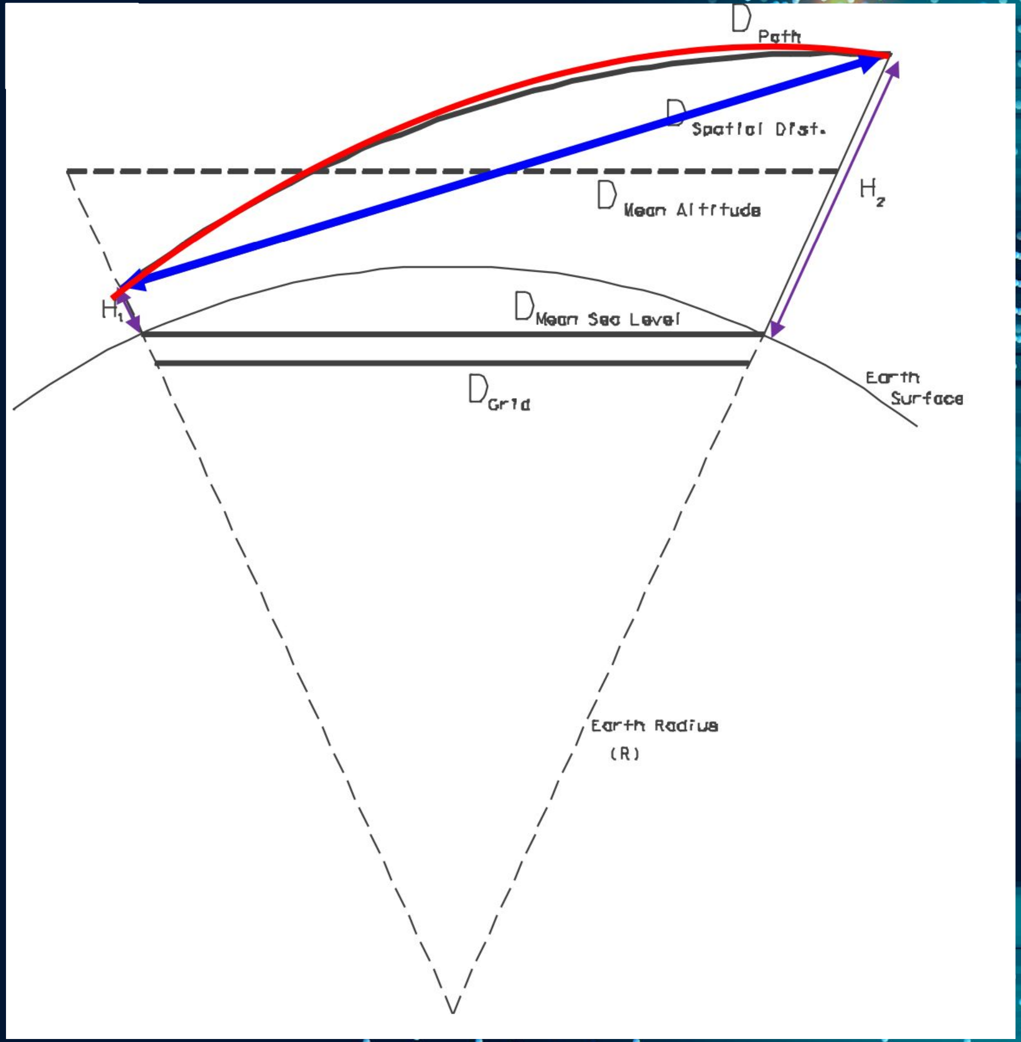
Very important diagram :

- ❑ Summarizes the “external” systematic errors
- ❑ Provides solution to key problem of the curved surface of the earth!

4.1.1 Atmospheric correction

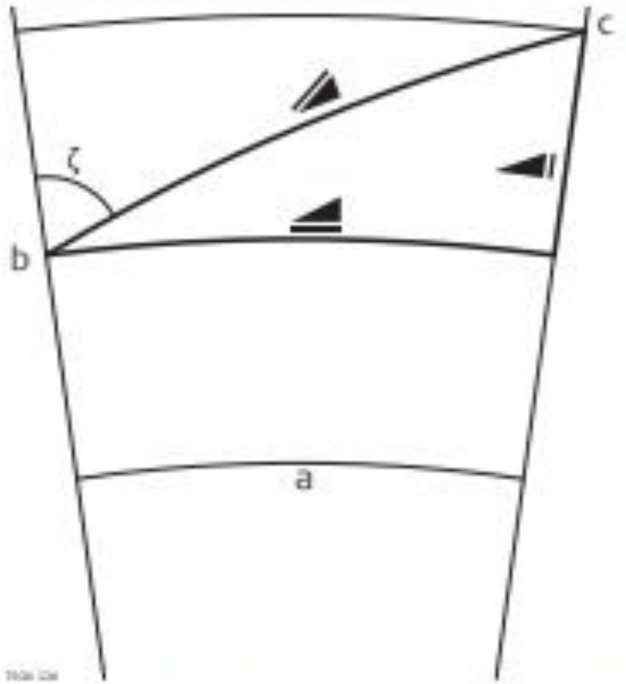
$D_{Path} \rightarrow D_{spatial}$

- ❑ Speed of light varies with: temperature, pressure→Parts per million (PPM)



14.8 Reduction Formulas

Formulas



a Mean Sea Level
b Instrument
c Reflector
Slope distance
Horizontal distance
Height difference

The instrument calculates the slope distance, horizontal distance, and height difference in accordance with the following formulas. Earth curvature (1/R) and mean refraction coefficient (k = 0.13) are automatically taken into account when calculating the horizontal distance and height difference. The calculated horizontal distance relates to the station height and not to the reflector height.

Slope distance

$$= D_0 \cdot (1 + ppm \cdot 10^{-6}) + mm$$

	Displayed slope distance [m]
D_0	Uncorrected distance [m]
ppm	Atmospheric scale correction [mm/km]
mm	prism constant [mm]

Horizontal distance

$$= Y - A \cdot X \cdot Y$$

	Horizontal distance [m]
Y	* sinζ
X	* cosζ
	ζ = Vertical circle reading
A	$(1 - k/2)/R = 1.47 * 10^{-7}$ [m^{-1}]
	k = 0.13 (mean refraction coefficient)
	R = $6.378 * 10^6$ m (radius of the earth)

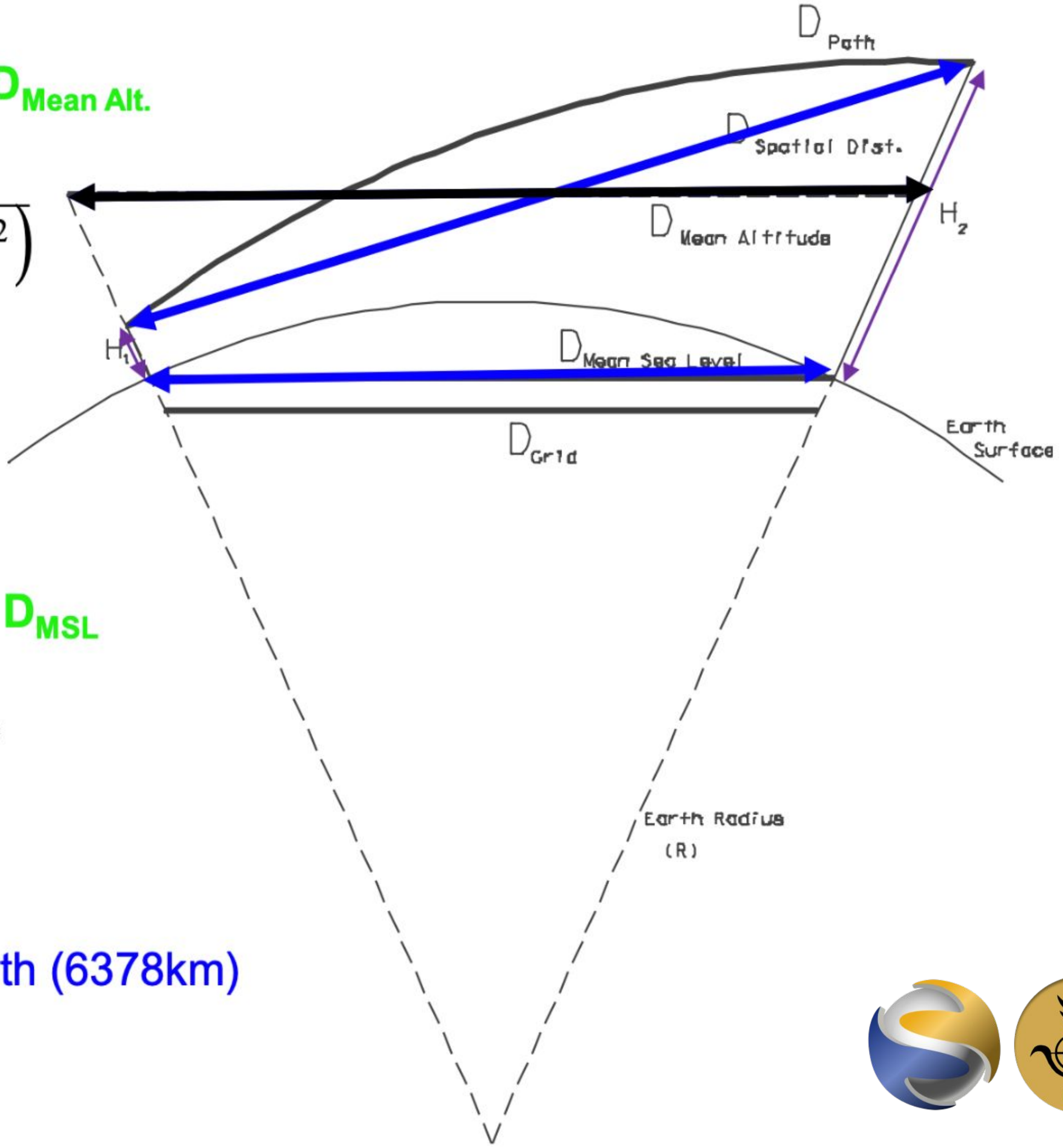
Height difference

$$= X + B \cdot Y^2$$

	Height difference [m]
Y	* sinζ
X	* cosζ
	ζ = Vertical circle reading
B	$(1 - k)/2R = 6.83 * 10^{-8}$ [m^{-1}]
	k = 0.13 (mean refraction coefficient)
	R = $6.378 * 10^6$ m (radius of the earth)

Slope correction $D_{Spatial} \rightarrow D_{Mean\ Alt.}$

$$D_{Mean.Alt.} = \sqrt{\left(D_{Spatial}^{2} - \Delta H^{2}\right)}$$



Mean sea-level $D_{Mean\ Alt.} \rightarrow D_{MSL}$

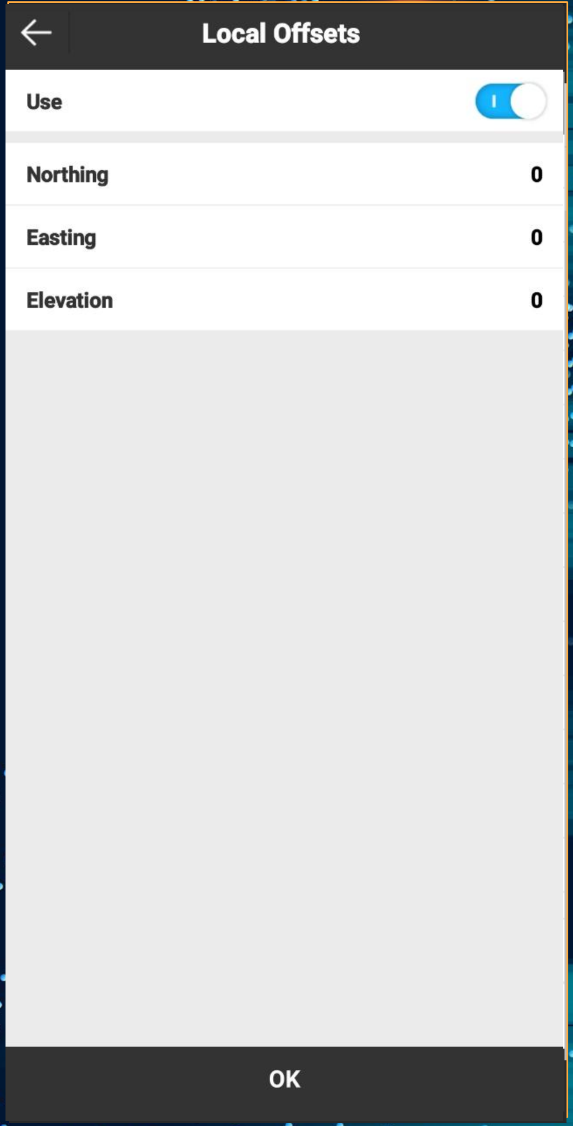
$$D_{MSL} = \frac{R}{R+H} . D_{\text{Mean Altitude}}$$

Where: $H = \frac{H_2 + H_1}{2}$ (km)

R= Radius of earth (6378km)

SurPad4.0-Coordinate System

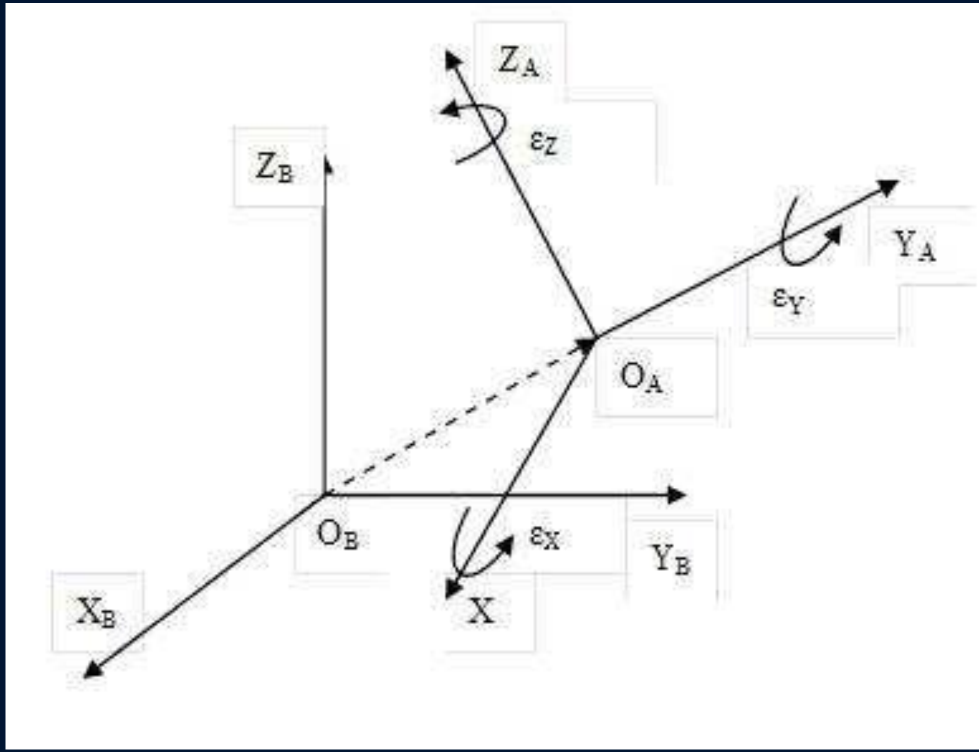
- Ellipsoid Parameter*
- Projections parameter*
- Seven-Parameter
- Four-Parameter/Horizontal Adjustment
- Grid File (Copy locally)
- Geoid File (Copy Locally)
- Local Offset



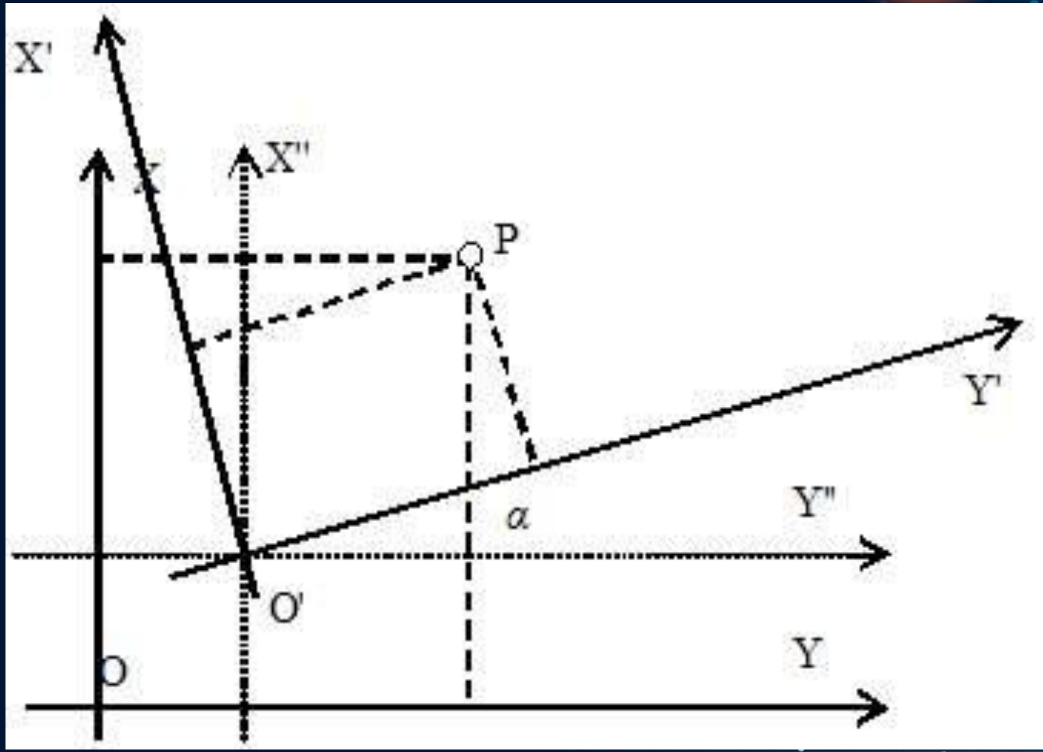
* Necessary parameters to calculate plane coordinate

SurPad4.0-Coordinate System

- Seven-Parameter (3D)

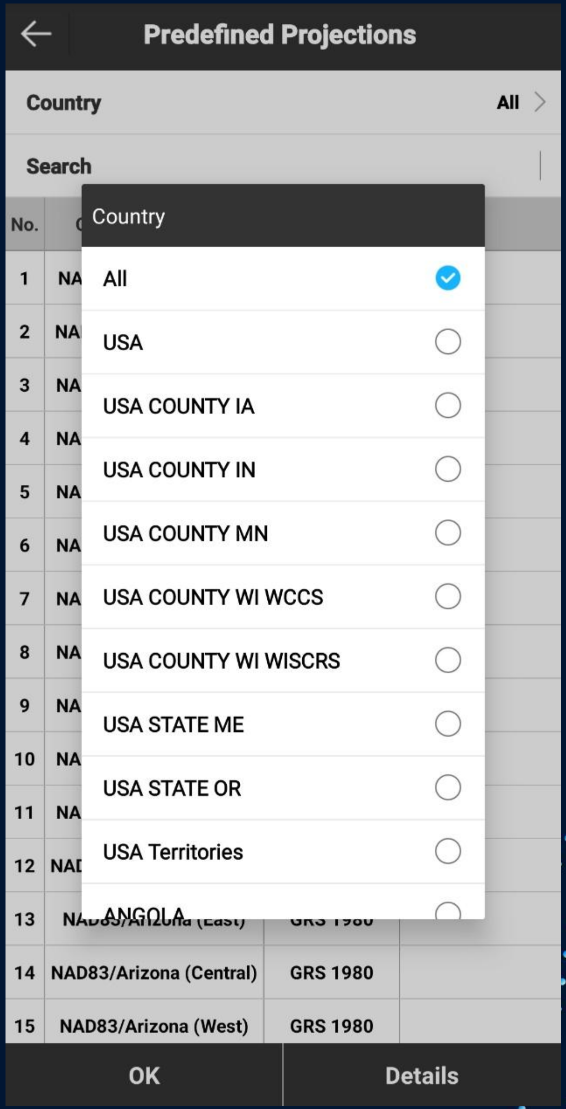


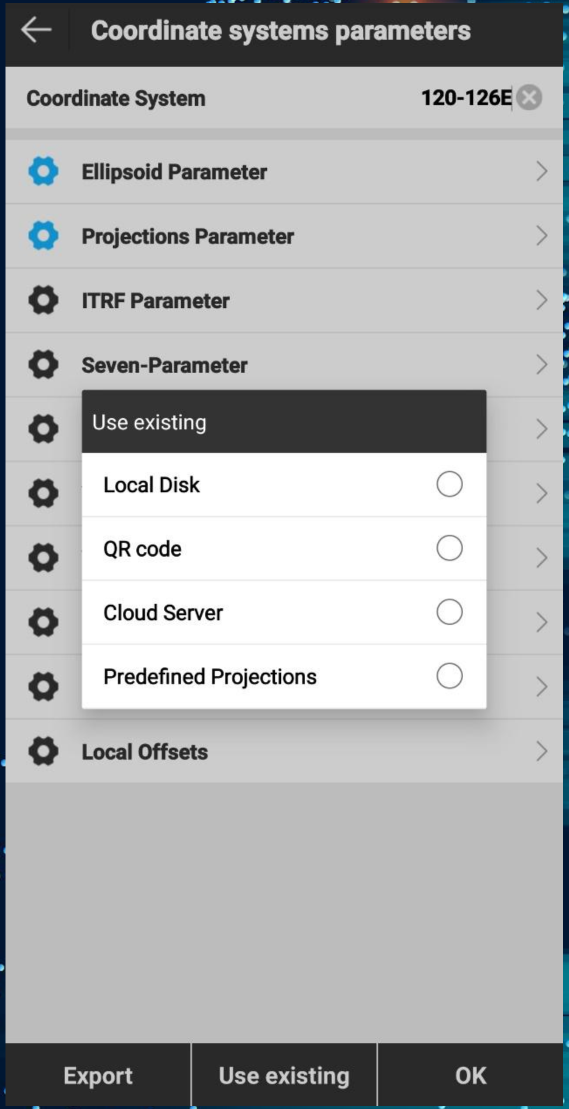
- Four-Parameter/Horizontal Adjustment (2D)

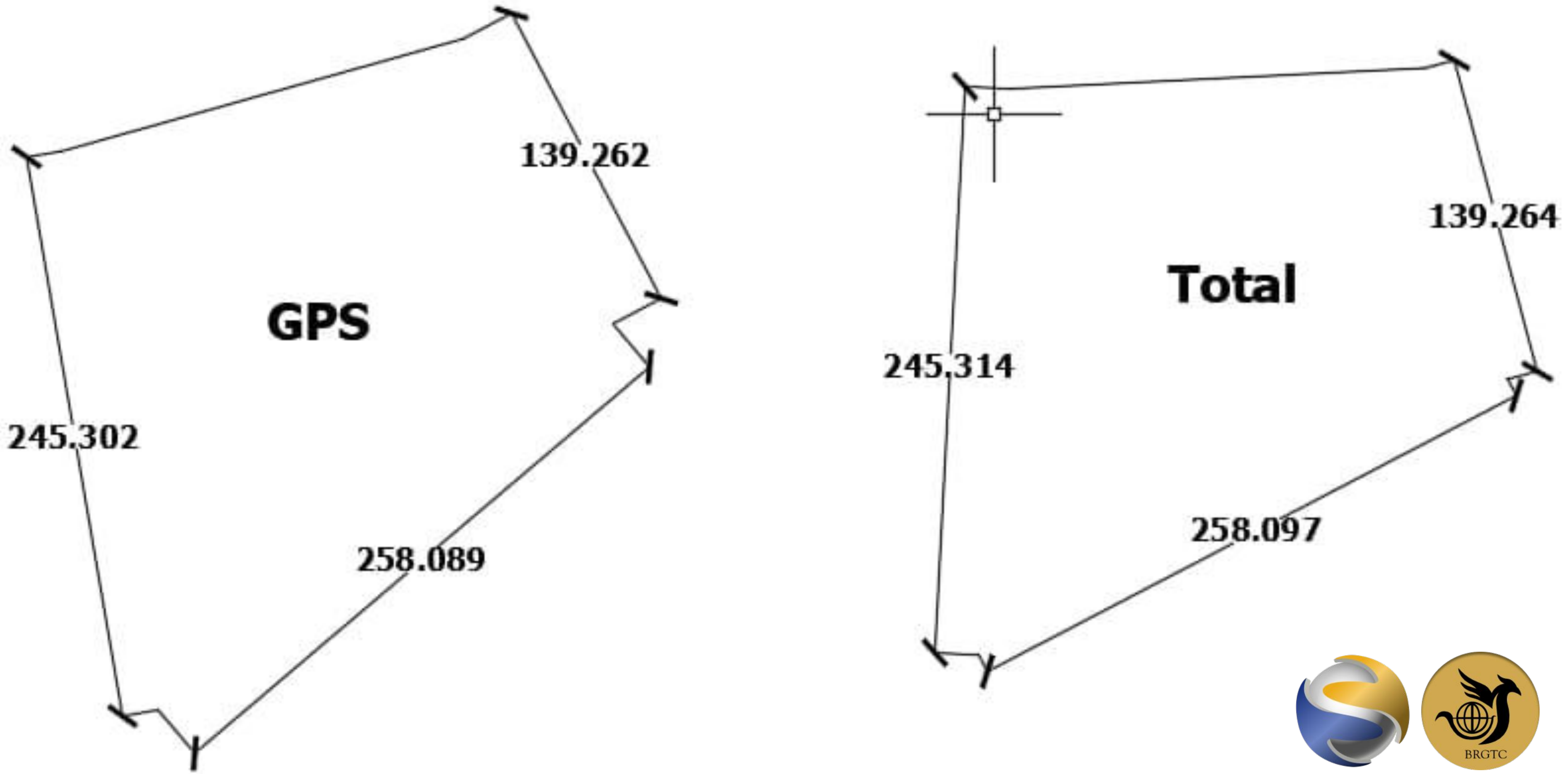


SurPad4.0-How to input coordinate system

- Input value manually
- Use predefined
- Scan QR Code
- Use local coordinate system file






139.262
GPS
245.302
258.089
139.264
Total
245.314
258.097


Naxoshxona

Thank you for Your Participation

Halmat Atta Ali

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