Topic : GIS – Map Coordinate & Position

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The Infinite Space

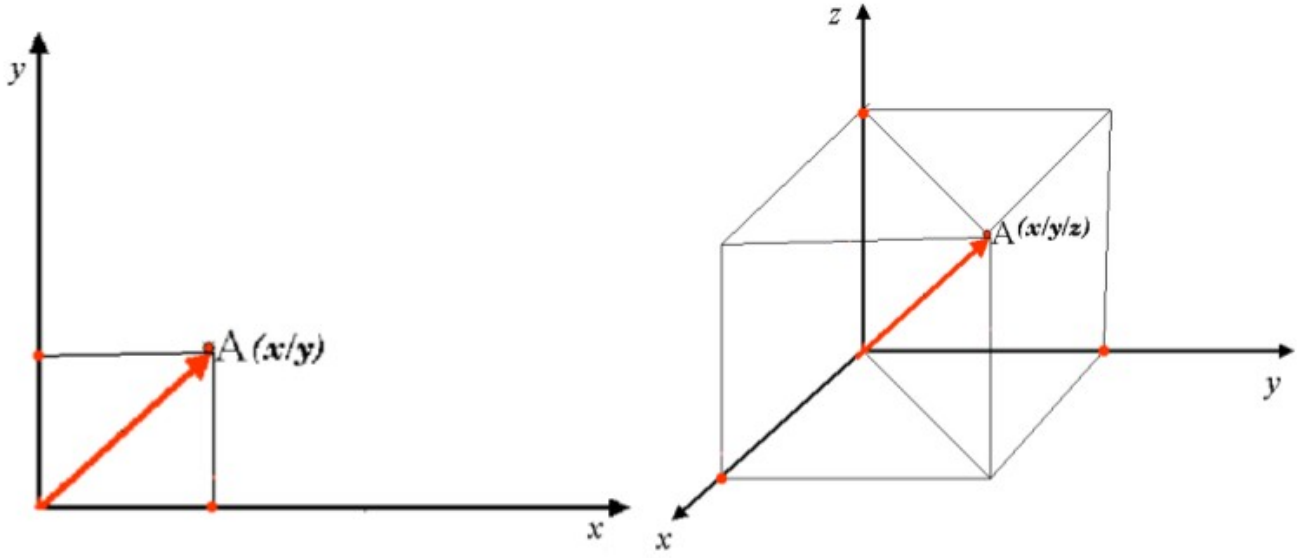
- Have you ever heard about multi-dimensional space? Or further, parallel universe?
- Have you ever heard that space and time are actually one (which is called as space-time)?
- Have you ever heard that our universe always expanded?
- Have you ever heard that long-long ago there is only one land in the earth, something which is called as “Pangea”?
- We live in a very large and changing universe. It would be hard to describe position.

Relativity

- We need some reference points to describe the position of everything.
- Tono's home is far east from Mordor
  - Relative to Mordor
- The computer is on the table
  - Relative to table
- My home is 4 meters west to Tono's home
  - Relative to Tono's home
- Indonesia is 6 degree N - 11 degree S, 95 degree E – 141 degree E
  - Relative to what?

How Do We Say Our Position

- 2D Coordinate system (x,y)
- 3D Coordinate system (x,y,z)
- Longitude-Latitude
- Angular Coordinate (r,alpha)
- Whatever.....

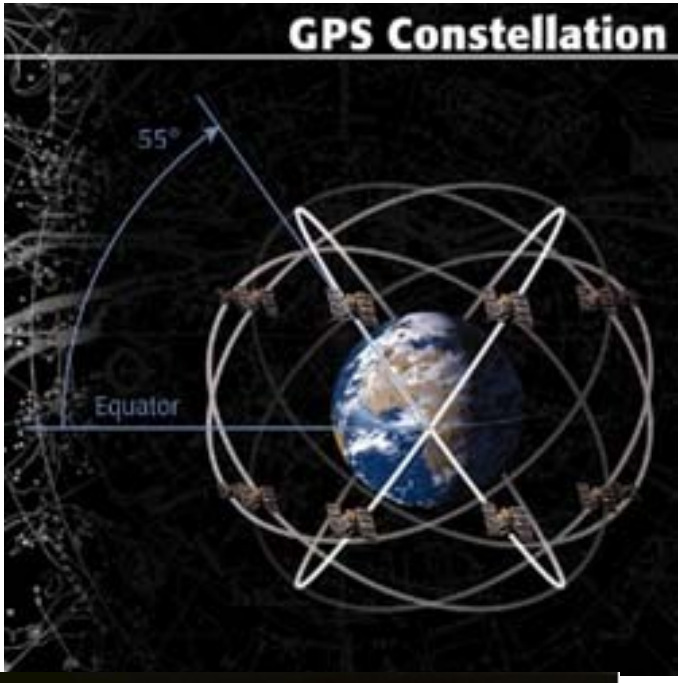


How Did Our Ancestor Determine Their Position

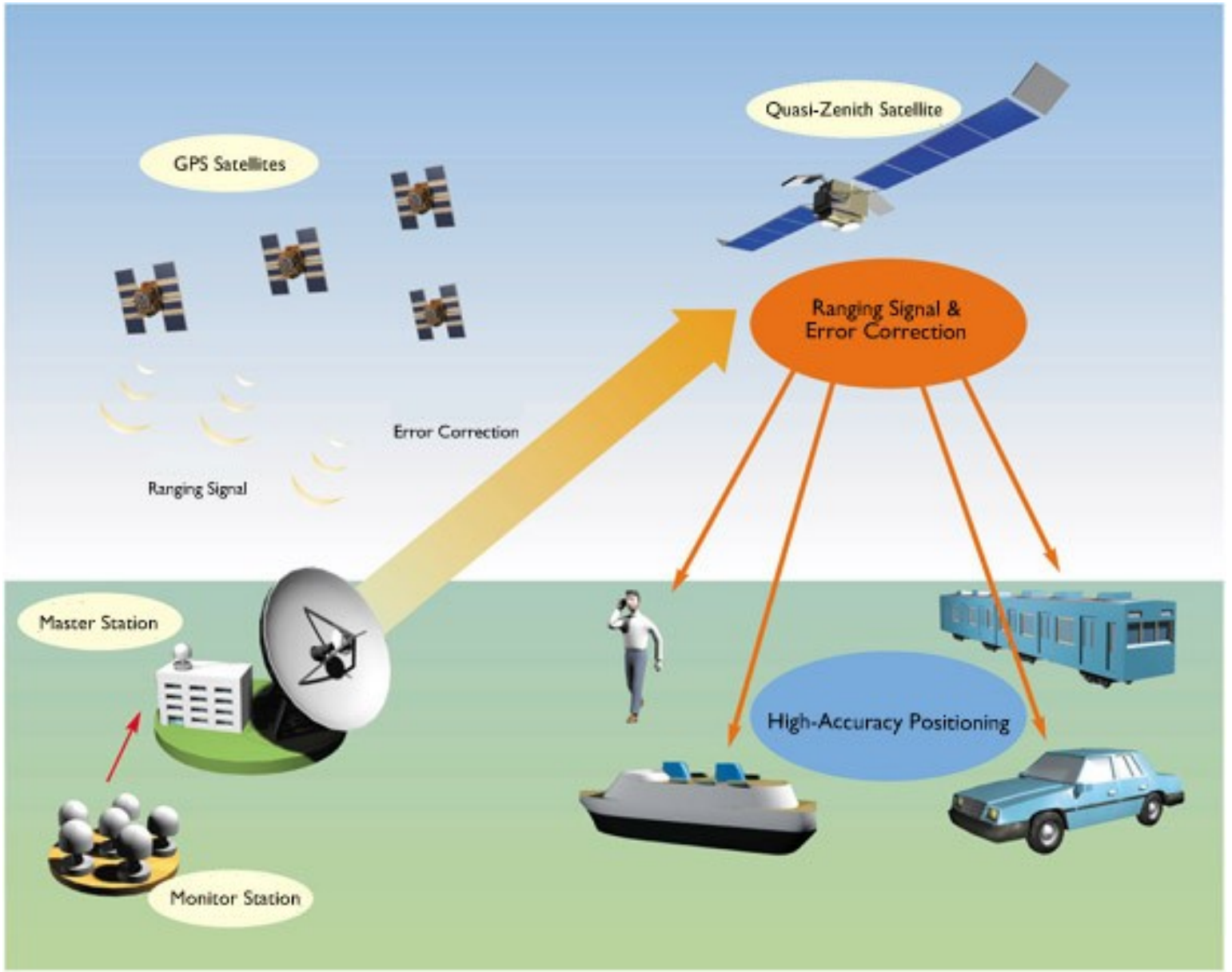
- Monument
- Detailed Map
- Star Constellation

How Do We Determine Our Position

- Global Positioning System (GPS)
  - We make *our own constellation*, consists of 24 operational + 3 backup satelites.
    - The satelites altitude is 12,000 miles (19,300 km)
    - They orbit the earth twice a day
  - We can see the satelites by using hand held device (officially called as GPS receiver, but we prefer to call it just GPS)

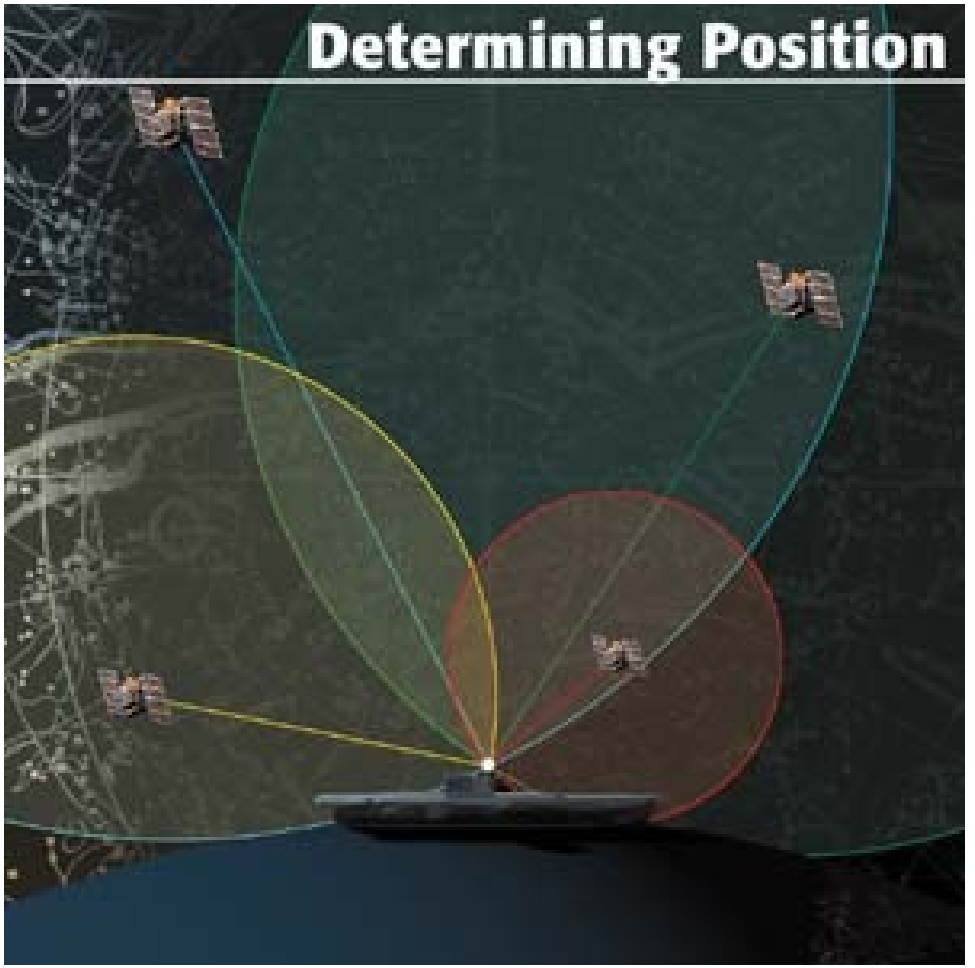


GPS in a Whole



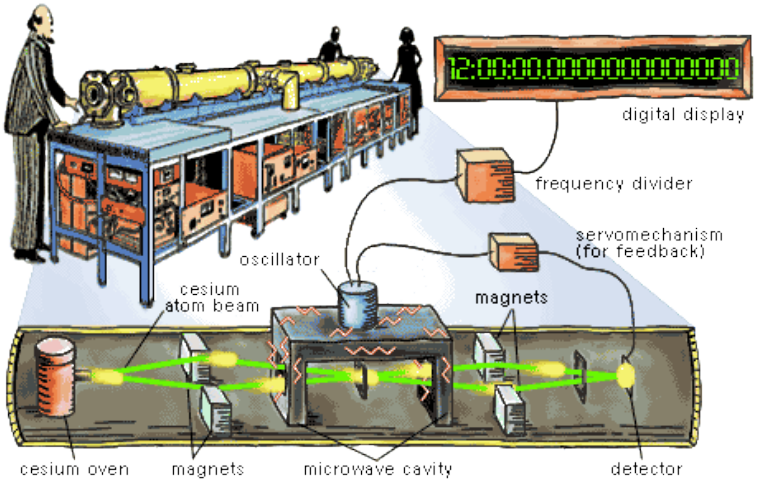
GPS in Detail

- By measuring the distance of the receiver to satelites, we can determine our position.
  - But how to measures the distance?
  - How exactly we determine our position?



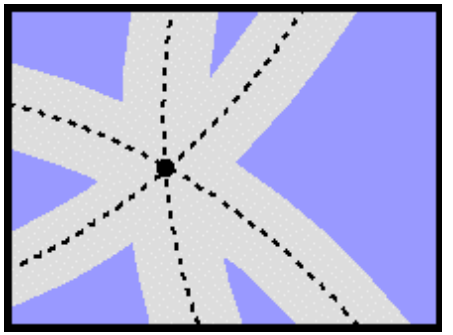
GPS-How far are you from the satelite?

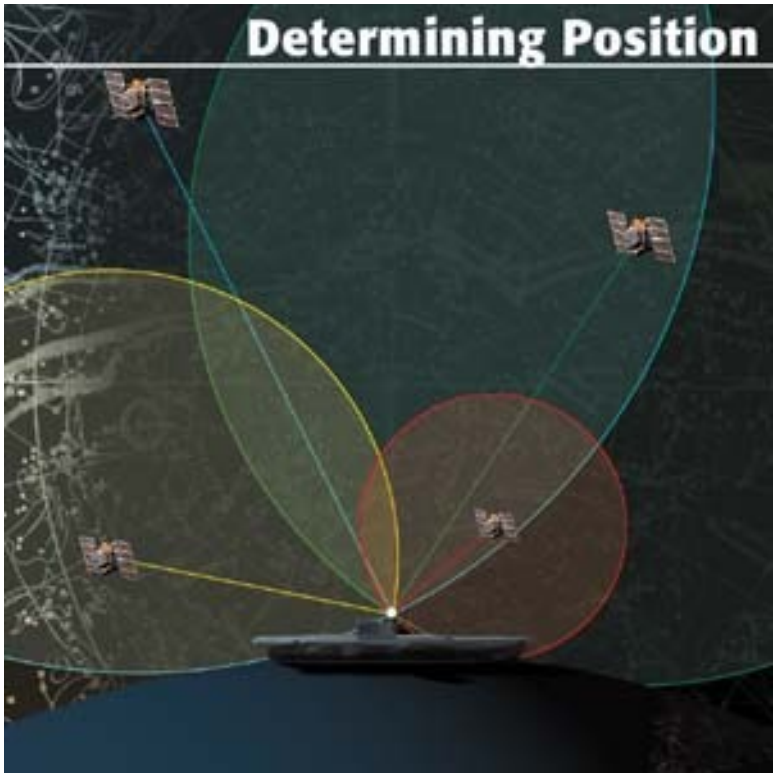
- Einstein says that space and time are actually one, which is called as spacetime. The calculation is actually complex (but let the physics guys take it)
- Let's make it easy:
  - The satelites have atomic clock
  - We have clock
  - Imagine the satelites broadcast the time of it's clock (and position) everytime
  - You got 11.04 AM from a satelite, while it is now 11.34. The velocity of the radio wave is 300 m/s. How far are you from the satelite?



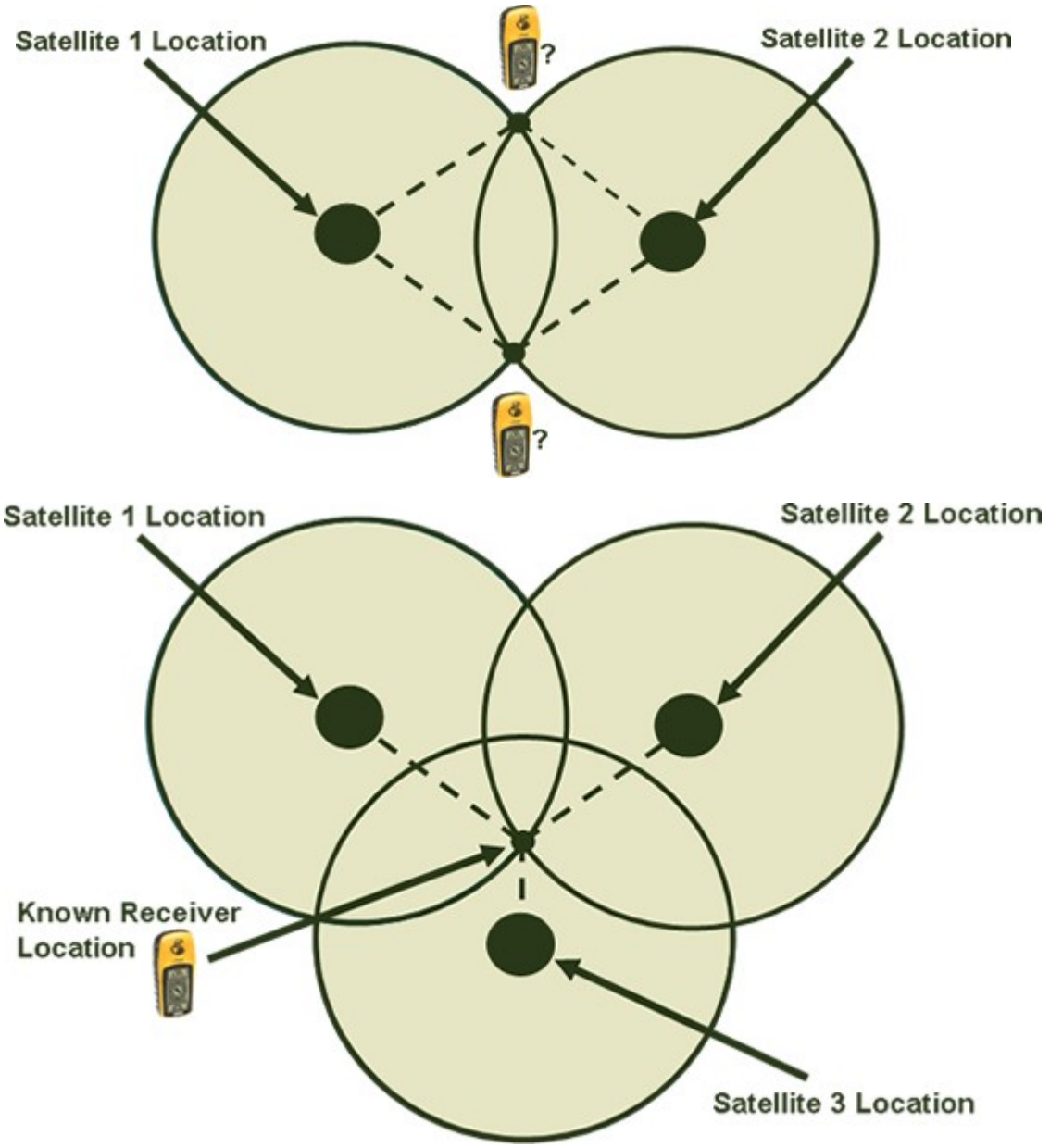
GPS-Know Your Position

- The satelites position are determined. There are complex calculation for it. For now, just accept as is.
- By receiving signals from 3 satelites we can calculate the intersection of 3 circles and determine our position.
- A bit math
  - Do you remember this formula :
    - x^2 + y^2 = r^2 ← (x,y) is position, r is radius.
  - How do you find “intersection” between two lines equations?

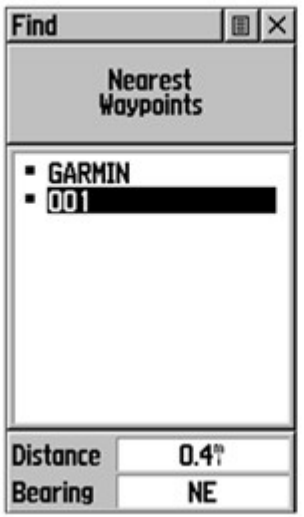


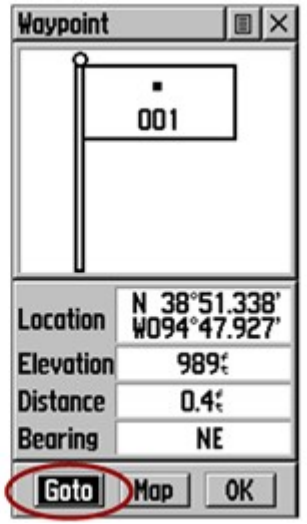


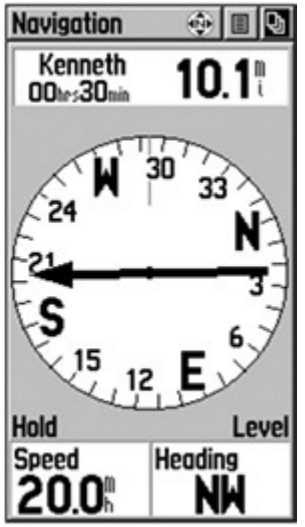
GPS-Know Your Position



GPS-How To Use





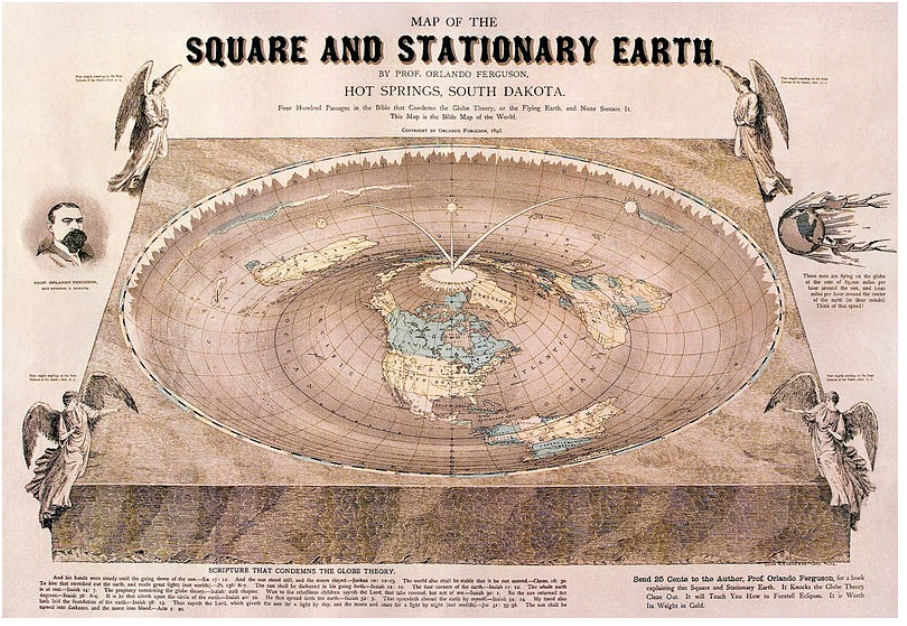


GPS-How accurate is it?

- Satelites have atomic clocks. It is pretty accurate (if you ignore Einstein relativity theory)
- Your GPS receiver doesn't have atomic clock, the time can be different. There can be a big uncertainty.
- Some reports that GPS has kilometers accuracy, some others reports that it has meters accuracy.

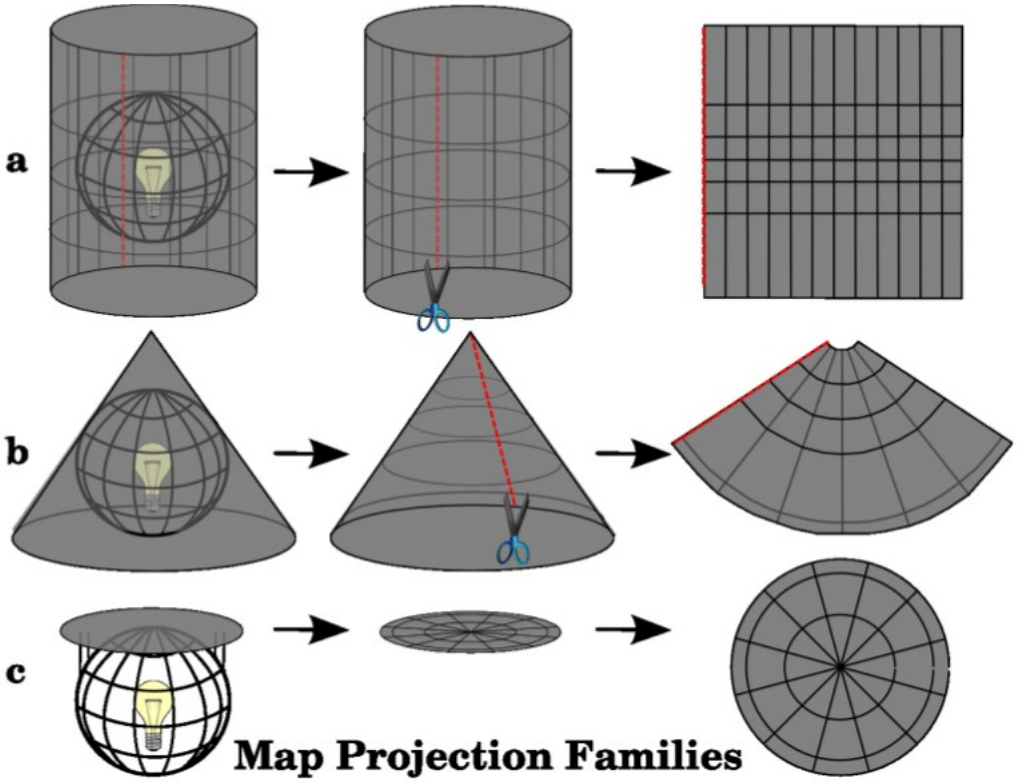
Flat Earth Theory

- Our ancestor thinks that earth is flat
- Some scientist found that earth is not flat
- Bad news: Now we need some complicated projection technique to draw the earth surface in the flat paper map.



Draw the Earth Surface

- In a marble-like surface : Globe
  - It is less portable rather than maps with the same ratio
- In a flat surface : Map
  - Projection needed
    - Cylindrical
    - Conical
    - Planar

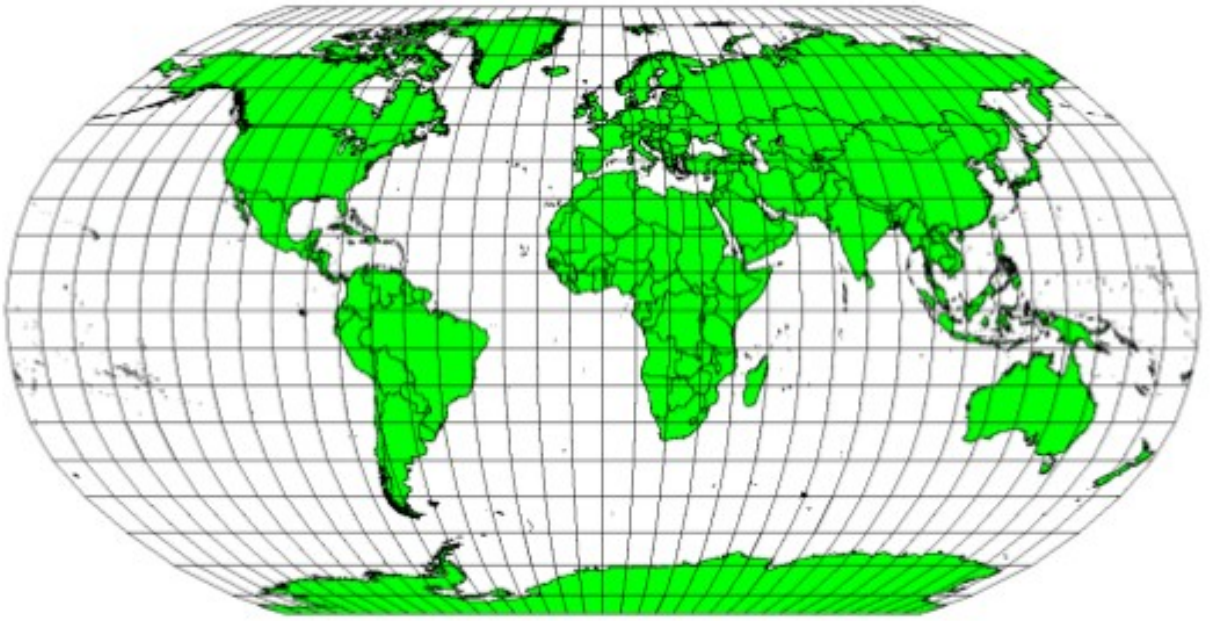


Something to think of

- Someone walks 3 meters to the north. Next he walks 7 meters to the east. And last he walks 3 meters to the south. Now he is in the first position as he start. How could that be?
- Googling for worldmap, locate Greenland and Australia. Which one is larger? Why is Greenland considered as island while Australia considered as continent?

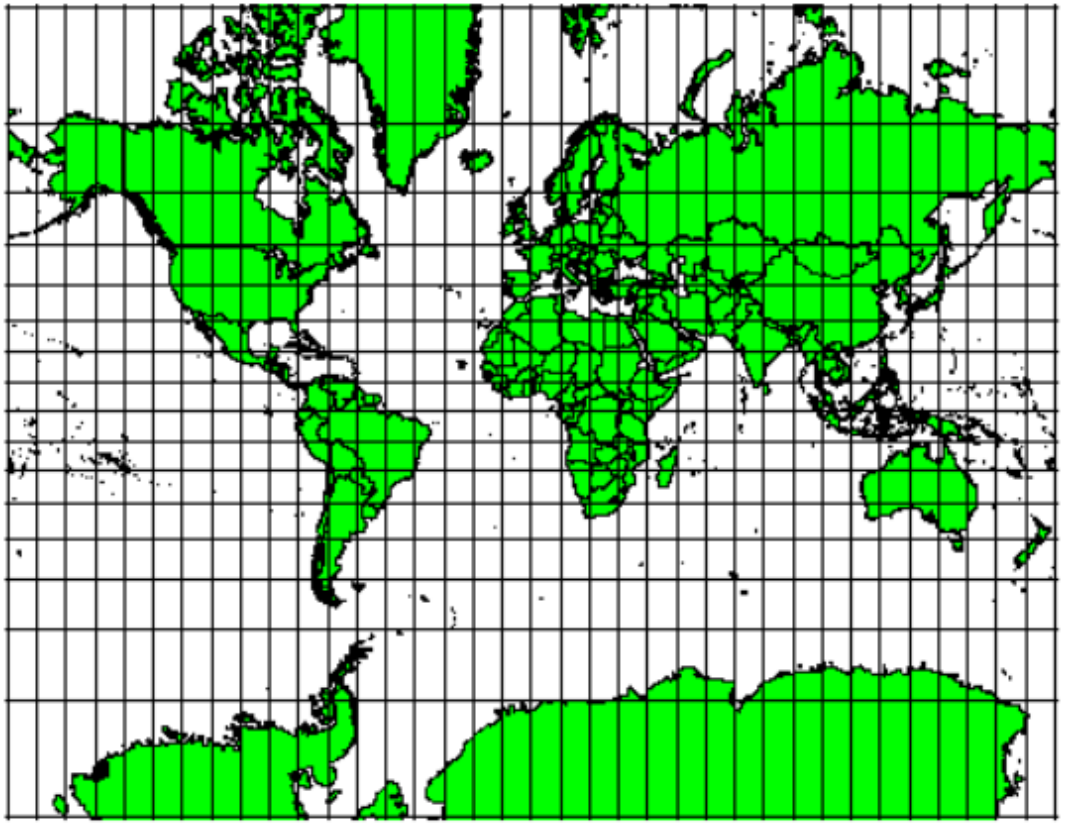
Map Projection Accuracy

- The projection may has different properties rather than the real earth projected
  - Angular Conformity (e.g : angular between east and north is 90 degree)
  - Distance
  - Area



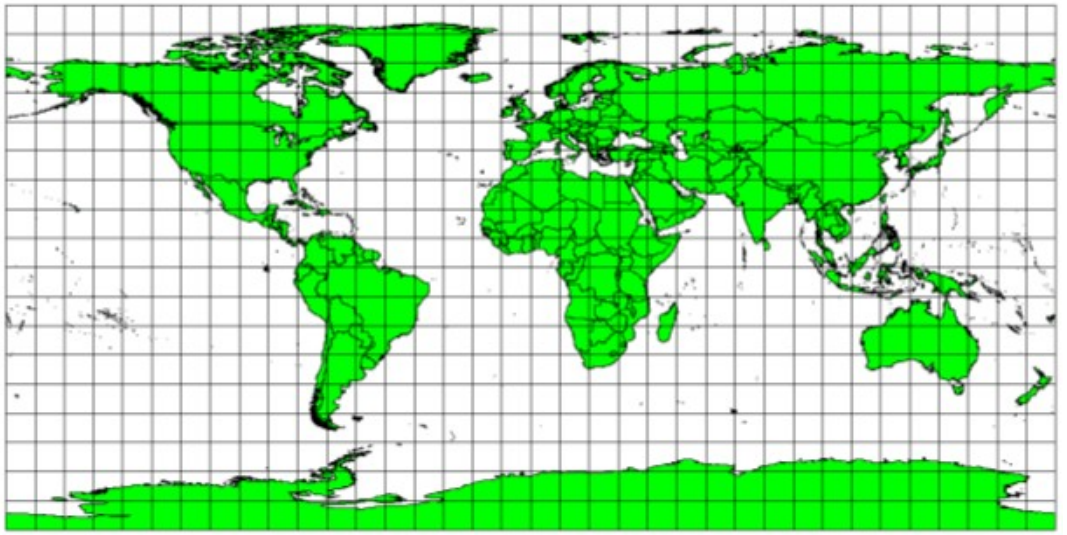
Map Projection With Angular Conformity

- It is hard to maintain angular conformity for large area.
- Keep angular conformity means take away distance and area accuracy
- e.g : Mercator projection



Map projection with equal distance

- Keep the distance accurate means put angular conformity away



Map projection with equal area

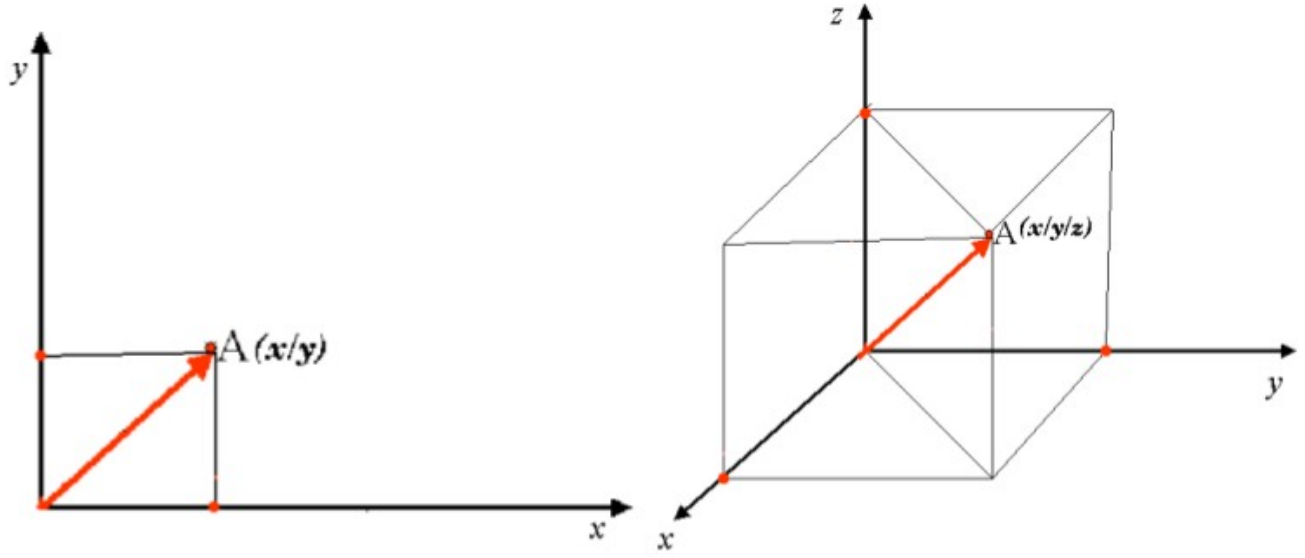
- Keep the area equal means put angular conformity away
- e.g: Lambert, Mollweide

On the fly-Projection

- In the case of we have different vector layers with different map projection, we need to choose one projection to be used by all layers. It is called on the fly projection

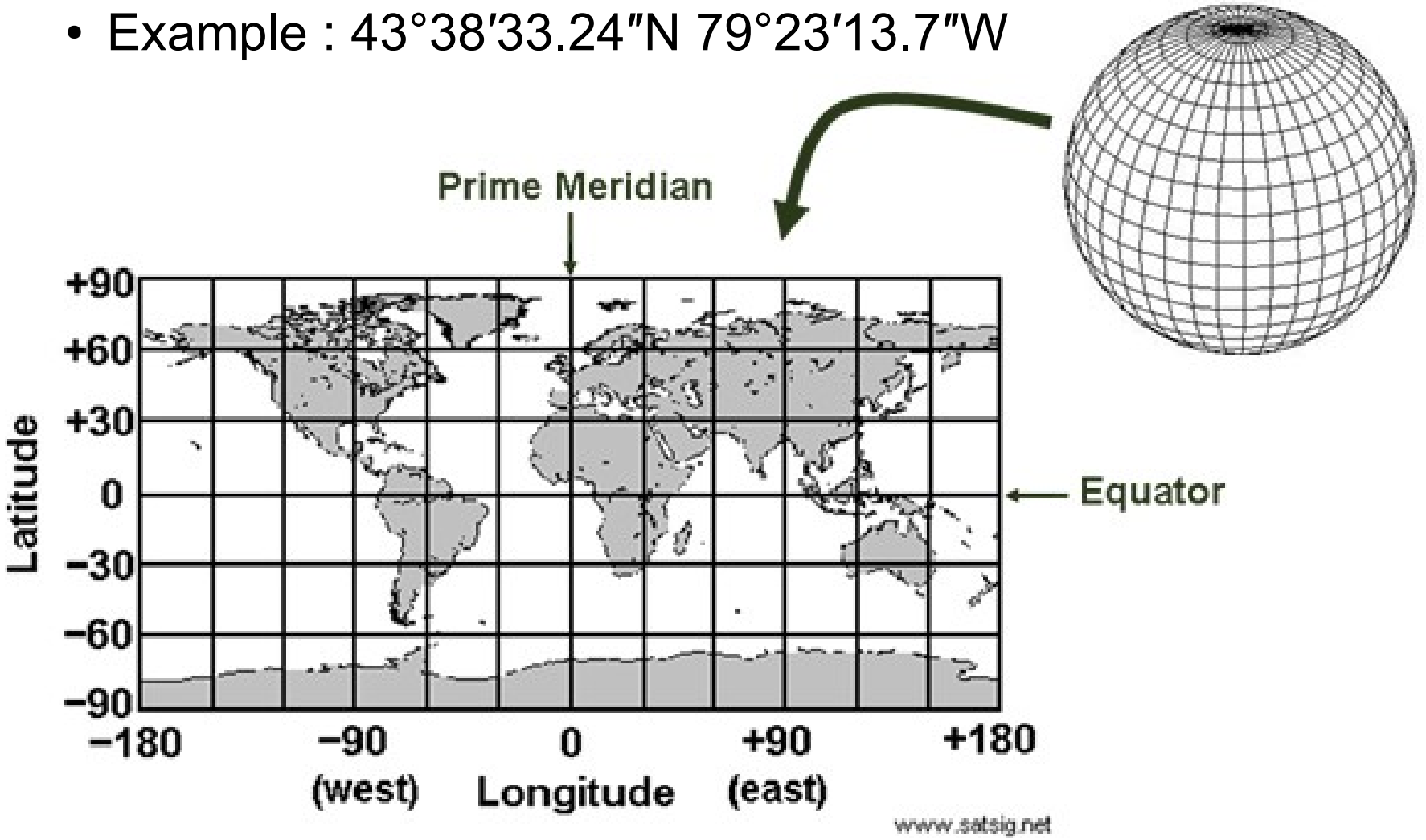
Coordinate Reference System

- It is basically an x-y coordinate system
- We need an absolute reference point
- We will talk about 2 methods
  - Geographic Reference System (WG 84)
  - Universal Transverse Mercator (UTM)



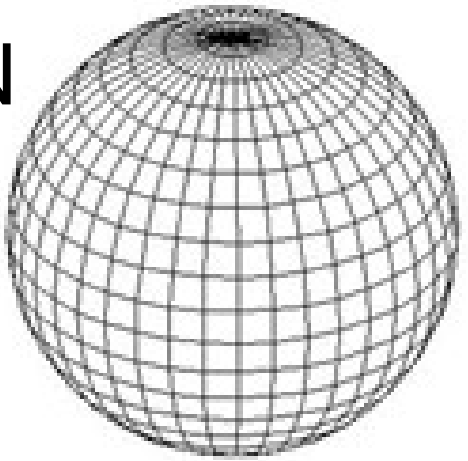
Geographic Reference System

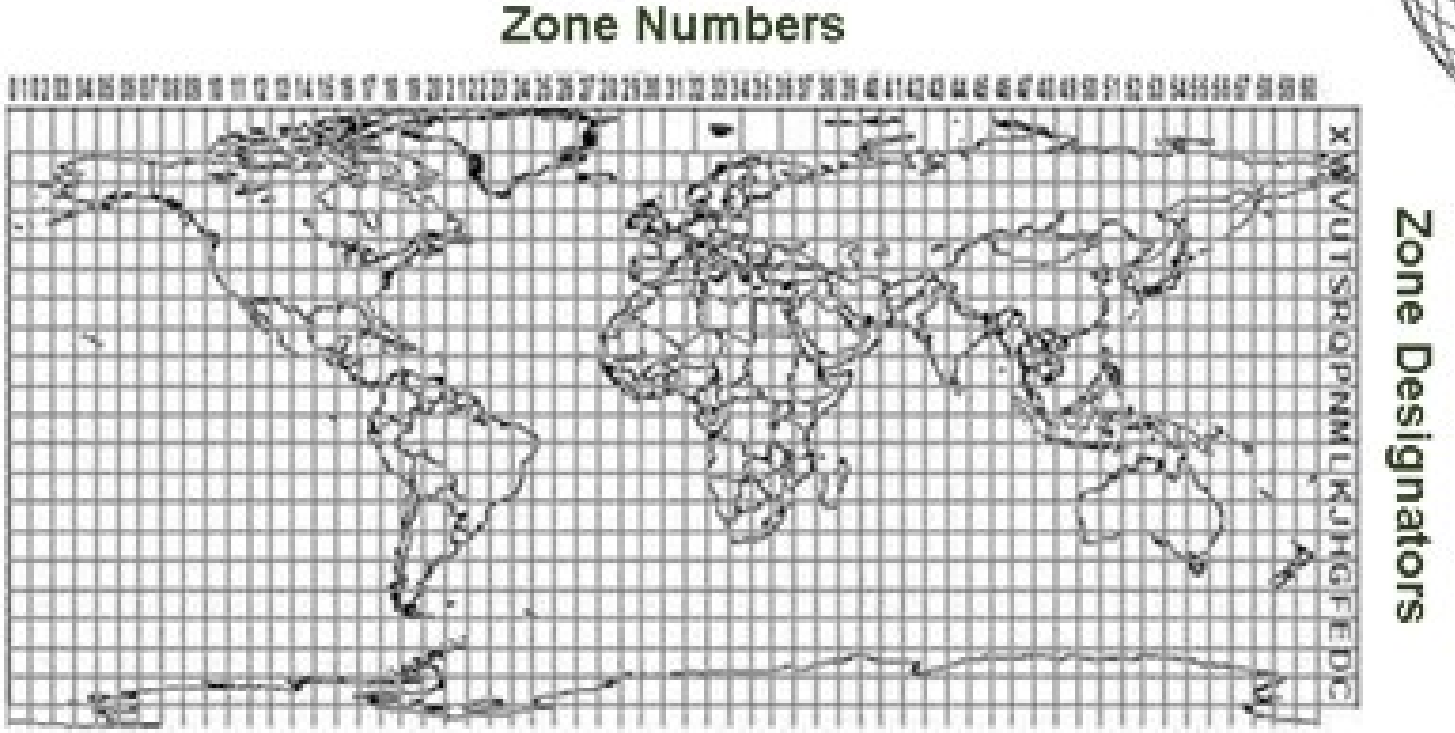
- Example : 43°38′33.24″N 79°23′13.7″W



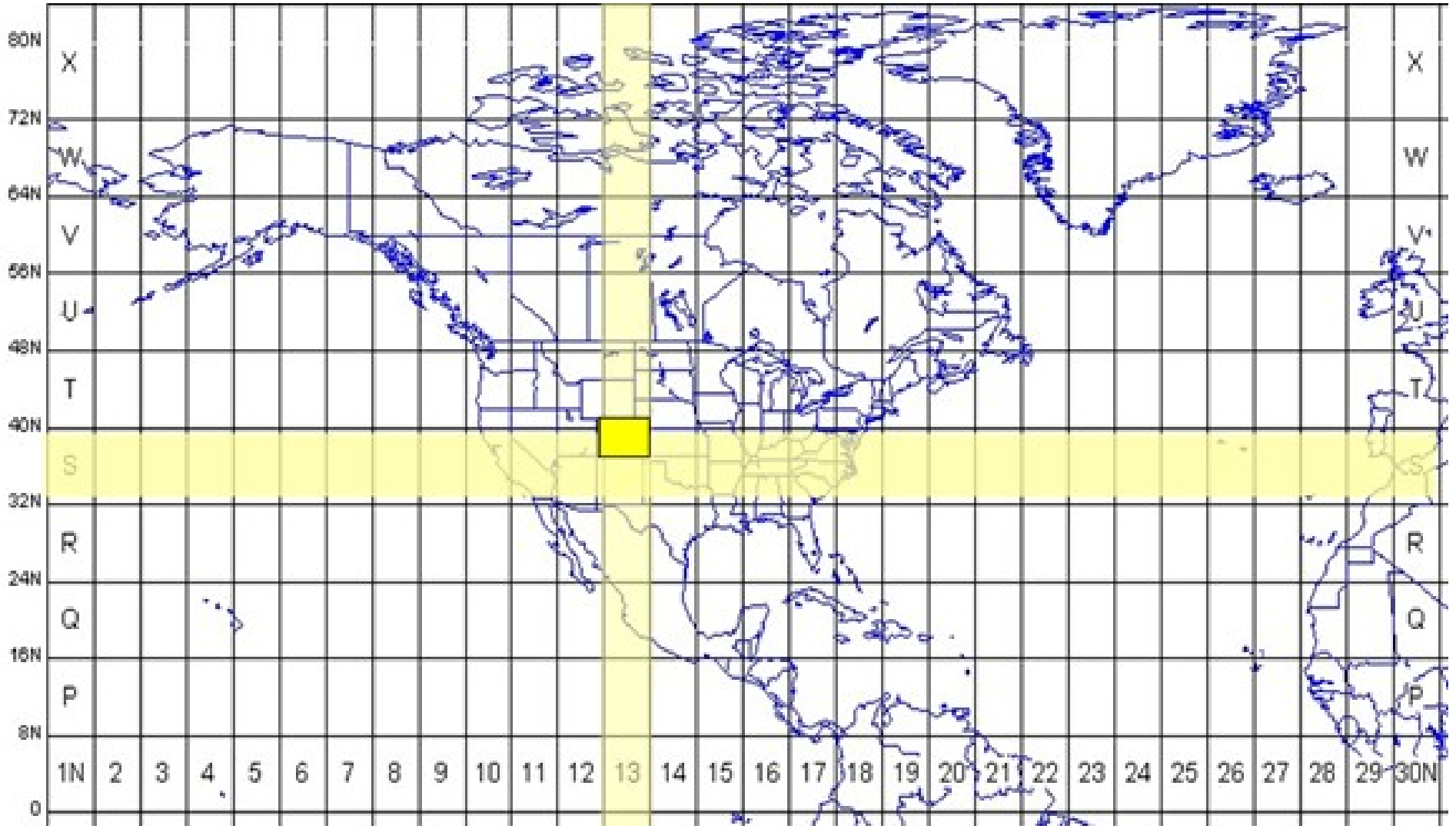
UTM (Universal Transverse Mercator)

- Example 17T 630084E 4833438N





UTM area


80N
72N
64N
56N
48N
40N
32N
24N
16N
8N
0
X
W
V
U
T
S
R
Q
P
1N 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30N

UTM in Detail

- A position on the Earth is given by the **UTM zone number** and the **easting** and **northing** coordinate pair in that zone.
- The point of origin of each UTM zone is the intersection of the **equator** and the **zone's central meridian**, but to avoid dealing with negative numbers **the central meridian of each zone is set at 500,000 meters East**. In any zone a point that has Easting 400,000 meters is 100 km west of the central meridian, measured on the transverse Mercator projection (or slightly more than 100 km measured on the actual surface of the earth). UTM eastings range from 167,000 meters to 833,000 meters at the equator (the range narrows towards the poles).
- In the **northern hemisphere** positions are measured **northward from zero** at the equator; the maximum "northing" value is about 10,000,000 meters at latitude 84 degrees, the north end of the UTM zones. In the **southern hemisphere northings decrease southward from the equator;** northing at the **equator is set at 10,000,000 meters** so no point has a negative northing value.

Thank you ...

ありがとう ...

谢谢 ...