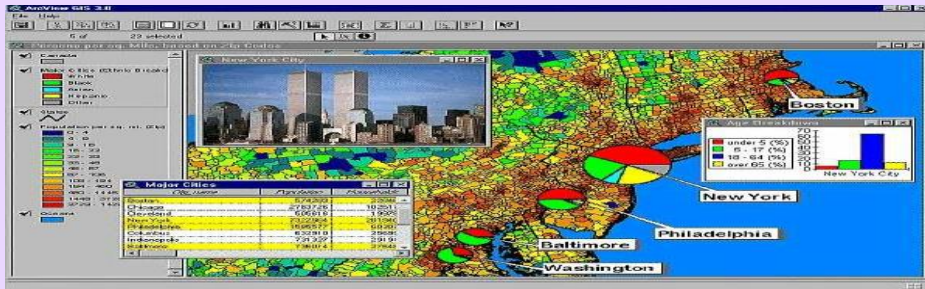


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Faculty of Agriculture

Soil Science Department

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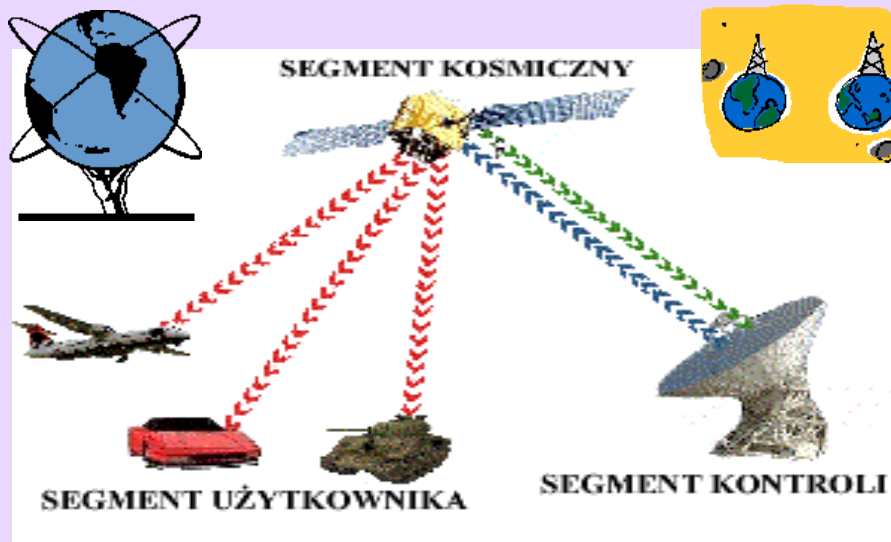
# Geographic Information Systems {GIS}

Geographical Information Systems – GIS

Dr. Ibraheem Yousif

Cairo University

## Global Positioning System (GPS)



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## The History of GPS

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- Feasibility studies begun in 1960's.
- Pentagon appropriates funding in 1973.
- First satellite launched in 1978.
- System declared fully operational in April, 1995.



## GPS

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- Stands for Global Positioning System
- GPS is used to get an exact location on or above the surface of the earth (1cm to 100m accuracy).
- Developed by DoD and made available to public in 1983.
- GPS is a very important data input source.
- GPS is one of two (soon to be more) GNSS – Global Navigation Satellite System

## GNSS : Global Navigation Satellite System

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- NAVSTAR – U.S. DoD (“GPS”)
- European Galileo Positioning System – upcoming.
- Chinese COMPASS navigation system – proposed.
- Indian IRNSS.
- French DORIS.
- GPS and GLONASS are free to use!



## GPS Uses

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- Trimble Navigation Ltd., breaks GPS uses into five categories:
  - Location – positioning things in space
  - Navigation – getting from point a to point b
  - Tracking - monitoring movements
  - Mapping – creating maps based on those positions
  - Timing – precision global timing

## GPS Uses

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- **Agriculture**
- **Surveying**
- **Navigation (air, sea, land)**
- **Engineering**
- **Military operations**
- **Unmanned vehicle guidance**
- **Mapping**



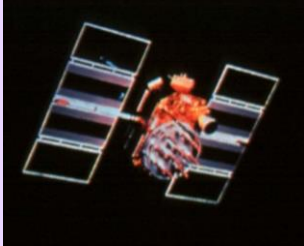
## GPS Uses

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- Here are just a few **mapping** examples:
  - Centerlines of roads
  - Hydrologic features (over time)
  - Bird nest/colony locations (over time)
  - Fire perimeters
  - Trail maps
  - Geologic/mining maps
  - Vegetation and habitat



## Characteristics of GPS

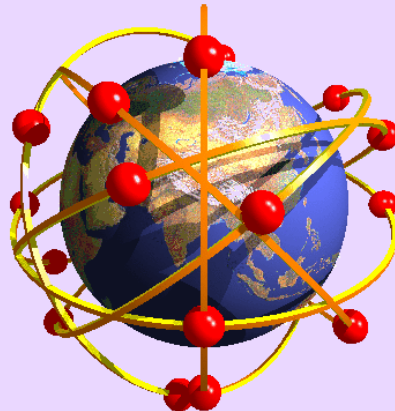


- **Free**
- **Precise**
- **Reliable**
- **All weather**
- **Anytime & anywhere**
- **Unlimited user capacity**

Almost!

## The Global Positioning System GPS

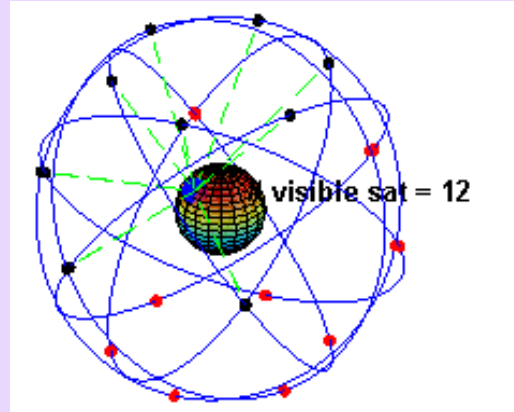
- A satellite-based positioning system available **24/24h** everywhere on the globe with an accuracy better than 100 m.



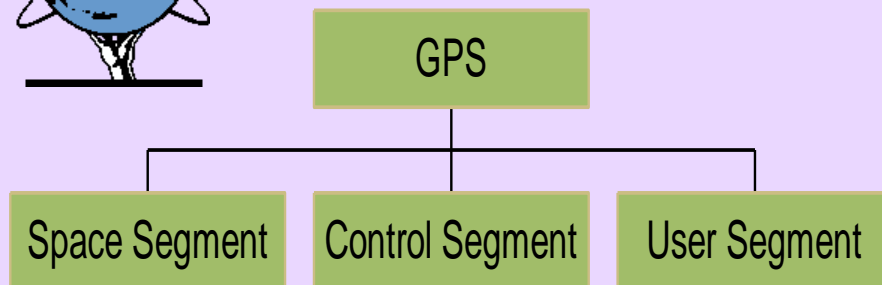
## The Global Positioning System GPS

➤ Originally designed for navigation and real-time positioning (**meter-level** accuracy): navigation (airplanes, ships, car, missiles, etc...)

➤ It is also capable of **mm-level** accuracy, with **important** scientific “by-products”:



## Components of the GPS



# Segments of GPS



## 1. Space Segment

*A constellation of 24 satellites*

## 2. Monitor Station

*A network of earth-based facilities*



## 3. Users & Equipment

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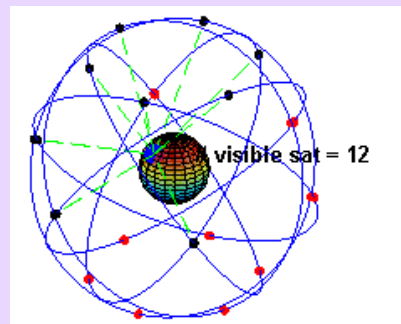
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Source: Trimble

# Three “segments”

- 1. The space segment= satellites:** Broadcast radio signals toward users on the Earth–Receive commands from the ground.
- 2. The control segment:** monitors the space segment and send commands to satellites.
- 3. The user segment:** receivers record and interpret the radio signals broadcast by the satellites

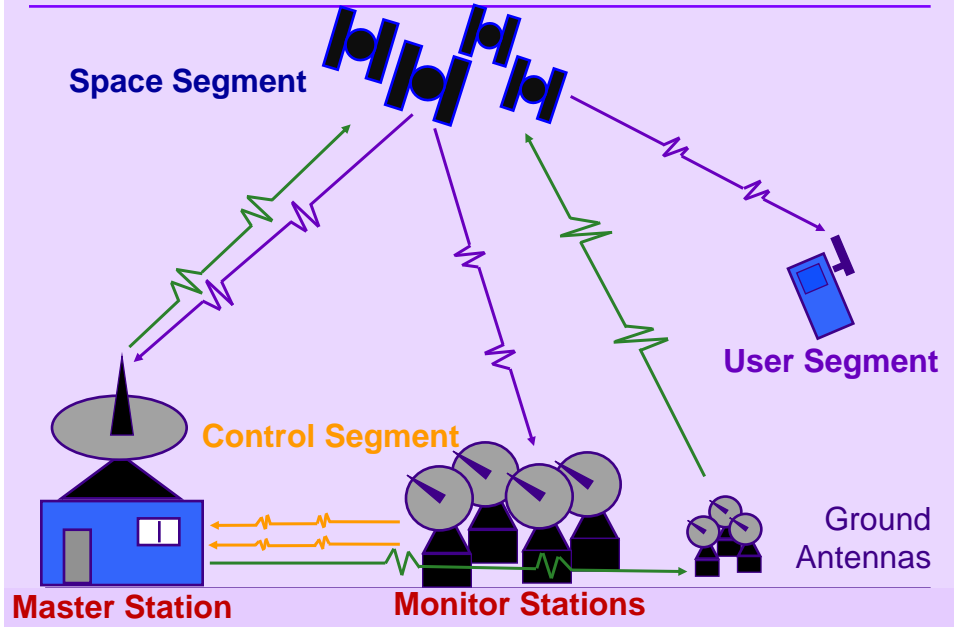


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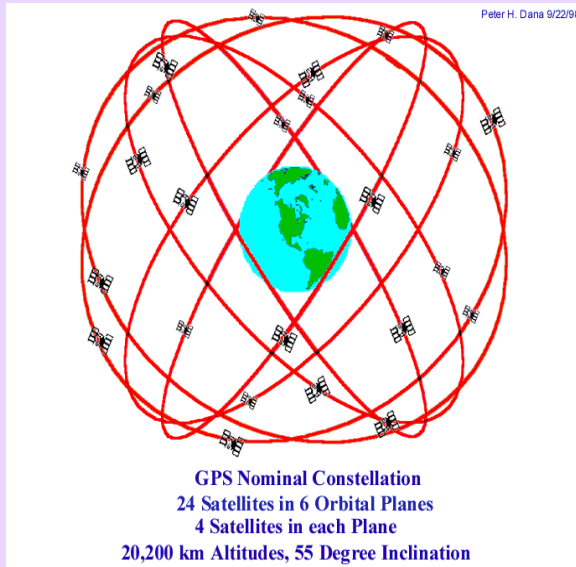
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## Three Segments of the GPS



## GPS components

### Space segment



## Control Segment

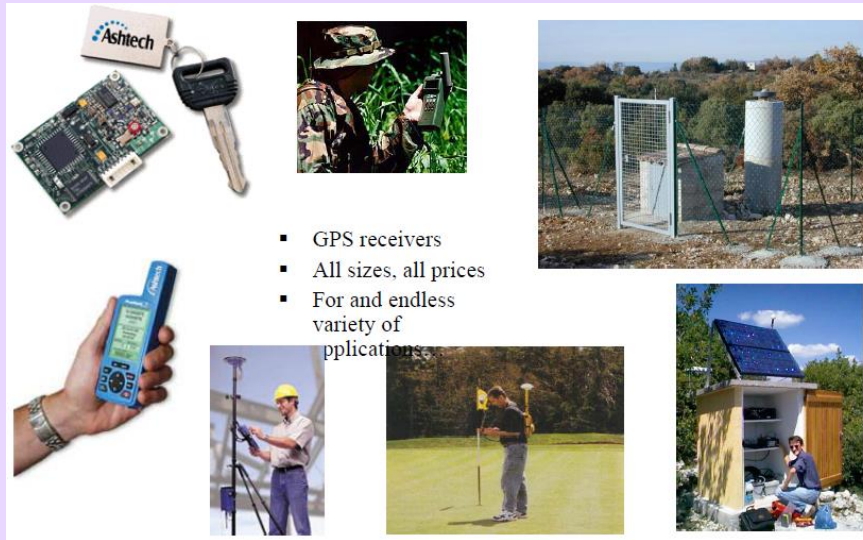


★ Master Control Station   
 ◆ Monitor Station   
 ▲ Ground Antenna

## GPS Monitoring Station



## User segment



- GPS receivers
- All sizes, all prices
- For an endless variety of applications

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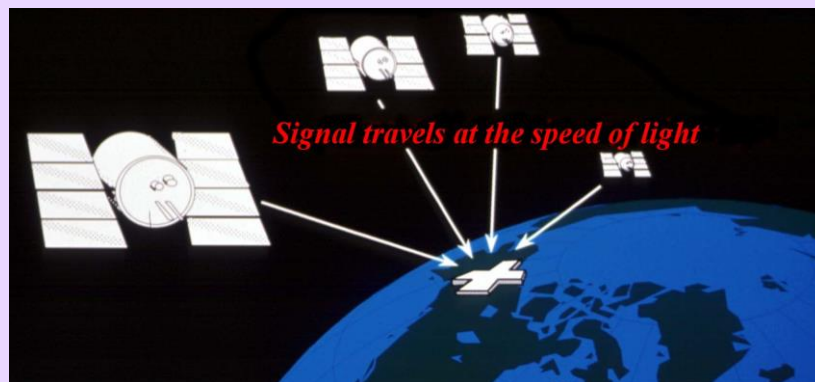
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## How GPS Works .....

Uses measurements from 4+ satellites

Distance = travel time x speed of light



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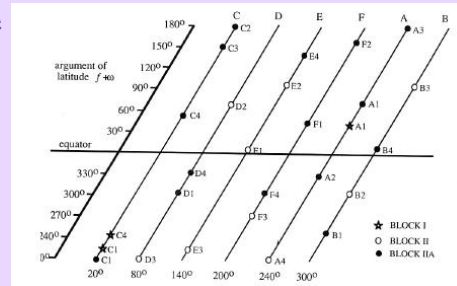
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Source: Trimble

## Orbital constellation

- **27** satellites (**24** operational + **3** spares) in circular orbits,
- mean altitude **20200** km–
- **6** evenly spaced orbital planes (**A to F**), inclination **55°**.
- **4-6** satellites per plane.
- In practice, **6-12** satellites are visible simultaneously.



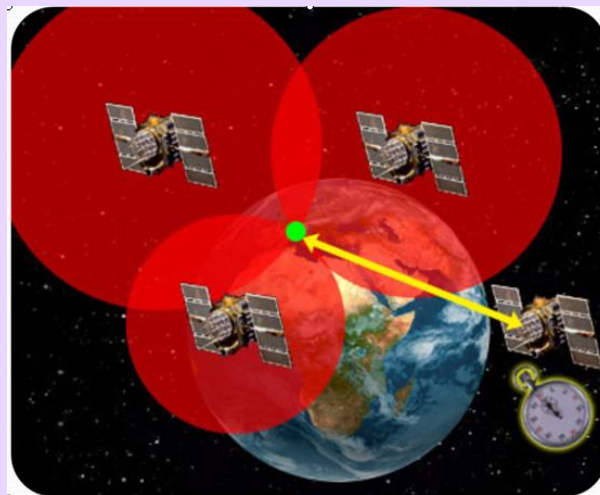
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## Trilateration

Intersection of spheres



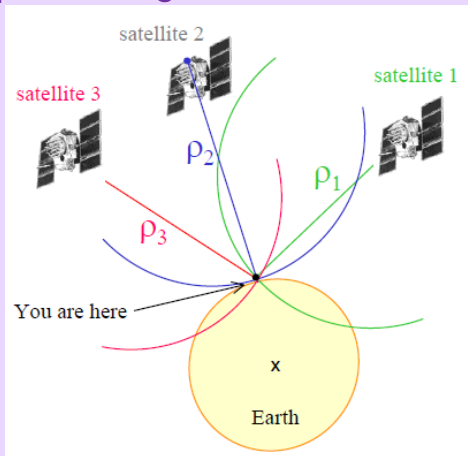
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## Principle of GPS positioning

- Satellite 1 sends a signal at time  $t_{e1}$ —Ground receiver receives it signal at time  $t_r$ —The range measurement  $\rho_1$  to satellite 1 is:
- **$\rho_1 = (t_r - t_{e1}) \times \text{speed of light}$**
- We are therefore located on a sphere with radius  $\rho_1$  centered on satellite 1—3 satellites  $\Rightarrow$  intersection of 3 spheres



## Measuring distance to satellites

**Distance = velocity \* travel time**

Distance is about 22,000 km

- We cannot see satellites
- We cannot *measure* exact distance

Calculating distance to satellite  
Using travel time of radio signal  
Travel time = ?

***approx. 0.07 sec !***

Using radio signal to calculate distance  
This signal travels with speed of light  
Speed of light = 299,174 km/sec

## Calculating Distance

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### Velocity x Time = Distance

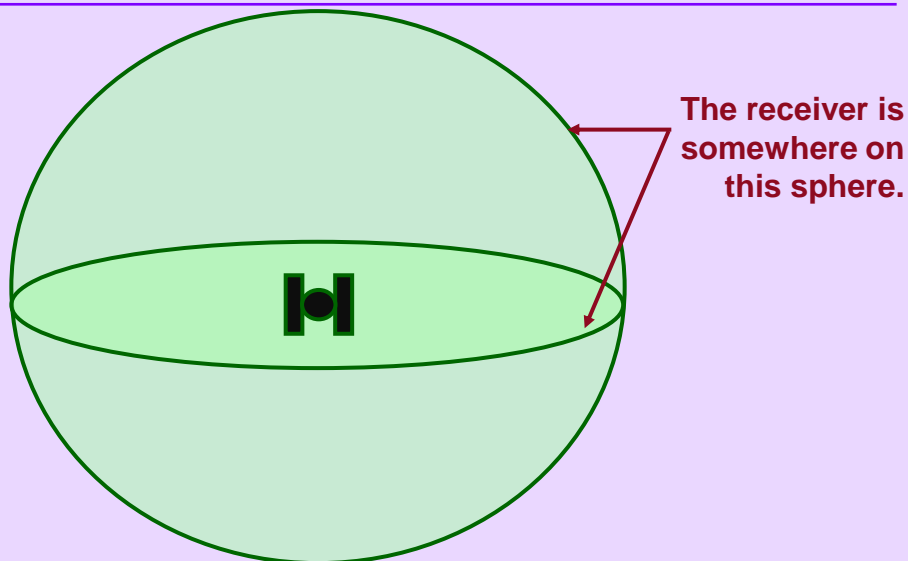
Radio waves travel at the speed of light, roughly **186,000 miles per second (mps)**

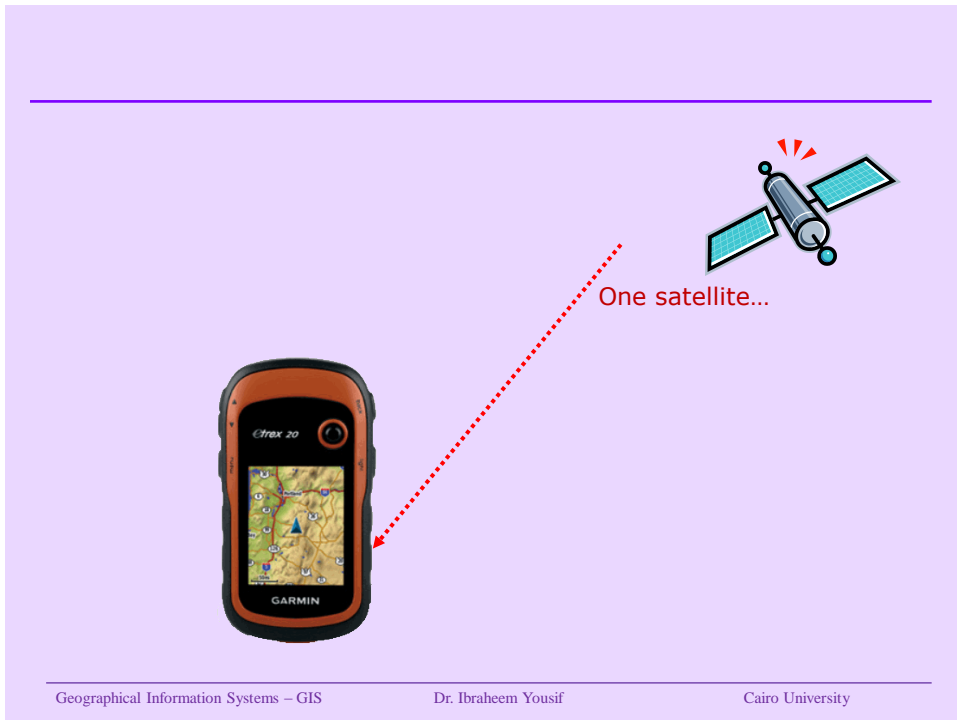
If it took 0.06 seconds to receive a signal transmitted by a satellite floating directly overhead, use this formula to find your distance from the satellite.

$$186,000 \text{ mps} \times 0.06 \text{ seconds} = 11,160 \text{ miles}$$

## Signal From One Satellite

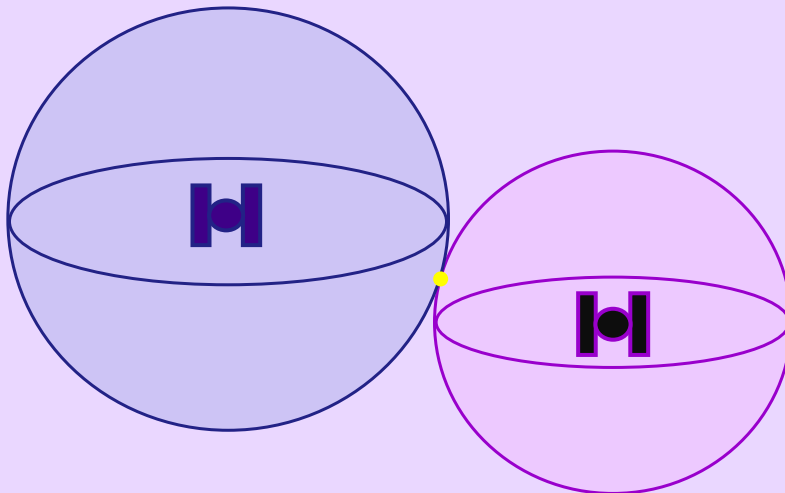
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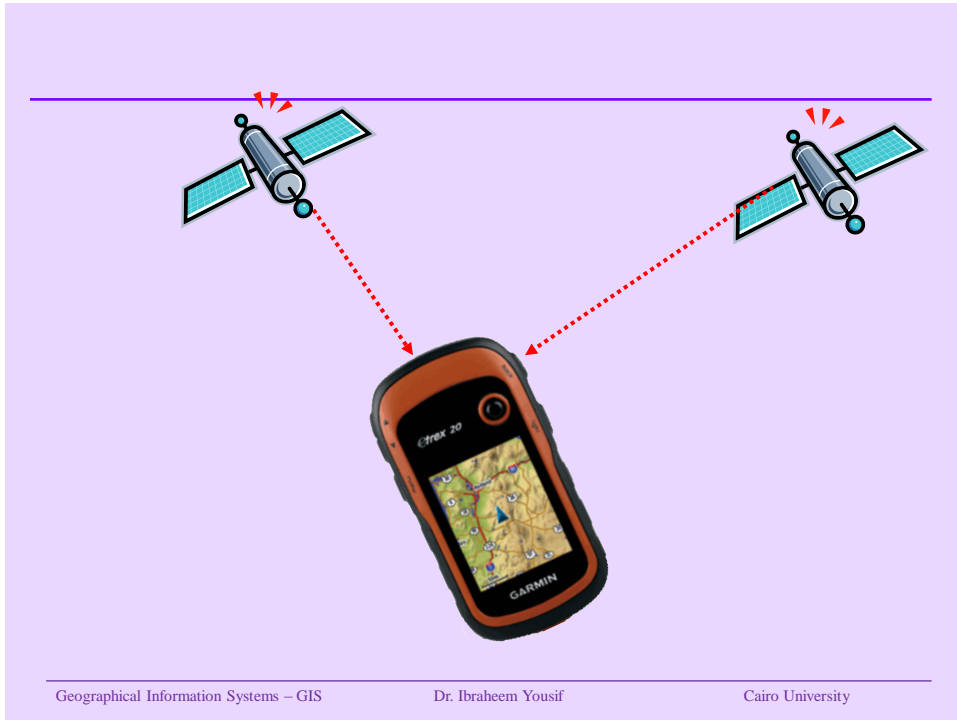




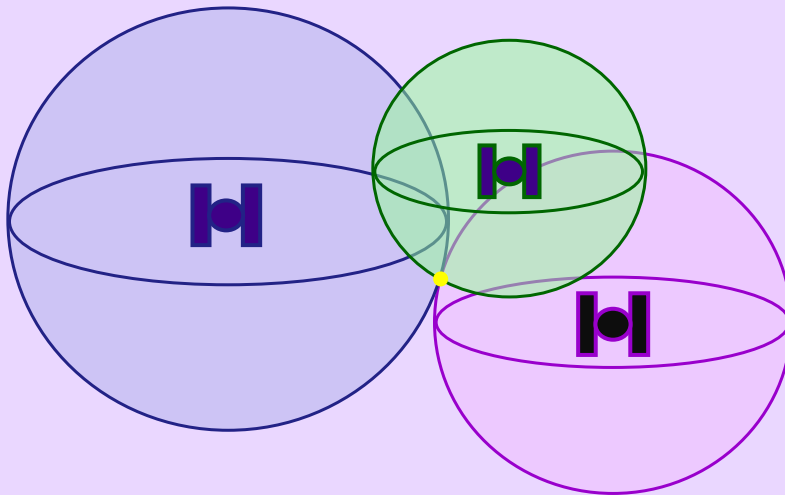
## Signals From Two Satellites

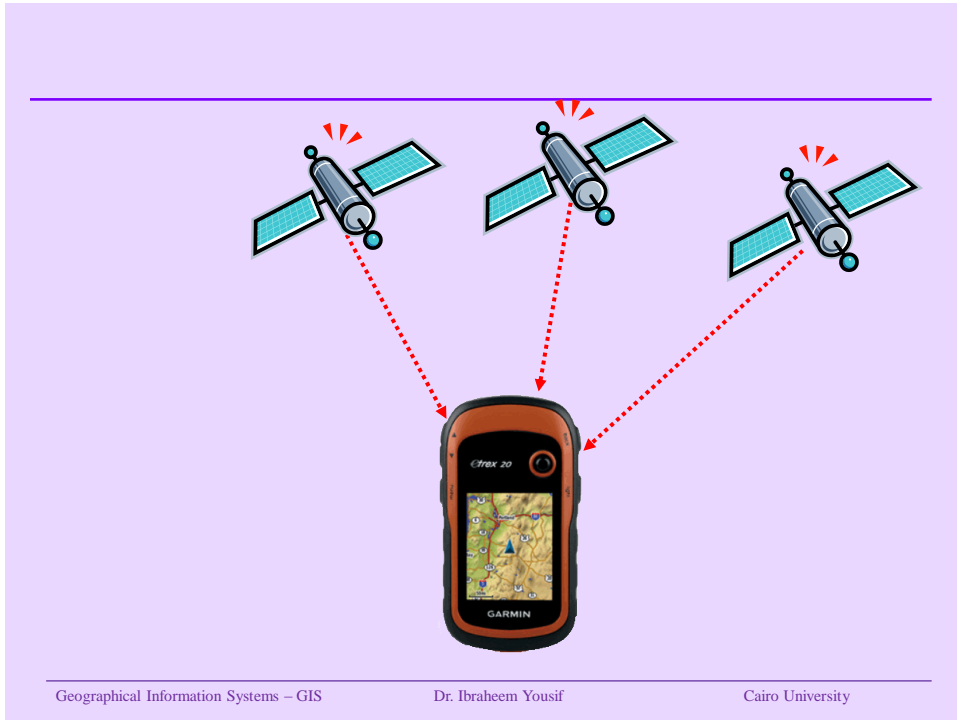
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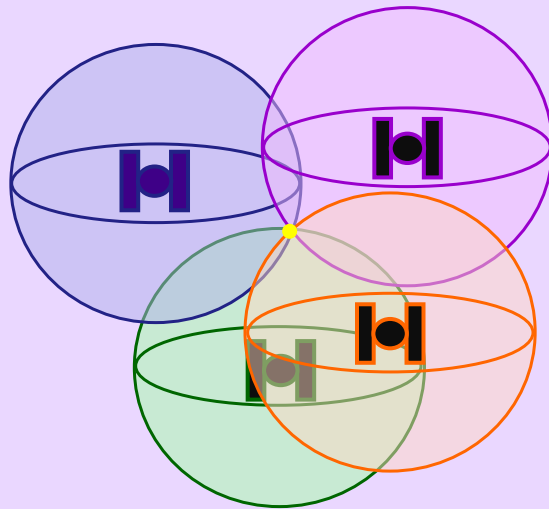


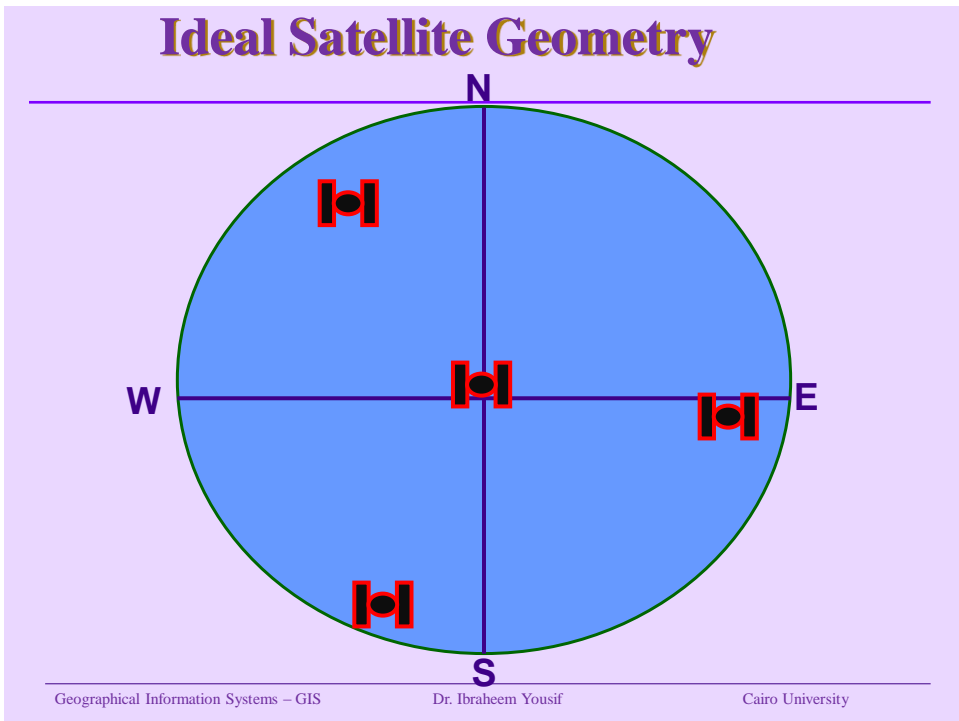
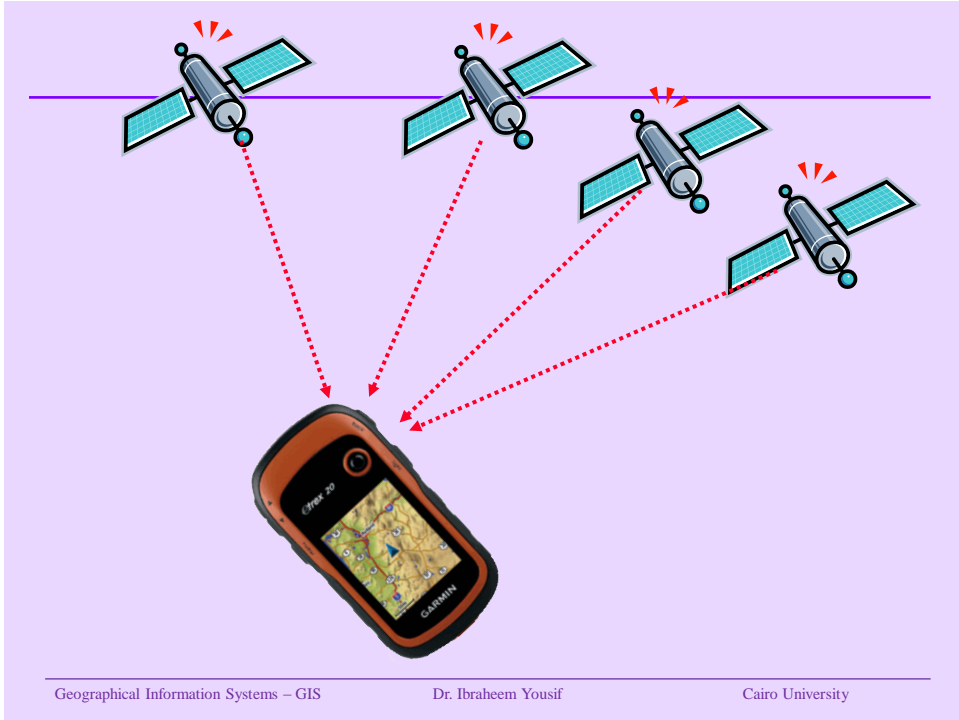
## Three Satellites (2D Positioning)



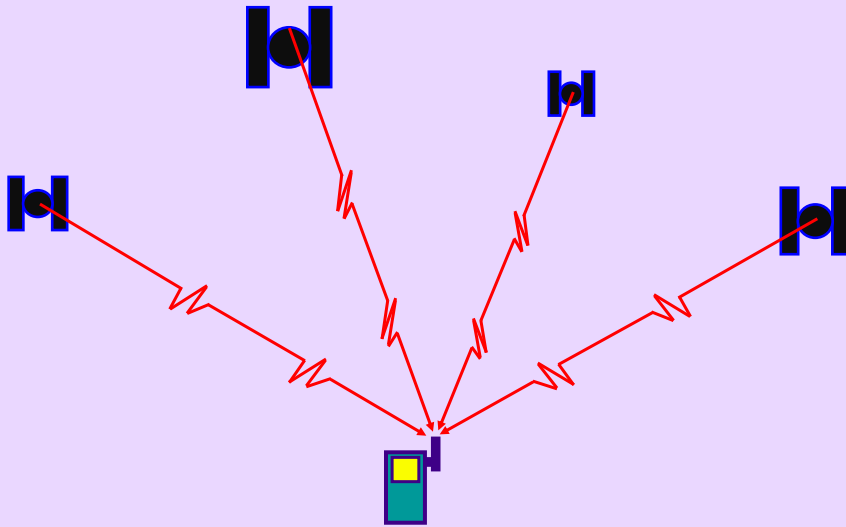


## Three Dimensional (3D) Positioning

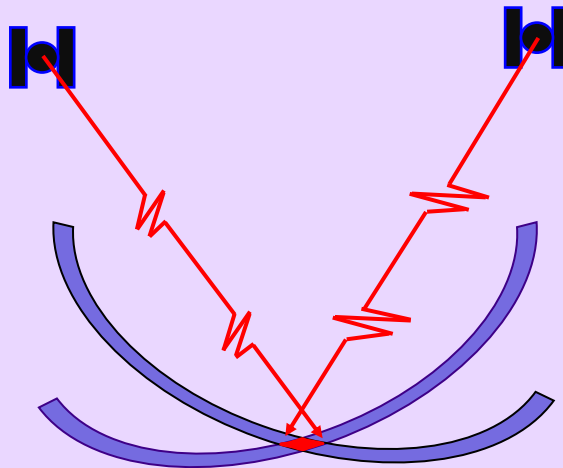


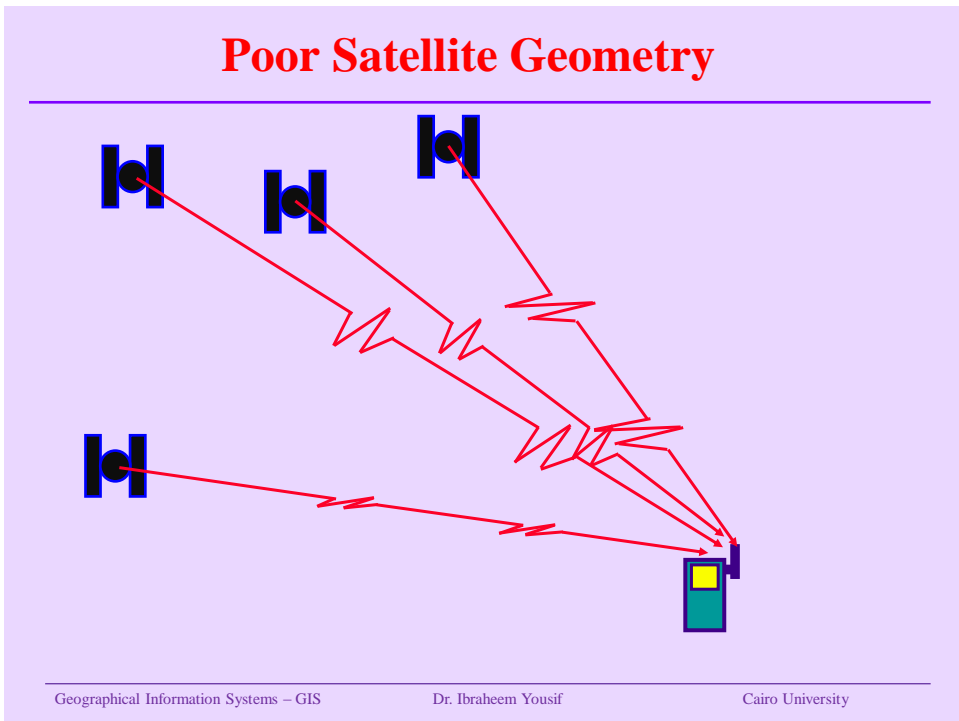
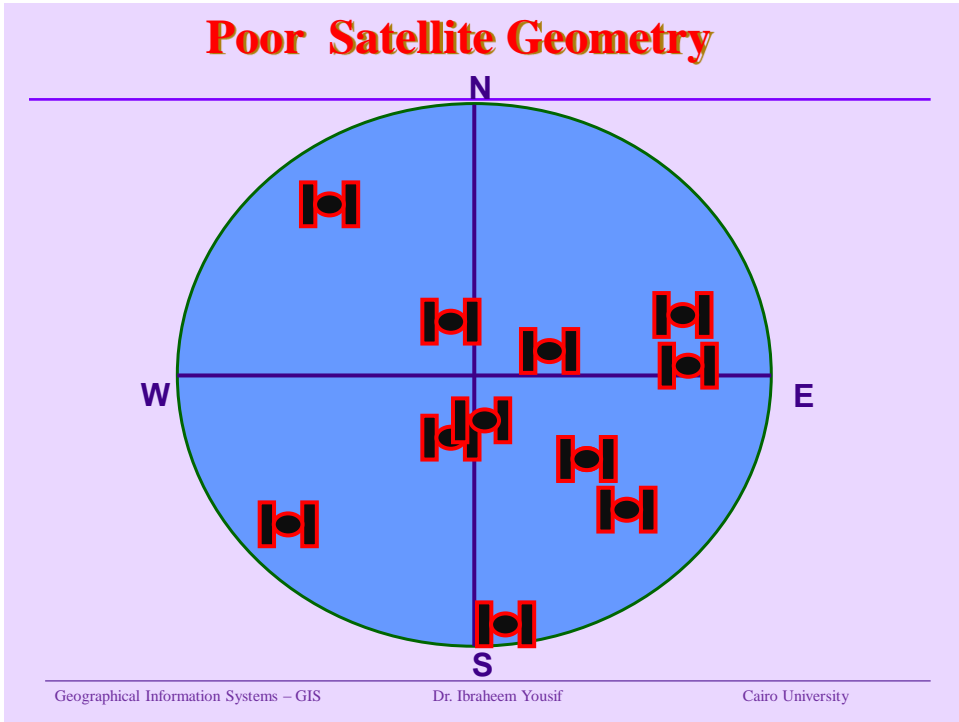


## Good Satellite Geometry

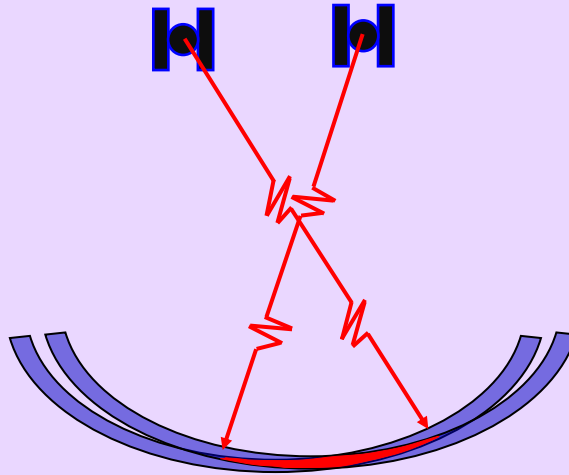


## Good Satellite Geometry

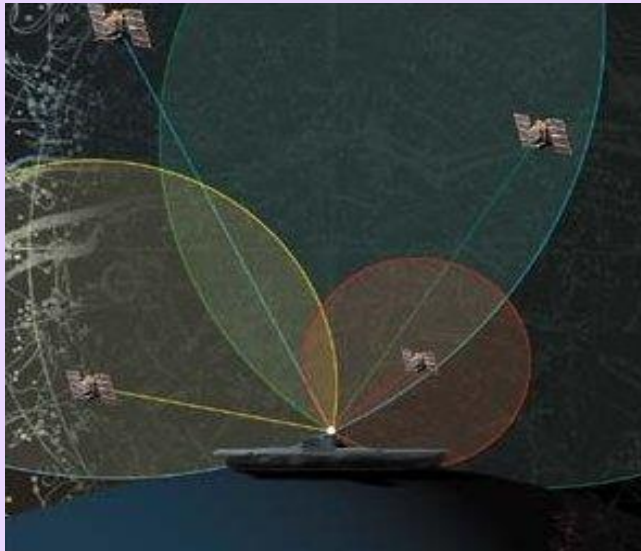




## Poor Satellite Geometry



## Determining GPS Position



## User Segment

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- **Military.**
- **Search and rescue.**
- **Disaster relief.**
- **Surveying.**
- **Marine, aeronautical and terrestrial navigation.**
- **Remote controlled vehicle and robot guidance.**
- **Satellite positioning and tracking.**
- **Shipping.**
- **Geographic Information Systems (GIS).**
- **Recreation.**

## Four Basic Functions of GPS

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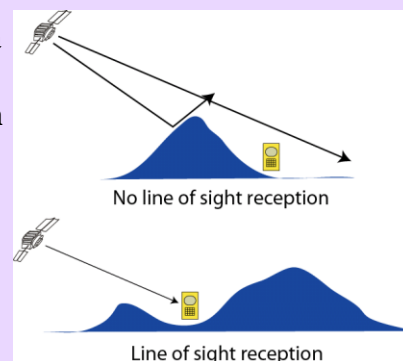
1. **Position and coordinates.**
2. **The distance and direction between any two waypoints, or a position and a waypoint.**
3. **Travel progress reports.**
4. **Accurate time measurement.**

# Sources of Error

- ◆ Gravitational effects
- ◆ Atmospheric effects
- ◆ Obstruction
- ◆ Multipath
- ◆ Satellite geometry
- ◆ Selective Availability
- ◆ Geometry of satellite positions
- ◆ Satellite clock errors
- ◆ Quality of GPS receiver

## Line of Sight Transmissions

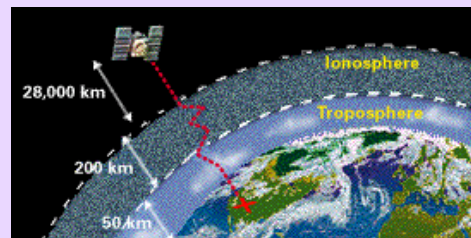
**Line of sight is the ability to draw a straight line between two objects without any other objects getting in the way. GPS transmission are line-of-sight transmissions.**



**Obstructions such as trees, buildings, or natural formations may prevent clear line of sight.**

## Errors and Accuracy

- **Gravitational** pull of other celestial bodies on the satellite, affecting orbit
- **Atmospheric effects** - signals travel at different speeds through ionosphere and troposphere.



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## Errors and Accuracy

- **Obstruction** - Signal blocked or strength reduced when passing through objects or water.

- Weather
- Metal
- Tree canopy
- Glass or plastic
- Microwave transmitters



- **Multipath** – Bouncing of signals may confuse the receiver.

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# Errors and Accuracy

- Satellite Constellation Geometry
  - Number of satellites available
  - Elevations or azimuths over time



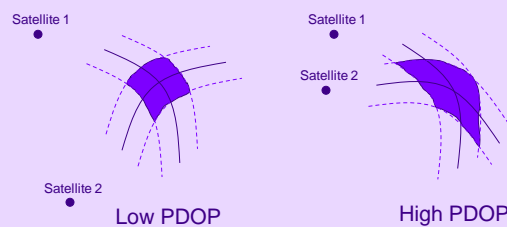
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## • PDOP

- Indicator of satellite geometry
- Accounts for location of each satellite relative to others
- Optimal accuracy when PDOP is LOW

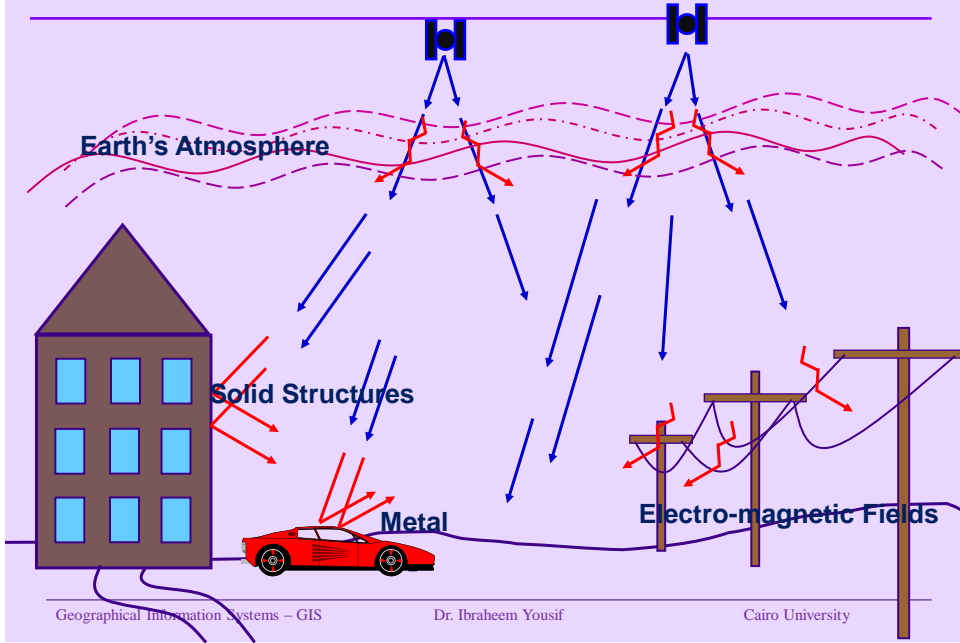


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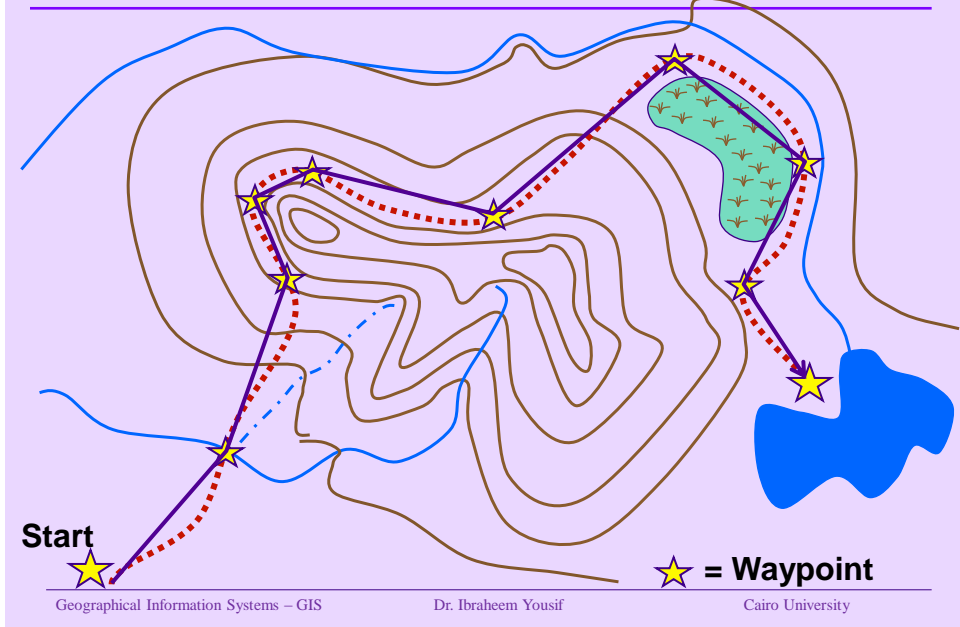
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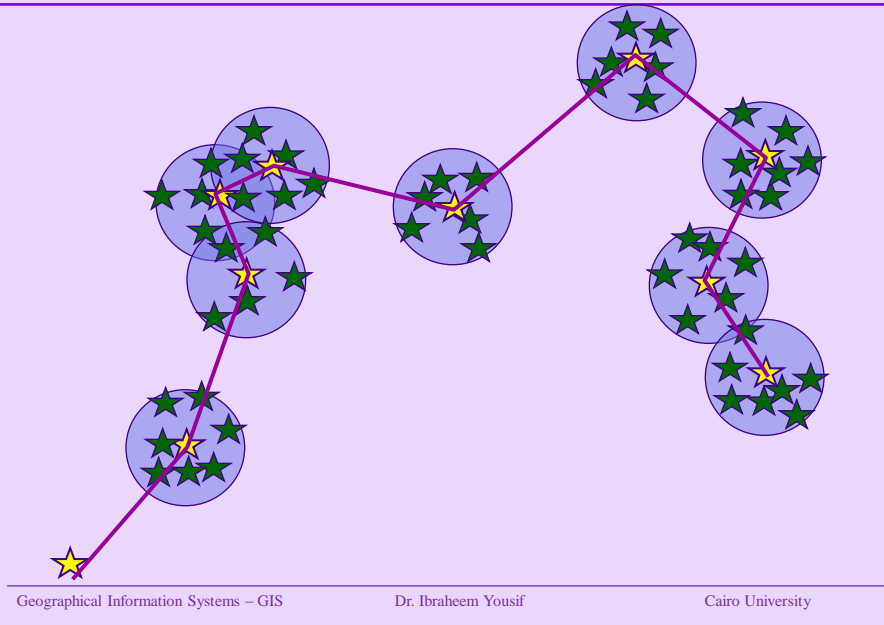
# Sources of Signal Interference



# Planning a Navigation Route



## How A Receiver Sees Your Route



## Selective Availability (S/A)

- The Defense Department dithered the satellite time message, reducing position accuracy to some GPS users.
- S/A was designed to **prevent America's enemies** from using GPS against us and our allies.
- In May 2000 the Pentagon **reduced** S/A to zero meters error.
- S/A could be **reactivated** at any time by the Pentagon.

# How accurate is GPS?

*Depends on some variables*

- **Time spent on measurement**
- **Design of receiver**
- **Postprocessing**
- **Relative positions of satellites.**

## Sources of GPS Error

### ◆ Standard Positioning Service (SPS ): Civilian Users

◆	<u>Source</u>	<u>Amount of Error</u>
➤	<b>Satellite clocks:</b>	1.5 to 3.6 meters
➤	<b>Orbital errors:</b>	< 1 meter
➤	<b>Ionosphere:</b>	5.0 to 7.0 meters
➤	<b>Troposphere:</b>	0.5 to 0.7 meters
➤	<b>Receiver noise:</b>	0.3 to 1.5 meters
➤	<b>Multipath:</b>	0.6 to 1.2 meters
➤	<b>Selective Availability</b>	(see notes)
➤	<b>User error:</b>	Up to a kilometer or more

## Advantages of GPS

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1. Fairly inexpensive
2. easy-to-use
3. Sufficient accuracy for many census mapping applications
4. high accuracy achievable with differential correction
5. Collected data can be read directly into GIS databases making intermediate data entry or data

## Disadvantages of GPS

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1. **Signal may be obstructed in dense urban or wooded areas**
2. **Standard GPS accuracy may be insufficient in urban areas making differential techniques necessary**

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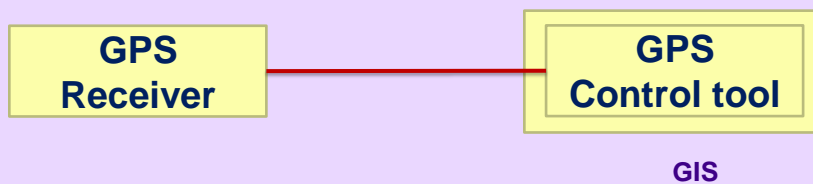
# How to connect between GPS and GIS

**1. Direct connection**

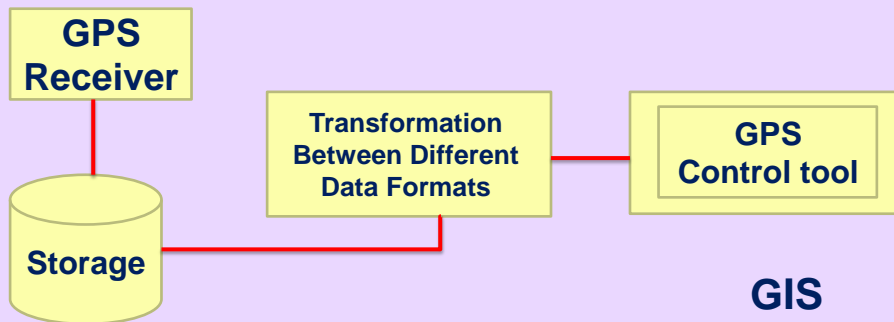
**2. Indirect connection**

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## 1. Direct connection



## 2. Indirect connection



**THANK YOU SO MUCH**