BHARATHIDASAN UNIVERSITY

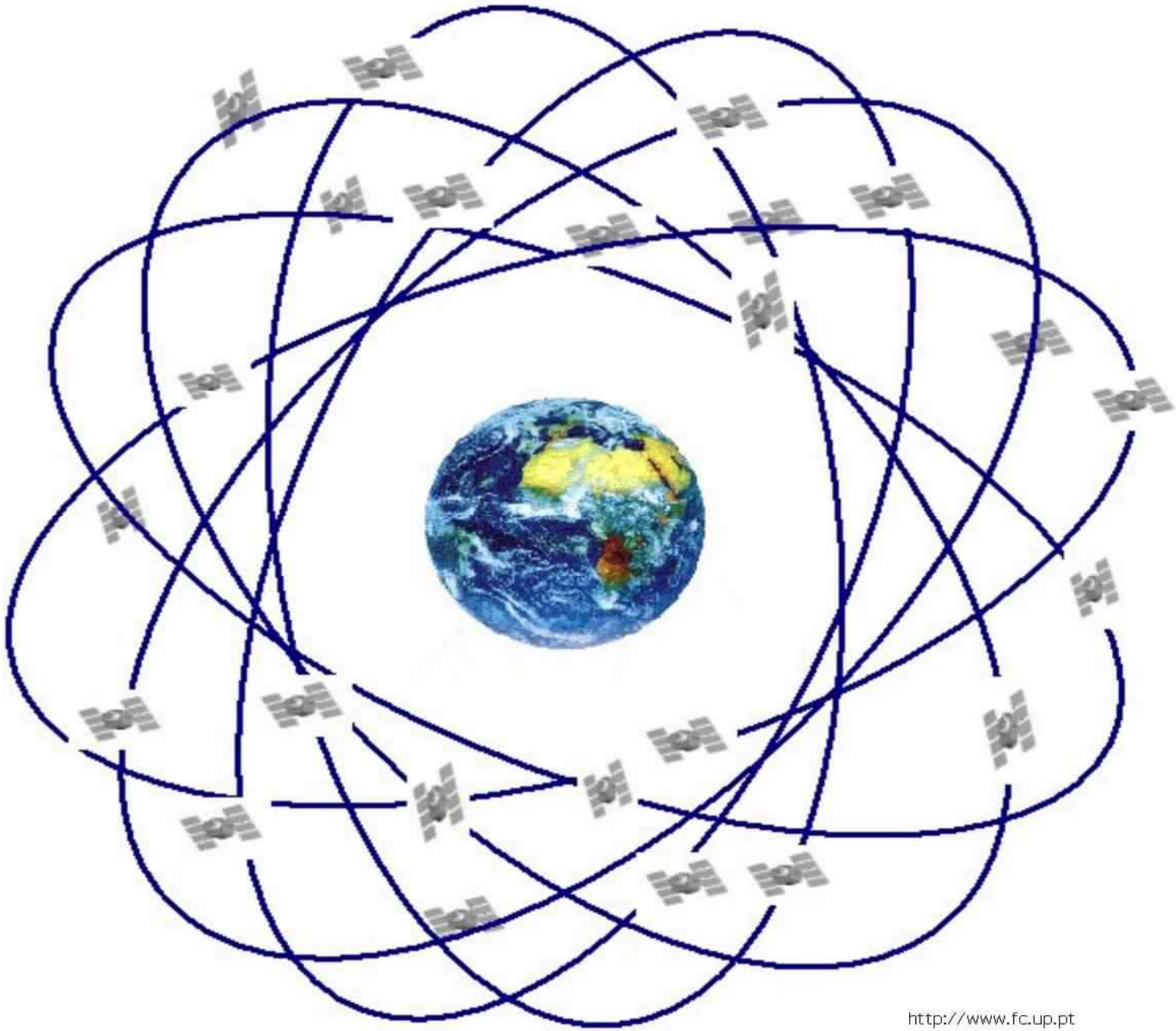
Tiruchirappalli- 620024,
Tamil Nadu, India

Programme: M.Sc., Environmental Science and Sustainable Management

Course Title : Remote Sensing and GIS
Course Code : 21PGCC03

Module-III
GPS

Dr. M.Prashanthi Devi
Professor
Department of Environmental Science and Management

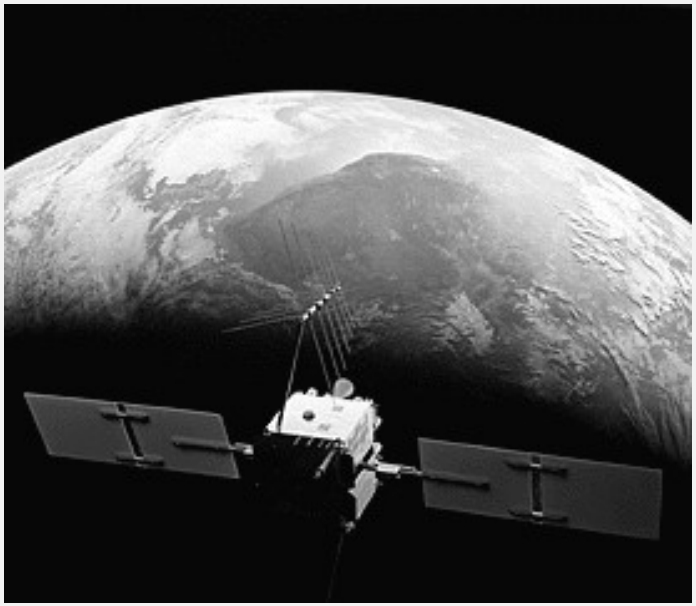

http://www.fc.up.pt

INTRODUCTION

- GPS provides specially coded satellite signals that can be processed with a GPS receiver, enabling the receiver to compute position, velocity and time.
- A minimum of four GPS satellite signals are required to compute positions in three dimensions and the time offset in the receiver clock.
- Accuracy and precision of data increases with more satellites.

WHAT IS THE GPS?

- Orbiting navigational satellites
  - Transmit position and time data
- Handheld receivers calculate
  - latitude
  - longitude
  - altitude
  - velocity
- Developed by
of Defense



HISTORY OF THE GPS

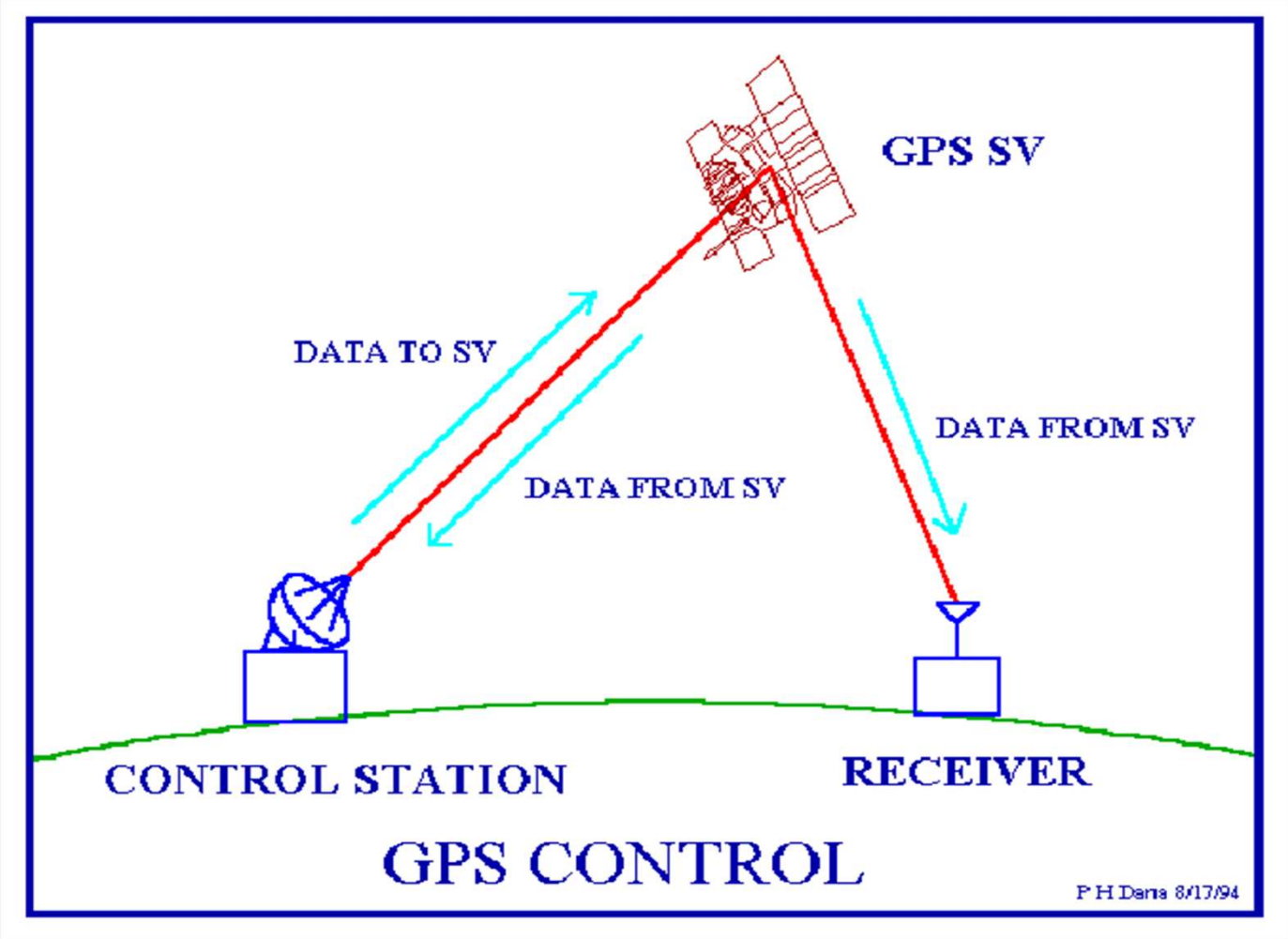
- 1969—Defense Navigation Satellite System (DNSS) formed
- 1973—NAVSTAR Global Positioning System developed
- 1978—first 4 satellites

Delta rocket launch

HISTORY OF THE GPS

- 1993—24th satellite launched; initial operational capability
- 1995—full operational capability
- May 2000—Military accuracy available to all users

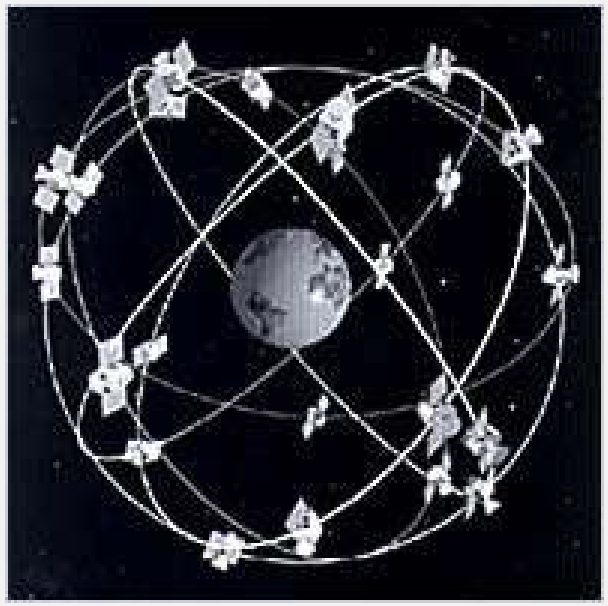
PARTS OF A GPS SYSTEM



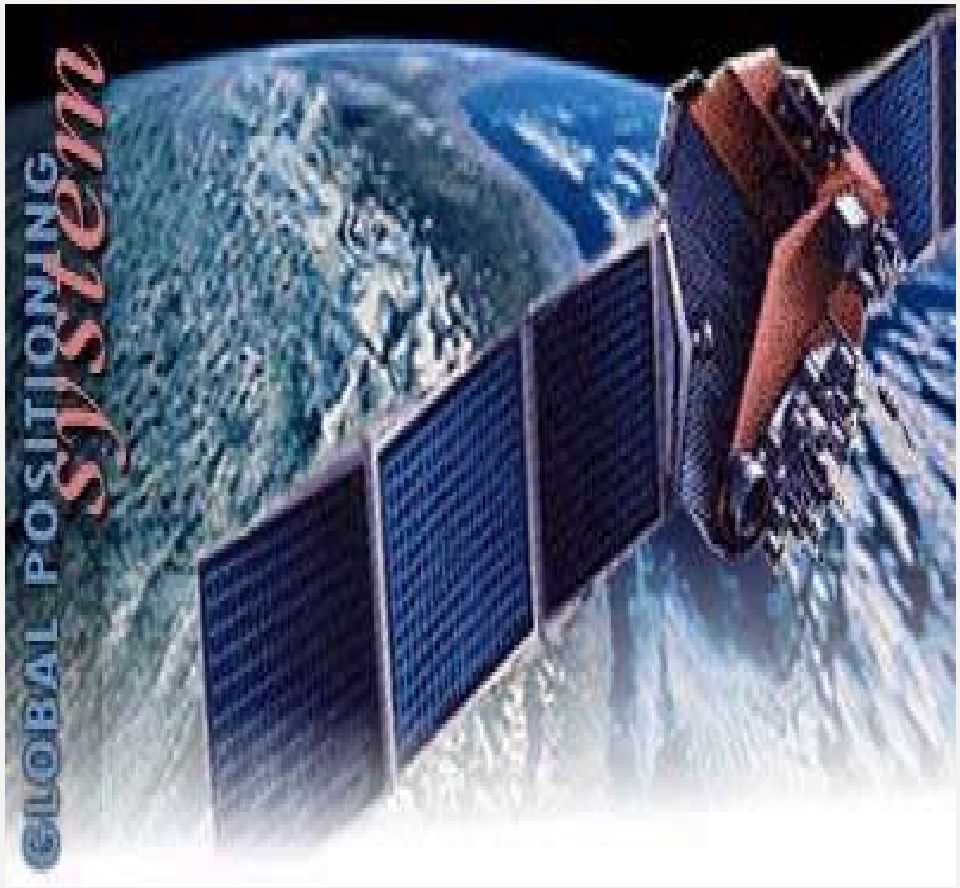
SATELLITES

- **About 31 satellites**
- **Very high orbits**
- **Several replaced every year.**

- 6 orbital planes ensure at least 4 or more satellites available at almost all times.
- There is a large gap to the north.



GPS SATELLITE VEHICLE



- Four atomic clocks
- Three nickel-cadmium batteries
- Two solar panels
  - Battery charging
  - Power generation
  - 1136 watts
- S band antenna—satellite control
- 12 element L band antenna—user communication

Block IIF satellite vehicle (fourth generation)

RECEIVER

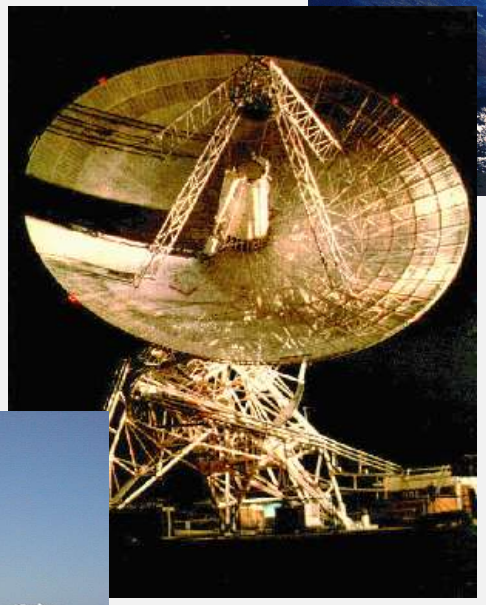
- 100 – 500$
- 10+ meter to below 1 m accuracy
- Computer cable
  - Download and upload maps, routes and waypoint.
  - Upgrade over the internet
- Computer Mapping Software
  - Can map out tracks and waypoints
  - Can plan and upload routes, tracks and waypoints
- Receivers may also have
  - Digital compasses
  - Barometric Altimeters
  - FRS Radio
  - Other features.

THREE OKAY, FOUR OR MORE BETTER

- 3 satellites are needed to acquire a position fix. (2D mode)
- 4 satellites are needed for an accurate position and to get elevation. (3D mode)
- More satellites are really needed because of errors that arise from a variety of sources.
  - Satellite positions (geometry)
  - Weather
  - Multipath
  - Timing errors
- Typical error is 10+ meters.
- All GPS are 12 channel: can receive up to 12 satellites

THREE SEGMENTS

- Space segment
- Control segment
- User segment

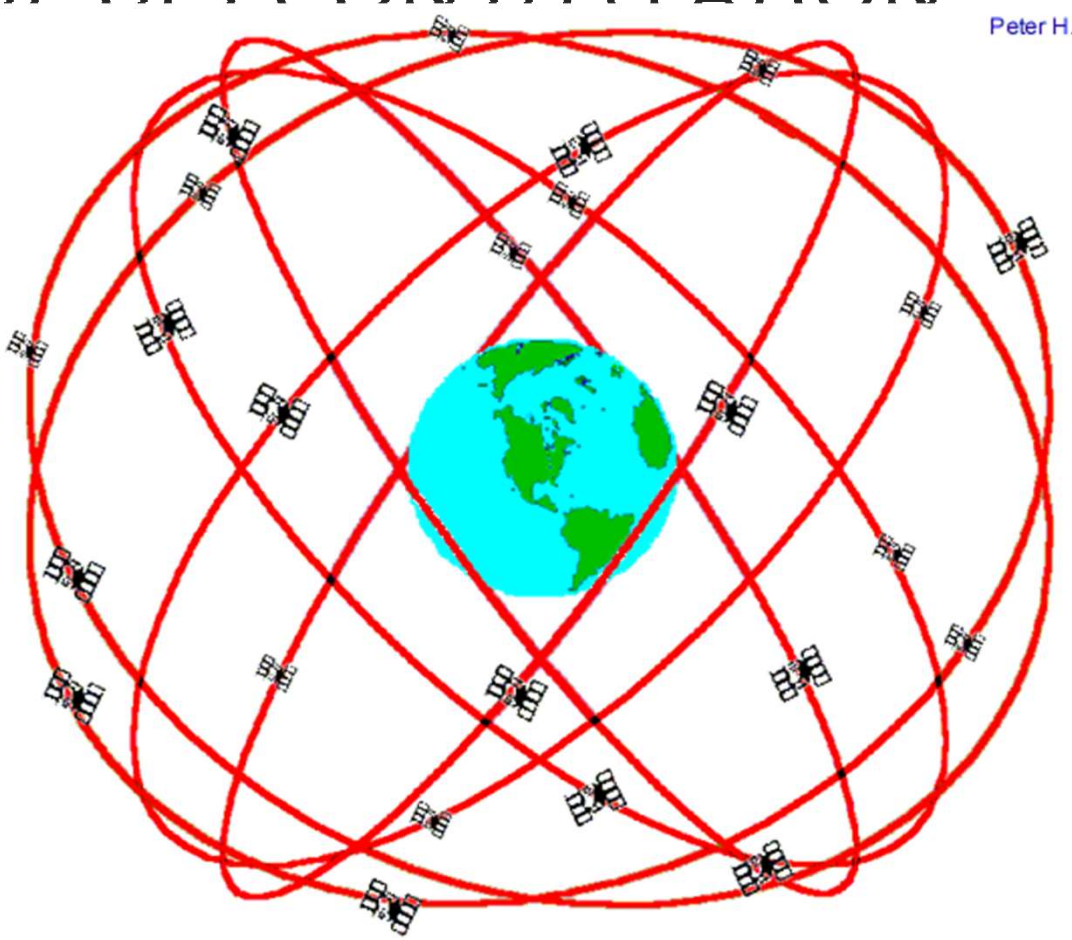


SPACE SEGMENT

SPACE SEGMENT-INFORMATION

- The GPS uses a constellation of 31 satellites that orbit the Earth at about 11,000 nautical miles, once every 12 hours.
- The orbital position is constantly monitored and updated by the ground stations.
- Each satellite is identified by number and broadcasts a unique signal.
- The signal travels at the speed of light.
- Each satellite has a very accurate clock, 0.000000003 seconds

THE GPS CONSTELLATION

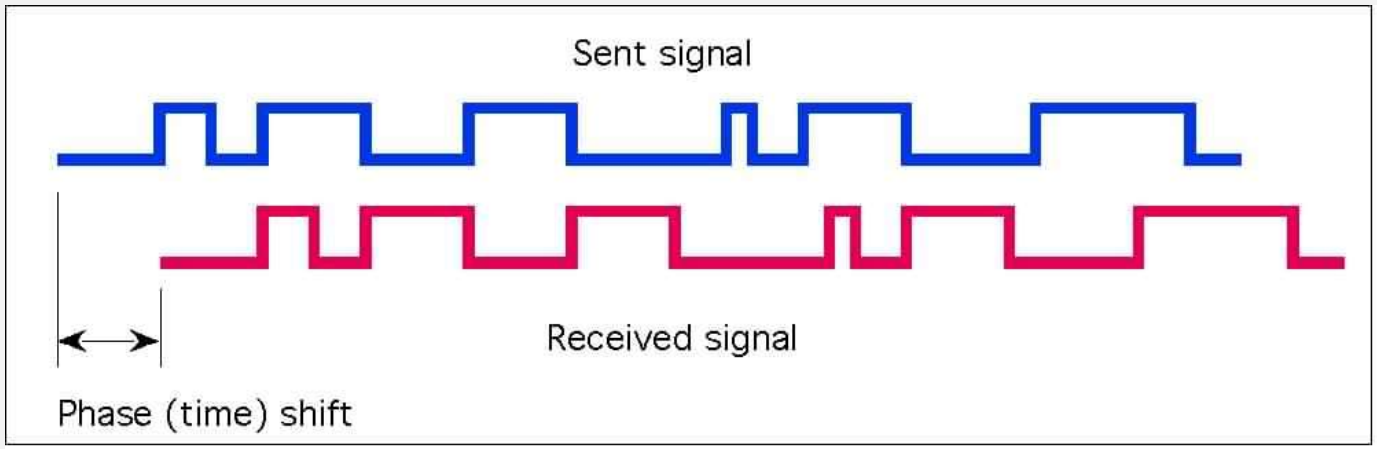


GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

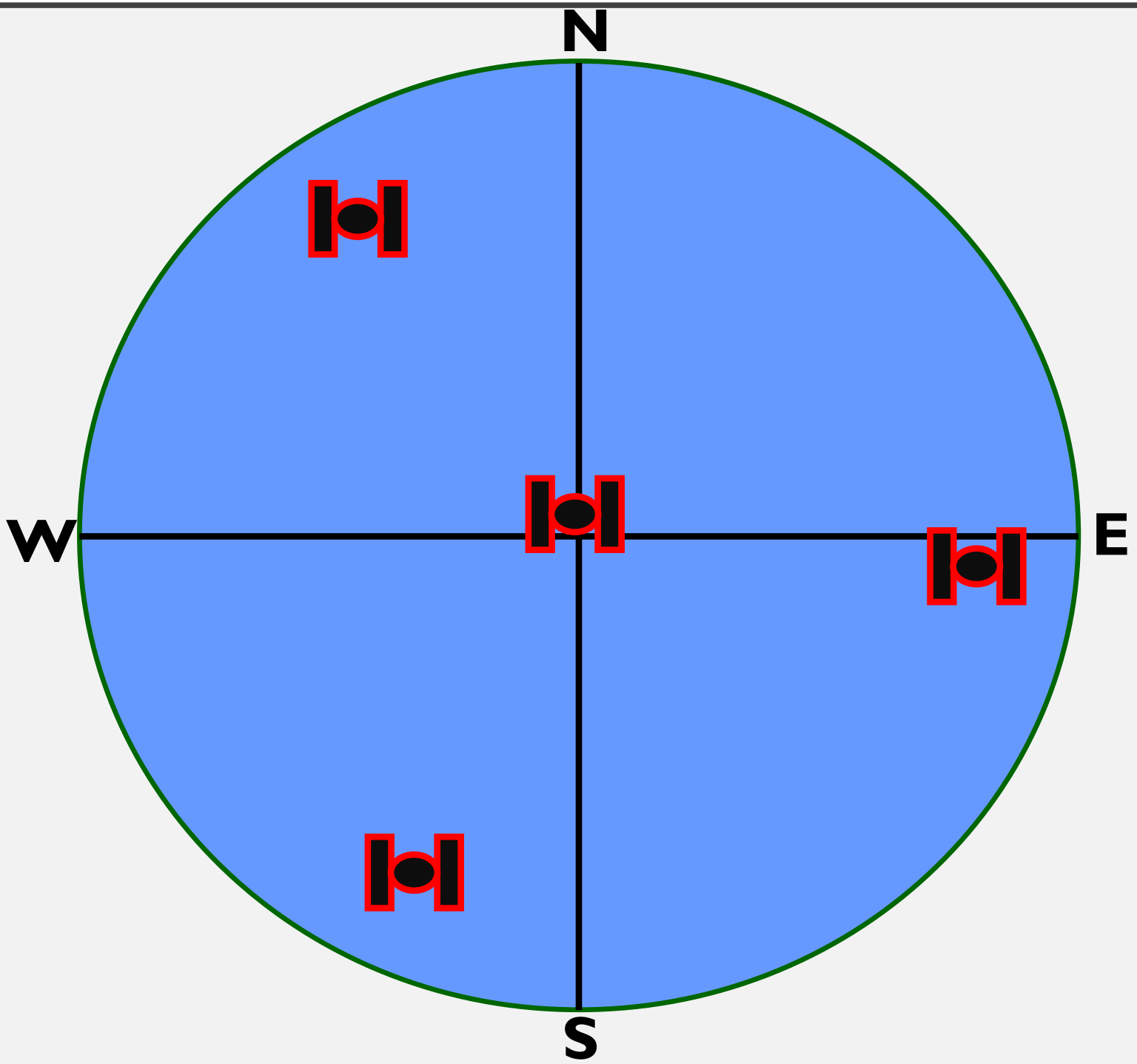
SPACE SEGMENT--SATELLITE SIGNALS

- Because the GPS receiver calculates its location by trilateration, the task of the receiver is to determine its distance from multiple satellites.

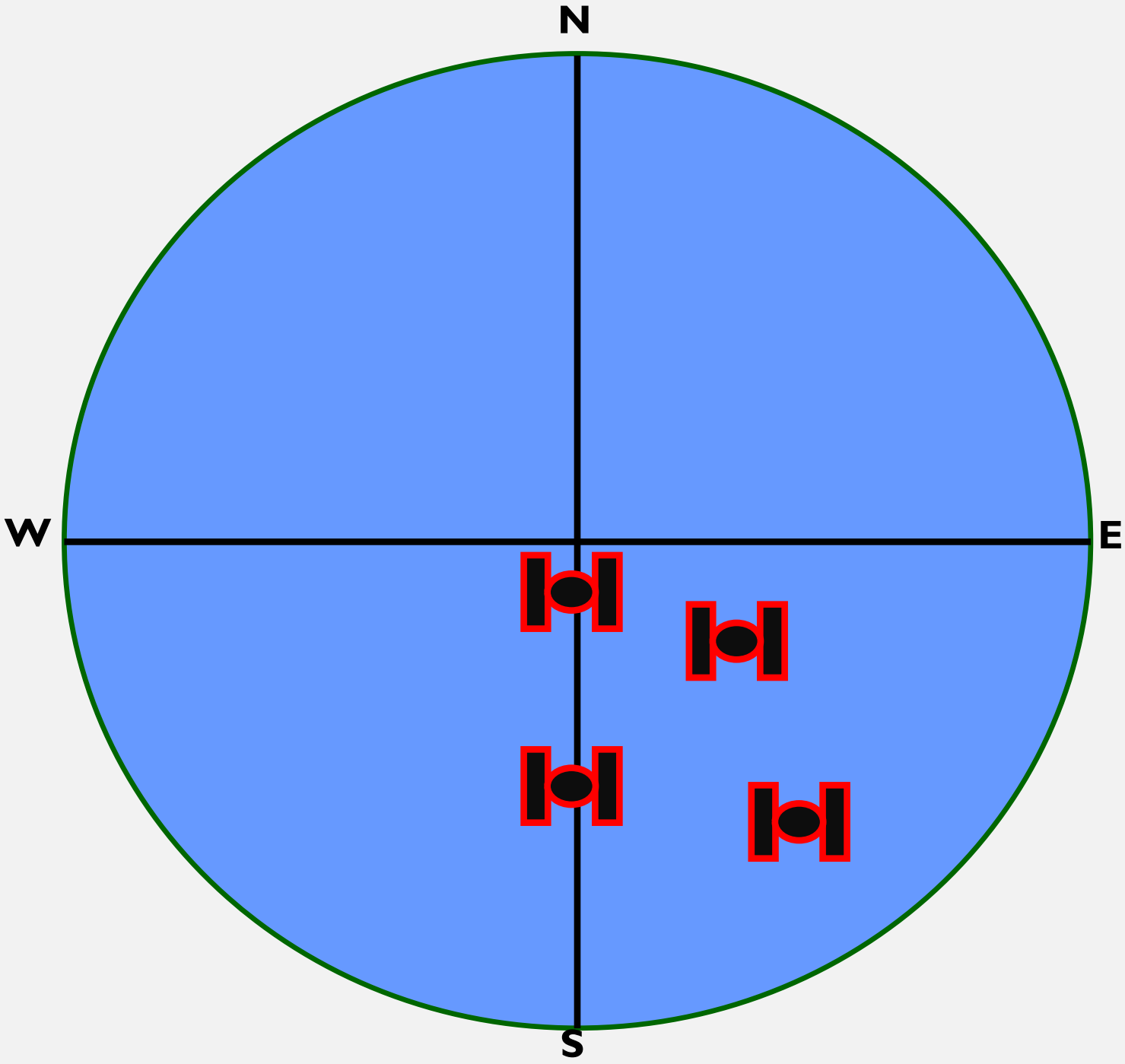
- Each satellite has a unique signal.
- It continuously broadcasts its signal and also sends out a time stamp every time it starts.
- The receiver has a copy of each satellite signal and determines the distance by recording the time between when the satellite says it starts its signal and when the signal reaches the receiver.



IDEAL SATELLITE GEOMETRY



POOR SATELLITE GEOMETRY



ACCURACY

- Accurate timing is the key to measuring distance to satellites.
- Satellites are accurate because they have four atomic clocks ($100,000 each) on board.
- Receiver clocks don't have to be too accurate because an extra satellite range measurement can remove errors.

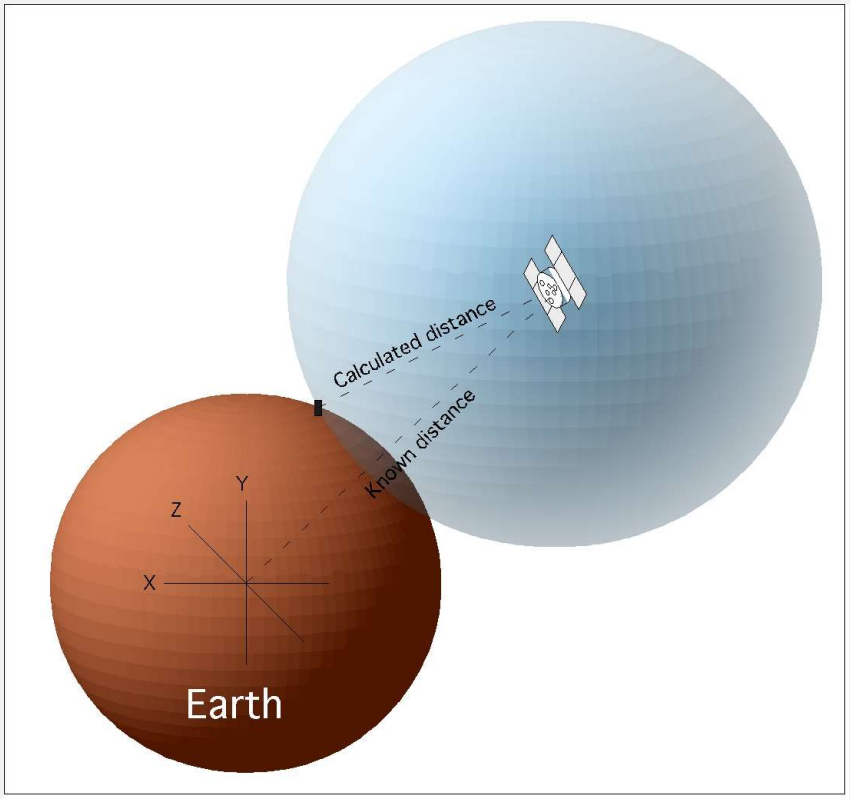
RECEIVER SEGMENT

RECEIVER

- The receiver collects, decodes and processes the satellite signals.
- The basic receiver does not include a transmitter.
- Different levels of precision are available.
- The receiver determines its location by trilateration.

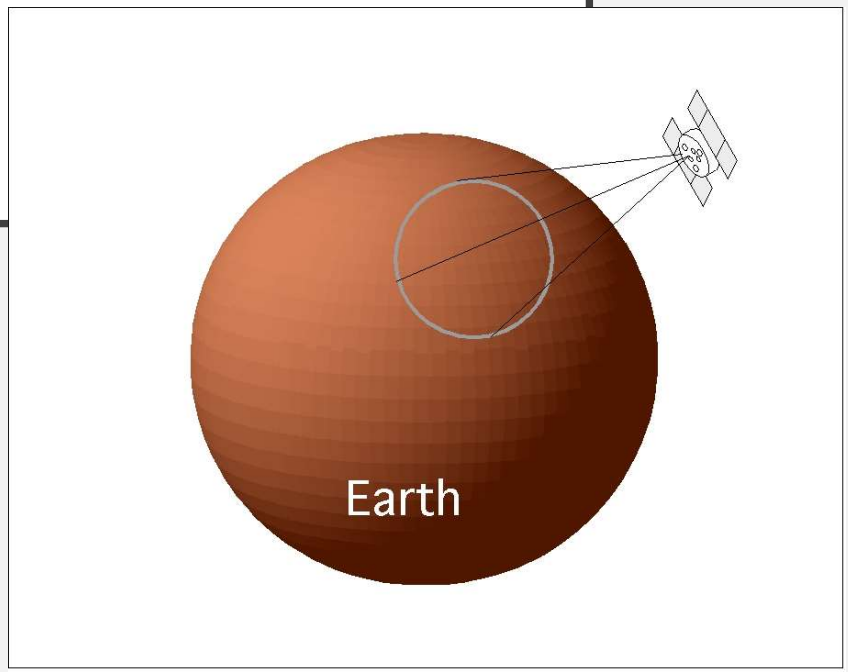
GPS TRILATERATION

- Each satellite knows its position and its distance from the center of the earth.
- Each satellite constantly broadcasts this information.
- With this information and the calculated distance, the receiver calculates its position.
- Just knowing the distance to one satellite doesn't provide enough information.



GPS TRILATERATI

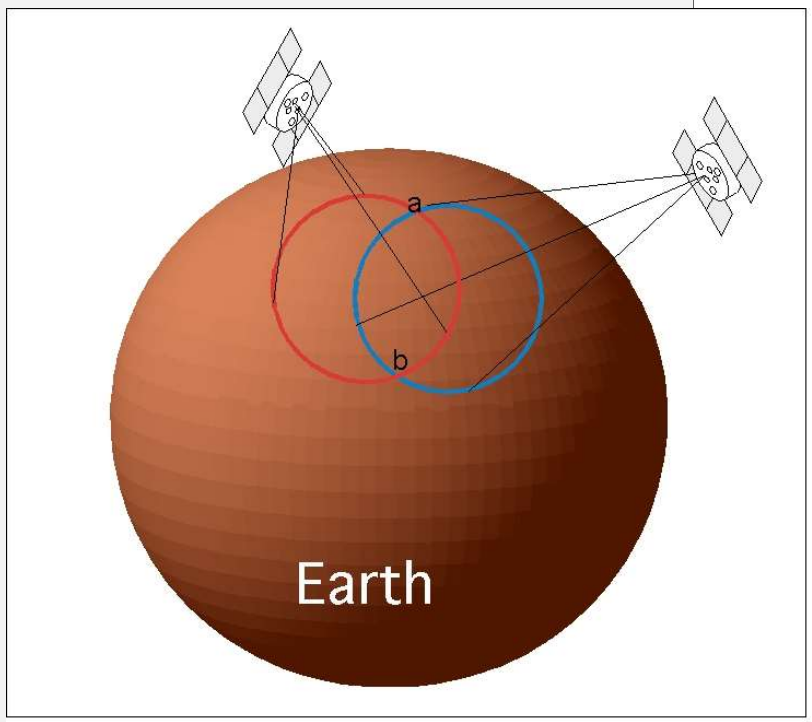
- When the receiver knows its distance from only one satellite, its location could be anywhere on the earths surface that is an equal distance from the satellite.
- Represented by the circle in the illustration.
- The receiver must have additional information.

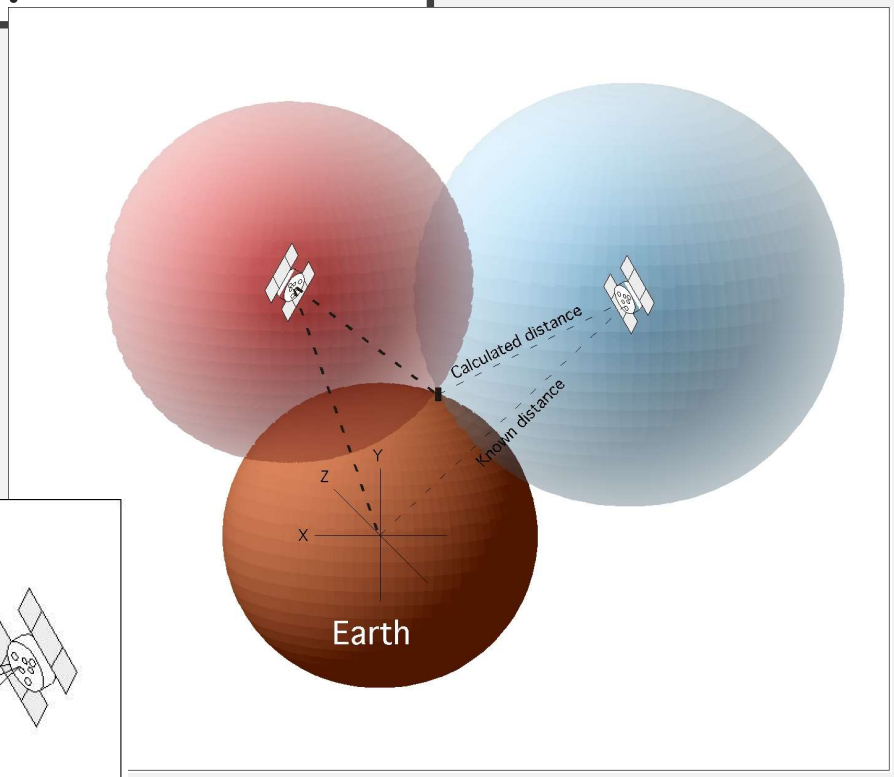


GPS TRILATERATION-- CONT.

With signals from two satellites, the receiver can narrow down its location to just two points on the earths surface.

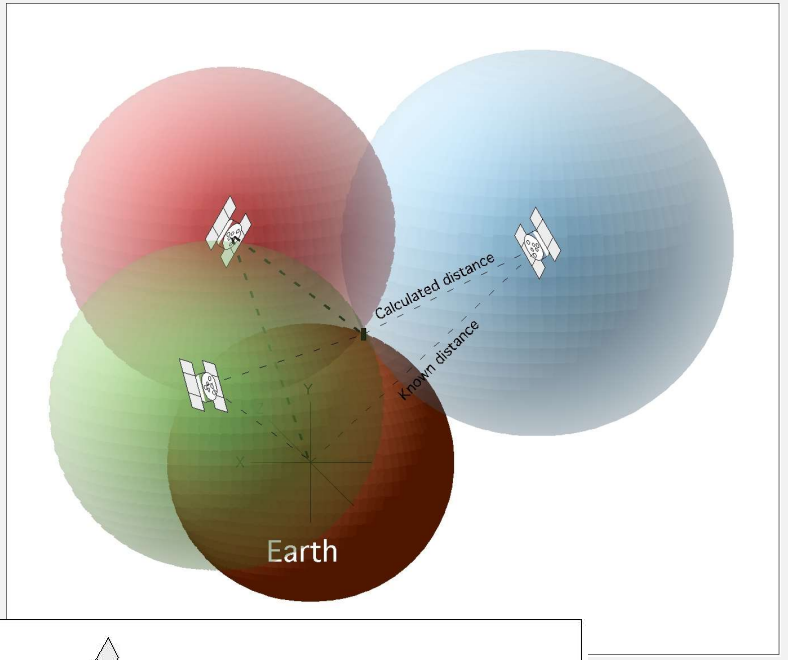
Were the two circles intersect.

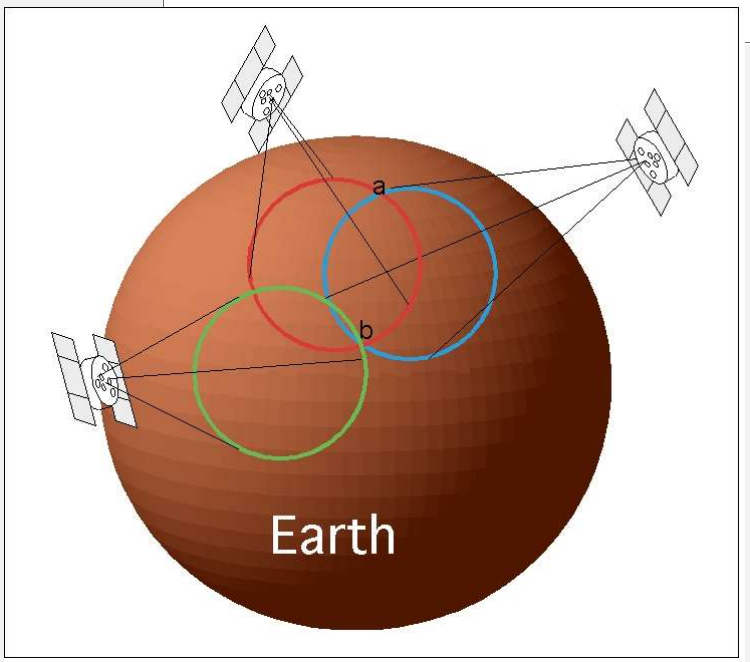




GPS TRILATERATION--CONT.

- Knowing its distance from three satellites, the receiver can determine its location because there is only two possible combinations and one of them is out in space.
- In this example, the receiver is located at b.
- The more satellite that are used, the greater the potential accuracy of the position location.





FACTORS INFLUENCING POSITION ACCURACY

The number of satellites (channels) the receiver can track.

- The number of channels a receiver has is part of it's design.
- The higher the number of channels---the greater the potential accuracy.
- The higher the number of channels---the greater the cost.

The number of satellites that are available at the time.

- Because of the way the satellites orbit, the same number are not available at all times.
- When planning precise GPS measurements it is important to check for satellite availability for the location and time of measurement.
- If a larger number of channels are required (6-10), and at the time of measurement the number available was less than that, the data will be less accurate.

- The number of different systems that the receiver can track.
  - WAAS [Wide Area Augmentation System] FAA & DOT
  - GLONASS [GLObal'naya NAvigatsionnaya Sputnikovaya Sistema] Russian

FACTORS INFLUENCING POSITION ACCURACY--CONT.

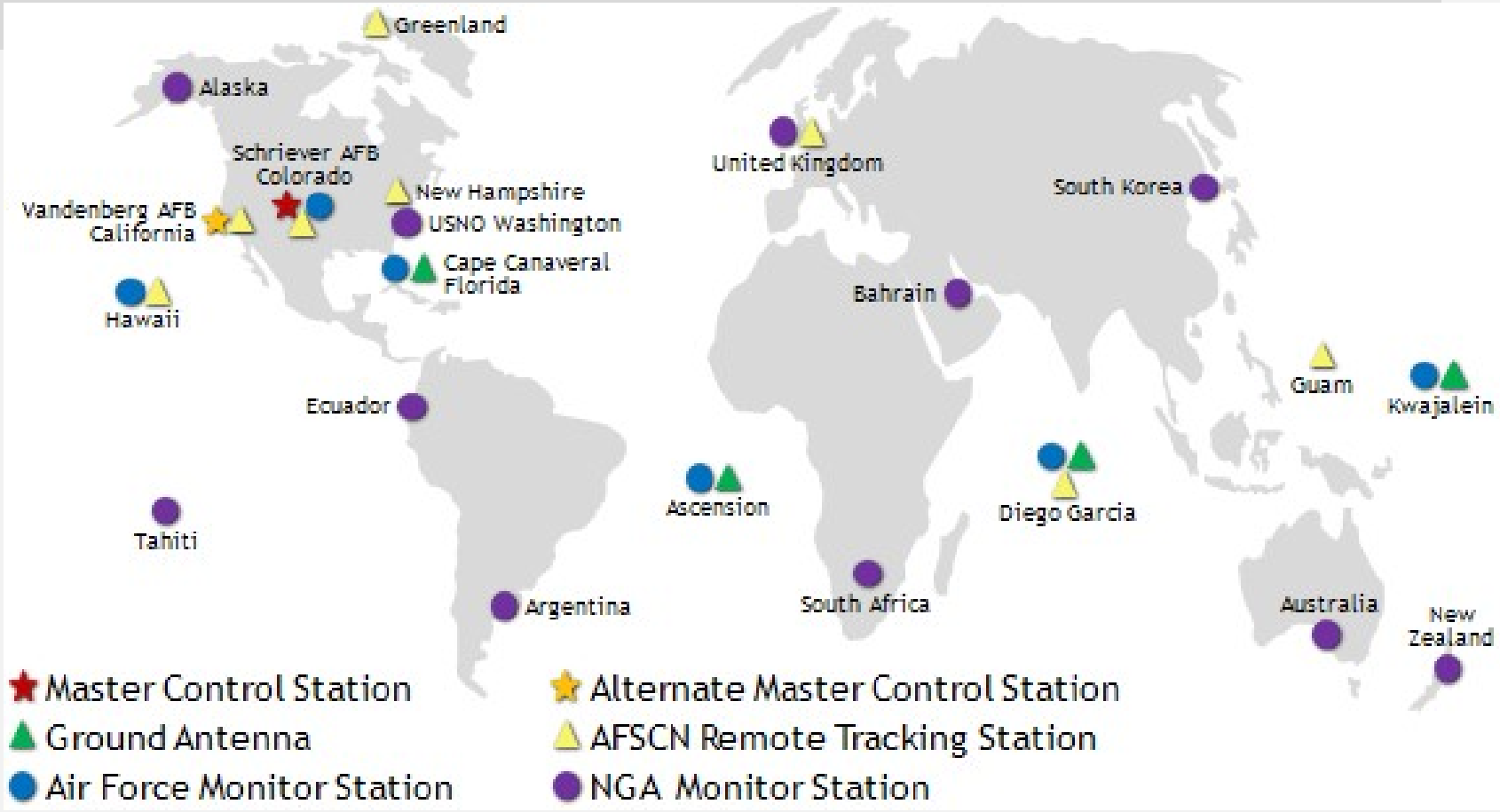
- The system errors that are occurring during the time the receiver is operating.
  - The GPS system has several errors that have the potential to reduce the accuracy.
  - To achieve high levels of precision, differential GPS must be used.
- Differential GPS uses one unit at a known location and a rover.
  - The stationary unit compares its calculated GPS location with the actual location and computes the error.
  - The rover data is adjusted for the error.
    - Real Time Kinematic (RTK)
    - Post processing

LOCATION

Once the GPS receiver has located its position it is usually displayed in one of two common formats:

- Latitude and longitude
- Universal transverse Mercator (UTM).

The ground segment has one master control, one alternative master control station, 12 command and control antennas and 16 monitoring sites.

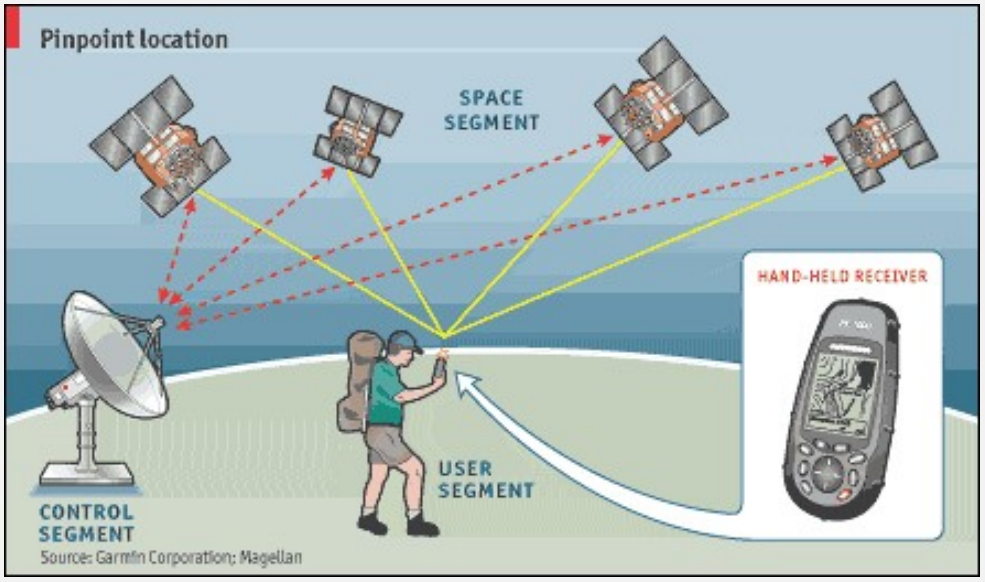


COMPONENTS OF THE SYSTEM

Ground control segment

- Master control station
  - Schreiver AFB, Colorado
- Five monitor stations
- Three ground antennas
- Backup control system

GPS COMMUNICATION AND CONTROL

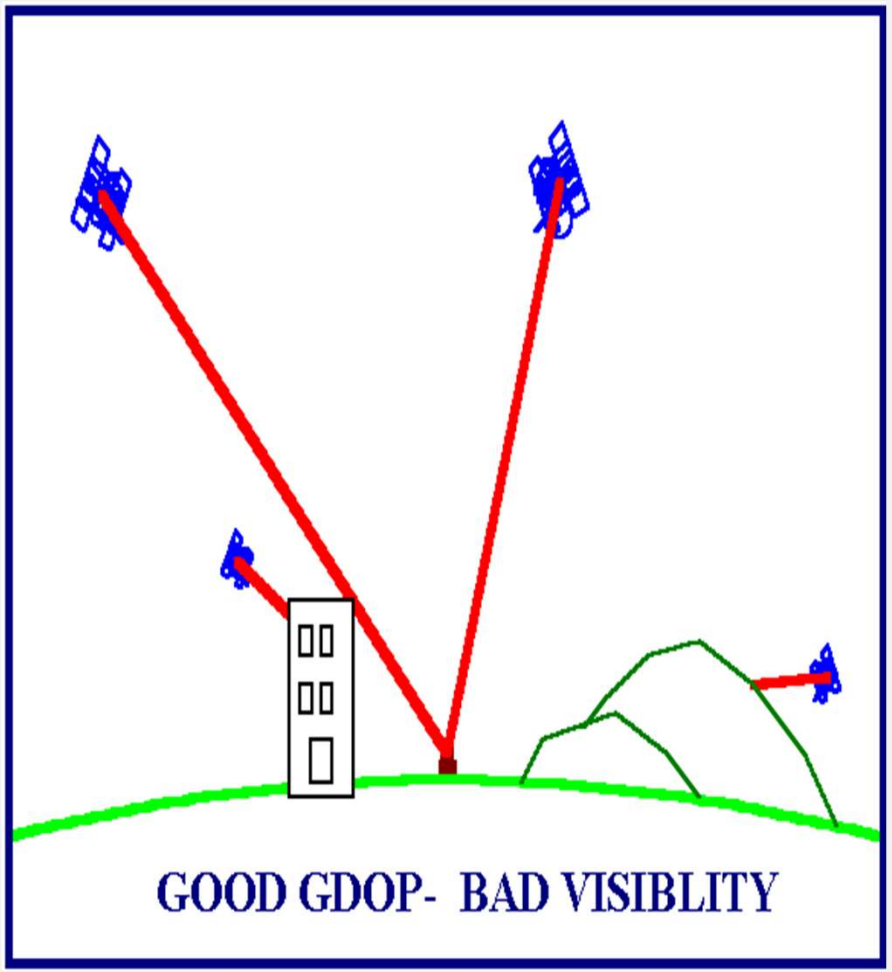


GPS GROUND CONTROL STATIONS

GPS ERRORS

- Satellite geometry
- Satellite orbits
- Multipath
- Atmospheric effects
- Clock

GPS CANNOT "SEE" THROUGH OBJECTS!

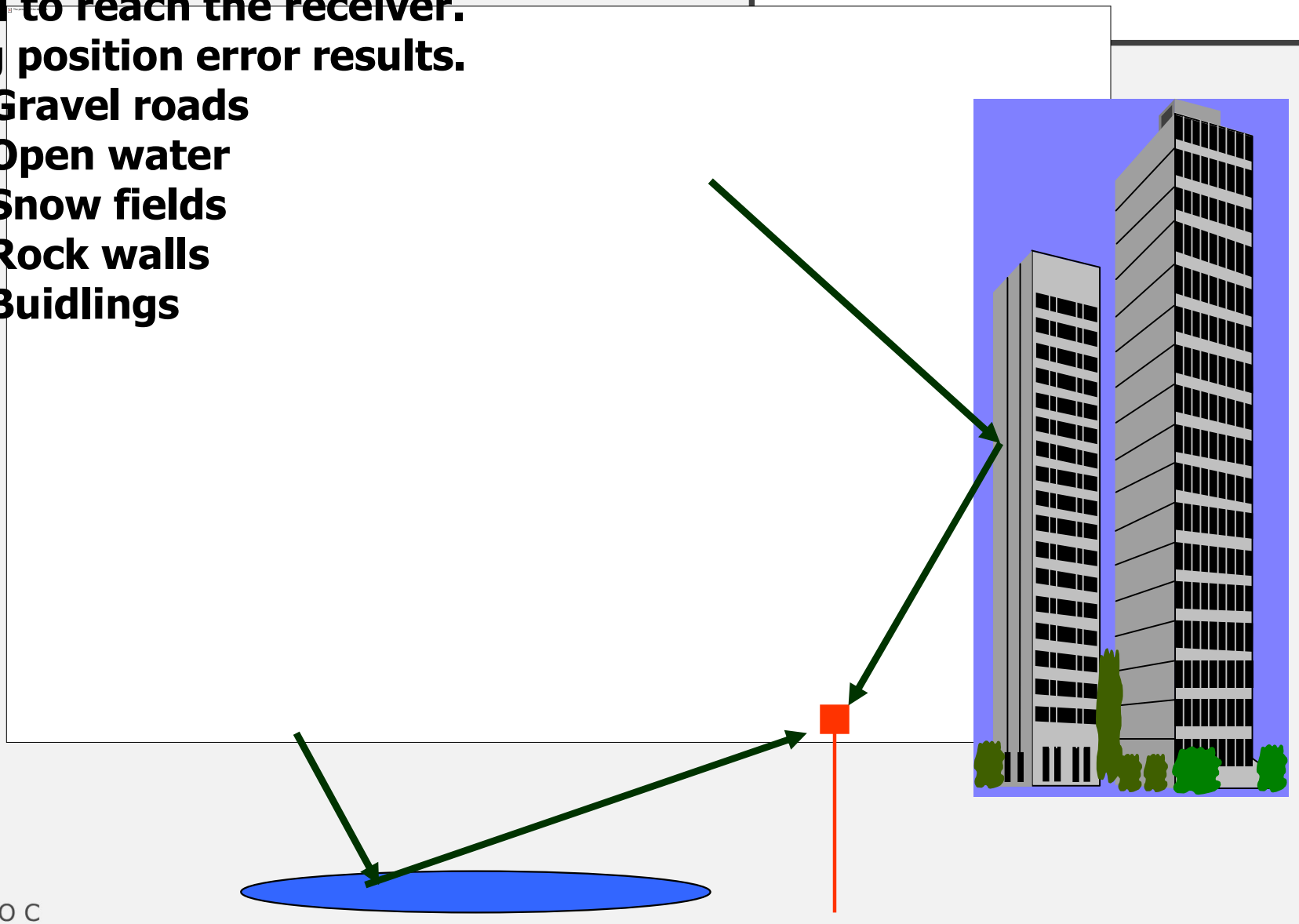


Some of the newer satellites and receivers can receive through thinner solid objects like cars, building walls and forest canopy.

Terrain and larger buildings are still too big.

MULTIPATH ERROR

- A signal that bounces of a smooth object and hits the receiver antenna.
- Increases the length of time for a signal to reach the receiver.
- A big position error results.
  - Gravel roads
  - Open water
  - Snow fields
  - Rock walls
  - Buidlings

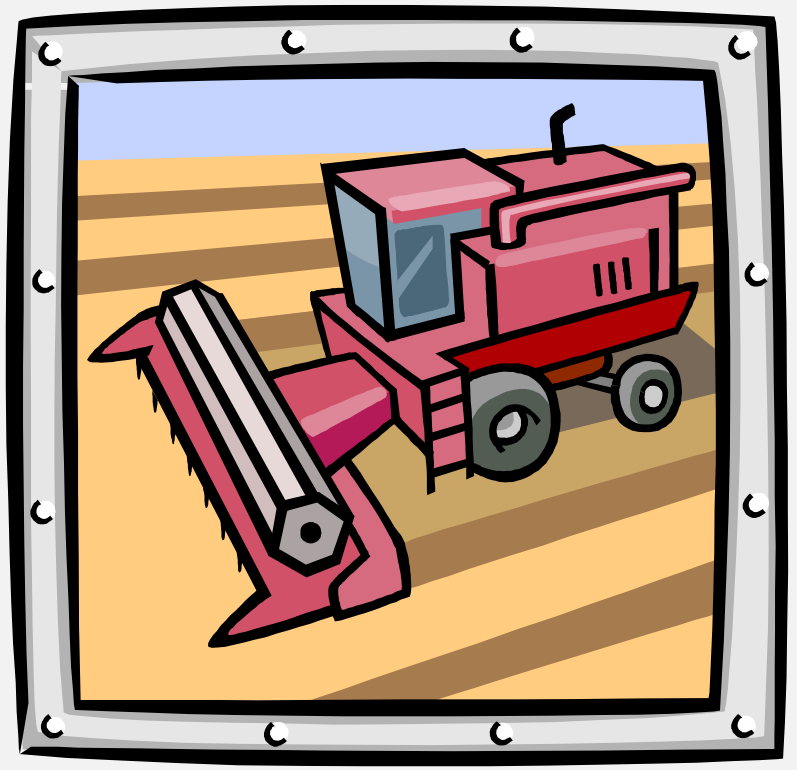


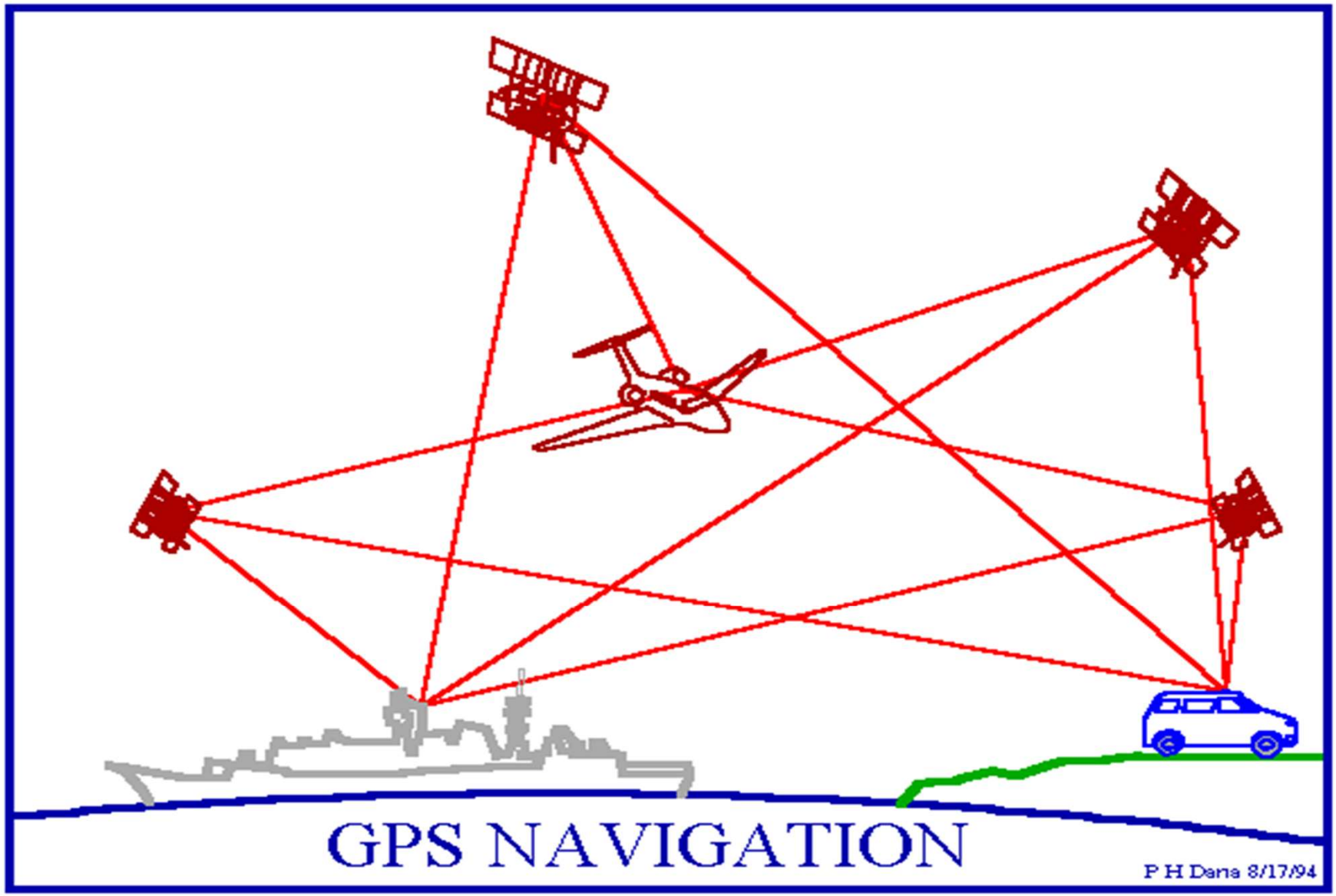
APPLICATION OF GPS TECHNOLOGY

- Location - determining a basic position
- Navigation - getting from one location to another
- Tracking - monitoring the movement of people and things
- Mapping - creating maps of the world
- Timing - bringing precise timing to the world

APPLICATION OF GPS TECHNOLOGY

- Private and recreation
  - Traveling by car
  - Hiking, climbing, biking
  - Vehicle control
- Mapping, survey, geology
- English Channel Tunnel
- Agriculture
- Aviation
  - General and commercial
  - Spacecraft
- Maritime




GPS NAVIGATION
P H Dana 8/17/94

GPS NEWS

- http://www.gpseducationresource.com/gpsnews.htm
- One–page reading exercise
  - Center of page—main topic
  - Four corners—questions & answers from reading
  - Four sides—specific facts from reading
  - Spaces between—supporting ideas, diagrams, definitions
  - Article citation on back of page

MILITARY USES FOR THE GPS

Operation Desert Storm

- Featureless terrain
- Initial purchase of 1000 portable commercial receivers
- More than 9000 receivers in use by end of the conflict
- Foot soldiers
- Vehicles
- Aircraft
- Marine vessels

GEOCACHING

- Cache of goodies established by individuals
- Coordinates published on Web
- Find cache
  - Leave a message
  - Leave some treasure
  - Take some treasure
- http://www.geocaching.com/

HANDHELD GPS RECEIVERS

- Garmin eTrex
  - ~$100
- Garmin-12
  - ~$150
- Casio GPS wristwatch
  - ~$300
- [The GPS Store]

DGPS