Introduction to GPS and positioning

MH. Mohamed Rinos
Senior Lecturer in GIS
SEUSL

SPACE BASED NAVIGATION SYSTEMS FOR POSITIONINING

Global Positioning System..

What is Position ???

- Where am I standing?
- Where I can find a Super Market?
- Where is my destination?
- Which rout should I used to reach my destination?

To answer the question “Where ?” …. Position is to be expressed

Positioning

- In other words the positioning means

Describing the Position

- Verbally

  - I am in Wijerama junction

  - To find the restaurant walk 150 m ahead from this point and turn your right

If the area being described is not familiar….

Describing the Position

- Graphically

If no landmarks exists in the area being described…

Describing the Position

- Co-ordinates
  - Identical for each position
  - Familiarization to the area is not required
  - Landmarks independent

Technological Development in Positioning

The Technological Development in Positioning can be chronologically classified into,

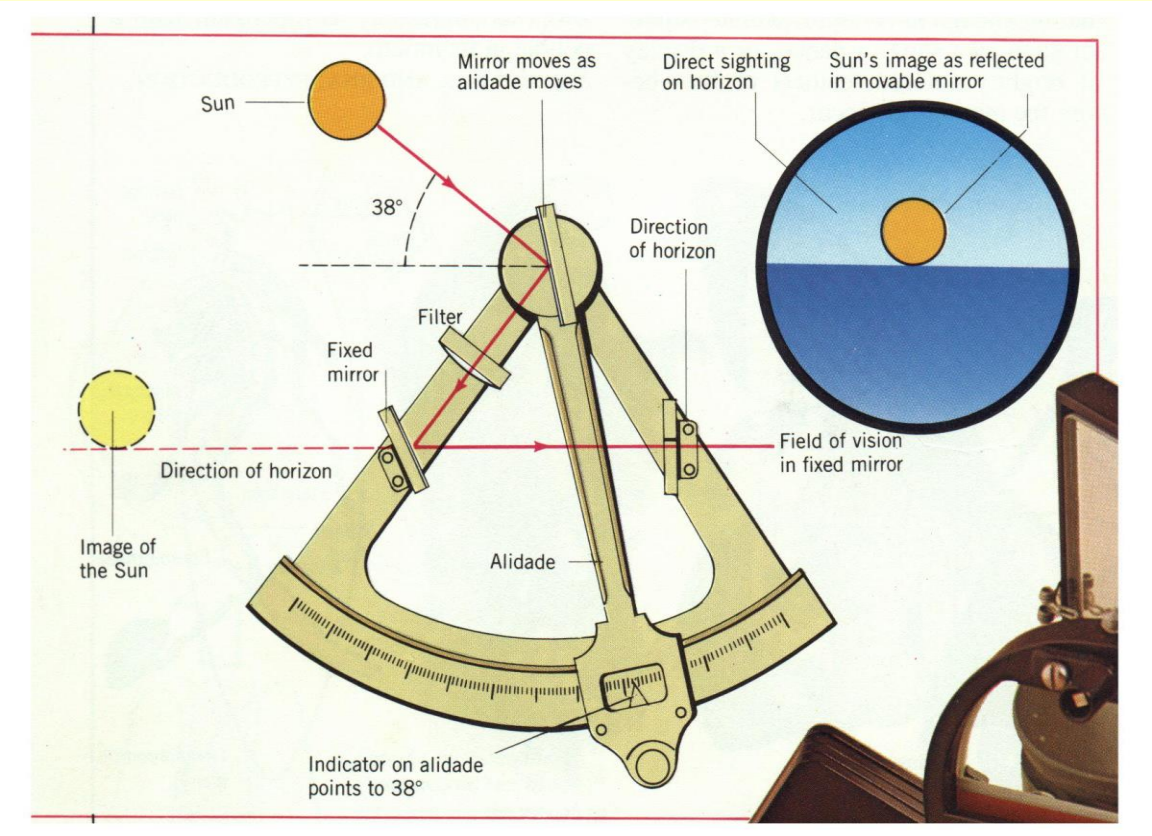
- Mechanical Period (1700 →)
- Optical Period (1900 →)
- Digital Period (1970 →)

Basic Types of Instruments

Surveying Instruments used for positioning can be classified in to three types.

- ⇩ Angle Measuring Instruments.
- ⇩ Distance Measuring Instruments.
- ⇩ Positioning Instruments.

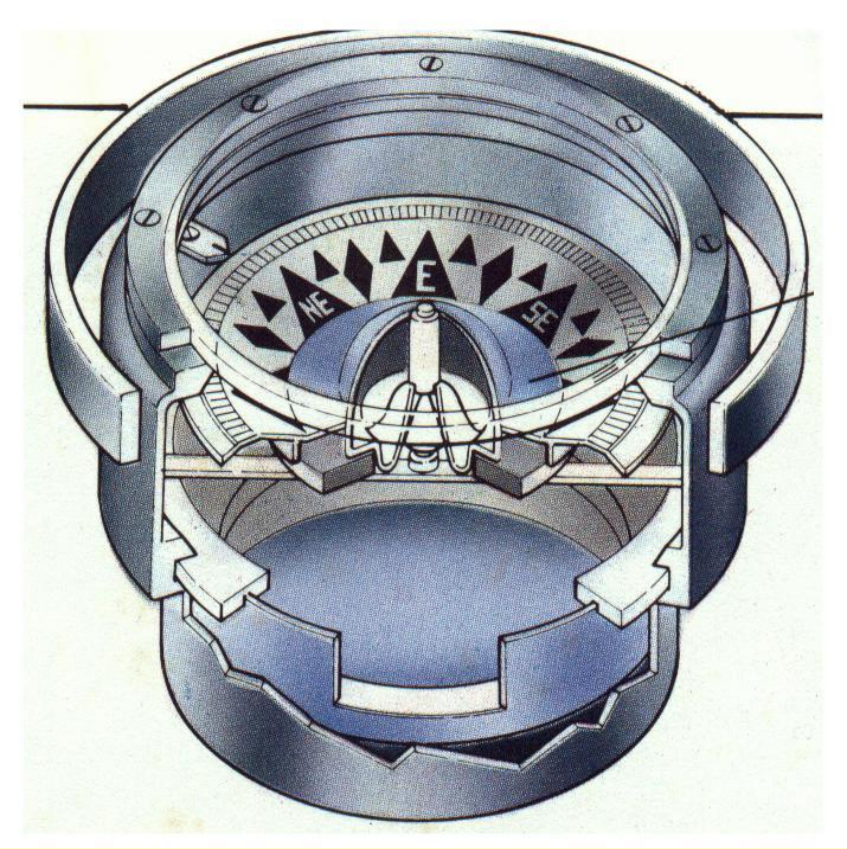
Sextant



Angle Measuring Instruments

The Sextant was designed in 1700 for stellar navigation. This instrument measures angles between ocean horizon and visible star.

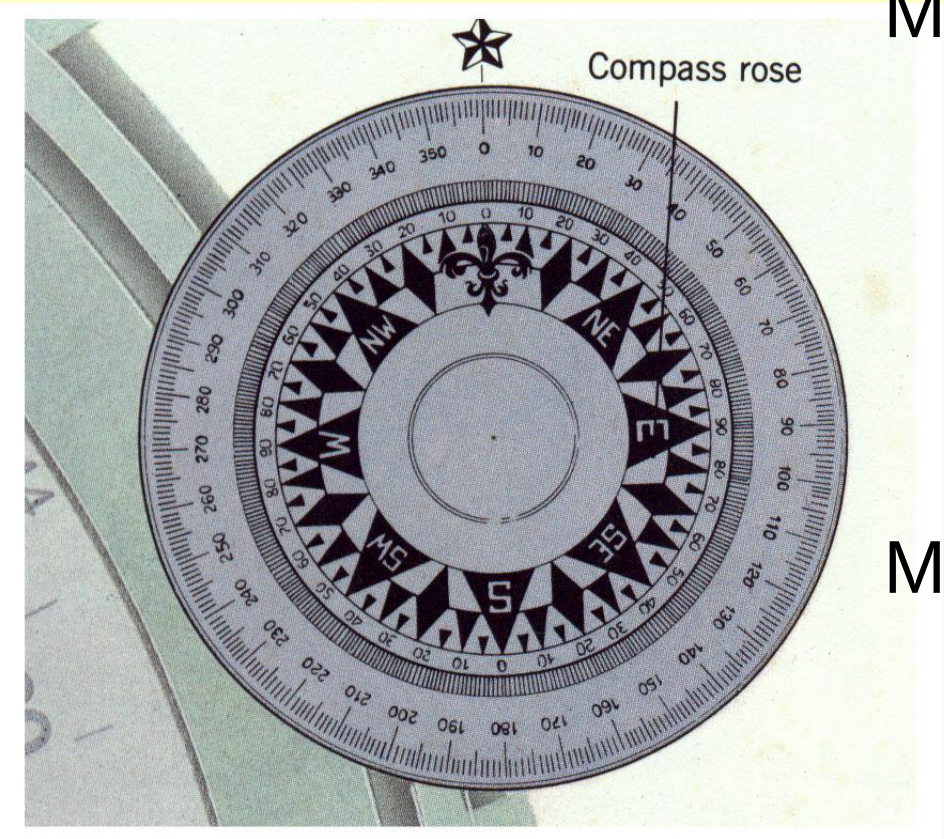
Compass



Compass

Compass is the world's most common navigational instrument. Every ship's bridge, air planes cockpit, surveyor's tool box & hiker's survival kit is equipped with one.

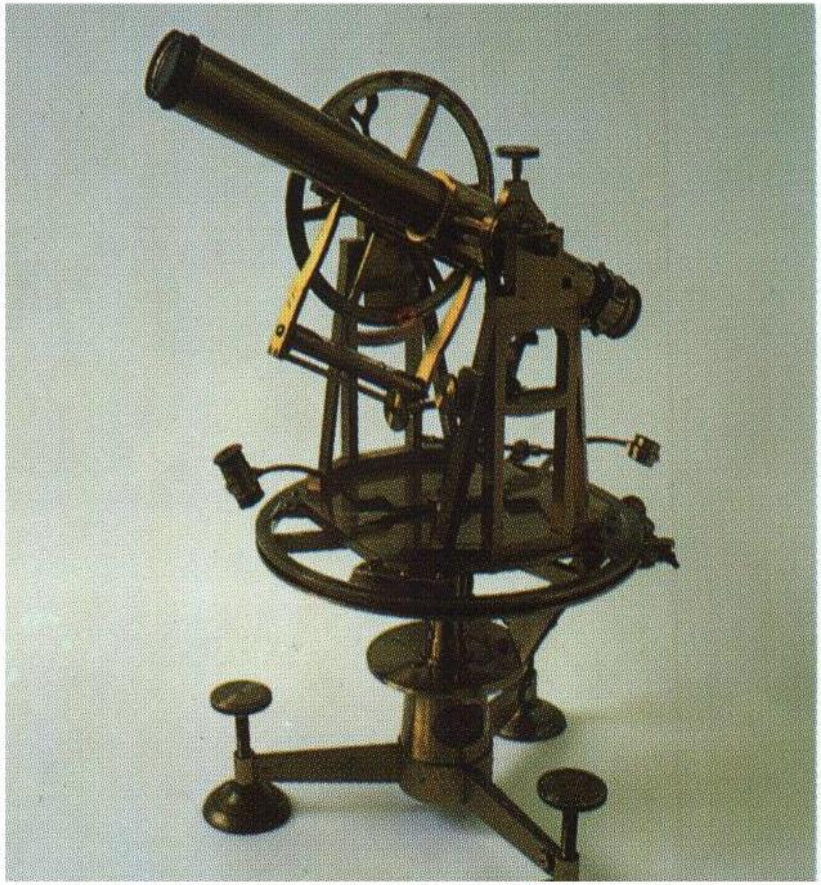
Magnetic North



Magnetic compass directs to the magnetic north which is different from the geographic north pole.

Magnetic Declination is defined as the angle between true & magnetic north.

Theodolite



Theodolite is designed to measure horizontal & vertical angles accurately.

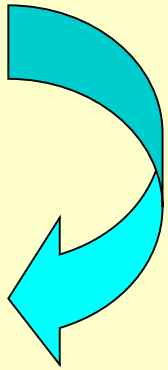
Theodolites can be classified as,

- Mechanical Theodolites
- Optical Theodolites
- Digital Theodolites

Modern Technology in Surveying

Modern Optical Theodolite

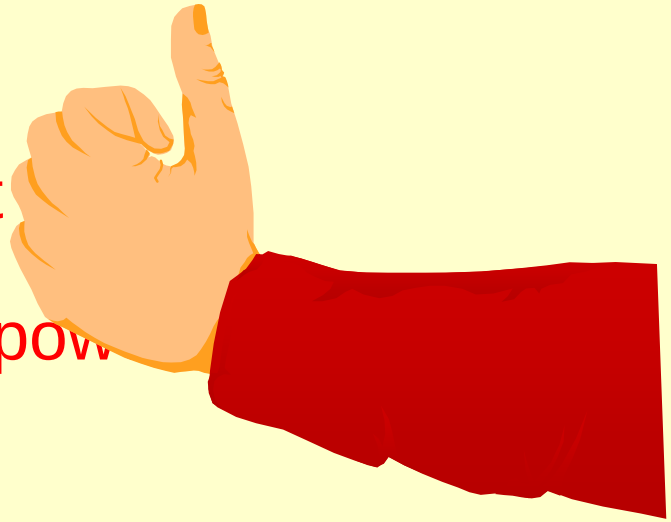
Astronomical Observations



Space Based Positioning Systems

Why GPS ?

- Weather Independent
- Does not require line of sight
- Gives high Geodetic Accuracy
- Can be operated day and night
- Quicker and requires less manpow
- Economical advantages
- Common Coordinate System
- Wide Range of Applications
- Competitively Priced



Global Positioning System (GPS)

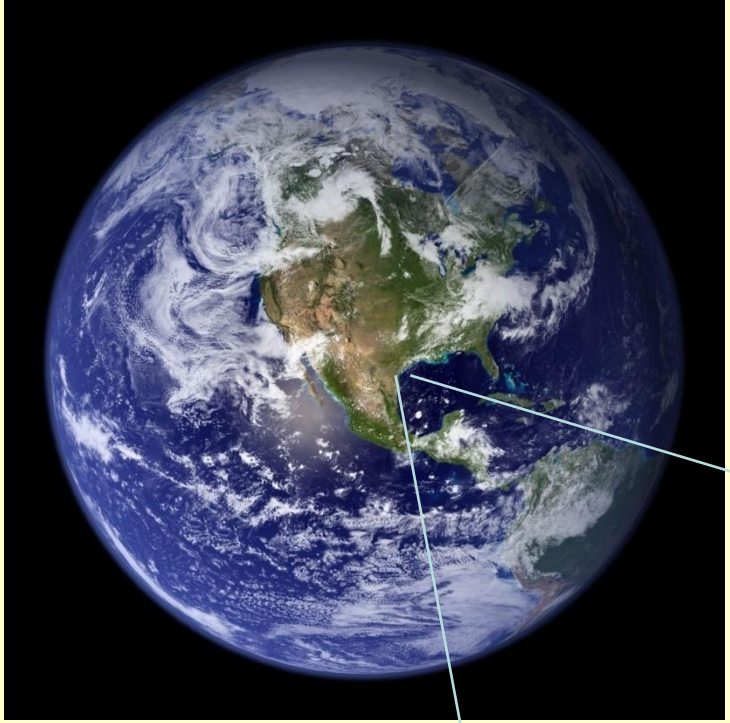
- In 1973 the U.S. Department of Defense decided to establish, develop, test, acquire, and deploy a spaceborne Global Positioning System (GPS). The result of this decision is the present NAVSTARGPS (NAVigation Satellite Timing And Ranging Global Positioning System).

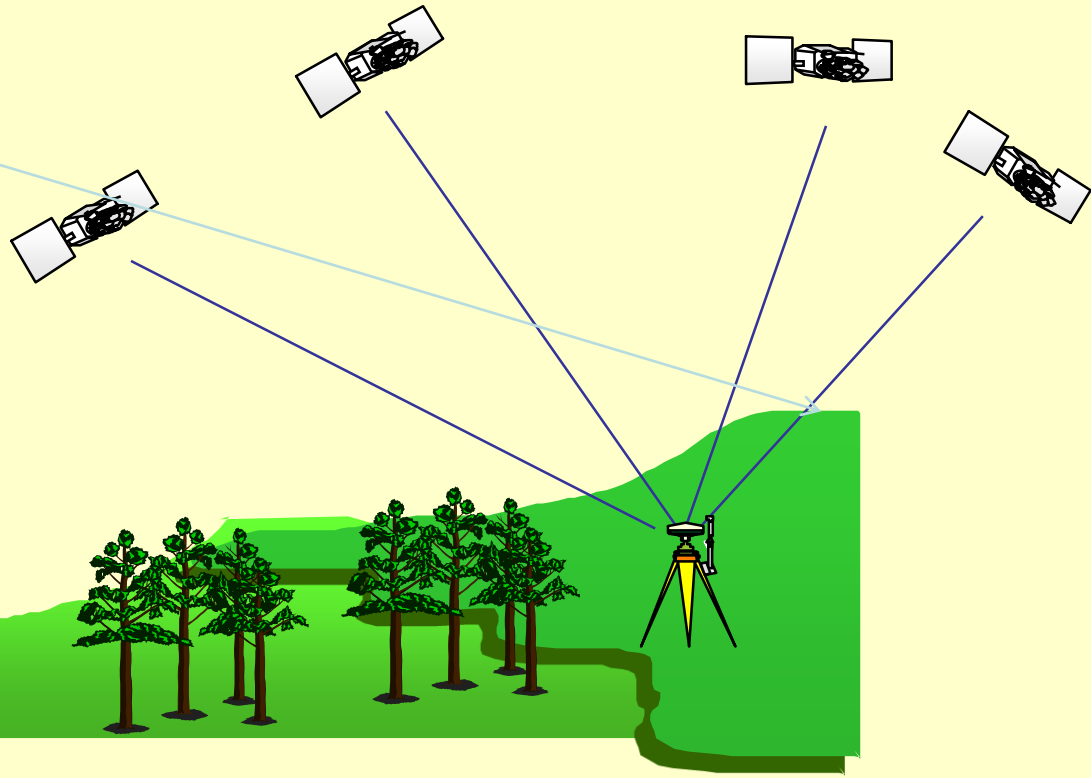
Global Positioning System (GPS)

A new dimension was added to surveying with the introduction of Global Positioning System (GPS) . This space technology uses a cluster of earth orbiting NavStar satellites to provide instantaneous positions all around the world. This system became very popular as it eliminates the barrier of inter-visibility in survey measurements.

Describing the Position using co-ordinates

- The earth is a three dimensional object, three parameters are necessary to determine a location unambiguously on the earth. (Positioning) These three parameters can take different forms such as,
- Cartesian – X,Y,Z
- Projected – North co-ordinate, East co-ordinate, Orthometric height
- Geographical – Latitude, Longitude, Ellipsoidal height
- Geodetic – Latitude, Longitude, Orthometric height



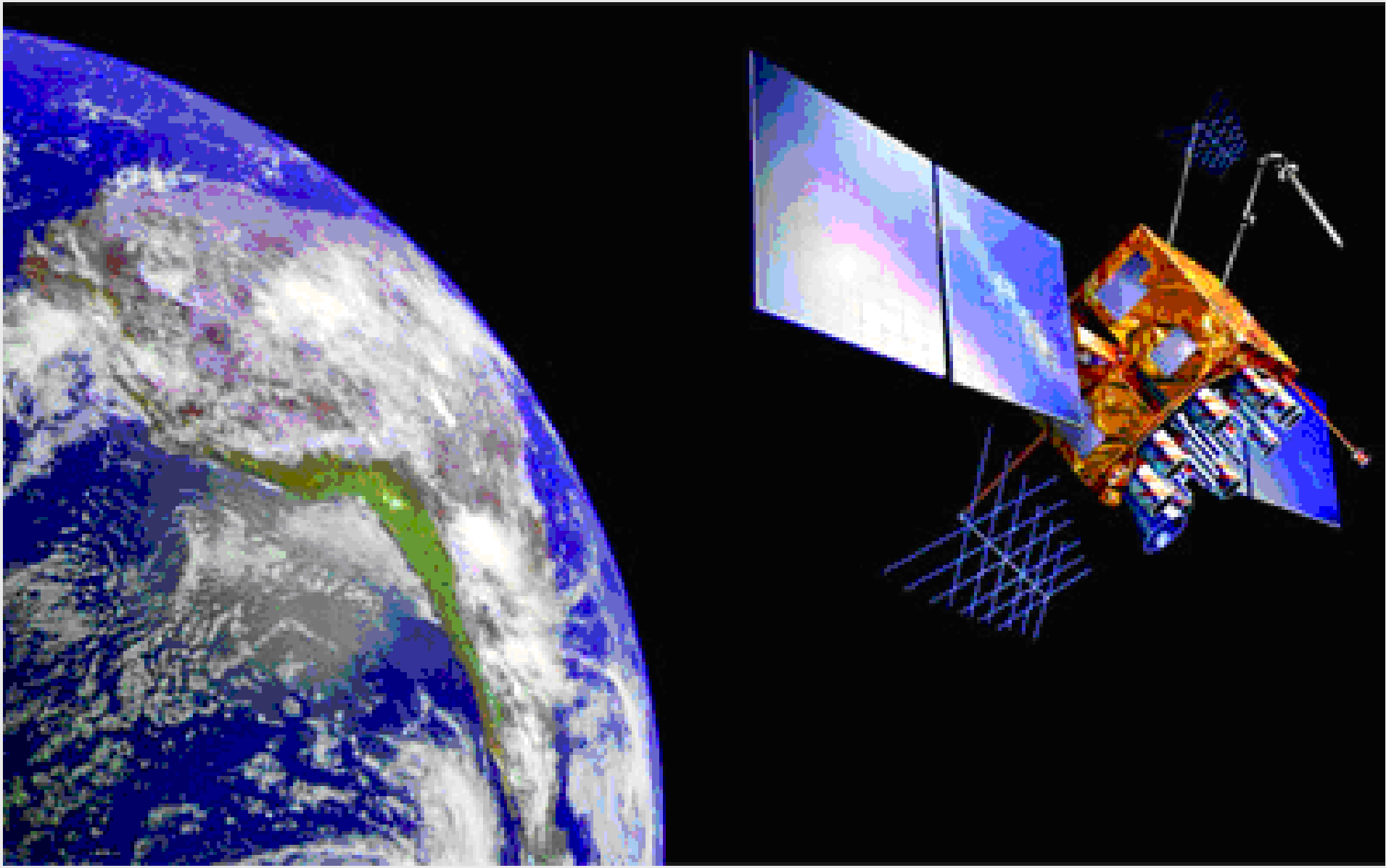


Navstar Global Positioning System (GPS)

Navigation System with Time And Ranging

The system is satellite based navigation system. Although it was designed to be a pure military tool at the beginning, the success achieved by the system forced it to allowed for the civilian usage.

With it's remarkable capabilities it has been used for wide spectrum of applications.



Segments of GPS

GPS Segments

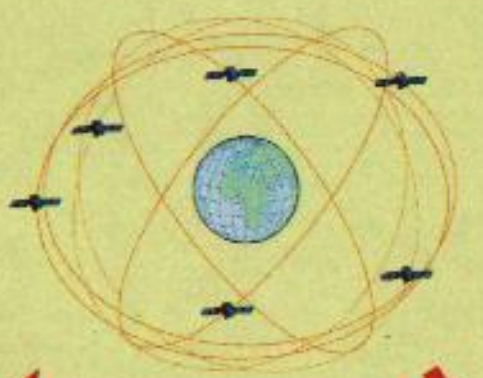
- The system can be divided in to three major segments.

1. Space Segment

2. Control Segment

3. User Segment

Three Segments

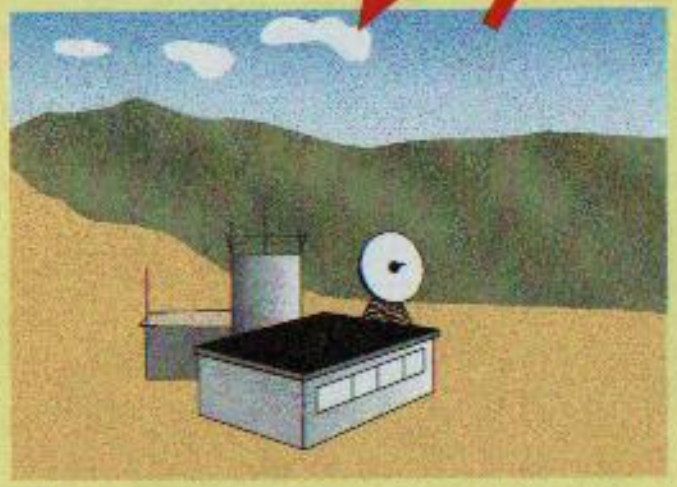


DOWNLINK

UPLINK

L1

L2



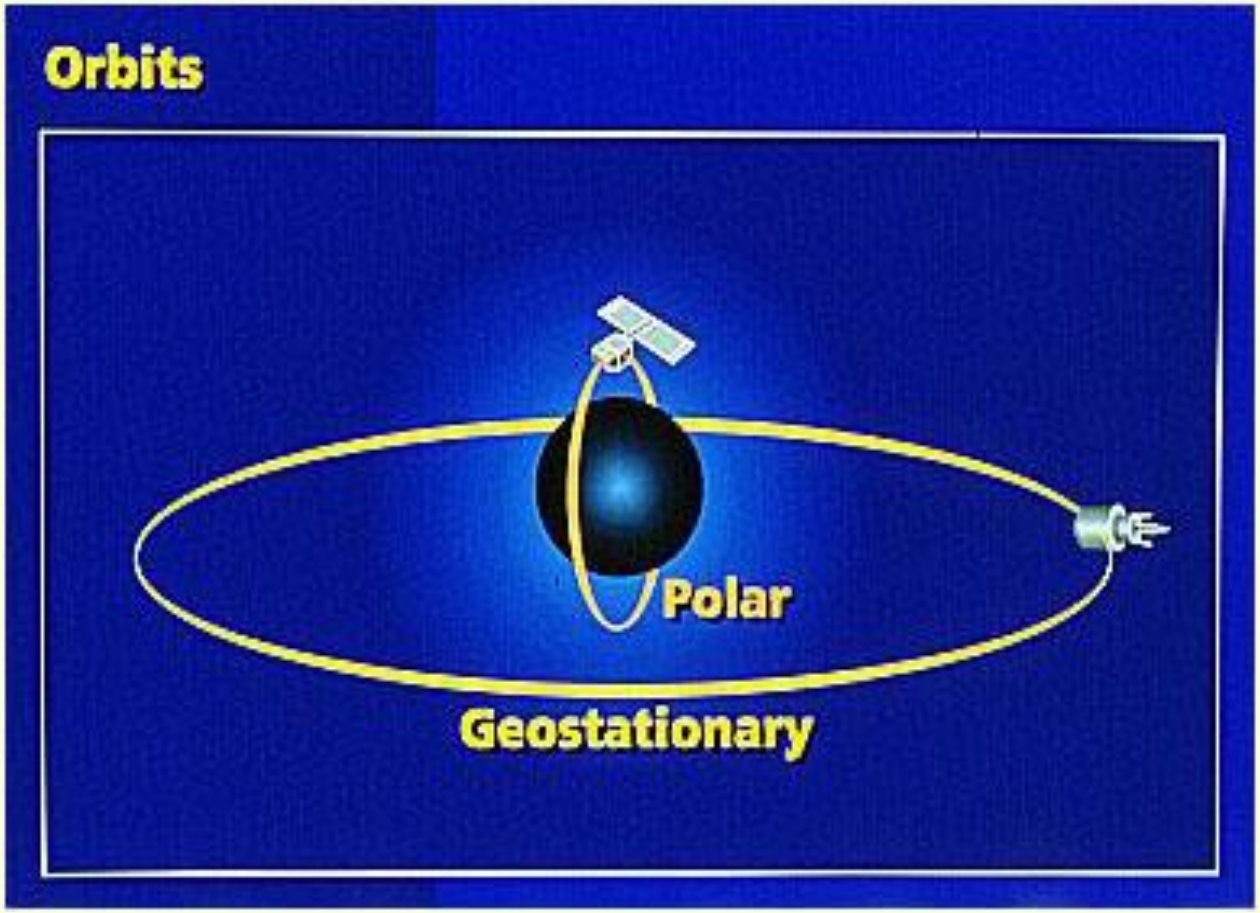
Control Segment

User Segment

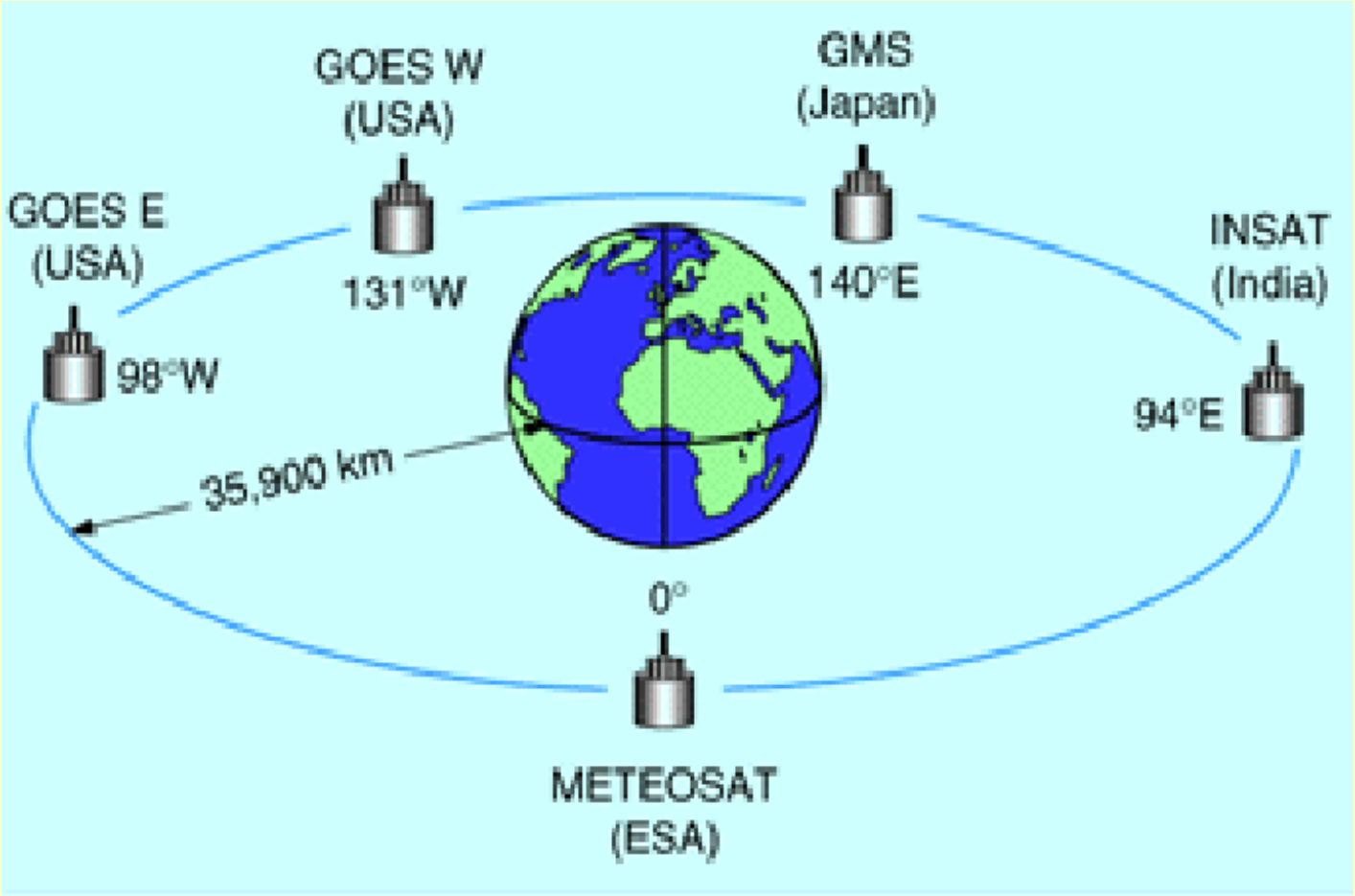
Space Segment

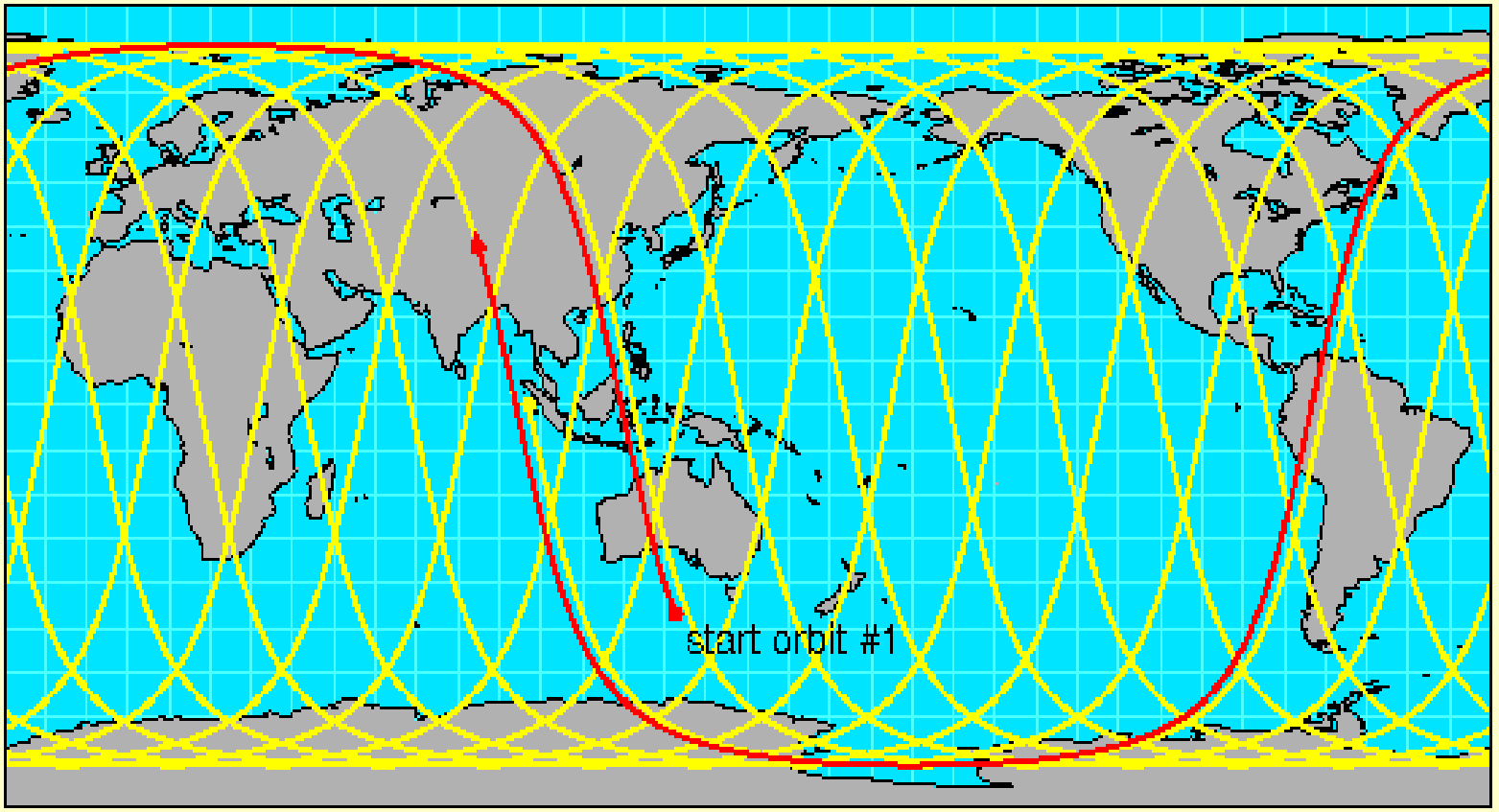
- The Space segment consist of 24 earth orbiting (orbital planes are centered on the Earth) satellites (now ??) in six different orbital planes
- Each orbital plane is 55° inclined to equatorial plane of the Earth
- GPS satellites continually transmits messages to the earth

Satellites and ORBITS



DIFFERENT SATELLITES IN GEOSTATIONARY ORBIT





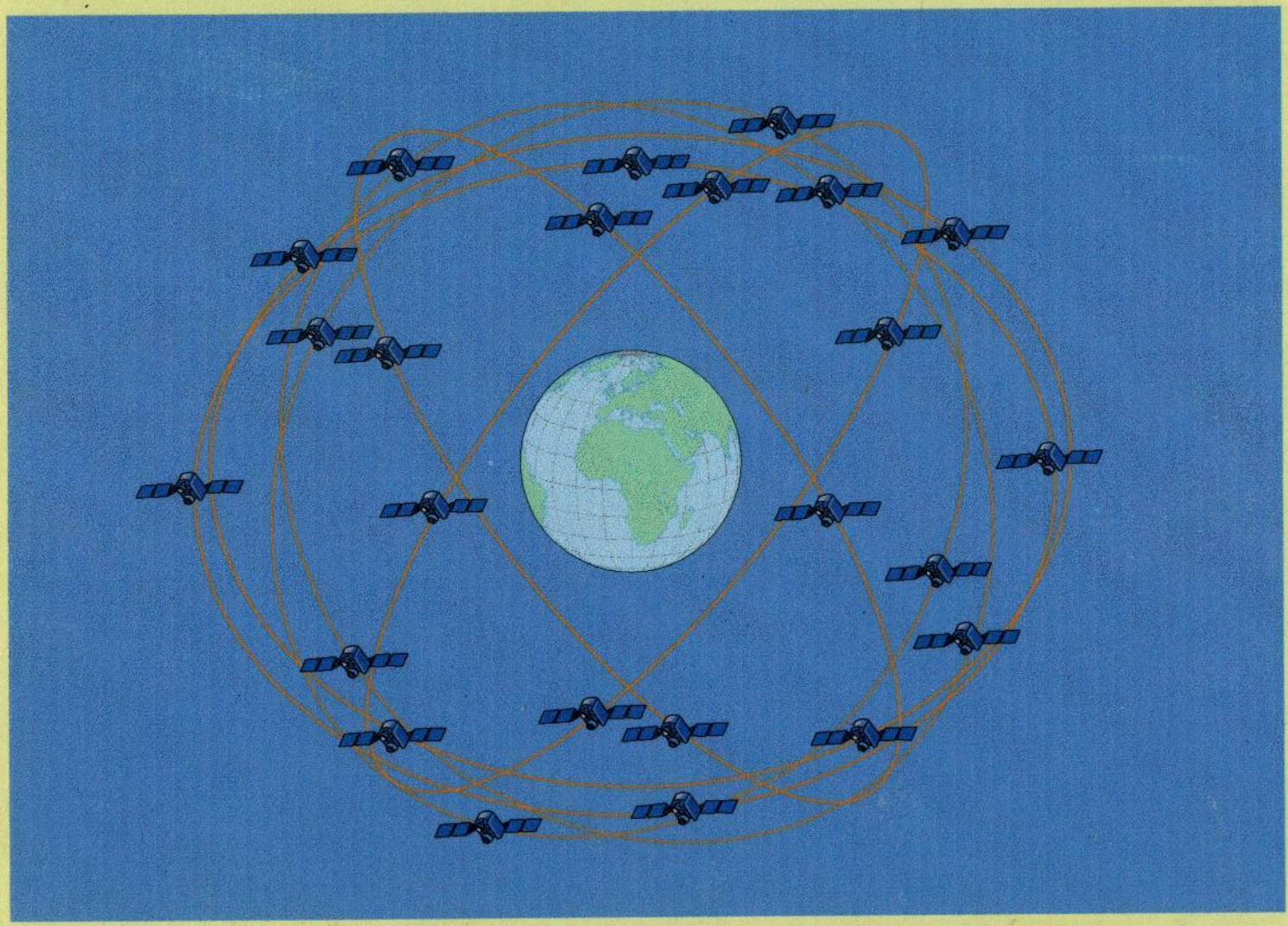
Sun-synchronous satellite's orbital Coverage of Earth

- Sun synchronous satellites pass over any given latitude at almost the same local time during each orbital pass. Therefore they image their swaths at about the same sun time during each pass, so that lighting remains roughly uniform.

SPECTRA™ PRECISION

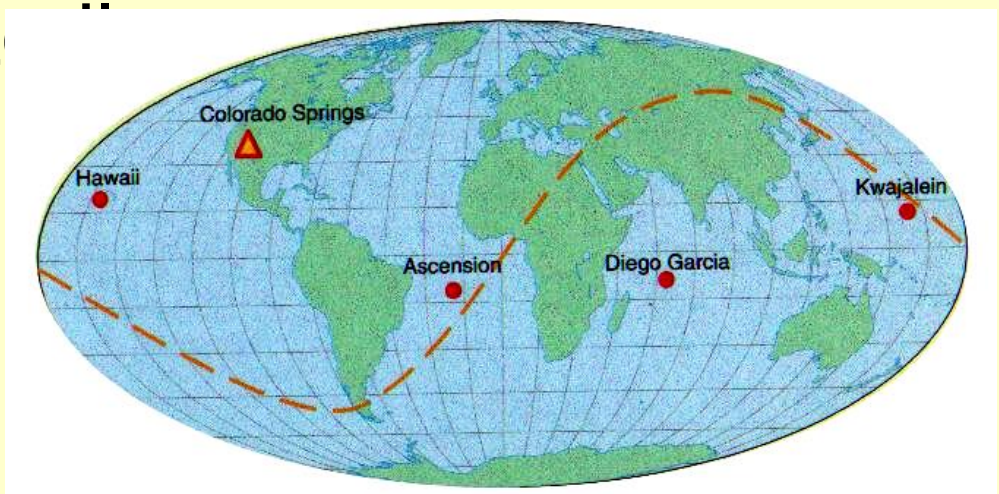
NAVSTAR GPS Global Positioning System

NAVigation System with Time And Ranging



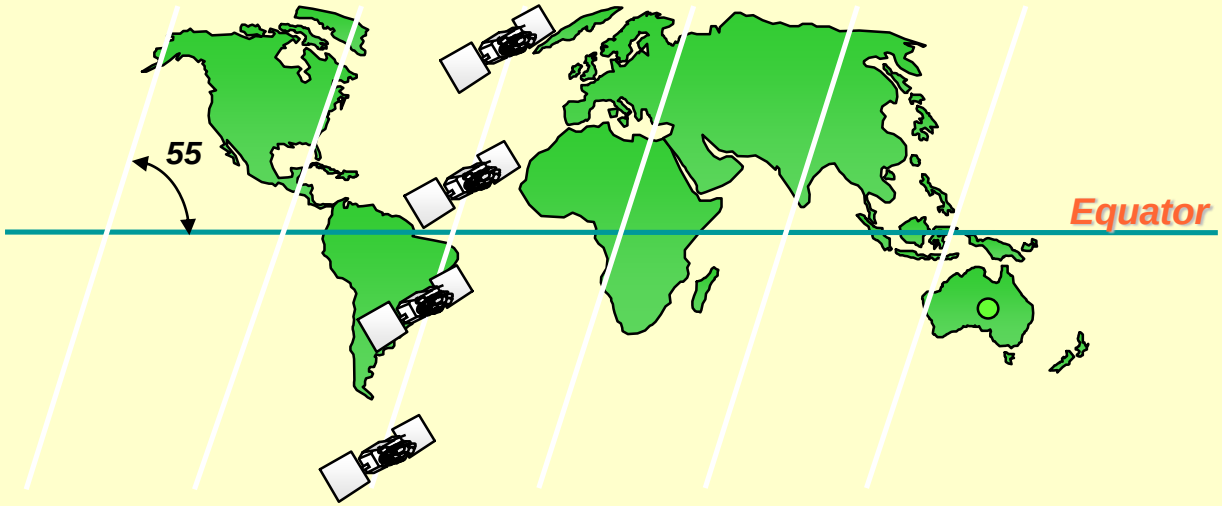
Space Segment

- All satellites are at the altitude of 20183 km. Above the Earth. This makes the period of the satellite exactly 12 sidereal hours (about 11hrs. 56 mins.)
- Therefore the foot print of the satellite will follow the same path on the earth surface repeat



Space Segment

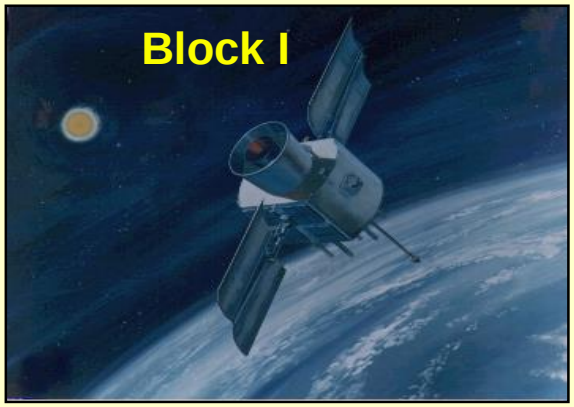
- 24 Satellites
  - 4 satellites in 6 Orbital Planes inclined at 55 Degrees
- 20200 Km above the Earth
- 12 Hourly orbits
  - In view for 4-5 hours
- Designed to last 7.5 years
- Different Classifications
  - Block 1, 2, 2A, 2R & 2 F,2R etc



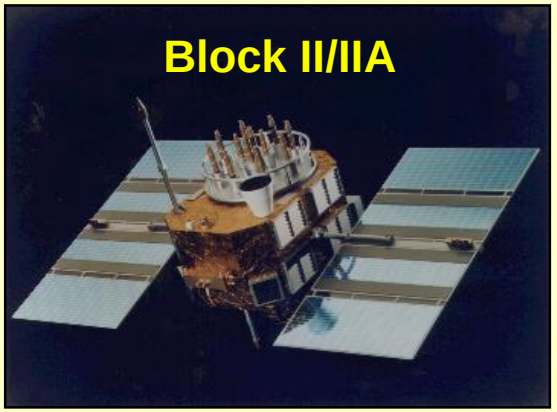
Space Segment

- Due to the above satellite configuration four to twelve (4-12) satellites are visible to any place on the earth at any time
- A satellite will stay above the horizon for around five hours
- The first GPS satellite was launch in 22 February 1978

Space Segment



First Launch: 22 Feb 78
On-Orbit: None



First Launch: 14 Apr 89
On-Orbit: 26 Healthy

First Launch: 22 Jul 1997
19 SVs in Production, 1 on Orbit

First Launch: 2003
Acquiring up to 33 SV's

Control Segment

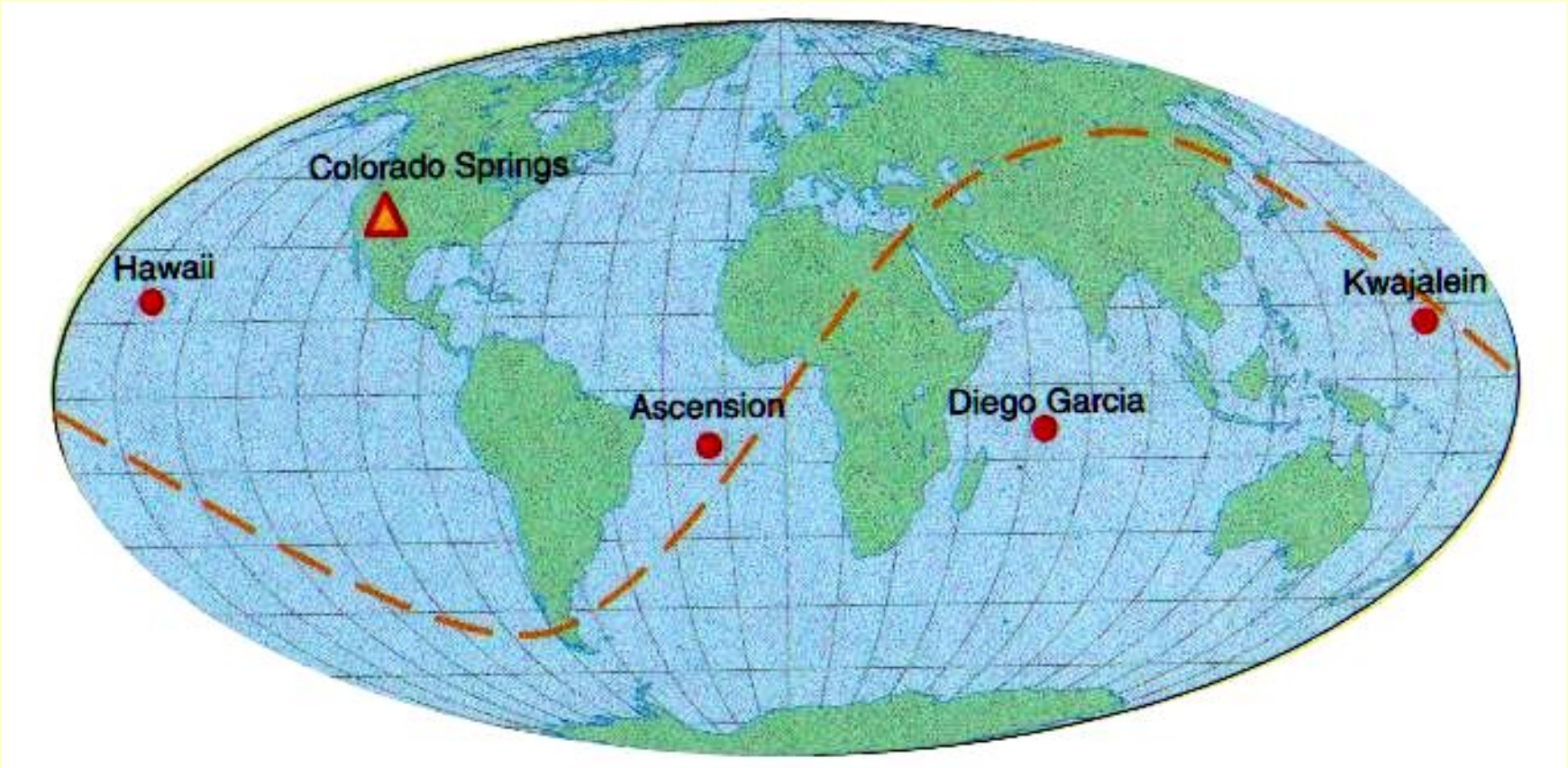
- The control segment is comprise of several ground tracking stations which are capable of tracking GPS satellites. The master Control Station (MCS) is located at Consolidated Space Operation Center at Falcon Air Force Base in Colorado. This station computes ephemeris and satellite clock corrections and upload satellites with updated values

Control Segment

- There are five monitoring station located at,
  - Ascension Islands
  - Diegeo Gracia
  - Hawaii
  - Kwajalein

- The flight paths of the satellites are tracked by these monitoring stations
- This tracking information is sent to the master control station

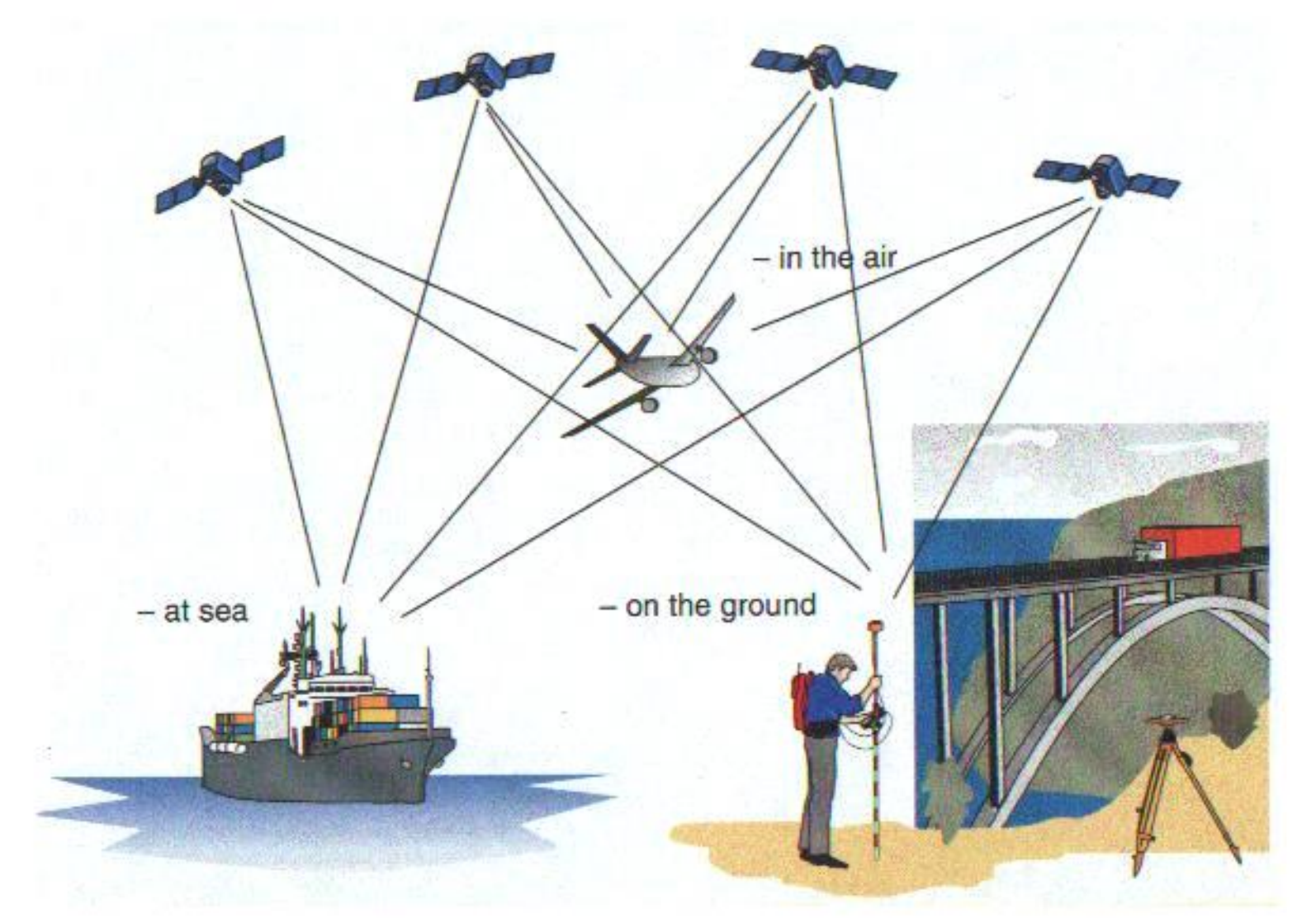
GPS Control Segment



User Segment

- The user community whom uses GPS as a tool for wide spectrum of applications are known as user segment
- Some of these users,
  - Navigators
  - Surveyors
  - GIS developers
  - Hikers

GPS Users

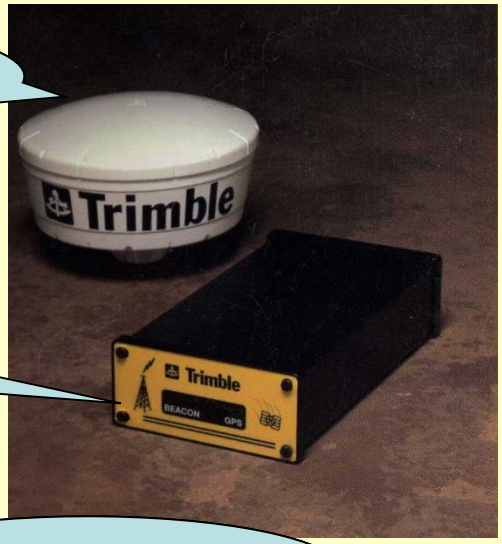


Components of a GPS unit

- Antenna – Focuses and tunes the frequencies transmitted by the satellites to the receiver
- Receiver/Processor equipped with a crystal clock – Receives and processes the received signals
- Controller – Controls the Unit and displays the location and other information to the user
- Data logger
- Connecting cables
- Power supply
  - Configuration of these components vary from one product to another

Components of a GPS unit

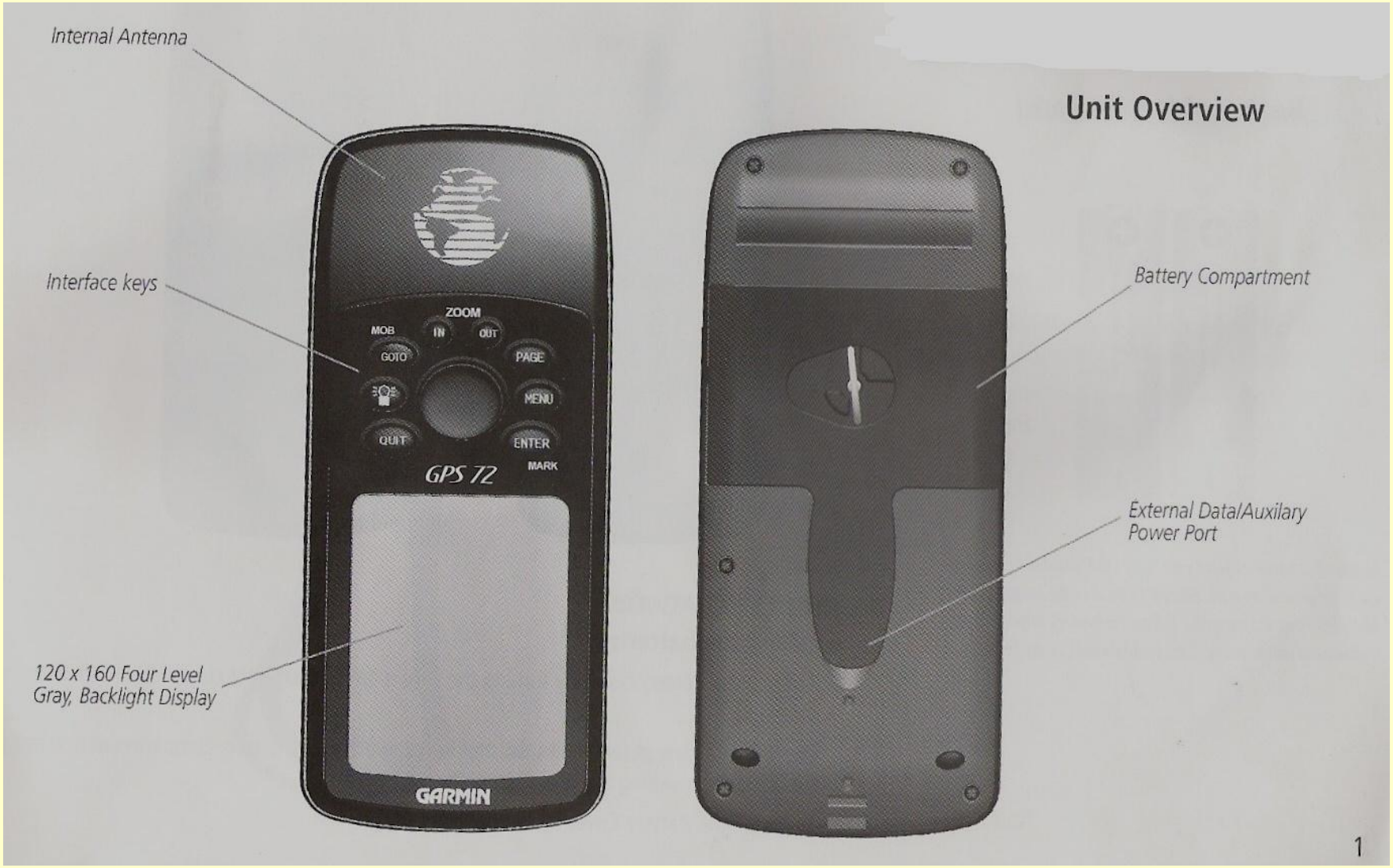
Antenna



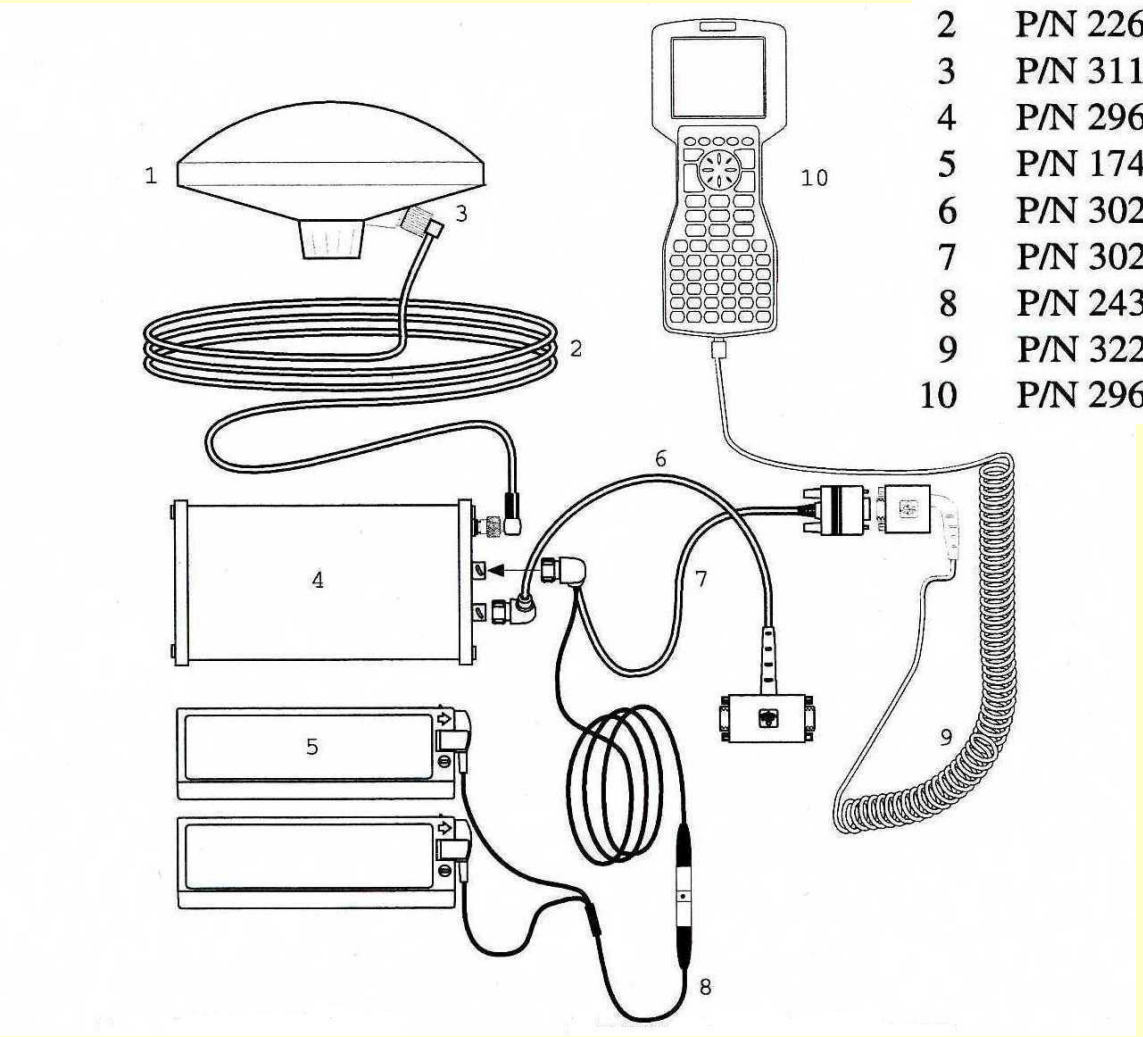
Receiver

Data logger

Garmin 72 GPS

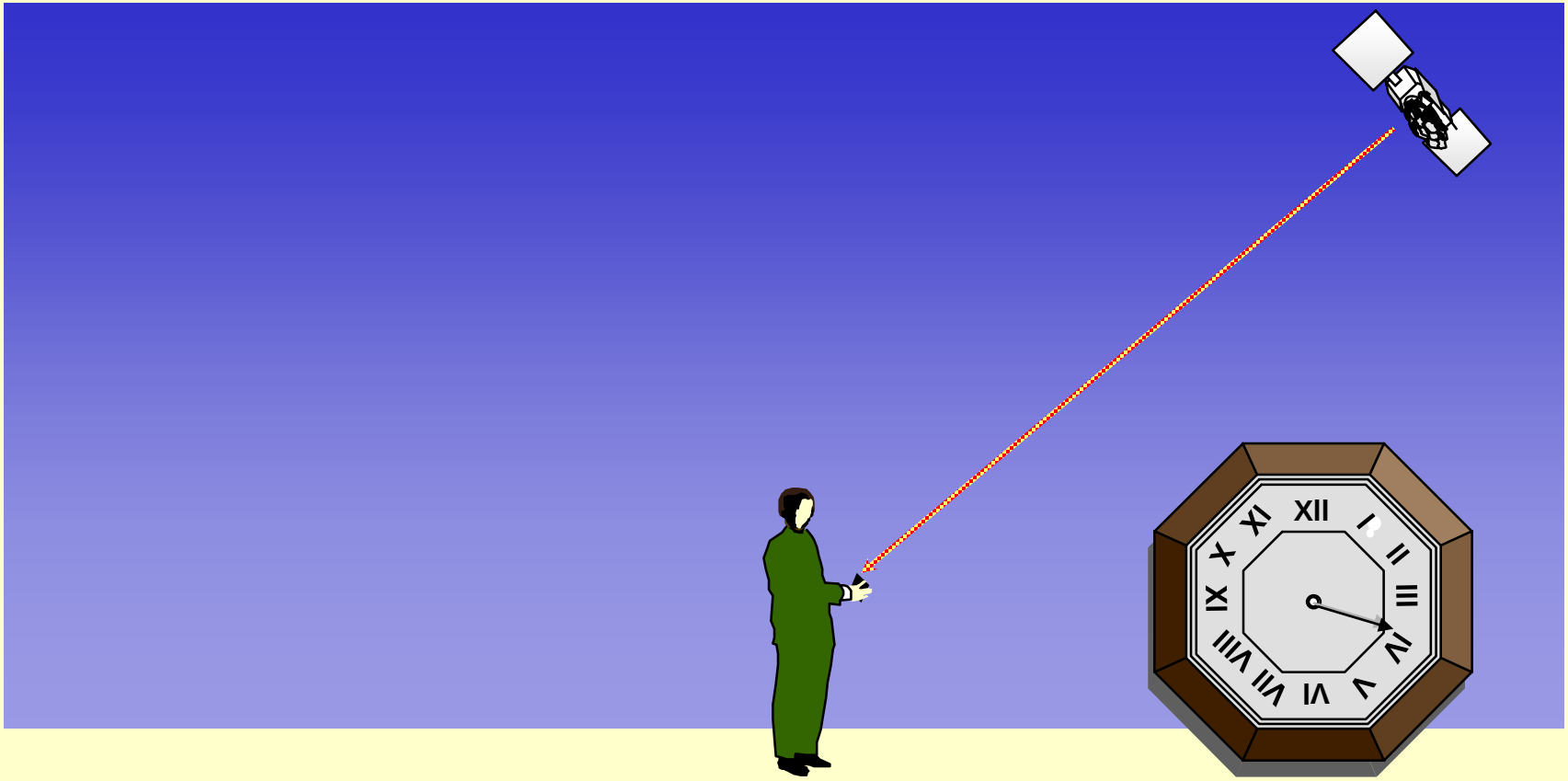


Cabling of a GPS Unit



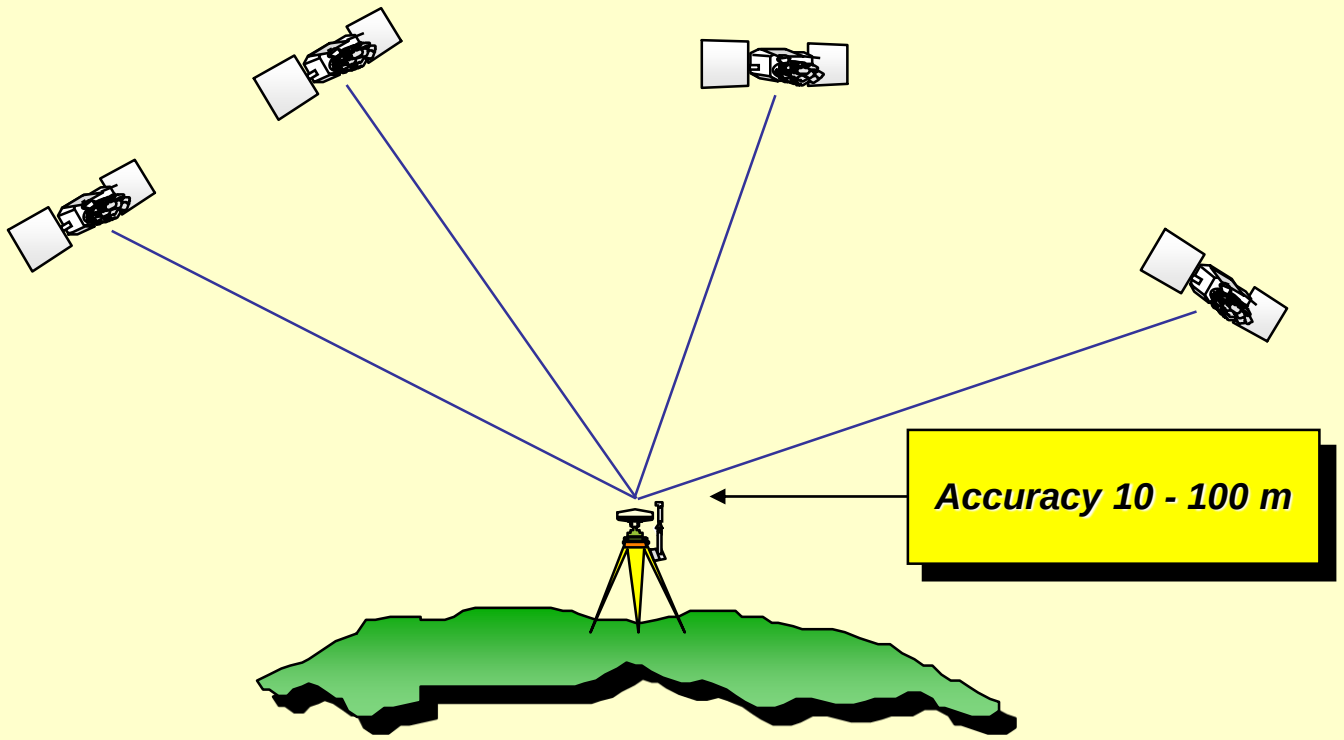
1	P/N 16741-00	Compact Dome Antenna
2	P/N 22628	Antenna Cable
3	P/N 31180	Antenna Cable Adapter
4	P/N 29654-11	12-channel Pro XR receiver
5	P/N 17466	Camcorder Batteries
6	P/N 30232-00	NMEA/RTCM Cable
7	P/N 30231-00	Data/Power Cable
8	P/N 24333	Dual Battery Cable
9	P/N 32287-00	TSC1 Data/ESP Cable
10	P/N 29673-50	TSC1 Handheld

Outline Principle : Range



Range = Time Taken x Speed of Light

Point Positioning



A receiver in autonomous mode provides navigation and positioning accuracy of about 10 to 100 m due to the effects of GPS errors!!?

Other Satellite Positioning Systems

Other Satellite Positioning Systems

- GLONASS (Russia)
- Galileo System (EU)
- Beidou Navigation System (China)
- COMPASS (China)
- IRNSS (India)

GLONASS

- **GLONASS** is the satellite navigation system, developed by the former Soviet Union and now operated for the Russian government by the Russian Space Forces
- It is an alternative and complementary to the United States' Global Positioning System (GPS) and the planned Galileo positioning system of the European Union (EU).

GLONASS

- Development on the GLONASS began in 1976, with a goal of global coverage by 1991
- Beginning on 12 October 1982, numerous rocket launches added satellites to the system until the constellation was completed in 1995
- Following completion, the system rapidly fell into disrepair with the collapse of the Russian economy
- Beginning in 2001, Russia committed to restoring the system, and accelerated the program with a goal of restoring global coverage

Galileo System

- Galileo is a global navigation satellite system currently being built by the European Union (EU) and European Space Agency (ESA)
- This project is an alternative and complementary to the U.S. Global Positioning System (GPS) and the Russian GLONASS
- The required satellites — the planned number is 30 — will be launched throughout the period from 2006 and the system is planned to be up and running under civilian control.

Thank You