UNIT IV

MODERN FIELD SURVEY SYSTEMS

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ELECTRONIC DISTANCE MEASUREMENTS (EDM)

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Electronic Distance Measurement (EDM)

- **Electronic distance measuring** instrument is a surveying instrument for measuring distance electronically between two points through electromagnetic waves.

DDM or Direct distance measurement – This is mainly done by chaining or taping.

ODM or Optical distance measurement – This measurement is conducted by tacheometry, horizontal subtense method or telemetric method. These are carried out with the help of optical wedge attachments.

EDM or Electromagnetic distance measurement – Electronic distance measurement (EDM) is a method of determining the length between two points, using phase changes, that occur as electromagnetic energy waves travels from one end of the line to the other end.

Electronic distance measurement in general is a term used as a method for distance measurement by electronic means. In this method instruments are used to measure distance that rely on propagation, reflection and reception of electromagnetic waves like radio, visible light or infrared waves.

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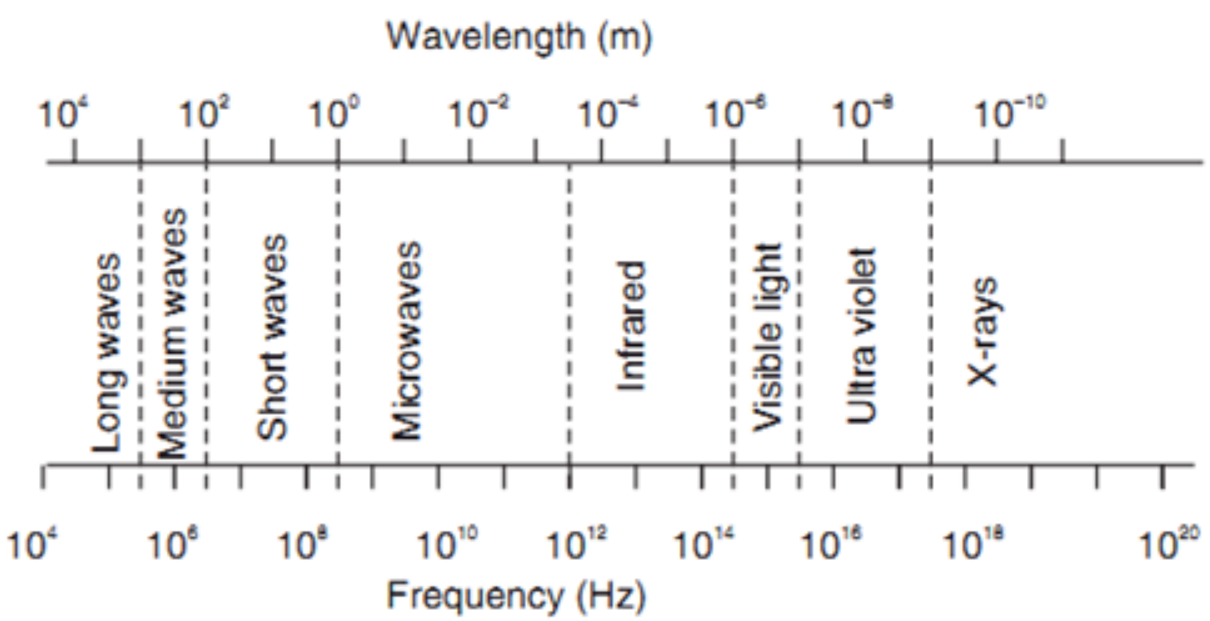
Electronic Distance Measurement (EDM)

Sun light or artificially generated electromagnetic wave consists of waves of different lengths. The spectrum of an electromagnetic wave is as shown below:



Among these waves microwaves, infrared waves and visible light waves are useful for the distance measurement.

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Electronic Distance Measurement (EDM)

Types of Electronic Distance Measurement Instrument:

EDM instruments are classified based on the type of carrier wave as

1. Microwave instruments
2. Infrared wave instruments
3. Light wave instruments.

1. Microwave Instruments

These instruments make use of microwaves. And named as **Tellurometers.** They are light and highly portable. Tellurometers can be used in day as well as in night.The range of these instruments is up to 100 km

2. Infrared Wave Instruments

In this instrument amplitude modulated infrared waves are used. Prism reflectors are used at the end of line to be measured. These instruments are light and economical and can be mounted on theodolite. With these instruments accuracy achieved is ± 10 mm. The range of these instruments is up to 3 km. The instruments available in trade name of **Distomat.**

3. Visible Light Wave Instruments

These instruments rely on propagation of modulated light waves. This type of instrument was first developed in Sweden and was named as **Geodimeter.** During night its range is up to 2.5 km while in day its range is up to 3 km. Accuracy of these instruments varies from 0.5 mm to 5 mm/km distance

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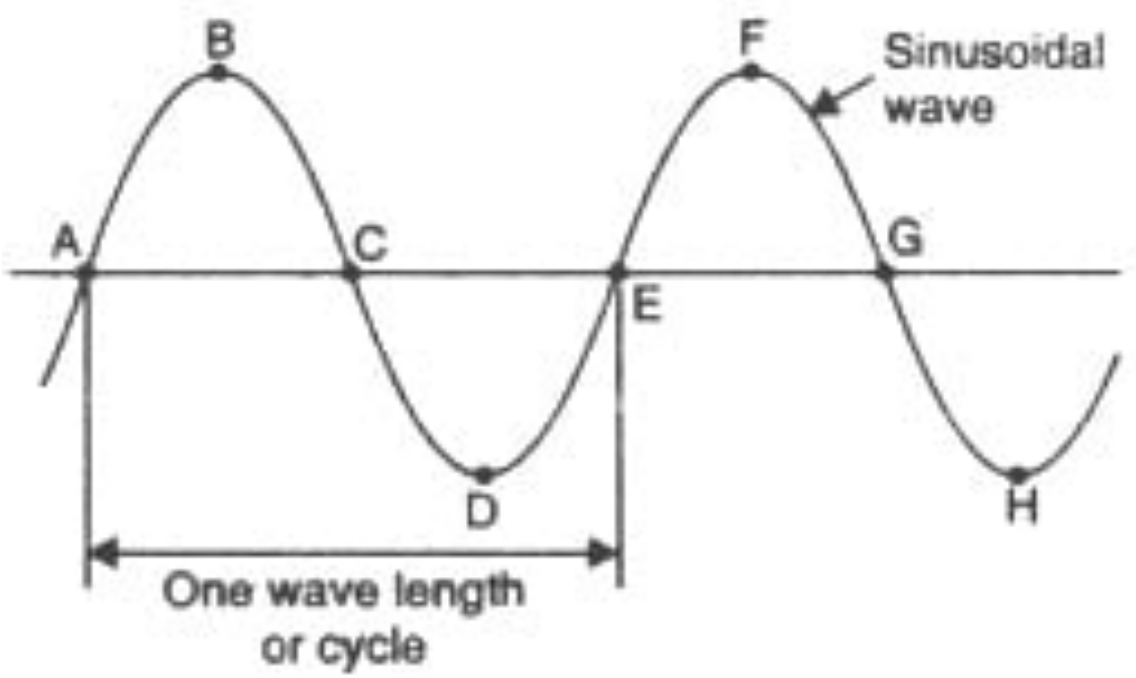
Electronic Distance Measurement (EDM)

Properties of Electro Magnetic waves:

Electro magnetic waves , though extremely complex in nature, can be represented in form of periodic sinusoidal waves.



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Electronic Distance Measurement (EDM)

Properties of Electro Magnetic waves:

1. The waves completes a ***cycle*** in moving from identical points A to E or B to F or D to H.
2. The number of times the wave completes a cycle in one second is termed as ***frequency*** of the wave. Represented by f (Hertz).
3. The length travelled in one cycle by the wave is termed as ***wavelength*** and denoted by λ .
4. The ***period*** is the time taken by the wave to travel through one cycle or one wavelength. It is represented by T seconds.
5. The velocity(v) of the wave is the distance travelled by in an second.

$$V = f.\lambda = (\frac{1}{T}\lambda)$$

$$f = 1/T; \ (T = \text{Time in seconds})$$

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Electronic Distance Measurement (EDM)

Properties of Electro Magnetic waves:

Another property of the wave, known as Phase of the wave and denoted by symbol ∅.

Point →	A	B	C	D	E	F	G	H
Phase $\phi°$	0	90	180	270	360 (or 0)	90	180	270

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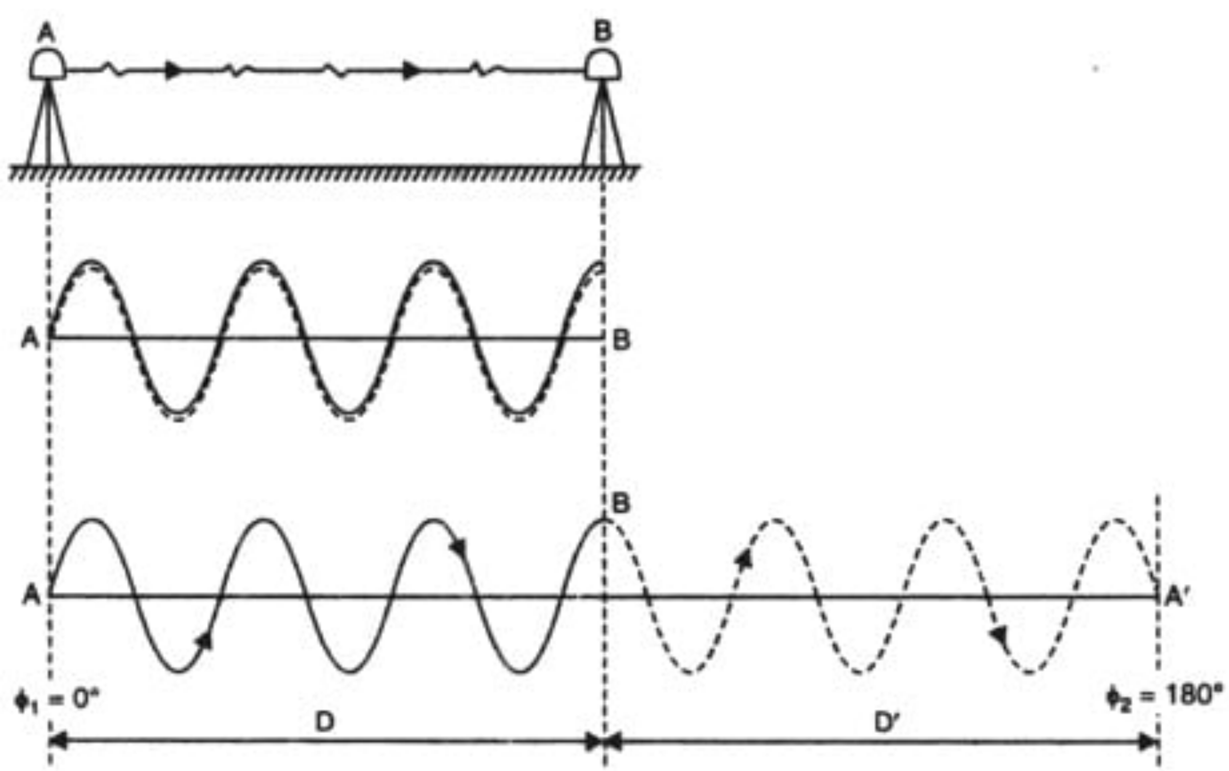
Electronic Distance Measurement (EDM)

Measurement of transit time:

Say AB is the survey line to me measured, having a length of D. The EDM equipment is placed at ends A and B. A transmitter is placed at A and a receiver is placed at B. the transmitter lets propagation of electromagnetic waves towards B. A timer is also placed. At the instant of transmission of wave from A the timer at B starts and stops at the instant of reception of incoming wave at B. This enable us to know the transit time for the wave from the point A to B.



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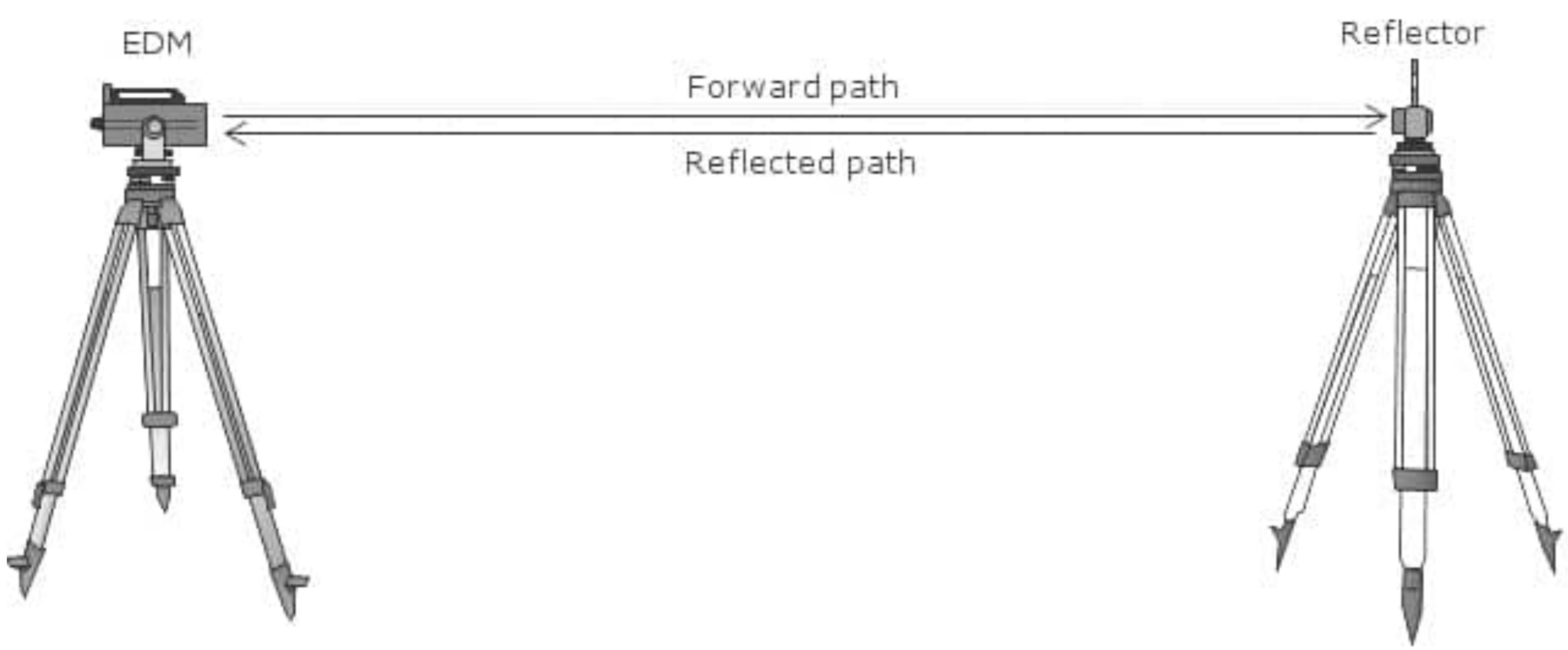
Electronic Distance Measurement (EDM)

Measurement of transit time:

From the transit time and known velocity, the distance can be easily measured. Now to solve the problem arise due to difficulty in starting the timer at B, a reflector can be placed as shown below instead of a receiver at B.



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Electronic Distance Measurement (EDM)

Measurement of distance with EDM and a Reflector:

As explained let the waves get transmitted from A and reflected from B. If the received signal is out of phase by a measure of $\Delta\varnothing$.

Thus, the distance is

$$D = \frac{1}{2}\left[n\Lambda + \left(\frac{\Delta\emptyset}{360}\right) \Lambda\right]$$

where n is the integral number of wavelength

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Electronic Distance Measurement (EDM)

Error in Electronic Distance Measurement Instruments:

Personal Errors

- Inaccuracy in initial setups of EDMs and the reflectors over the preferred stations
- Instrument and reflector measurements going wrong
- Atmospheric pressures and temperature determination errors

Instrumental Errors

- Calibration errors
- Chances of getting maladjusted time to time generating frequent errors
- Errors shown by the reflectors

Natural Errors

- Atmospheric variations in temperature, pressure as well as humidity. Micro wave EDM instruments are more susceptible to these.
- Multiple refraction of the signals.

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TOTAL STATION

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Total Station

Total station is a surveying equipment combination of **Electromagnetic Distance Measuring Instrument** and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument.

Capability of a Total Station:

Microprocessor unit in total station processes the data collected to compute:

1. **Averages** multiple **angle** measurements.
2. **Averages** multiple **distance** measurements.
3. Computes **horizontal** and **vertical distances.**
4. **Corrections** for temp, pressure and humidity.
5. **Computes** inverses, polars, resections.
6. **Computes** X, Y and Z **coordinates.**

Data collected and processed in a Total Station can be downloaded to computers for further processing.

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Total Station

Total stations with different accuracy, in angle measurement and different range of measurements are available in the market. Here are the parts of Total station.

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Accuracy of Total station:

The accuracy of a total station is dependent on instrument type.

- Angle Accuracy (Horizontal or Vertical) can range from 2” to 5”.
- Distance Accuracy can range from: +/- (0.8 + 1 ppm x D) mm to +/- (3 + 3 ppm x D) mm where D = distance measured

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Total Station

Applications of Using Total Stations:

There are many other facilities available, the total station can be used for the following purposes.

1. Detail survey i.e., data collection.
2. Control Survey (Traverse).
3. Height measurement (Remove elevation measurement- REM).
4. Fixing of missing pillars (or) Setting out (or) Stake out.
5. Resection.
6. Area & Volume calculations, etc.
7. Remote distance measurement (RDM) or Missing line measurement (MLM).

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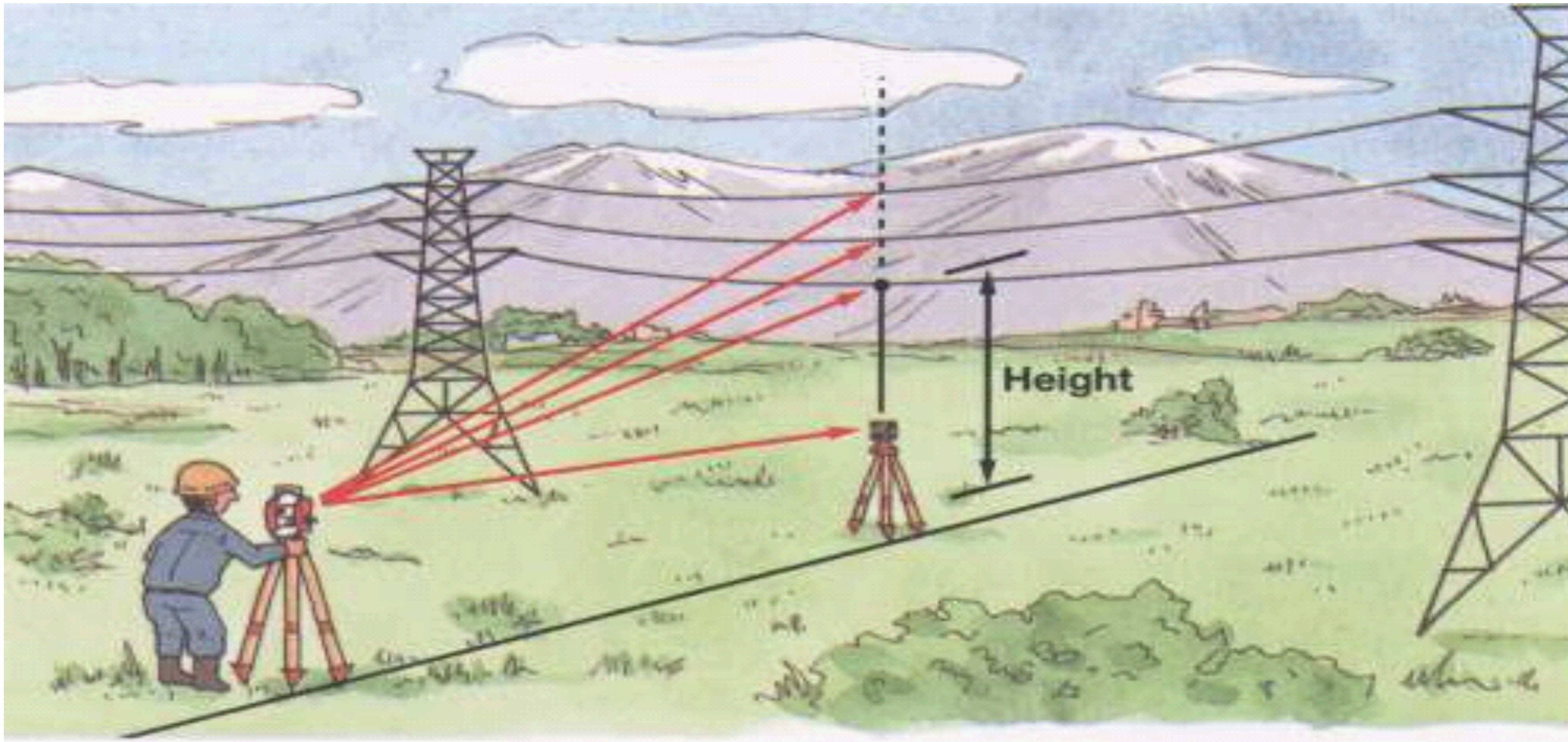
Total Station



REM

With REM measurement, a Prism (reference point) is set directly below the place to be measured, and by measuring the Prism, the height to the Target object can be measured. This makes it easy to determine the heights of electric power lines, bridge suspension cables, and other large items used in construction.

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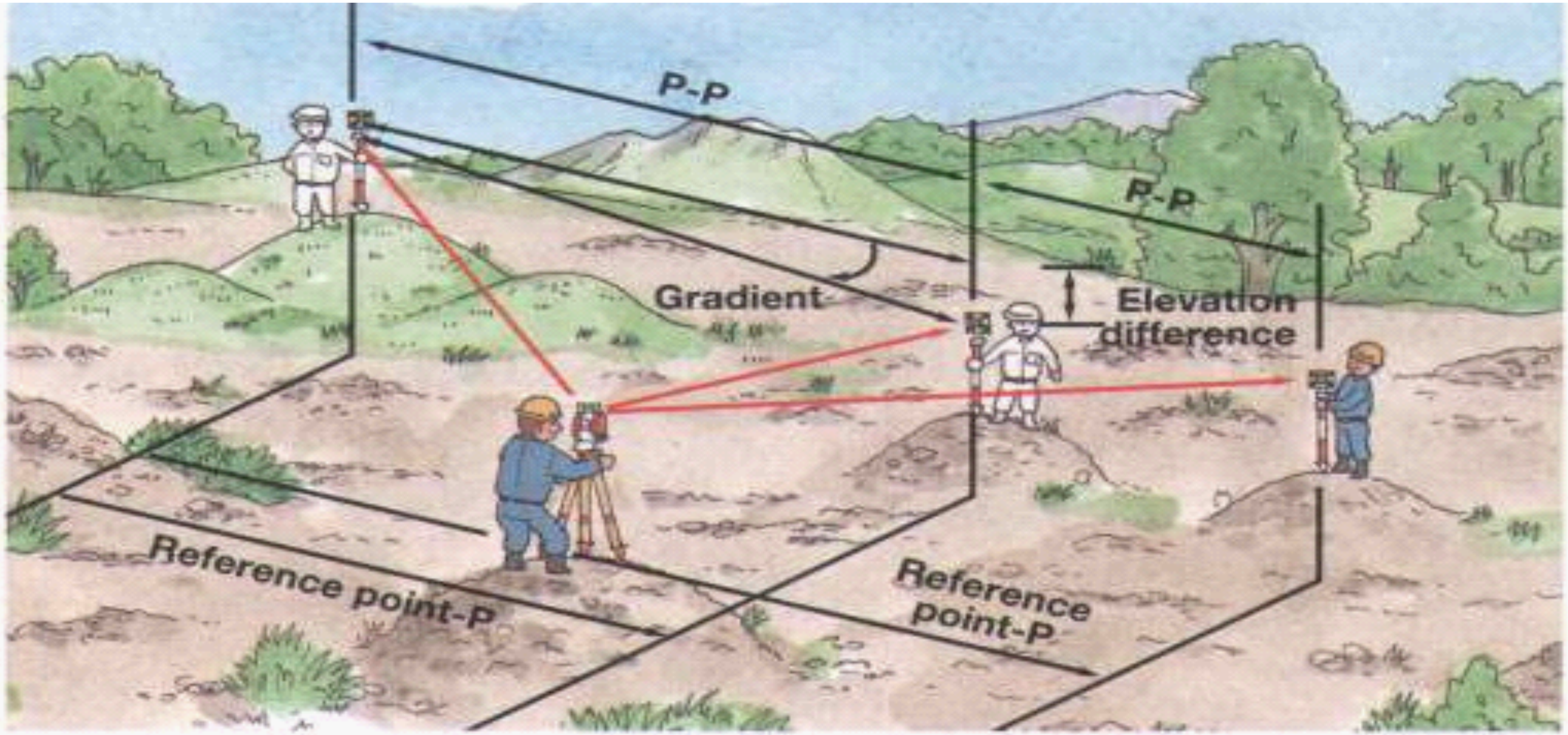
Total Station



RDM

With RDM measurement, the horizontal distance, slope distance, difference in height and percentage of slope between the reference point and the observation point are measured. The distance between one observation point and another one is measured as well.

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Advantages of Using Total Stations:

The following are some of the **major advantages of using total station** over the conventional surveying instruments:

1. Field work is carried out very fast.
2. Accuracy of measurement is high.
3. Manual errors involved in reading and recording are eliminated.
4. Calculation of coordinates is very fast and accurate. Even corrections for temperature and pressure are automatically made.
5. Computers can be employed for map making and plotting contour and cross-sections. Contour intervals and scales can be changed in no time

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Uses of Using Total Stations:

The uses of Total Station are as follows:

- Mine Survey
- Cadastral Survey
- Engineering Survey
- Large Scale Survey
- Road / Rail / Canal Survey etc,.

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GLOBAL POSITIONING SYSTEM (GPS)

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Global Positioning System (GPS)

- The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S. Department of Defense (DoD) in the early 1970s. Initially, GPS was developed as a military system to fulfil U.S. military needs
- GPS provides continuous positioning and timing information, anywhere in the world under any weather conditions
- GPS is the shortened form of NAVSTAR GPS. This is an acronym for **NA**Vigation **S**ystem with **T**ime **A**nd **R**anging **G**lobal **P**ositioning **S**ystem.
- GPS is a solution for one of mans longest and most troublesome problems. It provides an answer to the question **Where on earth am I** ?

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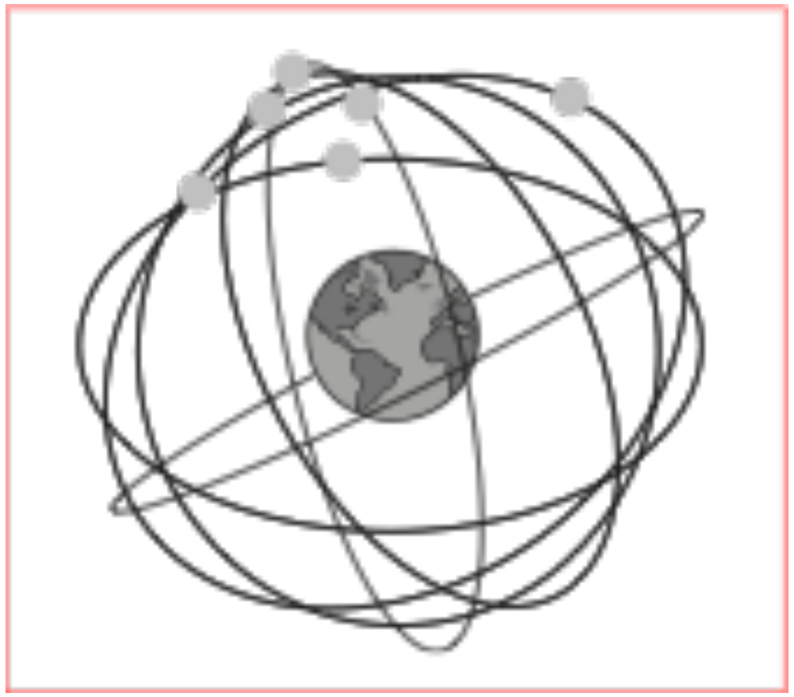
Global Positioning System (GPS)

- GPS is a satellite-based system that uses a constellation of 24 satellites to give a user an accurate position
- To ensure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes
- With this constellation geometry, four to ten GPS satellites will be visible anywhere in the world, if an elevation angle of 10° is considered
- GPS satellite orbits are nearly circular (an elliptical shape with a maxi- mum eccentricity is about 0.01), with an inclination of about 55° to the equator.



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Global Positioning System (GPS)

GPS Segments:

The total GPS configuration is comprised of three distinct segments:

1. **The Space Segment** : Satellites orbiting the earth.
2. **The Control Segment** : Stations positioned on the earths equator to control the satellites
3. **The User Segment**: Anybody that receives and uses the GPS signal

1) The Space Segment:

- The Space Segment is designed to consist of 24 satellites orbiting the earth at approximately 20200km every 12 hours .
- The space segment is so designed that there will be a minimum of 4 satellites visible above a 15° cut-off angle at any point of the earths surface at any one time.
- Four satellites are the minimum that must be visible for most applications .
- Each GPS satellite has several very accurate atomic clocks on board.

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2) The Control Segment:

- The Control Segment consists of one master control station, 5 monitor sta-tions and 4 ground antennas distributed amongst 5 locations roughly on the earths equator.
- The primary task of the operational control segment is tracking the GPS satellites in order to determine and predict satellite locations, system integrity, behaviour of the satellite atomic clocks, atmospheric data, the satellite almanac, and other considerations

3) The User Segment:

The User Segment comprises of anyone using a GPS receiver to receive the GPS signal and determine their position and/ or time. Typical applications within the user segment are land navigation for hikers, vehicle location, surveying, marine navigation, aerial navigation, machine control etc.

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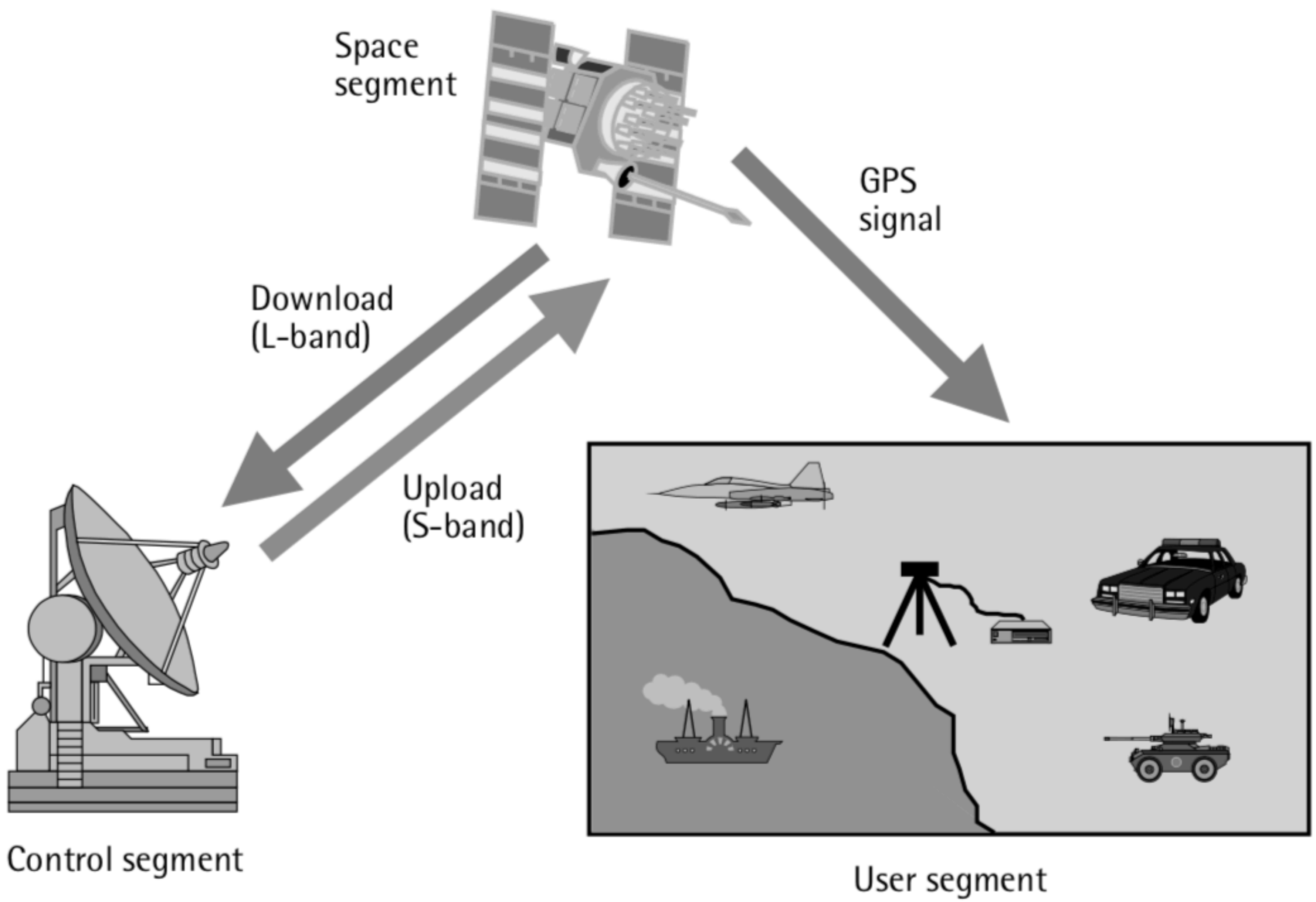
Global Positioning System (GPS)



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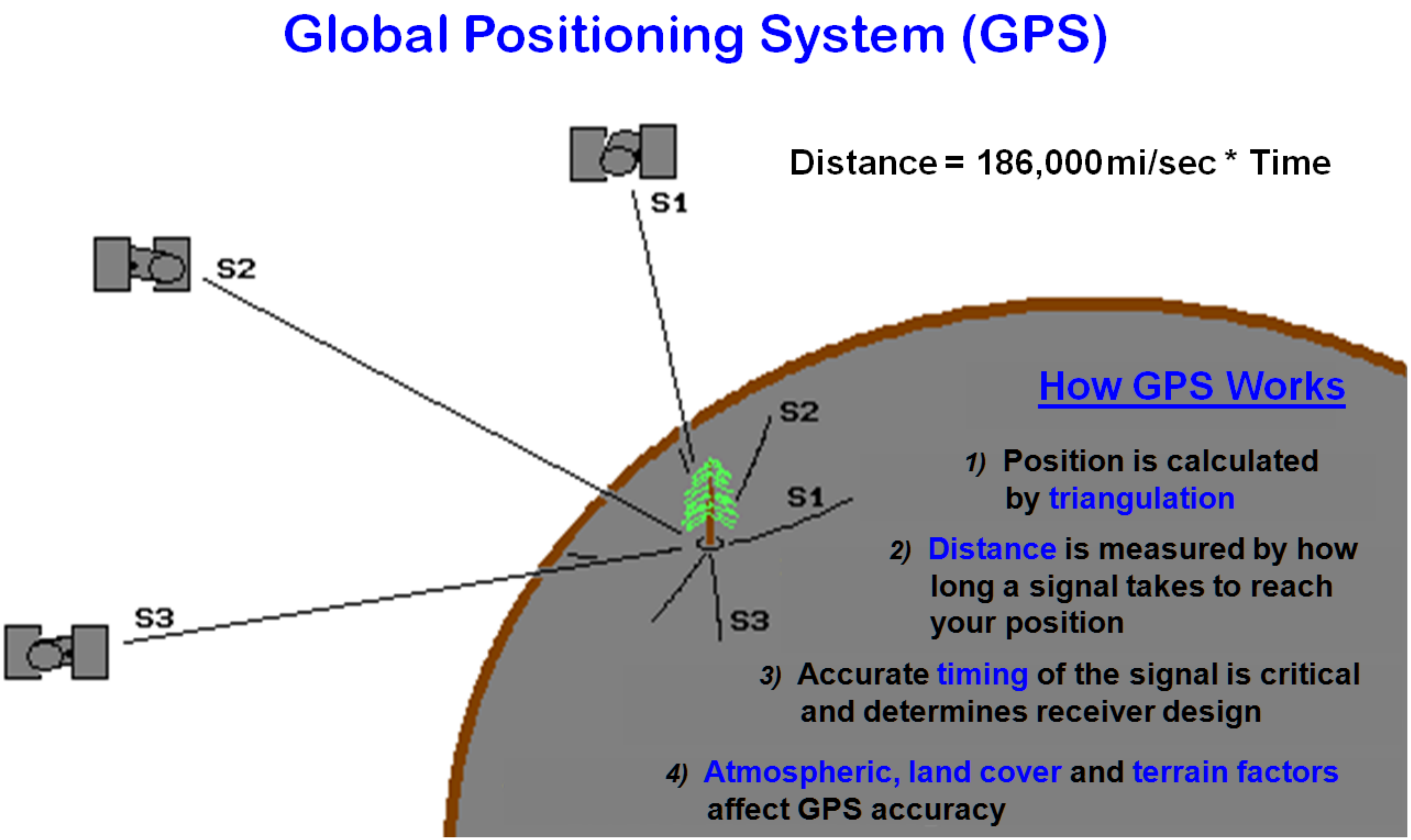

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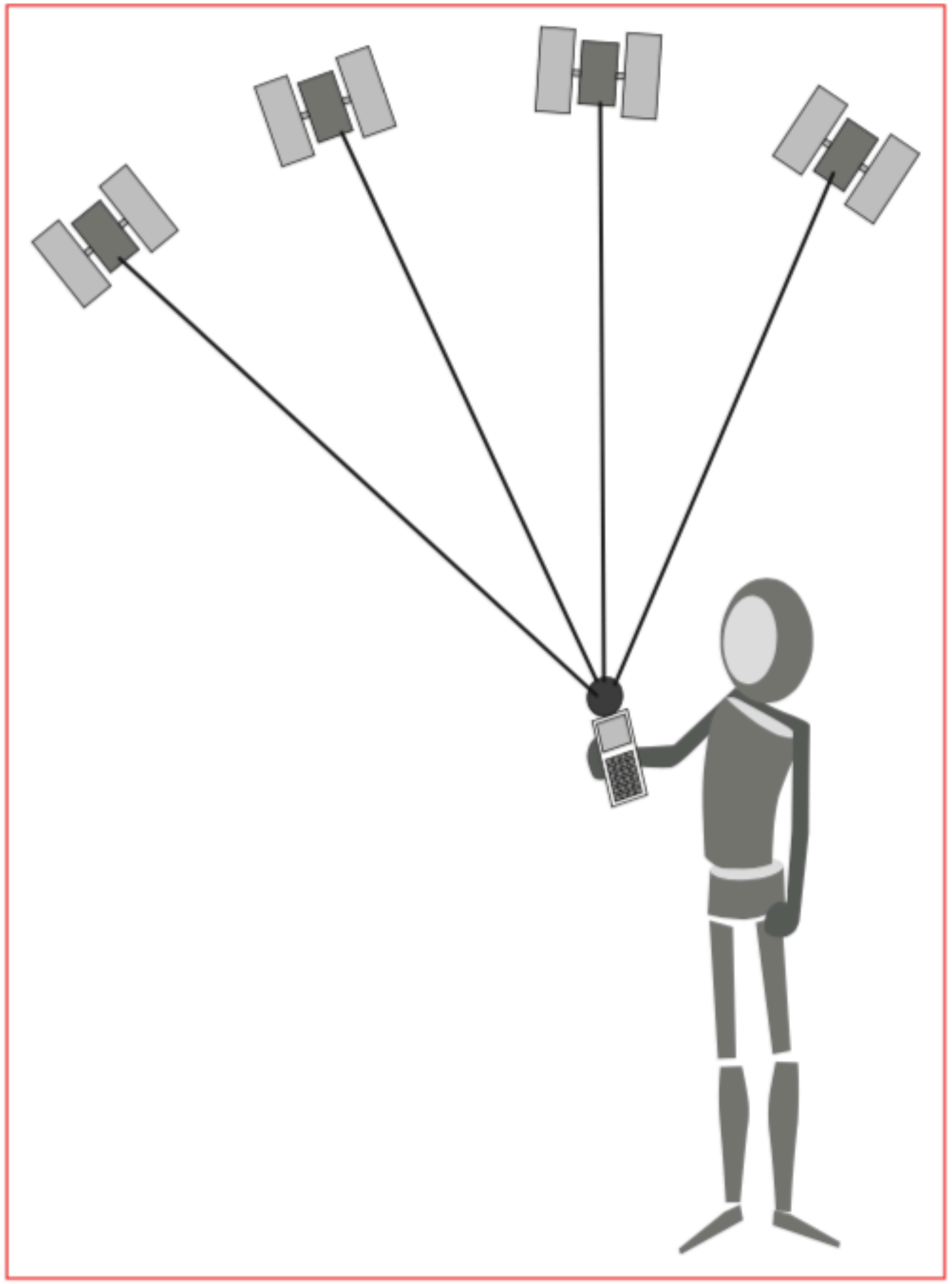
Global Positioning System (GPS)



At least four satellites are required to obtain a position and time in 3 dimensions

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Global Positioning System (GPS)

Errors & Biases:

It has been assumed that the position derived from GPS is very accurate and free of error, but there are several sources of error that degrade the GPS position from a theoretical few metres to tens of metres. These error sources are:

1. Ionospheric and atmospheric delays
2. Satellite and Receiver Clock Errors
3. Multi path Errors
4. Dilution of Precision
5. Selective Availability (S/A)

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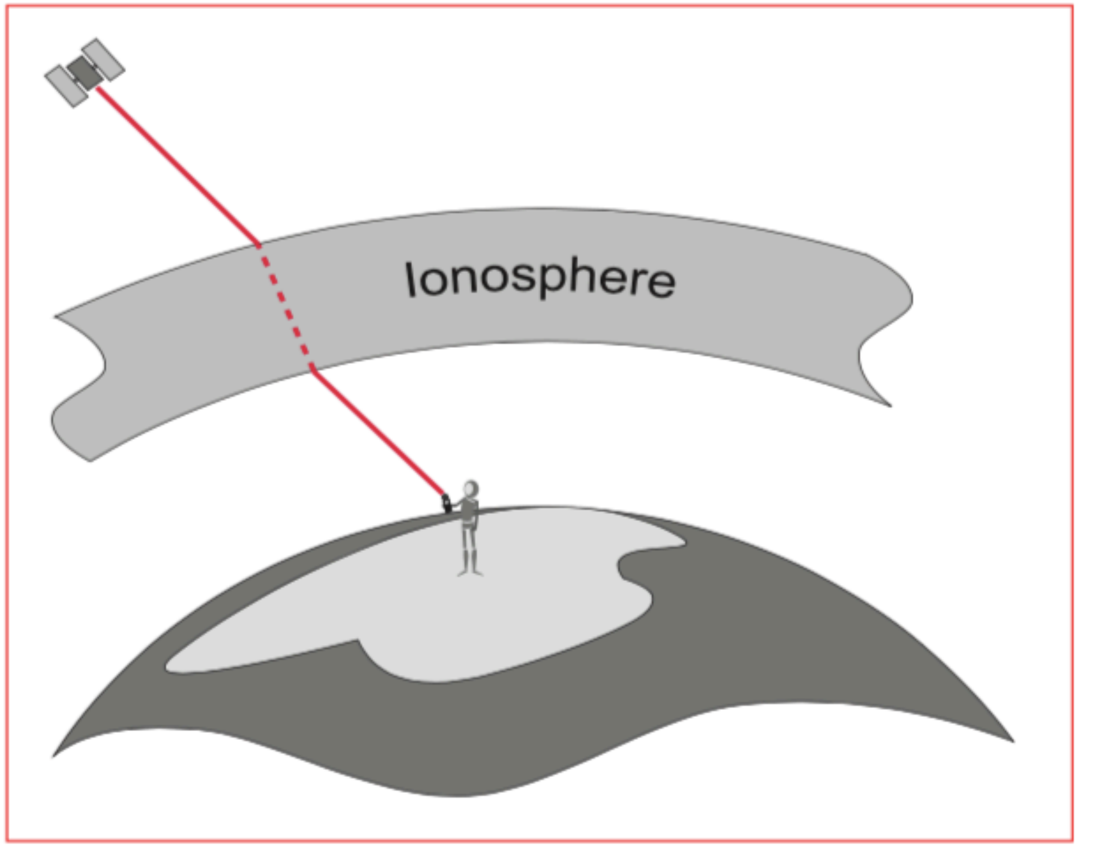
Global Positioning System (GPS)

1. Ionospheric and Atmospheric delays

As the satellite signal passes through the ionosphere, it can be slowed down, the effect being similar to light refracted through a glass block. These atmospheric delays can introduce an error in the range calculation as the velocity of the signal is affected



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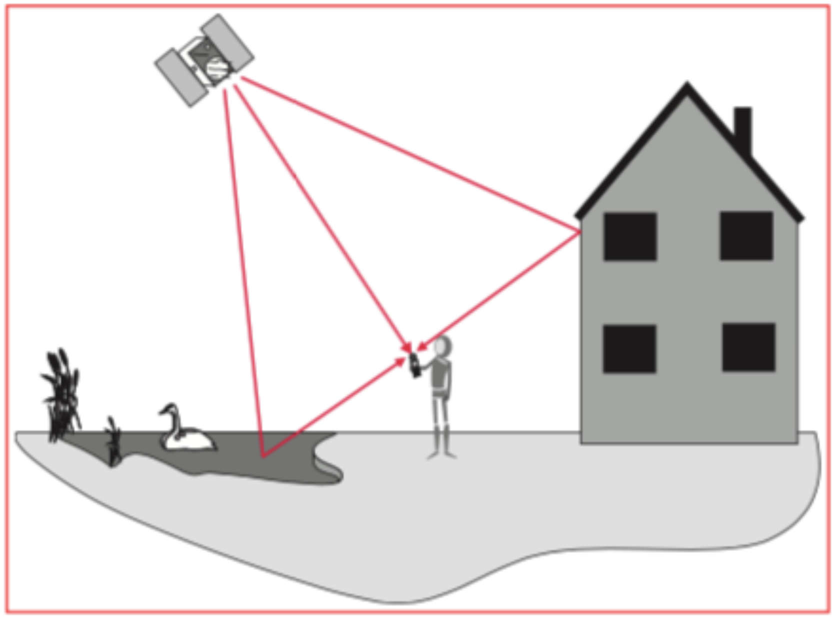
Global Positioning System (GPS)

2. Satellite and Receiver clock errors

Even though the clocks in the satellite are very accurate (to about 3 nanoseconds), they do sometimes drift slightly and cause small errors, affecting the accuracy of the position. The US Department of Defense monitors the satellite clocks using the Control Segment and can correct any drift that is found.

3. Multi path Errors

Multi path occurs when the receiver antenna is positioned close to a large reflecting surface such as a lake or building. The satellite signal does not travel directly to the antenna but hits the nearby object first and is reflected into the antenna creating a false measurement.



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Global Positioning System (GPS)

4.Dilution of Precision

The Dilution of Precision (DOP) is a measure of the strength of satellite geometry and is related to the spacing and position of the satellites in the sky. The DOP can magnify the effect of satellite ranging errors. When the satellites are well spaced, the position can be determined as being within the shaded area .

Different types of Dilution of Precision or DOP can be calculated depending on the dimension.

VDOP Vertical Dilution of Precision. Gives accuracy degradation in vertical direction.

HDOP Horizontal Dilution of Precision. Gives accuracy degradation in horizontal direction.

PDOP Positional Dilution of Precision. Gives accuracy degradation in 3D position.

GDOP Geometric Dilution of Precision. Gives accuracy degradation in 3D position and time.

The most useful DOP to know is GDOP since this is a combination of all the factors. The best way of minimising the effect of GDOP is to observe as many satellites 6 as possible.The most accurate positions will generally be computed when the GDOP is low

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5. Selective Availability (S/A)

Selective Availability is a process applied by the U.S. Department of Defense to the GPS signal. This is intended to deny civilian and hostile foreign powers the full accuracy of GPS by subjecting the satellite clocks to a process known as dithering which alters their time slightly.Currently, it is planned that S/A will be switched off by 2006 at the latest.

Applications & Uses of GPS:

Global positioning system applications generally fall into 5 major categories:

1. **Location** - determining a position
2. **Navigation** - getting from one location to another
3. **Tracking** - monitoring object or personal movement
4. **Mapping** - creating maps of the world
5. **Timing** - bringing precise timing to the world

Some of the applications that **GPS systems** are currently being used for around the world include mining, aviation, surveying, agriculture, marine, recreation, and military. These days doctors, scientists, farmers, soldiers, pilots, hikers, delivery drivers, sailors, fishermen, dispatchers, athletes, and people from many other walks of life are using GPS systems in ways that make their work more productive, safer, and easier.

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