

MODULE - 5

MODERN SURVEYING INSTRUMENTS

Electro magnetic distance measurement [EDM]

There are three types or methods of measuring distances between any two given points

(1) Direct distance measurement [DDM] :-

It is chaining or taping

(2) optical distance measurement [ODM] :-

(3) Electromagnetic distance measurement [EDM]

EDM is a general term embracing the measurement of distance using electronic methods.

* In electro magnetic method or electronic method, distances are measured with instruments that rely on propagation, reflection and subsequent reception of either radio waves, visible light waves or infrared waves.

Electromagnetic waves :- The EDM method

is based on generation, propagation, reflection

and subsequent reception of electromagnetic waves.

- * The type of electromagnetic waves generated depends on many factors but principally on the nature of electric signal used to generate the waves.
- * The method based on propagation of modulated light waves using an instrument called geodimeter was developed.
- * Another instrument TELLUROMETER was developed using radio waves.
- * modern, short and medium range EDM instruments such as DISTOMATES commonly used in Surveying, used modulated infrared rays.

Types of medium instruments depending upon the type of carrier waves employed EDM instruments can be classified into

- ① MICRO WAVE INSTRUMENTS
- ② VISIBLE LIGHT INSTRUMENTS
- ③ INFRARED INSTRUMENTS

① MICRO WAVE INSTRUMENTS :-

These instruments come under the category of long range instruments. wherein carrier frequencies of range 3 to 30 GHz enable distance measurements upto 1000 Km range.

- * Tellurometer comes under this category.

② VISIBLE LIGHT INSTRUMENTS :-

These instruments use as visible light as carrier wave with a higher frequency of a order of 5×10^{14} Hz.

- * Since the transmitting power of carrier wave of such high frequency falls off rapidly with the distance, the range of such EDM instrument is lesser than those of EBM microwave instrument
- * Goniometer comes under this category of instruments
- * The EDM instrument in this category has a range of 25 km.
- * The advantage of visible light EDM instrument is that only one instrument is required

③ INFRARED INSTRUMENTS :-

The EDM instruments in this group used infrared radiation band of wavelength about 0.9 μm as a carrier wave which is easily

obtained from gallium arsenide [Ga As] infrared emitting diode. These diodes can be easily, directly amplitude modulated at high frequencies.

* Thus, modulated carrier wave is obtained by an inexpensive method. Due to this reason there is predominance of infrared instruments in EDM.

* Wild distomates fall under these category of EDM instruments.

* The power output of diode is low hence the range of these instruments is limited to 2-5 Km.

Electromagnetic Spectrum :-

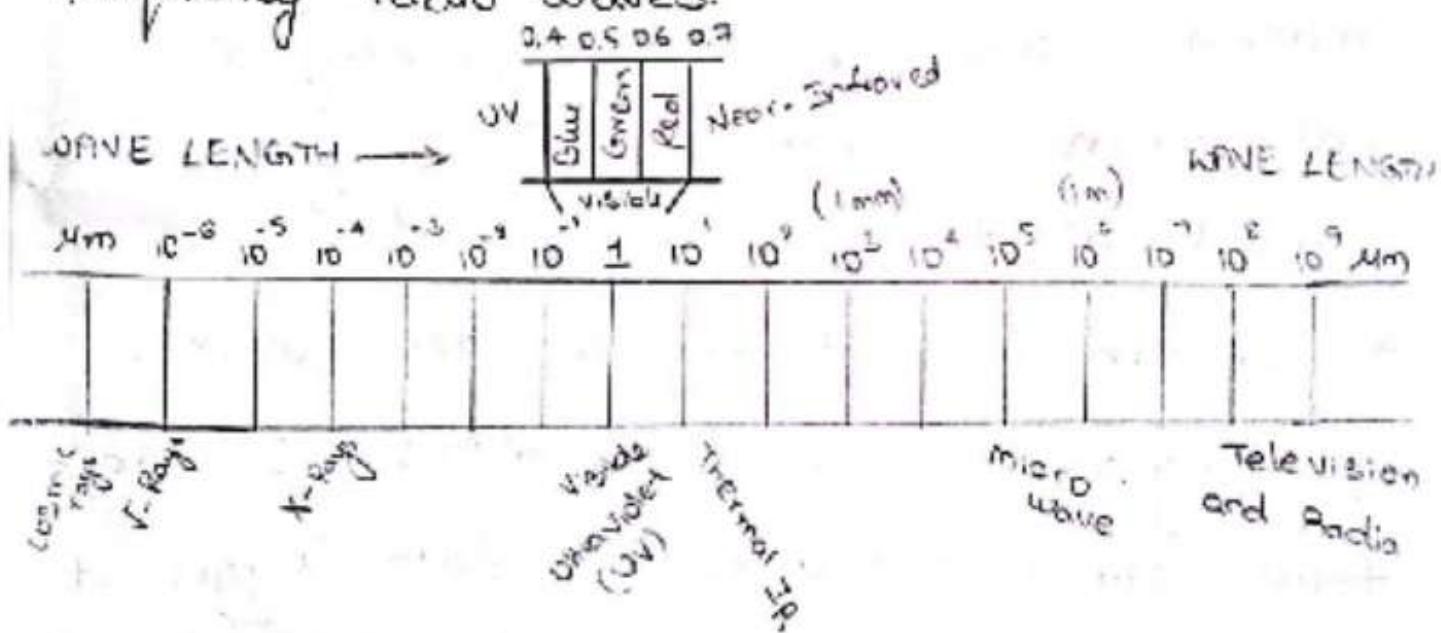
Electromagnetic radiation can be produced at a range of wavelengths and can be categorized according to its position into discrete regions which is generally referred to electromagnetic Spectrum.

* Thus the electromagnetic spectrum is the continuum of energy that ranges from meters to nano meters in wavelength travel.

at a speed of light, and propagates through a vacuum like the outer space.

* All matter radiates a range of electromagnetic energy with the peak intensity shifting toward progressively shorter wave length at an increasing temperature of the matter.

* In general the wavelengths and frequencies vary from shorter wavelength - high frequency cosmic waves to long wavelength low frequency radio waves.



Basic principles of remote sensing

Remote Sensing employ electromagnetic energy and to the great extend realise on the interaction of electro magnetic with matter [object]

* It refers to the sensing of electro magnetic

Source DigiNotes

Scanned by CamScanner

radiation which is reflected, scattered, or emitted from the object.

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principles of energy interaction in atmosphere and earth surface features

① Electromagnetic radiation and the atmosphere

(i) In Remote Sensing, electromagnetic radiation must pass through the atmosphere in order to reach the earth's surface. And to the Sensor after reflection and emission from earth's surface features.

(ii) The water vapour, oxygen, ozone, carbon dioxide, aerosols etc present in the atmosphere influence the electromagnetic radiation through the mechanism of
(a) scattering (b) absorption

(a) Scattering - It is unpredictable diffusion of radiation by molecules of the gases, dust and smoke in the atmosphere.

* Scattering reduces the image contrast and changes the spectral signatures of ground objects.

* Scattering is basically classified as
(i) Selective and Non Selective

Depending upon the size of the particle with which the electro magnetic radiation interact.

Non Selective Scatter

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Non Selective Scatter occurs when the diameter of the particles is several times more [approximately 10 times] than radiation wavelength

* For visible wavelengths, the main sources of non selective scattering are pollen grains, cloud droplets, ice and snow crystals and rain drops

* It scatters all wavelength of visible light with equal efficiency.

b) Absorption - In contrast to Scattering, atmospheric absorption results the effective loss of energy as a consequence of the nature of atmospheric constituents like molecules of ozone, carbon dioxide and water vapour

* oxygen absorbs in ultra violet regions and also as an absorption band, Similarly carbon dioxide prevents the number of wavelengths reaching the surface.

* water vapour is an extremely important observer of electro magnetic radiation within the infrared part of the spectrum.

Interaction of electromagnetic radiation with earth's surface

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Electromagnetic energy that strikes or encounters the matter [object] is called incident radiation.

* The electromagnetic radiation striking the surface may be

- (i) Reflected or scattered
- (ii) Absorbed
- (iii) Transmitted

Interaction with matter can change the following properties of incident radiation.

- (a) Intensity
- (b) Direction
- (c) wavelength
- (d) polarization and phase.

The Science of remote Sensing detects and records the changes.

The energy balance equation for radiation at a given wavelength [λ] can be expressed as follows :-

$$E_{I\lambda} = E_{R\lambda} + E_{A\lambda} + E_{T\lambda}$$

$E_{I\lambda}$ = Incident Energy

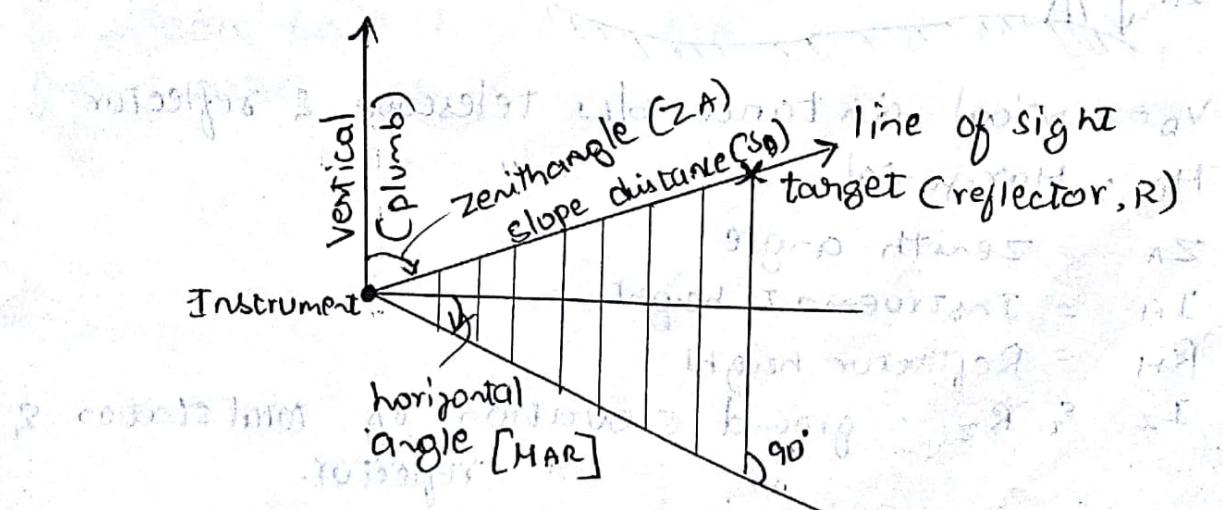
$E_{R\lambda}$ = Reflected Energy

$E_{A\lambda}$ = Absorbed energy

$E_{T\lambda}$ = Transmitted energy

Total station

- * A total station is a combination of an electronic theodolite & an electronic distance meter [EDM].
- * This combination makes it possible to determine the co-ordinates of a reflector by aligning the instruments cross-hairs on the reflector & simultaneously measuring the vertical, horizontal angles & slope distances.
- * A micro-processor in the instrument takes care of recording, readings & the necessary computations.
- * The data can be easily transferred to a computer, where it can be used to generate a map.
- * fundamental measurements = When aimed at an appropriate target, a total station measures 3 parameters.
 - a) The rotation of the instruments optical axis from the instrument north is a horizontal plane [horizontal angle]
 - b) The inclination of the optical axis from the local vertical ie vertical angle.
 - c) The distance between the instrument & the target. ie slope distance.



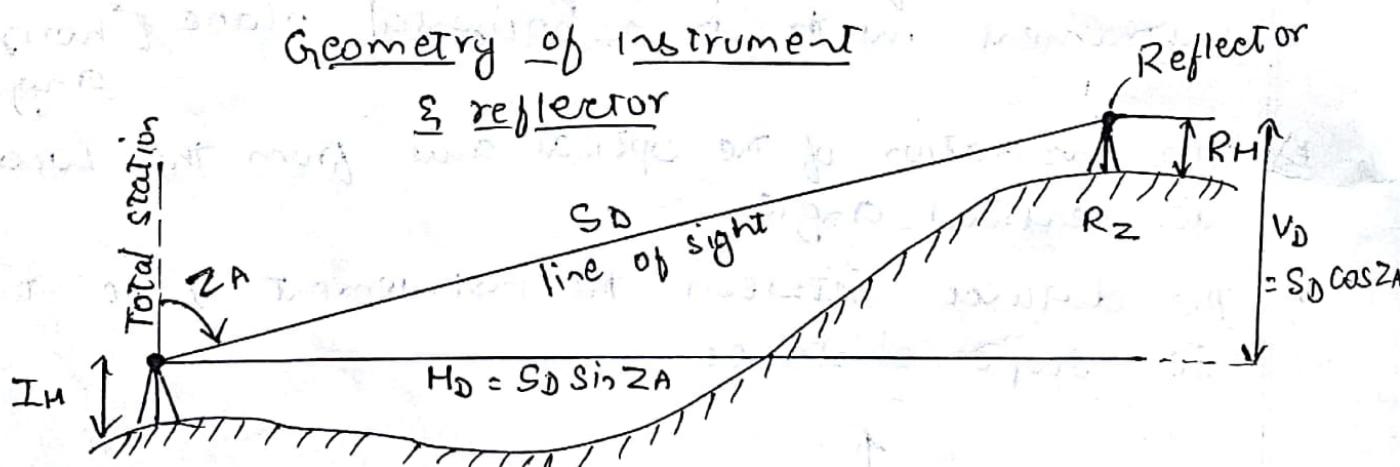
1) Horizontal angle = is the measurement

Horizontal angle is measured from the zero direction on the horizontal scale. When the user first sets up the instrument the choice of the zero direction is made - this is instrument north. The zero direction should be set so that it can be recovered if the instrument was set up at the same location at some later date. This is usually done by sighting to another benchmark or to a distance recognizable object.

2) vertical angle = vertical angle is measured to the local vertical direction. Vertical angle is usually measured as a zenith angle.

Measuring vertical angle requires that the instrument be exactly vertical.

Geometry of instrument



V_D = vertical distance b/w telescope & reflector

H_D = Horizontal d.

Z_A = Zenith angle

I_H = Instrument height

R_H = Reflector height

I_Z & R_Z = ground elevation of total station & reflector.

- 3) Slope distance = The instrument to reflector distance is measured using an electronic distance meter [EDM].

Applications of total station

1. It is used to measure horizontal & vertical angle.
2. It can measure slope distance
3. It is used for aligning lines.
4. used for setting out works related to dam, bridge etc.
5. used for planning areas of closed boundaries.
6. used for automation of old maps.
7. it can support local language.

Advantages of total station

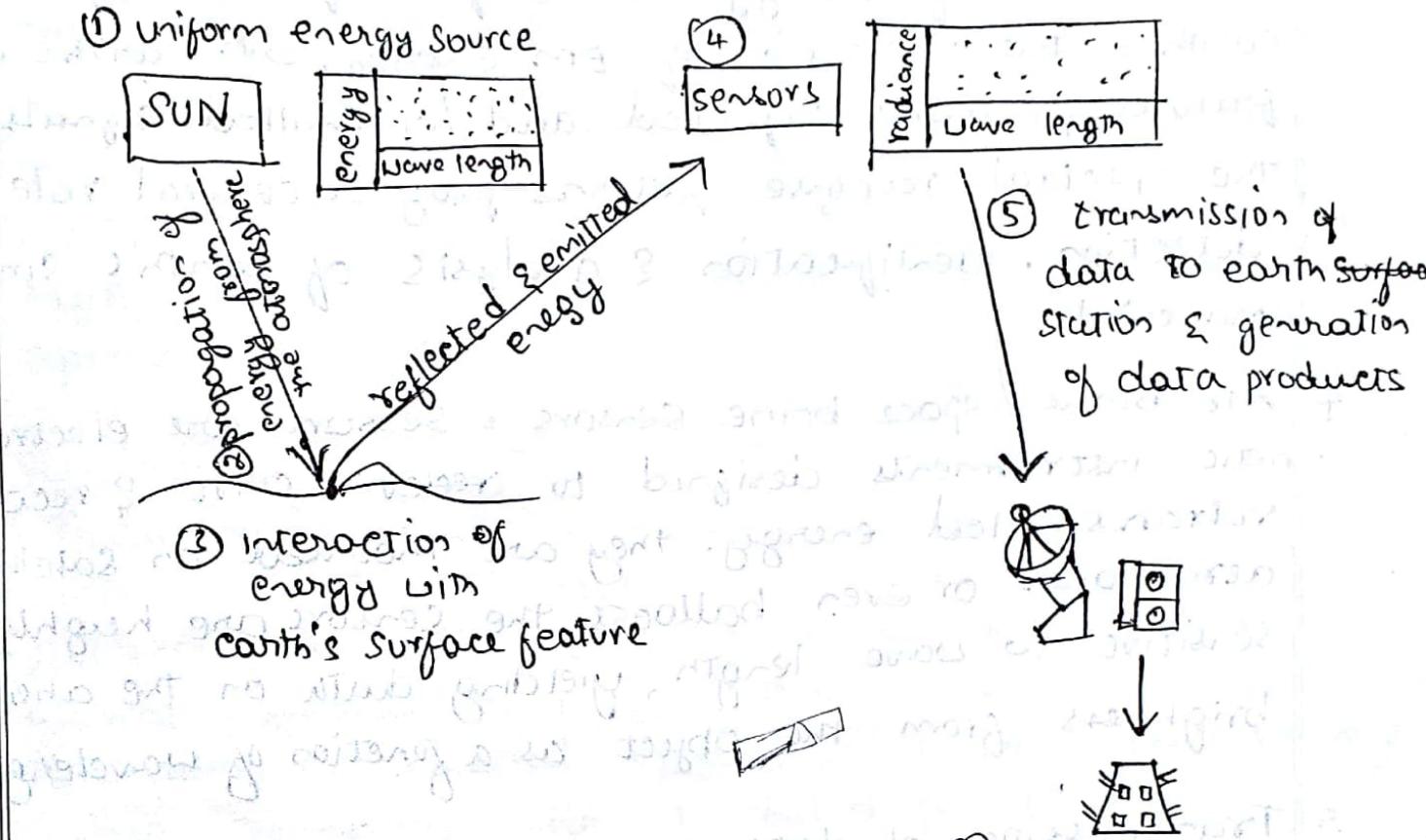
1. Surveying is carried out very fast.
2. accuracy of measurement is high.
3. Human errors in recording & observation are eliminated.
4. calculation of elevation & co-ordinates are accurate & fast.
5. correction for temp'r & pressure are gained automatically.
6. Data can be directly transferred to computer for further processing like plotting contours.

Remote Sensing

- * Remote sensing is broadly defined as science & art of collecting information about objects, area or phenomena from distance without being in physical contact with them.
- * The term remote sensing is restricted to methods that employ electromagnetic energy, as means of detecting & measuring target characteristics.
- * collecting the data is usually carried out by highly sophisticated sensors.
- * Remote sensing data basically consist of wavelength intensity information by collecting the electromagnetic radiation leaving the object at specific wavelengths & measuring its intensity.
- * most of modern remote sensing methods make use of reflected infrared bands, thermal infrared bands & microwave portion of electromagnetic spectrum.

Idealized Remote Sensing System

An idealised remote sensing system consist of the following stages.



1. **Energy source** = The uniform energy source provides energy over all wave lengths. The passive RS system relies on sun as the strongest source of EM energy, & measures energy that is either reflected & or emitted from the earth's surface features. However, active RS systems use their own source of EM energy.
2. **propagation of energy from the atmosphere** = The EM energy, from the source passes through the atmosphere on its way to earth's surface. Also, after reflection from the earth's surface, it again passes through the atmosphere on its way to sensor. The atmosphere modifies the wave length & spectral distribution of energy to some extent, & this modification varies particularly with the wavelength.

3. Interaction of energy with surface features of the earth = The interaction of EM energy, with earth's surface features generates reflected and /or emitted signals. The spectral response patterns play a central role in detection, identification & analysis of earth's surface material.
4. Air borne / space borne sensors = Sensors are electromagnetic instruments designed to receive & record retransmitted energy. They are mounted on satellites, aeroplanes or even balloons. The sensors are highly sensitive to wavelength, yielding data on the absolute brightness from the object as a function of wavelength.
5. Transmission of data to earth surface station & data product generation. = The data from the sensing system is transmitted to ground based earth stations along with the telemetry data. The real time data handling system consists of high density data types for recording & visual devices for quick look display. The data products are mainly classified into 2 categories :-
- i) pictorial or photographic product
 - ii) digital product.
6. Multiple data users = The multiple data are those who have knowledge of great depth, both of their respective disciplines as well as of remote sensing data & analysis techniques. The same set of data becomes

varies forms of information for different users with the understanding of their field & interpretation skills.

Applications of Remote Sensing

Major areas in which remote sensing is useful

agriculture

Forestry

Weather

Biodiversity

1) Extracting mineral deposits = Earth holds more than 4000 natural elements, each with their unique chemical composition & spectral reflectance. Hyperspectral remote sensing technology helps to build potential maps of these minerals.

2) Estimating surface elevation = NASA's SRTM [Shuttle Radar Topography Mission] is capable of scanning entire globe. A remote sensing technology, inter-aerometric synthetic aperture radar is used in it.

3) Estimating forest supplies = AVHRR, MODIS & SPOT are regularly used to measure the increase or decrease increment / decrement in global forests since forest are source of valuable materials such as paper, packaging, construction material, etc.

4) Elevation & contour derivation = Remote sensing technology named photogrammetry is used in contour mapping, developing surface models, conducting volumetric surveys & developing 3D maps.

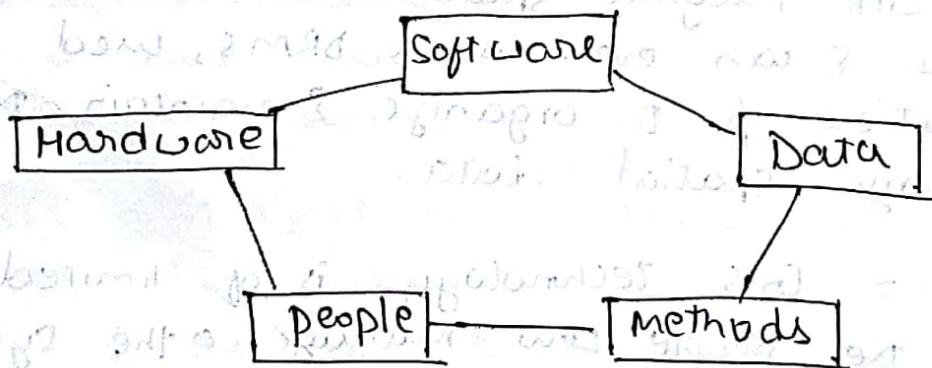
5. Discovering ancient archaeological sites = Remote sensing techniques such as infrared imagery & stereo imagery are used in archaeological field.
6. Developing biodiversity in parks = remote sensing technology is important for maintaining parks, since it can map landscape changes.
7. Detecting land cover & land use = RS is used to determine various physical properties of soil (land cover) & also how it is being utilized or what it is being occupied for (land use).
8. Delineating watersheds = DEM's [digital elevation model] are prepared using hydrologists' remote sensing technology that represents flow & location of water body.
9. Controlling forest fires = Data acquired by satellites using remote sensing enables fire fighters to be dispatched on time & over accurate locations so that damage from fires can be decreased to minimal.
10. Assessment of fuel economy = satellites have now become capable of measuring vehicle emissions including CO, HC, NO, etc.

11. Aerial photography for military surveillance:

Geographical Information System (GIS)

- * GIS is the system designed to capture, store, manipulate, analyze, manage, & present spatial or geographic data.
- * It refers to a no. of different technologies, processes, & methods.
- * It is attached to many operations & has many applications related to engineering, planning, management, transport, insurance etc.

Five Key components of GIS



- * Hardware = hardware is the computer on which a GIS operates. GIS software is run on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.
- * Software = GIS software provides the functions & tools needed to store, analyze, & display geographic information. Key software components are.

- a) Tools for input & manipulation of geographic information
 - b) A database management system [DBMS]
 - c) Tools that supports geographic query, analysis, & visualizations
 - d) A graphical user interface [GUI] for easy access of tools.
- * Data = possibly the most important component of a GIS is the data. Geographic data & related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources & can even use a DBMS, used by most organizations to organize & maintain their data, to manage spatial data.
- * people = GIS technology is of limited value without the people who manage the system & develop plans for applying it to real-world problems. GIS users range from technical specialists who design & maintain the system to those who use it to help them perform their everyday work.
- * Methods = A successful GIS operates according to a well-designed plan & business rules, which are the models & operating practices unique to each organization.

Application of GIS in civil engineering

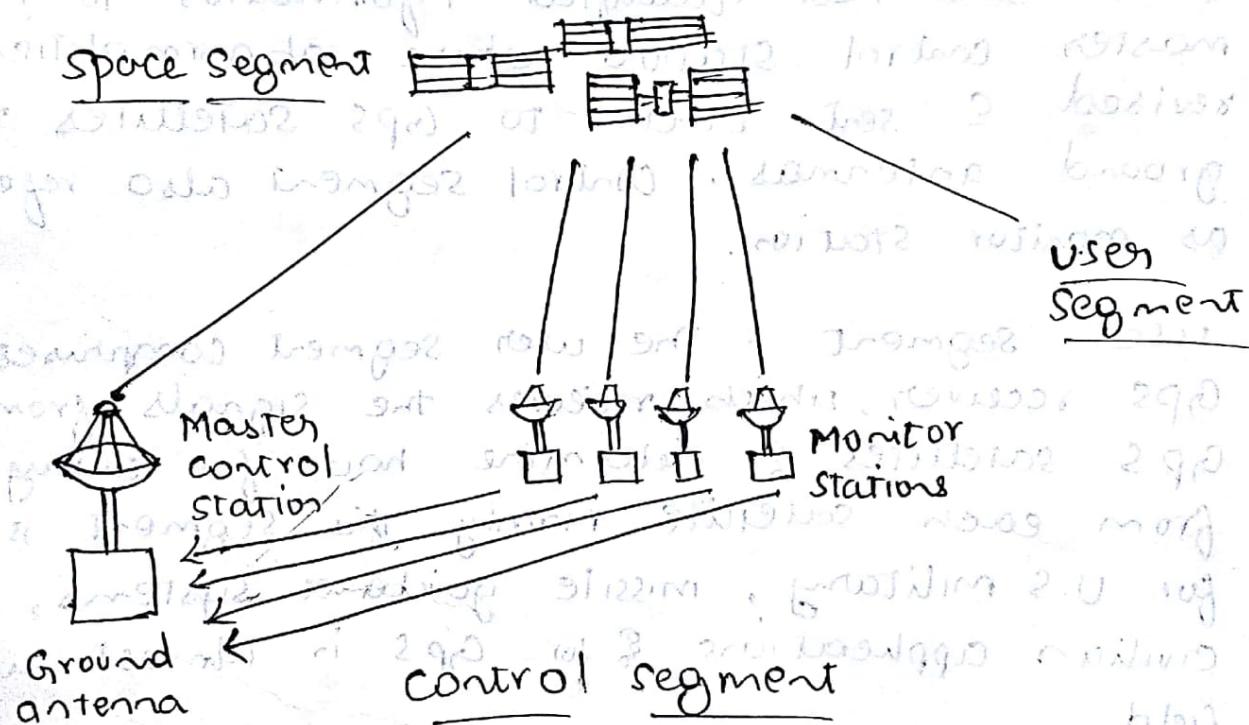
1. planning = In planning its major contribution is to give us with an organized set of data which can help professionals to combat complex scenarios relating to the selection of site, environmental impact, study of ecosystem, managing risk regarding the use of natural resources, sustainability issues, managing traffic congestion, routing of roads & pipelines etc.
2. Data collection : precise & accurate data is the core driving factors of an successful project. GIS is equipped with almost all those tools & functions that enables user to have access to the required data within a reasonable time.
3. Analysis = Analysis guides us about the validity or correctness of designs. Analysis that can be performed by GIS are :-
 - * Water distribution analysis
 - * Traffic management analysis
 - * Soil analysis
 - * Site feasibility analysis
 - * Environment impact analysis
 - * Volume or area analysis of catchment
 - * River or canals pattern analysis
 - * Temperature & humidity analysis.

4. construction = TO keep construction within budget & schedule GIS guides us to about how to utilize our resources on site efficiently by :-
- * timely usage of construction equipment
 - * working hours
 - * effects of seasonal fluctuations
 - * optimizing routes for dumpers & concrete trucks
 - * Earth filling & cutting
 - * calculation of volumes & areas of constructed phase thereby helping in estimation & valuations.
5. operations = operations are controlled by modeling a site that is compared by the baselines prepared in planning phase. Modeling of site may be in the form of raster images or CAD drawings. These can help us to keep the track of timely operation of activities.

Global positioning System [Gps]

Gps is a satellite navigation system that furnishes location & time information in all climate conditions to the user. Gps is used for navigation in planes, ships, cars & trucks also.

Working principle of Gps



- * Space Segment holds the 27th of satellites in the constellations. It comprises of 27 satellites, circling the earth every 12 hr at 12000 miles in altitude. The function of space segment is utilized for navigation signals to stores & retransmit the navigation message sent by the control segment. These transmissions are controlled by highly stable atomic clocks on the satellites. The Gps Space Segment is formed by a satellite

constellation with enough satellites to ensure that the users will have, at least, 4 ~~strata~~ simultaneous satellites in view from any points at earth surface at any time.

- * Control Segment = It comprises of a master control station & 5 monitor stations outfitted with atomic atomic clocks that are spread around globe. The 5 monitor stations monitor the GPS satellite signals & then send that qualified information to the master control station where abnormalities are revised & sent back to GPS satellites through ground antennas. Control segment also referred as monitor station.
- * User Segment = The user segment comprises of GPS receiver, which receives the signals from the GPS satellites & determine how far away it is from each satellite. Mainly this segment is used for U.S. military, missile guidance systems, civilian applications & for GPS is almost every field.

Applications of GPS in Civil Engineering

1. GPS is used to locate different points
2. preparing contour maps
3. To give alignments of roads, Bridges because precision is very essential