INSTITUTE OF AERONAUTICAL ENGINERRING

(AUTONOMOUS)

Dundigal, Hyderabad- 500 043

SURVEYING AND GEOMATICS
(Course Code : ACEB01)
Regulation: IARE-R18
B.Tech III SEM

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COURSE GOAL

- Surveying is the technique, profession, science and art of making all essential measurements to determine the relative position of points or physical and cultural details above, on, or beneath the surface of the Earth, and to depict them in a their objectives.
- Surveyors use elements of mathematics (geometry and trigonometry), physics, engineering and law. Surveyor measures certain dimensions that generally occur on the surface of the Earth.
- Surveying equipment, such as levels and theodolites, are used for accurate measurement of angular deviation, horizontal, usable form, or to establish the position of points or details.
- To accomplish vertical and slope distances with computerization, electronic distance measurement (EDM), total stations, remotes sensing, Photogrammetry, GPS surveying and laser scanning have supplemented to a large extent.

COURSE OUTLINE

MODULE	TITILE	CONTENT
I	INTRO-DUCTION	Principles, Linear, angular and graphical methods, Survey stations, Survey lines ranging, bearing of survey lines, levelling: Plane table surveying, Principles of levelling booking and reducing levels; differential, reciprocal levelling, profile levelling and cross sectioning. Digital and Auto Level, Errors in levelling; contouring: Characteristics, methods, uses; areas and volumes. Triangulation and Trilateration Theodolite survey: Instruments, Measurement of horizontal and vertical angle; Horizontal and vertical control methods, triangulation network signals. Baseline choices instruments and accessories extension of base lines corrections Satellite station reduction to centre, Inter

COURSE OUTLINE

MODULE	TITILE	CONTENT
II	Curves	Elements of simple and compound curves, Method of setting out, Elements of Reverse curve, Transition curve, length of curve, Elements of transition curve, Vertical curves.
III	MODERN FIELD SURVEY SYSTEMS	Principle of Electronic Distance Measurement, Modulation, Types of EDM instruments, Distomat, Total Station, Parts of a Total Station, Accessories, Advantages and Applications, Field Procedure for total station survey, Errors in Total Station Survey. Global Positioning Systems (GPS), Segments, GPS measurements, errors and biases, Surveying with GPS, Co-ordinate transformation, accuracy considerations

COURSE OUTLINE

MODULE	TITILE	CONTENT
IV	PHOTOGRAMMETRIC SURVEYING	Introduction, Basic concepts, perspective geometry of aerial photograph, relief and tilt displacements, terrestrial photogrammetry, flight planning; Stereoscopy, ground control extension for photographic mapping aerial triangulation, radial triangulation, methods; photographic mapping, mapping using paper prints, mapping using stereo plotting instruments, mosaics, map substitutes.
V	REMOTE SENSING	Introduction, Electromagnetic Spectrum, interaction of electromagnetic radiation with the atmosphere and earth surface, remote sensing data acquisition: platforms and sensors; visual image interpretation; digital image processing.

Text books:

1. Madhu, N, Sathikumar, R and Satheesh Gobi, "Advanced Surveying: Total Station, GIS and Remote Sensing", Pearson India, 2nd Edition, 2006.
2. Manoj, K. Arora and Badjatia, "Geomatics Engineering", Nem Chand & Bros, 2011.
3. Bhavikatti, S.S., "Surveying and Levelling", I.K. International, Vol. I and II, 2010.

References:

1. Chandra, A.M., "Higher Surveying", New Age International (P) Limited, 3rd Edition, 2002.
2. Anji Reddy, M., "Remote sensing and Geographical information system", B. S. Publications, 2001.
3. Arora, K.R., "Surveying", Standard Book House, Vol-I, II and III, 2015.

COURSE OBJECTIVES:

The course should enable the students to:

- Describe the function of surveying in civil engineering construction.
- Work with survey observations, and perform calculations
- Identify and calculate the errors in measurements and to develop corrected values for differential level circuits, horizontal distances and angles for open or closed-loop traverses
- Operate an automatic level to perform differential and profile leveling; properly record notes mathematically reduce and check levelling measurements

MODULE 1

INTRODUCTION TO SURVEYING

INTRODUCTION

Surveying is the technique of determining the relative position of different features on, above or beneath the surface of the earth by means of direct or indirect measurements and finally representing them on a sheet of paper known as plan or map.

During a survey, surveyors use various tools to do their job successfully and accurately, such as total stations, GPS receivers, prisms, 3D scanners, radio communicators, digital levels, dumpy level and surveying software etc

Primary Divisions of Surveying

Surveying may primarily be divided into two divisions:

Plane surveying.

The surveys in which earth surface is assumed as plane and the curvature of the earth is ignored, are known as *Plane surveys.*

Geodetic surveying.

The surveys in which curvature of the- earth is taken into account and higher degree of ac-curacy in linear and angular observations, is achieved, are known as *Geodetic surveys.*

Objectives of Surveying

Objectives of Surveying

To determine the relative position of any objects or points of the earth.

To determine the distance and angle between different objects.

To prepare a map or plan to represent an area on a horizontal plan.

To develop methods through the knowledge of modern science and the technology and use them in the field.

To solve measurement problems in an optimal way.

Principles of surveying

The main principle of surveying whether plane or geodetic is to work from the whole to part. To achieve this in actual practice, sufficient number of primary control points are es-tablished with higher precision in and around the area to be detailed surveyed. Minor control points in between primary control stations, are then established with less precision method. The details are surveyed with the help of these minor control points, adopting any one of the methods of surveying. The main idea of surveying from the whole to the part, is to prevent accumulation of errors and to localize the minor errors in the frame work of the control points.

Ranging

- Ranging required when line is longer than a chain/tape length
- Placing a line along the shortest distance between points
- When end stations are inter-visible, direct ranging can be done
- When end stations not inter-visible, indirect ranging is done

Measuring along slope

- For plotting, horizontal distances are required
- For a measured distance along slope, horizontal distance can be calculated. Horizontal length is less than length along slope For a given horizontal distance, slope distance can be calculated
- The increase in length along slope is called hypotenusal allowance

Horizontal distance

- Horizontal distance = L COS θ, Where L is the slope distance and θ is the slope angle.
- If slope is in gradient, 1:n, then
- Horizontal distance = $L\, n/[\sqrt{(1+n^2)}]$

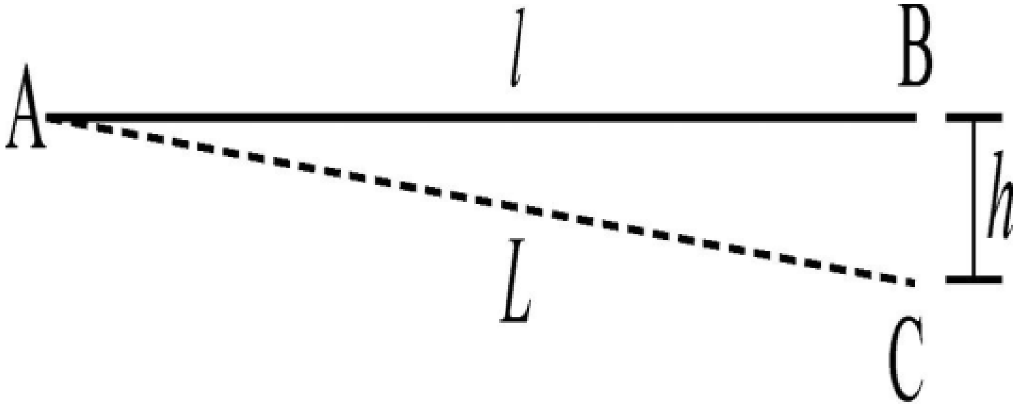
HYPOTENUSAL ALLOWANCE

- Hypotenusal allowance is given by
  $L [\sec \theta - 1]$, exactly and
- $L \theta^2/2$, where θ is in radians.

Or

- Hypotenusal allowance = $\sqrt{(L^2 + h^2)} - L$ (exact value) or $h^2/2L$ approximately.

- Correction = $h^2/2L$ or = $L\theta/2$
- Where h is the height for length L and
- Θ is the slope angle in radians



Traversing

- In traversing , the frame work consist of connected lines.
- The length are measured by a chain or a tape and the direction measured by angle measuring instruments.
- Hence in compass surveying direction of survey lines are determined with a compass and the length of the lines are measured with a tape or a chain. This process is known as compass traversing.

EQUIPMENTS AND ACCESSORIES FOR PLANE TABLING

The following instruments are used in plane table surveying.

1. Equipments
2. Plane Table
3. Tripod
4. Alidade

EQUIPMENTS AND ACCESSORIES FOR PLANE TABLING

- Trough Compass
- Spirit level
- U-Fork with Plumb bob
- Water proof cover
- Drawing paper
- Pins
- Drawing accessories

ACCESSORIES

Trough Compass:

- The trough compass is required for drawing the line showing magnetic meridian on the paper. It is used to orient the table to the magnetic meridian.
- When the freely suspended needle shows 0^0 at each end, a line is drawn on the drawing paper which represents the magnetic north.

MAJOR ADVANTAGES OF PLANE TABLE SURVEYING

- The plan is drawn by the surveyor himself while the area to be surveyed is before his eyes. Therefore, there is no possibility of omitting the necessary measurements.
- The surveyor Can compare the plotted work with the actual features of the area.

METHOD OF SETTING UP THE PLANE TABLE

- Three processes are involved in setting up the plane table over the station.
  - Leveling
  - Centering
  - Orientation

LEVELING AND CENTERING

- The Table should be set up at convenient height for working on the board, say about 1 m. The legs of Tripod should be spread well apart and firmly into the ground

LEVELING AND CENTERING

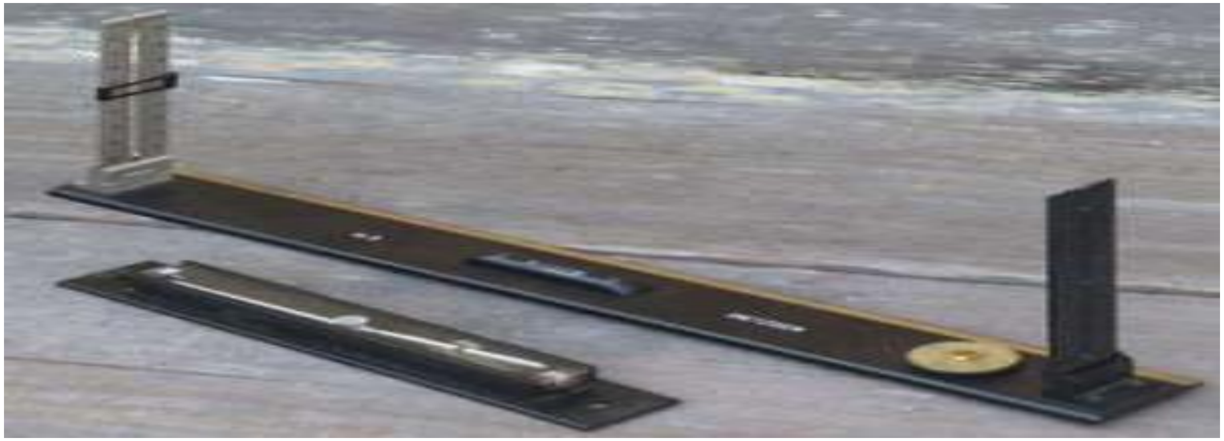
- The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground. The operation is known as centering the plane table. It is done by U-fork and plumb bob.
- For leveling the table ordinary spirit level may be used. The table is leveled by placing the level on the board in two positions at right angles and getting the bubble central in both directions.

ORIENTATION

- The Process by which the positions occupied by the board at various survey stations are kept parallel is known as the orientation. Thus, when a plane table is properly oriented, the lines on the board are parallel to the lines on ground which they represent.
- There are two methods of orientation:
  - By magnetic needle
  - By back sighting

BY MAGNETIC NEEDLE

- In this method, the magnetic north is drawn on paper at a particular station. At the next station, the trough compass is placed along the line of magnetic north and the table is turned in such a way that the ends of magnetic needle are opposite to zeros of the scale.
- The board is then fixed in position by clamps. This method is inaccurate in the since that the results are likely to be affected by the local attraction.



BY BACK SIGHTING

- Suppose a line is drawn from station A on paper as ab, representing line AB on ground
- The table is turned till the line of sight bisects the ranging rod at A. The board is then clamped in this position.
- This method is better than the previous one and it gives perfect orientation.

METHODS OF PLANE TABLING

There are four distinct methods of plane tabling:

- Method of Radiation
- Method of Intersection
- Method of Traversing
- Method of Resection

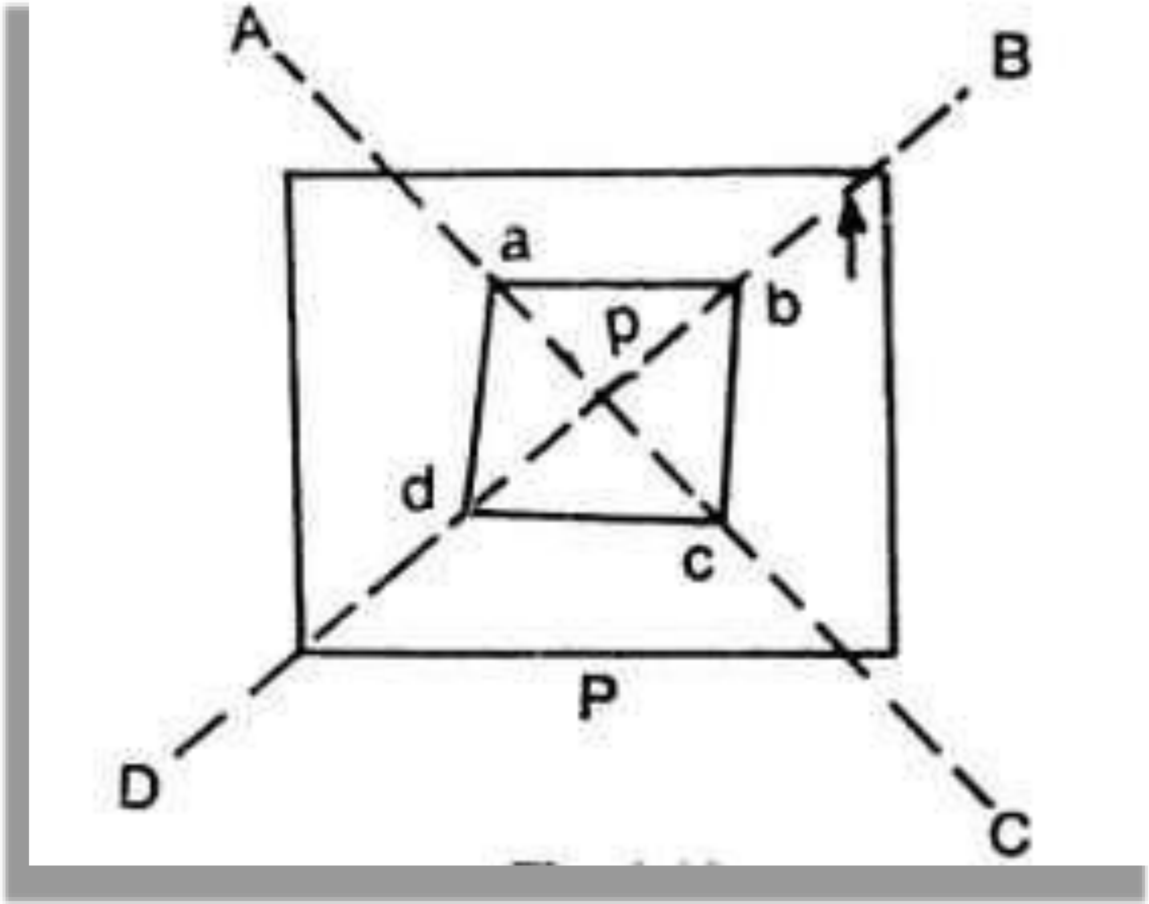
RADIATION METHOD

- In the radiation method of plane table surveying, the direction of the objects or points to be located are obtained by drawing radial lines along fiducially edge of alidade after getting the objects or points bisected along the line of sight of the alidade.
- The horizontal distances are then measured and scaled off on the corresponding radial lines to mark their positions on the drawing.

RADIATION METHOD

- Suppose P is a station on the ground from where the object A, B, C and D
  are visible.
- The plane table is set up over the station P. A drawing is fixed on the table, which is then leveled and centered. A point p is selected on the sheet to represent the station P.
- The north line is marked on the right-hand top corner of the sheet with trough compass or circular box compass.
- With the alidade touching p, the ranging rod at A,B, C and D are bisected and the rays are drawn.
- The distances PA, PB, PC and PD are measured and plotted to any suitable scale to obtain the points a, b, c and d representing A,B,C,D on paper.

RADIATION METHOD



METHOD OF INTERSECTION

- In intersection method of plane table surveying, the objects or points to be located are obtained at the point of intersection of radial lines drawn from two different stations.
- In this method, the plotting of plane table stations are to be carried out accurately. Checking is important and thus done by taking third sight from another station.
- The intersection method is suitable when distances of objects are large or cannot be measured properly. Thus, this method is preferred in small scale survey and for mountainous regions.

METHOD OF INTERSECTION

- Suppose A and B are two station and P is the object on the far bank of a river. Now it is required to fix the position of P on the sheet by the intersection of rays, drawn from A and B.
- The table is set up at A. It is leveled and centered so that a point a on the sheet is just over the station A. The north line is marked on the right-hand top corner, the Table is then clamped.
- With the alidade touching a, the object P and the ranging rod at B are bisected, and rays are drawn through the fiducially edge on alidade,

METHOD OF INTERSECTION

- The distance AB is measured and plotted to any suitable scale to obtain point b.
- The table is shifted and centered over B and leveled properly. Now the alidade is placed along the line ba and orientation is done by back sighting With the alidade touching b, the object P is bisected and a ray is drawn, suppose this ray intersects the previous rays at point p. the point p is the required plotted position of P

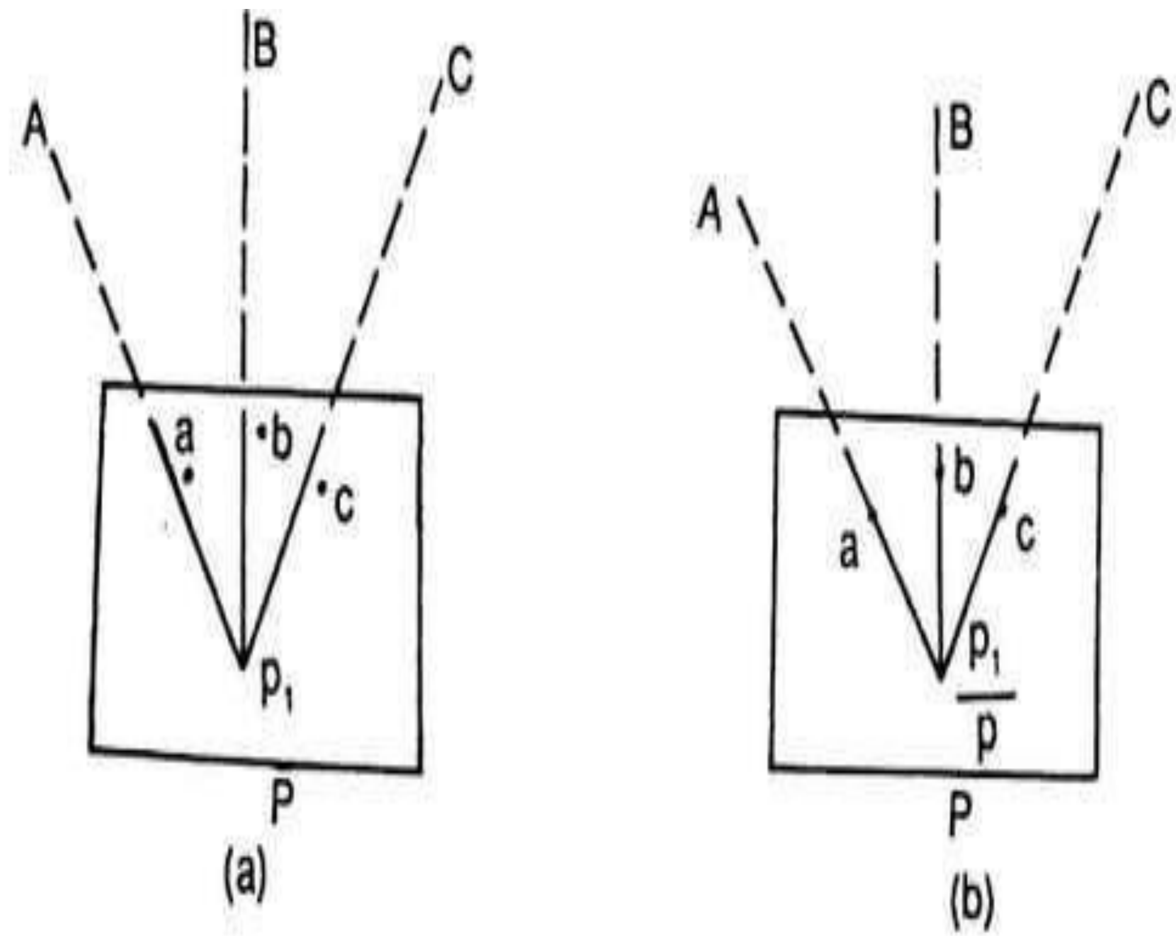
THE THREE POINT PROBLEM

- Again the alidade is placed along the line ac and the point C is bisected and the table is clamped. With the alidade touching a, the point B is bisected and a ray is drawn. Suppose this ray intersects the previous ray at a point d
- The alidade is placed along db and the point B is bisected. At this position the table is said to be perfectly oriented. Now the rays Aa, Bb and Cc are drawn. These three rays must meet at a point p which is the required point on the map. This point is transferred to the ground by U-fork and plumb bob.

The Mechanical Method

- Suppose A, B and C are the three well-defined points which have been plotted on the map as a, b and c. It is required to locate a station at P.
- The table is placed at P and leveled. A tracing paper is fixed on the map
and a point p is marked on it.
- With the alidade centered on P the points A, B and C are bisected and rays are drawn. These rays may not pass through the points a, b and c as the orientation is done approximately

THE MECHANICAL METHOD



THE THREE POINT PROBLEM

- Now a tracing paper is unfastened and moved over the map in such a way that the three rays simultaneously pass through the plotted positions a, b and c. Then the points p is pricked with a pin to give an impression p on the map. P is the required points on the map. The tracing paper is then removed.
- Then the alidade is centered on p and the rays are drawn towards A, Band C. These rays must pass through the points a, b and c

THE THREE POINT PROBLEM

The method of Trial and error

- Suppose a, B and C are the three well-defined points which have been plotted as a, b and c on the map. Now it is required to establish a station at P.
- The table is set up at P and leveled. Orientation is done by eye estimation
- With the alidade, rays Aa, Bb and Cc are drawn. As the orientation is approximately, the rays may not intersect at a point, but may form a small triangle the triangle of error.
- To get the actual point, this triangle of error is to be eliminated. By repeatedly turning the table clockwise or anticlockwise. The triangle is eliminated in such a way that the rays Aa, Bb and Cc finally meet at a point p. This is the required point on the map. This point is transferred to the ground by U-fork and plumb bob.

Plane table survey equipment is arranged in 4 steps as follows

- **Fixing of Plane Table**
- Fix the plane table to the tripod stand. Arrange the drawing sheet on the plane table using paper clips or thumb screws. The sheet should be in one position from first to last.
- **Leveling of Plane Table**
- Plane table should be leveled using spirit level. For small works, eye estimation can be ok.

- **Centering of Plane Table**
- The table should be centered by using plumbing fork. By which we can arrange the plotted point exactly over the ground point.
- **Orientation of Plane Table**
- Whenever we are using more than one instrument station, orientation is essential. It can be done by using compass or back sighting. In this case, the plane table is rotated such that plotted lines in the drawing sheet are parallel to corresponding lines on the ground.

Methods of Plane Table Surveying

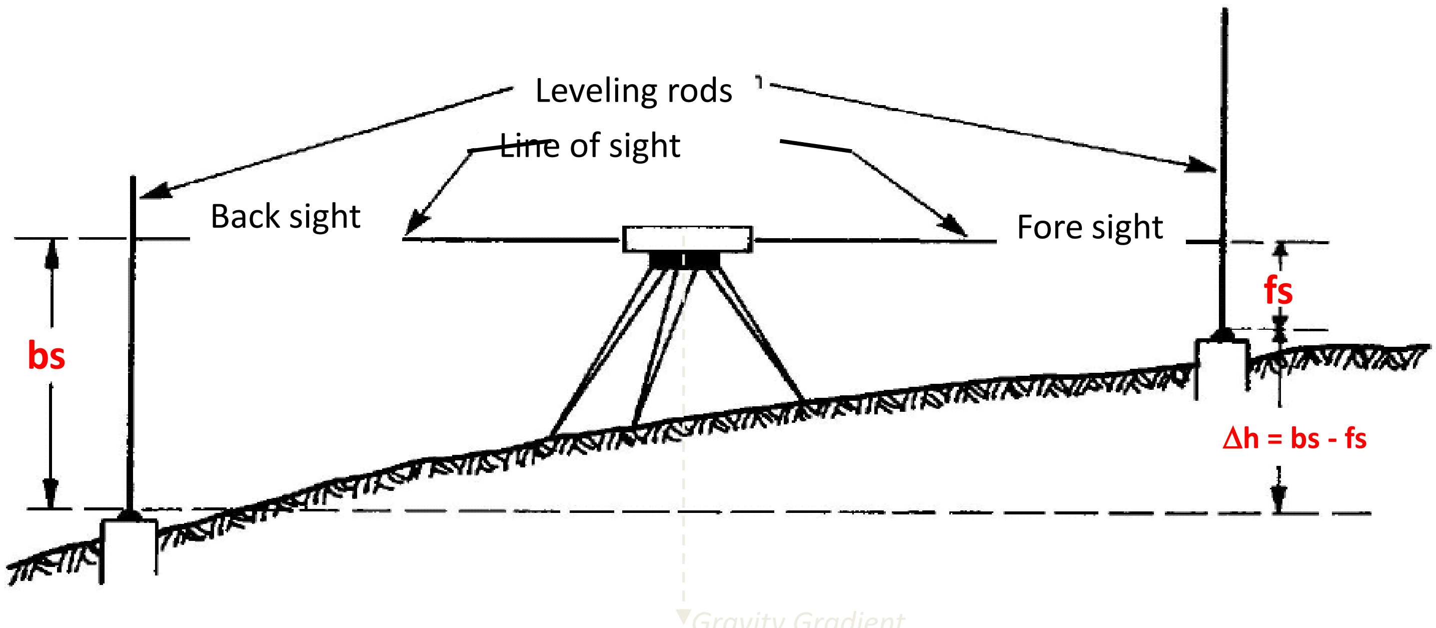
- Generally there are four methods are available to perform plane table surveying. They are
- Radiation
- Intersection
- Traversing
- Resection

What is “Leveling?”

- Levelling is the process by which differences in height between two or more points can be determined.
- Leveling is a branch of surveying, the object of which is to find or establish the elevation of a given point with respect to the given or assumed Datum (reference point).
- Common leveling instruments include the spirit level, the dumpy level, the digital level, and the laser level.

Basic Principle of Leveling

- Measures height differences between points
  - Along a line
  - Several points from one occupation



Vertical line: A line that follows the local direction of gravity as indicated by a plumb line.

Level surface: A curved surface that, at every point is perpendicular to the local plumb line (the direction in which gravity acts).

Level line: A line in a level surface

Horizontal plane: A plane perpendicular to the local direction of gravity. In plane surveying, it is a plane perpendicular to the local vertical line.

- *Horizontal line.* A line in a horizontal plane. In plane surveying, it is a line perpendicular to the local vertical.
- *Vertical datum.* Any level surface to which elevations are referenced. This is the surface that is arbitrarily assigned an elevation of zero.
- Elevation. The distance measured along a vertical line from a vertical datum to a point or object.

Old Datum: Mean Sea Level

- Mean Sea Level (MSL)
- Average height over a 19-year period
- 26 gauging stations along the Atlantic Ocean, Pacific Ocean and the Gulf of Mexico

Devices are classified leveling in terms of accuracy into three categories

- Precision: the settlement where the bubble is very sensitive as are high magnification power and uses this type of work and Geodetic Survey businesses that require high precision.
- Precision medium: It is less accurate than the first category and dominated the use of this type in most engineering projects.
- low-precision devices: and make this kind of hardware specifically for the purposes of settlement approximate as in building projects Ltd. and settlement cases within short distance.

Datum line (M.S.L.) :- Is the level (line), which are attributed to it points levels on the surface of the Earth. Which is the average sea level.

Reduced level (R.L) :- Is the high point from datum line. Benchmark (B .M) :- Are fixed points information site and attributed placed in different places until you start racing
them when conducting settlement .

Back sight (B.S.) :- Is the first reading taken after placing the device in any position so that we see the greatest possible number of points required to find the elevation .

Fore sight (F.S) :- Is the last reading taken before the transfer device

Leveling of the instrument is done to make the vertical

Axis of the instrument truly vertical. It is achieved by carrying out the following steps:

Step 1: The level tube is brought parallel to any two of the foot screws, by rotating the upper part of the instrument.

Step 2: The bubble is brought to the centre of the level tube by rotating both the foot screws either inward or outward. (The bubble moves in the same direction as the left thumb.)

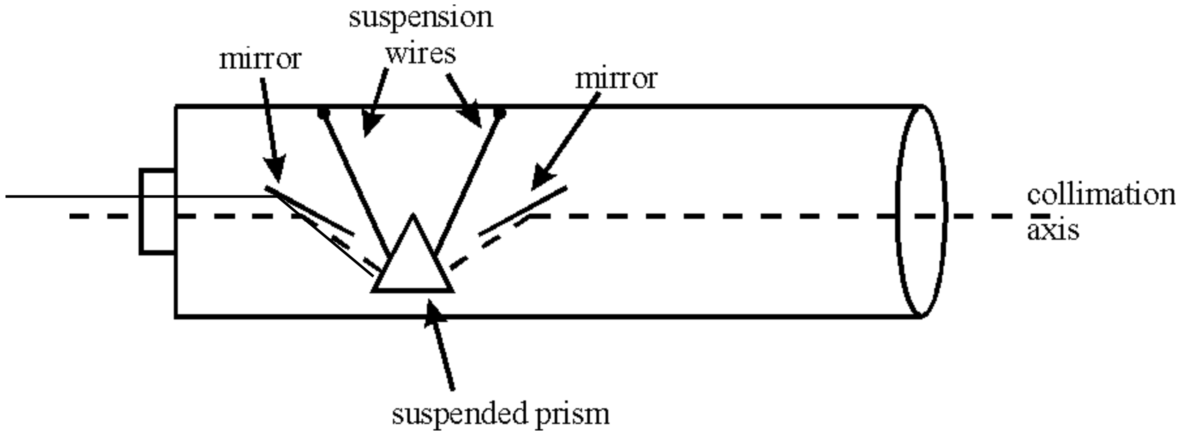
Step 3: The level tube is then brought over the third foot screw again by rotating the upper part of the instrument. Step 4: The bubble is then again brought to the centre of the level tube by rotating the third foot screw either inward or outward.

Leveling Errors

- There are a large number of potential sources of errors in leveling. Many of these are only significant for precise leveling over long distances. For the short segments of leveling that will occur in connecting a TGBM to nearby benchmarks there are only four worth mentioning:
- · Collimation Error
- · Error due to Earth Curvature
- · Error due to Parallax Error
- · Error due to Refraction

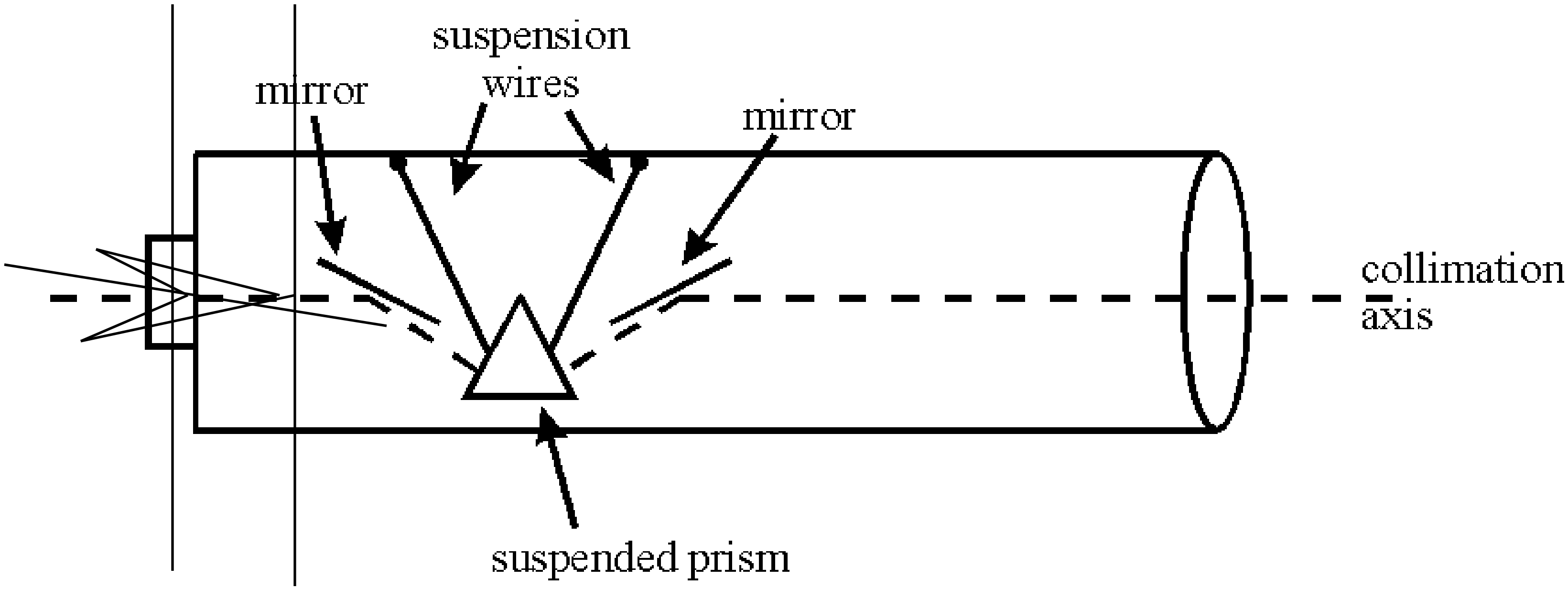
Collimation Error

- The Automatic Prism compensator goes out of alignment.
- The level provides readings outside of its specification



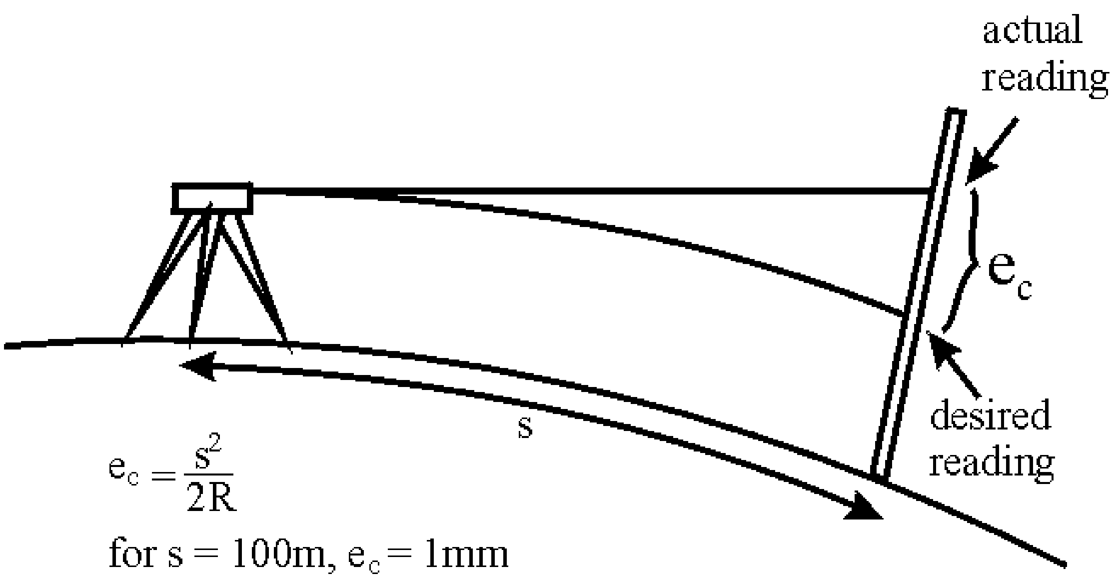
Parallax Error

- When using an optical instrument — both the image and cross hairs can be focused- if either is imprecisely focused, the cross hairs will appear to move with respect to the object focused, if one moves one's head horizontally in front of the eyepiece.



Curvature of the Earth

- Due to the curvature of the Earth, the line of sight at the instrument will deviate from a horizontal line as one moves away from the level



Contour: An imaginary line on the ground surface joining the points of equal elevation is known as contour.

In other words, contour is a line in which the ground surface is intersected by a level surface obtained by joining points of equal elevation. This line on the map represents a contour and is called contour line.

Contour Map

A map showing contour lines is known as Contour map.

A contour map gives an idea of the altitudes of the surface features as well as their relative positions in plan serves the purpose of both, a plan and a section.

PURPOSE OF CONTOURING

Contour survey is carried out at the starting of any engineering project such as a road, a railway, a canal, a dam, a building etc.

- For preparing contour maps in order to select the most economical or suitable site.
- To locate the alignment of a canal so that it should follow a ridge line.
- To mark the alignment of roads and railways so that the quantity of earthwork both in cutting and filling should be minimum.

CONTOUR INTERVAL

The constant vertical distance between two consecutive contours is called the contour interval.

HORIZONTAL EQUIVALENT

- The horizontal distance between any two adjacent contours is called as horizontal equivalent.
- The contour interval is constant between the consecutive contours while the horizontal equivalent is variable and depends upon the slope of the ground.

CHARACTERISTICS OF CONTOURS

i) All points in a contour line have the same elevation.

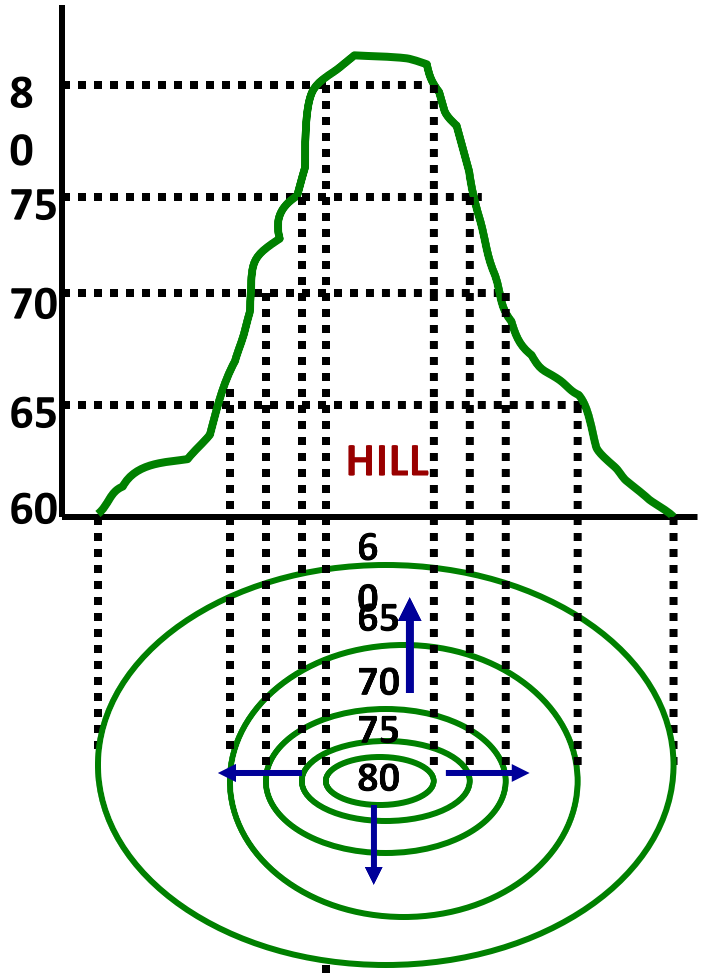
ii) Flat ground is indicated where the …contours are widely separated and steep- slope where they run close together.

iii) A uniform slope is indicated when the contour lines are uniformly spaced and

iv) A plane surface when they are straight, parallel and equally spaced.

CHARACTERISTICS OF CONTOURS

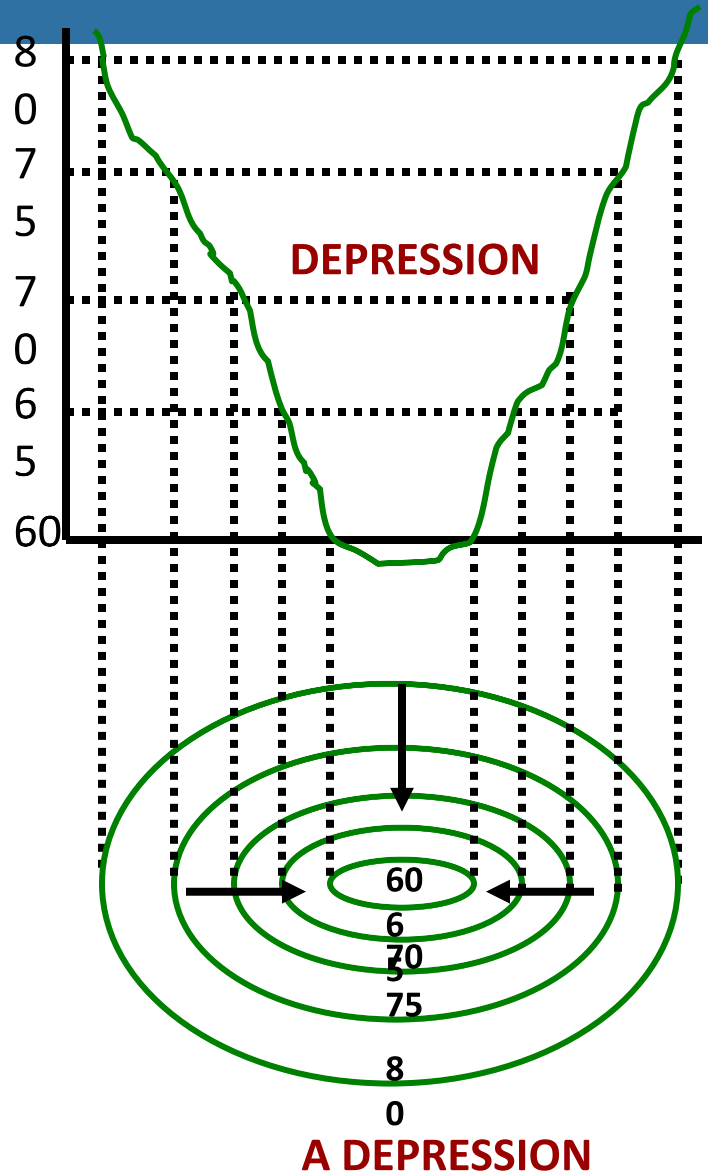
v) A series of closed contour lines on the map represent a hill , if the higher values are inside



A HILL

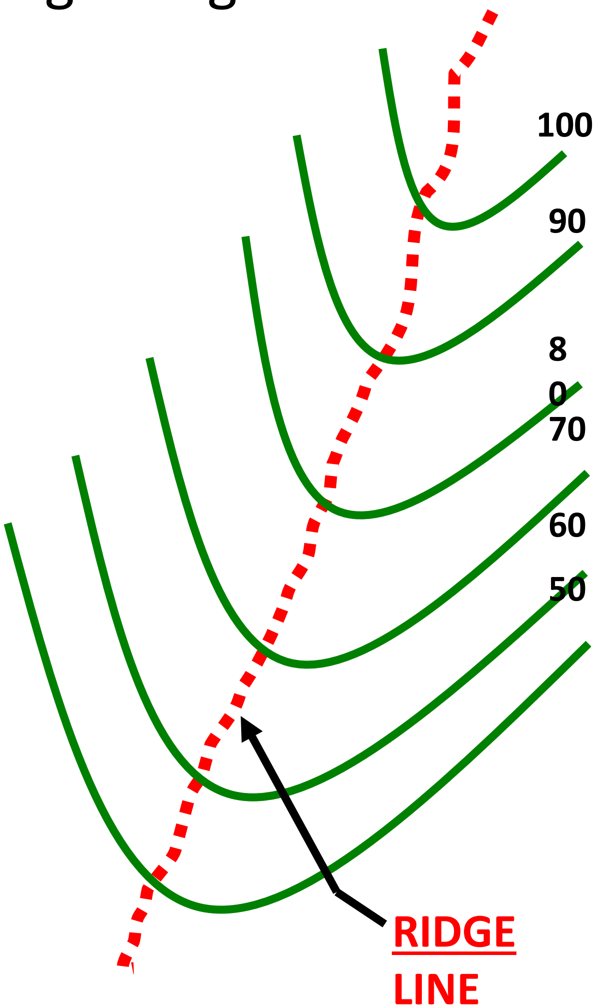
CHARACTERISTICS OF CONTOURS

vi) A series of closed contour lines on the map indicate a depression if the higher values are outside



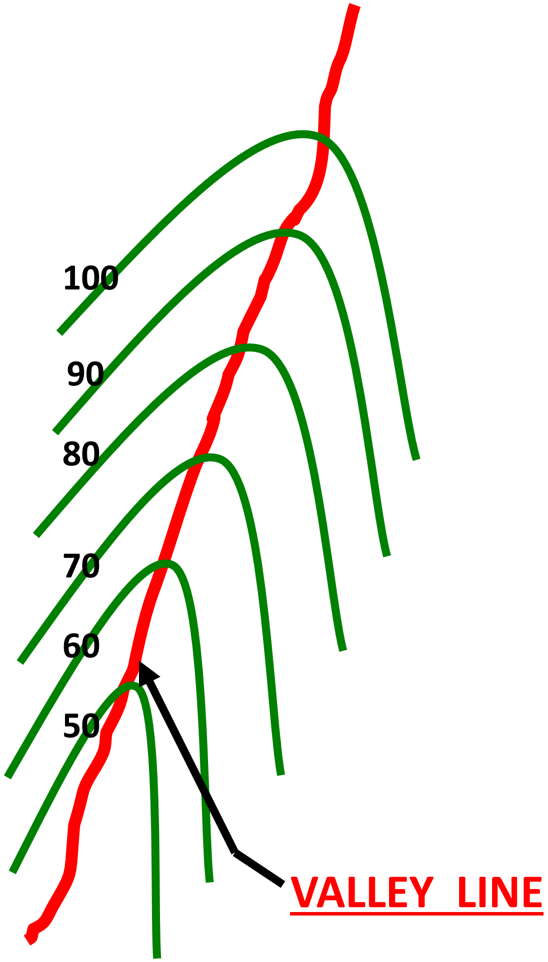
CHARACTERISTICS OF CONTOURS

vii) Contour line cross ridge or valley line at right angles.



If the higher values are inside the bend or loop in the contour, it indicates a Ridge.

vii) Contour line cross ridge or valley line at right angles.



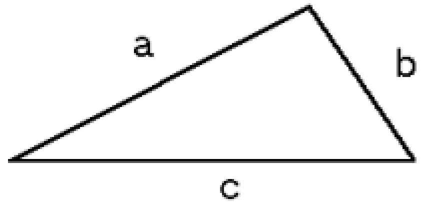
If the higher values are outside the bend, it represents a Valley

Introduction

Areas and Volumes are often required in the context of design, eg. we might need the surface area of a lake, the area of crops, of a car park or a roof, the volume of a dam embankment, or of a road cutting. Volumes are often calculated by integrating the area at regular intervals eg. along a road centre line, or by using regularly spaced contours. We simply use what you already know about numerical integration from numerical methods).

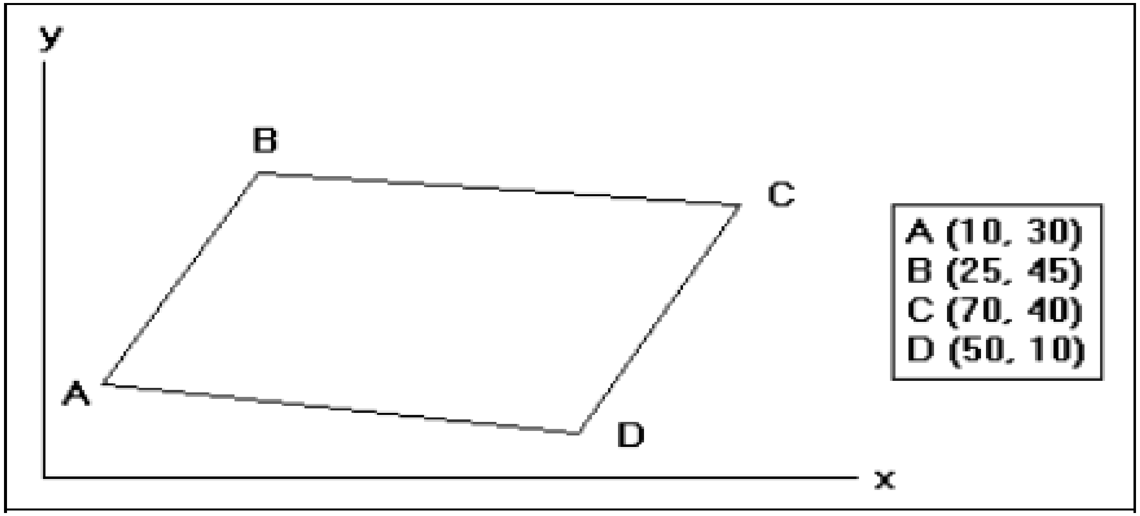
Objectives

After completing this topic you should be able to calculate the areas of polygons and irregular figures and the volumes of irregular and curved solids



Triangles if s = (a + b + c) / 2 then
area = S.(S-a)(S-b)(S-c)

Calculating area of a polygon from Coordinates: If the coordinate points are numbered clockwise: area = 1 2 ∑ i=1 n (Ni . Ei+1 - Ei . Ni+1) This formula is not easy to remember, so let's look at a practical application



Arrange the data in columns as shown below, repeating the last line at the top.

D	50	10
A	10	30
B	25	45
C	70	40
D	50	10

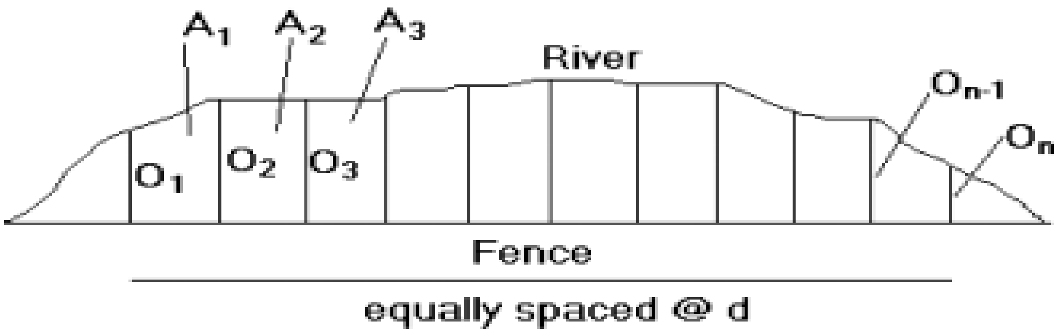
Diagram to go in here

area = (1/2) x (10 x 10 + 25 x 30 + 45 x 70 + 40 x 50
– 50 x 30 - 10 x 45 - 25 x 40 - 70 x 10)
= 1175

The computation of volumes of various quantities from the measurements done in the field is required in the design and planning on many engineering works. The volume of earth work is required for suitable alignment of road works, canal and sewer lines, soil and water conservation works, farm pond and percolation pond consent. The computation of volume of various materials such as coal, gravel and is required to check the stock files, volume computations are also required for estimation of capacities of bins tanks etc.

Calculating areas with the Trapezoidal Rule

(as used in integrating functions)



$A_1 = d \,.\, (O_1 + O_2) / 2$

$A_2 = d \,.\, (O_2 + O_3) / 2$

$A_3 = d \,.\, (O_3 + O_4) / 2$

Hence, the total area is:

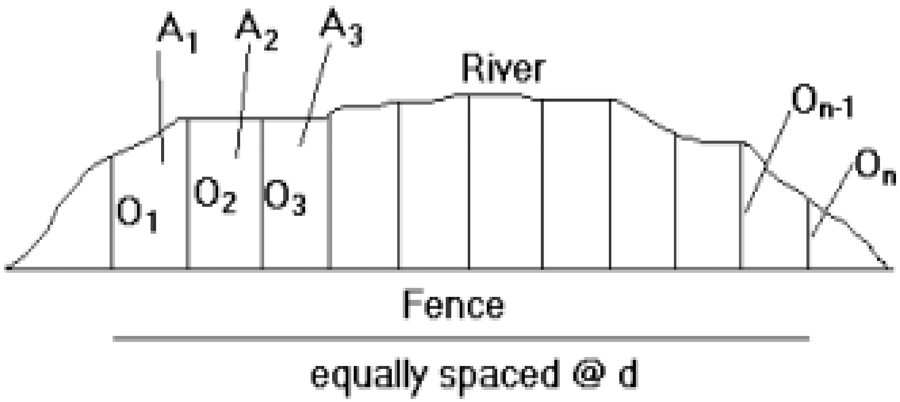
$$A = (d/2) \,.\, [O_1 + 2.O_2 + 2.O_3 + ... + 2.O_{n-1} + O_n]$$

The Trapezoidal Rule assumes **straight line segments** on the boundary.

Doing better with Simpson's Rule

Simpson's Rule assumes a parabola fitted to 3 adjacent points, rather than the straight lines between adjacent points assumed by the Trapezoidal Rule.

This may be more accurate than the Trapezoidal Rule because boundaries are often curved.

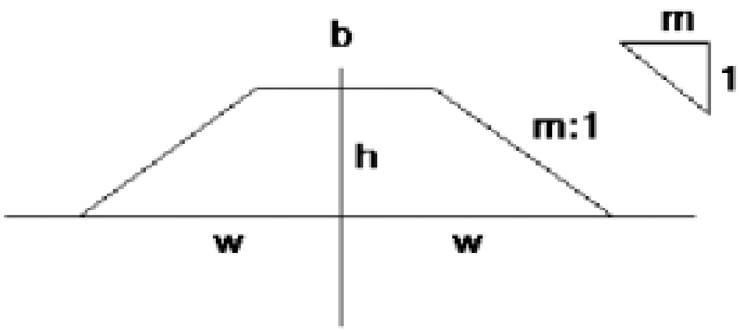


Volumes can be calculated in a number of ways. It is common to calculate the area of each of several equally spaced slices (either vertical cross-sections, or horizontal contours), and integrate these using Simpson's Rule or similar. A second method is to use spot levels, and calculate the volume of a series of wedges or square cells

Cross-sections are well suited for calculating volumes of roads, pipelines, channels, dam embankments, etc. Formulae are given below for the most common cross-section cases.

Horizontal ground

Man-made structures usually have constant side slopes : eg (simple case)



w = b/2 + m.h

\ Area = h . [2.w + b] / 2 = h.(b + m.h)

Computation of area using different methods

1. The following offsets were taken from a chain line to an irregular boundary line at an interval of 10 m. 0, 2.50, 3.50, 5.00, 4.60, 3.20, 0 m. Compute the area between the chain line, the irregular boundary line and the end offsets by:

(a) Trapezoidal Rule

(b) Simpson's Rule

(a) Trapezoidal Rule

Here d = 10

$$\text{Area} = \frac{10}{2}\{0+0+2(2.50+3.50+5.00+4.60+3.20)\} = 5 * 37.60 = \mathbf{188\ m^2}$$

(b) Simpson's Rule

D = 10

$$\text{Area} = \frac{10}{3}\{0+0+4(2.50+5.00+3.20)+2(3.50+4.60)\} = \frac{10}{3} * 59.00 = \mathbf{196.66\ m^2}$$

2. The following offsets were taken from a survey line to a curved boundary line:

Distance (m)	0	5	10	15	20	30	40	60	80
Offset (m)	2.50	3.80	4.60	5.20	6.10	4.70	5.80	3.90	2.20

Find the area between the survey line, the curved boundary line and the first and last offsets by (a) Trapezoidal Rule and (b) Simpson's Rule.

Here, the intervals between the offsets are not regular throughout the length. Soothe section is divided into three compartments.

Let,

Δ_1 = Area of the 1st section

Δ_2 = Are of the 2nd section

Δ_3 = Area of the 3rd section

Here,

$d_1 = 5$ m

$d_2 = 10$ m

$d_3 = 20$ m

(a) Trapezoidal Rule:

$$\Delta_1 = \frac{5}{2}\{2.50 + 6.10 + 2(3.80 + 4.60 + 5.20)\} = 89.50 \text{ m}^2$$

$$\Delta_2 = \frac{10}{2}\{6.10 + 5.80 + 2(4.70)\} = 106.50 \text{ m}^2$$

$$\Delta_3 = \frac{20}{2}\{5.80 + 2.20 + 2(3.90)\} = 158.00 \text{ m}^2$$

Total Area = 89.50 + 106.50 + 158.00 = **354.00 m^2**

(b) By Simpson's Rule

$$\Delta_1 = \frac{5}{3}\{2.50 + 6.10 + 4(3.80 + 5.20) + 2(4.60)\} = 89.66 \text{ m}^2$$

$$\Delta_2 = \frac{10}{3}\{6.10 + 5.80 + 4.70\} = 102.33 \text{ m}^2$$

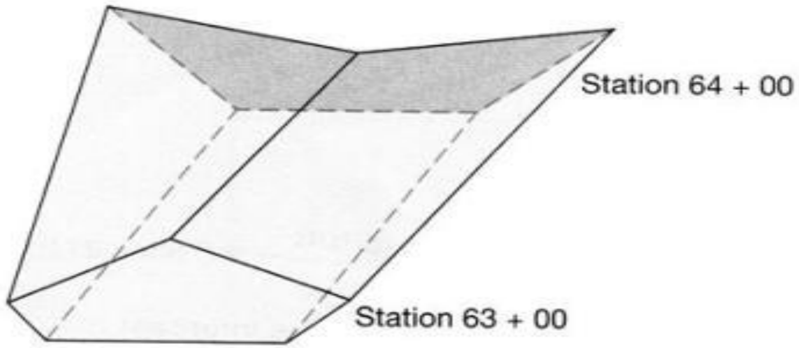
$$\Delta_3 = \frac{20}{3}\{5.80 + 2.20 + 4(3.90)\} = 157.33 \text{ m}^2$$

Total area = 89.66 + 102.33 + 157.33 = **349.32 m^2**

Prismoidal Method

- The prismoidal formula applies to volumes of all geometric solids that can be considered prismoids.

$$V = \frac{2d}{6}[A_1 + A_n + 4(A_2 + A_4 + ... + A_{n-2}) + 2(A_3 + A_5 + ... + A_{n-1})]$$



Simpson's rule

In this rule, the boundaries between the ends of ordinates are assumed to form an arc of a parabola. Hence Simpson's rule is sometimes called the parabolic rule.

Refer to Fig. 7.13.

Let

O_1, O_2, O_3 = three consecutive ordinates

d = common distance between the ordinates

Area AFeDC = area of trapezium AFDC + area of segment FeDEF

Simpson's Rule

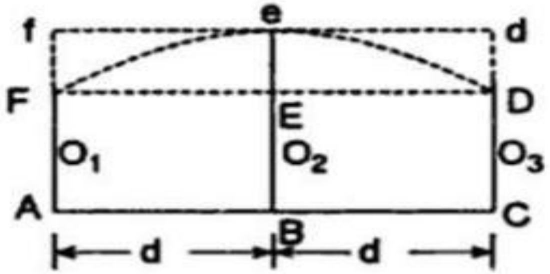


Fig. 7.13

Here,

$$\text{Area of trapezium} = \frac{O_1 + O_3}{2} \times 2d$$

$$\text{Area of segment} = \frac{2}{3} \times \text{area of parallelogram FfdD}$$

$$= \frac{2}{3} \times \text{Ee} \times 2d = \frac{2}{3} \times \left\{O_2 - \frac{O_1 + O_3}{2}\right\} \times 2d$$

Trapezoidal rule

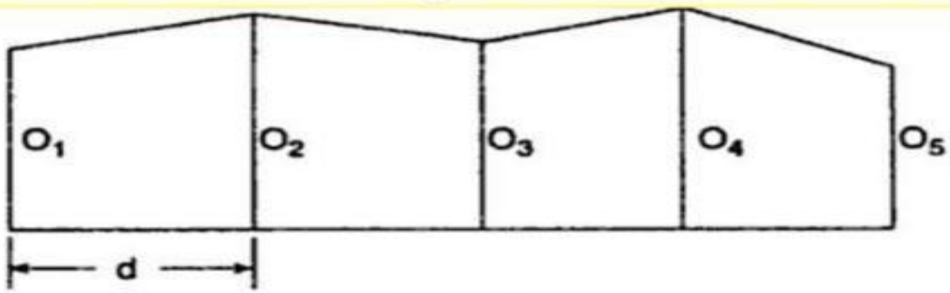


Fig. 7.12

Let $O_1, O_2, \ldots, O_n$ = ordinates at equal intervals

d = common distance

$$\text{1st area} = \frac{O_1 + O_2}{2} \times d$$

$$\text{2nd area} = \frac{O_2 + O_3}{2} \times d$$

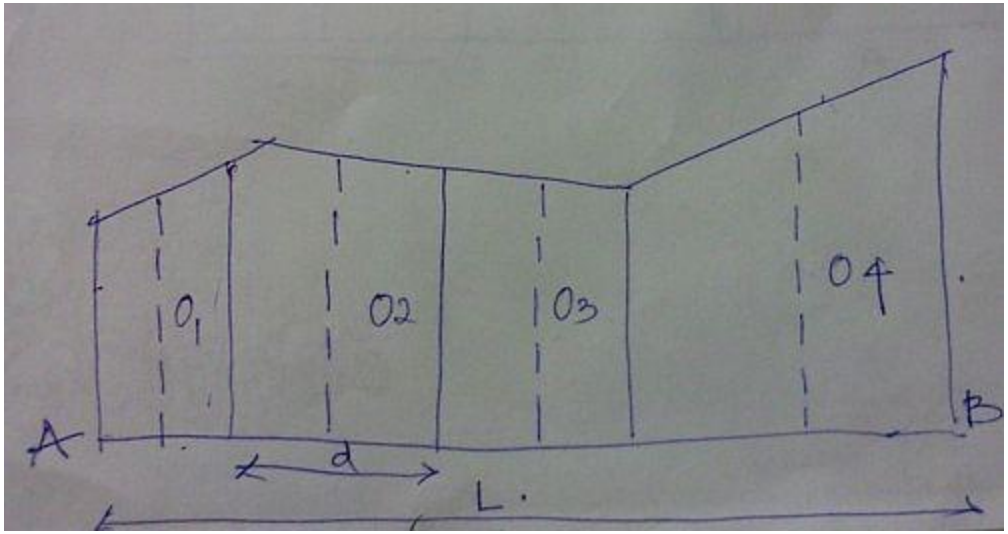
$$\text{3rd area} = \frac{O_3 + O_4}{2} \times d$$

$$\text{Last area} = \frac{O_{n-1} + O_n}{2} \times d$$

$$\text{Total area} = \frac{d}{2}\{O_1 + 2O_1 + 2O_2 + \ldots + 2O_{n-1} + O_n\}$$

$$= \frac{\text{common distance}}{2}\{(\text{1st ordinate + last ordinate} + 2\ (\text{sum of other ordinate})\}$$

Computation of area using different methods



Midpoint-ordinate rule

The rule states that if the sum of all the ordinates taken at midpoints of each division multiplied by the length of the base line having the ordinates (9 divided by number of equal parts).

Problems

The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line. The ordinates are measured at midpoint of the division are 10, 13, 17, 16, 19, 21, 20 and 18m. Calculate the are enclosed by the midpoint ordinate rule.

Ordinates

O1 = 10

O2 = 13

O3 = 17

O4 = 16

O5 = 19

O6 = 21

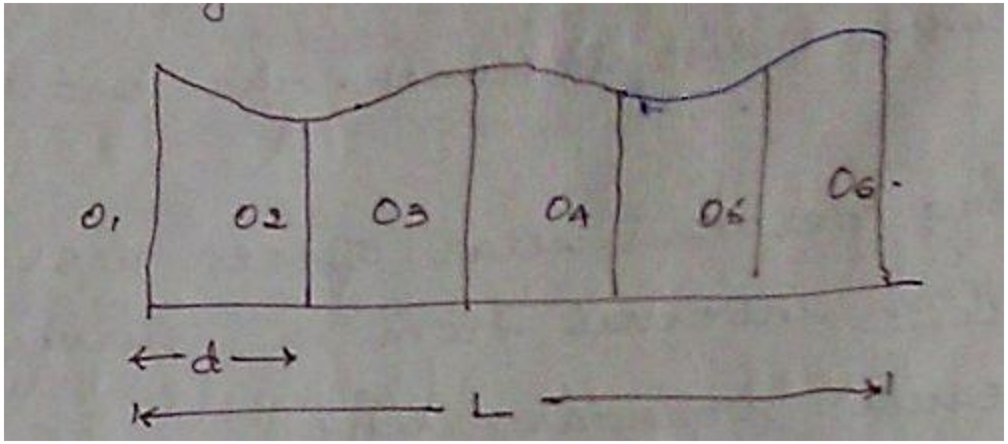
O7 = 20 and O8 = 18

Common distance, d =10m

Number of equal parts of the baseline, n = 8

Length of baseline, L = n *d = 8*10 = 80m

Average Ordinate Rule



Average Ordinate Rule

The rule states that (to the average of all the ordinates taken at each of the division of equal length multiplies by baseline length divided by number of ordinates).

Problems

The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line.

9, 12, 17, 15, 19, 21, 24, 22, 18

Calculate area enclosed between the survey line and irregular boundary line.

Area = [(O1+ O2+ O3+ …. + O9)*L]/(n+1)

= [(9+12+17+15+19+21+24+22+18)*8*10]/(8+1)

= 139538sqm

Simpson's Rule Statement

It states that, sum of first and last ordinates has to be done. Add twice the sum of remaining odd ordinates and four times the sum of remaining even ordinates. Multiply to this total sum by 1/3rd of the common distance between the ordinates which gives the required area.

Problem

Chainage	0	25	50	75	100	125	150
Offset 'm'	3.6	5.0	6.5	5.5	7.3	6.0	4.0

The following offsets are taken from a chain line to an irregular boundary towards right side of the chain line.

Common distance, d = 25m

Area = $d/3[(O_1+O_7) + 2\ (O_3+O_5)+4(O_2+O4+O_6)]$

= $25/3[(3.6+4)+2(6.5+7.3)+4(5+5.5+6)]$

Area = 843.33sqm

COMPUTATION OF VOLUMES

The computation of volumes of various quantities from the measurements done in the field is required in the design and planning on many engineering works. The volume of earth work is required for suitable alignment of road works, canal and sewer lines, soil and water conservation works, farm pond and percolation pond consent. The computation of volume of various materials such as coal, gravel and is required to check the stock files, volume computations are also required for estimation of capacities of bins tanks etc.

COMPUTATION OF VOLUMES

For estimation of volume of earth work cross sections are taken at right angles to a fixed line, which runs continuously through the earth work. The spacing of the cross sections will depend upon the accuracy required. The volume of earth work is computed once the various cross-sections are known, adopting Prismoidal rule and trapezoidal rule

Problem

1. Compute the cost of earth work involved in cutting open a trench of following size. Length 200 m, side slope 2: 1, depth of trench 4 m, bottom, width of trench 1.5 m. Cost of earth work Rs. 50 per m3 . Cross sectional area of trench, A = (b + sh)*h

A = (1.5 + 2*4)*4 A = 9.5 * 4 = 38 m2

∴ Volume of earth work, V = A*L = 38 * 200 = 7600 m3

∴ Cost of earth work = 7600 * 50 = Rs. 3,80,000.00

Problem

Compute the volume of earth work involved in constructing a farm pond of the following size: size, at bottom 6 x 4 m. Side slope 2: 1, depth of pond 4 m work out the cost of earth work also if it costs Rs. 50 per cubic metre.

Size of pond at bottom = 6 x 4 m

Area at bottom = 24 m^2 (a_1)

Size of pond at ground level:

Length of pond = 6 + 8 + 8 = 22 m

Breadth of pond = 4 + 8 + 8 = 20 m

Cross sectional area of pond at ground level = 20 * 22 = 440 m^2 (a_3)

Area of pond at mid height = $\frac{(22+6)}{2} * \frac{(20+4)}{2} = 14 * 12 = 168\ m^2$ (a_2)

Using prismoidal rule, $V = \frac{D}{2}[a_2 + a_3 + 2(a_2)]$

$$V = \frac{D}{2}[24 + 440 + 2(168)]$$

$$V = \frac{2}{2}[464 + 336] = 800\ m^3$$

∴ Cost of earth work = 50 * 800 = **Rs. 40, 000**

Measurement of Volume of Earth work from Cross-Sections:

The length of the project along the centre line is divided into a series of solids known as prismoids by the planes of cross-sections. The spacing of the sections should depend upon the character of ground and the accuracy required in measurement.

They are generally run at 20m or 30m intervals, but sections should also be taken at points of change from cutting to filling, if these are known, and at places where a marked change of slop occurs either longitudinally or transversely.

The areas of the cross-sections which have been taken are first calculated and the volumes of the prismoids between successive cross- sections are then obtained by using the Trapezoidal formula or the prismoidal formula. The former is used in the preliminary estimates and for ordinary results, while the latter is employed in the final estimates and for precise results.

Formulae for Areas of Cross-Sections:

- The following are the various cross-sections usually met with whose areas are to be computed:
- Level section.
- Two-level section.
- Side-hill two-level section.
- Three-level section.
- Multi-level section.

Level section

1. Level-Section (Fig. 12.2):

In this case the ground is level transversely.

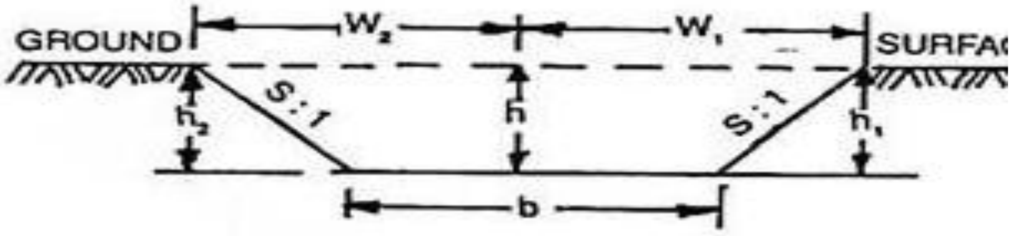


Fig. 12.2

$$h_1 = h_2 = h$$

$$w_1 = w_2$$

$$= \frac{b}{2} + sh$$

$$A = \frac{1}{2}[b + (b + 2sh)]h$$

$$= (b + sh)\, h \quad \ldots \quad \ldots \quad \ldots$$

2. Two-Level Section (Fig. 12.1):

In this case, the ground is sloping transversely, but the slope of the ground does not intersect the formation level.

$$w_1 = \frac{b}{2} + \frac{rs}{r-s}\left(h + \frac{b}{2r}\right)$$

$$w_2 = \frac{b}{2} + \frac{rs}{(r+s)}\left(h - \frac{b}{2r}\right)$$

$$h_1 = h + \frac{w_1}{r}$$

$$h_2 = h - \frac{w_2}{r}$$

$$A = \frac{1}{2}\left[(w_1 + w_2)\left(h + \frac{b}{2s}\right) - \frac{b^2}{2s}\right]$$

$$= \left[\frac{s(\frac{b}{2})^2 + r^2bh + r^2sh^2}{(r^2 - s^2)}\right] \quad \ldots \quad \ldots \quad \text{(Eqn. 12.2)}$$

4. Three-Level Section (Fig. 12.4):

In this case, the transverse slope of the ground is not uniform.

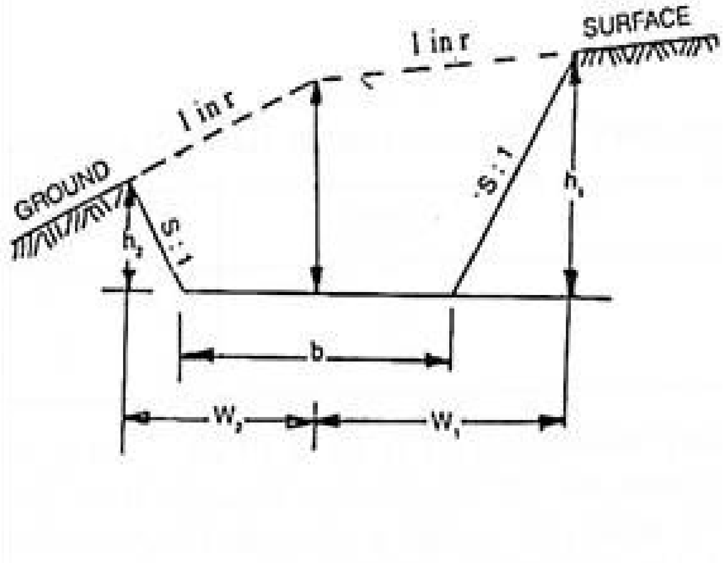


Fig. 12.4

$$w_1 = \frac{r_1 s}{(r_1 - s)}\left(h + \frac{b}{rs}\right)$$

$$w_2 = \frac{r_2 s}{(r_2 + s)}\left(h + \frac{b}{2s}\right)$$

$$h_1 = \left(h + \frac{w_1}{r_1}\right)$$

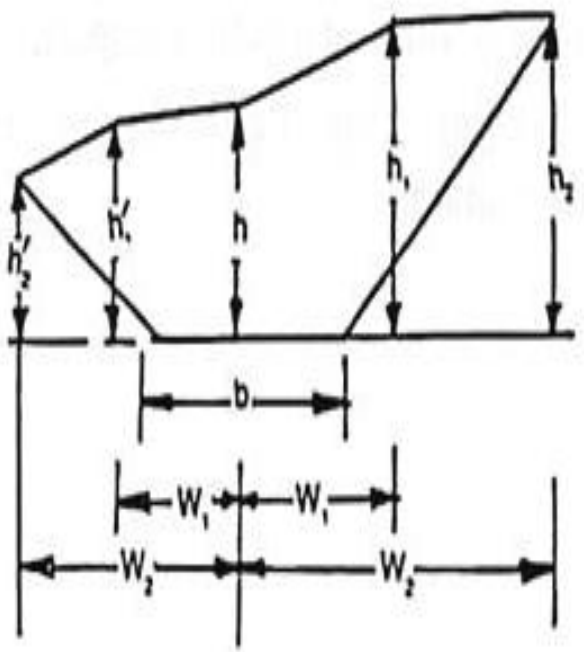
$$h_2 = \left(h - \frac{w_2}{r_2}\right)$$

The formulae for w_1 and w_2 may apply to both side widths according as the ground rises or falls from the centre to both sides.

$$A = \left[\frac{1}{2}h(w_1 + w_2) + \frac{b}{4}(h_1 + h_2)\right] \quad \ldots \quad \ldots \quad \text{(Eqn. 12.5}$$

5. Multi-Level Section (Fig. 12.5):

In this case, the transverse slope of the ground is not uniform but-has multiple cross-slopes as is clear from the figure.



The notes regarding the cross-section are recorded as follows:

Left	Centre	Right
$\frac{\pm h'_2}{w'_2}$ $\frac{\pm h'_1}{w'_1}$	$\frac{\pm h}{0}$	$\frac{\pm h_1}{w_1}$ $\frac{\pm h_2}{w_2}$

The numerator denotes cutting (+ve) or filling (-ve) at the various points, and the denominator their horizontal distances from the centre line of the-section. The area of the section is calculated from these notes by coordinate method. The co-ordinates may be written in the determinant form irrespective of the signs.

$$\frac{0}{b/2} \times \frac{h'_2}{w'_2} \times \frac{h'_1}{w'_1} \overset{+}{\times} \frac{h}{0} \times \frac{h_1}{w_1} \times \frac{h_2}{w_2} \times \frac{0}{b/2}$$

Formula

Let Σ F= sum of the product of the co-ordinates joined by full lines.

Σ D= sum of the products of the co-ordinates joined by dotted lines.

Then, $A = 1/2\ (\Sigma F - \Sigma D)$

THEODOLITE AND TRAVERSE SURVEYING:-

Types of Theodolites

- There are two different kinds of theodolites: digital and non digital. Non digital theodolites are rarely used anymore. Digital theodolites consist of a telescope that is mounted on a base, as well as an electronic readout screen that is used to display horizontal and vertical angles. Digital theodolites are convenient because the digital readouts take the place of traditional graduated circles and this creates more accurate readings.

- Theodolites are mainly used for surveying, but they are also useful in these applications:
- Navigating
- Meteorology
- Laying out building corners and lines
- Measuring and laying out angles and straight lines
- Aligning wood frame walls
- Forming panels
- Plumbing a column or building corner

- It is important to clearly understand the terms associated with the theodolite and its use and meaning. The following are some important terms and their definitions.
- **Vertical axis** It is a line passing through the centre of the horizontal circle and perpendicular to it. The vertical axis is perpendicular to the line of sight and the trunnion axis or the horizontal axis. The instrument is rotated about this axis for sighting different points

- **Horizontal axis** It is the axis about which the telescope rotates when rotated in a vertical plane. This axis is perpendicular to the line of collimation and the vertical axis.
- **Telescope axis** It is the line joining the optical centre of the object glass to the centre of the eyepiece

- **Line of collimation** It is the line joining the intersection of the cross hairs to the optical centre of the object glass and its continuation. This is also called the line of sight.
- **Axis of the bubble tube** It is the line tangential to the longitudinal curve of the bubble tube at its centre.

- **Centering** Centering the theodolite means setting up the theodolite exactly over the station mark. At this position the plumb bob attached to the base of the instrument lies exactly over the station mark.

- **Transiting** It is the process of rotating the telescope about the horizontal axis through 180^o . The telescope points in the opposite direction after transiting. This process is also known as *plunging* or *reversing.*

- **Swinging** It is the process of rotating the telescope about the vertical axis for the purpose of pointing the telescope in different directions. The right swing is a rotation in the clockwise direction and the left swing is a rotation in the counter-clockwise direction.
- **Face-left or normal position** This is the position in which as the sighting is done, the vertical circle is to the left of the observer.

- **Face-right or inverted position** This is the position in which as the sighting is done, the vertical circle is to the right of the observer.

- **Changing face** It is the operation of changing from face left to face right and vice versa. This is done by transiting the telescope and swinging it through 180 o .

- **Face-left observation** It is the reading taken when the instrument is in the normal or face-left position.

- **Face-right observation** It is the reading taken when the instrument is in the inverted or face-right position

Problems on Trigonometric leveling

- **Case 1)**
  Determination of elevation of object when the base is accessible the object is Vertical
  It is assumed that the horizontal distance between the instrument and the object can be measured accurately. In Fig. 1, let B = instrument station F = point to be observed = center of the instrument AF = vertical object D = CE
  = horizontal distance 1
  = height of the instrument at Bh = height FES = reading on the levelling staff held vertical on the Bench Mark (B.M)
  = angle of elevation of the top of the object
  so, H=D tan z

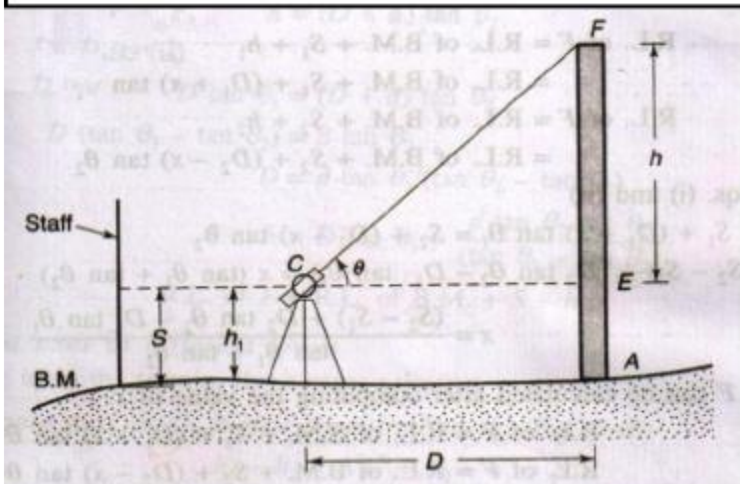


Fig. 1

R.L of F= R.L of B.M. + h + D tan z

Corrections for curvature and refraction

C =0.06735(D*D) so the true R.L is R.L of B.M. + h +D tanz + C

- If the both the angle of depression and elevation are given to us then we can directly find the height of the whole building.
- Let us assume the angle of elevation is z1 and angle of depression is z2 and the object is accessible and the distance between instrument and foot of building is D
- then,

$$\text{Height of building} = D \tan z1 + D \tan z2$$

- Case 2

Base of the object is not accessible

Case 2. Base of the object inaccessible, Instrument stations in the vertical plane as the elevated object.

(a) Instrument axes at the same level

Δ PA'P', h= D tan α1

Δ PB'P', h= (b+D) tan α2

D tan α1 = (b+D) tan α2

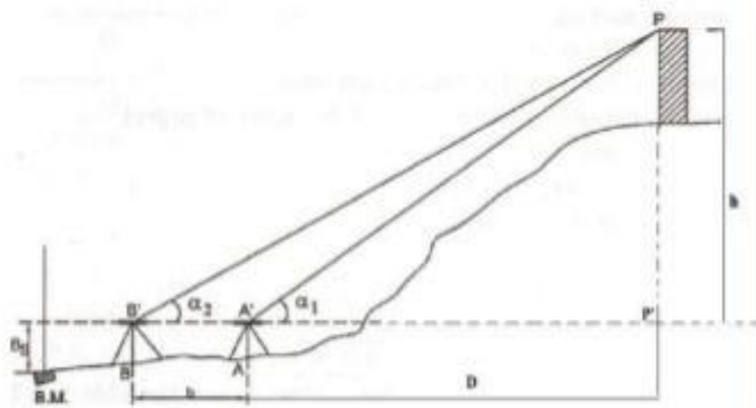
D tan α1 = b tan α2 + D tan α2

D(tan α1 - tan α2) = b tan α2

$$D = \frac{b \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$$

$$h = \frac{b \tan \alpha_2 . \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$$

R.L of P = R.L of B.M + Bs + h



- **Base of the object is not accessible**

Case 3. Base of the object inaccessible, Instrument stations not in the same vertical plane as the elevated object.

Set up instrument on A
Measure $\alpha 1$ to P
$\angle BAC = \theta$

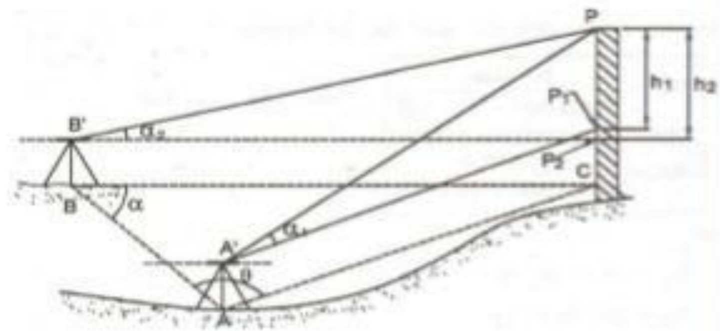
Set up instrument on B
Measure $\alpha 2$ to P
$\angle ABC = \alpha$

$\angle ACB = 180 - (\theta + \alpha)$

Sin Rule:

$$BC = \frac{b \cdot \sin\theta}{\sin\{180^\circ - (\theta + \alpha)\}}$$

$$AC = \frac{b \cdot \sin\alpha}{\sin\{180^\circ - (\theta + \alpha}$$



$h1 = AC \tan \alpha 1$

$h2 = BC \tan \alpha 2$

Problems on Trigonometric leveling

Principles

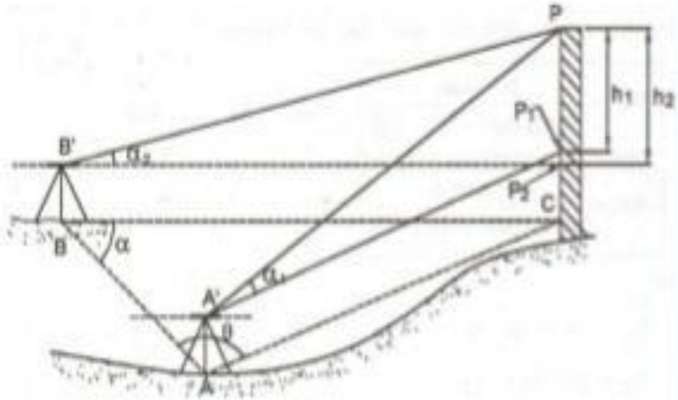
Trigonometric leveling is so named because it uses a total station instrument's (TSI) slope distance and zenith angle meeasurements to mathematically compute an elevation difference which, with a few more bits of information, can be used to determine a point's elevation. Using appropriate procedures, and controlling errors, elevation accuracy can be better than 0.1 ft. Because trigonometric leveling is not limited to a horizontal line of sight, it is more flexible and provides faster elevation data collection than differential leveling.

- **Base of the object is not accessible**
- The instrument stations and the elevated object not in the same vertical plane
- This is the most practical case on field if we consider in comparison with other cases
- In this case we use the sine law for finding the distances example D1 and D2

  For example

$$(d \sin z1)/\sin z3 = D2$$

Case 3. Base of the object inaccessible, Instrument stations not in the same vertical plane as the elevated object.



Set up instrument on A
Measure $\alpha 1$ to P
$\angle BAC = \theta$

Set up instrument on B
Measure $\alpha 2$ to P
$\angle ABC = \alpha$

$\angle ACB = 180 - (\theta + \alpha)$

Sin Rule:

BC=	$\dfrac{b \cdot \sin\theta}{\sin\{180^\circ - (\theta + \alpha)\}}$
AC=	$\dfrac{b \cdot \sin\alpha}{\sin\{180^\circ - (\theta + \alpha)}$

$h1 = AC \tan \alpha 1$

$h2 = BC \tan \alpha 2$

- HEIGHTS And DISTANCES
- When the distance btw the stations is not large, the distance btw the stations measured on the surface of the earth or computed trigonometrically may be assumed as a plane distance.
- The amount of correction due to curvature of the earth surface an refraction just be ignored.
- Depending on field conditions, the following three cases are involved

MODULE 2
CURVES

Types of Curve

Curves

- Horizontal Curve

Vertical Curve

Circular Curve

1) Simple curve
2) Compound Curve
3) Reverse Curve

Transition Curve

1) Cubic parabola
2) Spiral Curve
3) Lemniscate

Summit Curve

Valley Curve

Types of Circular Curve

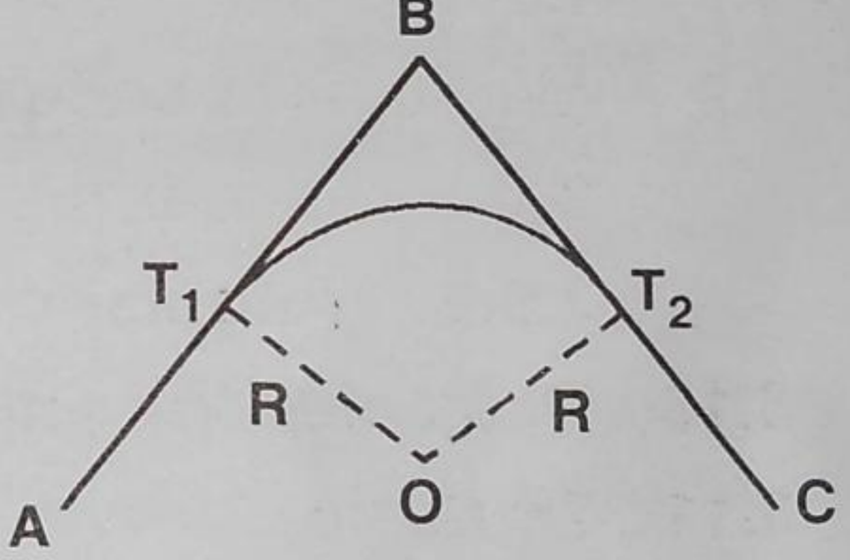


Fig. 3.1 Simple Curve

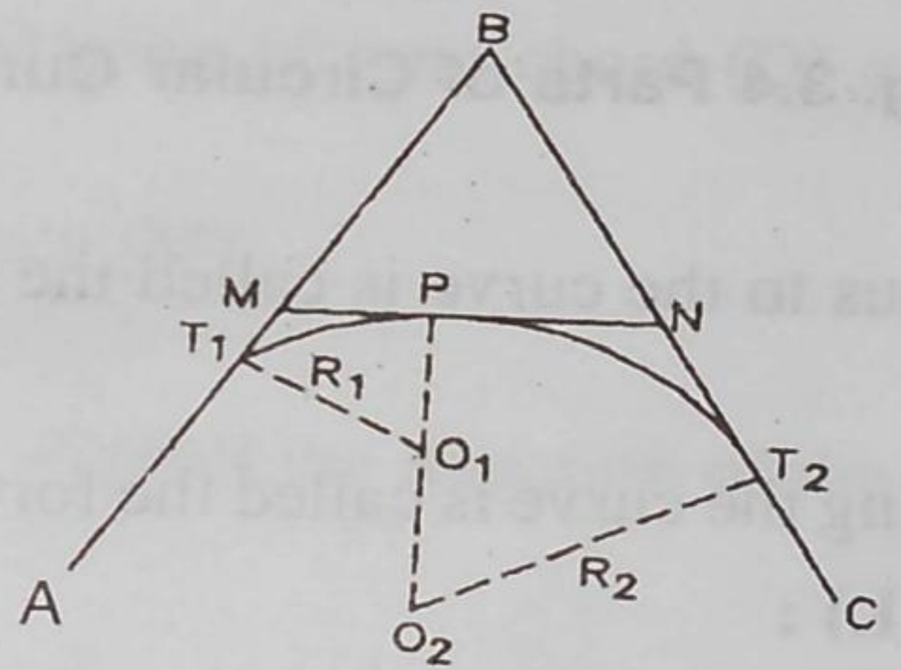


Fig. 3.2 Compound curve

Types of Circular Curve

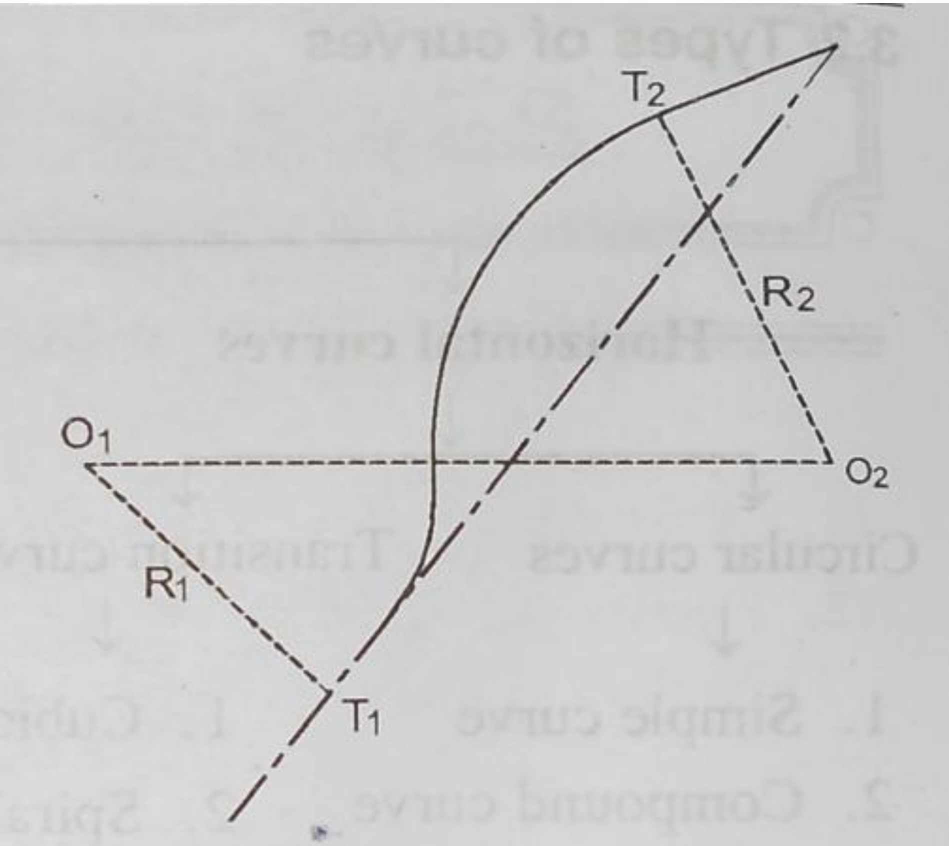


Fig. 3.3 Reverse Curve

Definition and Notation of Simple Curve

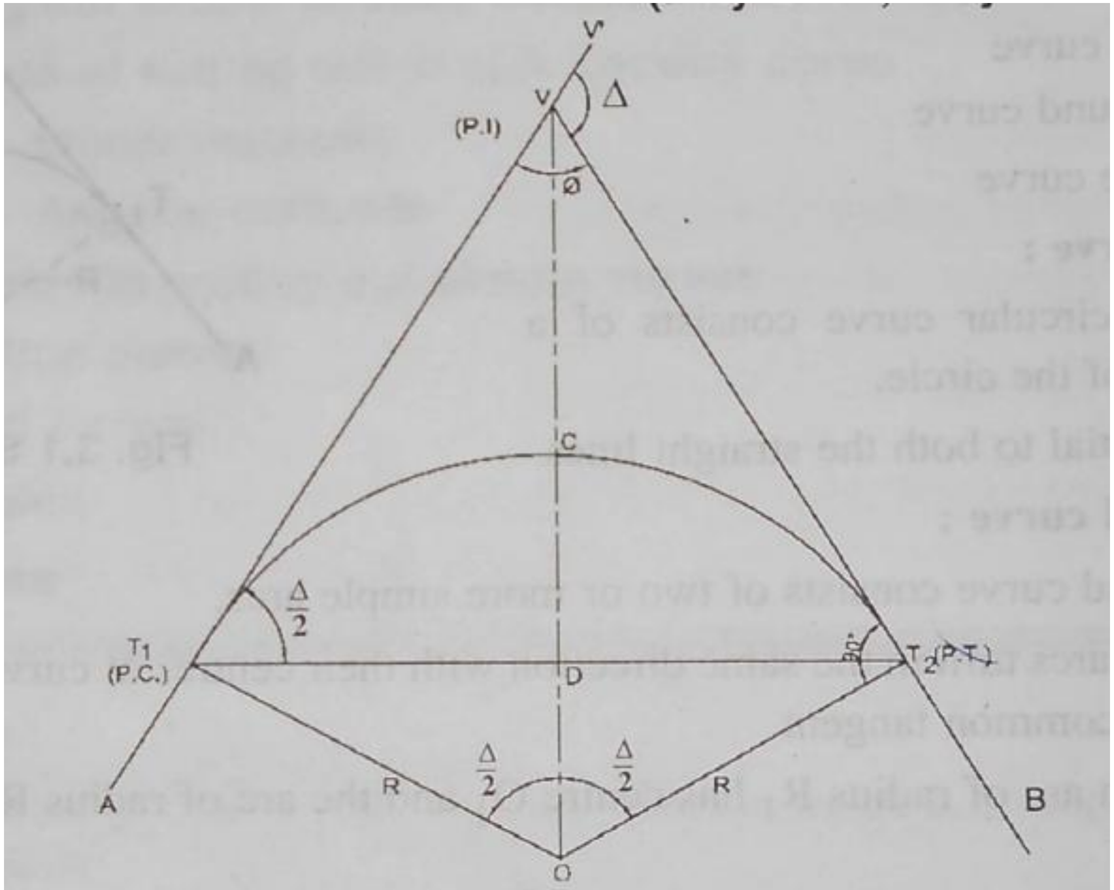
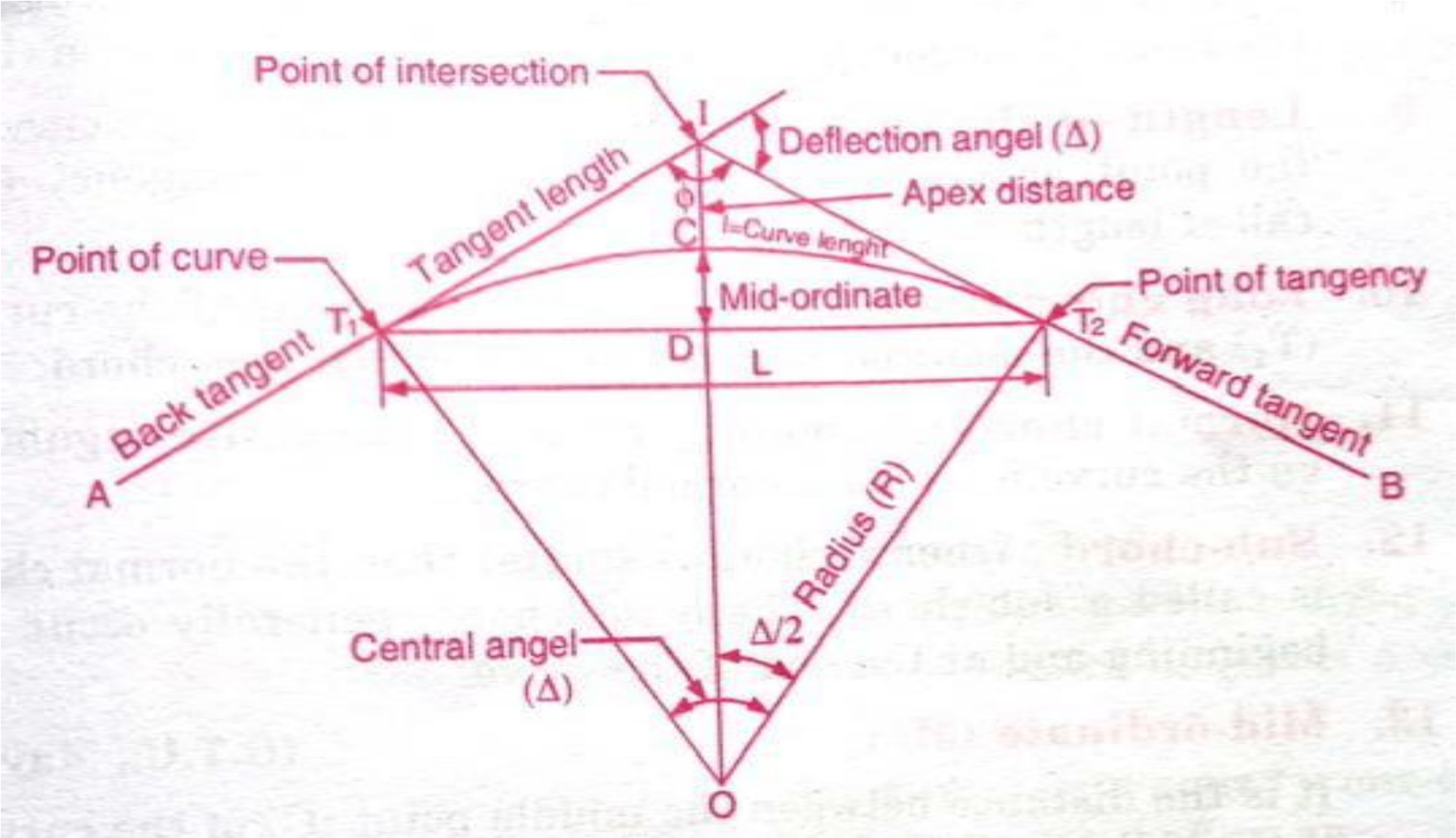


Fig. 3.4 Parts of Circular Curve



Point of intersection
I
Deflection angel (Δ)
Tangent length
φ
Apex distance
C
l=Curve lenght
Point of curve
Mid-ordinate
Point of tangency
T1
T2
D
L
Back tangent
Forward tangent
A
B
Radius (R)
Δ/2
Central angel
(Δ)
O

- 1) Back tangent **or** First Tangent - AT_1
  - Pervious to the curve

  2) Forward Tangent **or** Second tangent- B T_2

  - Following the curve.

  3) Point of Intersection (P.I.) **or** Vertex. (v)

  If the tangents AT_1 and BT_2 .are produced they will meet in a point called the point of intersection

  4)Point of curve (P.C.) –Beginning Point T_1 of a curve. Alignment changes from a tangent to curve.

- 5) Point of Tangency - PT End point of curve (T_2)

  6) Intersection Angle (Ø) The Angle AVB between tangent AV and tangent VB is called...

  7) Deflection Angl (Δ)

  The angle at P.I. between tangent AV and VB is called..

  8)Tangent Distance –

  It is the distance between P.C. and P.I.

  9) External Distance – CI

  The distance from the mid point of the curve to P.I. It is also called the apex distance.

  10) Length of curve – l

  It is the total length of curve from P.C. to P.T.

$$Sin\frac{D}{2} = \frac{10}{R}$$

$$\therefore R = \frac{10}{Sin\frac{D}{2}}$$

When D is small, $sin\frac{D}{2}$ may taken equal to $\frac{D}{2}$

$$\therefore Sin\frac{D}{2} = \frac{D}{2}$$

$$\therefore R = \frac{10}{\frac{D}{2} X \frac{\pi}{180}}$$

$$\therefore R = \frac{1145.92}{D}$$

Relation between Radius and degree of curve.

(b) By Arc Definition :

The angle subtended at the centre of curve by an arc of 20 mt. length is called degree of curve.

$$\frac{2\pi R}{360} = \frac{20}{D}$$

$$\therefore R = \frac{20 \times 360}{2\pi D}$$

$$R = \frac{1146}{D}$$

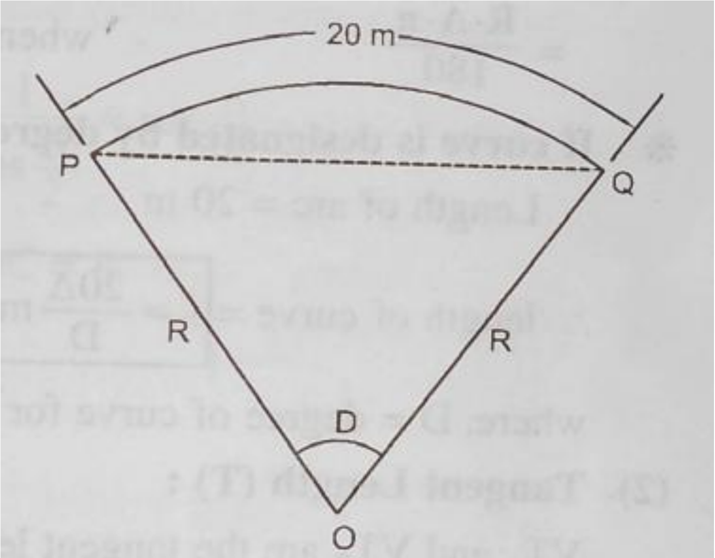
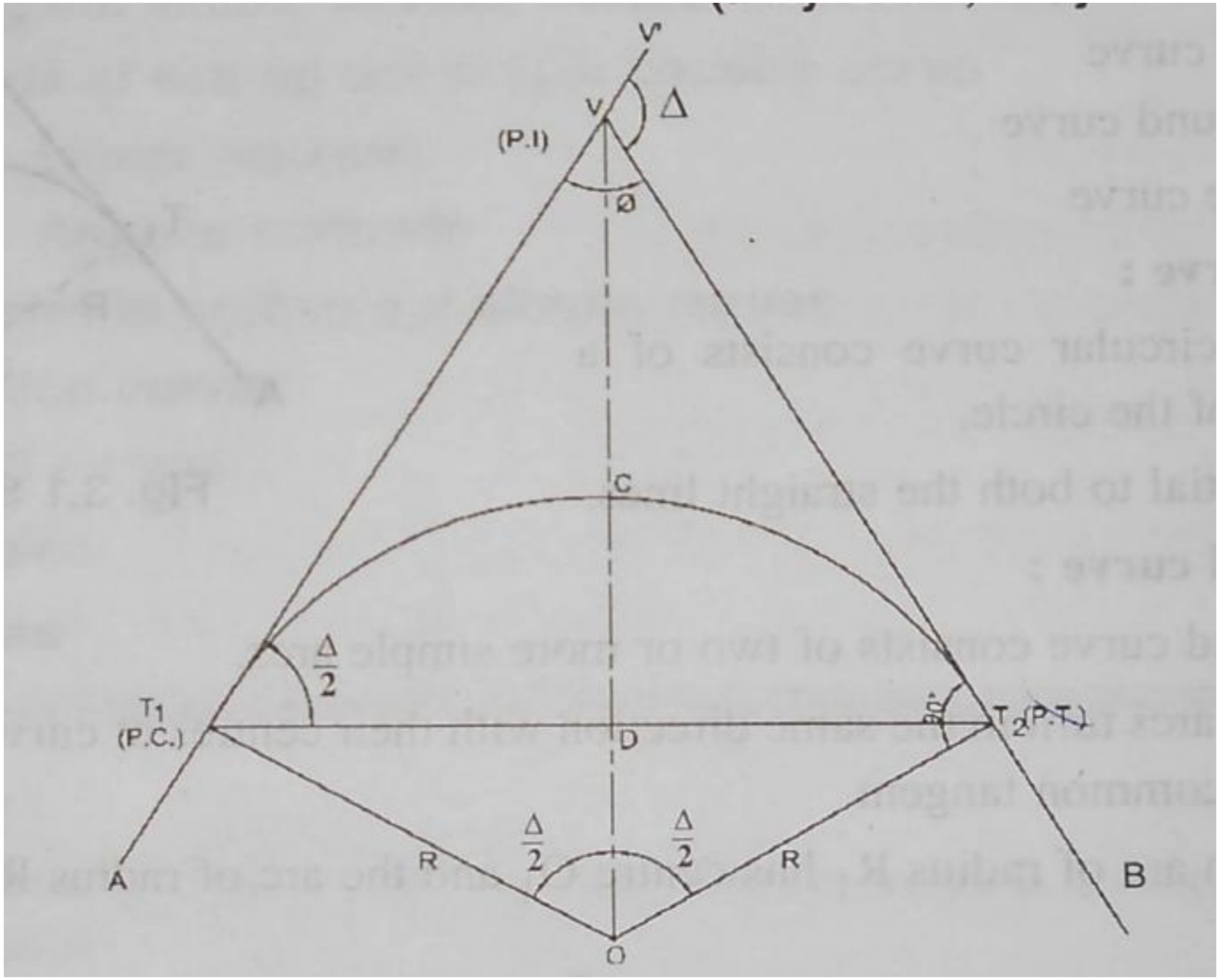


Fig. 3.6

Elements of Simple circular curve



Elements of Simple circular curve

- T_1 = P.C.= Point of tangency=Point of curve.
- T_2 = P.T.= Second point of tangency.
- V or I = P.I. = Point of intersection.
- Δ = Deflection angle.
- Ø = Intersection angle.
- R = Radius of curve.

- A circular curve has a radius of 150 mt and 60^{o} deflection angle. What is its degree(i) By arc definition and 9ii) by chord definition.
- Solution:

(i) By arc definition Assuming chord length 30mt

Setting out of single Circular curve

First step- Locate tangent point

- - By tape measurements.

  -Intersection of both tangents point V- Point of intersection.

  - Set theodolite at V and measure angle Ø

  - $\because \text{Deflection angle} = 180 -$ Ø (Measure by theodolite)

  - Calculate tangent length $\therefore T = R \tan \frac{\Delta}{2}$

  - Fix point $T_1 T_2$

Setting out of single Circular curve

- Chainage of tangents:
- - Point A is the starting point of chain line
- Chainage of point V, B, D are measured from point A.
- - Chainage of T_1 = Chainage of V- T (Tangent length)
- T_2 =Chainage of T_1 + Length of curve (l)

$$l = \frac{R \Delta \pi}{180}$$

Setting out of single Circular curve

- Normal chord and Sub chord:
- -For alignment pegs are driven.
- The distance between two pegs is normally 20m
- Peg station are called main stations.
- The chord joining the tangents point T_1 and the first main peg station is called First sub chord.
- All the chord joining adjacent peg stations are called full chord or normal chord.
- The length of normal chord is 20 mt.
- The point joining last main peg station and tangent T_2 is called last sub chord.

Methods of Setting out of single Circular curve

- Two Methods
- 1) Linear Methods
- 2) Angular Methods.

- 1) Linear Methods
- - (i) By offsets or ordinate from the long chord.
- (ii) By successive bisection of arcs or chords.
- (iii) By offsets from the tangents.
- (iv) By offsets from the chord produced.

(i) By offsets or ordinate from the long chord.

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

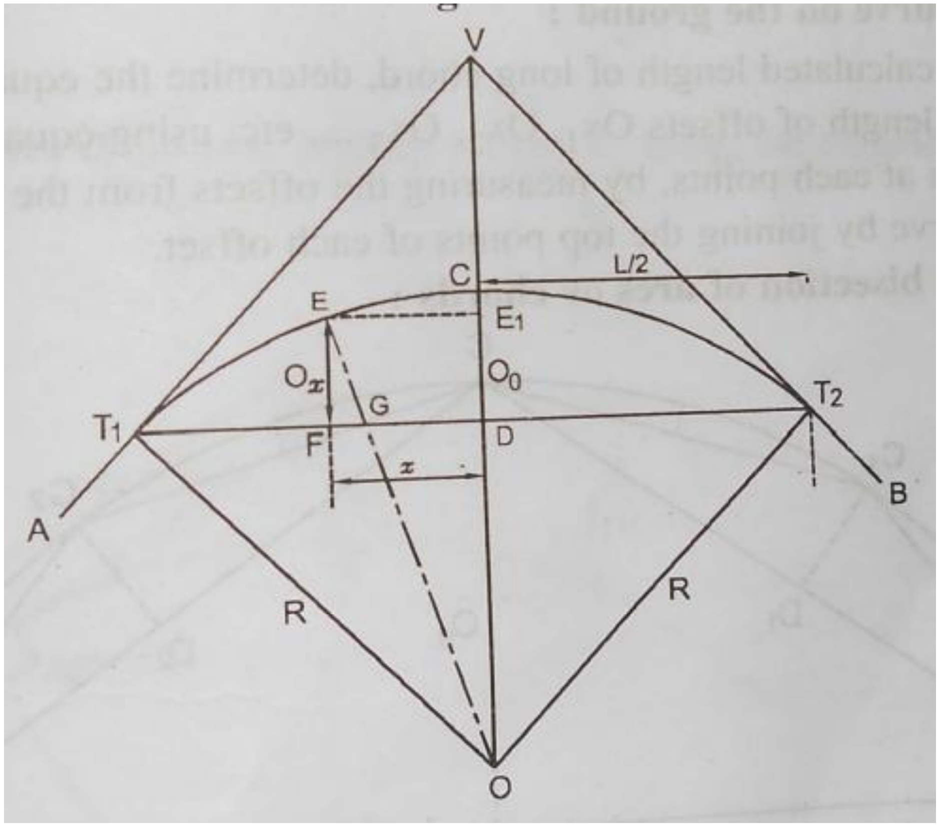
R = Radius of curve

O0 = Mid ordinate

Ox = Ordinate at distance x

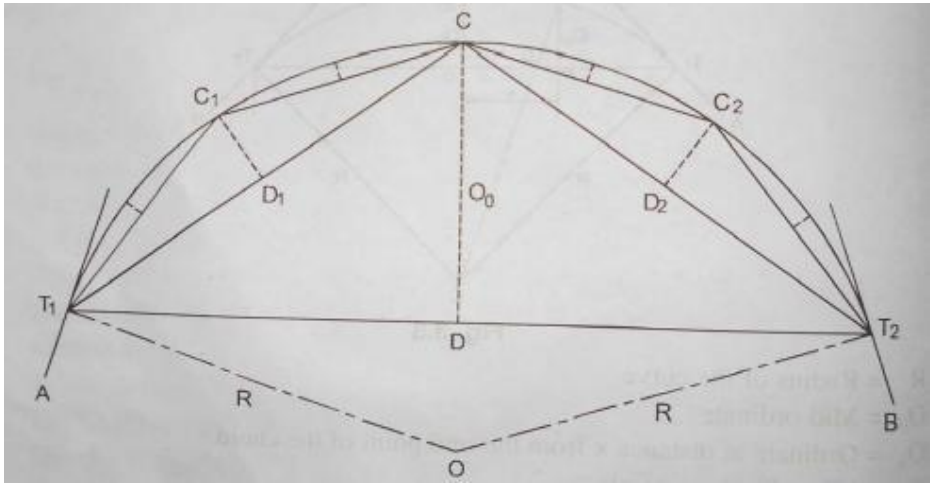
T1, T2 = tangents point

L = Length of long chord.



(ii) By successive bisection of arcs or chords.

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$



- T1-T2= L
- T1-C = L
- T2-C = L
- C-C1, C-C2=L
- C1-T1, C2-T2=L

By offsets from the tangents

Radial offset

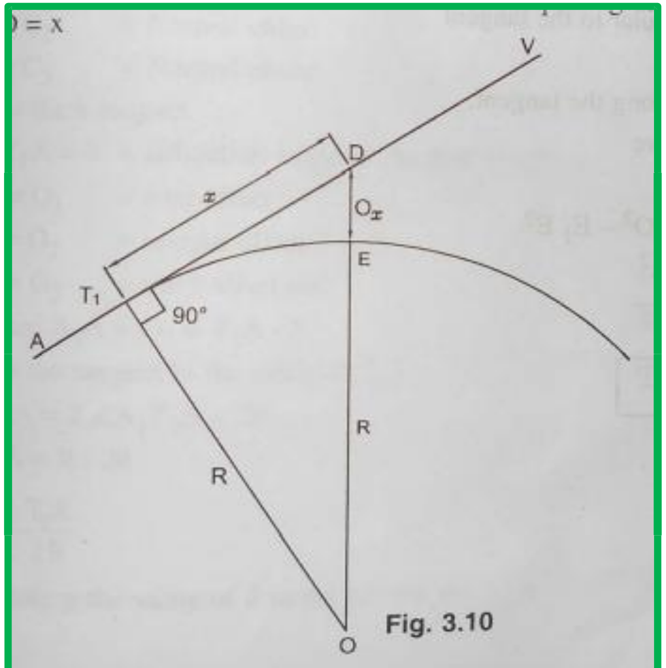
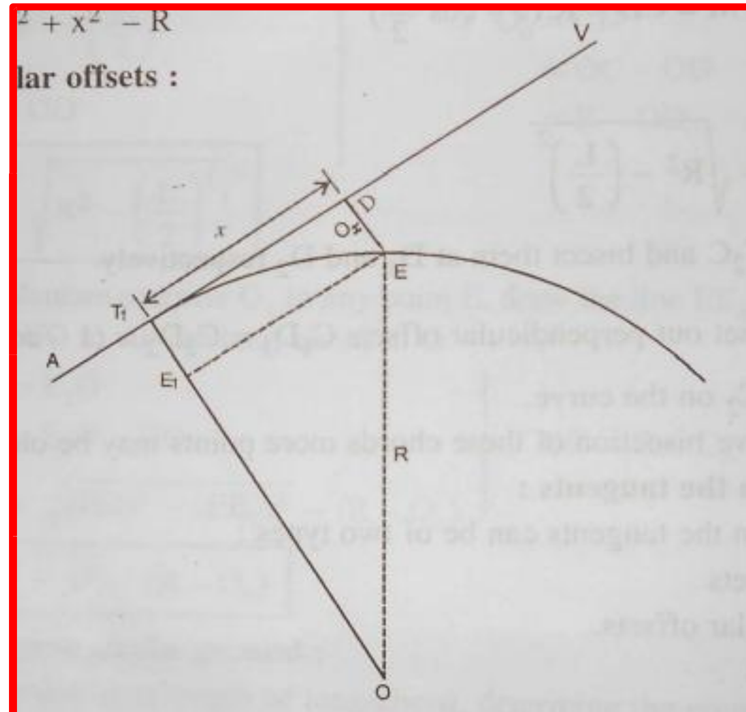


Fig. 3.10

$$O_x = \sqrt{R^2 + x^2} - R$$

Perpendicular offset



$$O_x = R - \sqrt{R^2 - x^2}$$

Angular Method

- Used when length of curve is large
- More accurate than the linear methods.
- Theodolite is used

- **The angular methods are:**

1) Rankine method of tangential angles.
   OR
   One theodolite method
2) Two theodolite method.

Obstacles in setting out simple curves

- Case –I -When P.I. is inaccessible
- Case –II -When P.C. is inaccessible
- Case –III -When P.T. is inaccessible
- Case –IV - When both P.C. and P.T. is inaccessible.
- Case –V - When obstacles to chaining.

TRANSITION CURVE

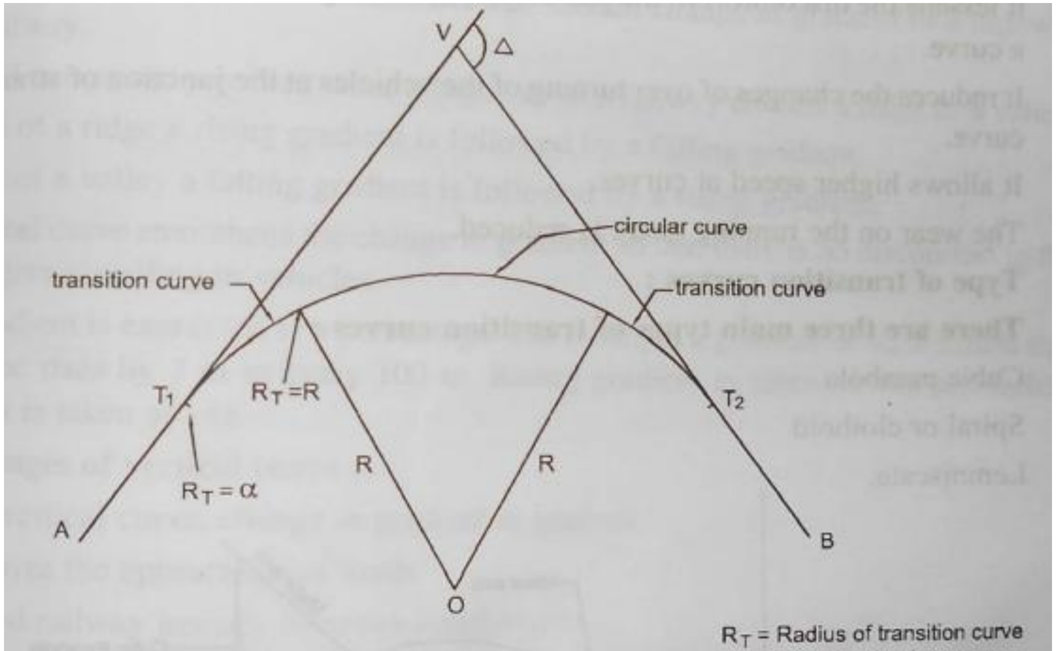


Fig. 3.20

Requirement of transition curve

- Tangential to straight
- Meet circular curve tangentially
- At origin curvature should zero.
- Curvature should same at junction of circular curve.
- Rate of increase of curvature = rate increase of super elevation.
- Length of transition curve = full super elevation attained.

Purpose of transition curve

- Curvature is increase gradually.
- Medium for gradual introduction of superelevation
- Provide Extra widening gradually
- **Advantages**
- Increase comfort to passenger on curve
- Reduce overturning
- Allow higher speed
- Less wear on gear, tyre

Types of transition curve

- **Cubic parabola**
- - For railway
- **Spiral or Clothoid**

 - Ideal transition

 - Radius α   Distance

- **Lemniscates**

 - Used for road

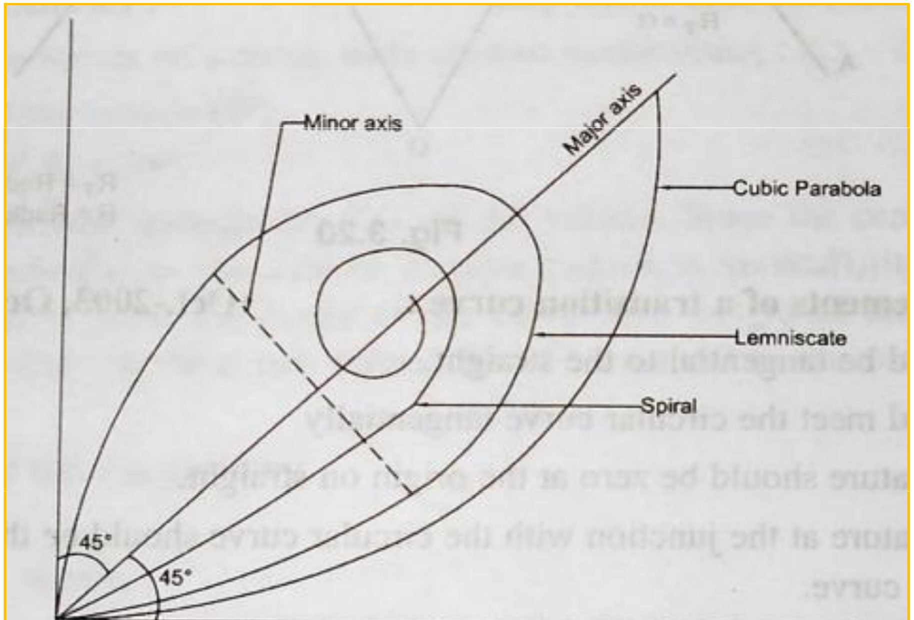


Fig. 3.21

Vertical curve

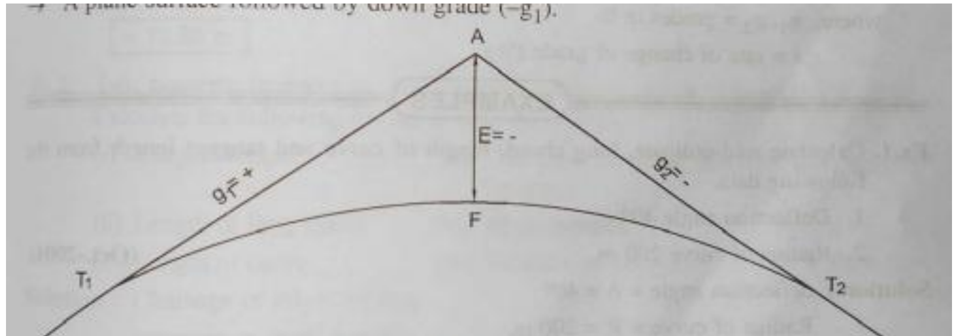


Fig. 3.22 Summit Curve

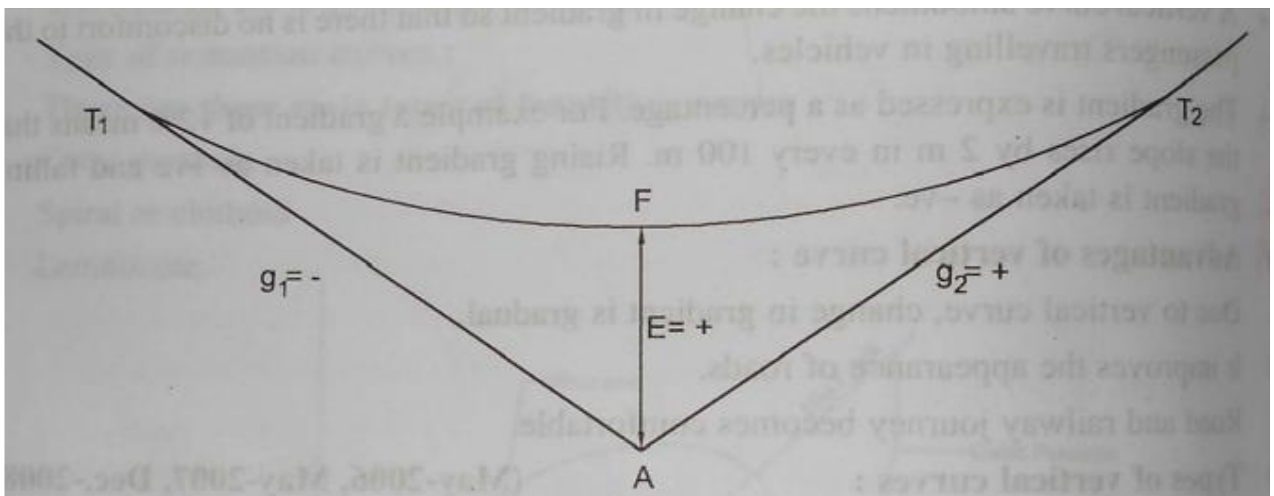


Fig. 3.23 Valley Curve

MODULE 3
MODERN FIELD SURVEY SYSTEMS

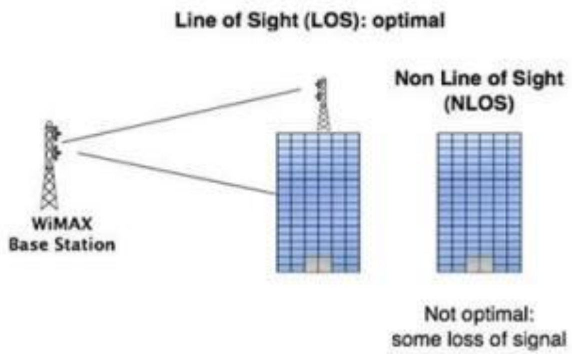
Total station is a surveying equipment combination of Electromagnetic Distance Measuring Instrument and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping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

- Total Station Setup and Operation

ADVANTAGES OF TOTAL STATION SURVEYING

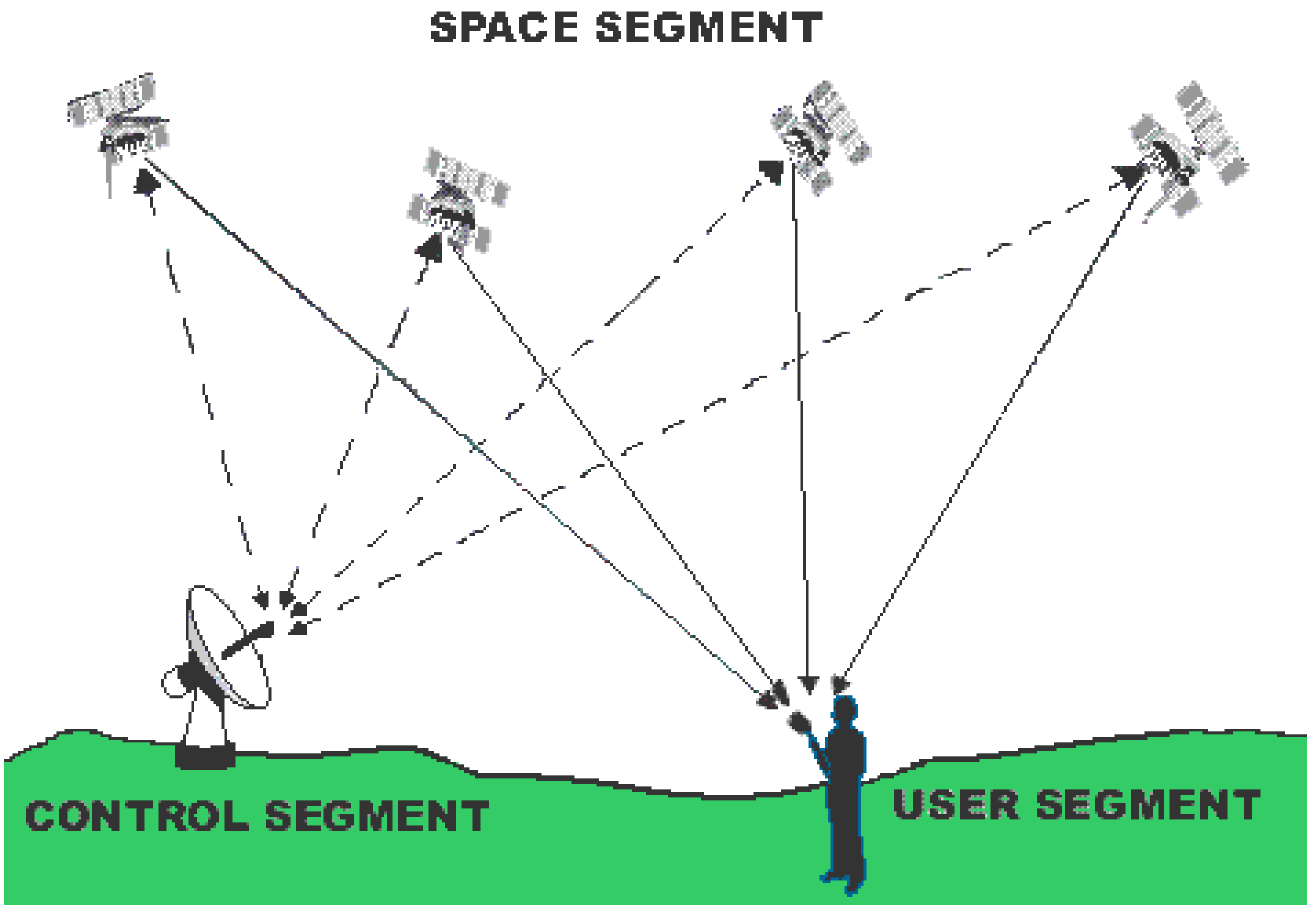
- Accurately gathers enormous amount of survey measurements quickly
- Receiving and transmitting measured or layout data increases processing efficiency
- Read and write errors are eliminated
- Data is saved and managed on a PC
- Designs can be implemented from planning stage
- Overall reduction in man hours spend on the job

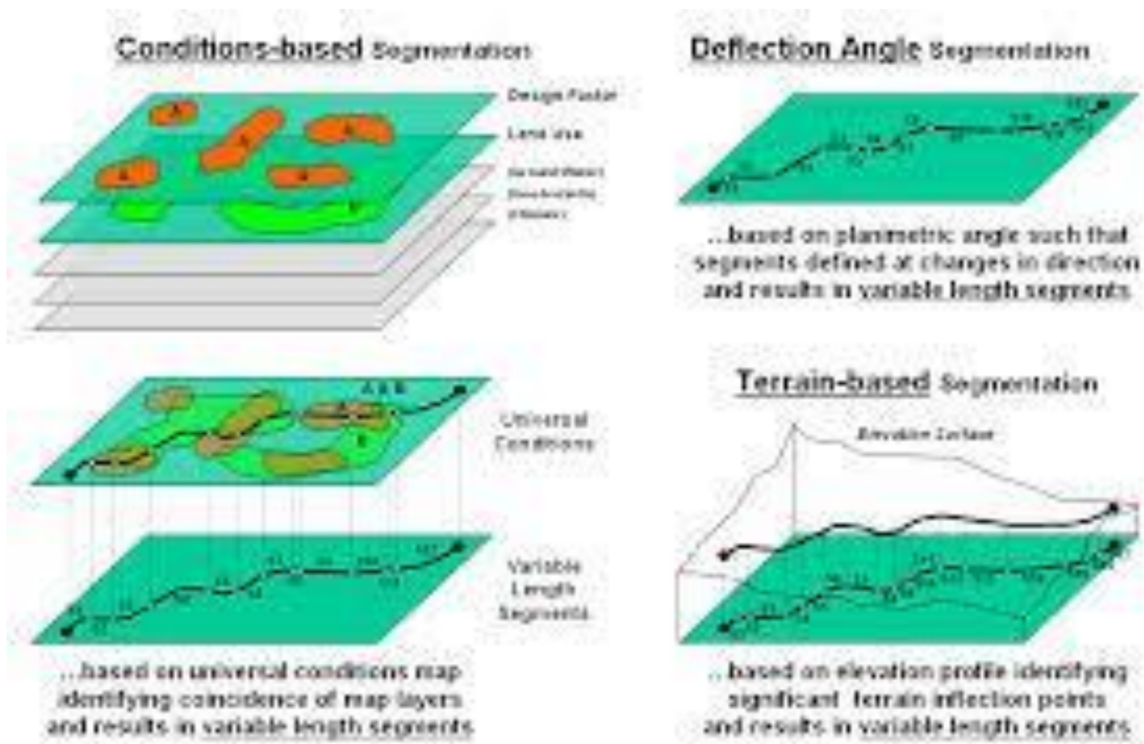
Disadvantages



- Line-of-sight (*LOS*) is required for long distance (5-30 mile) connections.
- Heavy rains can disrupt the service.
- Other wireless electronics in the vicinity can interfere with the WiMAX connection and cause a reduction in data throughput or even a total disconnect.

SURVEYING




Conditions-based Segmentation
Design Factor
Land Use
Universal Conditions
Variable Length Segments
...based on universal conditions map identifying coincidence of map layers and results in variable length segments
Deflection Angle Segmentation
...based on planimetric angle such that segments defined at changes in direction and results in variable length segments
Terrain-based Segmentation
Elevation Surface
..based on elevation profile identifying significant terrain inflection points and results in variable length segments

Capability of a Total Station

- Microprocessor unit in total station processes the data collected to compute:
- Average of multiple angles measured.
- Average of multiple distance measured.
- Horizontal distance.
- Distance between any two points.
- Elevation of objects and
- All the three coordinates of the observed points

Surveying

- Important Operations of Total Station
- Distance Measurement
- Angle Measurements
- Data Processing
- Display
- Electronic Book

Uses of Total Station

- When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen.
- This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers

WHAT IS GPS?

GPS means

- A space-based satellite navigation system

  provides location and time information in all weather.

- Maintained by the United States government and is freely accessible by anyone with a GPS receiver.

OVERVEIW

- Official name : “Navigational Satellite Timing And Ranging Global Positioning System” (NAVSTAR GPS)

- Consists of **30+ GPS satellites** in medium Earth orbit (2000km - 35,000 km).

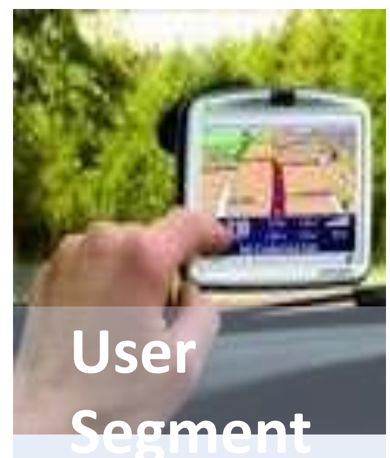
- Made up of two dozen satellites working in harmony are known as a satellite
constellation

- Mainly used for navigation, map-making and surveying.

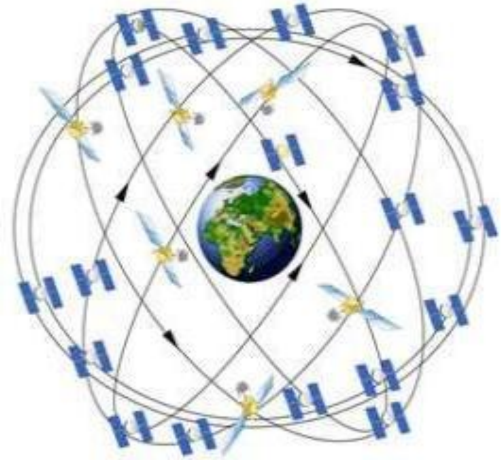
GPS ELEMENTS.

Three segments

1. Space segment.
2. Control segment.
3. User segment.



SPACE SEGMENT



•GPS satellites fly in circular orbits at an altitude of 20,200 km and with a period of 12 hours.

- Powered by solar cells.
- The satellites continuously orient themselves to point their solar panels toward the sun and their antenna toward the earth.
- Orbital planes are centered on the Earth.
- Orbits are designed so that, at least, six satellites are always within line of sight from any location on the planet.

CONTROL SEGMENT

- The CS consists of 3 entities:
    - Master Control System
    - Monitor Stations
    - Ground Antennas

MASTER CONTROL STATION

- ✓ The master control station, located at Falcon Air Force Base in Colorado Springs,
- ✓ Responsible for overall management of the remote monitoring and transmission sites.
- ✓ Check-up is performed twice a day, by each of 6 stations, as the satellites complete their journeys around the earth.
- ✓ Can reposition satellites to maintain an optimal GPS constellation.

GROUND ANTENNAS

- Ground antennas monitor and track the satellites from horizon to horizon.
- They also transmit correction information to individual satellites.
- Communicate with the GPS satellites for command and control purposes.

USER SEGMENT.

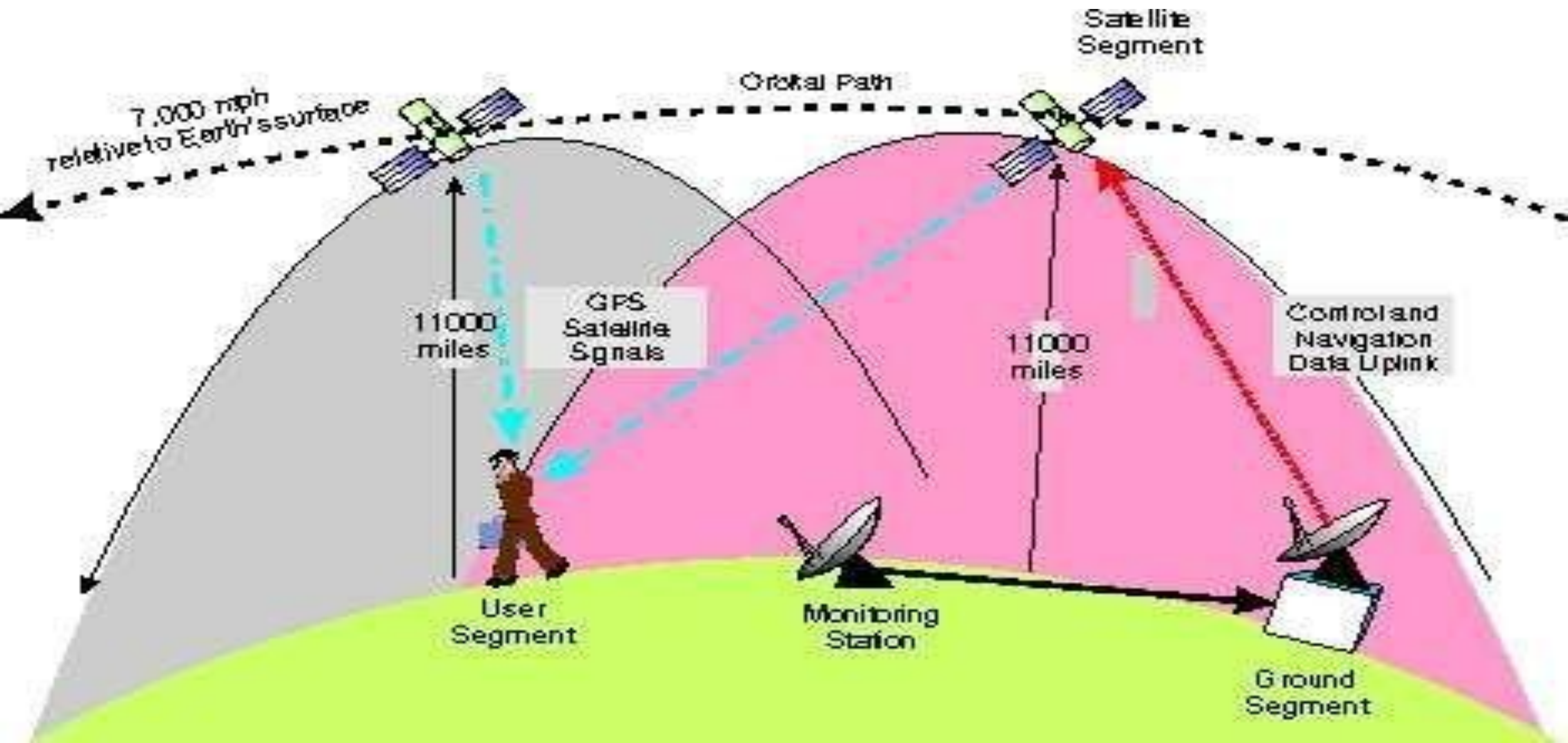
- GPS receivers are generally composed of

1. an antenna(tuned to the frequencies transmitted by the satellites),
2. receiver-processors, and
3. highly-stable clock(commonly a crystal oscillator).

- They can also include a display for showing location and speed information to the user.

- A receiver is often described by its number of channels (this signifies how many satellites it can monitor simultaneously).

- As of recent, receivers usually have between twelve and twenty channels.



Satellite Segment
Orbital Path
7,000 mph relative to Earth's surface
11000 miles
GPS Satellite Signals
11000 miles
Control and Navigation Data Uplink
User Segment
Monitoring Station
Ground Segment

WORKING PRINCIPLE

Geometric Principle:

You can find one's location if you know its distance from other, already-known locations.

- Things which need to be determined:
  - Current Locations of GPS Satellites.
  - The Distance Between Receiver's Position and the GPS Satellites.

CURRENT LOCATIONS OF GPS SATELLITES

- GPS satellites are orbiting the earth at an altitude of 11,000 miles.
- The orbits, and the locations of the satellites, are known in advance.
- GPS receivers store this orbit information for all of the GPS satellites in an ALMANAC*.

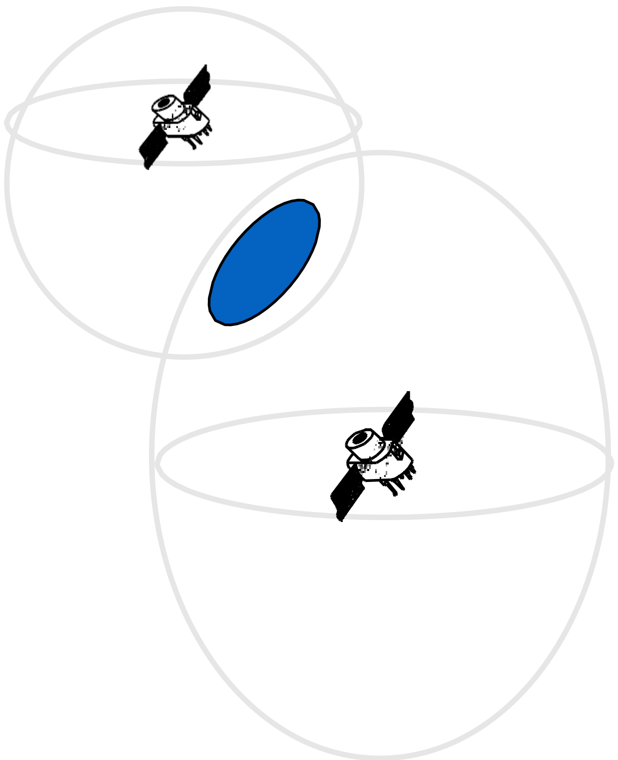
* The Almanac is a file which contains positional information for all of the GPS satellites

DISTANCE B/W RECEIVER'S POSITION AND GPS SATELLITES.

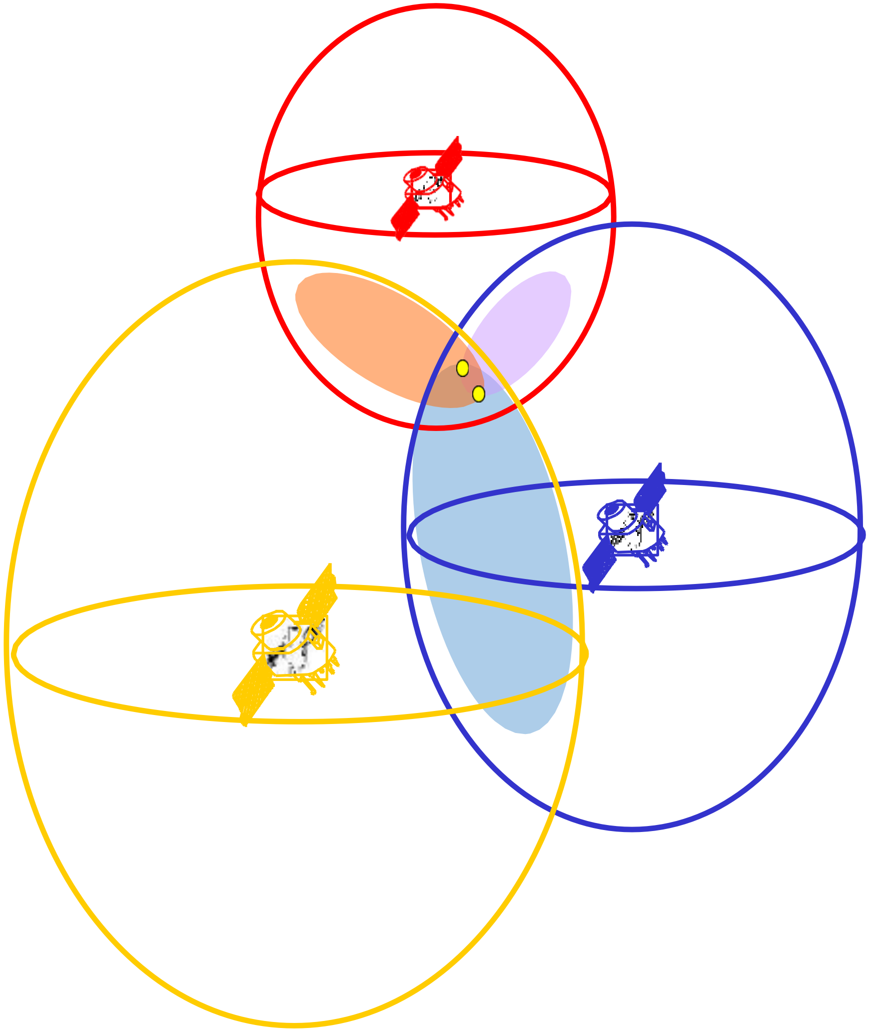
A GPS receiver can tell its own position by using the position data of itself, and compares that data with 3 or more GPS satellites.

To get the distance to each satellite,

- By measuring the amount of time taken by radio signal (the GPS signal) to travel from the satellite to the receiver.
- Radio waves travel at the speed of light, i.e. about 186,000 miles per second.
- The distance from the satellite to the receiver can be determined by the formula "distance = speed x time".
- Hence receiver's position find out using trilateration.

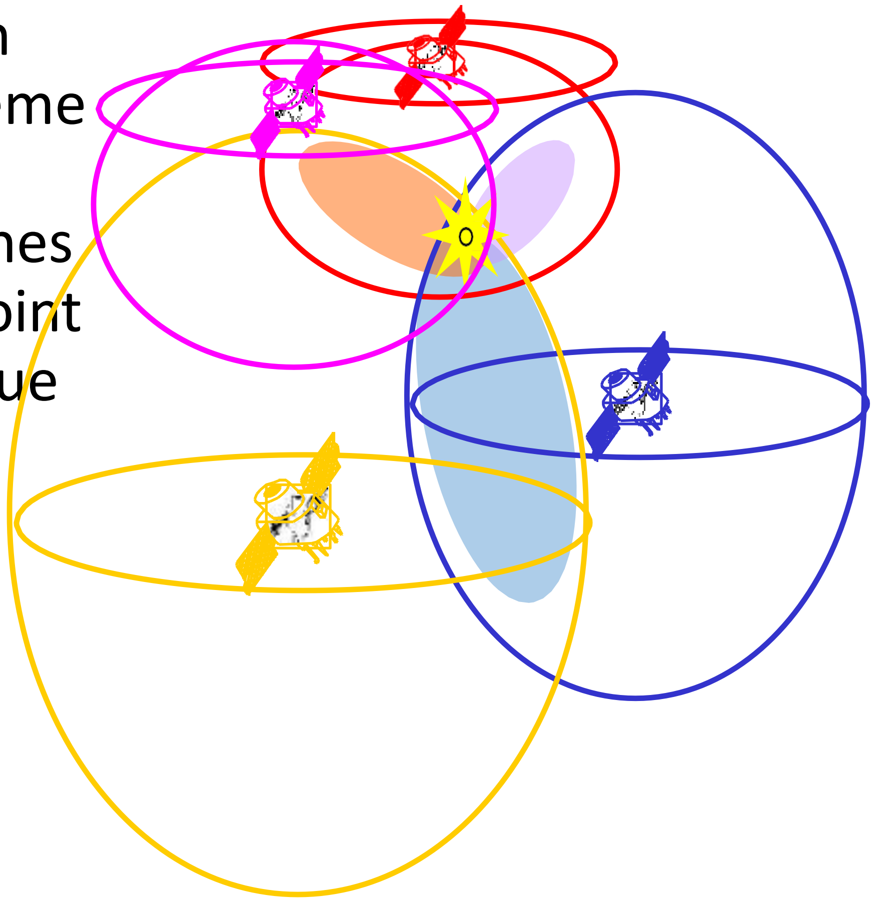


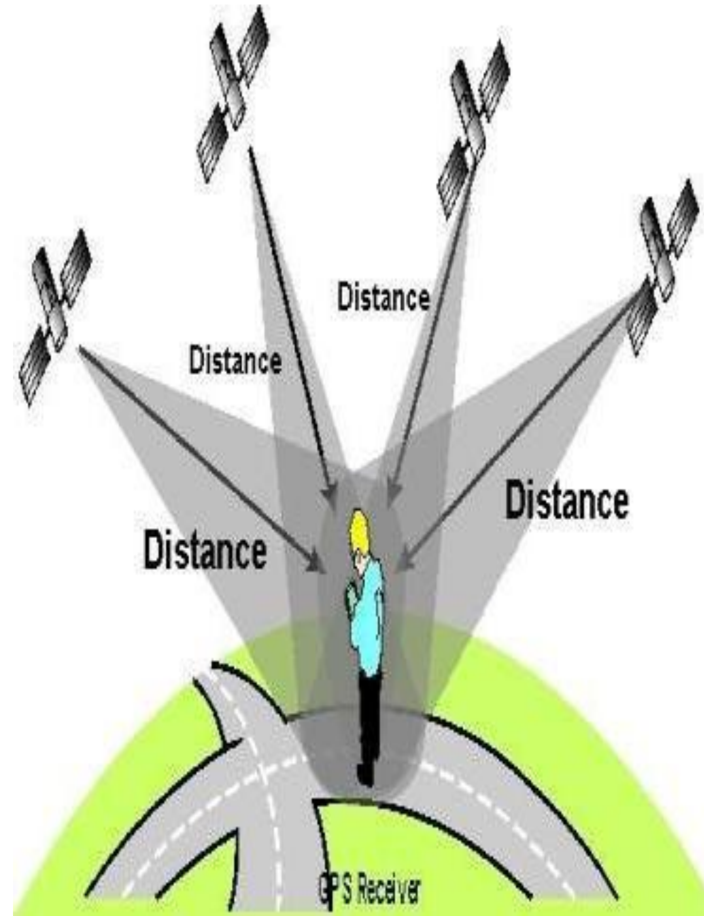
Distance measurements from two satellites limits our location to the intersection of two spheres, which is a circle.



- A third measurement narrows our location to just two points.

•A fourth measurement determines which point is our true location





ACCURACY

- The position calculated by a GPS receiver relies on three accurate measurements:
  - Current time
  - Position of the satellite
  - Time delay for the signal
- The GPS signal in space will provide a "worst case" accuracy of
  7.8 meters at a 95% confidence level.
- GPS time is accurate to about 14 nanoseconds.
- Higher accuracy is available today by using GPS in combination with augmentation systems. These enable real-time positioning to within a few centimeters.

GPS SIGNALS

- Coarse/Acquisition code.
- Precision code.
- Navigation message.
- Almanac.
- Data updates.

GPS FREQUENCIES.

- L1 (1575.42 MHz)
- L2 (1227.60 MHz)
- L3 (1381.05 MHz)
- L4 (1379.913 MHz)
- L5 (1176.45 MHz)

FREQUENCY INFORMATION

- The C/A code is transmitted on the L1 frequency.
- The Precision-code is transmitted on both the L1 and L2 frequencies.
- L3 is used by the Defense Support Program to signal detection of missile launches, nuclear detonations, and other applications.
- L4 is used for additional correction to the part of the atmosphere that is ionized by solar radiation.
- L5 is used as a civilian safety-of-life signal.

FREQUENCY L2C

- Launched in 2005, L2C is civilian GPS signal, designed specifically to meet commercial needs.
- L2C enables ionospheric correction, a technique that boosts accuracy.
- Delivers faster signal acquisition, enhanced reliability, and greater operating range.
- L2C broadcasts at a higher effective power making it easier to receive under trees and even indoors.

METHODS OF IMPROVING ACCURACY.

- Precision monitoring
  - Dual Frequency Monitoring
  - Carrier-Phase Enhancement (CPGPS)
  - Relative Kinematic Positioning (RKP)

- Augmentation

AUGMENTATION SYSTEM.

Nationwide Differential GPS System (NDGPS)

- Ground-based augmentation system that provides increased accuracy and integrity of GPS information to users on U.S. land and waterways.
- The system consists of the Maritime Differential GPS System operated by the U.S. Coast Guard and an inland component funded by the Department of Transportation.

Wide Area Augmentation System (WAAS)

- Satellite-based augmentation system operated by the Federal Aviation Administration (FAA), supports aircraft navigation across North America.

- **Global Differential GPS (GDGPS)**
  - High accuracy GPS augmentation system, developed by the NASA Jet Propulsion Laboratory (JPL) to support the real-time positioning, timing, and determination requirements of NASA science missions.
  - Future NASA plans include using the Tracking and Data Relay Satellite System (TDRSS) to transmit via satellite a real-time differential correction message.

LIMITATIONS

- GPS can provide worldwide, three-dimensional positions, 24 hours a day, in any type of weather.
- But, There must be a relatively clear "line of sight" between the GPS antenna and four or more satellites.
- Hence it becomes too difficult to ensure reliable positioning. These difficulties are particularly prevalent in urban areas.
- The GPS signal may bounce off nearby objects causing another problem called multi path interference.

APPLICATIONS

Surveying: Surveyors use absolute locations to make maps and determine property boundaries.

Telematics: GPS technology integrated with computers and mobile communications technology in automotive navigation systems.

MODULE 4
PHOTOGRAMMETRIC SURVEYING

WHAT IS PHOTOGRAMMETRY?

Photos – light

Gramma – to draw

Metron – to measure

“Photogrammetry is the technique of measuring objects from photographs”

“The art, science and technology of obtaining reliable spatial information about physical objects and the environment through the processes of recording, measuring and interpreting image data”

Types of Photogrammetry

Close-range Photogrammetry the camera is close to the subject and is typically hand held or on a tripod

PROCESS FLOW

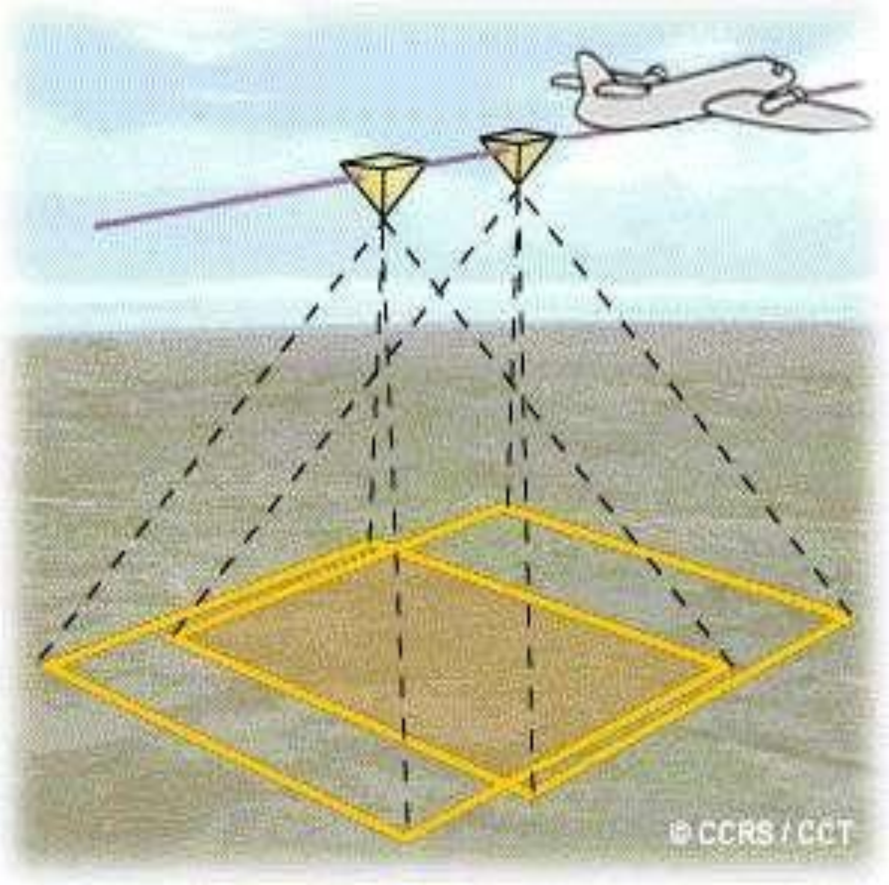
- RAW DATA FORM CLIENT (SCANS)
- AERIAL TRIANGULATION
- DATA CAPTURING
- DEM GENARATION
- CONTOUR GENARATION
- ORTHOPHOTO GENARATION

AERIALTRIANGULATION

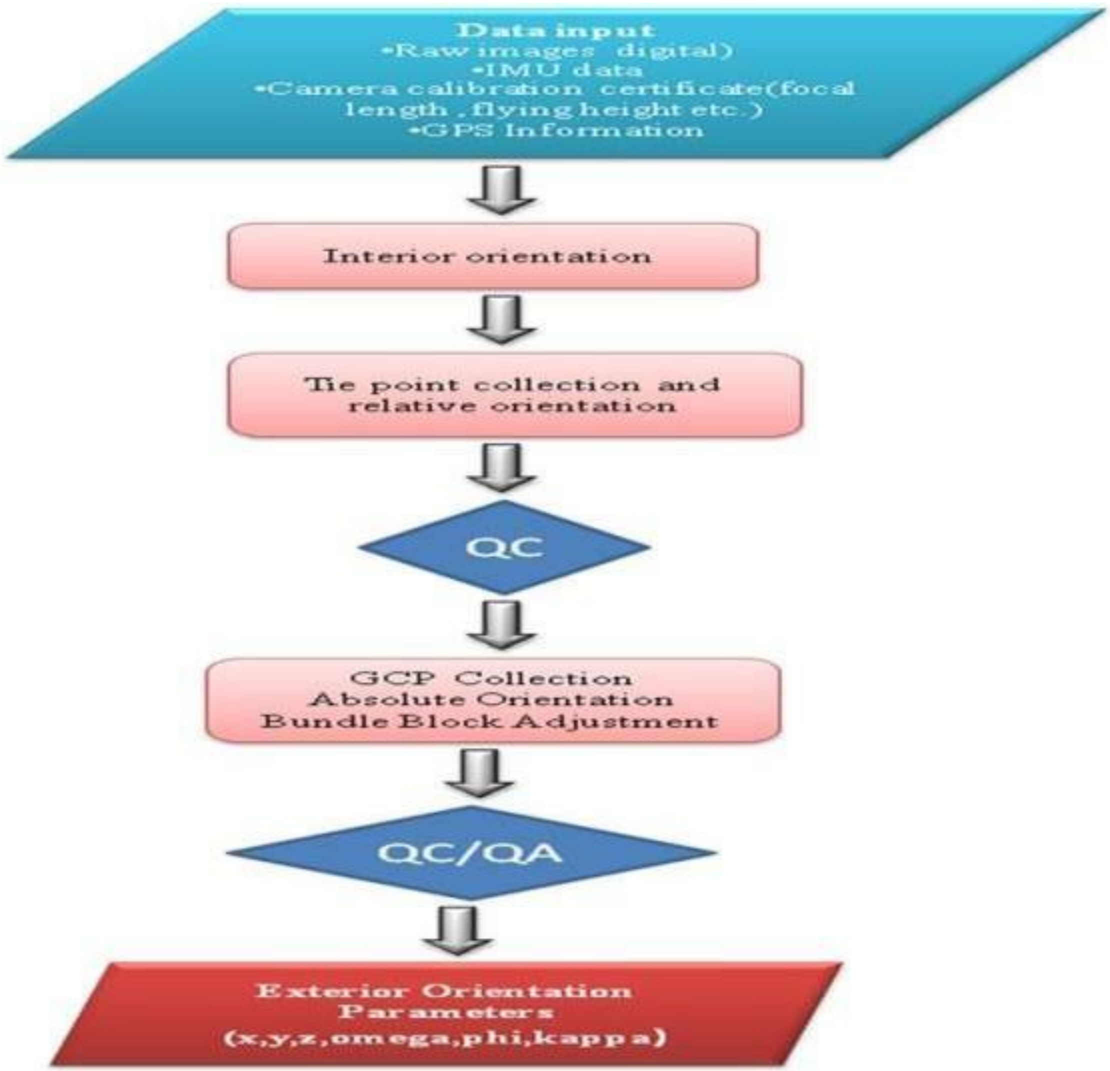
- In **Aerial Photogrammetry** the camera is mounted in an aircraft and is usually pointed vertically towards the ground
- Multiple overlapping photos of the ground are taken as the aircraft flies along a flight path
- These photos are processed in a stereo-plotter

STEREO PHOTOGRAPHY

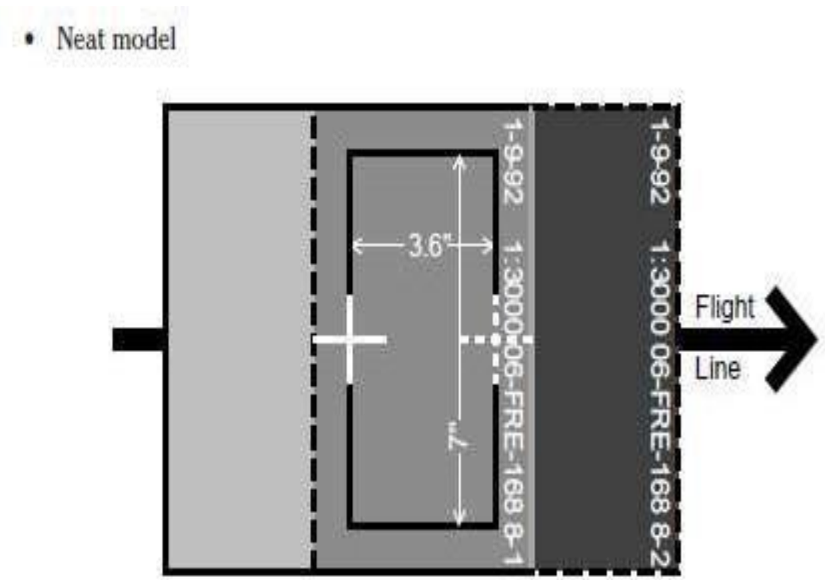
- Adjacent but overlapping aerial photos are called stereo-pairs and are needed to determine parallax and stereo/3D viewing



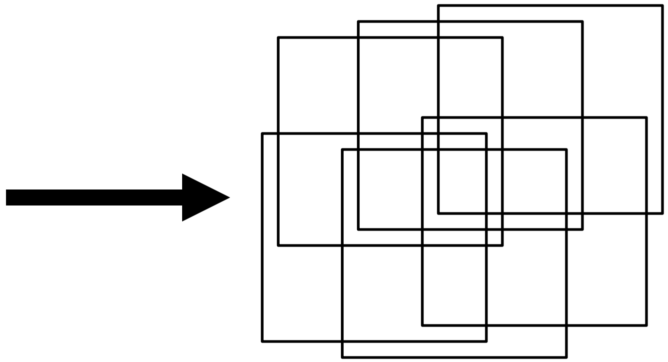
AERIAL TRIANGULATION



OVERLAPPING STEREO PHOTOGRAPHY



- Endlap - ~60%
- Sidelap - ~20-30%

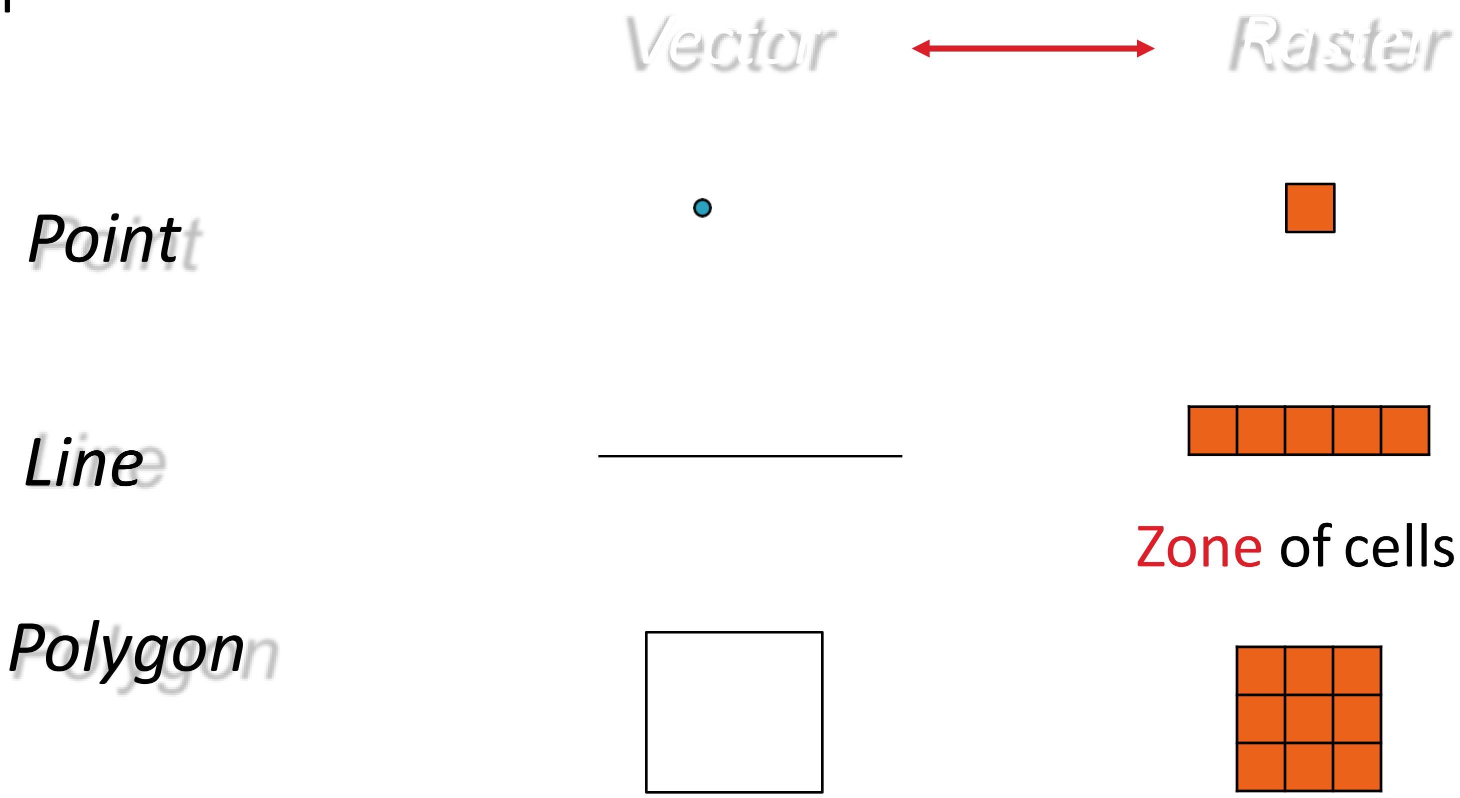


PLANEMETEIC FEATURE EXTRACTION

- RASTER AND VECTOR DATA
- THE DATA PREPARATION
- PLANMETRIC FEATURES
- DATA OUTPUT

RASTER AND VECTOR DATA

Raster data are described by a cell grid, one value per cell

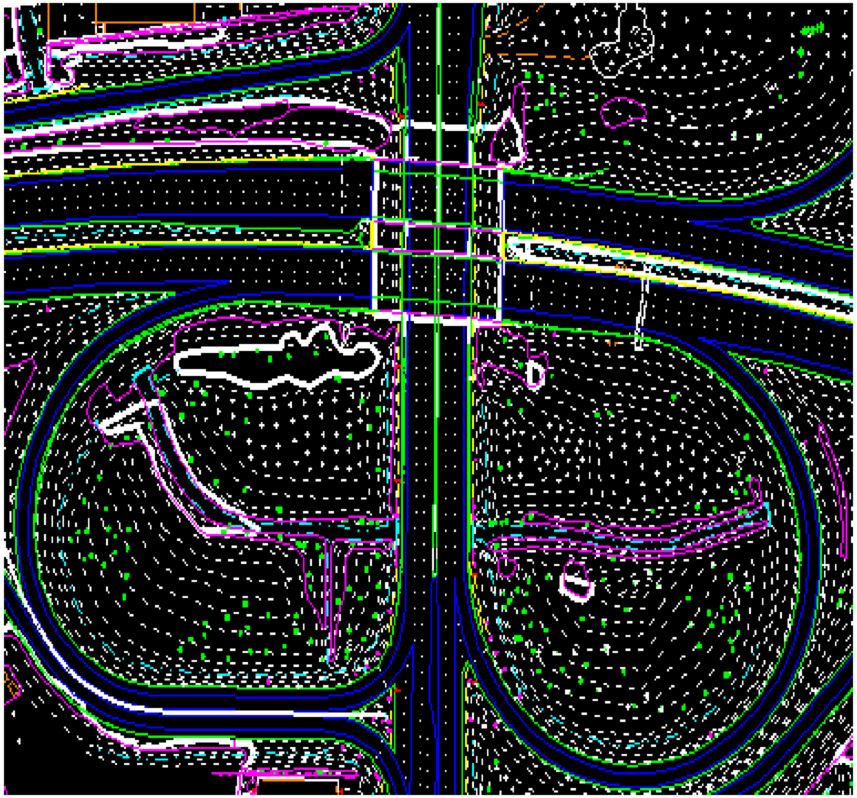


THE DATA PREPARATION

- Buildings
- Transportation Features
- Hydro Features
- Utilities
- Vegetation
- Breaklines
- DTM points
- Bridges

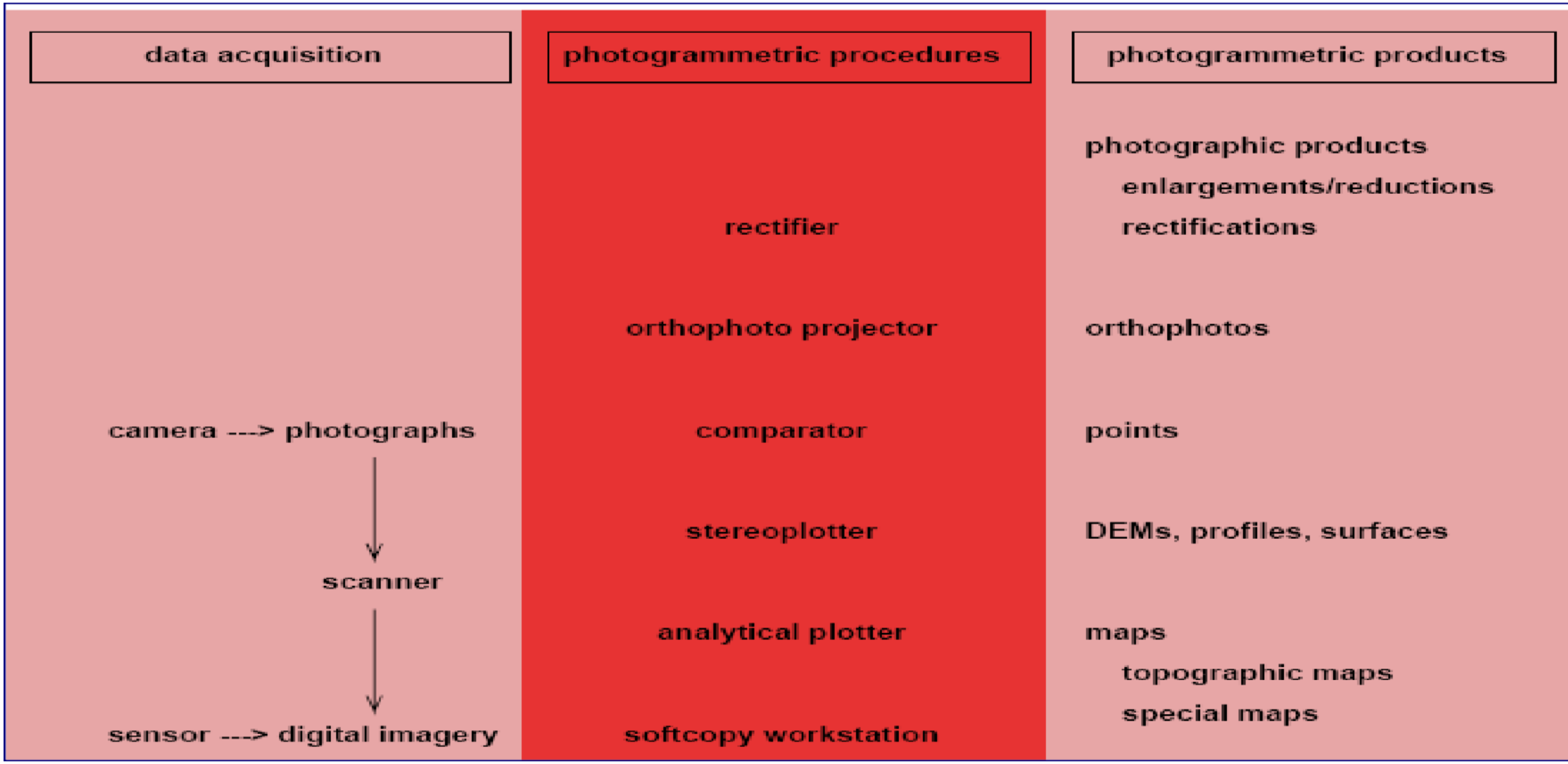
PLANEMETEIC FEATURES

Stereo Image



Vector Data

DATA OUTPUT



Photogrammetry portrayed as systems approach. The input is usually referred to as data acquisition, the “black box" involves photogrammetric procedures and instruments; the output comprises photogrammetric products.

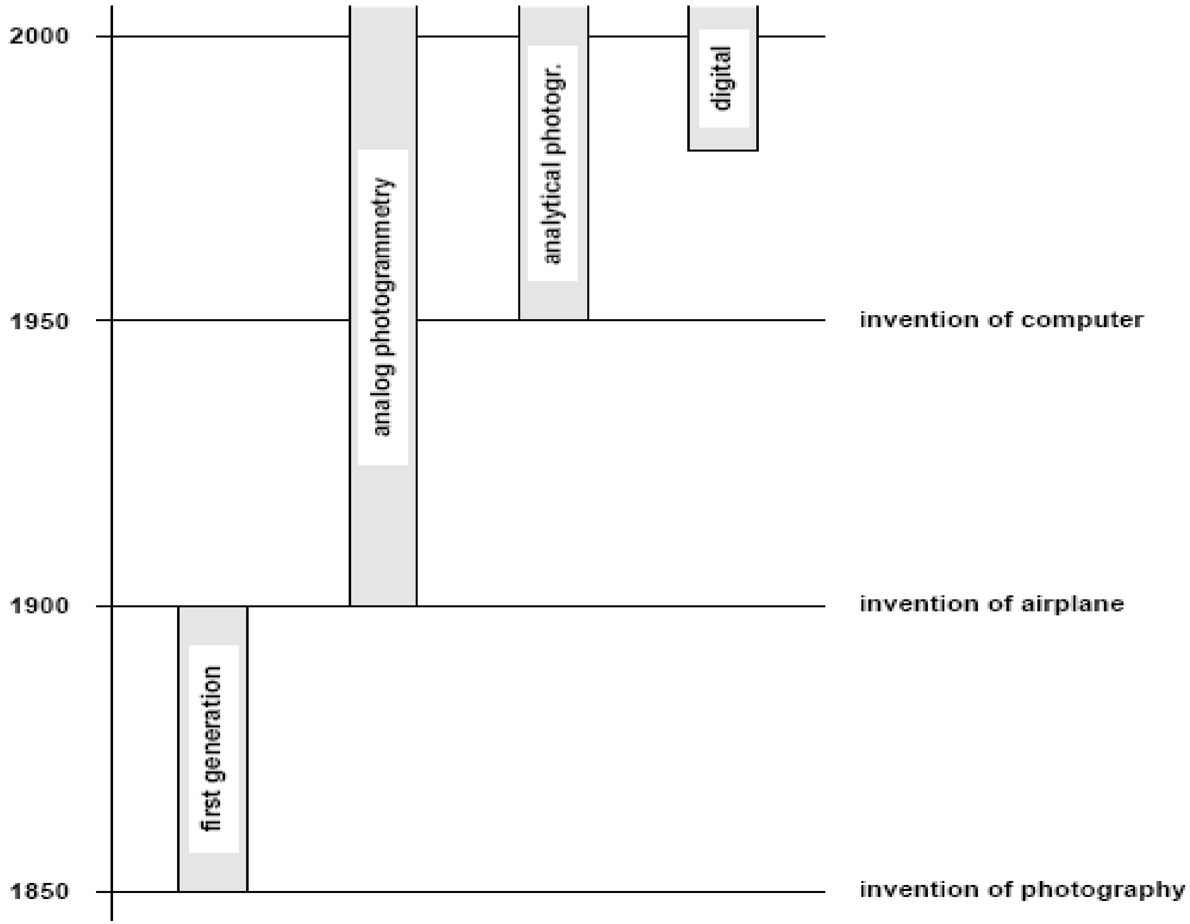


Figure 1.5: Major photogrammetric phases as a result of technological innovations.

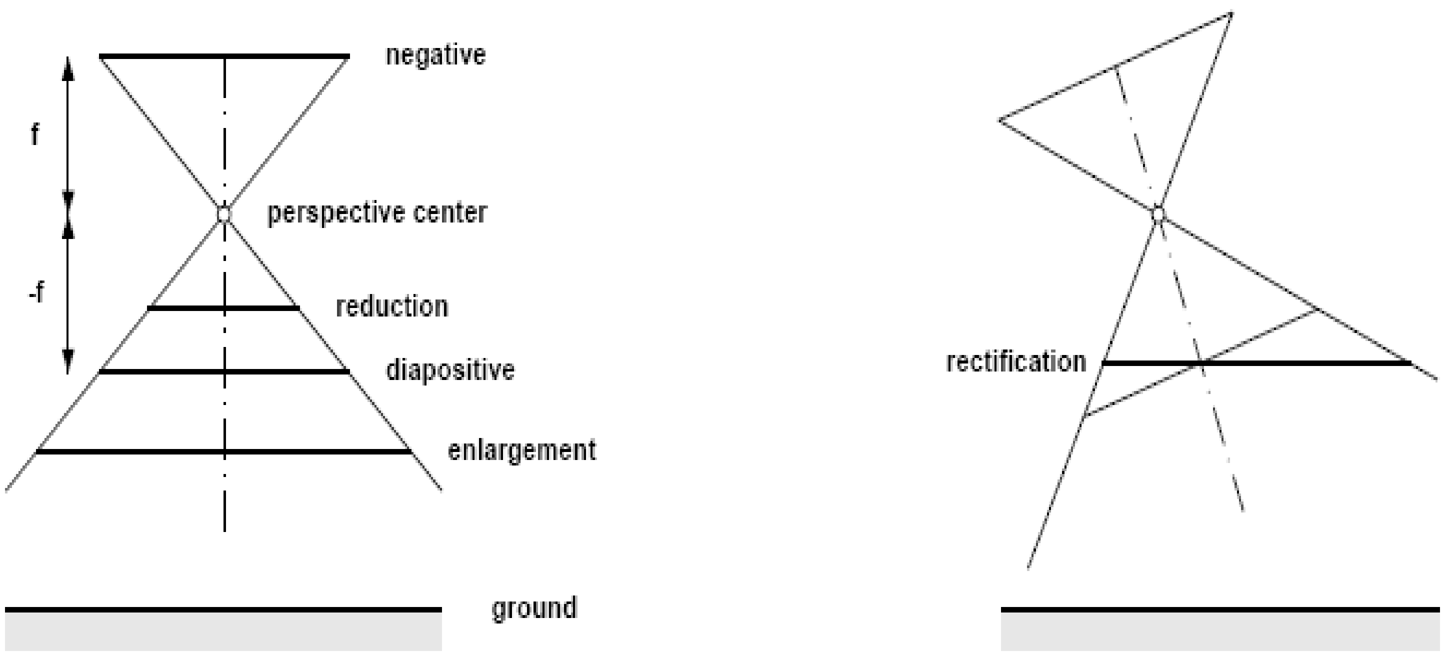
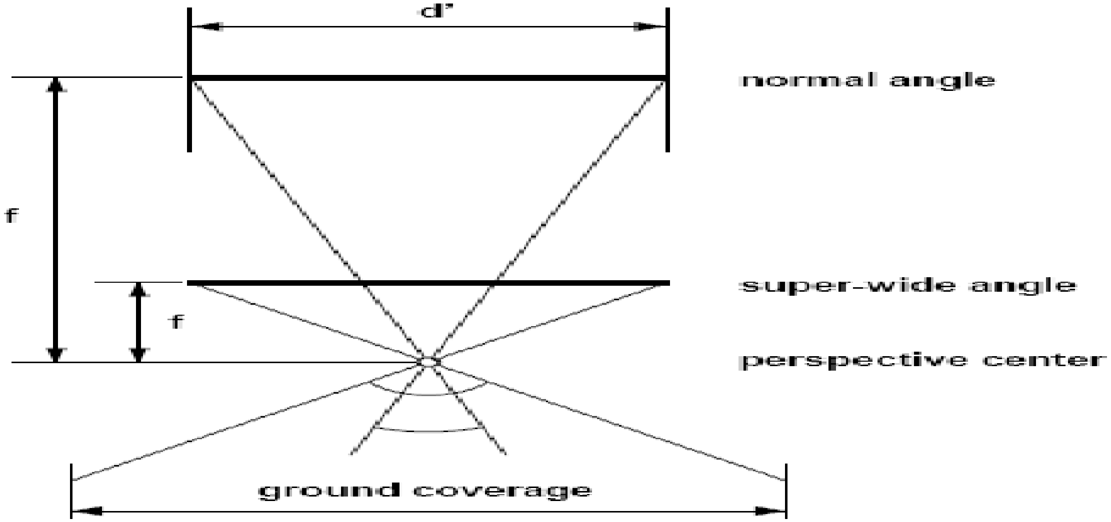


Figure 1.4: Negative, diapositive, enlargement reduction and plane rectification.

An airplane flying with velocity v advances by a distance $D = v\,t$ during the exposure time t. Since the object on the ground is stationary, its image moves by a



distance $d = D/m$ where m is the photo scale. We have

$$d = \frac{v\,t}{m} = \frac{v\,t\,f}{H}$$

with f the focal length and H the flying height.
Example:

exposure time t	1/300 sec
velocity v	300 km/h
focal length f	150 mm
flying height H	1500 m
image motion d	28 μm

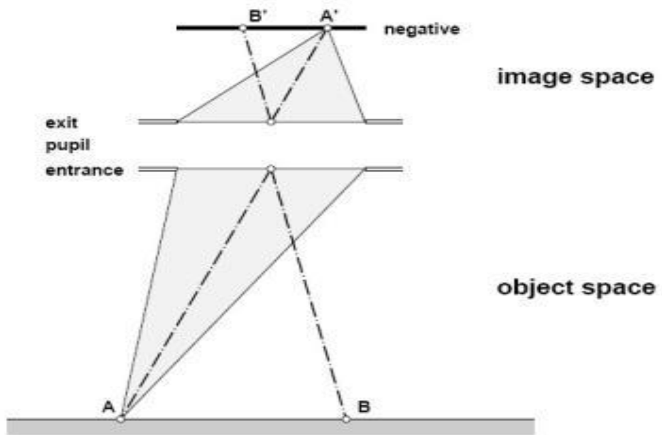


Figure 4.3: The concept of image and object space.

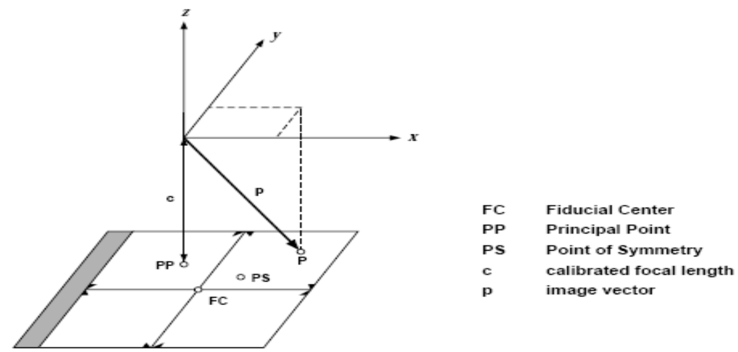


Figure 5.2: Definition of the photo-coordinate system.

Photo scale

$$m_b = \frac{c}{H}$$

$$m_P = \frac{CP'}{CP}$$

$$CP' = \sqrt{x_P^2 + y_P^2 + c^2}$$

$$CP = \sqrt{(X_P - X_C)^2 + (Y_P - Y_C)^2 + (Z_P - Z_C)^2}$$

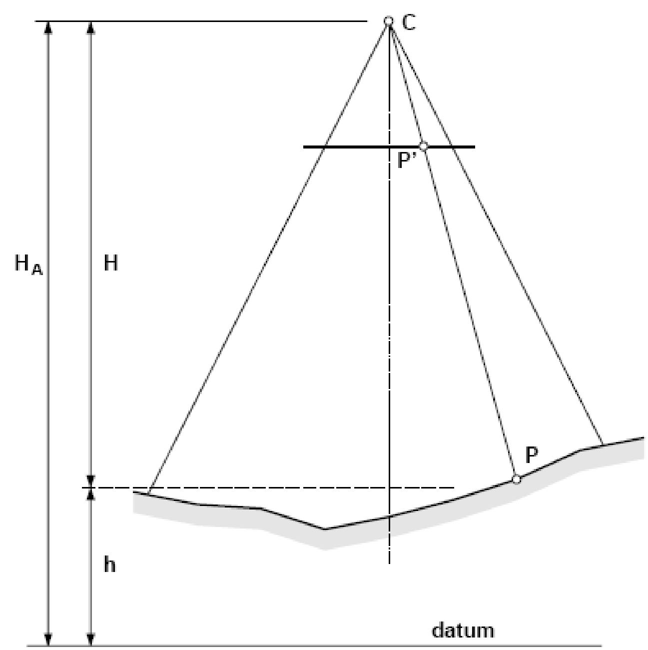


Figure 4.4: Flight height, flight altitude and scale of aerial photograph.

4.3.3 Photo scale

We use the representative fraction for scale expressions, in form of a ratio, e.g. 1 : 5,000. As illustrated in Fig. 4.4 the scale of a near vertical photograph can be approximated by

$$m_b = \frac{c}{H} \tag{4.1}$$

where m_b is the *photograph scale number*, c the calibrated focal length, and H the *flight height* above mean ground elevation. Note that the flight height H refers to the average ground elevation. If it is with respect to the datum, then it is called *flight altitude* H_A, with $H_A = H + h$.

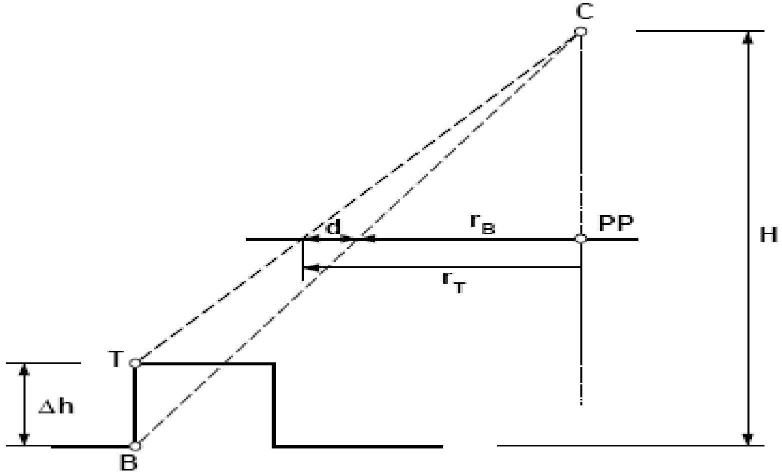
The photograph scale varies from point to point. For example, the scale for point P can easily be determined as the ratio of image distance CP' to object distance CP by

$$m_P = \frac{CP'}{CP} \tag{4.2}$$

$$CP\prime = \sqrt{x_P^2 + y_P^2 + c^2} \tag{4.3}$$

$$CP = \sqrt{(X_P - X_C)^2 + (Y_P - Y_C)^2 + (Z_P - Z_C)^2} \tag{4.4}$$

Relief displacement

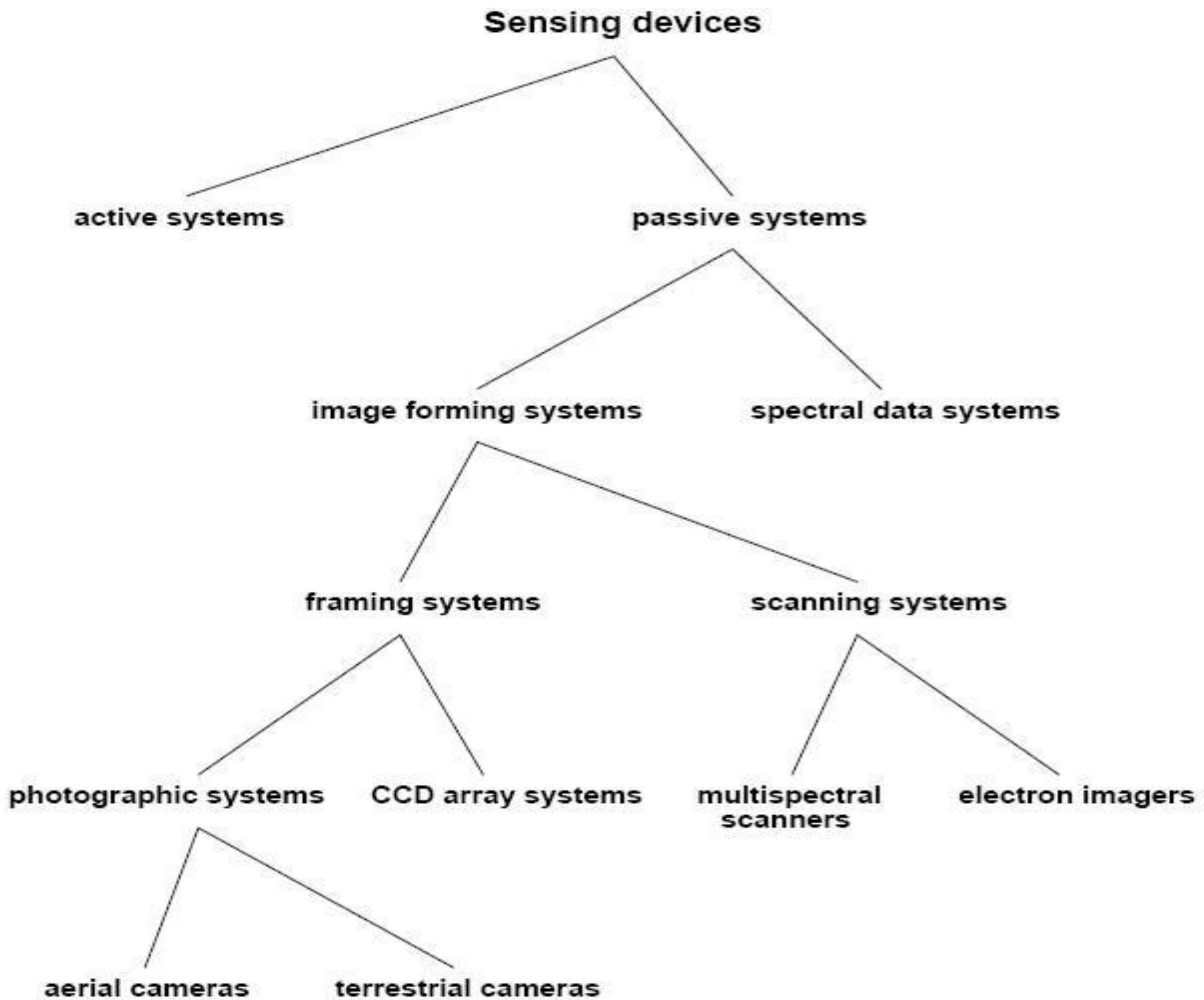


The magnitude of relief displacement for a true vertical photograph can be determined by the following equation

$$d = \frac{r\ \Delta h}{H} = \frac{r'\ \Delta h}{H - \Delta h} \tag{4.5}$$

where $r = \sqrt{x_T^2 + y_T^2}$, $r' = \sqrt{x_B^2 + y_B^2}$, and Δh the elevation difference of two points on a vertical. Eq. 4.5 can be used to determine the elevation Δh of a vertical object

$$h = \frac{d\ H}{r} \tag{4.6}$$


Sensing devices
active systems
passive systems
image forming systems
spectral data systems
framing systems
scanning systems
photographic systems
CCD array systems
multispectral scanners
electron imagers
aerial cameras
terrestrial cameras

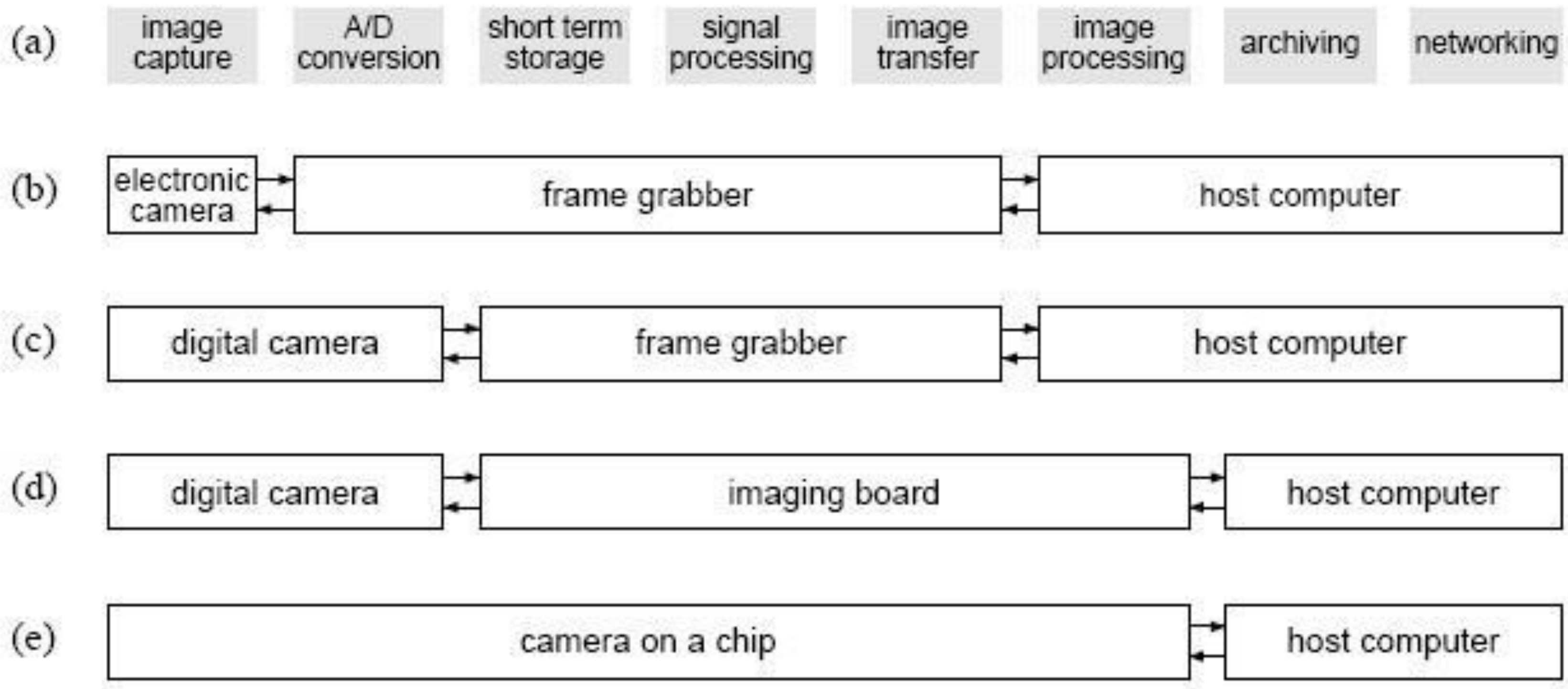
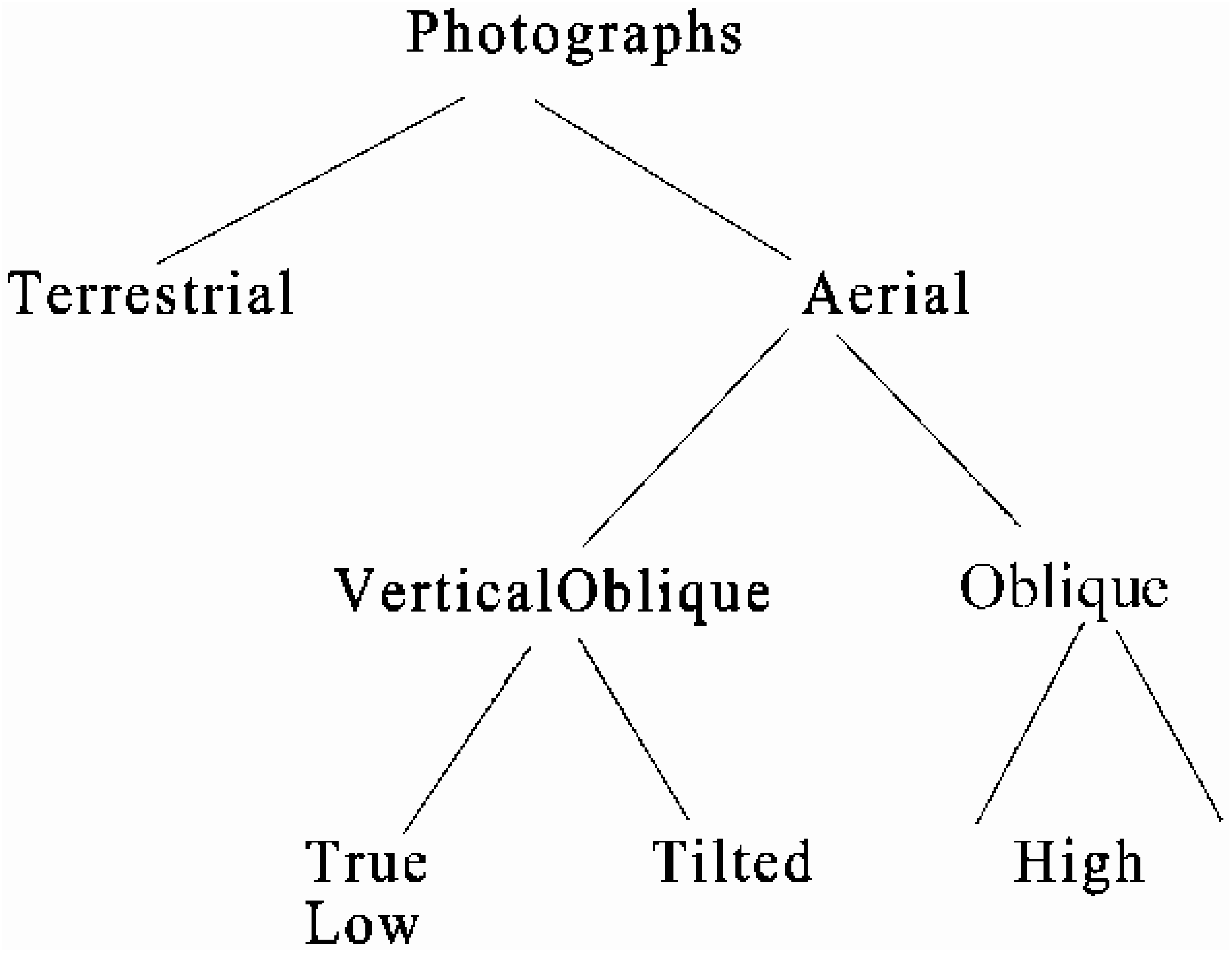
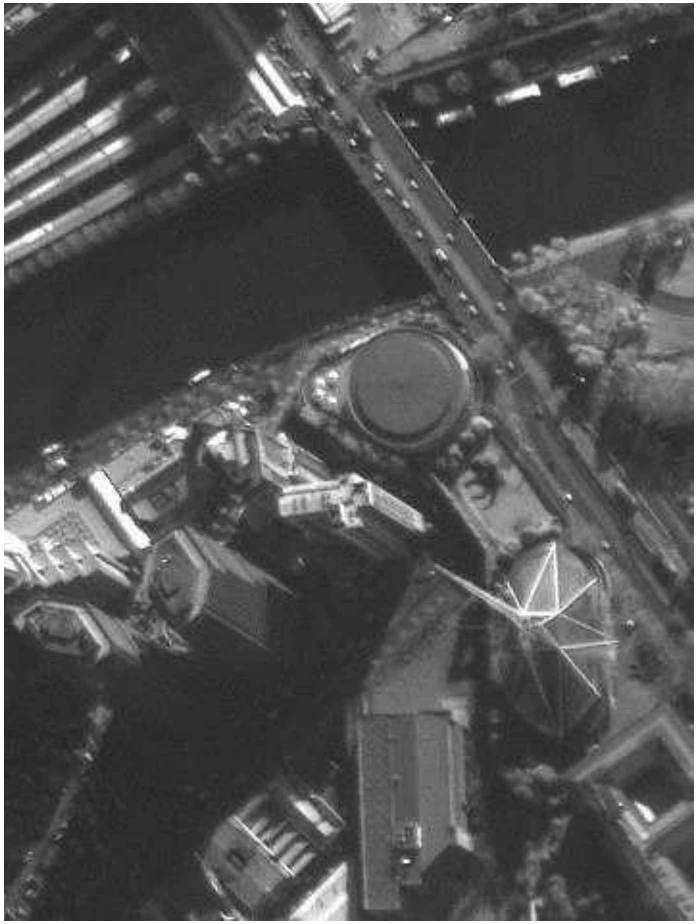


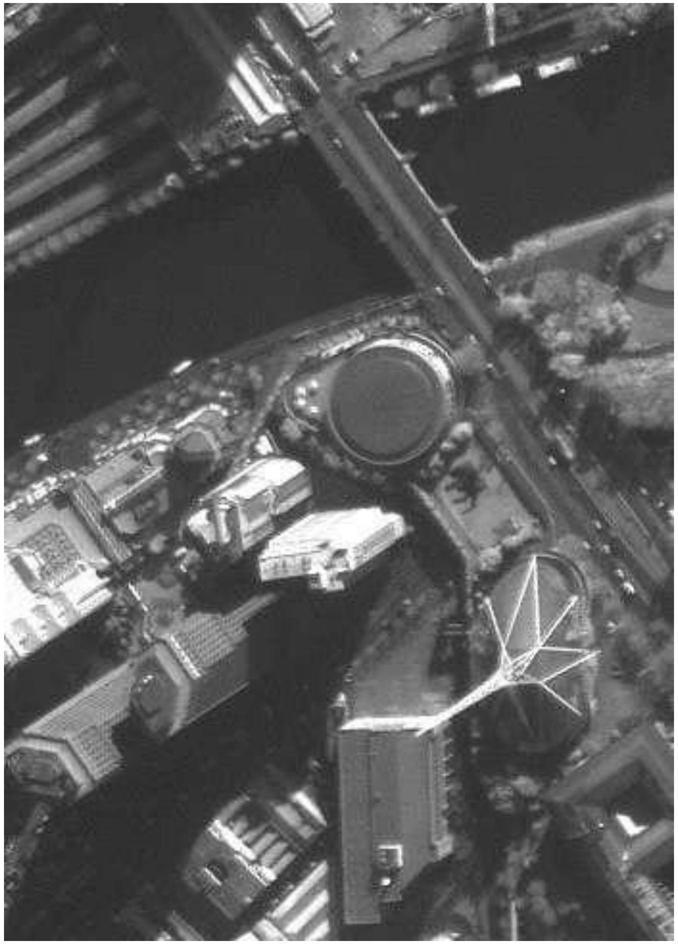
Figure 3.2: Functional block diagram of a solid-state camera. A real camera may not have all components. The diagram is simplified, e.g. external signals received by the camera are not shown.

Types of photographs

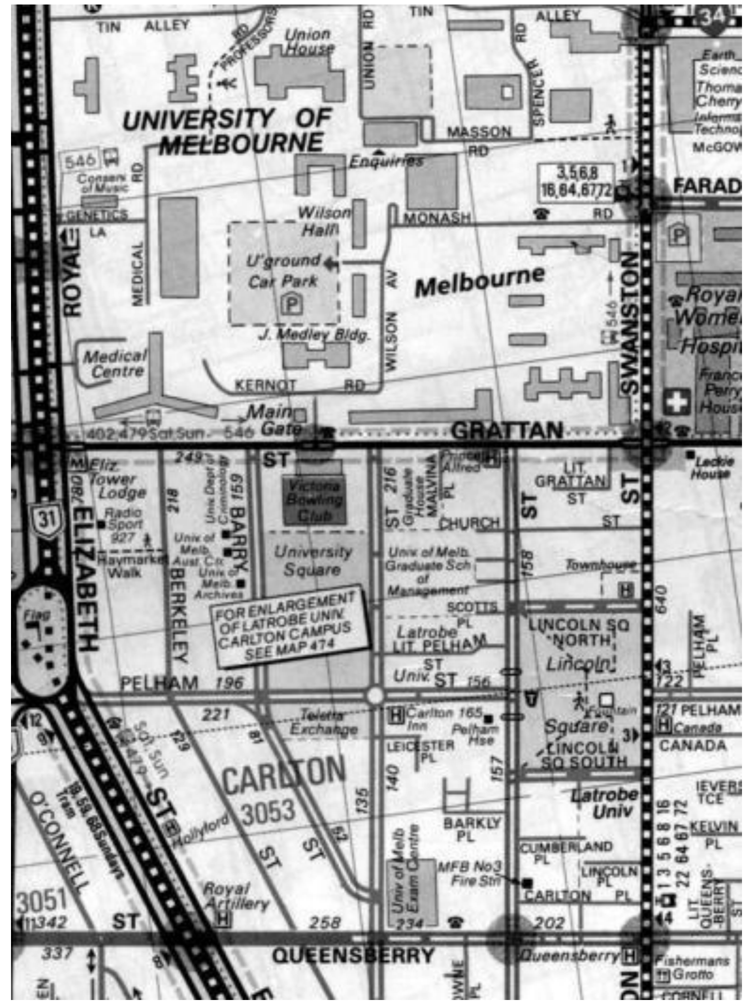


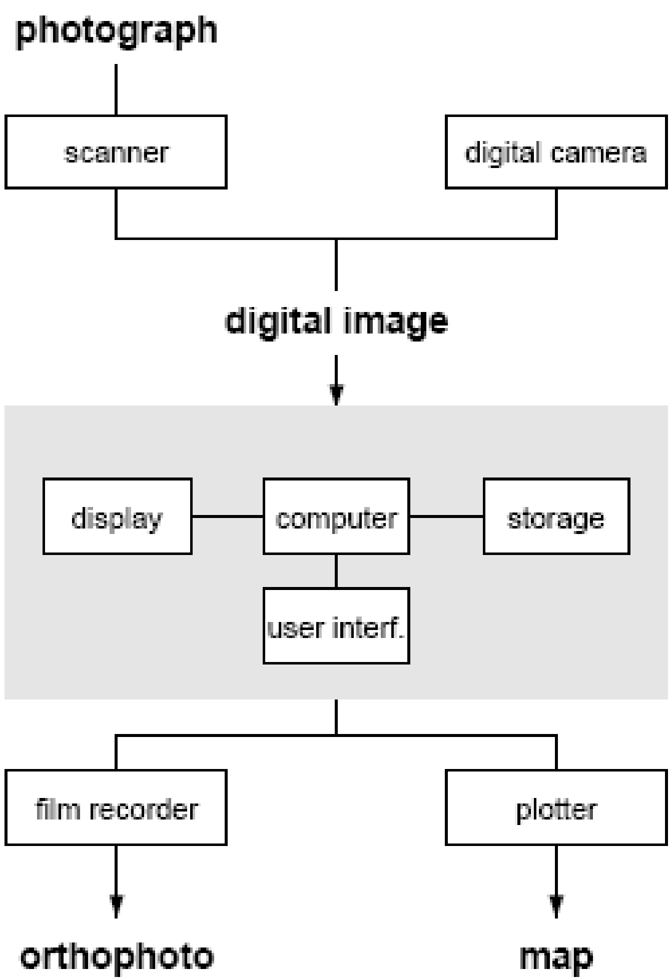
Stereo satellite imagery





Example products: Maps





Digital Photogrammetric Workstation (DPW)

MODULE 5
REMOTE SENSING

Introduction

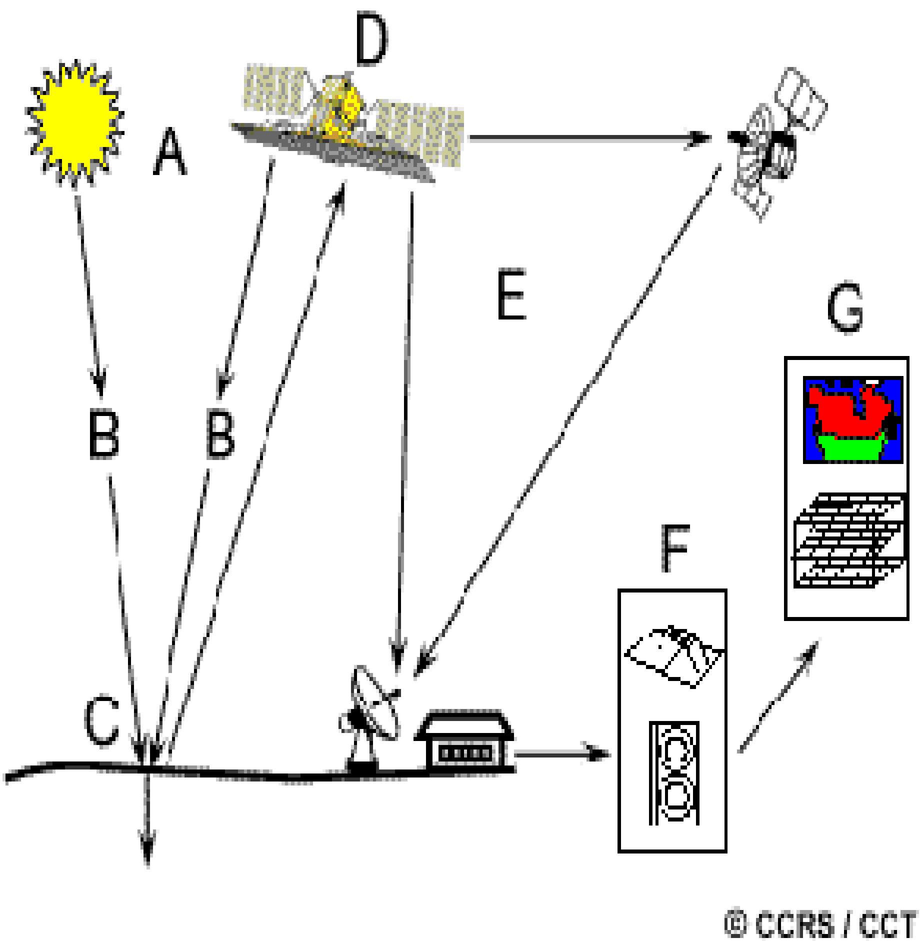
- Remote sensing is a technology for sampling electromagnetic radiation to acquire and read non-immediate geospatial data from which to pull info more or less features and objects on his Earths land surface, seas, and air.

- Remote sensing is a method for getting information about of different objects on the planet, without any physical contacts with it.

Advantages of Remote Sensing

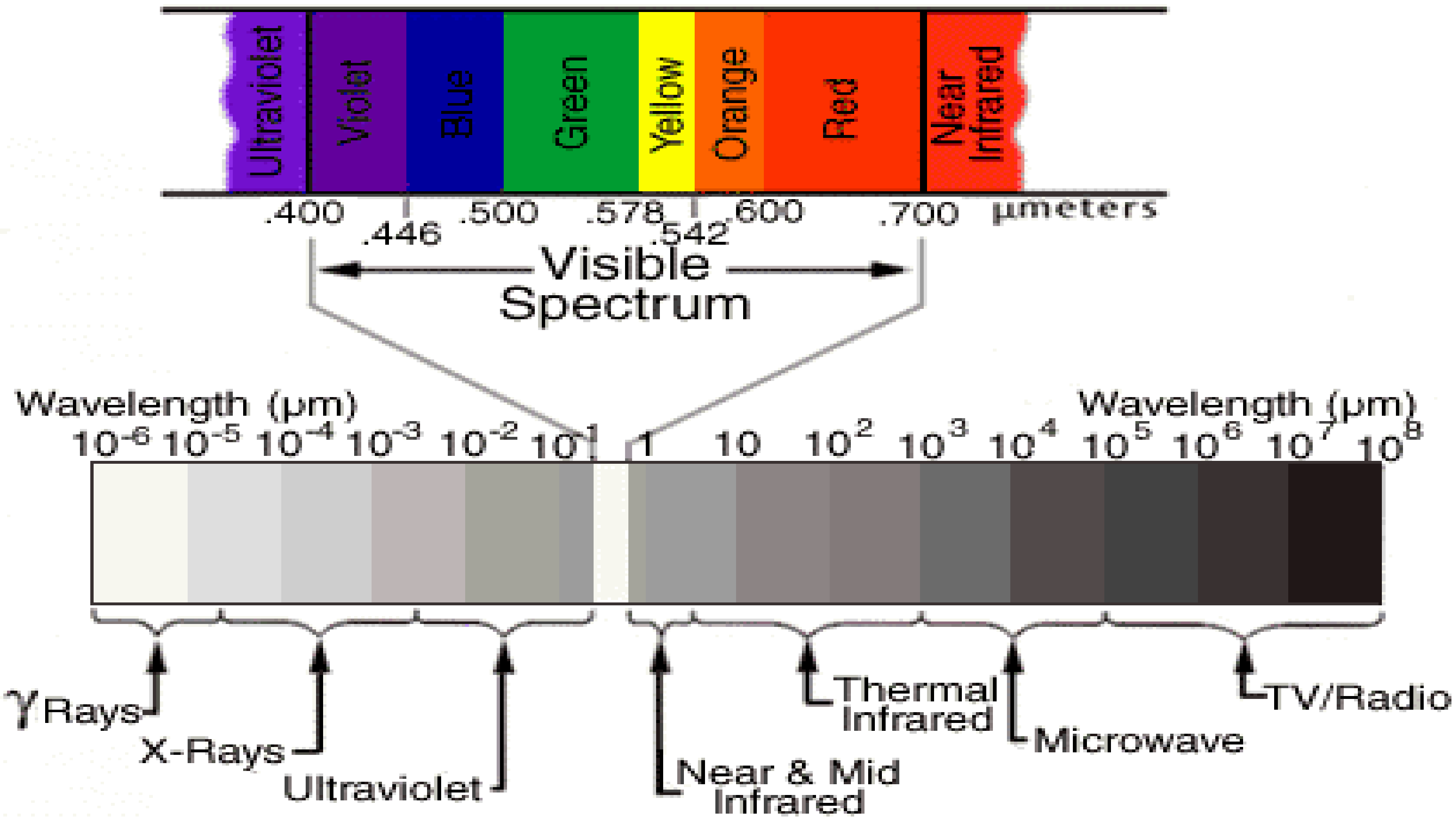
- Provides a view for the large region
- Offers Geo-referenced information and digital information
- Most of the remote sensors operate in every season, every day, every time and even in real tough weather

Elements of Remote Sensing

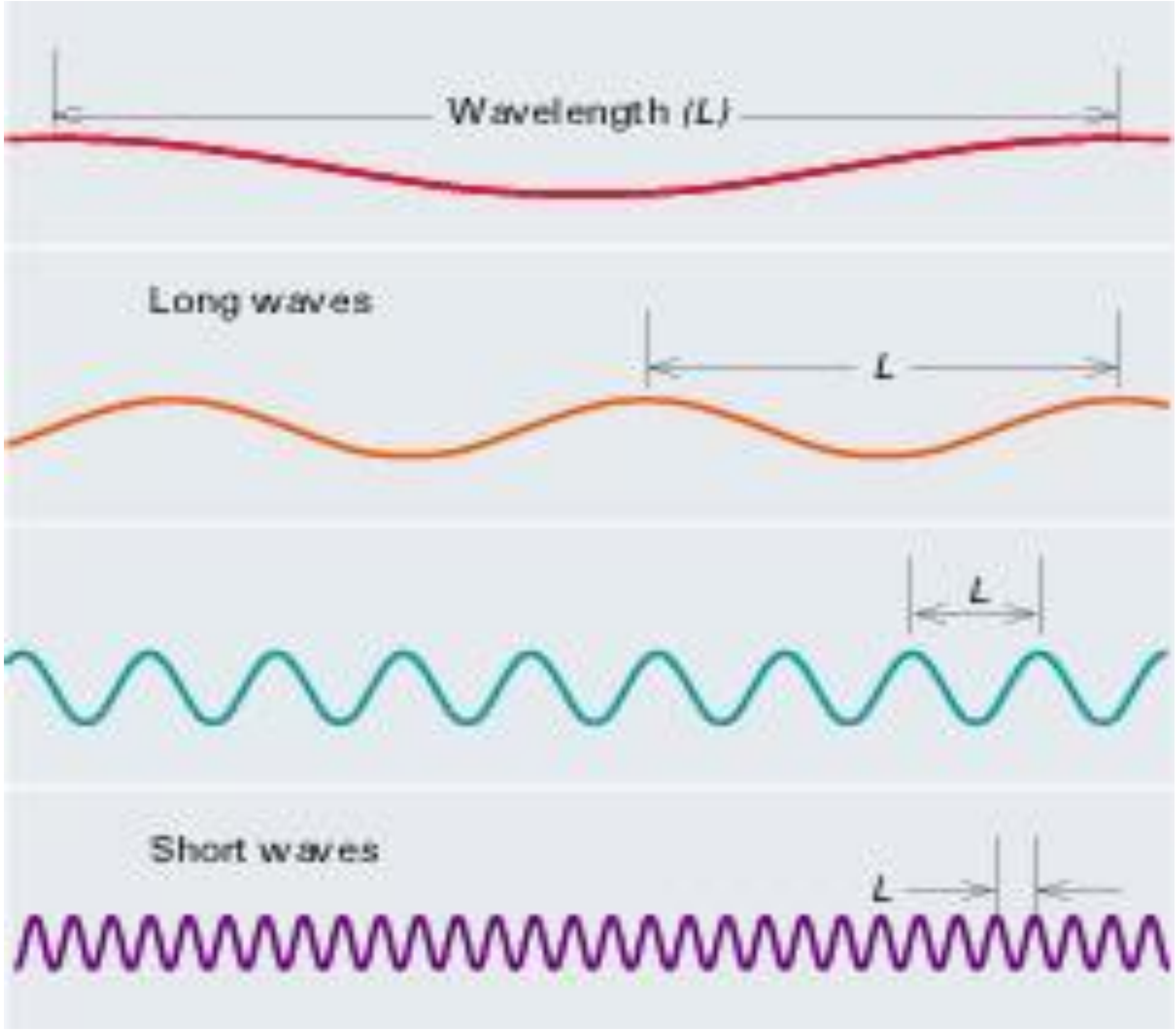


- Energy Source or Illumination (A)
- Radiation and the Atmosphere (B)
- Interaction with the Target (C)
- Recording of Energy by the Sensor (D)
- Transmission, Reception, and Processing (E)
- Interpretation and Analysis (F)
- Application (G)

Electromagnetic Spectrum



Electromagnetic Radiation



REMOTE SENSING PLATFORMS

Types of platforms :

1. Ground based platforms
   - Short range systems(50-100 m)
   - Medium Range Systems (150-250 m)
   - Long range Systems (up to 1 km)

2. Airborne platforms

3. Space-borne platforms

Types of platforms :

Ground Based Platforms:

Mobile hydraulic platforms (up to 15 m height)

Types of platforms :

Portable Masts

- Unstable in wind conditions

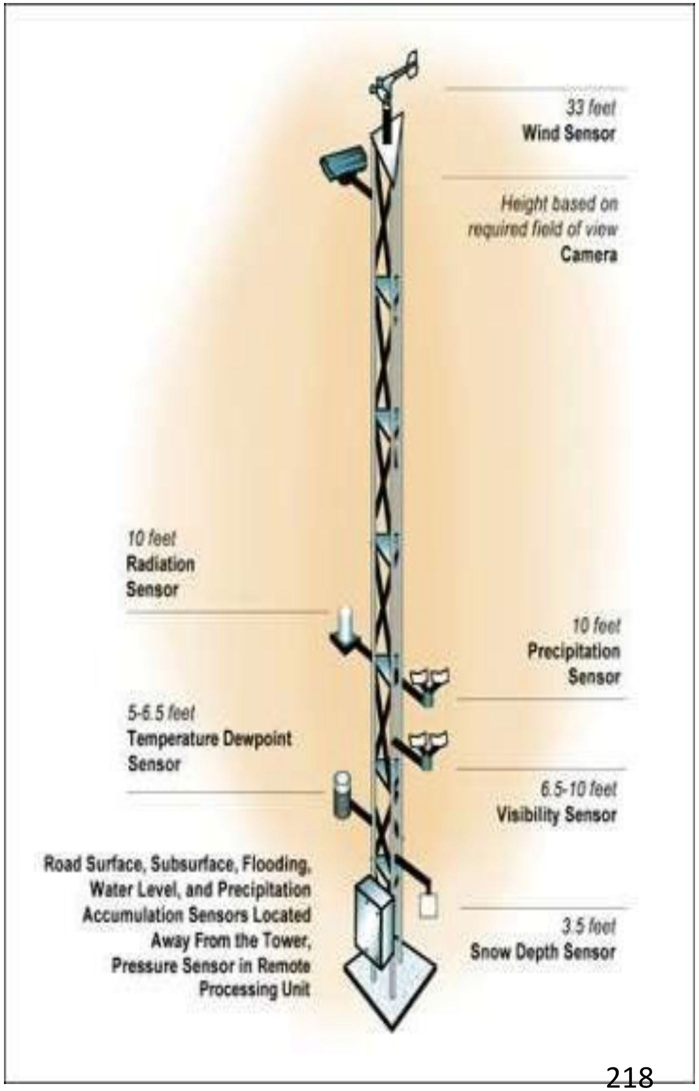
REMOTE SENSING PLATFORMS

Types of platforms :

Towers:

- Greater rigidity than masts

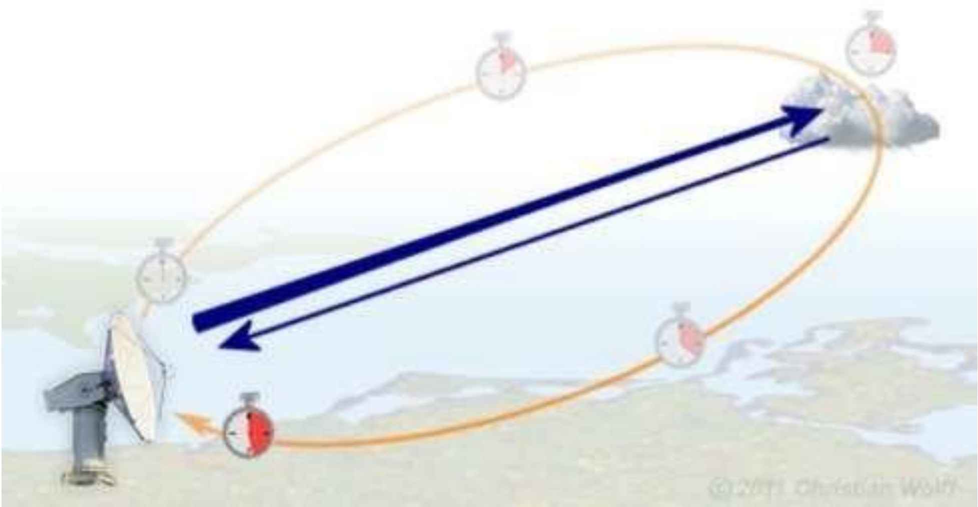

WisDOT



Types of platforms :

Weather Surveillance Radar

- Detects and tracks typhoons and cloud masses



REMOTE SENSING PLATFORMS

Types of platforms :

Airborne Platforms:

Balloons based :

- Altitude range is 22-40 km
- Tool to probing the atmosphere
- Useful to test the instruments under development

REMOTE SENSING PLATFORMS

Types of platforms :

Airborne Platforms:

Radiosonde:

Relative humidity in the atmosphere

Rawinsonde:

Measure wind velocity, temperature, pressure and relative humidity

REMOTE SENSING PLATFORMS

Types of platforms :

Aircraft:

Advantages:

- High spatial resolution (20 cm or less)
- Analog photography is possible (analog photo gives high resolution)

REMOTE SENSING PLATFORMS

Types of platforms :

Aircraft:

Dis Advantages:

- Permission to intrude into foreign airspace is required
- Many passes to cover larger area
- Swath is much less compare to satellite
- High cost per unit area

REMOTE SENSING PLATFORMS

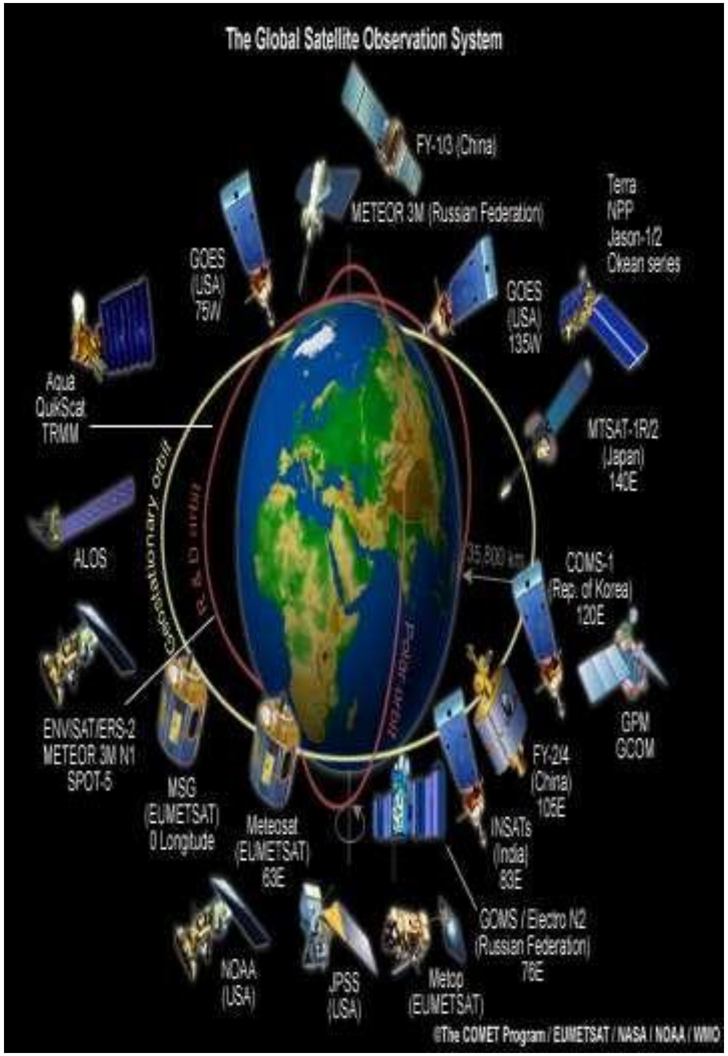
Types of platforms :

Space borne platforms:

- Sensors are mounted on-board a spacecraft
- Rockets, satellites and space shuttles.

Advantages :

- Cover large area
- Repetitive coverage of an area of interest.



REMOTE SENSING SENSORS

Sensor :

Common Definition :

- Sensors are Sophisticated devices that are frequently used to detect and respond to electrical or optical signals
- A Sensor converts the Physical parameter into a signal which can be measured electrically

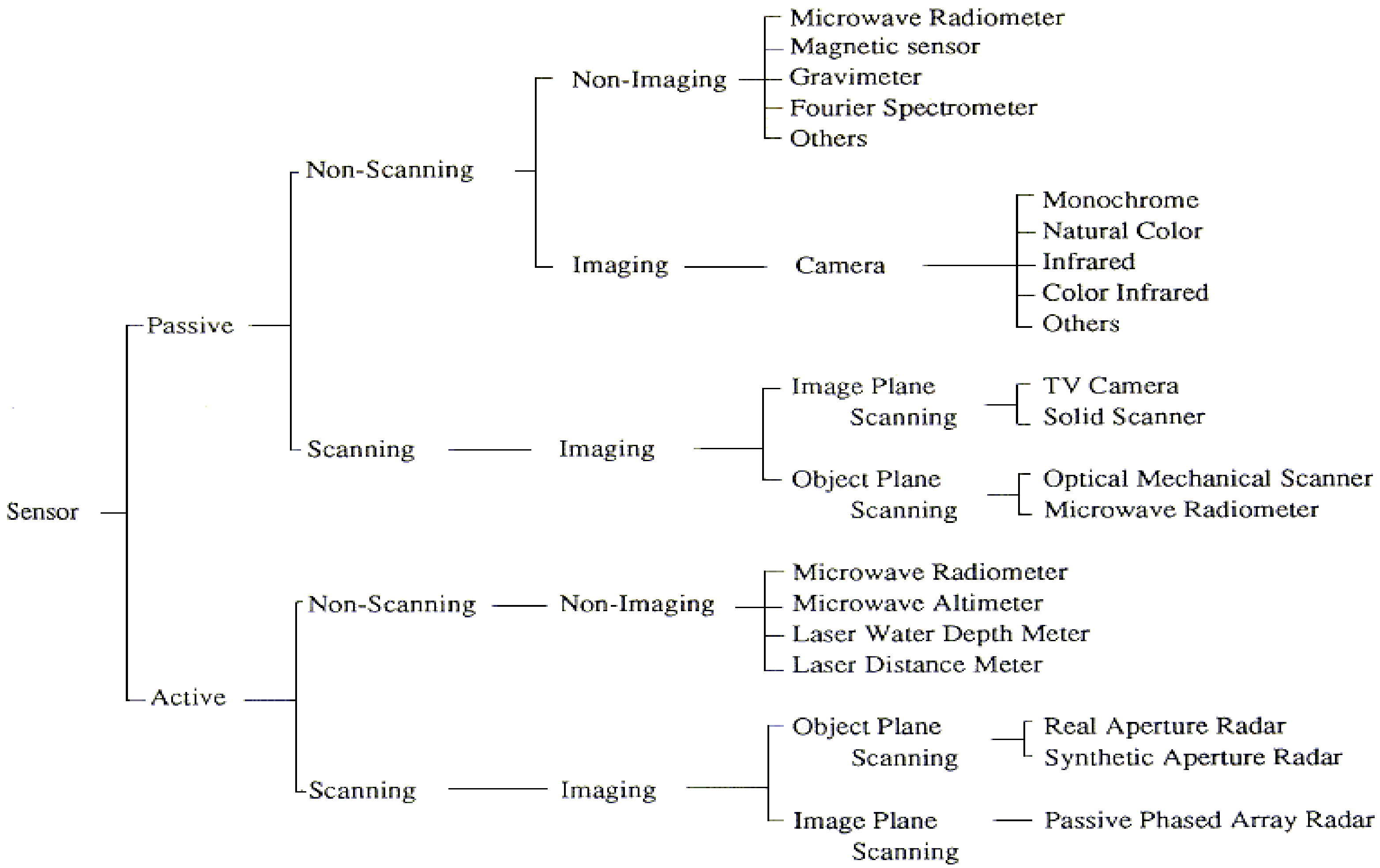
REMOTE SENSING SENSORS

Definition in Remote Sensing :

- Sensor is a device that gathers energy (EMR) converts into signal and present it into a signal and present it in a form (image) suitable for obtaining information about the objet under investigation

REMOTE SENSING SENSORS

Types of sensors :



REMOTE SENSING SENSORS

Types of sensors :

Active sensors:

These sensors detect reflected responses from objects which are irradiated from artificially generated energy sources

Ex : Radar, camera with flash light

Passive sensors:

These sensors detect reflected EMR from natural source

Ex : camera without flash light (depends on solar energy), and all RS sensors.

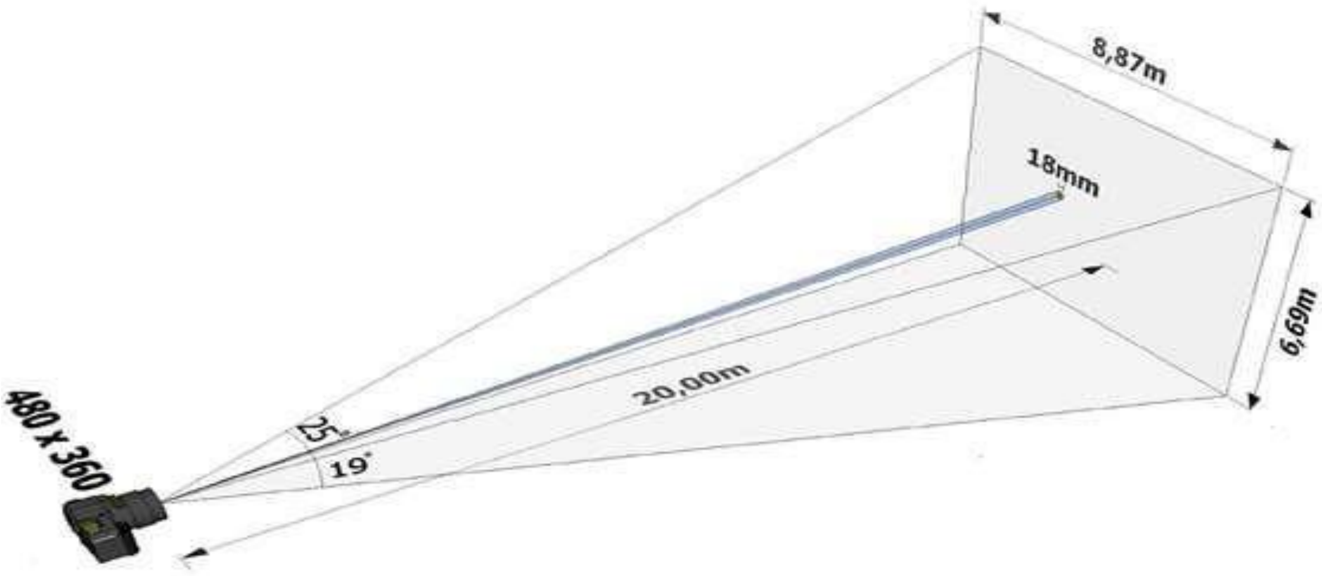
REMOTE SENSING SENSORS

Types of sensors :

Non Scanning or Framing sensors:

Measure the radiation coming from entire scene at once

Ex: Our eyes, Photo cameras



REMOTE SENSING SENSORS

Types of sensors :

Imaging sensors:

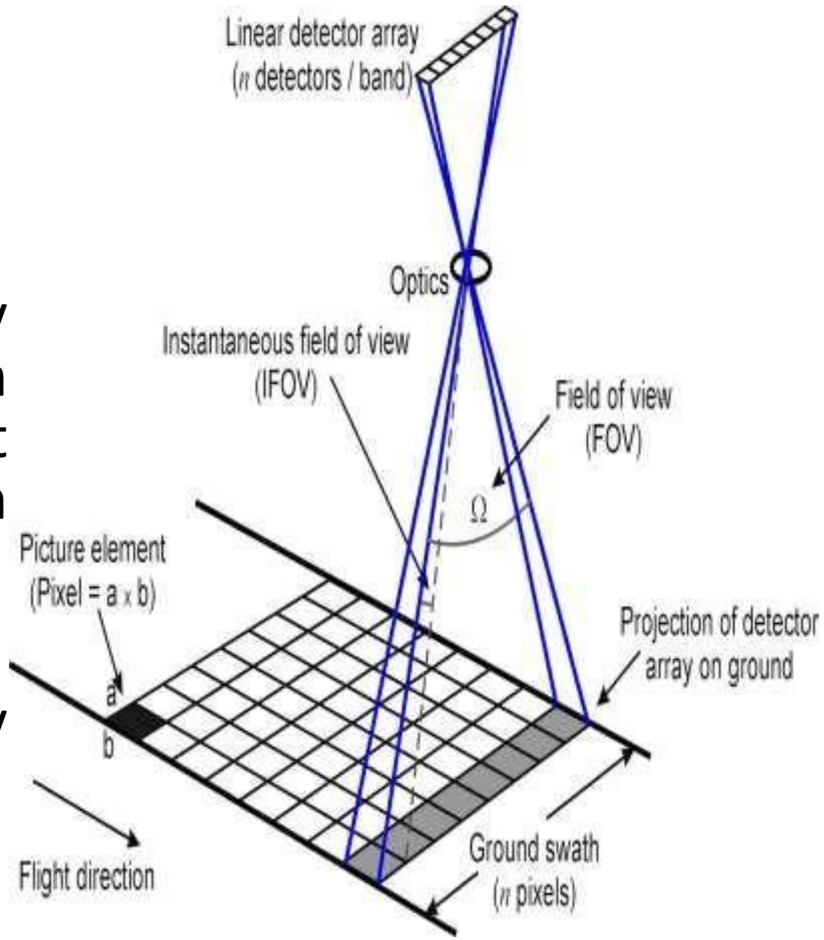
Form image by collected radiation

1. Scanning sensors:

The scene is sensed by point by point or measure the radiation coming from point by point (equivalent to small areas with in the scene)

Along track Scanners:

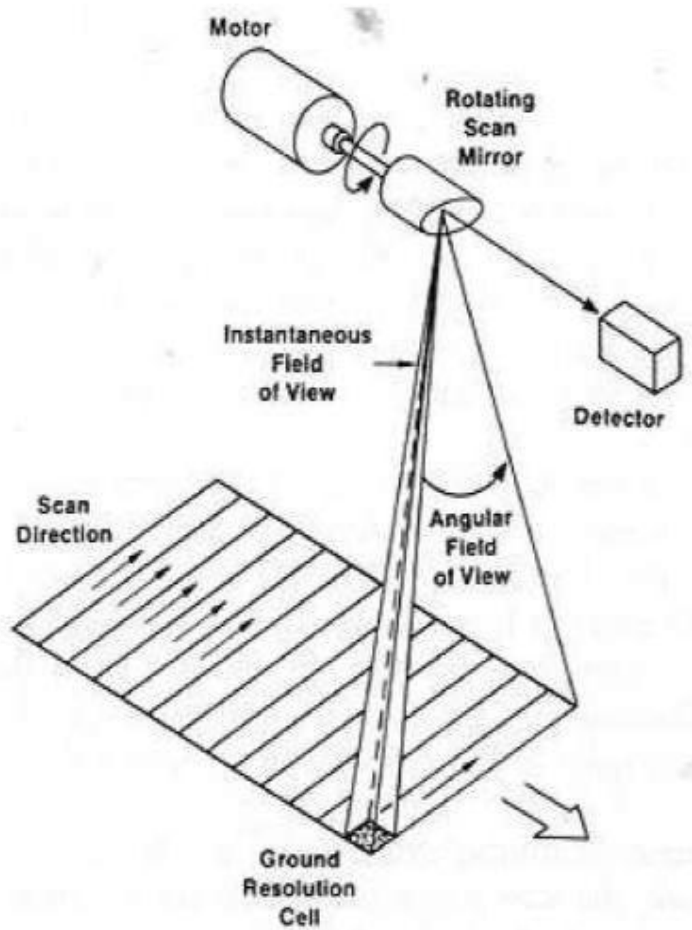
Image is acquired by line by line

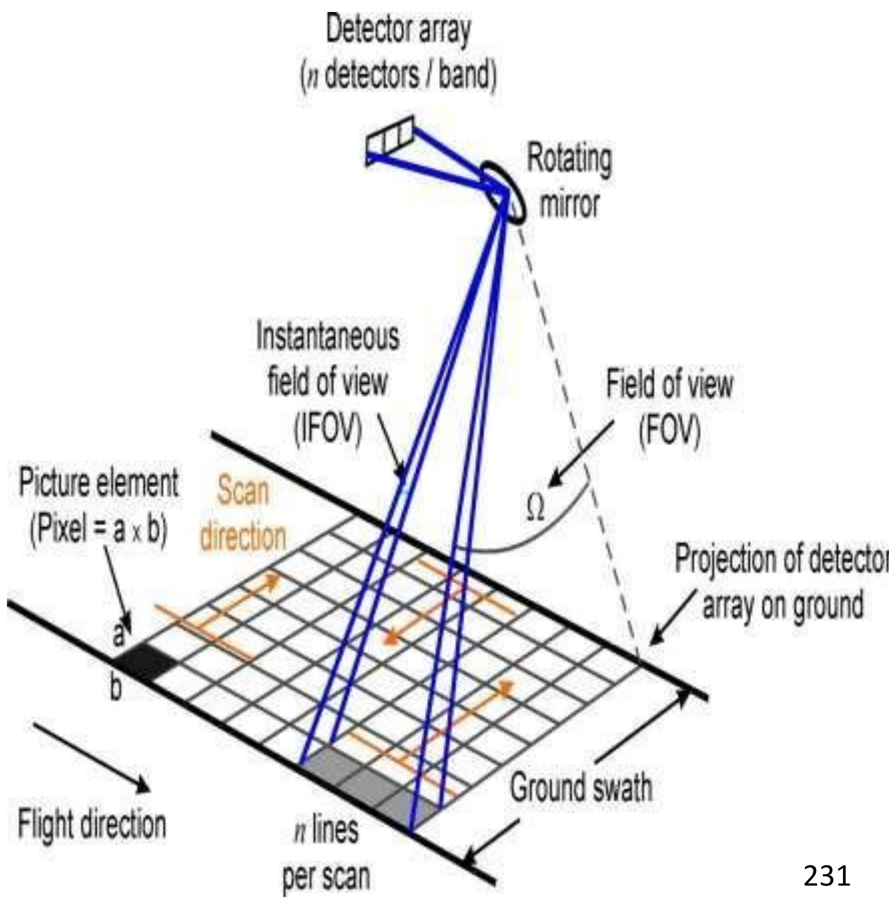


Types of sensors :

Across track Scanners:

Image is acquired by pixel by pixel





REMOTE SENSING SENSORS

Types of sensors :

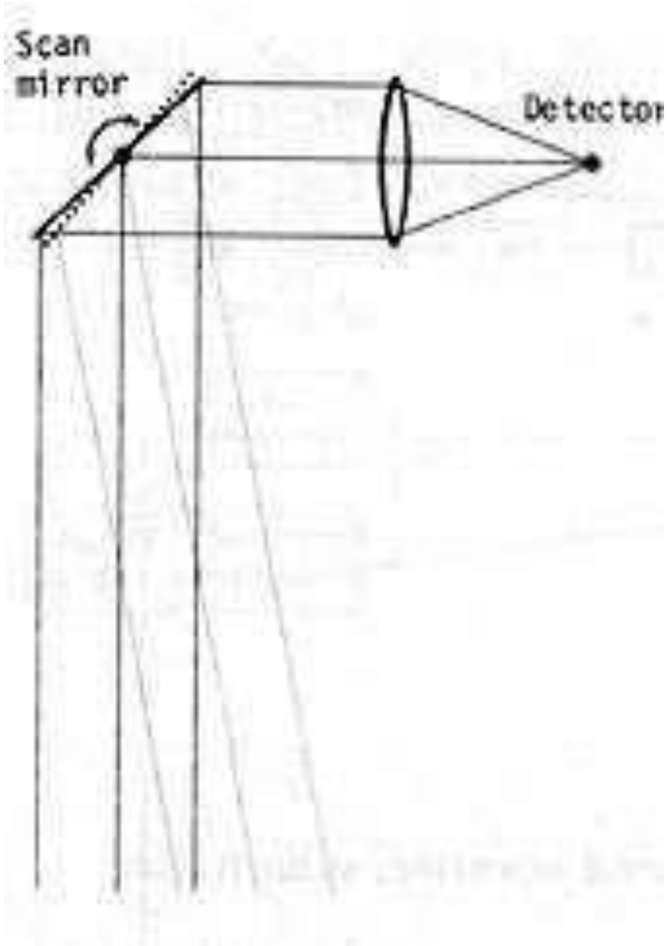
2. Non imaging sensors:

- These sensors do not form the image
- These are used to record spectral quantity or parameter as a function of time

Ex: temperature measurement, study of atmosphere

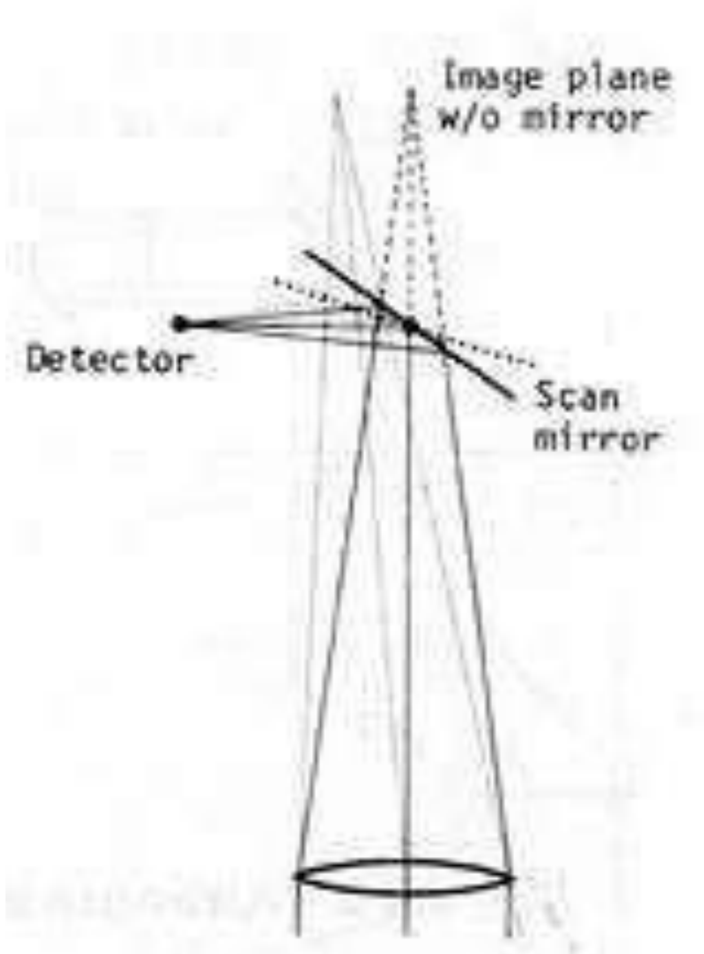
Types of sensors :

Image Plane Scanning:



- Types of sensors :

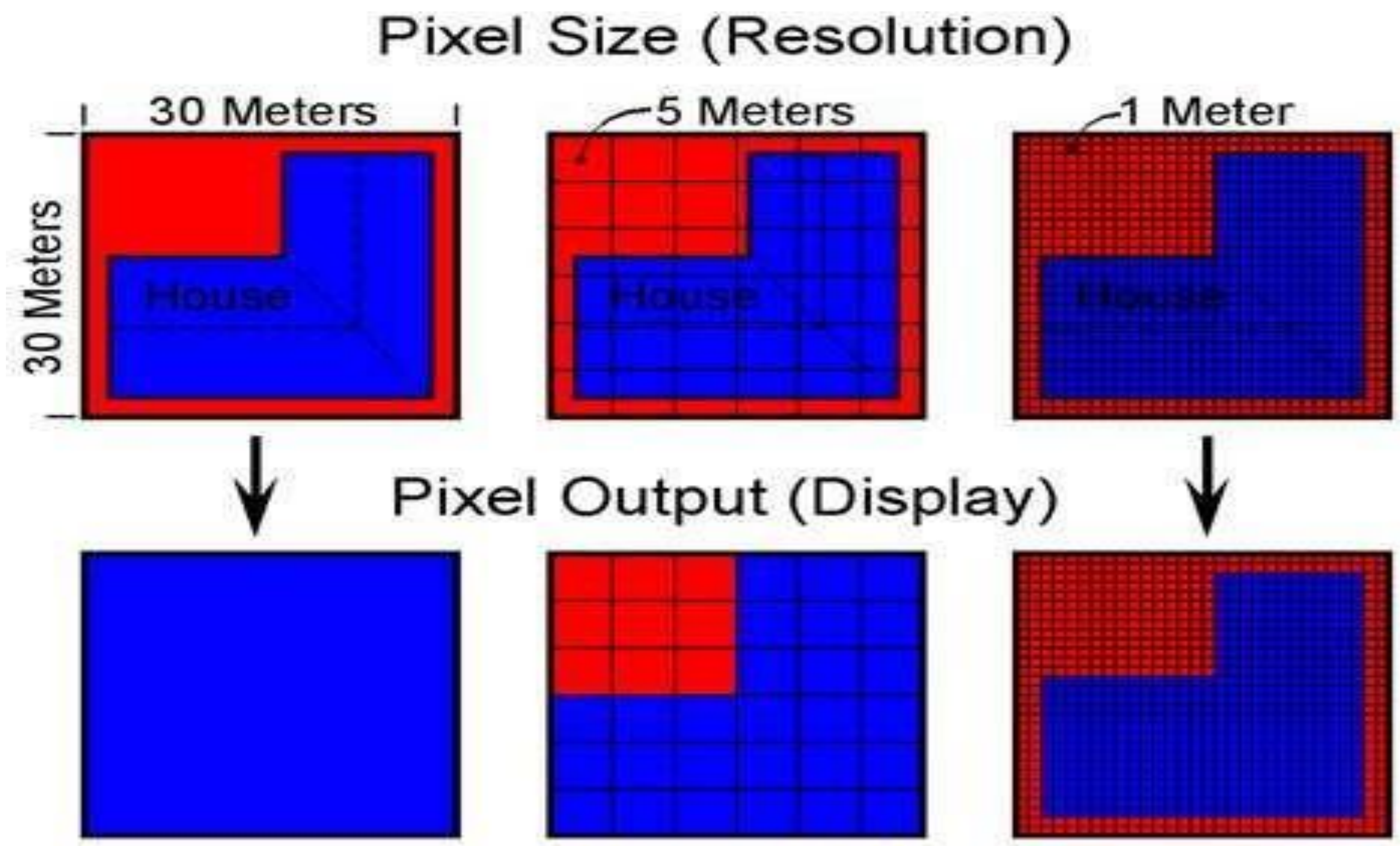
Object Plane Scanning



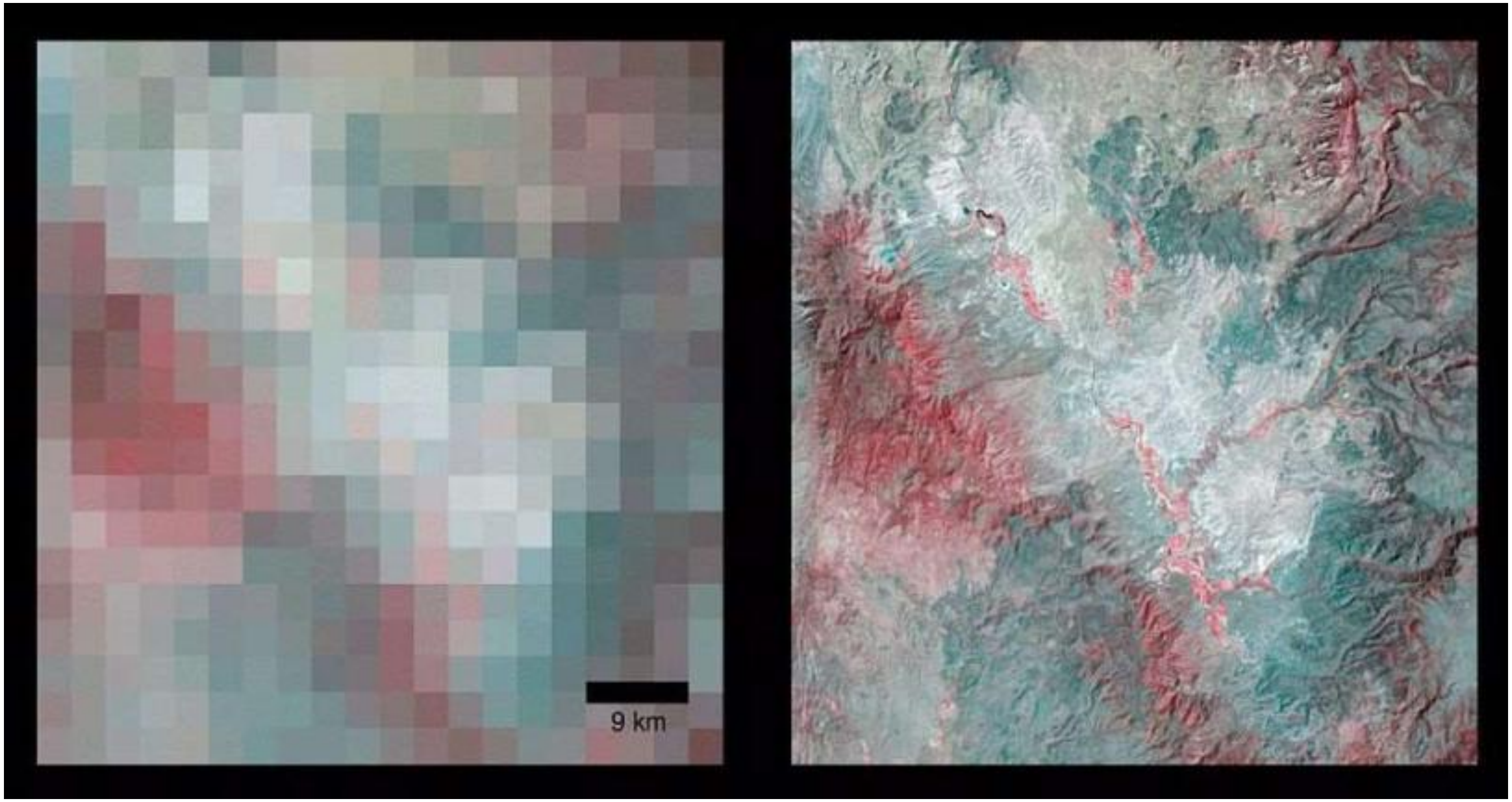
CHARECTERISTICS OF SENSORS

1. Spatial resolution
2. Spectral resolution
3. Radiometric resolution
4. Temporal resolution

Spatial resolution



Spatial resolution

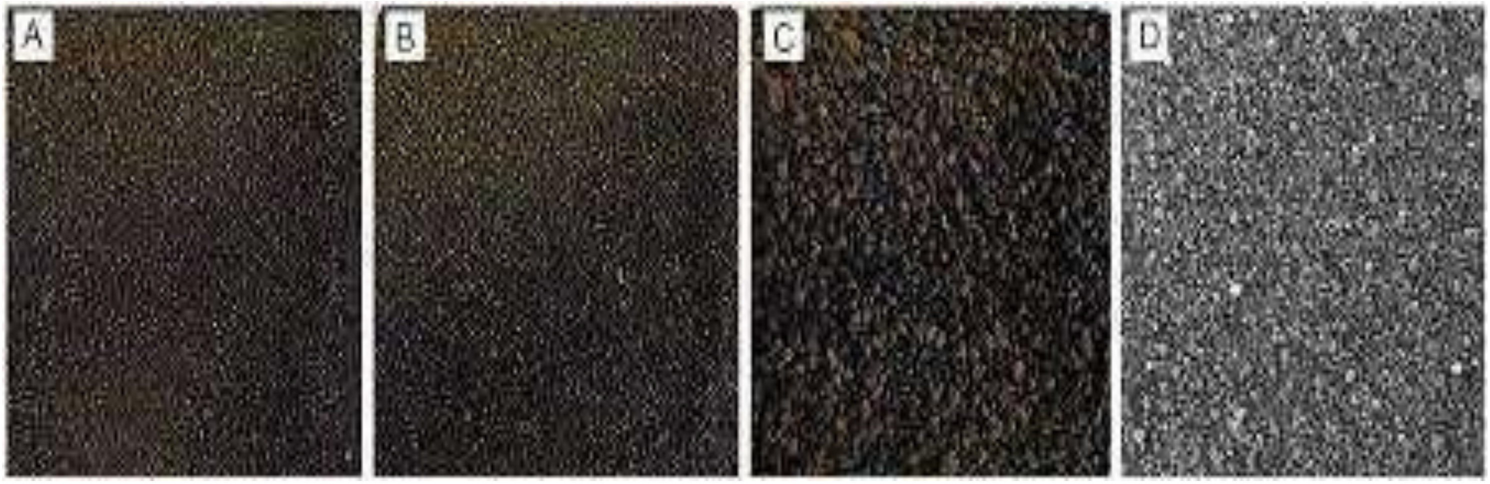


Spatial resolution

CHARECTERISTICS OF SENSORS

Spectral resolution

- It describes the ability of a sensor to define fine wavelength ranges
- Sand is appear as coarser in finer wavelength bands



CHARECTERISTICS OF SENSORS

Radiometric resolution

- It describes the ability of sensor to discriminate very slight differences in energy
- The number of brightness levels depends upon the number of bits used

Radiometric resolution

Temporal resolution

It refers to how often it records imagery of a particular area, which means the frequency of repetitive coverage

Digital Image Processing is the manipulation of the digital data with the help of the computer hardware and software to produce digital maps in which specific information has been extracted and highlighted.

Different Stages in Digital Image Processing

- Satellite remote sensing data in general and digital data in particular have been used as basic inputs for the inventory and mapping of natural resources of the earth surface like forestry, soils, geology and agriculture. Space borne remote sensing data suffer from a variety of radiometric, atmospheric and geometric errors, earth's rotation and so on.
- These distortions would diminish the accuracy of the information extracted and reduce the utility of the data. So these errors required to be corrected.

Pre – processing

Remotely sensed raw data generally contains flaws and deficiencies received from imaging sensor mounted on the satellite. The correction of deficiencies and removal of flaws present in the data through some methods are termed as pre–processing methods this correction model involves to correct geometric distortions, to calibrate the data radiometric ally and to eliminate noise present in the data. All the pre–processing methods are consider under three heads, namely,

- Radiometric correction method,
- Atmospheric correction method,
- Geometric correction methods.

Radiometric correction method

Radiometric errors are caused by detected imbalance and atmospheric deficiencies. Radiometric corrections are transformation on the data in order to remove error, which are geometrically independent. Radiometric corrections are also called as cosmetic corrections and are done to improve the visual appearance of the image. Some of the radiometric distortions are as follows:

1. Correction for missing lines
2. Correction for periodic line striping
3. Random noise correction

Atmospheric correction method

- The value recorded at any pixel location on the remotely sensed image is not a record of the true ground – leaving radiant at that point, for the signal is attenuated due to absorption and scattering.
- The atmosphere has effect on the measured brightness value of a pixel. Other difficulties are caused by the variation in the illumination geometry. Atmospheric path radiance introduces haze in the imagery where by decreasing the contrast of the data.

Geometric correction methods

- Remotely sensed images are not maps. Frequently information extracted from remotely sensed images is integrated with the map data in Geographical Information System (GIS). The transformation of the remotely sensed image into a map with the scale and projection properties is called geometric corrections. Geometric corrections of remotely sensed image is required when the image is to be used in one of the following circumstances:
- To transform an image to match your map projection
- To locate points of the interest on map and image.
- To overlay temporal sequence of images of the same area, perhaps acquired by different sensors.
- To integrate remotely sensed data with GIS.


Thank you