

# Introduction to Modern Surveying

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**Abstract:** Surveying or land surveying is the technique, profession, and science of determining the terrestrial or three-dimensional positions of points and the distances and angles between them.

Revolutionary changes have taken place in last few years in surveying instruments that are used for measuring level differences, distances and angles. This has become possible because of introduction of electronics in these measurements. With rapid advancements in the technology and availability of cheaper and innovative electronic components, these instruments have become affordable and easy to use. This module outlines developments in the technology for various survey measurements such as digital levels, electronic distance measuring instruments, electronic theodolites, and total stations.

**Keywords:** *Electronic Distance Measurement (EDM) Instruments, Total Station, Global Positioning System (GPS), Automatic Level*

## 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.

**According to the American Congress on Surveying and Mapping (ACSM)**, Surveying is the 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 usable form, or to establish the position of points or details.

Surveying also includes the technique of establishing points by predetermined angular and linear measurements. From the plans, sections, and maps prepared by surveying, the area and volume of a particular plot of land can be calculated. A map represents the horizontal projection of the area surveyed and not the actual area. But the vertical distance can be represented more correctly by drawing sections.

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. Surveying is the process of analyzing and recording the characteristics of a land area span to help design a plan or map for construction.

Total Station is the currently preferred Surveying equipment in the industry.

### Categories of Surveying are:

- **Geodetic Surveying:**  
Surveys are carried out on a large scale with the help of control networks spanning over long distances.
- **Cadastral Surveying:**  
Surveys are carried out to define land ownership and boundaries.
- **Topographical Surveying:**  
Surveys are carried out to determine land structure along with variation in land heights.
- **As Built Surveying:**  
Surveys are carried out after completion of a construction project to check variance from proposed design.
- **Photogrammetry (Aerial Surveying):**  
Surveys are carried out by taking photographs from elevated ground stations.
- **LIDAR (Aerial Surveying):**  
Surveys are carried out using remote sensors and light reflected by lasers to measure distances.

### Fundamental techniques used for Surveying are:

- **Triangulation:**  
In this technique numerous triangles are inter-connected and overlapped to measure angles from a surveying station.
- **Trilateration:**  
It follows the same technique as in Triangulation with additional use of Electronic Distance Meter (EDM).
- **Traverse:**  
In this technique multiple lines of pre-measured lengths are inter-connected to measure angles and distances.
- **Leveling:**  
In this technique the difference in heights in a terrain are measured with the help of graduated rods.
- **Radiation:**

In this technique radiating lines are drawn from a focal point to defined boundaries converted to a small scale surveying sheet. Surveying finds multiple industrial applications across various domains. It is an integral part of Civil Engineering Discipline.

## 2. Modern Surveying Instruments and Their Uses

Following are the modern surveying instruments which are used for surveying:

- Electronic Distance Measurement (EDM) Instruments
- Total Station
- Global Positioning System (GPS)
- Automatic Level

### 1. Electronic Distance Measurement (EDM) Instruments

Direct measurement of distances and their directions can be obtained by using electronic instruments that rely on propagation, reflection and reception of either light waves or radio waves. They may be broadly classified into three types.

- a. Infrared wave instruments
- b. Light wave instruments
- c. Microwave instruments

#### a. Infrared Wave Instruments

These instruments measure distances by using amplitude modulated infrared waves. At the end of the line, prisms mounted on target are used to reflect the waves. These instruments are light and economical and can be mounted on theodolites for angular measurements. The range of such an instrument will be 3 km and the accuracy achieved is  $\pm 10$  mm.

It is a very small, compact EDM, particularly useful in building construction and other Civil Engineering works, where distance measurements are less than 500 m. It is an EDM that makes the meaning tape redundant. To measure the distance, one has to simply point the instrument to the reflector, touch a key and read the result.

#### b. Light Wave Instruments

These are the instruments which measures distances based on propagation of modulated light waves. The accuracy of such an instrument varies from 0.5 to 5 mm / km distance and has a range of nearly 3 km.

**Eg: Geodimeter**



## Geodimeter

**Geodimeter** is an instrument which works based on the propagation of modulated light waves, was developed by E. Bergstrand of the Swedish Geological Survey in collaboration with the manufacturer M/s AGA of Swedish. The instrument is more suitable for night time observations and requires a prism system at the end of the line for reflecting the waves.

### c. Microwave Instruments

These instruments make use of high frequency radio waves. These instruments were invented as early as 1950 in South Africa by Dr. T.L. Wadley. The range of these instruments is up to 100 km and can be used both during day and night.

#### Eg. Tellurometer



**Tellurometer**

It is an EDM which uses high frequency radio waves (micro-waves) for measuring distances. It is a highly portable instrument and can be worked with 12 to 24-volt battery.

For measuring distance, two Tellurometers are required, one to be stationed at each end of the line, with two highly skilled persons, to take observations. One instrument is used as a master unit and the other as a remote unit.

Just by pressing a button a master can be converted into remote unit and vice-versa. A speech facility (communication facility) is provided to each operator to interact during measurement.

### Total Station

Total Station is a lightweight, compact and fully integrated electronic instrument combining the capability of an EDM and an angular measuring instrument such as wild theodolite.

Total Station can perform the following functions:

- Distance measurement
- Angular measurement
- Data processing
- Digital display of point details
- Storing data in an electronic field book



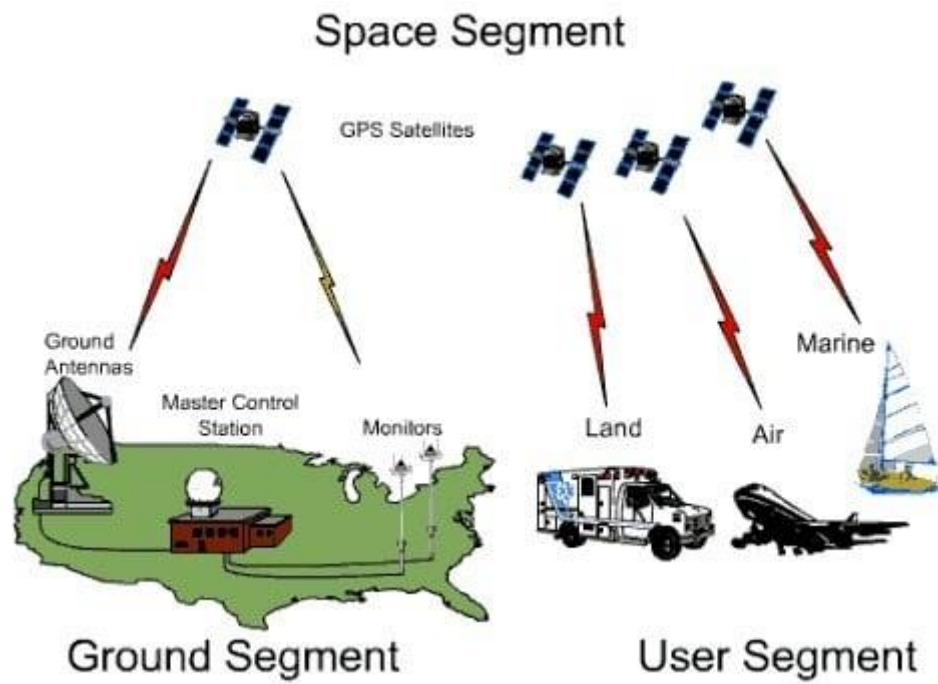
The important features of total station are,

1. Keyboard-control – all the functions are controlled by operating key board.
2. Digital panel – the panel displays the values of distance, angle, height and the coordinates of the observed point, where the reflector (target) is kept.
3. Remote height object – the heights of some inaccessible objects such as towers can be read directly. The microprocessor provided in the instrument applies the correction for earth's curvature and mean refraction, automatically.
4. Traversing program – the coordinates of the reflector and the angle or bearing on the reflector can be stored and can be recalled for next set up of instrument.
5. Setting out for distance direction and height -whenever a particular direction and horizontal distance is to be entered for the purpose of locating the point on the ground using a target, then the instrument displays the angle through which the theodolite has to be turned and the distance by which the reflector should move.

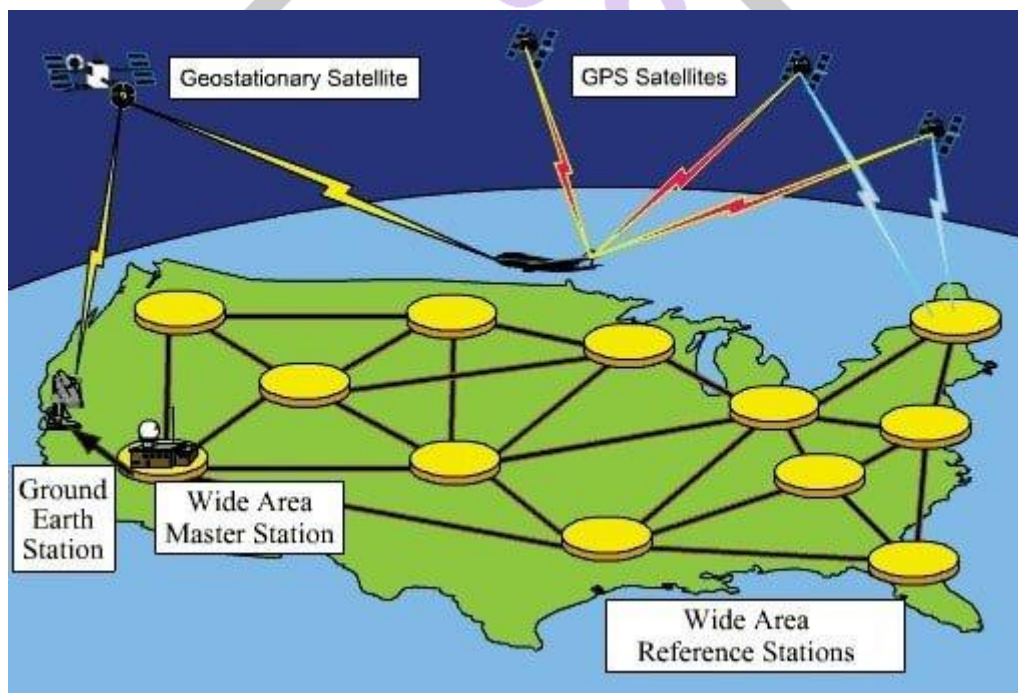
### **Global Positioning System (GPS)**

Global Positioning System (GPS) is developed by U.S. Defense department and is called Navigational System with Time and Ranging Global Positioning System (NAVSTAR GPS) or simply GPS.

For this purpose U.S. Air Force has stationed 24 satellites at an altitude of 20200 km above the earth's surface. The satellites have been positioned in such a way, at least four satellites will be visible from any point on earth.



The user needs a GPS receiver to locate the position of any point on ground. The receiver processes the signals received from the satellite and compute the position (latitude and longitude) and elevation of a point with reference to datum.



**Automatic Level**

An automatic level is a special leveling instrument used in surveying which contains an optical compensator which maintains line of sight or line of collimation even though instrument is slightly tilted.

**E.g.:** Wild NAK2 Automatic level



### 3. Conclusion-

1. Surveying is the basic need of Civil Engineering nowadays.
2. Modern surveying equipments like Total Station gives both manual and digital values.
3. These Instruments are very useful for both land, marine survey etc.

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