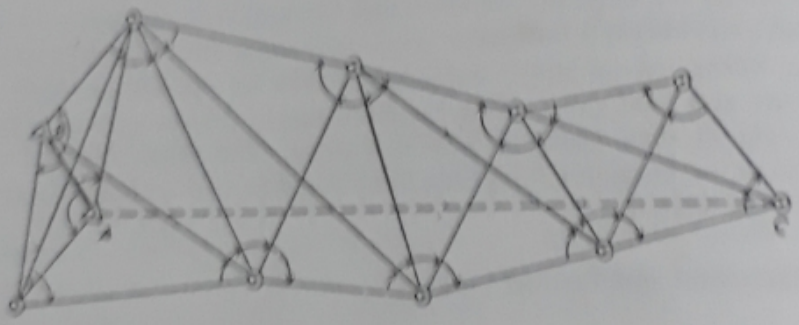
Horizontal and Vertical Controls:

Horizontal Control: Two types of controls are established from the Datum Point and Datum Plane. The first is the horizontal control. It consists of points from which horizontal distances and azimuths can be measured in linear units discounting elevation on the earth's surface. Such points are derived by Triangulation which is a method of establishing control stations by means of a set of mutually connected triangles.

The process of triangulation begins with a reconnaissance survey to select a number of prominent points which constitute the vertices of a set of triangles. These stations are known as trigonometrical stations. In between these points, the elevation of several other points is also determined by precise primary horizontal control levelling. These are called Bench Marks. The trigonometrical stations are the primary horizontal control stations, and the Bench Marks the primary vertical control stations.

The next step begins with the determination and measurement of the base line (Fig. 67). Base line is selected on a ground which is free from obstructions to accurate measurements. It is, usually, one of the sides of the first triangle in the triangulation. An object is sighted from both ends of this line. When rays are drawn from each end of the line to the object, we get a triangle. Each angle or azimuth is carefully measured several times and checked by adding the three

Fig. 67: A simple Triangulation Net
(From Geodesy for the Layman).



angles of the triangle to see if they total 180°. Another object is sighted and angular measurements are repeated for the next triangle whose base is formed by a side of the previous triangle. This process is repeated until all triangles of the system are completed. It must be noted that in a triangulation the base line is the only side of a triangle which is measured. All the other sides of the triangles are calculated trigonometrically. Given a side and two angles of a triangle, the remaining sides and angles can be easily determined. These triangulation stations and Bench Marks are then plotted on a projection selected for the purpose. The topographical and other details are incorporated after the plane and socio-geographic surveys are also completed.

Known Data: 1. length of the base line AB,2. Latitude and Longitude of points

A and B, 3. Azimuth of line AB.

Measured Data : Angles to new control points.

Computed Data : 1. Latitude and longitude of point C, and other new points. 2. Length and azimuth of line AC. 3. Length and azimuth of all other lines.

There are four orders of triangulation. The basis for this classification is the degree of accuracy desired. The first order triangulation requires that all triangles must close within 1 second of error and the side lengths must agree to earth measurements within 1 foot in 25,000 ft. or 30 cms in 7620 metres. The second order triangulation permits angular discrepancy of 3 seconds and the horizontal discrepancy of 1 foot in 10,000 feet or 30 cms in 3048 metres. The respective figures for third and fourth order triangulations are 5 seconds and more than five seconds and 1 foot in 5,000 feet or 30 cms in 1524 metres and 1 foot in 500 feet or 30 cm in 152.4 metres respectively. The accuracy required in the first and second order triangulations can be had only if geodetic adjustments are made to conform to the earth's ellipsoid and geoid. The triangulations of these two orders are, therefore, the results of geodetic surveys. The third and the fourth order triangulations are used in plane surveying.

Normally, triangulation is carried out by parties of surveyors from preplanned stations along the arcs of the spherical triangles. If there are obstacles in the way of the parties moving from one station to another a method known as flare triangulation is employed. Parties locate themselves at all the stations from which measurements have to be taken and magnesium flares are parachuted from aircraft or 'shot' into the air from ships at suitable points between them. Intersections of lines are marked simultaneously at all the stations and thus reasonably accurate 'bridges' are established. This type of connection was established between Norway and Denmark.

In cases where the distances between the points are too long to be intervisible, the above noted methods of triangulation are not helpful. The method of trilateration is used in such situations (Fig. 67). Trilateration involves the use of radar and other electronic devices. Instruments used in trilateration are geodimeter and tellurometer. In the former, light is focused from one point to another. The focused light is received an a mirror installed in the receiving station. The mirror reflects the light back. The time taken by the light to travel back gives the horizontal distance between the points.