Geodesy 1 (GED203)

Lecture No: 8

GEODETIC CONTROL NETWORKS

Reda FEKRY

reda.abdelkawy@feng.bu.edu.eg

Overview of Previous lecture

DISCUSSION OF THE MODEL ANSWER OF THE MIDTERM EXAM

Overview of today's lecture

DEFINITION OF GEODETIC CONTROL

TYPES OF GEODETIC CONTROL

TRIANGULATION VS TRILATERATION

ROUTINE OF TRIANGULATION SURVEY

PRINCIPLE OF TRIANGULATION

CLASSIFICATION OF TRIANGULATION NETWORKS

EGYPTIAN GEODETIC NETWORKS

APPLICATIONS OF GEODETIC NETWORKS

Expected Learning Outcomes

- Understand the concept of geodetic control and its importance in surveying and mapping.
- Learn the differences between triangulation and trilateration as methods used in geodetic surveys.
- Gain knowledge of the standard procedures and steps involved in conducting a triangulation survey.
- Understand the fundamental principle of triangulation, which involves measuring angles and distances between control points to determine their precise positions.
- Learn about the geodetic networks in Egypt, understanding their historical significance and contributions to surveying and mapping in the region.
- Explore the various applications of geodetic networks in surveying, mapping, and geodesy.

Geodetic Control Networks

Geodetic Control

❑ Horizontal Positioning

- Triangulation
- Trilateration
- Traversing
- Astronomical positioning
- Global Positioning System (GPS)

❑ Vertical Positioning

- Geodetic Leveling
- Trigonometric Leveling
- Barometric Leveling

Horizontal Control Networks

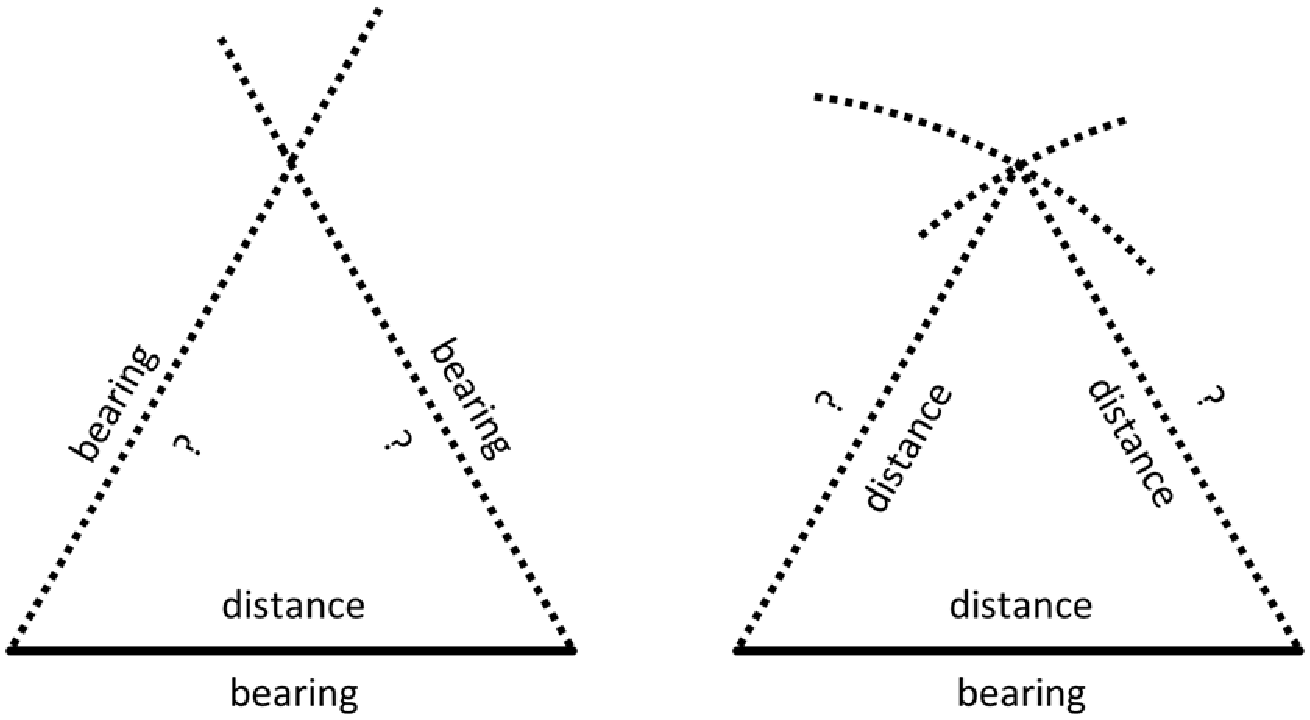
Triangulation Vs Trilateration

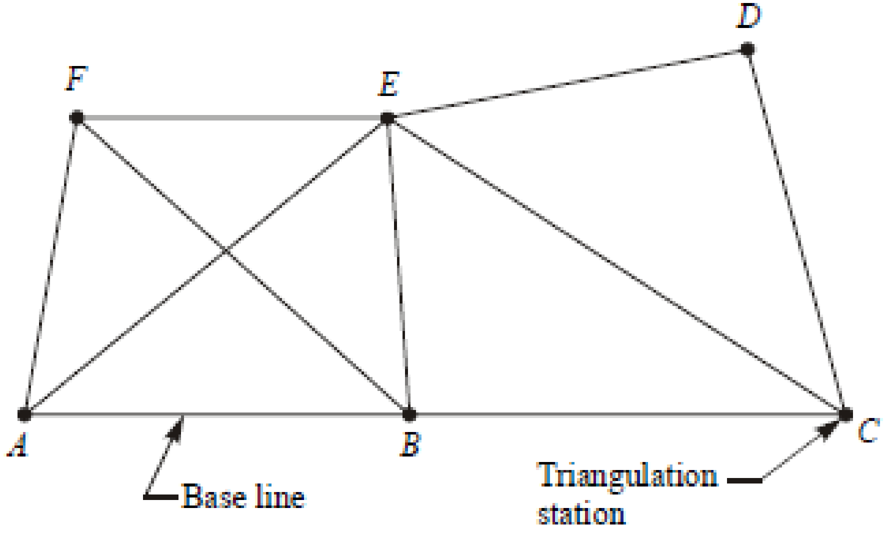
Triangulation	Trilateration
The triangles formed in the area is determined by **measuring their angles.**	The triangles formed in the area is determined by **measuring their sides.**
A base line whose value is known is taken as a reference for proceeding the measurement.	The azimuth of a line is the known value and it is taken as the reference to proceed the measurement.
To control scale error, check base lines are measured.	To control angular error, check angles are measured
Intervisibility between stations is essential	It is possible to measure distances without intervisibility
More internal checks	Less internal checks compared to triangulation
Once the angles are measured, the sides are sides of the triangles are calculated using sine rule.	Once the sides of the triangular figures are determined, the angles are calculated using cosine law.

TRIANGULATION VS TRILATERATION

Triangulation
(2 missing distances)

Trilateration
(2 missing bearings)





TRIANGULATION

Definition

- The process of a measuring system comprised of connected triangles whose vertices are stations marked on the surface of the earth and in which angular observations are supported by occasional distance and astronomical observation.

Purpose

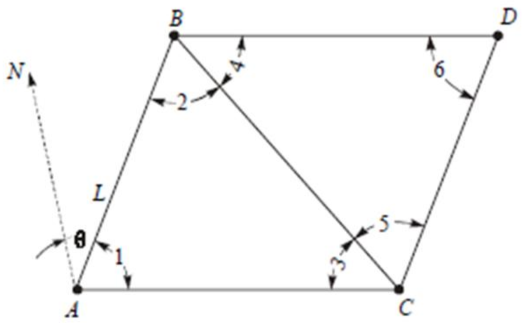
- To establish the accurate control points for plane and geodetic surveys of large areas
- To establish the accurate control points for photogrammetric surveys
- Accurate location of engineering works

Routine of Triangulation Survey

- **The routine of triangulation survey, broadly consists of**
  - (a) field work, and (b) computations.
- **The field work of triangulation is divided into the following operations :**
  - Reconnaissance
  - Erection of signals and towers
  - Measurement of base line
  - Measurement of horizontal angles
  - Measurement of vertical angles
  - Astronomical observations to determine the azimuth of the lines.

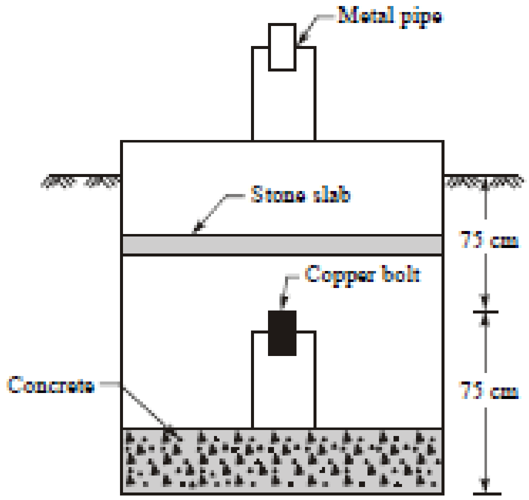
PRINCIPLE OF TRIANGULATION

- Entire area to be surveyed is converted into framework of triangles
- If the length and bearing of one side and three angles of a triangle are measured precisely, the lengths and directions of other two sides can be computed.
- Precisely measured line is called **base line**.
- Computed two lines are used as base lines for two interconnected triangles.
- Vertices of the individual triangles are known as **triangulation stations**.
- Extending this process network of triangles can be computed over the entire area.
- As a **check** the length of one side of last triangle is also measured and compared with the computed one.
- Subsidiary bases are measured at suitable **intervals** to minimize accumulation of **errors** in lengths.
- Astronomical observations are made at intermediate stations to control the error in azimuth.
- Those triangulation stations are called **Laplace Stations**.



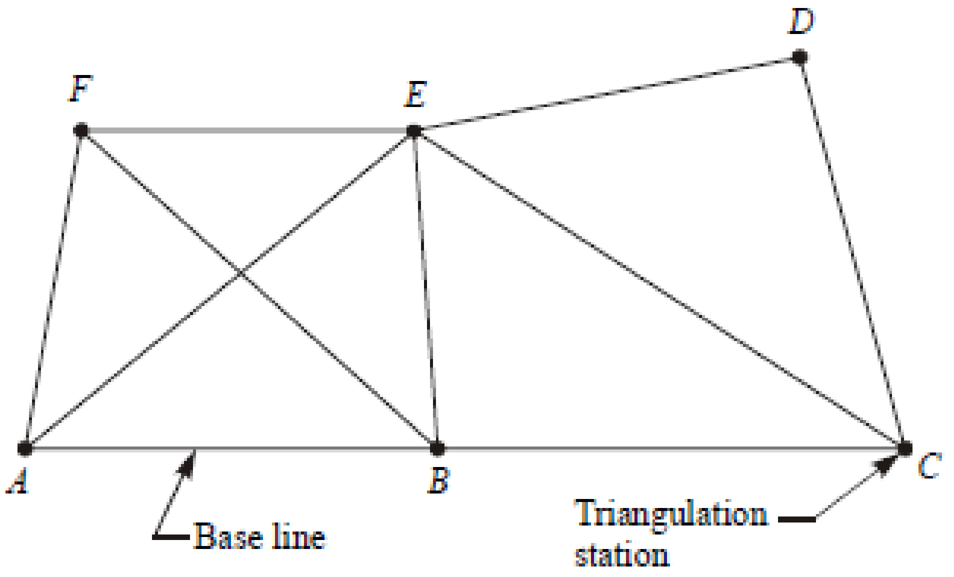
Criteria for Selection of Stations

Triangulation stations must be selected carefully to save a lot of time and funds by keeping the following key points in mind:



- Triangulation stations should be intervisible.
- Stations should be easily accessible with instruments.
- Station should form well-conditioned triangles.
- Stations should be located so that the survey lines are neither too small nor too long
- Cost of clearing and cutting and building towers should be minimum
- No line of sight should pass over the industrial areas to avoid irregular atmospheric refraction

Fixation of Stations



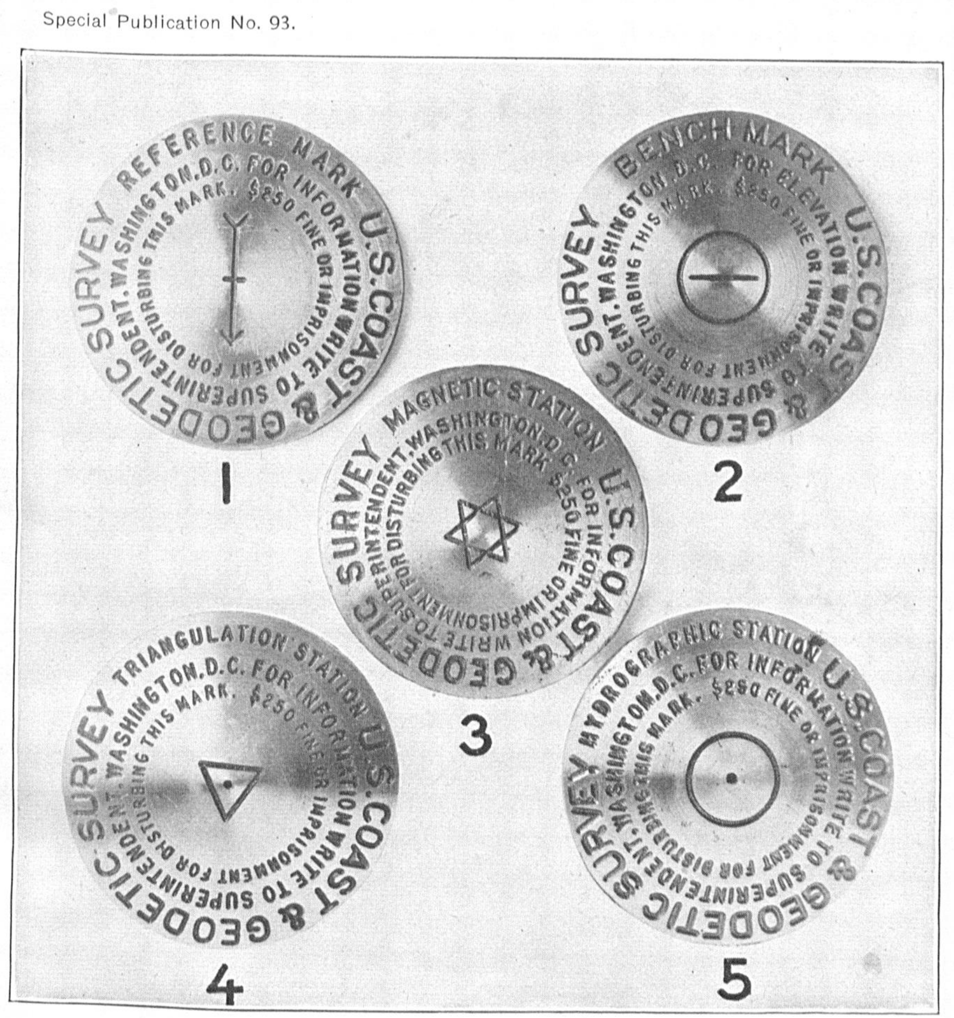
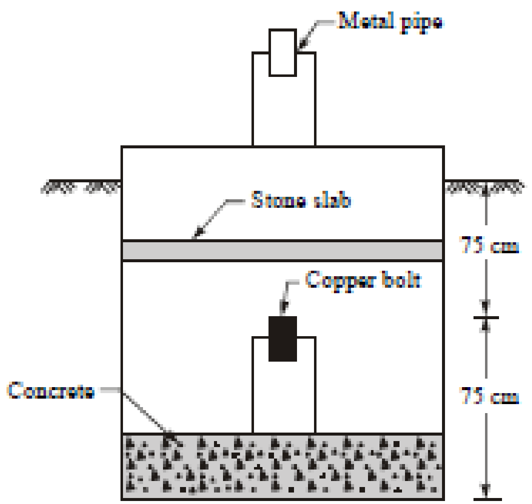
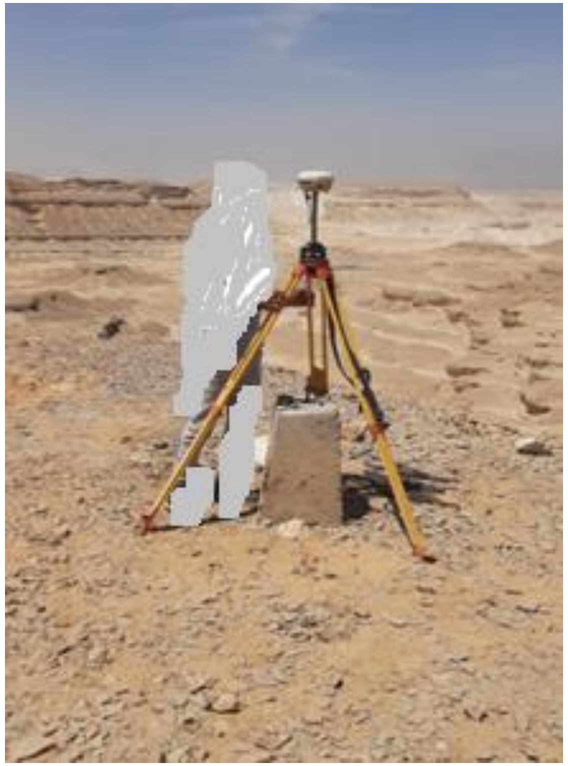


FIG. 26.—STANDARD MARKS OF THE U. S. COAST AND GEODETIC SURVEY.

1. Reference mark.
2. Bench mark.
3. Magnetic station mark.
4. Triangulation station mark.
5. Hydrographic station mark.

Fixation of Stations





Which of these stations are well-structured?

Factors to be Considered in Selecting a figure

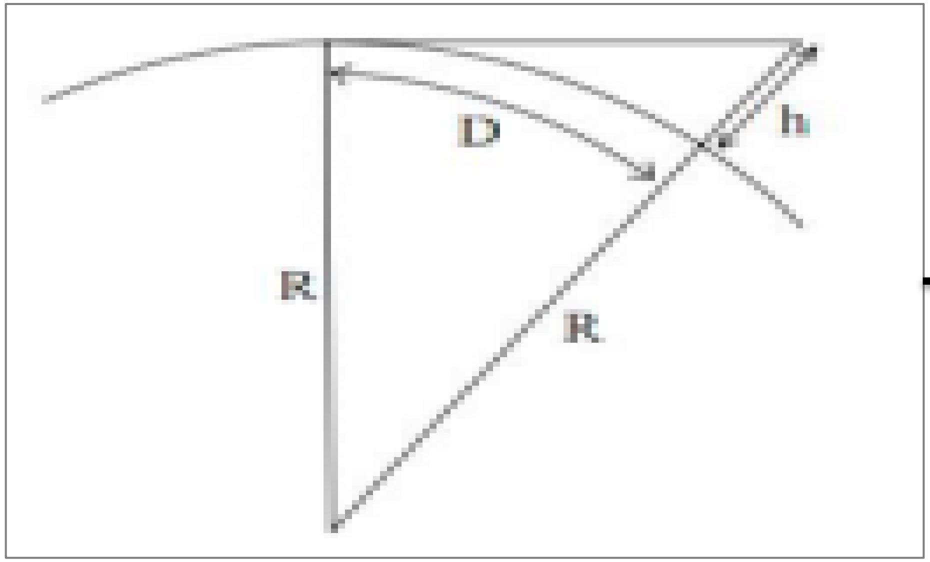
- Simple triangles should be preferably equilateral.
- Braced quadrilaterals should be preferably squares.
- Centered polygons should be regular.
- No angle of the figure, opposite a known side should be small.
- The triangles, whose angles are less than 30° or more than 120° should be avoided in the chain of triangles.
- In case of quadrilaterals no angle should be less than 30° or greater than 150°.
- The sides of the figures should be of comparable length.

INTERVISIBILITY BETWEEN STATIONS

- Does the intervening ground obstruct the intervisibility?

- The distance of horizon from the station of known elevation is given by:

$$h = \frac{D^2}{2R}(1 - 2k)$$



Special Publication No. 93.

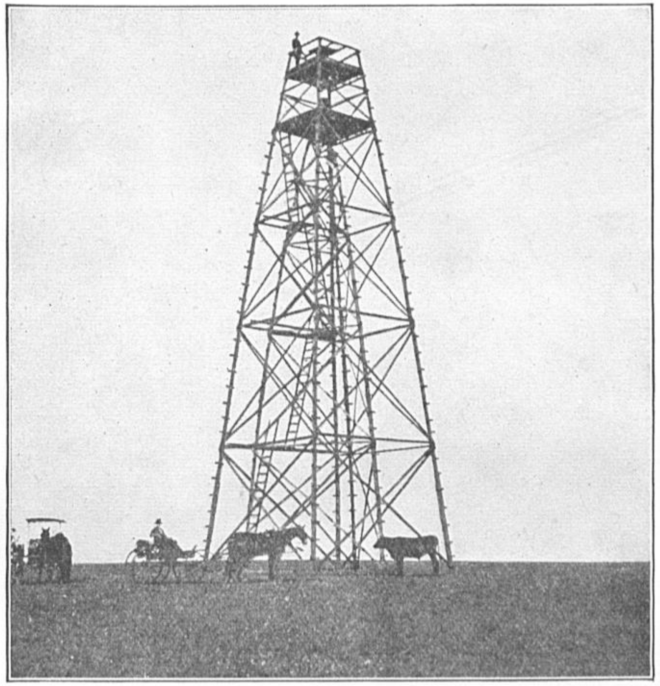


FIG. 27.—COMPLETED 60-FOOT SIGNAL.

Strength of Figure

$$R = F\sum(\delta_A^2 + \delta_A\delta_B + \delta_B^2)$$

R: Strength of Figure

F: Strength of Figure Factor, $F = \frac{D-C}{D}$, D: number of directions, C: number of conditions

δ_A, δ_B : The logarithmic differences corresponding to 1" for distance angles A and B

Satellite Station

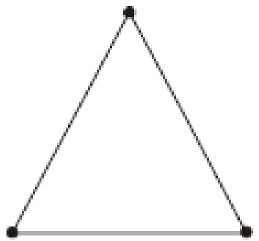
- In order to secure well condition triangle or better intervisibility objects such as church tops, flag poles or towers etc. are sometime selected as triangulation stations.
- If the instruments is impossible to set up over that point a subsidiary station known as a satellite station or false station is selected as near as possible to the main station.
- Observations are made to the other stations with the same precision from the satellite station.

CLASSIFICATION OF TRIANGULATION SYSTEM

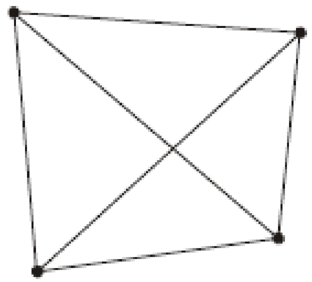
S.No.	Characteristics	First-order triangulation	Second-order triangulation	Third-order triangulation
1.	Length of base lines	8 to 12 km	2 to 5 km	100 to 500 m
2.	Lengths of sides	16 to 150 km	10 to 25 km	2 to 10 km
3.	Average triangular error (after correction for spherical excess)	less than 1″	3″	12″
4.	Maximum station closure	not more than 3″	8″	15″
5.	Actual error of base	1 in 50,000	1 in 25,000	1 in 10,000
6.	Probable error of base	1 in 10,00,000	1 in 500,000	1 in 250,000
7.	Discrepancy between two measures (k is distance in kilometre)	$5\sqrt{k}$ mm	$10\sqrt{k}$ mm	$25\sqrt{k}$ mm
8.	Probable error of the computed distances	1 in 50,000 to 1 in 250,000	1 in 20,000 to 1 in 50,000	1 in 5,000 to 1 in 20,000
9.	Probable error in astronomical azimuth	0.5″	5″	10″

TRIANGULATION FIGURES AND LAYOUTS

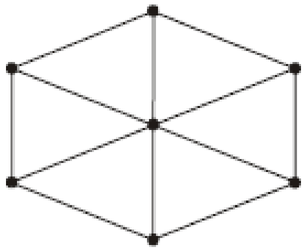
1. **Single chain of triangles**
2. **Double chain of triangles**
3. **Braced quadrilaterals**
4. **Centered triangles and polygons**
5. **A combination of these systems.**



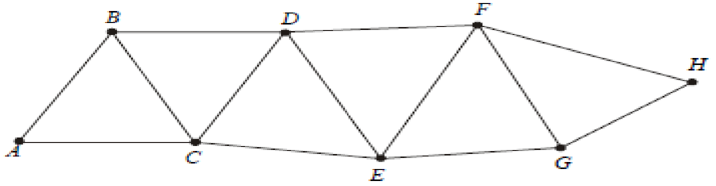
Triangle



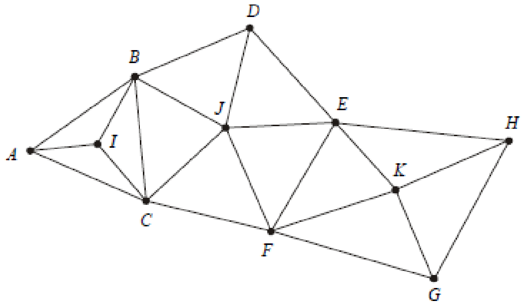
Braced quadrilateral



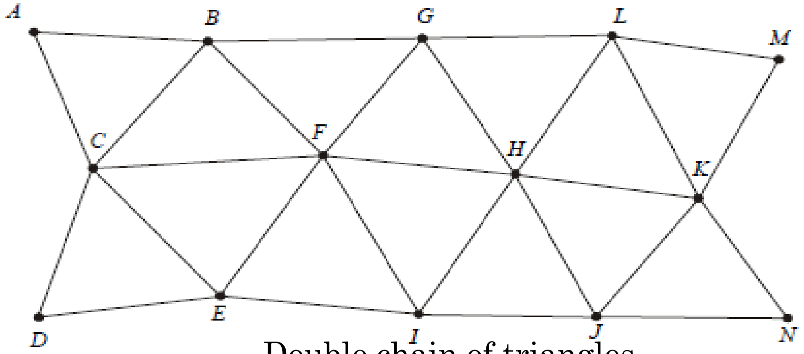
Polygon with central station



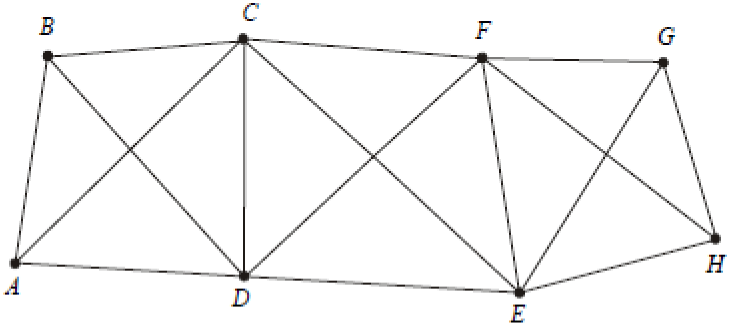
Single chain of triangles



Centered triangles and polygons

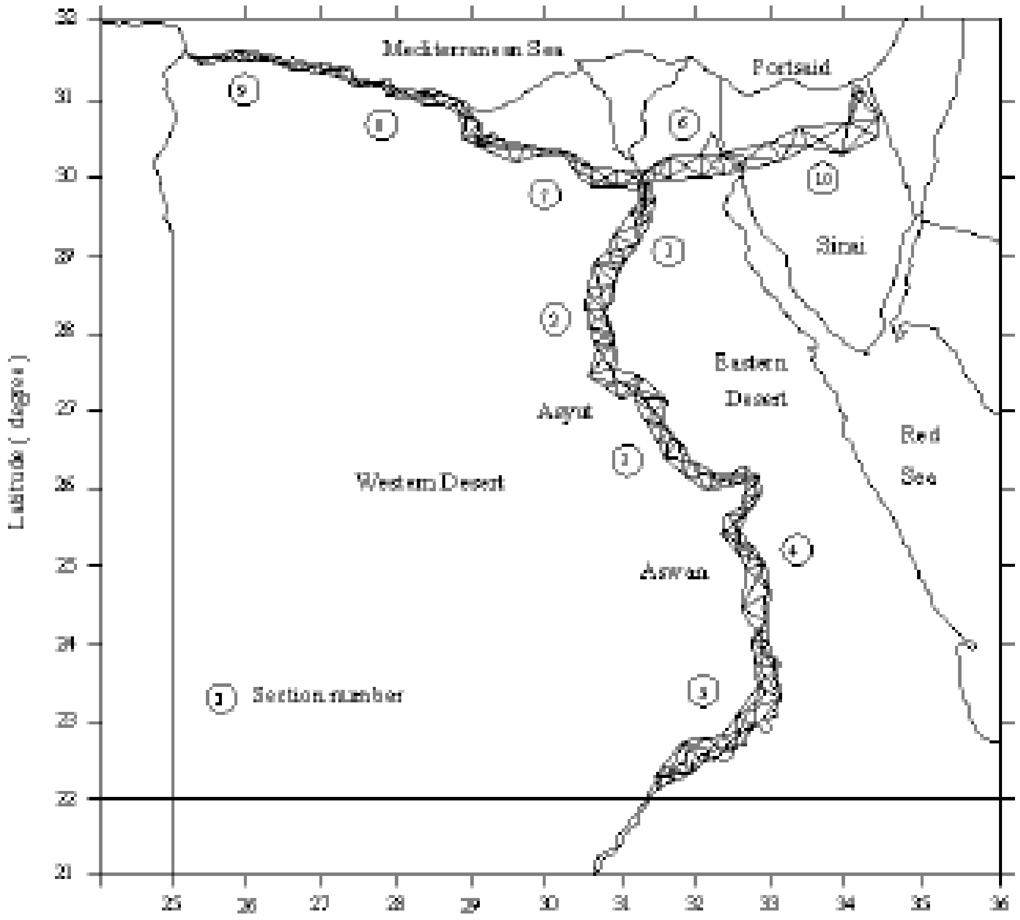


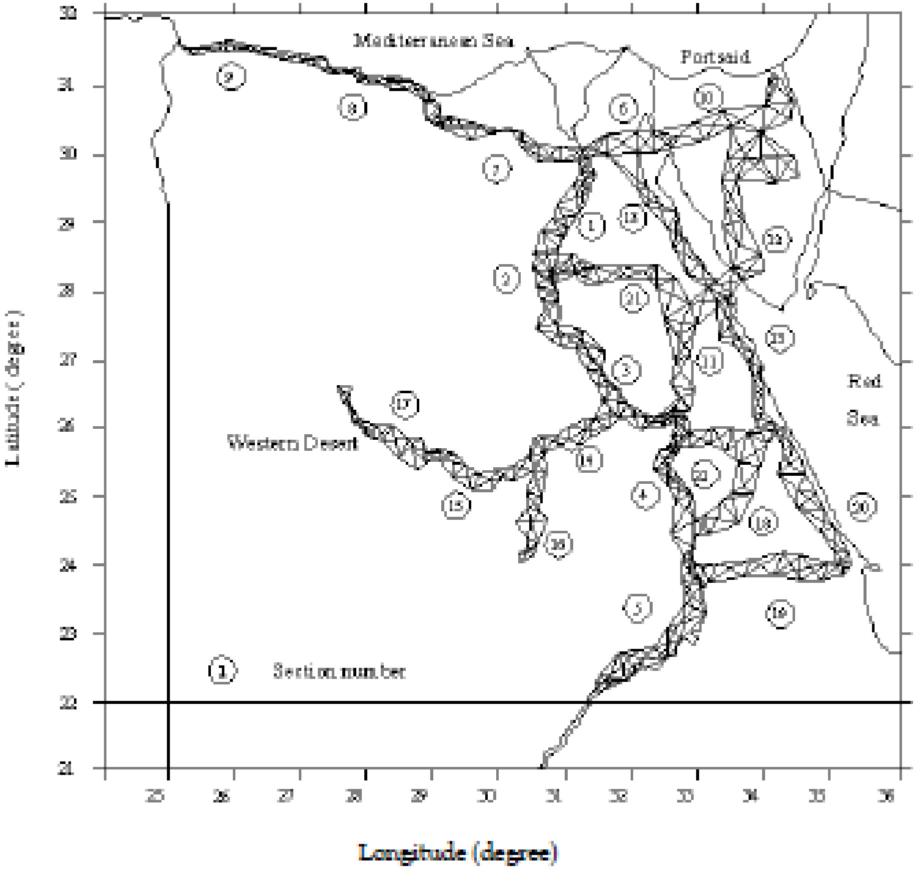
Double chain of triangles



Braced quadrilaterals

EGYPTIAN GEODETIC NETWORKS - TRADITIONAL

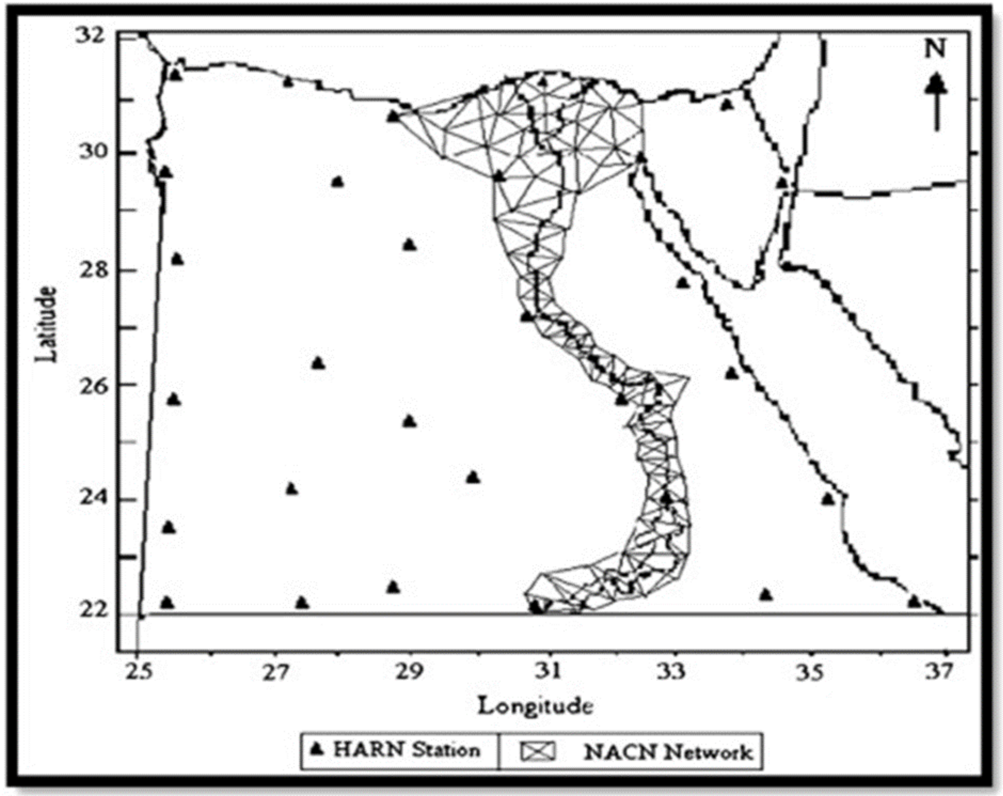




Egyptian Geodetic Networks - GPS

HARN order-A

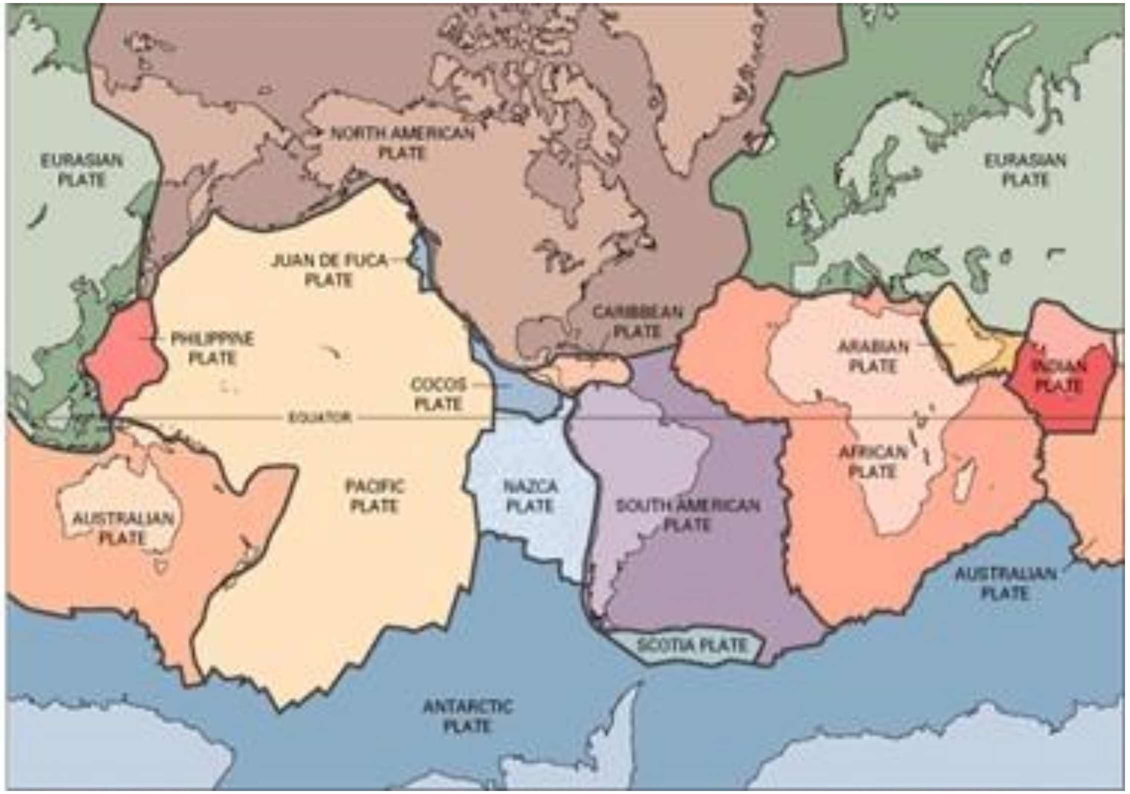
- 30 stations covering the Egyptian territory with an average spacing of approximately 200 km.
- Its relative accuracy estimate is 1:10,000,000 or 10 ppm.



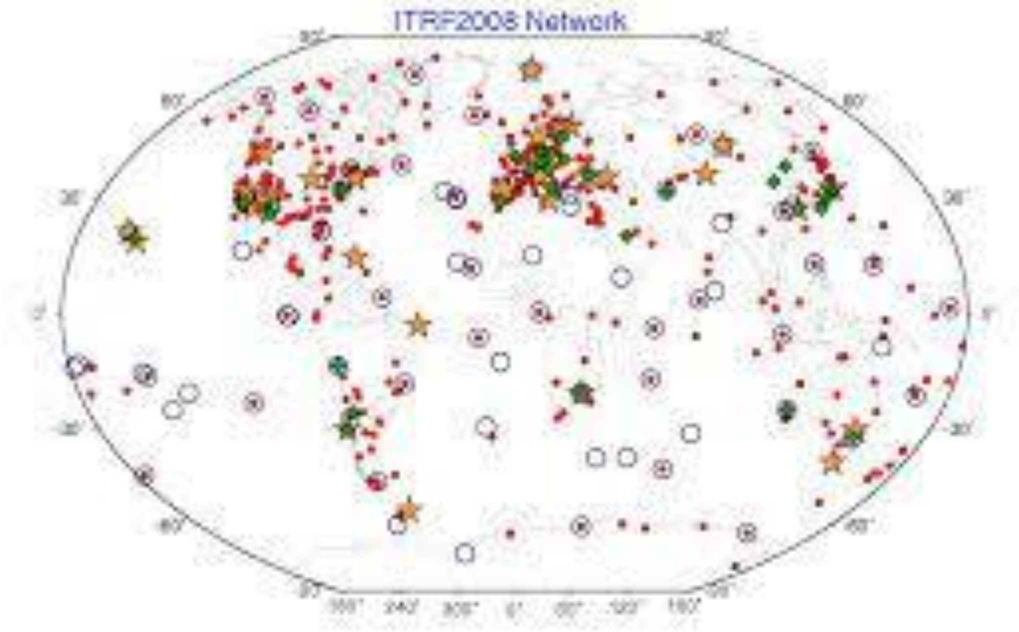
National Agricultural Cadastral Network (NACN) – HARN order-B

- 140 stations covering the Nile valley and Delta with a spacing of approximately 50 km.
- The relative accuracy estimate is 1:1,000,000 or 1 ppm.

Applications of Geodetic Control



The major tectonic plates. Source: USGS



THANK YOU

End of Presentation