ELECTRONIC SURVEYING MEASUERMENT

CHAPTER 7

CE 260 Surveying

History

Tape, Transit, Stadia, EDM & Data Collector

Prior to the total station, transits with EDMs and data collectors were used to record large numbers of points, and for measuring long distances. The systems were heavy, prone to failure, and many times the parts incompatible. Prior to these systems, optical (stadia) and manual (tape) systems were used to measure distances.

EDM

EDM = **E**lectronic **D**istance **M**easuring

- First introduced in the late 1950's
- At first they were complicated, large, heavy, and suited primarily for long distances
- Current EDM's use either infrared (light waves) or microwaves (radio waves)
- Microwaves require transmitters/receivers at both ends
- Infrared use a transmitter at one end and a reflecting prism at the other end.
- They come in long (10-20 km), medium (3-10 km), and short range (.5-3 km).
- They are typically mounted on top of a theodolite.

*EDM Properties *

Ranges

- Long (10-20 km),
- Med (3-10),
- Short (.5-3).
- Range limits up to 50 km

EDM can be mounted on telescope of most theodolite or on tribrach.
With theodolite it can measure horizontal and vertical distance.

← Total station

=

Theodolite with built in EDM

+

microprocessor

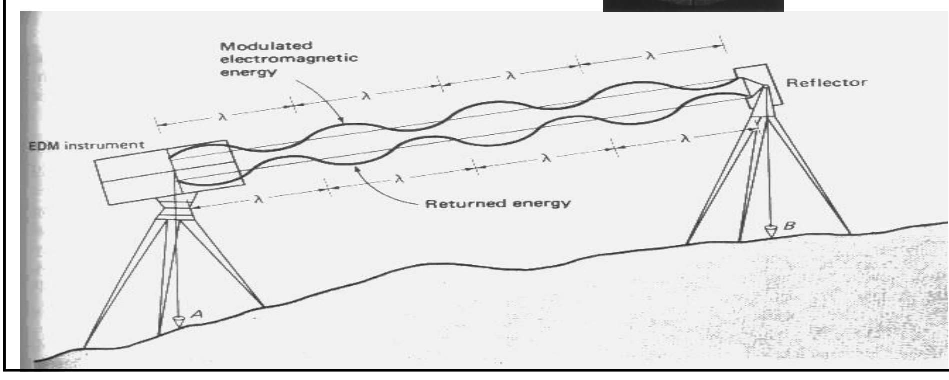
The Total Station

Measures and Records:
Horizontal Angles
Vertical Angles
and
Slope Distances

Calculates:
Horizontal Distance
Vertical Distance
Azimuths of Lines
X,Y,Z Coordinates
Layout
Etc.

Principles of EDM measurement

Operation:
A wave is transmitted and the returning wave is measured to find the distance traveled.



Principles of EDM measurement

- Distances determined by calculating the number of wavelengths traveled.

$$L = \frac{n\lambda + \phi}{2}$$

- Errors are generally small and insignificant for short distances.
- For longer distances they can be more important.
- Errors can be accounted for manually, or by the EDM if it has the capability.

Velocity of light can be affected by:

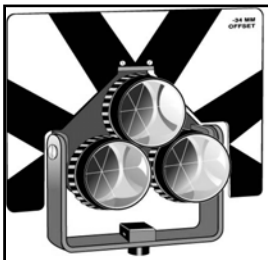
Temperature
Atmospheric pressure
Water vapor content

EDM Characteristics

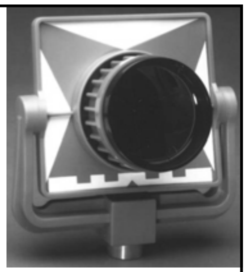
- 750-1000 meters range
- Accuracy ±(5mm + 5 ppm)
- Operating temperature between -20 to +50 degrees centigrade
- 1.5 seconds typical for computing a distance, 1 second when tracking.
- Slope reduction either manual or automatic.
- Some Instruments average repeated measurements.

Signal attenuation.

- battery operated and can perform between 350 and 1400 measurements.



Prisms



- Made from cube glass corners
- Have the property of reflecting rays back precisely in the same direction.
- They can be tribrach-mounted and centered with an optical plummet, or they can be attached to a range pole and held vertical on a point with the aid of a bulls-eye level.

EDM Accuracy

Distance (ft)	Error (ft)	Linear Precision	PPM
10	0.0164	1:600	1670
25	0.0165	1:1,500	670
50	0.0166	1:3,000	330
100	0.0167	1:6,000	170
300	0.0173	1:17,000	60
500	0.0179	1:28,000	35
1,000	0.0194	1:50,000	20
2,000	0.0224	1:90,000	10
4,000	0.0284	1:140,000	7
6,000	0.0344	1:170,000	6

Table 1: EDM Error Tabulated Over Distance Where Error is ±(5 mm + 3 PPM)

Two types of errors

Constant instrumental error

and

measuring error

· **Typical accuracy ± 5 mm + 5 ppm**

Both the prism and EDM should be corrected for off-center characteristics.

· The prism/instrument constant (about 30 to 40 mm) can be measured by measure AC, AB, and BC and then constant = AC-AB-BC

o------------------------------o-------------o

A B C

EDM Operation

Operation is divided into the following four steps.

1-Setup

· EDM Mounted on a tribrach or to a theodolite.

· The prism is set up on a tribrach or a prism pole over the remote point.

· The instrument is turned on to insure it is in good working order.

· The height of the prism and instrument are measured and recorded.

EDM Operation

2-Aim

- Aim is done by built in optical devices on the EDM or by the use of the theodolite telescope.
- If there is a sighting device on top of the EDM it will be higher than the electric signal.
- Fine tune sighting adjustments until an optimal signal is achieved.

EDM Operation

3-Measure

Slope distances are computed by pressing a “measure” button.

Many now compute horizontal and vertical distances as well, but will require further input.

Most EDM’s have a tracking mode (for layouts)

Hand-held radios help since long distances make communication difficult. Some models of

EDMs come with communications devices built in.

Some EDMs transmit the result as well so that the surveyor holding the prism will be immediately aware of the results (useful when tracking)

EDM Operation

4-Record

Conventionally in field note book

Manually in a data collection device.

Automatically recorded by some total station devices.

Uses

Topo & As Builts

Monitoring & Control

Construction Layout

Uses

•**Total stations are ideal for collecting large numbers of points.**

•**They are commonly used for all aspects of modern surveying. Only when harsh conditions, exist or distances are short will a transit and tape be used**.

Problems

Total stations are dependant on batteries and electronics. The LCD screen does not work well when it is cold and battery life is also short, batteries and electronics both do not work well when wet,

Total stations are typically heavier that a transit and tape

Loss of data is an important consideration

Plane Geometry

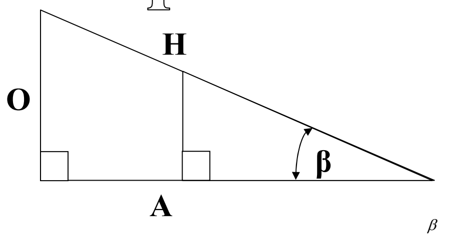
"The Flat Earth Society"

Plane geometry vs. Spherical geometry

Angles
error ≈ 1" within 200 km² area

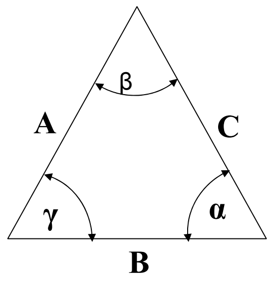
Distances
Error ≈ 0.009 mm per km

Simple Plane Geometry



$$Sin\beta = \frac{O}{H} = \frac{xO}{xH}$$
$$Cos\beta = \frac{A}{H} = \frac{xA}{xH}$$
$$Tan\beta = \frac{O}{A} = \frac{xO}{xA}$$

$$\frac{Sin\beta}{B} = \frac{Sin\alpha}{A} = \frac{Sin\gamma}{C}$$
$$C^2 = A^2 + B^2 - 2AB \times Cos\gamma$$

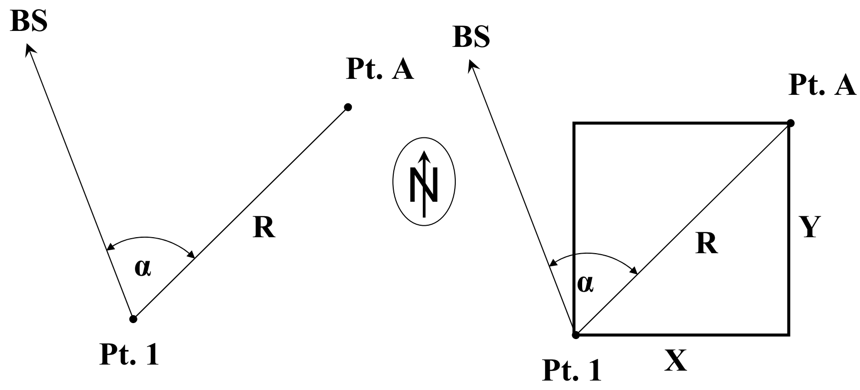


Geometry of EDM Measurements

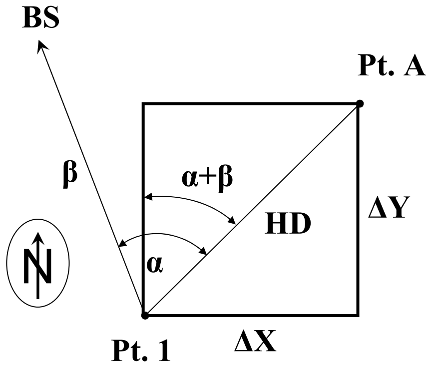
- Relatively simple if hi = HR
- More complicated when the EDM is on top of the theodolite and the prism is higher than the target

(delta HR not equal to delta hi).

Plane Coordinates



Horz. Coordinates



β = BS Bearing
α = HA
α+β = Bearing of 1toA

$(\Delta X, \Delta Y)$ From $(\mathrm{HD}, \alpha, \beta)$

$$\Delta X = HD \times Sin(\alpha + \beta)$$

$$\Delta Y = HD \times Cos(\alpha + \beta)$$

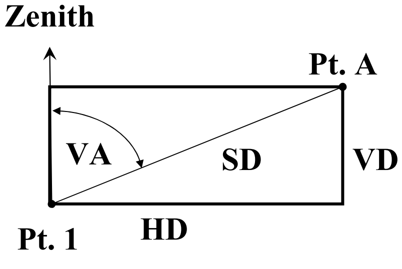
$(\mathrm{R}, [\alpha + \beta])$ From $(\Delta \mathrm{X}, \Delta \mathrm{Y})$

$$HD = \sqrt{\Delta X^2 + \Delta Y^2}$$

$$[\alpha + \beta] = ArcTan\left(\frac{\Delta X}{\Delta Y}\right)$$

$$[\alpha + \beta] = ArcSin\left(\frac{\Delta X}{HD}\right)$$

Vert. Coordinates



Zenith = Up
Nadir = Down
Horizon = 90°

(HD, VD) From (SD, VA)

$$HD = SD \times Sin(VA)$$

$$VD = SD \times Cos(VA)$$

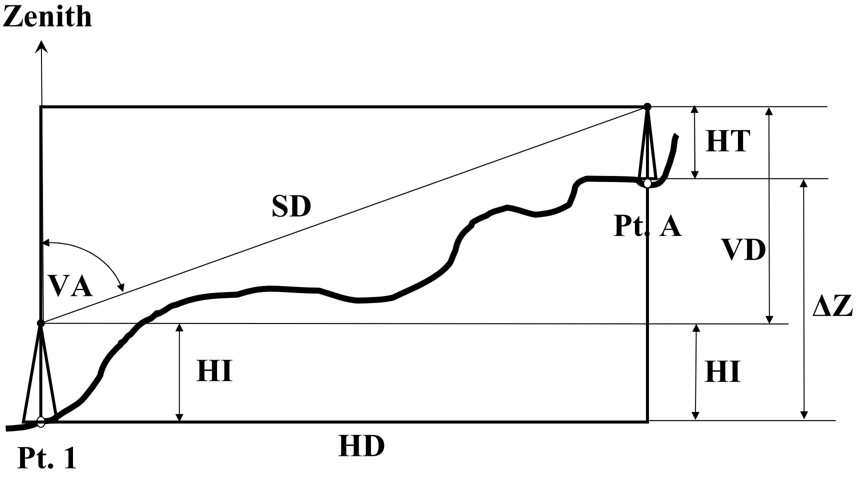
$(\mathrm{SD}, \mathrm{VA})$ From $(\mathrm{HD}, \mathrm{VD})$

$$SD = \sqrt{HD^2 + VD^2}$$

$$VA = ArcTan\left(\frac{HD}{VD}\right)$$

$$[VA] = ArcSin\left(\frac{HD}{SD}\right)$$

Trig Leveling



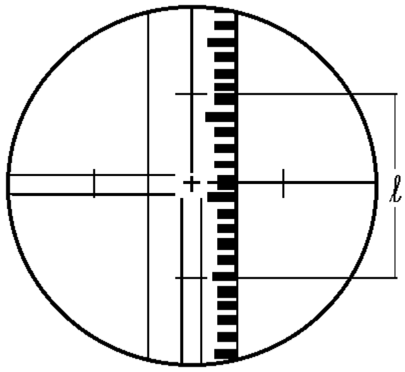
Stadia Principles

- A form of tachometric measurement that relies on a fixed-angle intercept.
- It is used for the location of natural features that themselves cannot be precisely defined or located
- Two additional cross-hairs are placed in the scope so that if a rod were held 100 feet away from the telescope (with it being level) the difference on the rod would be 1.00 feet.
- Distance is determined by D=100S where S is the rod interval.

PRACTICAL APPLICATION

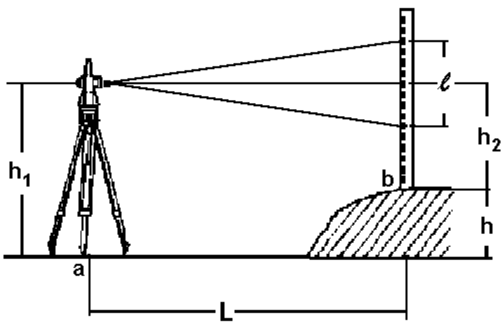
- Use the stadia lines to measure the target distance and elevation.

The stadia lines on the telescope reticle correspond to the focal distance.
This ratio will always be supplied by the manufacturer of the equipment.
For most levels, transits, and theodolites the stadia lines correspond to one hundredth (1/100) of the focal distance



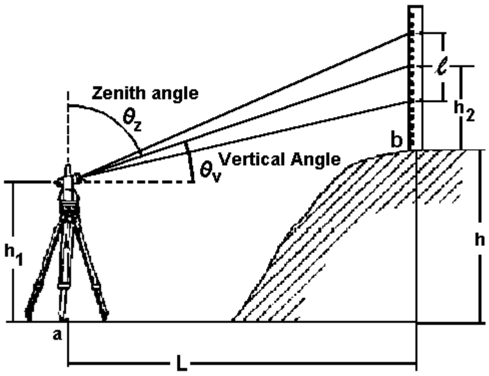
TELESCOPE HORIZONTAL

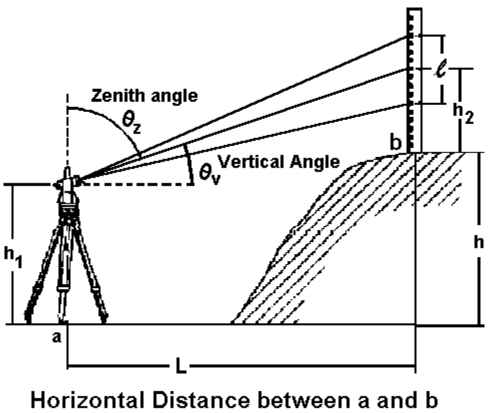
- *The horizontal distance between a and b:*
- *L = 100 x l*
- *The height difference between a and b:*
- *h = h1 - h2*



TELESCOPE NOT HORIZONTAL

- D = 100S
- S = S’cos(q)
- D = 100S’cos(q)
- H = Dcos(q)
- H = 100S’cos^2(q)
- V = Dsin(q)
- D = 100S’cos(q)
- V = 100S’cos(q)sin(q)
- Elev B = Elev A + hi ±V - RR





Horizontal Distance between a and b

$L = 100 \times \ell \times \cos^2\theta_v$

$L = 100 \times \ell \times \sin^2\theta_z$

Height Difference between a and b

$h = 50 \times \ell \times \sin(2\theta_v) + h_1 - h_2$

$h = 50 \times \ell \times \sin(2\theta_z) + h_1 - h_2$