Total Stations

Total stations

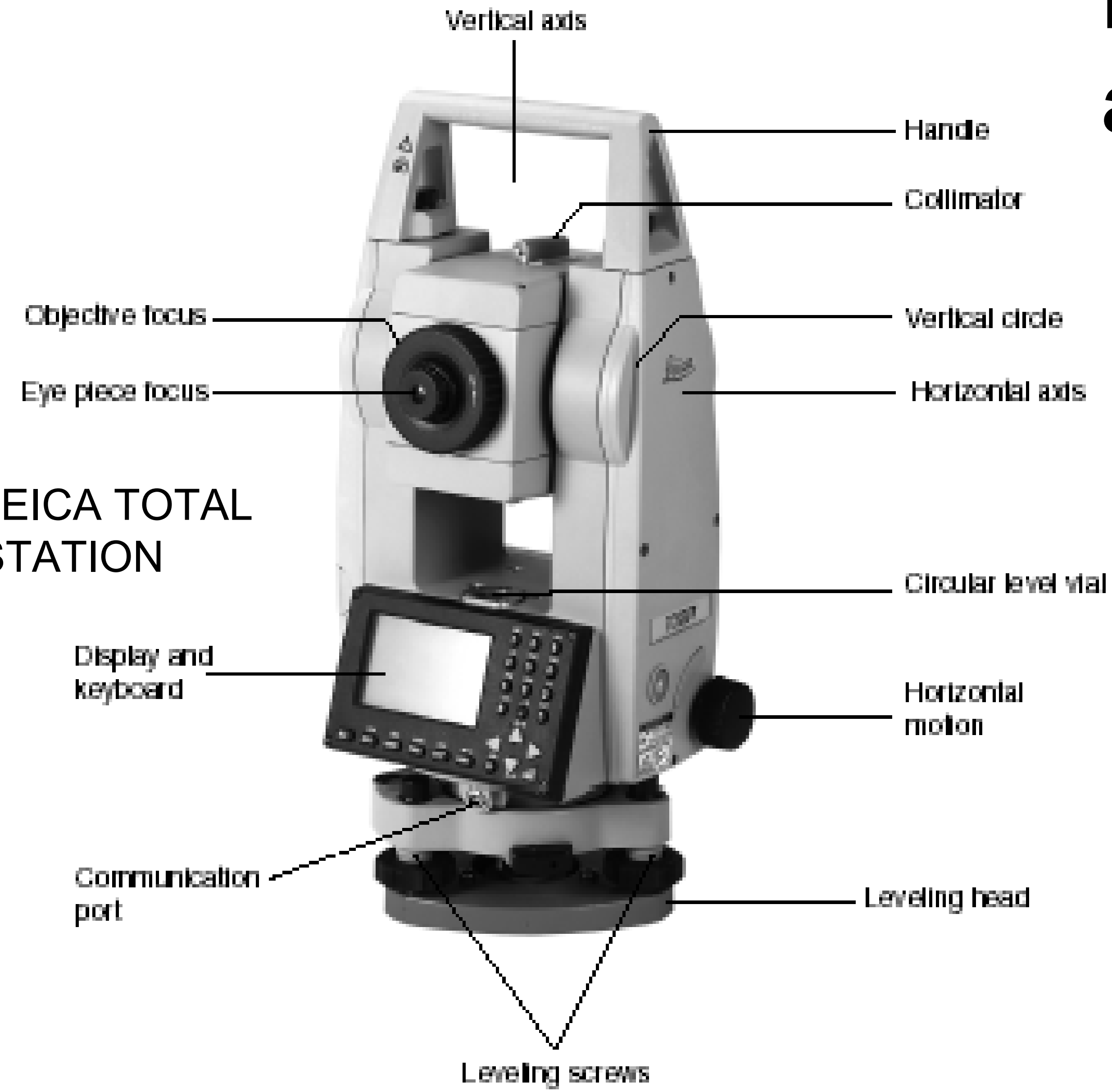
- A total station must include:
  - Electronic theodolite
  - EDM
  - Processor “computing power”
- A total station can read and record horizontal and vertical angles through the theodolite, slope distances through the EDM, and perform various mathematical operations through the processor.
- Programs and functions are different from one brand to the other, but most of the surveying functions are built into the any total station such as:
  - averaging angles and distances,
  - determining X, Y, Z (elevation) coordinates from angles and distances measured,

- setting out of points,
- remote object elevations,
- distance between remote points,
- Traversing: calculations of errors and adjustments
- Resection: computation of unknown occupied point coordinates by observing known points.
- making atmospheric and instrumental corrections.

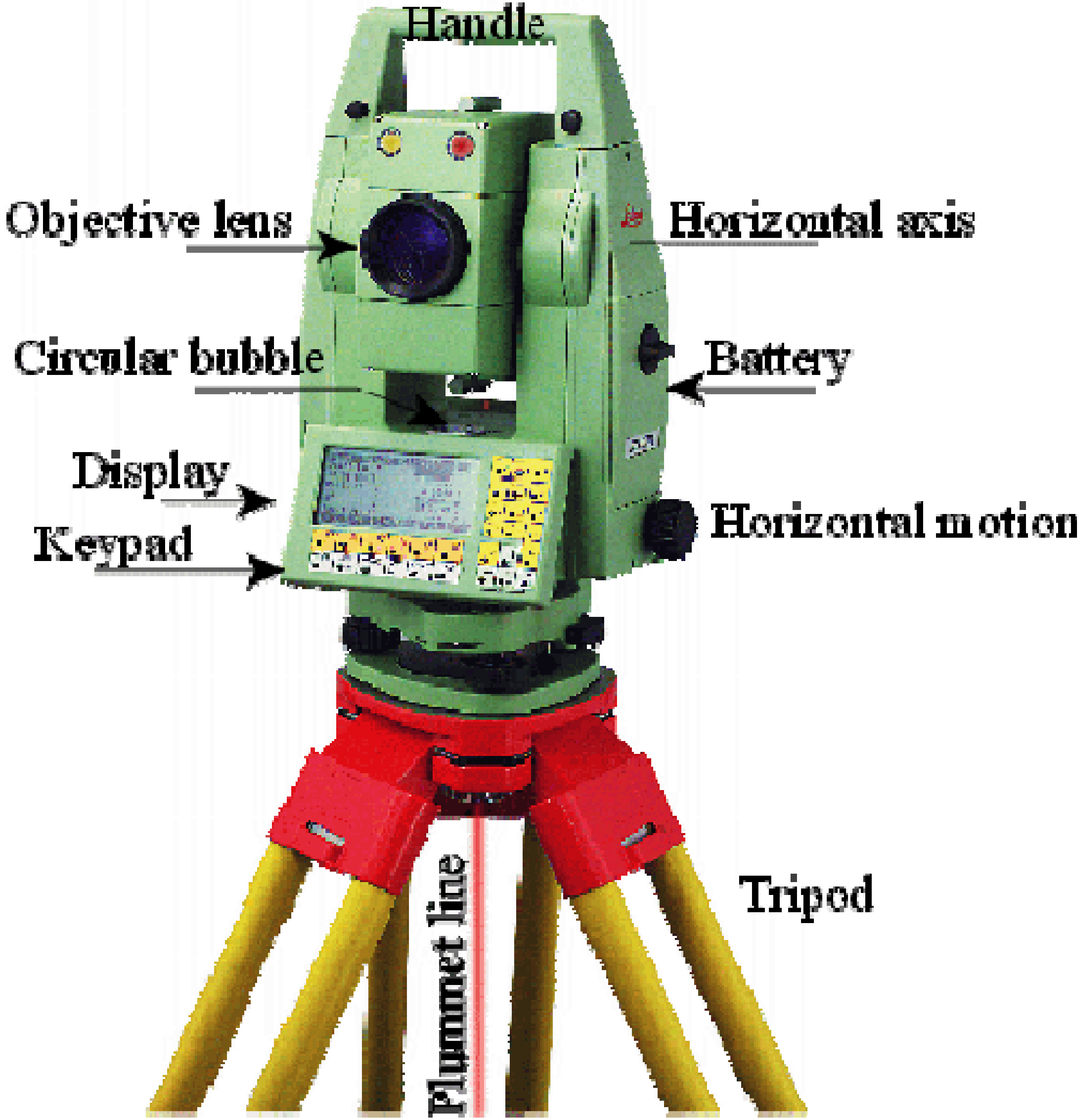
- Measurements are recorded on “data collectors of various types such as cards or little instruments.
- Data can be uploaded from a computer to the TS; and Data can be downloaded to a computer from the TS through a card reader or directly from the TS to the computer via a cable.
- Total stations display the amount of battery charge and will allow the input of variables such as the prism constant and *ppm* for atmospheric effect.

Major Parts of a Total Station

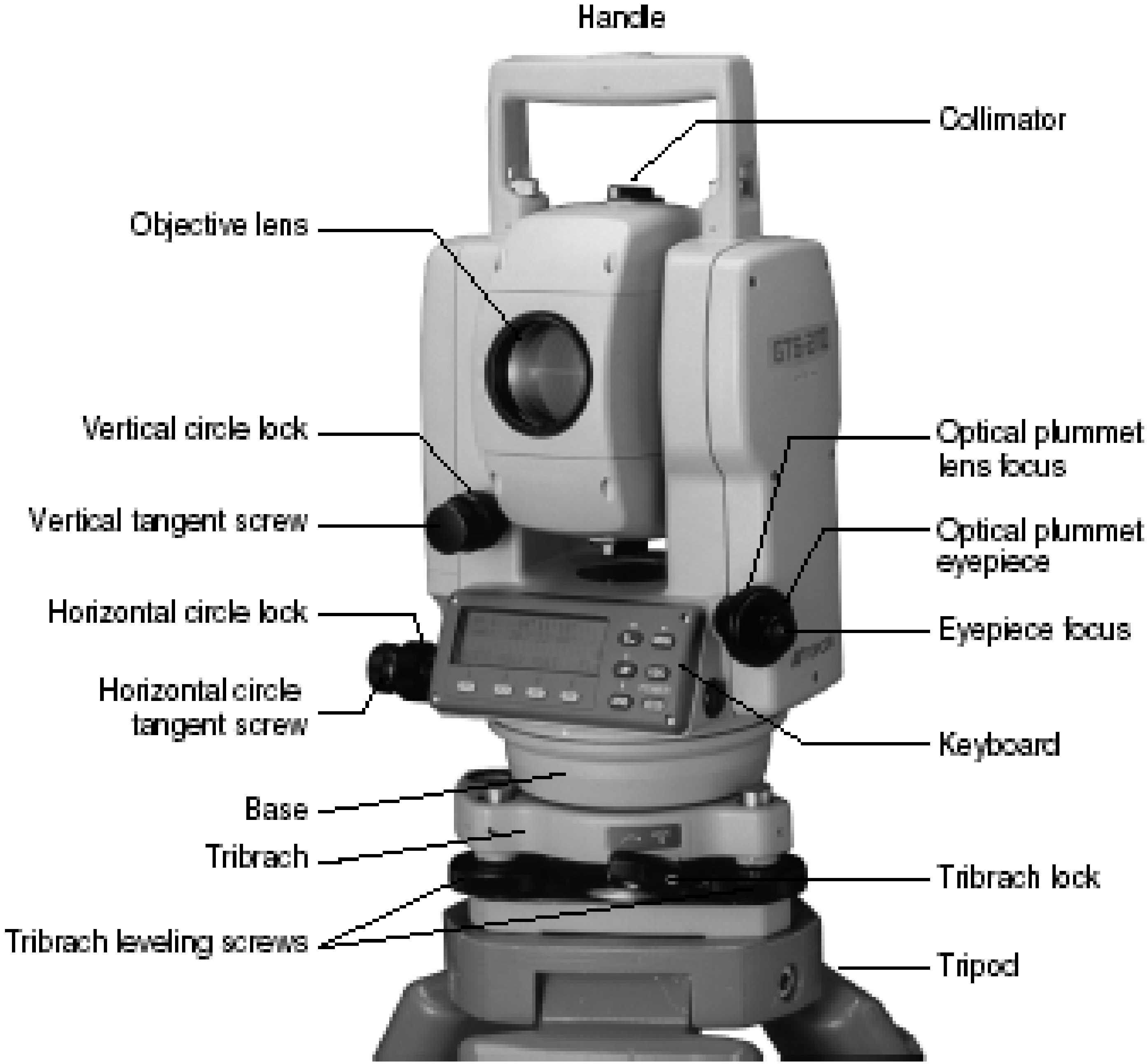
LEICA TOTAL STATION



Parts of a total station instrument, with view of eyepiece end of telescope. (Courtesy Leica Geosystems, Inc.)

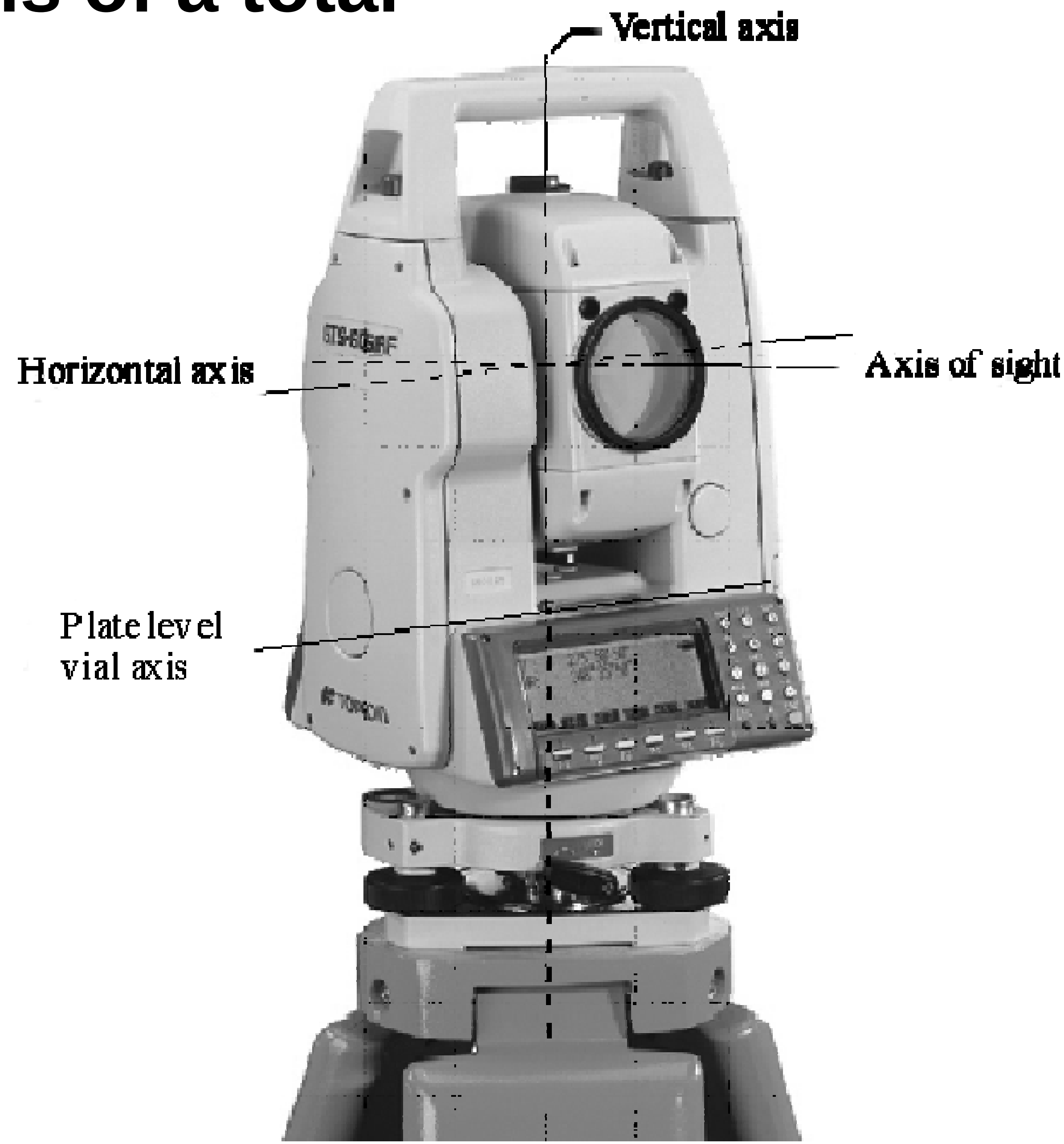

Handle
Objective lens
Horizontal axis
Circular bubble
Battery
Display
Keypad
Horizontal motion
Tripod
Plummet line

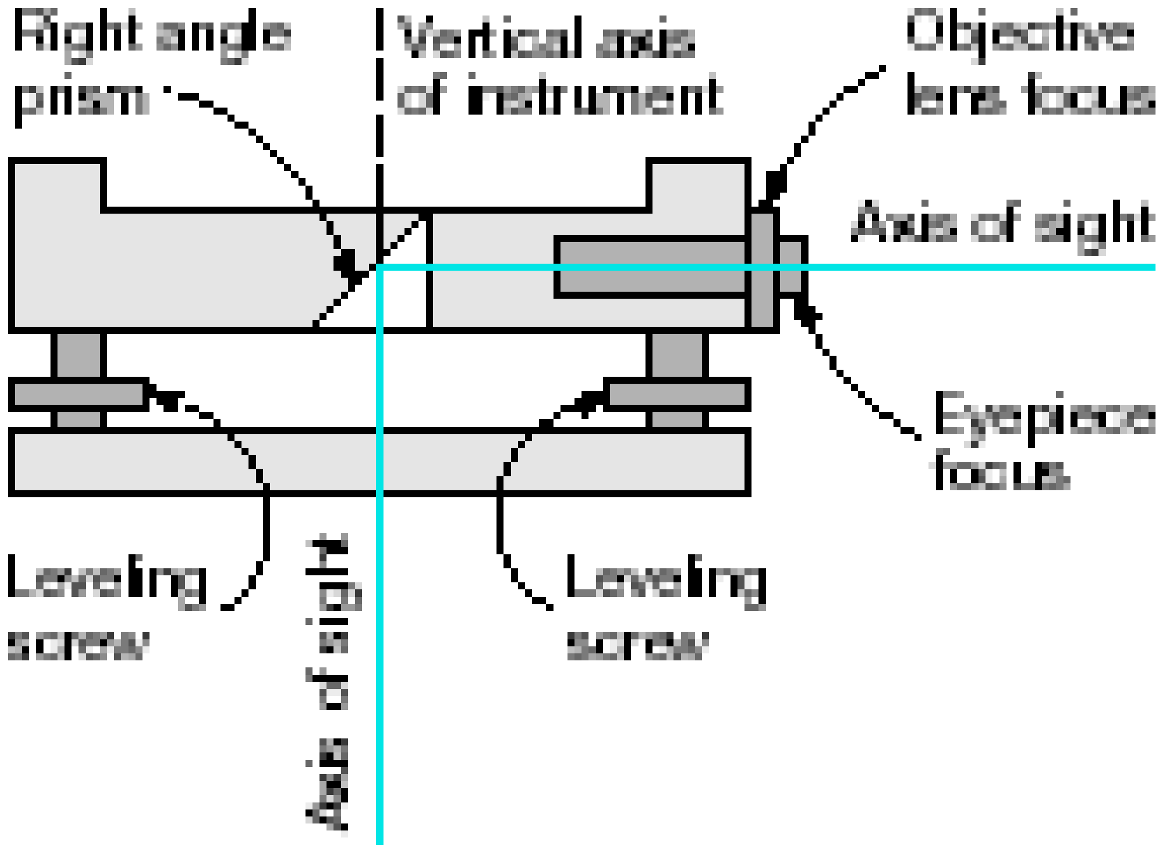
TOPCON TOTAL STATION



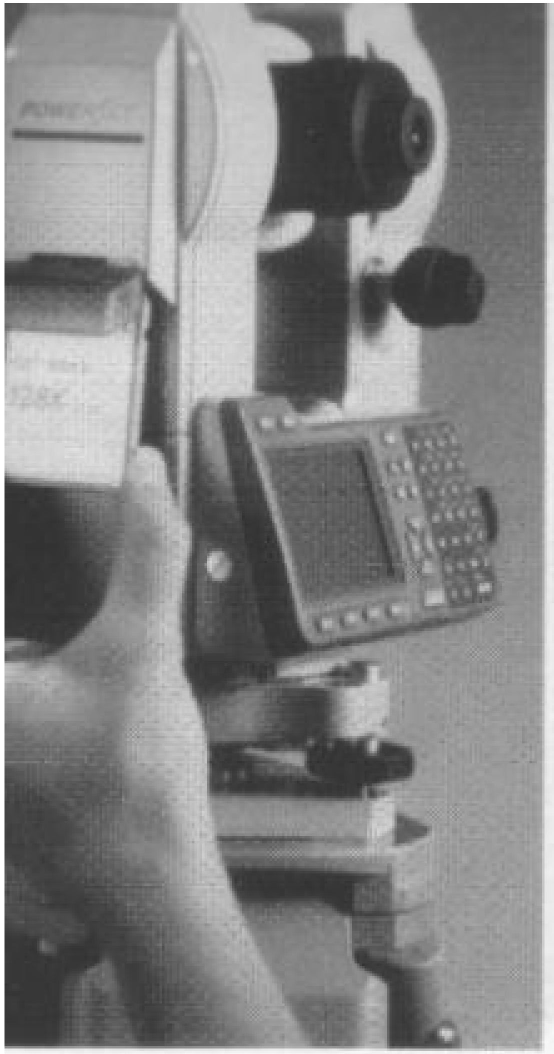
Parts of a total station instrument with view of objective end of the telescope. (Courtesy Topcon America Corp.)

Major axis of a total station





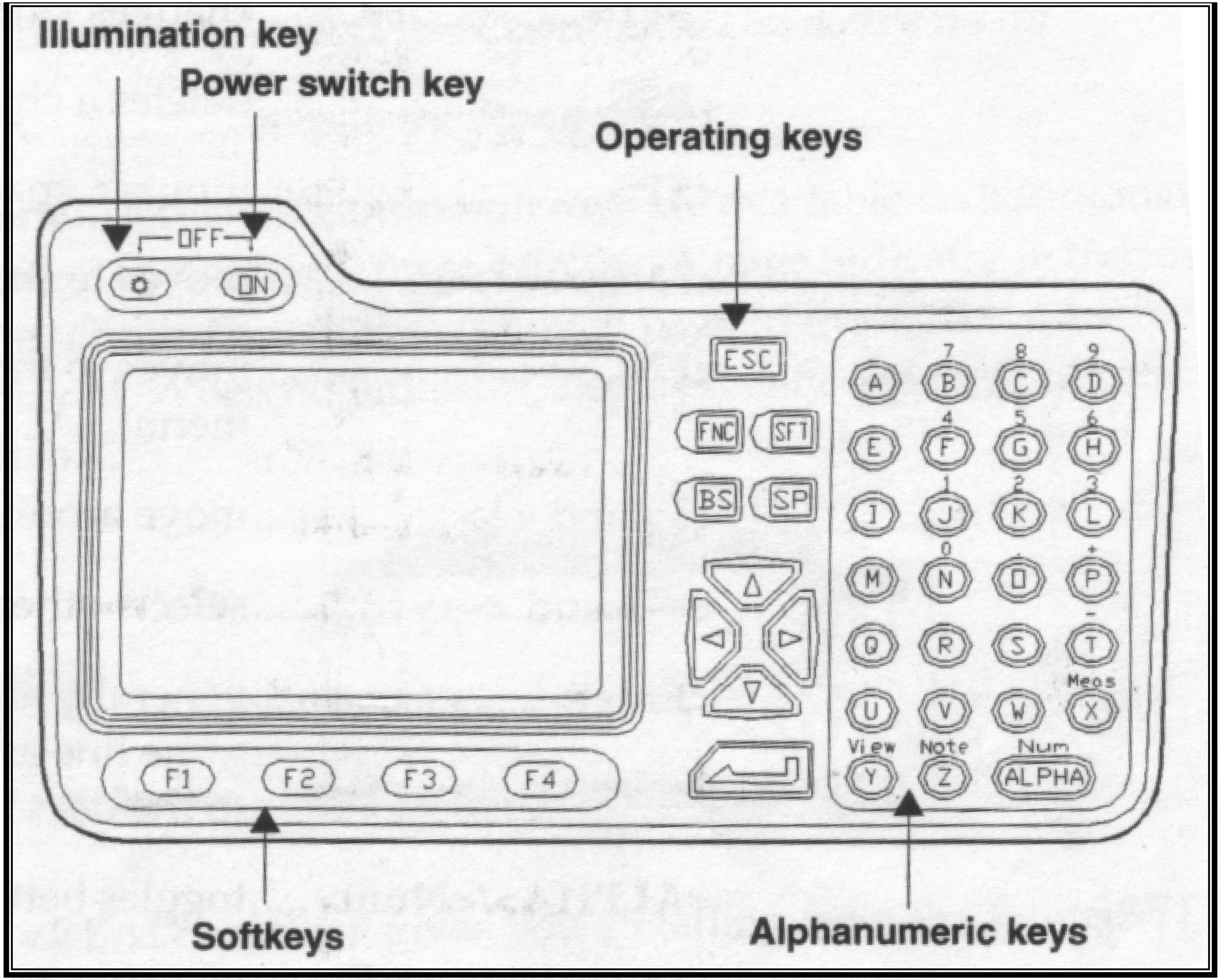
Optical Plummet



Memory Card

Sokkia Total Station Display

Topcon Data Collector



Sokkia PowerSET Keyboard Layout

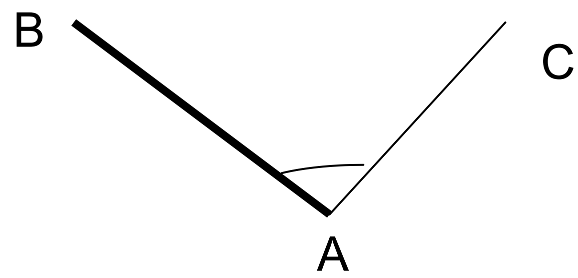
Azimuth Equations

Important to remember and understand:

$$tan(AZ_{AB}) = \frac{\Delta X}{\Delta Y} = \frac{X_B - X_A}{Y_B - Y_A} = \frac{Departure}{Latitude}$$

$$\Delta X = d * sin(AZ)$$

$$\Delta Y = d * cos(AZ)$$



Azimuth of a line (AC)=Azimuth of the line AB ±angle (BAC)

Total station (TS) Operation

Background

Knowing the azimuth of a line such as C1- R, and the length of the line, coordinates of (R) can easily be computed and displayed on the screen:

$X_R = X_C + \Delta X_{RC}$, $Y_R = Y_C + \Delta Y_{RC}$

Where: $\Delta X_{RC} = Length_{RC} \sin(AZ)_{RC}$ and

$\Delta Y_{RC} = Length_{RC} \cos(AZ)_{RC}$

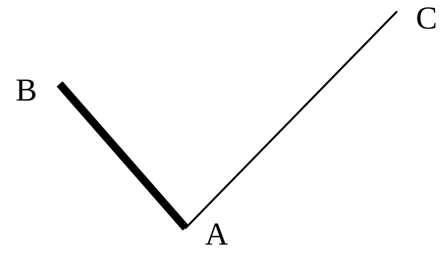
- So, for a TS to compute coordinates, it needs to measure the distance from a known point such as C in the example, and the azimuth of the line RC.

- We do not measure Azimuth, why?? But we measure angles.
- For this we need to start with a known length and a known azimuth, we measure the angle from the line of known azimuth and compute the azimuth of the new line, then solve for the new point.

EXAMPLE:

Compute the coordinates of point C if the coordinates of points B and A were:

Point	X (m)	Y(m)
B	738.23	654.34
A	823.58	457.50



A total station was used to measure angles and distances from point A. The angle BAC was 95° 45’ 34”, the length AC was 255.84 m,

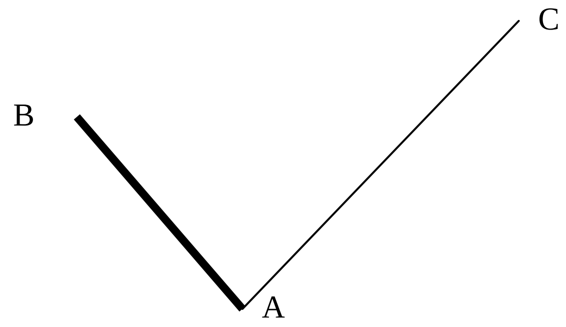
Answer

- Compute the azimuth of the line AB:

$$tan(AZ_{AB}) = \frac{\Delta X}{\Delta Y} = \frac{X_B - X_A}{Y_B - Y_A} = \frac{Departure}{Latitude}$$

- Compute the azimuth of the line AC:

Azimuth AC = Azimuth AB + 95° 45’ 34”



- $X_C = X_A + L_{CA} \sin Az_{AC}$
- $Y_C = Y_A + L_{CA} \cos Az_{AC}$

- This is how a TS computes coordinates. Before computations, it needs to know the coordinates where it is at and a reference azimuth. This process is called “orientation” of the total station.

Total station (TS) Operation

1. **Upload data to the TS from a computer if needed such as:**

   - names (codes) and coordinates of control stations such as C1, C2, and so on. What are codes and why are they important??

   - azimuth of a known line such as the azimuth of C_1-C_2

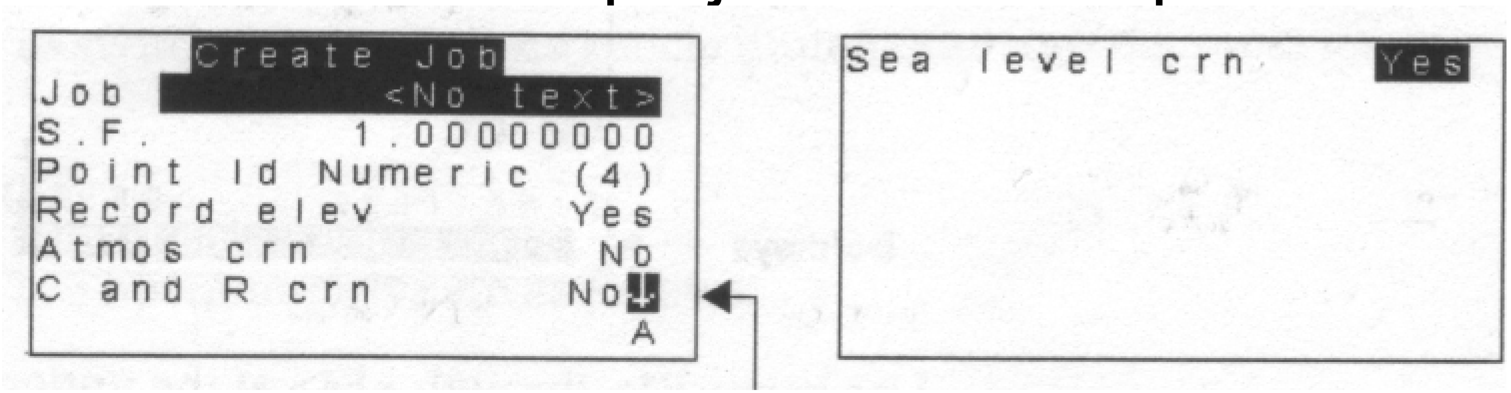
   - coordinates of points to be set-out such as points on a road, corners of a building, etc.

2. When you turn on the instrument you first **check and update**:

- Power level: Sokkia goes from “0” weak to “3” strong.
- Prism Constant “P.C”
- Temperature and pressure for environmental effects “ displayed variable is *ppm*”
- Curvature and refraction corrections
- Sea level Correction
- Instrument height, measure it and update it
- Target height.

– Measuring units: meter or feet for distances and angles in degrees or grad.

– Create a new “Job file”, or open an existing one to append or add to it. Measurements are stored in electronic files called “job files” this way you have the data associated with a certain project in one place, data of different projects will not get mixed. This also allows you to use the same instrument to work at different projects and keep their data



Creating a Job File in a Sokkia Power Set TS

3- TS Orientation

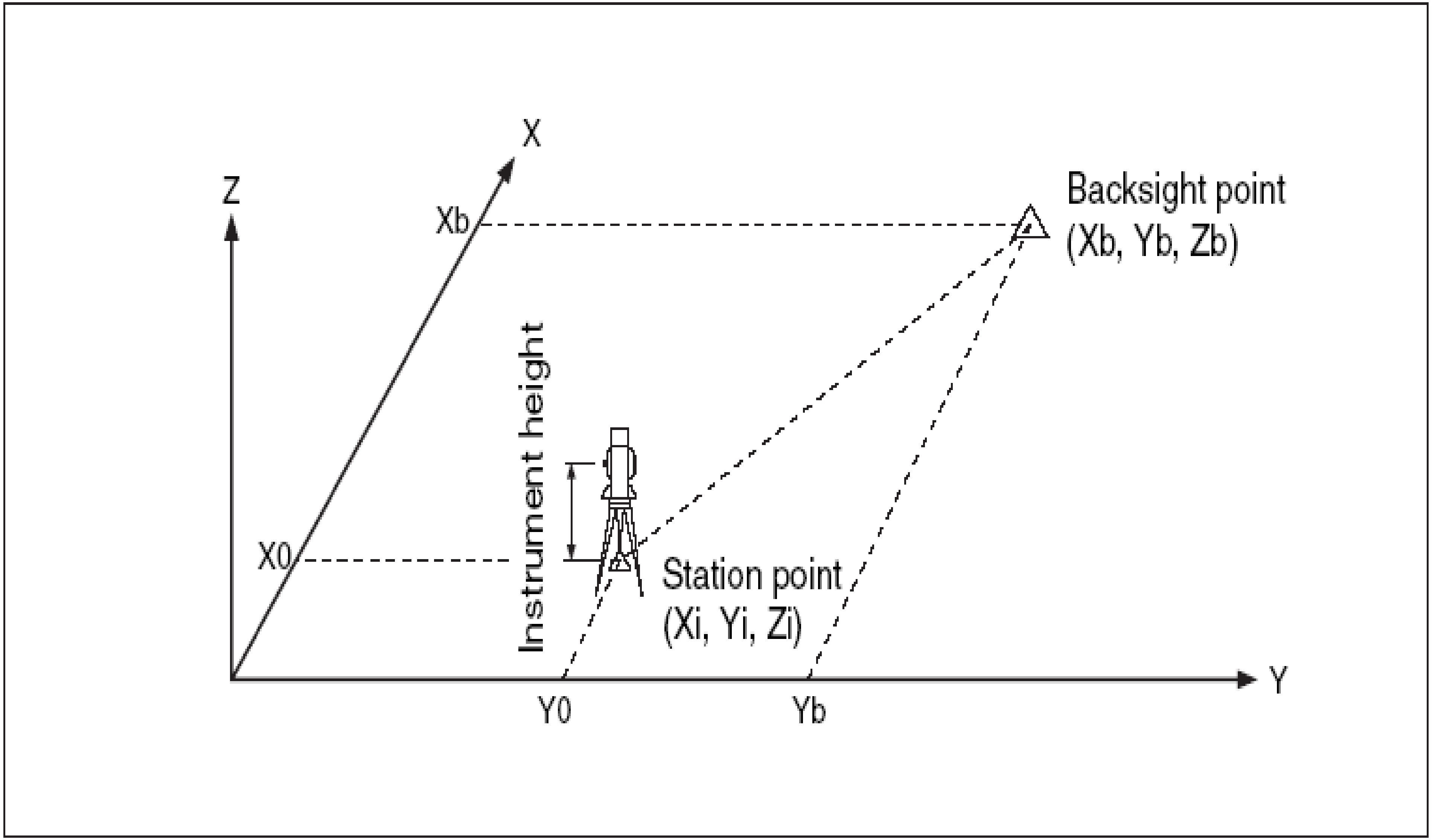
set it up so that a horizontal zero reading is north, or local north. In other words, the goal of the orientation process is to “tell” the TS where it is and where north is. You do that by occupying a point such as C_1 called the **station** and perform the orientation by one several methods such as:

<u>3-1 Using two known points</u>

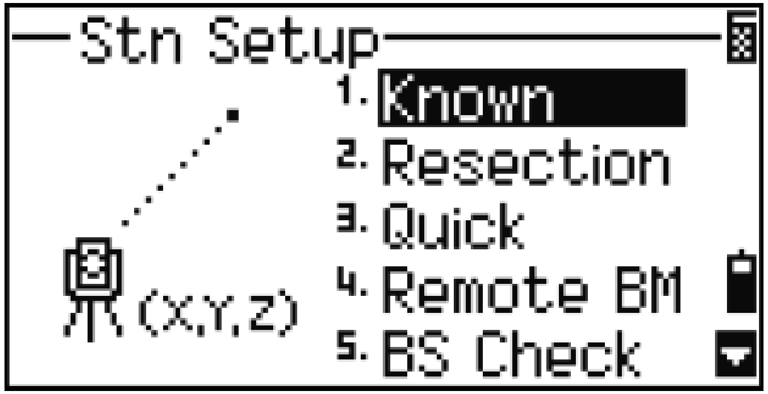
Occupy one of the known points, say (O), aim at a prism on a another known point such as (b) called “**backsight**”. The TS will compute the azimuth of the line O-b = $\tan^{-1}\{(Xb - Xo)/(Yb - Yo)\}$

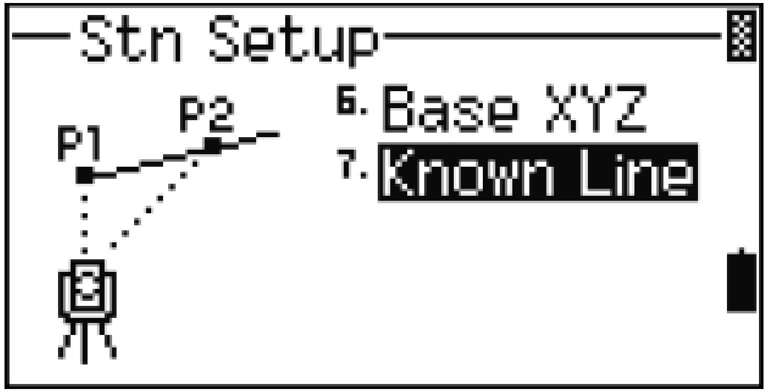
Now the total station knows where it is:

- on point (O) of known stored coordinates, and
- where north is: it knows that the line O-b is at angle from north that is equal to the azimuth of the line O-b.

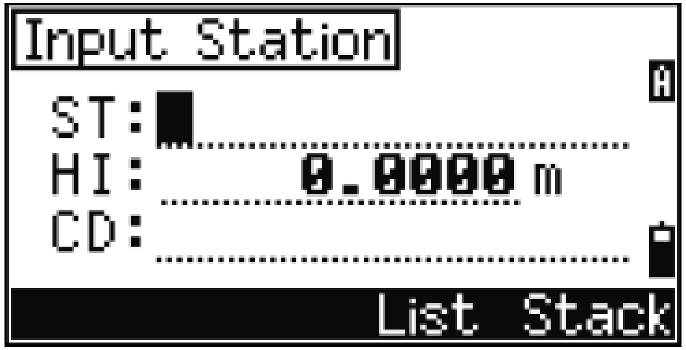


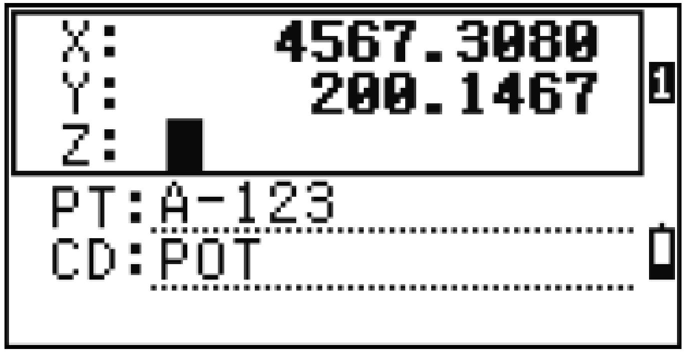
Geometry of a Two-Point TS Orientation



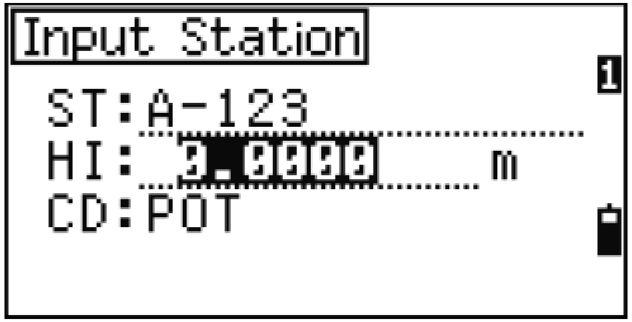


First you select a method for orientation “Nikon TS” for example



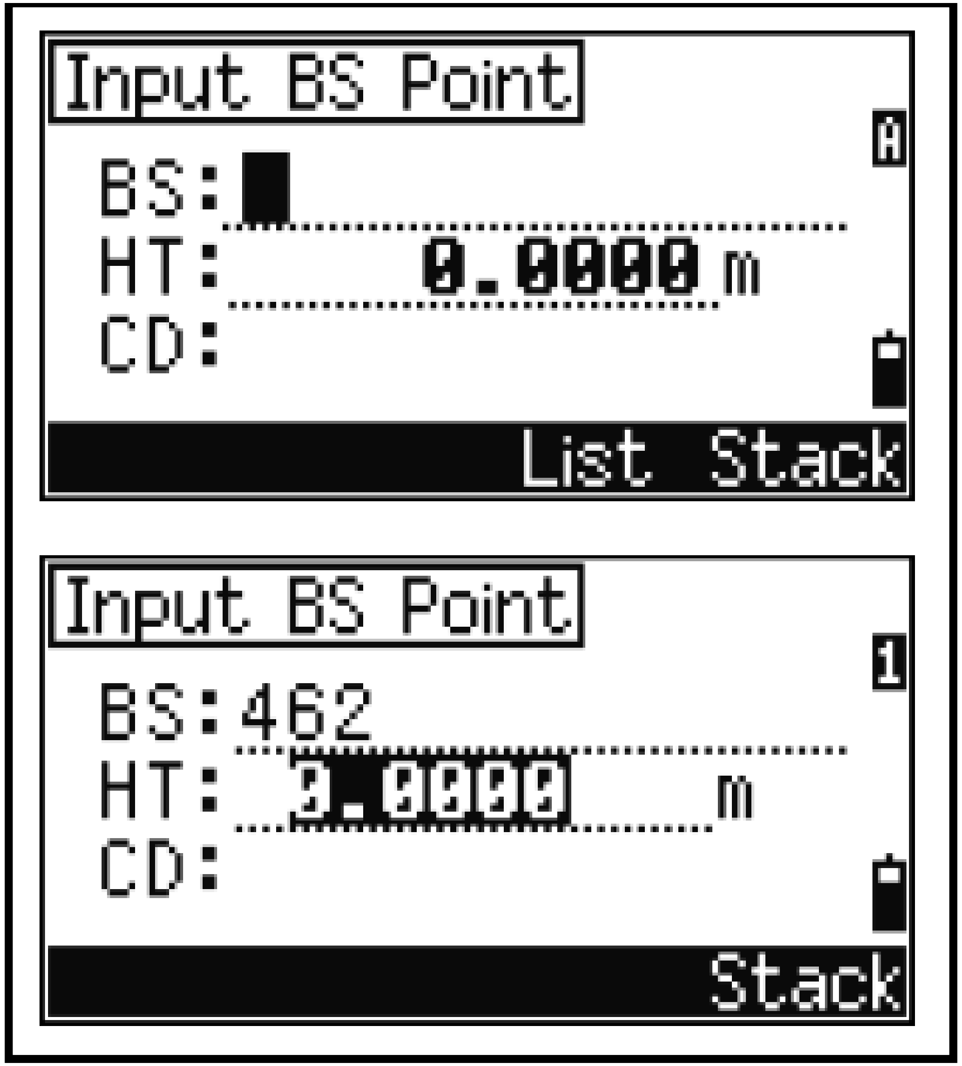


Then input the station name “A-123”, if stored, the coordinates and code are displayed.

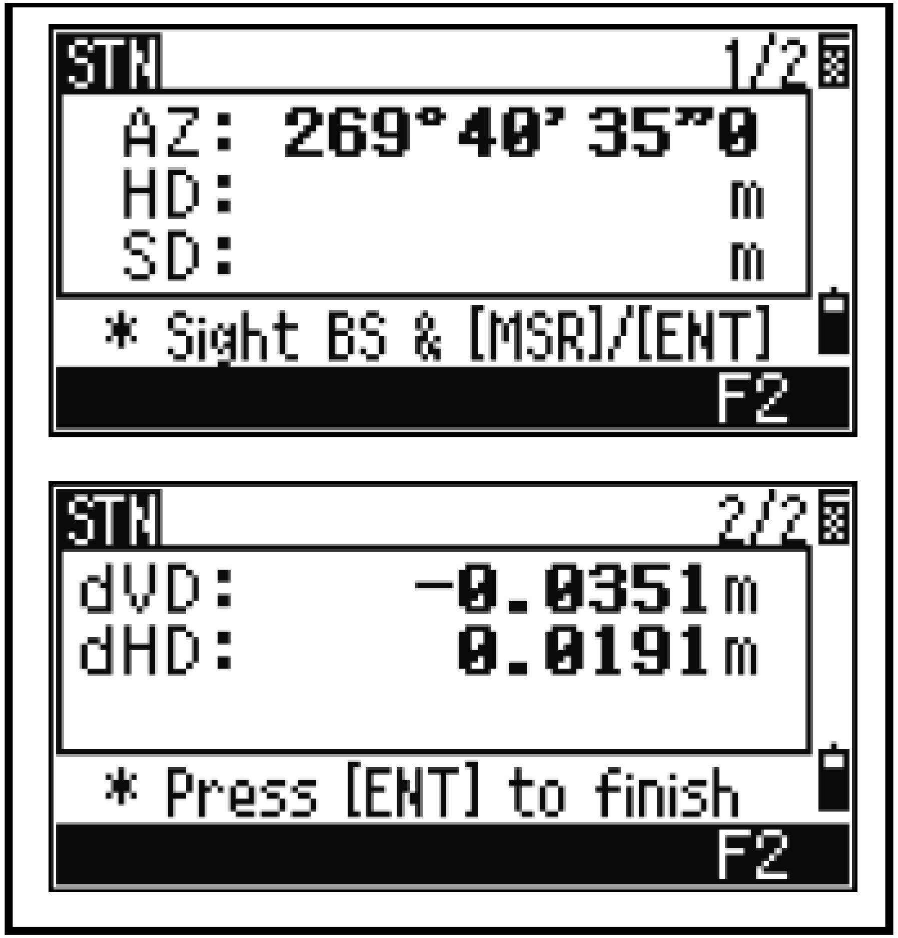


Now the point is selected, you may enter the instrument height. The TS knows now where it is and how height the TS is above the ground.

In the following screen, the user chose to input the backsight point by coordinates.



Enter the Backsight point number and then its target height.



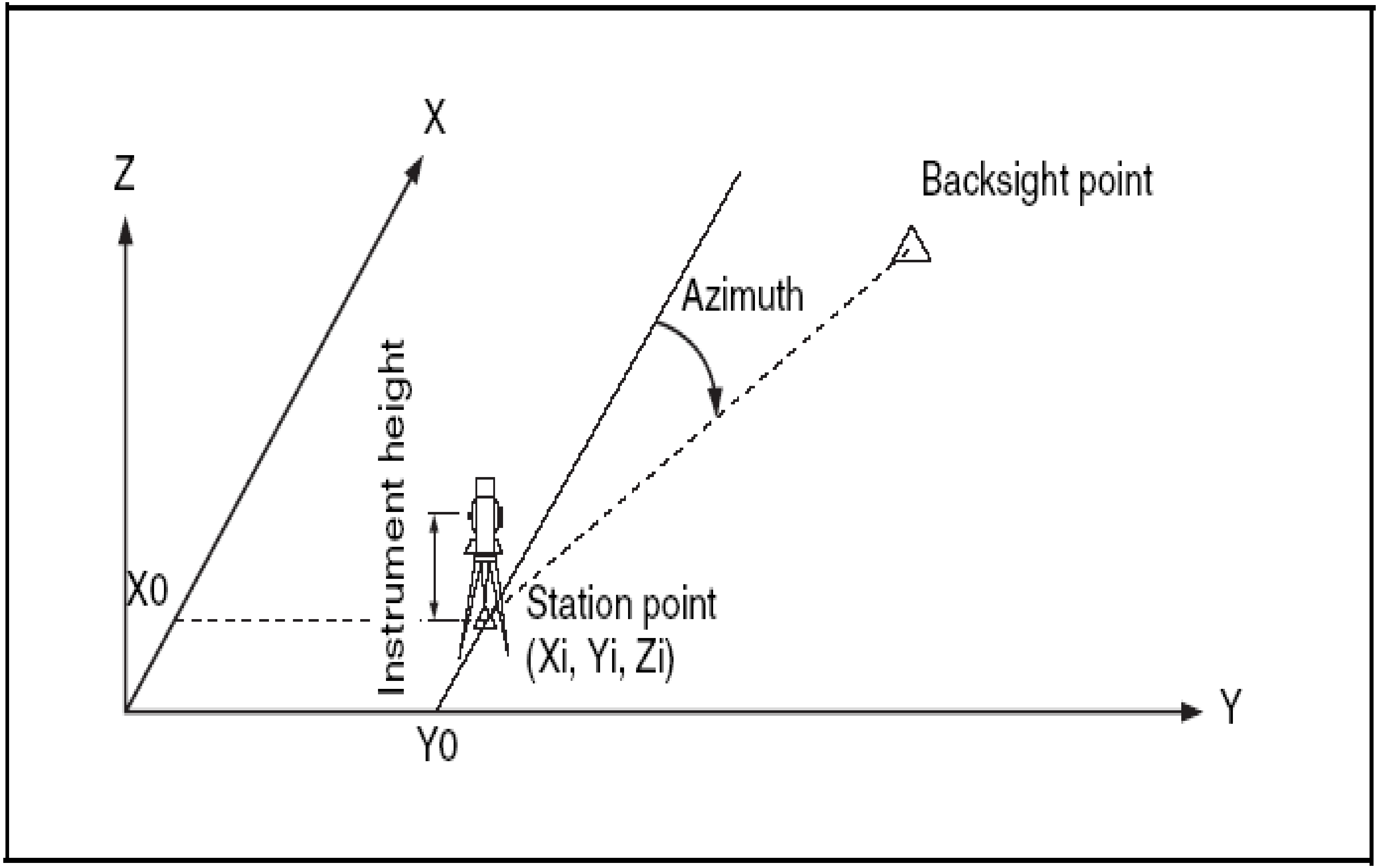
Aim at the backsight point and press the required button, “MSR OR ENT” in this Nikon TS. You get the difference in distance.

This difference is the difference between the computed and the measured distance between the points.

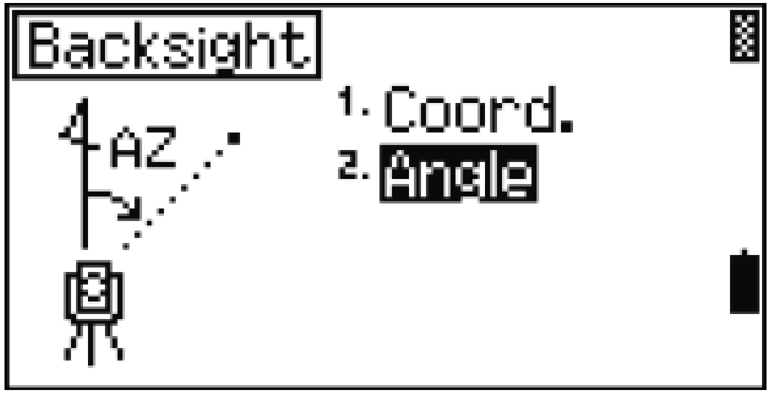
3-2 Orientation of TS by Entering the Azimuth Angle

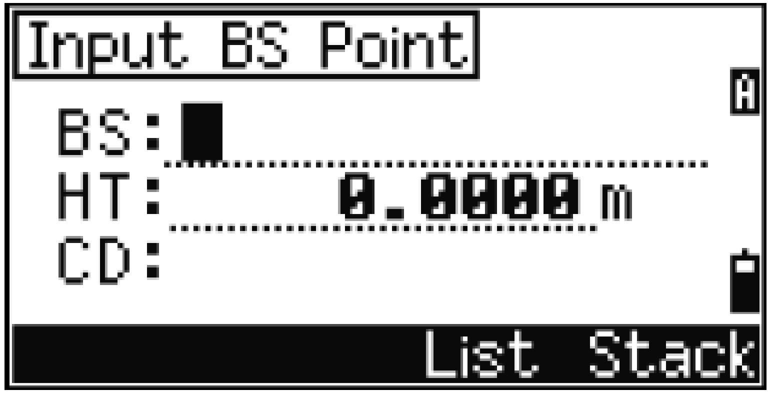
-If we know the azimuth of a line that starts at the STATION, but not the coordinates of the BACKSIGHT point. For example, we now the azimuth of the line that connects a point on the roof of known coordinates “STATION” and the azimuth to Cairo Tower, but we do not know the coordinates of Cairo tower.

- Set the TS on the Station and enter the information of the station as the previous method.
- Input the azimuth of the line that connects the station and the backsight points, instead of the coordinates of the backsight point as before

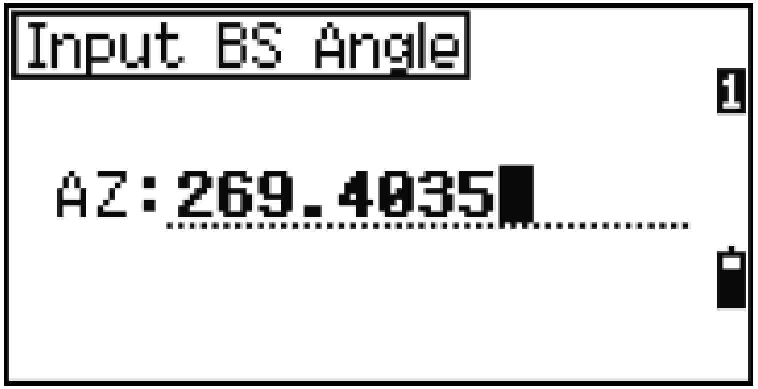


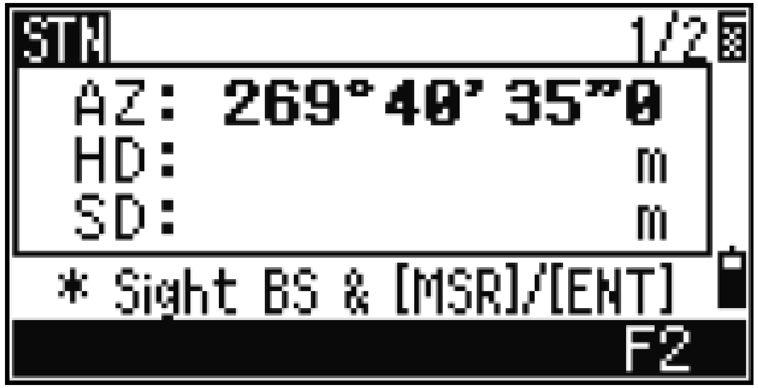
Geometry of TS Orientation by Azimuth





First you select a method for orientation "Nikon TS" for example. This time select " Angle"





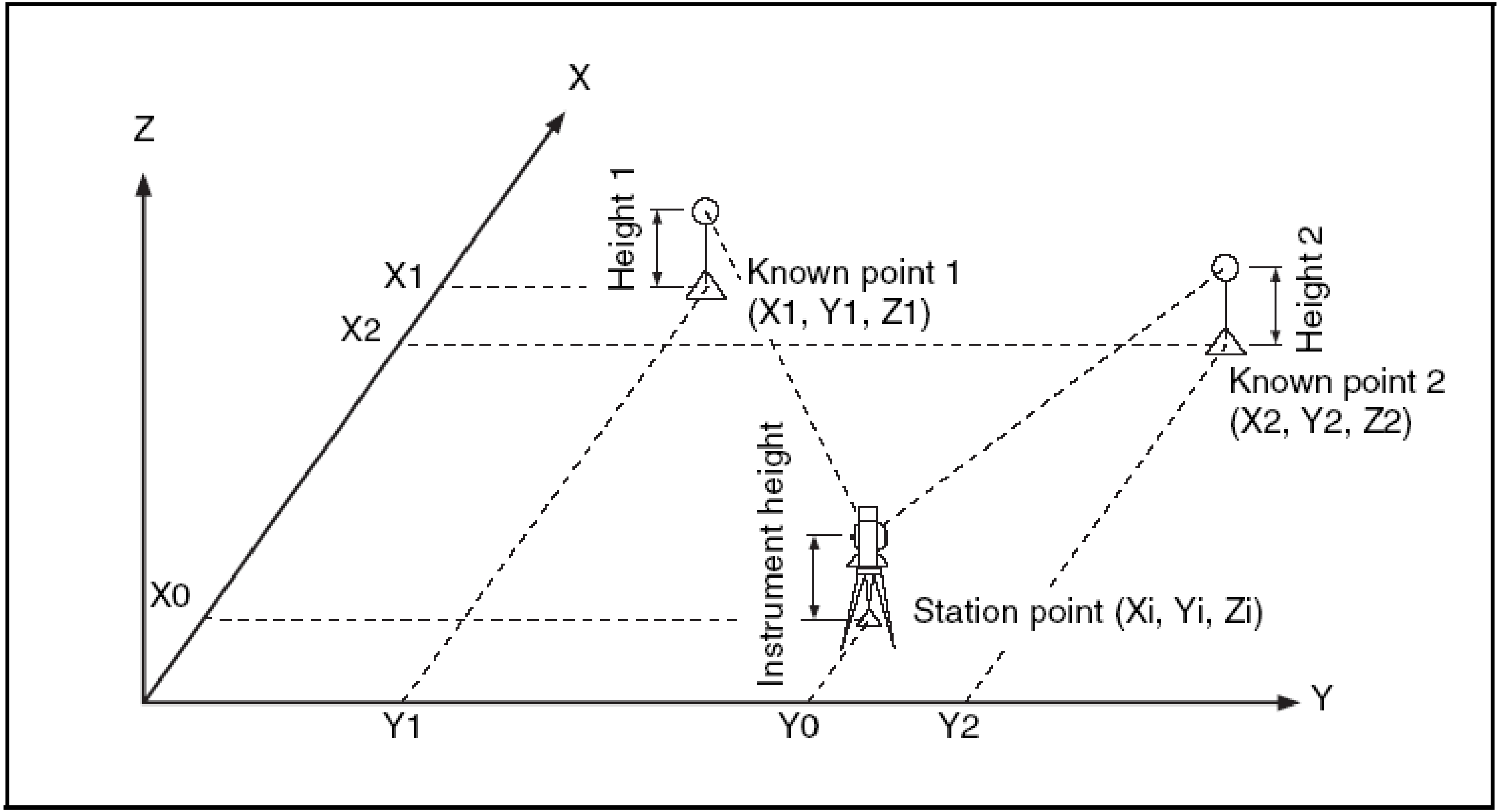
The total station asks for the azimuth, or display it if previously uploaded. Aim at the backsight, the display lists the difference in azimuth

3-3 Orientation of TS using a Multiple Point Resection

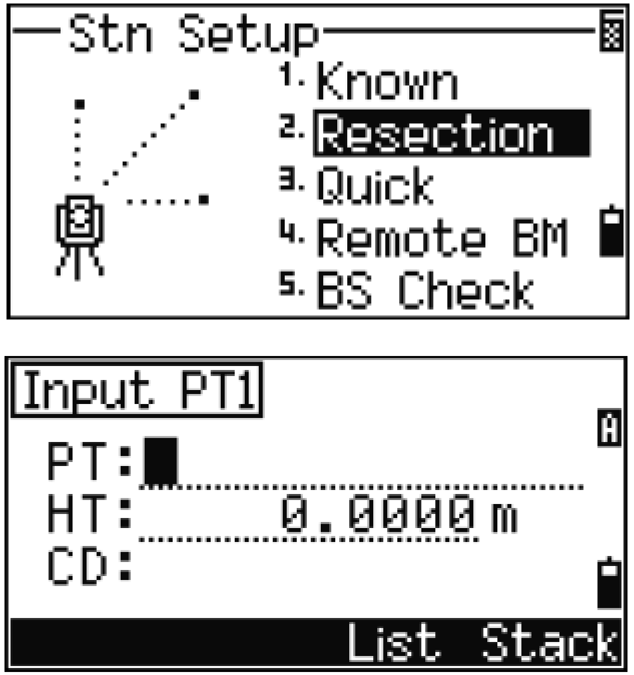
A resection orients the TS using angle. Distance measurements to Known points.

TS is on an unknown point, observe three angles to three known targets OR angles and distances to TWO known targets. Why is that and when to use which????

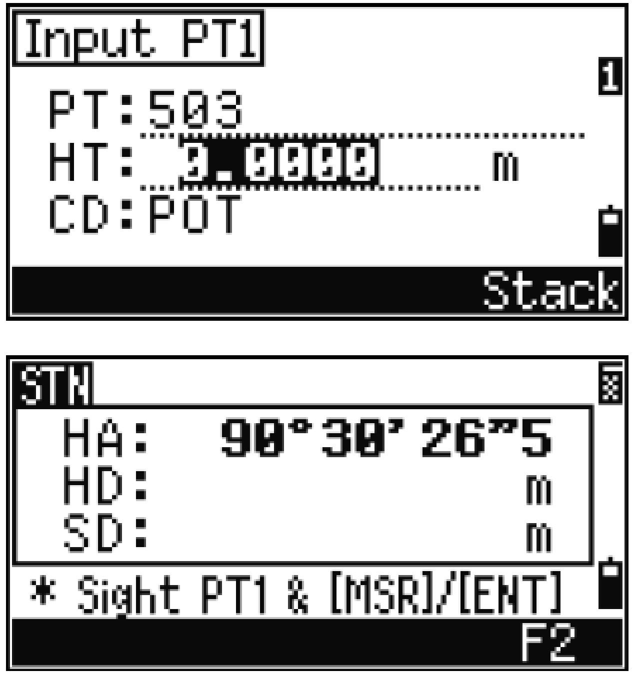
The TS will solve a resection problem and solves for the location of the STATION and the Azimuth of the directions to the known lines.



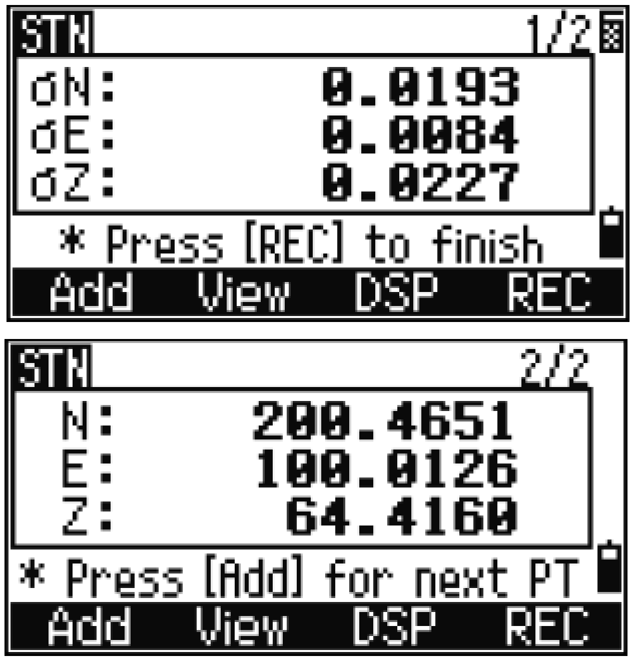
Geometry of TS Orientation by Resection


Stn Setup
1. Known
2. Resection
3. Quick
4. Remote BM
5. BS Check
Input PT1
PT:
HT: 0.0000 m
CD:
List Stack

1

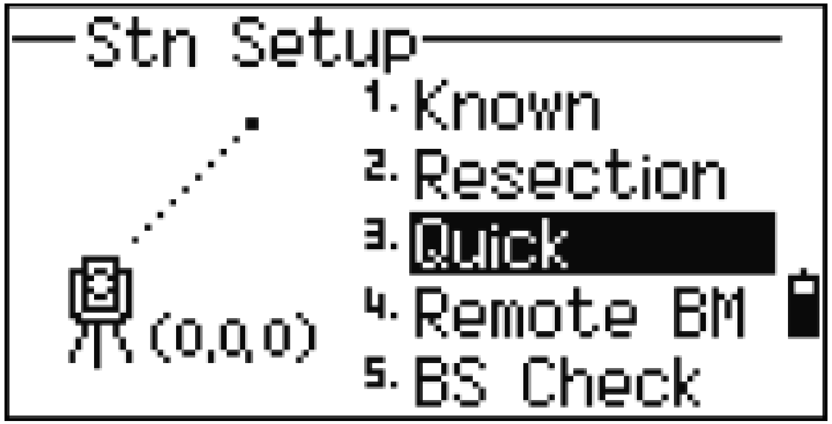

Input PT1
PT:503
HT: m
CD:POT
Stack
STN
HA: 90°30'26"5
HD: m
SD: m
* Sight PT1 & [MSR]/[ENT]
F2

2


STN 1/2
σN: 0.0193
σE: 0.0084
σZ: 0.0227
* Press [REC] to finish
Add View DSP REC
STN 2/2
N: 200.4651
E: 100.0126
Z: 64.4160
* Press [Add] for next PT
Add View DSP REC

3

3-3 Orientation of TS using local coordinates



- Used if local coordinates are used, assume coordinates of STATION and choose a direction to call North, or zero Azimuth.

- All coordinates will be in that local coordinate system, distances and angles will be correct, but Azimuth is not.
- Used in small scale projects when there is no need to relate to the surroundings.

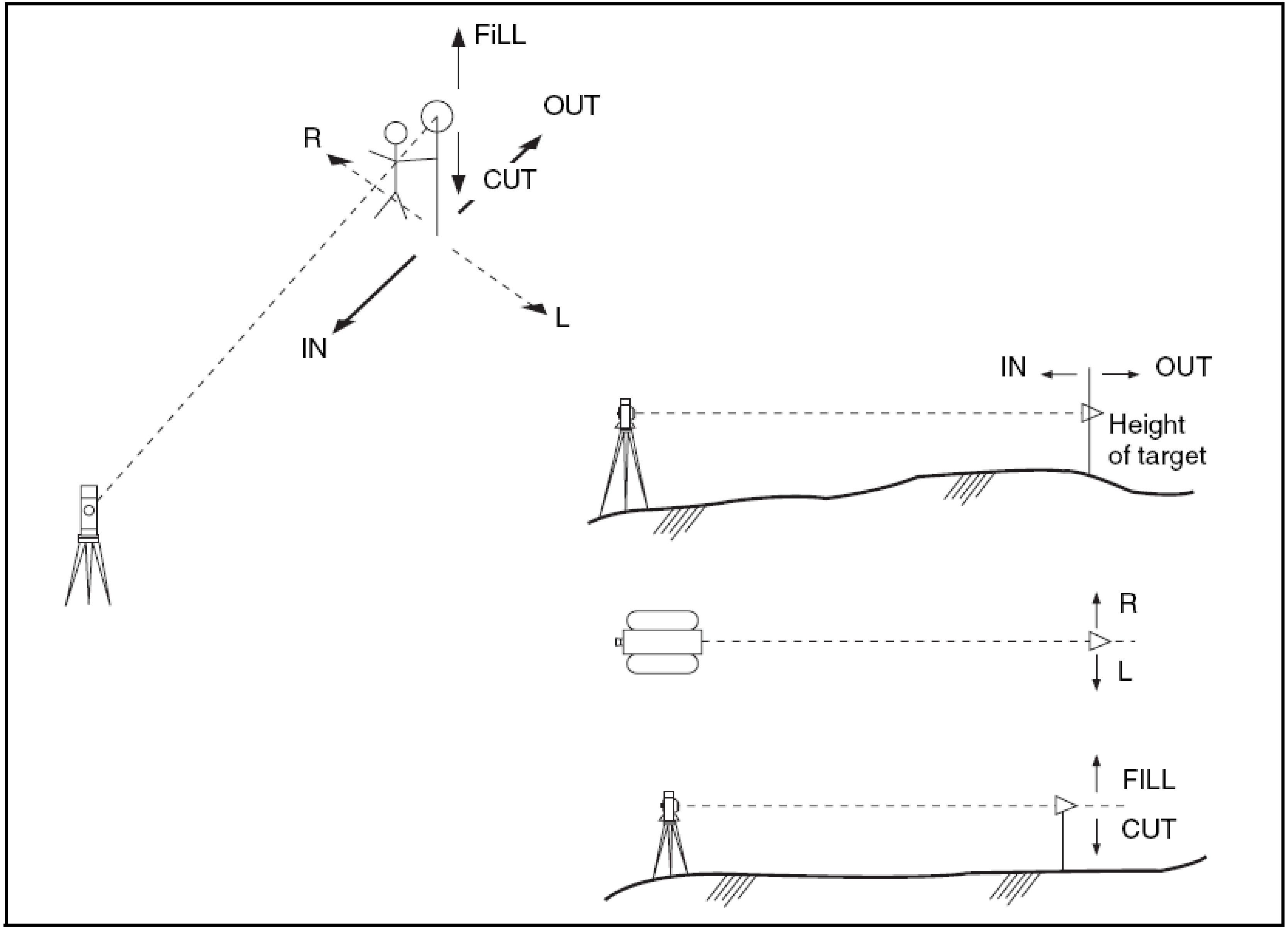
4- Topographic Survey الرفع

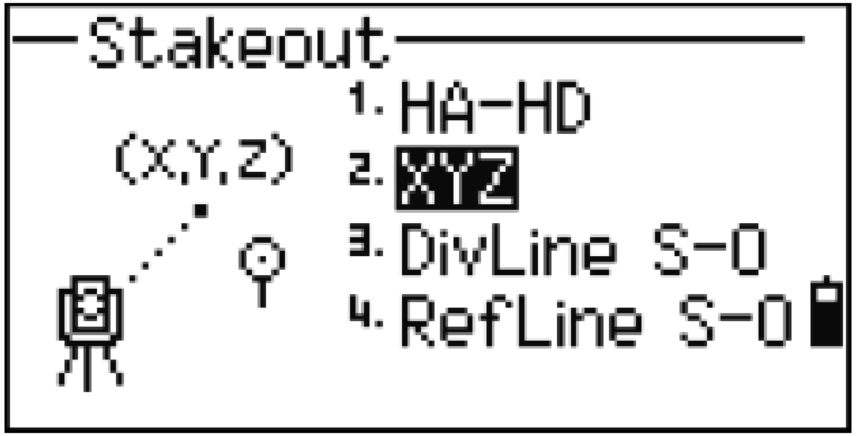
- The total station can give directly reduced coordinates of surveyed points (Easting, Northing and elevation) or (X, Y, and Z) if you input the station coordinates (E0, N0, H0), height of instrument (hi), and **initial orientation of the instrument before you begin**. You will also need to input the reflector height (hr) of measured points.
- Place the prism on the point to be surveyed, aim the total station at it, measure, and record the coordinates
- Points have IDs or point number that can be increase automatically and have codes that make the description of points clear and drawing a map easier and more automated.
- A group of points will form a map, the data is downloaded to a computer and a software is used to draw the map.

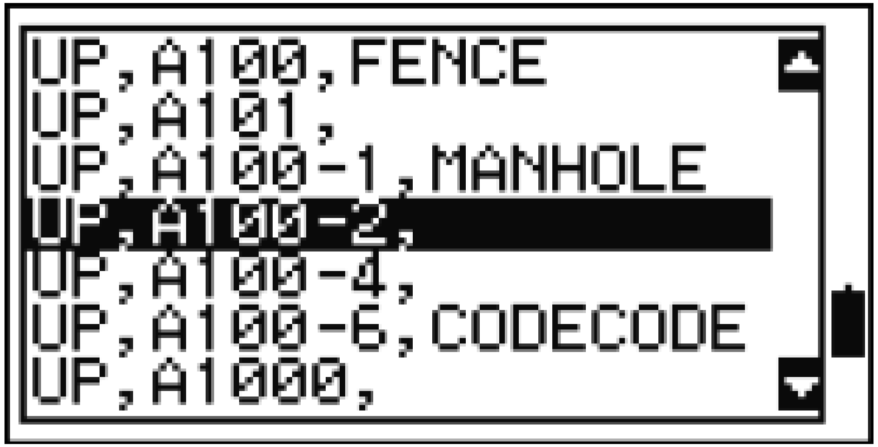
5- Set out Surveys التوقيع

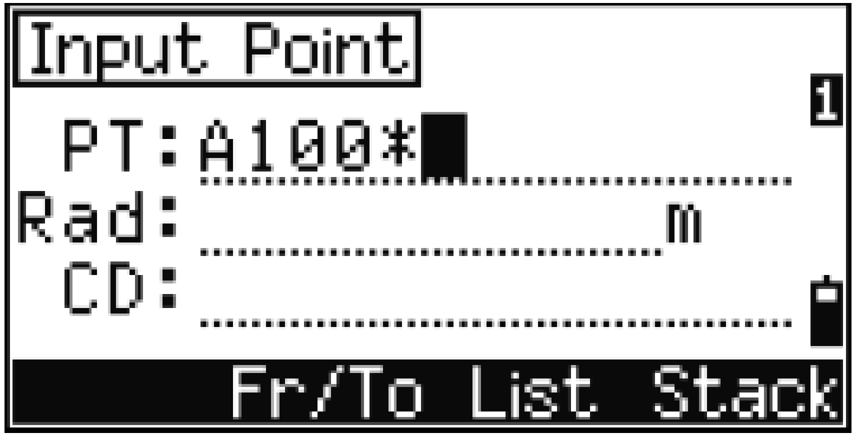
- To mark points in the field that are on a drawing or a map, and of given coordinates. Such as corners of a building, edges of a road, tress, etc.
- You first create a job file and define the variables, and upload all the points from a computer to the total station of possible. Coordinates can be entered manually if needed.
- Orient the TS onsite using one of the previously described methods.
- Select a method for setting out, usually by coordinates.
- Enter the number of the point to be located the TS might display the angle to rotate and the distance to measure.
- Rotate the TS by the angle needed and ask a person holding the prism to move in that direction the required distance, approximately.

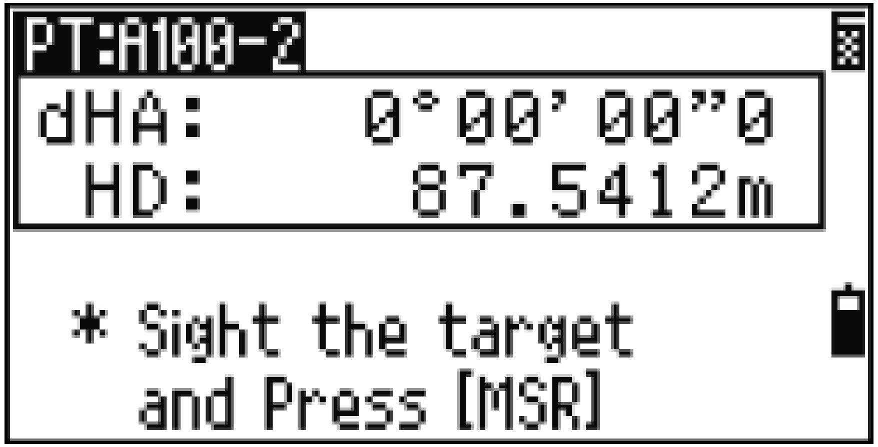
- Guide the person holding the prism to be on the required direction by sighting through the telescope, once you see the prism in the telescope, measure.
- The total station shows the difference in distance and maybe the angle.
- Do not rotate the TS, tell the assistant to move by that difference along the line, towards you or away from you.
- Repeat this process until you are satisfied with the difference in distances, should be minimal, and mark that point on the ground.
- Move to the next point in the file within the TS, and repeat the process.

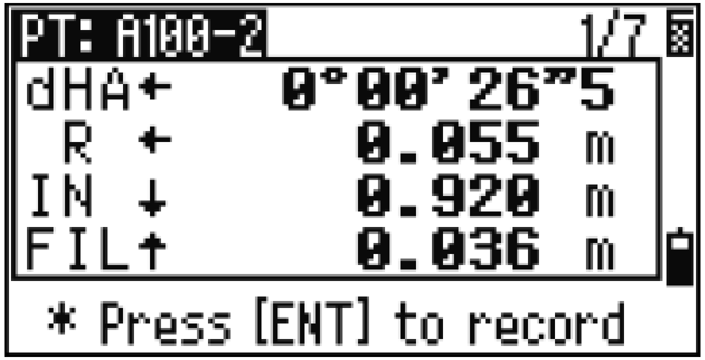

FiLL
OUT
R
CUT
IN
L
IN
OUT
Height
of target
R
L
FILL
CUT


Stakeout
(X,Y,Z)
1. HA-HD
2. XYZ
3. DivLine S-O
4. RefLine S-O


UP,A100,FENCE
UP,A101,
UP,A100-1,MANHOLE
UP,A100-2,
UP,A100-4,
UP,A100-6,CODECODE
UP,A1000,


Input Point
PT:A100*
Rad: m
CD:
Fr/To List Stack


PT:A100-2
dHA: 0°00'00"0
HD: 87.5412m
* Sight the target
and Press [MSR]

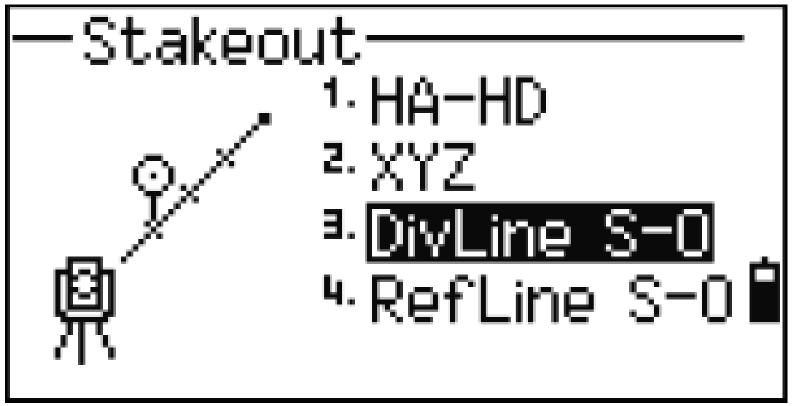

PT: A100-2 1/7
dHA← 0°00'26"5
R ← 0.055 m
IN ↓ 0.920 m
FIL↑ 0.036 m
* Press [ENT] to record

Examples of Functions within the TS

- Programs within a TS to make repeated surveying operations faster such as traversing, remote distance, remote elevation, offsets, and so on. Some of them might not be available in all brands “kinds’ of TS.

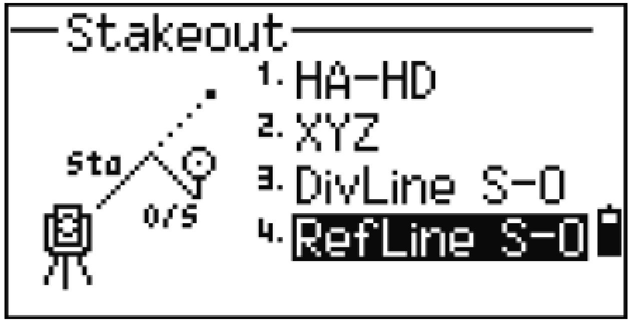
1- Line Division

This function divides the line between the instrument and the first target by an input span number. It then guides you to stake out the points, one by one.



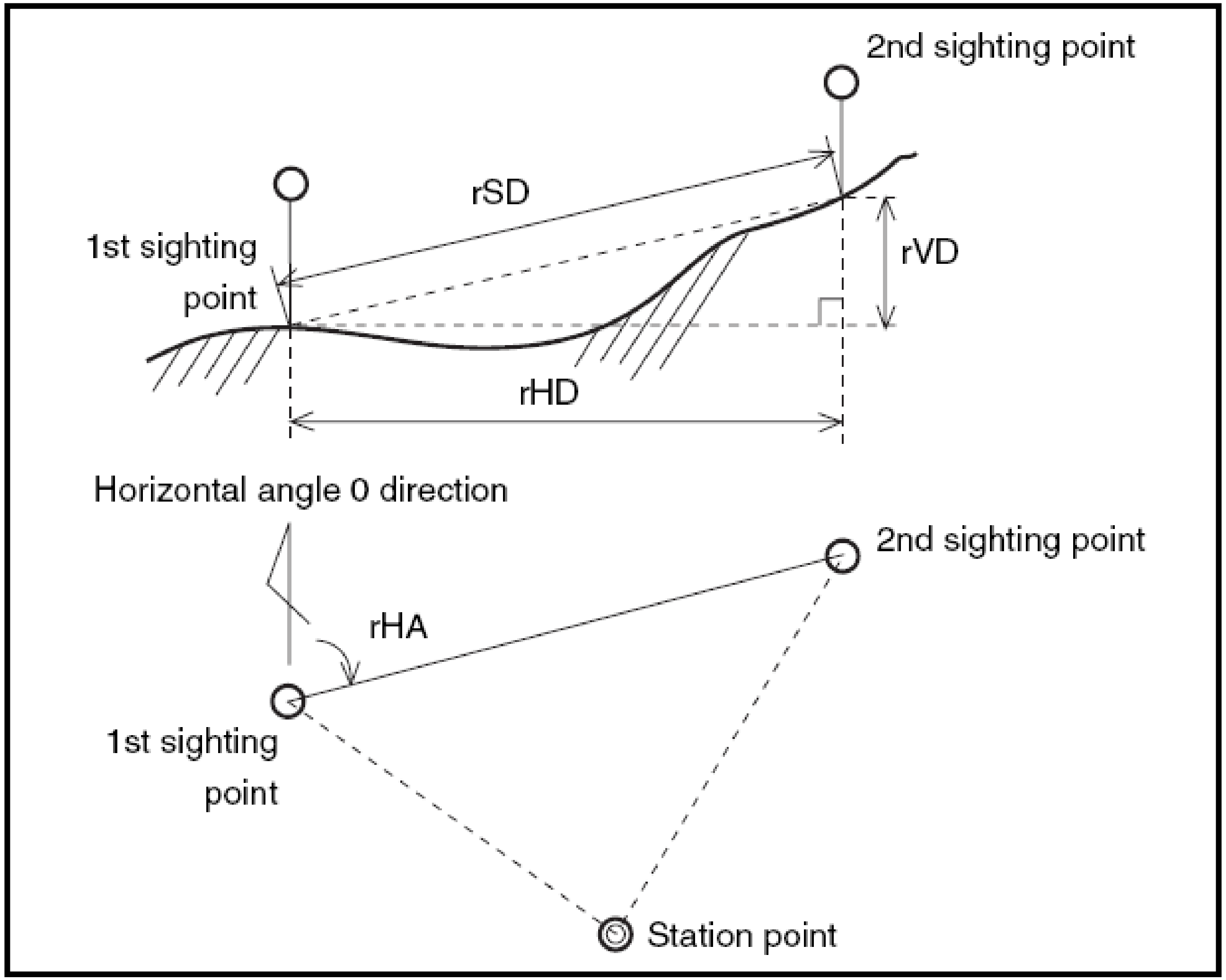
2- Offset

This function allows you to stake out point based on offset from a line for example



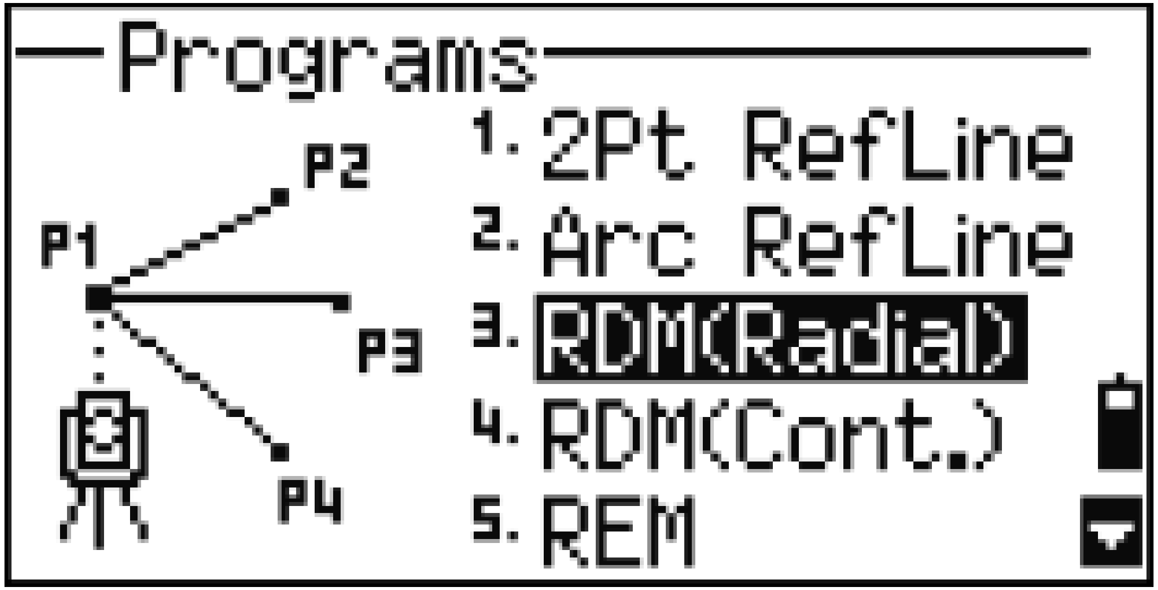
3- Remote Distance (Missing Distance)

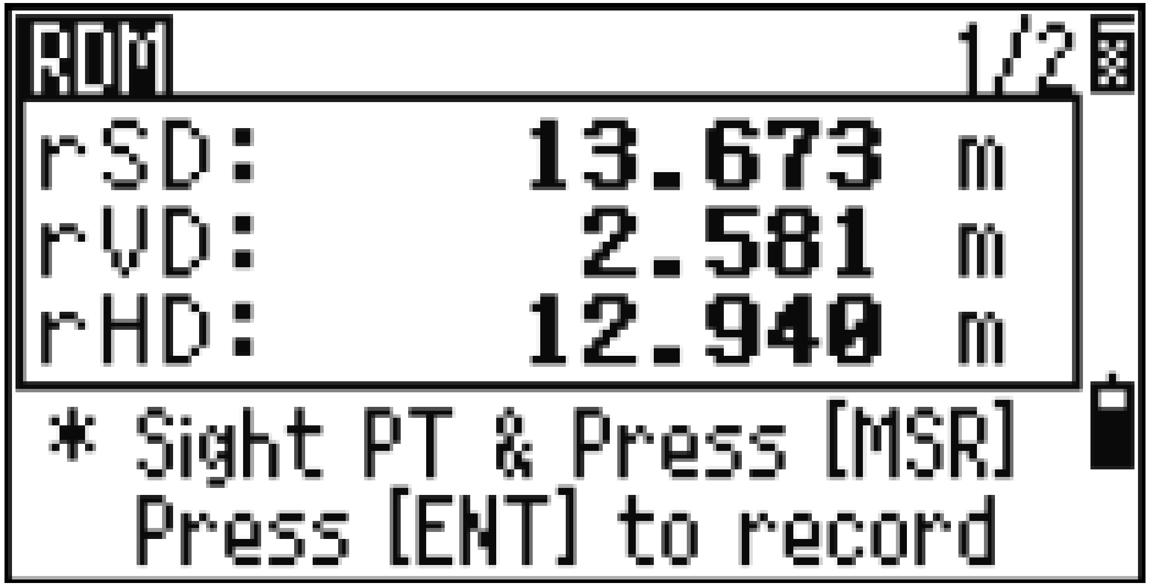
This function measures the horizontal, slope and vertical distances between two points and the azimuth of the line that connects them.



Example

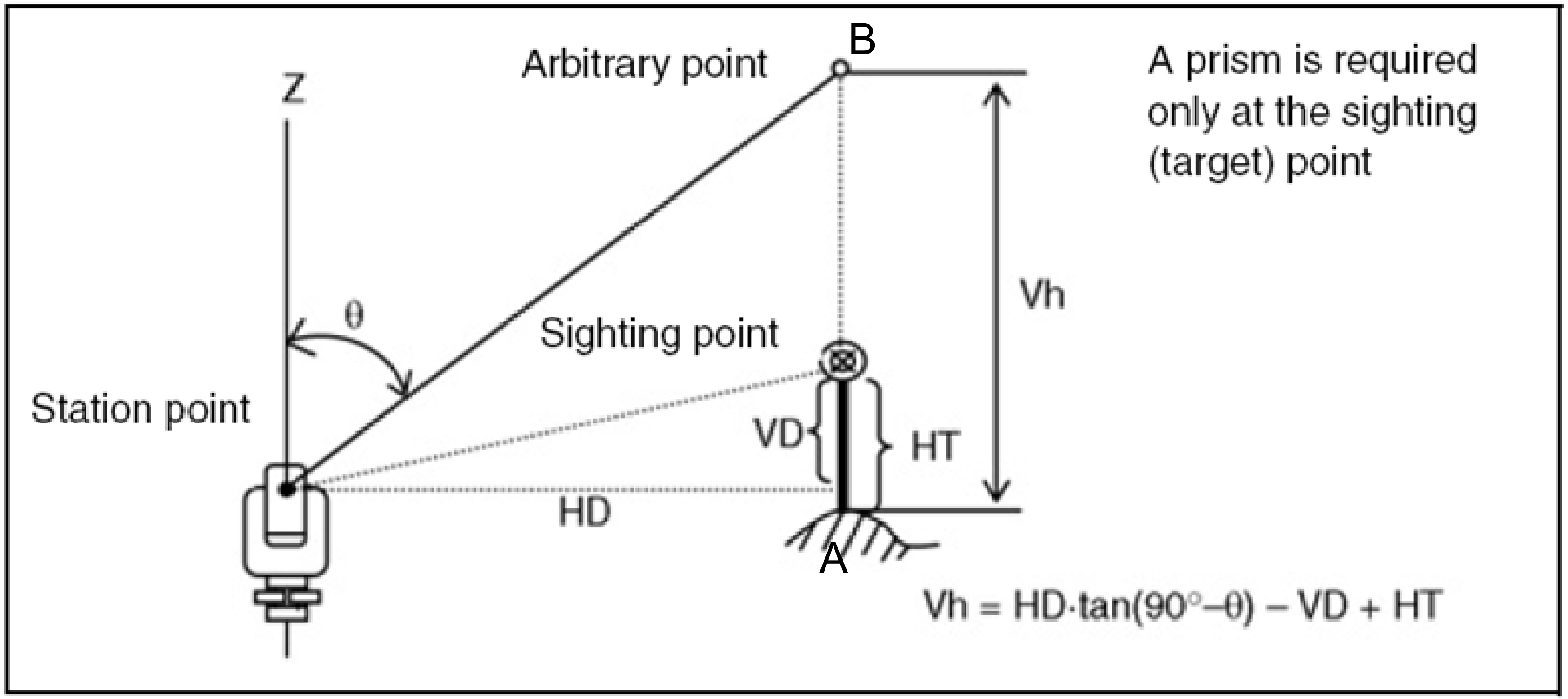
Compute the length and azimuth of the line AC if the total station at point B measured the angle ABC and the lengths AB and BC. The total station was properly oriented and the horizontal readings at A and C were 20° 12’ 14” and 55° 13’ 25”, the lengths of the lines BA and BC were 250.01m, and 234.42m.


Programs
P2
P1
P3
P4
1. 2Pt RefLine
2. Arc RefLine
3. RDM(Radial)
4. RDM(Cont.)
5. REM


RDM
1/2
rSD: 13.673 m
rVD: 2.581 m
rHD: 12.940 m
* Sight PT & Press [MSR]
Press [ENT] to record

4- Remote Elevation

To measure the elevation of high points, such as the top of a tower or a building. You set a prism below the point on the ground, measure the horizontal and vertical distances to the target. Then measure the Zenith angle (θ) to the high target.



Example

To define the height of a steel communication tower, a total station was used to collect measurements. A prism was placed at the bottom center of the tower, the total station was aimed at the prism, the HD was 50 m and the vertical distance between the centers of the TS and the prism was 0.8m. The TS was then aimed at the top of the tower and the vertical angle measured was 67° 20’ 30”. If the height of the prism was 1.3 m, calculate the height of the tower above ground.

If the elevation of the ground under the tower was 38.64 m, what is the elevation of the top of the tower?

Most common mistakes when using a TS

1- Entering wrong point number

2- Switching STATION and BACKSIGHT points

3- Other errors in orientation, such as aiming at a wrong point.

4- Improper centering and/or targeting

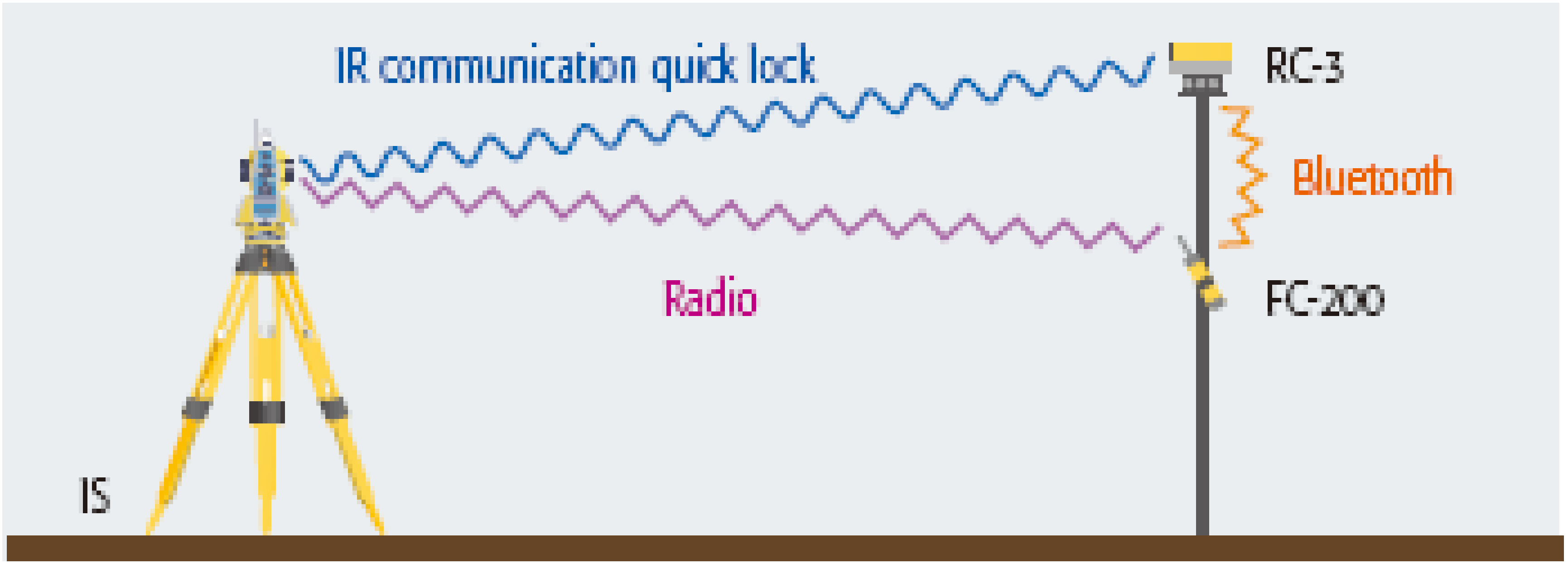
5- Ignoring corrections or entering inaccurate parameters such as P.C., temperature, and pressure.

Advanced Total Stations

- Reflectorless or prismless TS up to 2000m on white surfaces today
- Robotic TS “ONE MAN CREW”

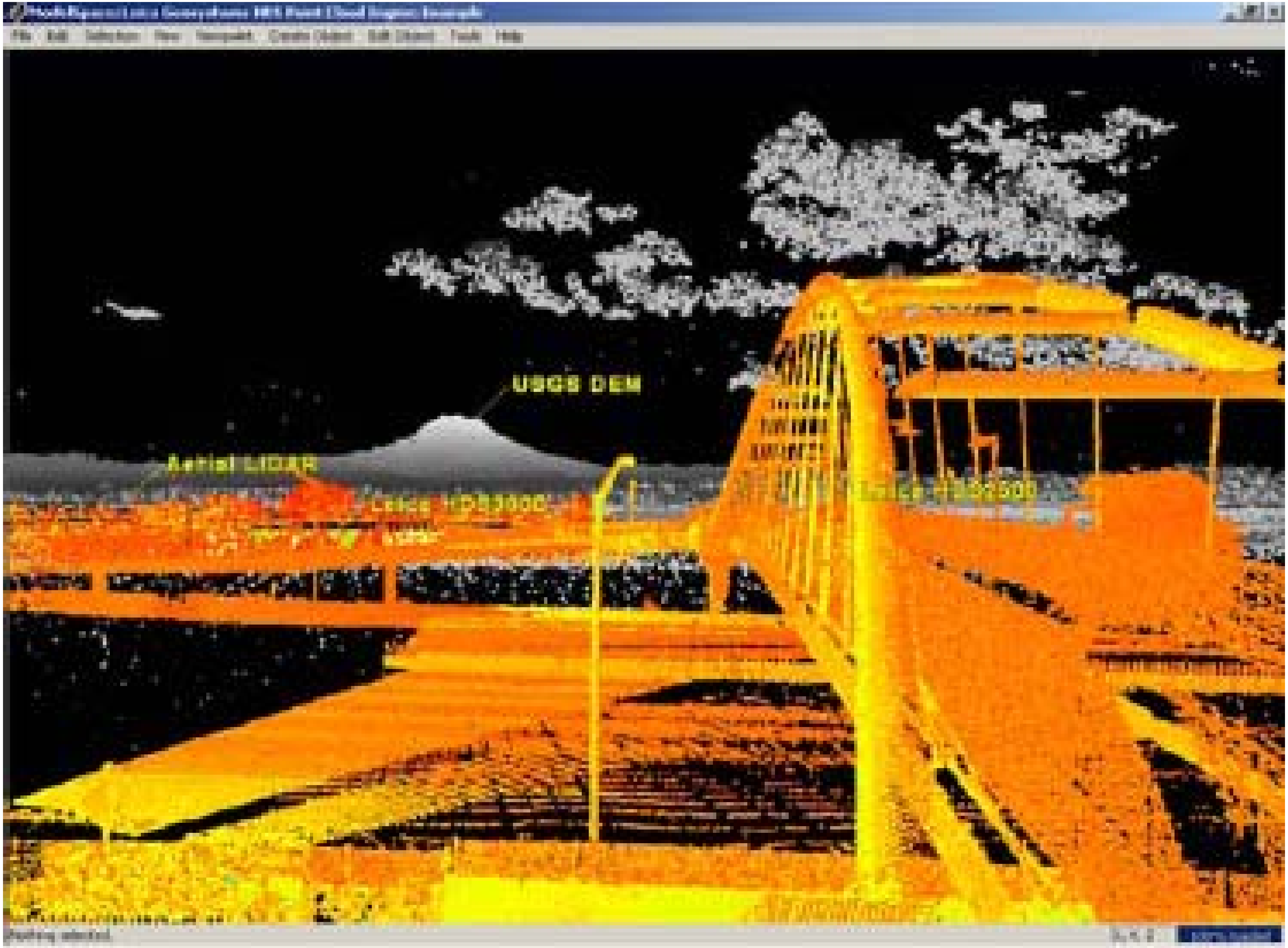
One-man Survey System - Quick-lock and IR communication technology

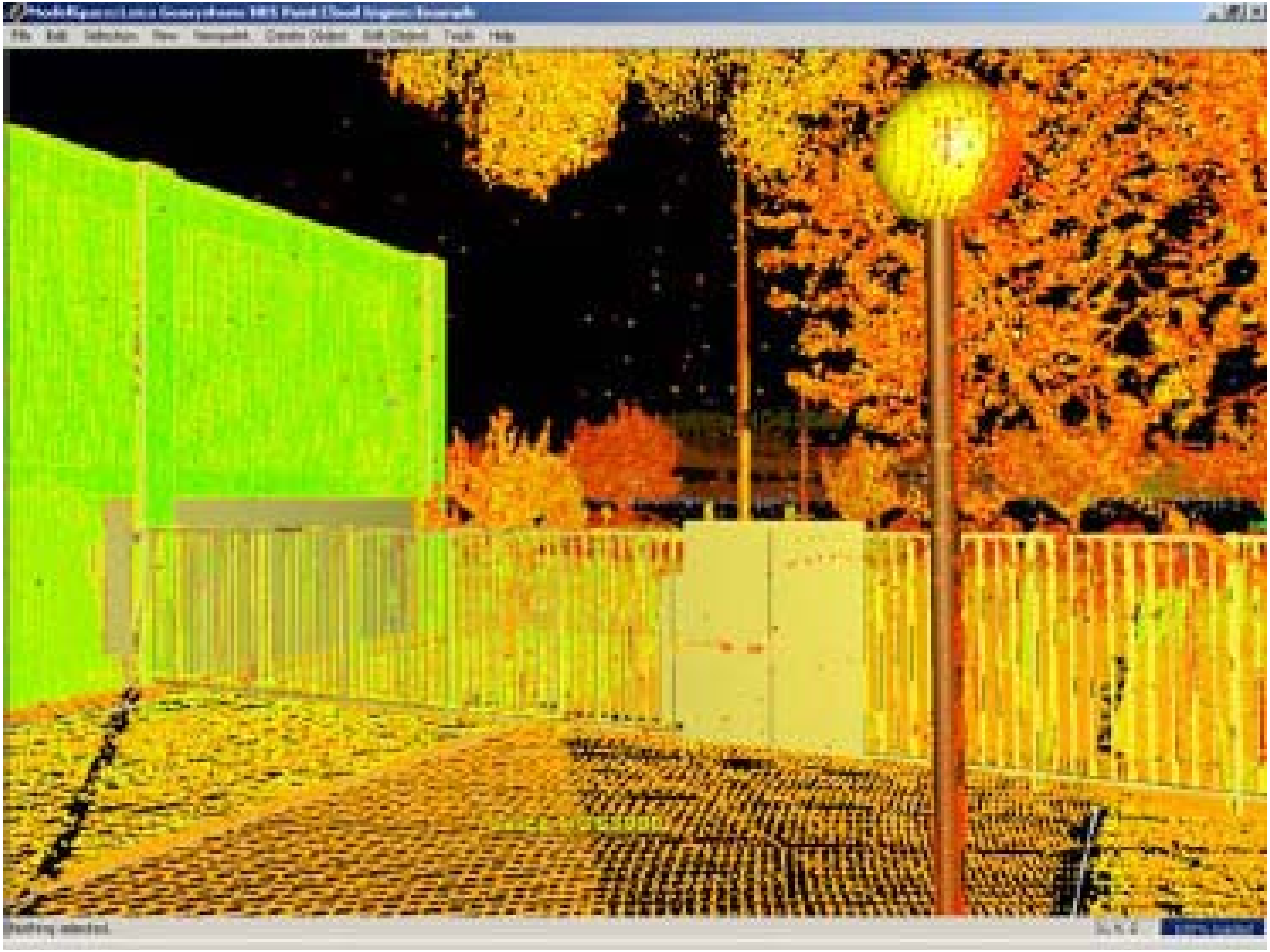
The IS can be the one-man survey system when combined with the data collector and RC-3 system, the third generation of Topcon's World's first Quick-lock technology. By just pressing the button, the RC-3 quickly reacquires the IS again anywhere it is headed for. The IS one-man system ensures the stress-free, efficient survey.

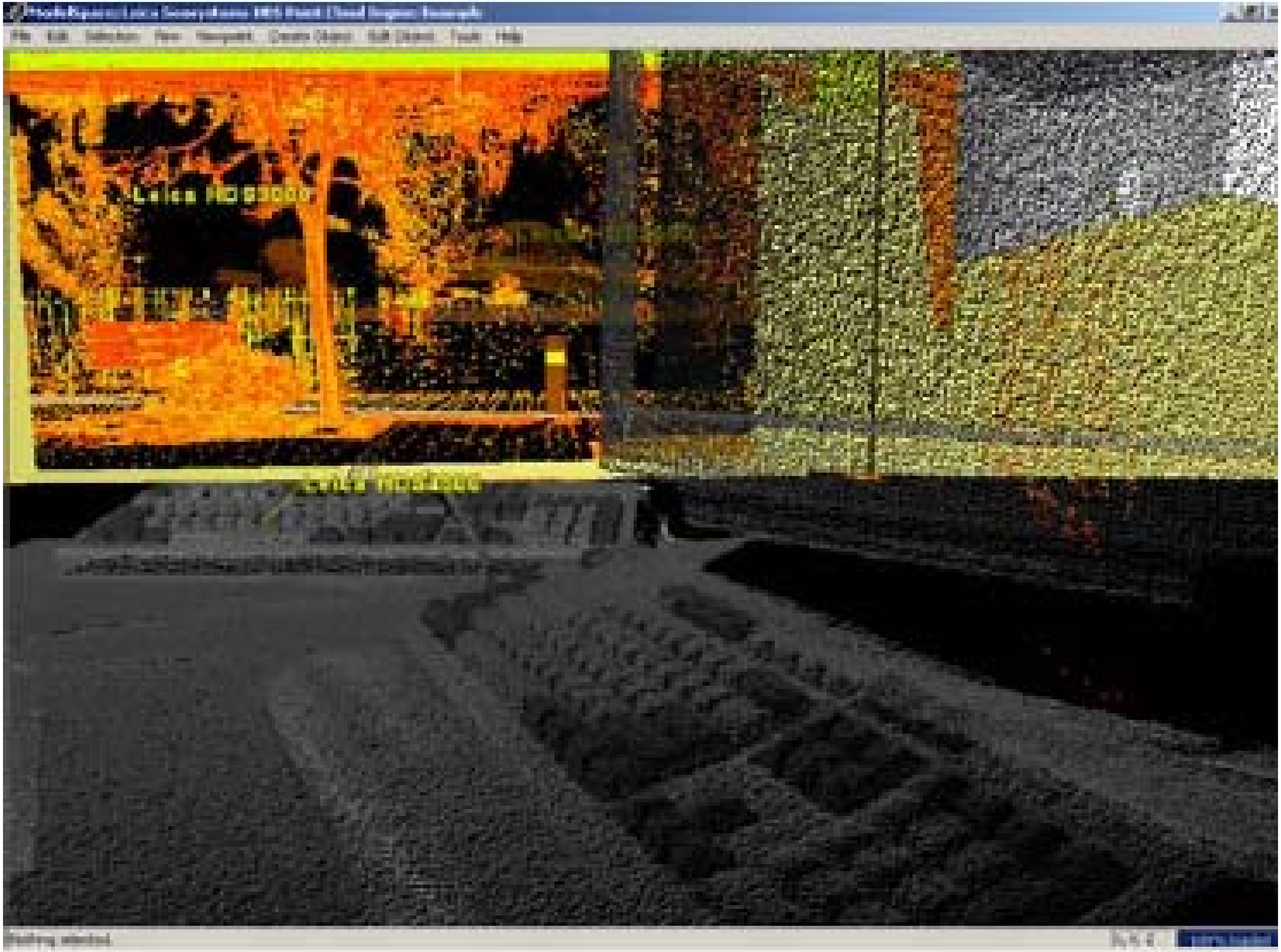


High Definition Survey (HDS)
(Terrestrial Laser Scanners)

The scanner sends millions of laser pulses to measure coordinates as it rotates to scan the features around

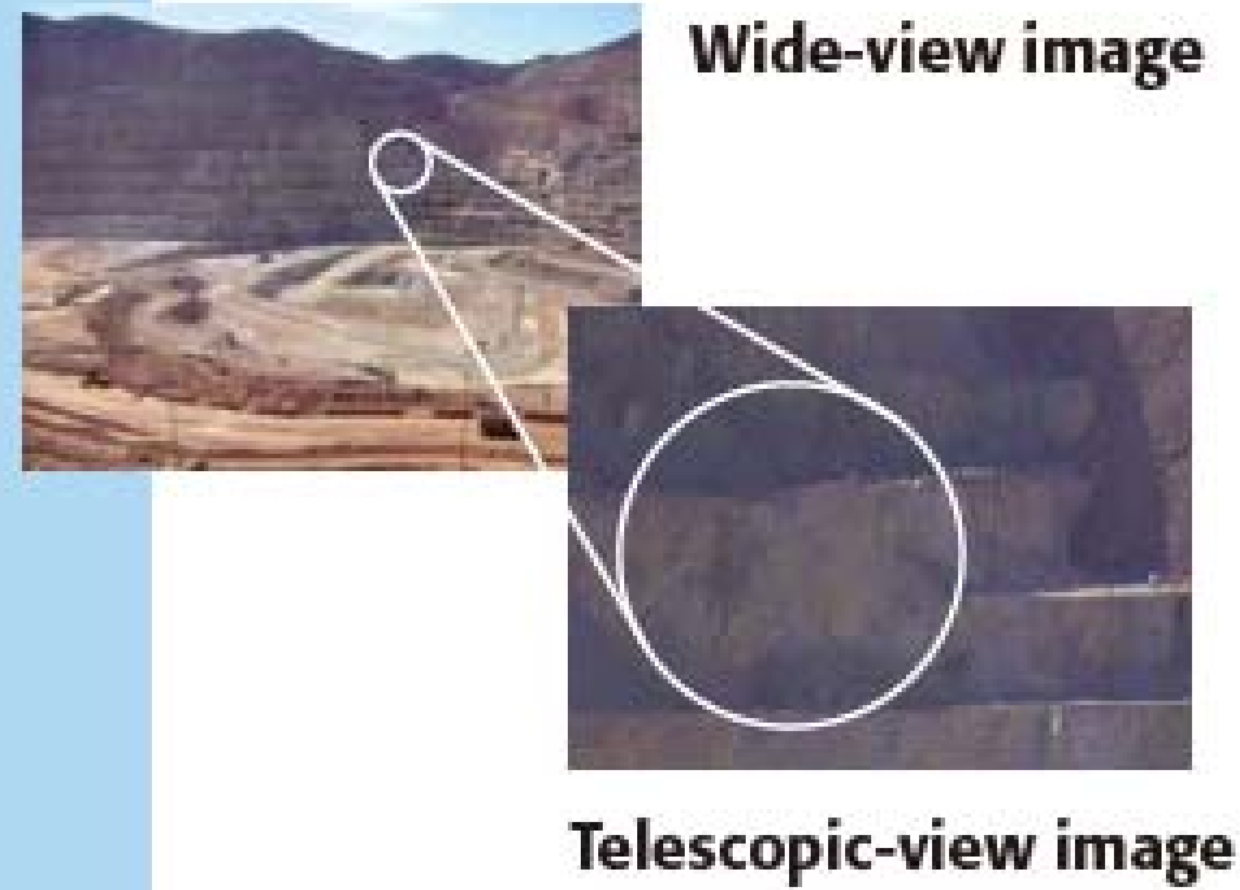

USGS DEM
Aerial LIDAR
Leica HDS3000




Leica HDS3000

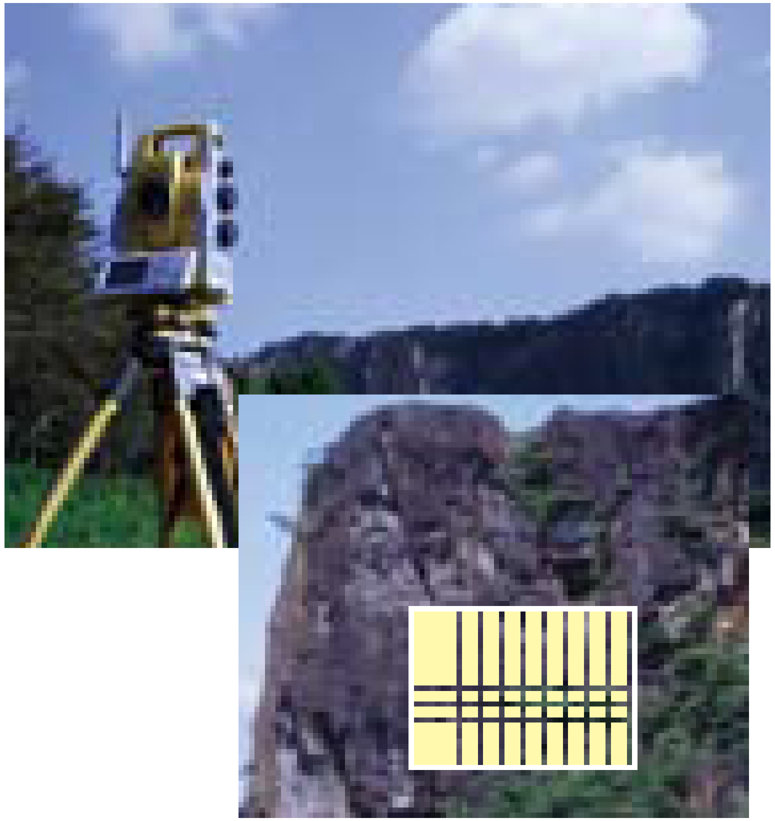
All-in-One Total Stations

- More than one technology
- The Topcon IS Imaging Station includes:
  - Robotic total station
  - 3D Scanner
  - Imaging system
- Can perform as a regular or a robotic total station



"Touch Drive" to handle the instrument

Touching the object on the image causes the instrument to rotate to the tapped object. The telescopic-view image provides zoom display with the same view angle of telescope. The Touch Drive also enables pinpoint measurement that allows the accurate collimation just like looking in the telescope.

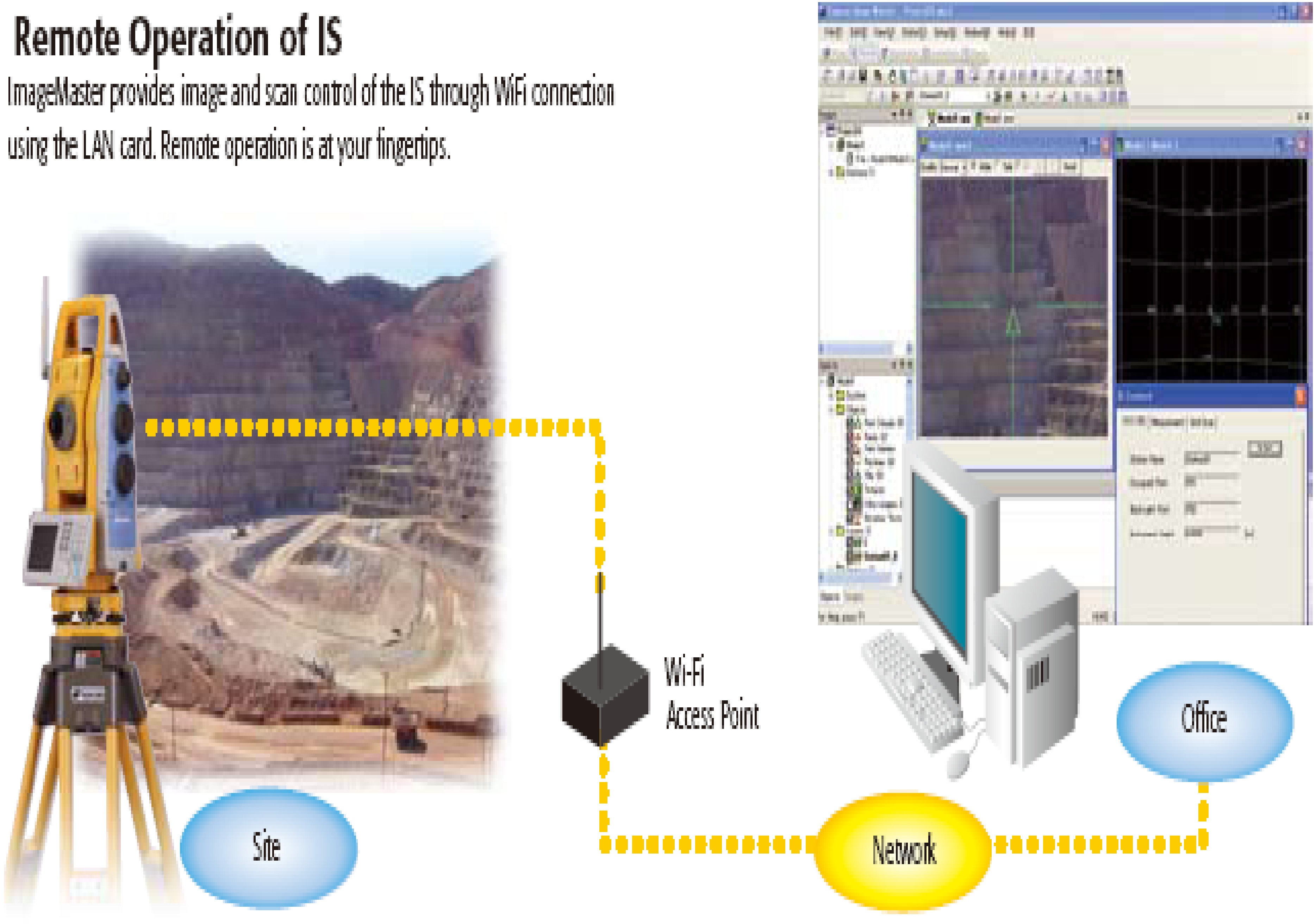


“Grid Scan”, the high-speed scan

The high speed measurement Grid Scan obtains 3D data by automatic scanning at a specified pitch within a specified area. With the Topcon's image analyzing software, a 3D model can be created from the data.

Remote Operation of IS

ImageMaster provides image and scan control of the IS through WiFi connection using the LAN card. Remote operation is at your fingertips.



3D Measurement by Images

The IS can create a 3D model by automatically measuring the DSM (Digital Surface Model) from stereo images.
The 3D-data process like contour lines or cross-section view can also be done easily with the IS.