AMHERST COLLEGE

Department of Geology

GEOLOGY 41 - Environmental and Solid Earth Geophysics

Lab 4: Surveying and the TOTAL Station

EQUIPMENT:
- **warm clothes**
- **TOTAL Station**
- **tripod**
- **prisms (2)**
- **prism poles(2)**
- **notebook**
- **pen**
- **calculator**
- **more warm clothes**
- **even more warm clothes**

It is important to know the location of any geophysical survey to greater precision than is needed for the task at hand. If the purpose of the survey is to determine the location of drums of buried toxic materials, then you must know your location well enough to be able to return to the site to remove the drums.

There are a variety of methods commonly employed to locate a geophysical project. Several of these surveying techniques are described below.

GPS

Global Positioning System receivers can provide real-time location with approximately +/-10 meter horizontal (and poorer vertical) precision. A GPS receiver can determine its location by determining its distance from 4 or more satellites each of which broadcasts a time signal. The travel time (and therefore the distance) from each satellite is determined from the time signals. Using the distances from 4 (or more) satellites a 3d position is determined. A wide variety of factors limit the precision of GPS precision causing a stationary receiver to appear to move (slightly). Time corrections can be created for the GPS signals to keep a stationary receiver from moving. These corrections can then be applied to unknown locations measured with a second receiver. This two-receiver technique known as differential GPS can provide near real-time decimeter precision. With GPS you get you locations as a set of geographical coordinates (e.g., lat, long, elevation). GPS's strength lies in its ease of operation and ability to determine geographically referenced locations anywhere in the world. The weakness of GPS is in the difficulty in relating your positions with existing surveying and mapping.

Topographic maps, aerial photographs and satellite images

The US (like most industrialized countries) has been mapped onto high-quality topographic maps. The finest resolution is the national 1:24,000 (approximately 4 cm to the km) series that has elevation contour intervals that range from 5 to 80 feet. Horizontal resolution is commonly better than the line width on the map, but vertical resolution is approximately +/- a topographic contour. With a topo map, you determine your location relative to features that you can recognize (e.g., roads, buildings, streams, hills).

Aerial photographs are commonly available at even larger scales (finer resolution). These can give good horizontal resolution, but often lack any vertical resolution. Furthermore, they often are distorted (slightly) by the camera lens and have different scales at the center and edges of the photo. Like maps, photos let you determine your position relative to geographical features that you can recognize. The strength of both maps and photos lies in their ability to tie in with existing surveying and mapping.

Pace and compass surveying

A quick and dirty method of getting relative locations with moderate precision is to measure the horizontal distance from a datum (known point from which the rest of the survey will be referenced) by walking it out and counting paces. A magnetic compass is used to determine the direction from the datum. The combination of distance and direction uniquely locates the point. Pace and compass surveying gives you locations relative to some previously determined point or points. Its strength lies in its ease, speed and lack of equipment.

Traditional surveying

Traditional surveying locates unknown points by measuring angles (both horizontal and vertical from two known points -at either end of a **baseline**. From a carefully oriented and measured baseline extremely high precision is possible. Most of our maps are ultimately based upon this type of surveying. Traditional surveying, like pace and compass surveying, gives you locations relative to your previously determined baseline. Its strength lies in it very high precision.

LAB EXERCISE
Surveying with a total station

A total station combines an electronic transit with a laser range finder (distance measurer). The transit operator sights on a pole-mounted prism. Horizontal angles (relative to a previously determined baseline) and vertical angles from the transit to the prism are measured. By pressing a button on the total station, a laser sights on the prism, determining the distance to the prism. By combining the angles with the measured slope distance, horizontal distances and elevation (vertical distances) can be calculated

Today we are going to use a total station to see if two points on 2 different floors of the ESMNH building are directly over each other.

I) A total station measures angles and distances with great precision, but it cannot determine the orientation (with respect to north) of the angles. That must be done with a magnetic (low precision) or sun (high precision) compass or by using the locations of two known points.

II) **Before doing anything, carefully plan your survey**. In order to complete the survey, we will need to be able to see from the first mark to the total station and from there through an intermediate set of points to the second mark.
We will want to plan the locations of the intermediate points so that we can minimize the number of times that we need to move the total station to see from one mark to the other. Mark the intermediate points by putting masking tape on the floor. Make sure that you include points that will allow you to orient your survey (2 points along a wall, 2 points along the center of a hall, or 2 points along a line of any known orientation.
[See Peter with your plan before starting]

III) Set up the total station at your first site.
Set up the tripod and place the transit on top of it. Adjust the legs of the tripod so that the total station is at a comfortable viewing height and so that it is nearly level (use bullseye level).
Look through the site tube on the side of the transit to see that it is directly above your site. Move the tripod so that the transit is exactly located.
Carefully level the transit using the three leveling knobs on the base of the transit (turn the transit so that you can use the spirit level to check level). The transit must be as level as possible

IV) **Power up the transit**.
It will read a (**H**) horizontal angle of 0°. The vertical angle (**V**) will read **0 set**.
Rotate the transit telescope head to change the vertical angle. It should then read start to read the vertical angle (90° if you are looking horizontally). If the station is not level, a **b** will appear in the vertical angle (**V**) display.
The orientation of the telescope when you power up the transit is the direction 000°.
Unless you have oriented the transit so that it is pointing due north when you power up, 000° will not be north.
If you point the transit towards a known direction and either power up or press the **0 set** button (twice), that direction will become 000°.
Alternatively, you can rotate the transit so that it reads any horizontal angle, press **Hold**. Then, rotate the transit to that direction, press **Hold** again. The transit will then be oriented with respect to that direction.

V) **Determine the location of an unknown point relative to the station.**
Set the prism pole to a convenient height (the pole height is arbitrary, but should not be changed during the survey). Place the pole on the unknown point, holding it vertical (use the bullseye level). Aim the prism so that you can see the total station. Adjust the horizontal and vertical angles of the total station so that you can sight on the prism. Both angles are controlled by a pair of knobs. Loosen the larger (inner knob) to allow the transit to rotate freely. When you are close to the correct orientation tighten that knob and use the smaller (outer) knob to precisely adjust the angle. You should be able to read the horizontal and vertical angles.

Next, press the key. After a few seconds, the upper display will show the slope distance. Press the key again for horizontal distance then press the key a third time for relative elevation. Note: the line on the upper display indicates whether slope, horizontal, or vertical distances are indicated.

Then, press the arrow key (the one above) . The upper display will show northing (horizontal distance parallel to 000°'), the lower display will show easting (horizontal distance parallel to 090°'). Press the arrow key again for relative elevation. Note: the line on the display indicates the direction along which the distances are measured.

You can measure angles by pressing **Ang%.**

In your notebook, carefully record the locations as:

- location number
- location description
  - horizontal angle
  - vertical angle
  - slope distance
  - horizontal distance
  - vertical distance
  - northing from station
  - easting from station

Systematic (and possibly compulsive) record keeping will keep you from making fatal errors. Sketch the locations, angles and distances on the photo **WHILE** in the field. Be sure that your sketch of each location makes sense before moving on to the next location. **A copy of your notebook and field sketch map MUST be handed in with this lab.**

Sight every point that you can see from your present location.

VI) Move the total station to your next site. From the new site (and all other sites) you will need to do the following:

A) **Backsight** to your previous site.
Power up the transit. Rotate the transit so that it reads the horizontal angle that you just measured. Press **Hold**. Place the pole on the previous site and sight on the pole. Press **Hold** again. Flip the transit head over so that it is pointing in the reciprocal direction. The transit is now oriented so that horizontal angles read at this new site will be the same as those from the previous site.

B) Follow the instructions in V (above) and locate new positions. Record your measurements and add to your sketch.

VII) Draw up your map. Think through the map before starting or you will draw it more than once. Carefully refer to your sketch map. What is the approximate size of area? Plan to put your map on 11" x 17" paper (28 x 43 cm). Choose a scale that will fit the map on this paper nearly filling it. Orient the map. If your X-Y grid is not oriented N-S and E-W (which is very likely), determine its orientation from the known line orientation.

Use your X-Y orientations to determine the relative location of all points surveyed from your first station location. Be sure to determine the location of the second station site. Then use your X-Y locations from the second (and all other) station site(s) to determine the relative location of all points surveyed from each station location. Use the oriented baseline to determine the orientation of N and draw a N arrow.