

***Use of
Sokkia SET 4B_{II}
Electronic Total Stations***

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Kenneth M. Cruikshank

Department of Geology
Portland State University
Portland OR 97207-0751

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Introduction

The Geology Department with the assistance of the National Science Foundation (NSF DUE-96-50263), the Office of Sponsored Research, the College of Liberal Arts and Sciences, and the College of Engineering has purchased six Sokkia SET 4B_{II} Total Stations. These instruments can measure angles to 5" (0.00139°) and distances to $\pm 5 \text{ mm} + 3 \text{ ppm}$ (5 mm + 3 mm per km) by bouncing an infrared beam off a reflector. For each Total Station we have a Sokkia SDR-33 Electronic Notebook. These notebooks can store data from a Total Station and perform many surveying computations. The data can be transferred from the SDR-33 to a personal computer for further processing. Extra hardware for precise surveying was also purchased under the grant. A list of equipment available is given in an appendix.

This notes explain how to setup and use this equipment. Since surveying is very much a hands-on skill, the surveying projects in the park blocks are an important part of the course. Although we will teach some surveying techniques, this course is not a substitute for learning about surveying. Some surveying texts are listed in the reference list.

We will cover some techniques for precise surveying (e.g., landslide monitoring), and for making detailed maps. You will also learn how to download data to a PC, load it into Microsoft Excel, and plot the data using a simple mapping program like Golden Software Surfer (although you are welcome to use whatever mapping software you wish).

Outline Setting up Sokkia SET 4B_{II} Total Stations

Essentially you will always use the following 9 steps, however you should remember surveying consists of a series of tasks that get done in a different order depending on where you are in your survey. For this reason the document is contains instructions on how to complete a series of tasks, however it is up to you to make sure that you apply the tasks in the correct order. The first instrument setup requires different kinds of decision making than subsequent instrument setups.

- 1) Plan your survey. Decide on how you are going to proceed and what measurements you are going to have to make. What is the desired level of accuracy? How many instrument stations will be needed? What will you use for elevation, position, and orientation control?
- 2) Set up and level tripod and instrument over a point.
- 3) Attach and setup SDR33 data recorder if you are using one
- 4) Turn Instrument ON.
- 5) Loosen the clamp on the telescope.
- 6) Rotate the telescope about the vertical axis by 360°. You should hear a beep at this point.
- 7) Rotate the telescope about the horizontal axis by 360°. You should hear a beep at this point.
- 8) Configure the total station
- 9) Determine the orientation to a backsight point. Point the total station at this point, and take your backsight. This can be done manually using the instrument keyboard or via a SDR33. If the current station and backsight station are in the SDR33 memory, then it will determine the angle and set the instrument, otherwise you will have to provide coordinates and angles.

You are now ready to start using the Instrument

Guide to using this document

There are a variety of tasks that can be performed with a Total Station. Exactly how you setup and configure the system depends on the task. To help you figure out which parts of this document are relevant to the various tasks you can use the table below.

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Procedure for setting up a tripod & leveling Total Station

This can be one of the most time consuming procedures in surveying, and one of the most crucial. Any error in setting up the tripod is carried through the entire survey. Generally small setup errors (1 or 2 mm) are not a problem because they are non-systematic, and the EDM on Total Stations have an error of $\pm 3-5$ mm. I suggest the following procedure.

- 1) **Setup tripod.** Open up the tripod and extend the legs. Adjust the approximate height so that the total station will be at eye level. I suggest that you attach a tribrac to the tripod, and use one of the reflector posts — these contain an optical plummet. Start by setting one leg of the tripod on the ground. *This will be the “anchor” leg, and should not be adjusted in the following procedure.* Holding the other two tripod legs, and keeping the anchor leg in the same position, move the tripod until the plummet (or optical plummet) is over the point. Do not worry about having the tripod level. When you are over the point, anchor the two remaining legs. You should still be exactly over your point, although your tripod will not be level yet.
- 2) **Level the tripod.** By changing the length of two legs you used to position the tripod, level the top surface of the tripod using the bulls-eye level. The bubble should be within the inner circle. Be as precise as possible. *Do not change the length of the anchor leg.* After this procedure you should be directly over the same point you were over in step 1.
- 3) **Attach instrument to tribrac.** Set instrument into tribrac and lock in place. Align the long bubble-level between two posts of the tribrac. Turning BOTH posts in *opposite* directions, center the bubble in the level. Turn the Instrument though 90° to align it with the third leg. Turn only the third leg until level. The instrument will now be level.
- 4) **Check alignment over point.** Use the optical plumb on the instrument to check that you are still over your point. If you are not, you may slide the entire tribrac assembly slightly to get over the point. If you move the tribrac, repeat the leveling procedure.

Procedure for configuring Total Station

- 1) **Index the Total Station.** The first step is attach a battery pack and turn on the power. The instrument will beep a couple of times. After a few seconds the display should have 0 SET displayed on the screen. Loosen the vertical and horizontal clamps (parts 24 and 30 on the attached instrument diagram), and turn the instrument 360° about the vertical axis and horizontal axis. The instrument should beep, and you will see angles in the display area rather than 0 SET. At this point the instrument is indexed.
- 2) **Set up a notebook page**, or use the *Instrument Station Setup Checklist*. You will fill out this page before you enter all the numbers into the Total Station. This is done to make sure that nothing is missed.
- 3) **Measure Instrument Height.** Record instrument height. This should be measured from the ground to the tilting axis of the instrument. If setting up over a benchmark, measure height to top of BM *and* the height above the ground. The tilting axis of the instrument is marked on the side opposite from the on/off switch. It is a small hole inside a raised circle.
- 4) **Measure Temperature**, and record,
- 5) **Measure Pressure**, and record.
- 6) **Enter PPM Correction into Total Station.** The speed of light in air, and thus the distance measured, changes with the density of the air. Measuring the temperature and pressure allows an atmospheric correction to be calculated. The correction factor is in terms of parts per million (ppm), or mm/km. From the temperature and pressure you can look up the correction factor in a chart included with the total station, or you can enter the temperature and pressure in the instrument and it will calculate the correction
We apply the correction to the instrument. This way the corrected distance is passed to the SDR33 notebook. You must make sure that the SDR does not repeat the correction!
To enter the temperature and pressure, press the $\overset{\text{ENT}}{\text{SHIFT}}$ key (bottom right) then the EDM key (written in gold above the top left key). From the menu select item [3. ppm], then item [2. Temp & Press]. Enter the temperature and press ENT, then enter the pressure and press ENT. At this time the top item in the three-line display above the main display will show the ppm correction.
- 7) **Record instrument coordinates.** The instrument coordinate is a function of the task that you are performing and how much surveying you have already done in the current project. E_o , N_o , H_o are the E and N coordinates of the station. H_o is, for our “plane-table” mapping purposes, the ground elevation. For the first instrument station you may want $E_o = 0.0$, $N_o = 0.0$, and $H_o = 100.0$. For subsequent instrument stations use the coordinates of the point that you are setting up on. These will be entered into the SDR33 notebook if you are using one.
- 8) **Record reflector heights and prism constants for each reflector.** The instruments are set for a default prism constant of -40mm. Some of the prisms – the large orange and black triple-prisms – have are -30mm prism constants. Measure the reflector height, DO NOT rely on the calibration on the rod’s being correct.
- 9) **Enter a backsight, or desired angle.** What you use for a backsight very much depends on where you are in a survey, and what task you are performing. Details are given below. How you enter this depends on if your are using a SDR33 and on how much information the SDR33 contains.

Entering a Backsight

Backsights are how the instrument is oriented into an existing survey network. The concept of backsight appears to give students problems. The best way is always follow do the following:

- (1) Before getting moving an instrument, always take a reading to the next instrument station
- (2) When you setup at the new instrument station, always orient the instrument with respect to the previous instrument station. This is the backsight.

The backsight is a key step in setting up the instrument correctly. It is essential to get the instrument oriented correctly, and it is impossible to orient the instrument with any accuracy using a compass. Surveying measures the angle between two lines of sight, the actual bearing of the lines is generally not of importance. The important thing is to get a survey internally correct. You can establish the absolute orientation of your network of points by surveying in two known locations. For example, you may use existing benchmarks, or GPS to control two of your points.

Using the Total Station Keyboard

Case I. Starting a new job

- Point the Total Station at some clearly defined feature that you can accurately line up on again. The feature you use for orientation control should be as far away as possible. Think about your choice of orientation!
- Press the [3] key. This will put the display in theodolite mode. The vertical (ZA) and horizontal (HAR) angles will now be displayed. Now either press:
- $\overset{\text{ENT}}{\text{SHIFT}}$ then the [0 SET] key to set a the instrument to zero (North)
or
• $\overset{\text{ENT}}{\text{SHIFT}}$ then the [1] key. Now type in the horizontal angle in the form of *ddd.mmss*, where *d* is degrees, *m* is minutes, and *s* is seconds using the numeric keypad. Press $\overset{\text{ENT}}{\text{SHIFT}}$ when done.

Case II. Continuing an existing job

- Point the Total Station at a target at the previous instrument station. Or, if you only have one instrument station, and you are picking up where you left off, then point the instrument at the clearly defined feature that you used for orientation control when you first started.
- Press the [3] key. This will put the display in theodolite mode. The vertical (ZA) and horizontal (HAR) angles will now be displayed. Now press:
 $\overset{\text{ENT}}{\text{SHIFT}}$ then the [1] key. Now type in the horizontal angle in the form of *ddd.mmss*, where *d* is degrees, *m* is minutes, and *s* is seconds using the numeric keypad. The angle entered should be 180° different from the horizontal angle that was measured from the previous instrument station to the current instrument station. Press $\overset{\text{ENT}}{\text{SHIFT}}$ when done.

Using the SDR33 Electronic Notebook

The SDR33 will not let you begin to collect data without either specifying a backsight or telling it that no backsight is needed. You should have the SDR-33 notebook setup correctly before you enter a backsight to orient the Total Station (see p. 5).

Case I. Starting a new job

If you are starting a new job this is the time to set up your coordinate system. If you are making a control-point map then you will want to orient “North” along the long axis of your mapping project. Point the total station along the long axis and use the instrument control panel

to set the direction to zero (see instructions below). Then, when the SDR33 prompts you for the instrument station number, enter any number (usually 1). When prompted for a backsight reading, just press OK, and then confirm that you want to skip the backsight. The SDR will not reset the instrument under these conditions.

If you are making a precise survey of a quadrilateral, then it is the angle between lines that is important, so you do not need to set a backsight. In fact, you do not need to set the orientation of the instrument, you can just start taking readings. When the SDR33 asks you for a backsight, just press OK and confirm that you do not want a backsight reading. See the instructions for surveying a quadrilateral for more details.

Case II. Continuing an existing job

If you are continuing a job where it is important to orient the instrument, you should set up the instrument over a known point, and set up a reflector over a second known point. When starting to use the SDR33 specify the station number where the instrument is located. If the point number exists in the current job, then the SDR will display the stations coordinates and ask you for an instrument height. If the point number is not found in the current job then you will need to enter the coordinates of the current instrument station and the instrument height.

After specifying the location of the instrument you have to indicate the backsight point number. Again, if this point exists in the current job, you will be asked to point the instrument at a target over this point and take a reading. If the point does not exist, you are given the choice of either entering the coordinates of the backsight point, or the direction to that point. Once you have entered the information about this point, then you will be asked to take a reading to this point

The SDR will set the horizontal circle to value you entered, or from its record of point. It will then take a reading to the point and verify that the range and elevation difference match what is in the job database (if it is a pre-existing point).

Short Instructions for SDR33 Setup

This section is intended as a quick reminder of the steps you need to perform. It assumes you are familiar with the way in which the SDR-33 works. It is well worth becoming familiar with the SDR-33, it can make your surveying much more efficient.

There are two small “camera” batteries. These should be installed first. Make sure you get them in the correct way. Then install two 9v batteries. Always make sure that you have a spare set of 9v batteries before you go to the field. The camera batteries will maintain data stored in memory if the 9v batteries run out, but they cannot run the SDR-33. Never store batteries in the data recorder since it will constantly draw power from them, even when off, to maintain memory. Remove all batteries when done with the data in the recorder. *Check that you have downloaded all data before you remove the batteries!* The best method is to manually delete the surveying jobs. You can only delete a job if it has been downloaded.

You should run through the following setup each time you use the SDR-33. People using the data recorder before you may have used different settings.

Systematically move down the Function menu, starting with the *Job Menu item*. Check that each field is the way you want it. I would suggest checking the settings even if you were the last person to use the data recorder.

Turn the data recorder on. If you do not get to the screen with the Functions menu, either press the ^{I/O}Clear button, or press the F1 key (this is the FUNC softkey). The following is a rundown of the Function menu items. The options for each field are explained in the SDR33 manual. Below are suggested settings, and where appropriate I have made some suggestions on which settings to use.

Job

Specify a job name, or select a pre-existing job name. To select a pre-existing job, just highlight the name and press OK. To define a new job, press the “New” softkey (F1).

When defining a new job, you will be asked to fill out the following items

Job: Specify a name

S.F.: Leave this set at 1.0000000000. This scale factor can be used to reduce you measurements to a plane coordinate system.

Point Id: Usually use “Numeric”. This used 4-digit numbers to distinguish between points.

Record elev: You usually want the elevation. Set field to “Yes”

Atmos crn: Set to “No”

C and R crn: Set to “No”

Sea Level crn: Set to “No”

REMEMBER: use the ENTER key (bottom left corner) after you change a field. The OK key will enter a field and often assume you are then done with that menu.

After defining a job, you will be able to enter a comment. To skip this, just press OK.

Instrument

Make sure the SDR33 is connected to the total station. Under Model type, select SET 2-way, and press OK. The SDR33 will then get the serial number and current settings from the Total Station. It will also check the measurement modes being used by the SDR33.

Job Settings

Job: Job name will be here

Atmos crn: Set to “No”. We are having the instrument make this correction

C and R crn: Set to "No".
Sea Level crn: Set to "No".

Configure Reading

Type: Total Stn

Auto pt num: The number displayed here is the next automatic point number that will be used. It is usually set to 1000. I suggest using point numbers less than 1000 to indicate instrument points, and greater than 1000 to indicate surveyed points. If you are "Plane table" mapping with the total station, then you may want to set this number to 2, and use 1 as your first instrument point.

Topo view stored: Set to "OBS". This stores the observations - horizontal angle, vertical angle, and slope distance.

Combine F1/F2: Generally set to "No". If it is set to yes, the SDR33 will force you to take a F1 reading, then a F2 reading. It will then average the values and inform you if the difference between reading is greater than any tolerances you have set.

dist rdgs: Generally leave as "1". This is the number of distance reading the instrument will take. If greater than one, the distances are averaged. If you are only measuring angles then you can set this value to 0. This disables the EDM for normal readings.

Tracking: Generally "No". If set to "Yes" then the EDM constantly takes measurements.

Code list active: Generally "No", unless you have developed a code list.

Info blocks: Set to "0". This is the number of comment block associated with each reading.

Code fields: Set to "0".

Recip Calc: Set to "Prompted"

Tolerances

This screen lets you specify tolerances. If you have the SDR average F1/F2 readings, or when it compares a backsight reading with previous values, if the new values differ by more than the tolerances, you will be warned, and asked what you want to do.

Type: Generally "Total Stn"

Tol H.obs: Generally 30 sec

Tol V.obs: Generally 30 sec

Edm tol (mm): Generally 5 mm

Edm tol (ppm): Generally 3mm

Units

Angle: Generally use "Degrees"

Dist: Generally use "Meters". This is the 1990's ...

Pressure: Generally use "Millibar". This is the same as hecto-Pascals (hPa). The digital barometers we have use hPa.

Temp: Generally use "Celsius". Our thermometers are in °C.

Coord: Generally use "N-E-Elev".

Other grades: Generally use "%"

Sideslope grade: Generally use "%"

Sta..ing: Generally use "10+00"

Decimals shown: Generally use "3"

Zero azimuth: Generally use "North"

Communications

See handout on downloading data.

Date and Time

Here you want to set the current time and date. The *TimeOut* is the time in minutes after that if there had been no keyboard activity the SDR-33 will turn itself off. The *Timestamp* is the time increment between the SDR-33 saving the current time in the data recorder. It is best to set 0, this turns off the *Timestamp* feature. If you happen to be trying to record a reading at the same time that the SDR-33 is saving a timestamp you can have problems.

Date: Current date

Time: Current time

Time out: Suggest 10

Timestamp: Suggest 0

Job deletion

Use this menu item to select jobs for deletion. You cannot delete a job that has not been downloaded. You should delete all jobs before removing the batteries. This way you can check that everything has been saved!

Calculator

The SDR-33 has a built-in HP style calculator. This is handy for doing field calculations.

Feature code list

This allows you to have abbreviations for commonly used terms. If you have the *Code List Active* item in the Configure Menu set to yes then the SDR will insert the test associated with the abbreviation when making notes associated with a point. This is also used to identify different types of features you survey in. Plotting software can be configured to look at the feature and plot different symbols for that feature.

Hardware

This gives you a summary of the current hardware. Use this menu to change contrast, check batter condition, turn on the backlight, and change the volume level. The SYSTEM softkey gives you version numbers, and an idea of how much memory has been used, and how much is still available.

Upgrade

This option allows programs to be sent from a PC to the data recorder.

User program

The user can write their own programs for processing or collecting data using the data recorder. This allows you to load and run one of these programs.

Language

This should always read: English US.

Use of Pretel Alti+ A2 Altimeters

Why the pressure and temperature are needed

An important correction for the Electronic Distance Meter (EDM) is a correction for the speed of light in the atmosphere. The air density and humidity affect the speed of light. A good measure of the density comes from measuring temperature and pressure. The effect of humidity is about two orders of magnitude smaller than the density effect, so it is normally ignored. The correction factor is given in terms of PPM or parts-per-million. This is the equivalent to millimeters per kilometer. When surveying on the PSU campus, you will probably see a small correction – perhaps 8-10 ppm. Since you are measuring distances about 100m, the correction is less than 1 mm. This is small compared to the uncertainty in the standard distance measurement (3-5 mm \pm 5 ppm). However, in many cases the correction can get large (40 - 50 ppm in eastern Oregon during the summer) and you may be surveying over distances of several hundred meters. At this point the correction factor becomes important. You should always be in the habit of entering your Temperature and Pressure correction.

The temperature correction is obtained using a standard thermometer. To get the pressure we use a barometer. Below are instructions for using the barometers we keep with the Total Stations.

To turn Alti+A2 on

Press either the left or right button. There is no off button for the barometers, they will turn themselves off after 30 seconds.

To change between Altitude and Pressure readings

Press the left button. This will toggle between Altitude (ft or m) and Pressure (InHg or hPa)

To change units (metric or imperial)

Press and hold the right button for several seconds

- 30' will appear – continue to hold the button down
- CAL will appear – continue to hold the button down
- *m* or *ft* will appear – release the button
- *m* or *ft* will alternately appear for a few seconds each
- If you want metric, wait until *m* appears and then press the left button
- If you want imperial, wait until *ft* appears and then press the left button

The altimeter will now give readings in feet and inches of mercury or meters and hecto-Pascals (or milli-bars)

Procedure of making angle and distance measurements

Measuring angles and distances using the instrument keyboard

- Set the backsight
- Enter the PPM correction
- Align the crosshairs on the target
- Press the [3] key so that you can see the vertical and horizontal angle
- If you only want the angles, you can read them from the screen. The horizontal angle you see is the angle clockwise from the zero-direction of the instrument.
- To get a distance to the target, press the [7] or [8] key. The [7] key will give you the slope distance, and the [8] key will give you the horizontal distance. Note that the value returned in the double line of the triangle depicted on the key.
- The [9] key returns the elevation difference between the telescope and the reflector, this is NOT the ground elevation difference unless the reflector is at the same height as the instrument.

To get coordinates of a point using the instrument keyboard

- Set the backsight (must be the same as the coordinate system you are using!)
- Enter the PPM correction
- Use the [SHFT]-[S-O] key you can enter the coordinates of the instrument station
- Use the [SHFT]-[7] key to enter the instrument height
- Use the [SHFT]-[8] key to enter the reflector height
- Press the [4] key. This will return the coordinates of the reflector

Using the SDR-33 and the Topography program

- Configure the SDR-33 and attached it to the total station
- Press the *Clear* button until you enter the first menu
- Press the *SURV* (survey) menu key (F2)
- Highlight *Topography* and press *OK*
- At this point you will be asked to enter the station number. How you use station numbering will depend on the kind of surveying you will be doing. Enter a station number and deal with taking a backsight.
- Align the crosshairs on the target
- Press the large blue key in the bottom right corner. This will take a reading.
- **NOTE:** The first time you take a reading from a station the instrument may set the PPM correction to zero. If this happens, press the Clear key on the SDR after the reading is complete, then re-enter the PPM correction and take the reading again.
- The screen will now show you the angles and slope distances. You can enter a description of the point, and a target height. If need be you can also change the point number. When the screen contains all needed data, press the OK button. If you want to reject the data and re-take the readings, press the clear button (top right corner). This will take you back to the "Take reading" screen.
- Coordinates for the point can be seen using the [View] key.

Procedure for precise measuring of angles

Since there is no absolute north in the Total Station, we measure relative angles. Angles can be measured more accurately than distances. This requires that you always measure the angle between two reflectors. If you measure all angles in a geometric shape then you have the ability to error-check your measurements.

It should be noted that there are many different methods for measuring angles accurately. Several methods are mentioned below. The first procedure listed is simple and straightforward to do with the SDR-33 electronic notebook.

Note that the Sokkia Total Stations return angles in Degrees, Minutes, and Seconds. Many calculators have “time” functions for converting from hours, minutes and seconds to decimal hours. You can use these functions to convert angles to decimal degrees. Hewlett-Packard calculators will allow you to add and subtract hours, minutes and seconds, and give you the results in hours, minutes and seconds.

When to use these methods

All the methods listed below are designed to determine an angle as accurately as possible. All use double centering. This is the technique of making a “normal” or F1 reading, followed by a “reverse” or F2 reading, and combining them to give a single measurement. Double centering can eliminate 90% of instrument and operator errors. The difference in techniques is on the order that you make multiple F1 and F2 measurements, and the order in which you apply corrections. Pick the method that works best for you or the situation you are working with.

When using a Total Station for “plane-table” mapping it is not necessary to use the double centering technique. The Total Station in the F1 position will provide more than sufficient accuracy for this type of mapping.

Double centering should be used whenever you want to accurately determine angles and distances between stations. Such cases would be in surveying well locations, or strain markers on a landslide. When surveying in well surveys you should make observations in all directions. This allows you to average out elevation differences.

Using the SDR33 to average angles for you

With the instrument is set up on point 1, and reflectors are at stations 2 & 3, the following procedure should be successfully completed three times. Move to the OPTIONS menu, and set the *Combine F1/F2* field to YES. For this procedure all points in your geometric shape should have a unique point number.

A. With the instrument in Position 1 (Face 1, V1, or normal position)

- Align crosshairs on point 1
- Take a reading
- Set the Point Number field to 1, and enter the correct target height
- Select OK.

B. With the instrument in Position 2 (Face 2, V2, or inverted position)

- Align crosshairs on point 1
- Take a reading
- Check that the Point Number field is 1, and the target height is entered
- Select OK

The SDR33 will now average your two readings and make sure that they are within tolerances, if not, you will be warned.

C. With the instrument in Position 1 (Face 1, V1, or normal position)

- Align crosshairs on point 2
- Take a reading
- Set the Point Number field to 2, and enter the correct target height
- Select OK.

D. With the instrument in Position 2 (Face 2, V2, or inverted position)

- Align crosshairs on point 2
- Take a reading
- Check that the Point Number field is 2, and the target height is entered
- Select OK

You now want to go back to step A. When you take a reading, it is important to make sure that you enter the correct point number for the target location. This way the SDR33 will average your new reading with existing readings. When done, you will have a record of all of your angles and the averaged angles. You can then check the quality of your data using the geometric shape you surveyed (see next section).

A common method that does not use SDR33 averaging functions

The following procedure can be used to measure the angle between two lines. In this discussion it assumes that you are out to survey a quadrilateral. This is commonly used to obtain very accurate angles. The procedure is such that each angle is checked each time. There are methods for the sequence of measurements that are faster, but the whole sequence has to be repeated if a mistake is found. Using this method is a little more time consuming, but you have less work to do if you find a mistake. It is perhaps a good sequence to use for inexperienced users. Experienced users may prefer to work out a faster sequence of making measurements.

With the instrument is set up on point A, and reflectors are at stations B & C, the following procedure should be successfully completed three times.

A. With the instrument in Position 1 (Face 1, V1, or normal position)

- Align crosshairs on point B
- Record vertical and horizontal angles, and slope distance
- Align crosshairs on point C
- Record vertical and horizontal angles, and slope distance
- Take the difference between the two horizontal angle readings. This is the angle \widehat{BAC}_I .

B. With the instrument in Position 2 (Face 2, V2, or inverted position)

- Align crosshairs on point B
- Record vertical and horizontal angles, and slope distance
- Align crosshairs on point C
- Record vertical and horizontal angles, and slope distance
- Take the difference between the two horizontal angle readings. This is the angle \widehat{BAC}_{II} .

C. Check the angle

Take the difference between \hat{BAC}_I and \hat{BAC}_{II} . Is the difference less than your pre-determined tolerance? If difference is less than your tolerance, accept the reading and continue. If the difference is greater than your tolerance, reject the data and repeat the measurements.

For the SET 4B_{II} you may want to use an angle tolerance of 0.004 degrees (15 seconds). When you have completed three successful measurements, average the three measurements to obtain a single angle for \hat{BAC}

To survey a quadrangle, ABCD, you should set up on each of the points, and measure the following angles: \hat{DAB} , \hat{ABC} , \hat{BCD} , and \hat{CDA} . You should also record all the slope distances. To survey a quadrangle, you need at least 4 instrument-setups, and 48 angle/distance measurements.

- ◇ **Check 1:** The angles should sum to 360°. If they do not this represents your angular closure error.
- ◇ **Check 2:** Assign point A as coordinates (0,0). From point A calculate the coordinates of point B. From B calculate the coordinates of point C, from C calculate the coordinates of point D, and then from D calculate the coordinates of point A. You should come out with (0,0). Any difference is your closure error.

Another method for measuring angles

I observed the following procedure while working with surveyors from the Engineering Bureau of the City of Los Angeles. This is a good method to use if you are not closing a geometric shape. However, you should always close a geometric shape (that is measure all angles and distances within a shape). We were re-surveying sub-surface benchmarks looking for surface deformation from the 1994 Northridge earthquake.

In this method we make a F1/F2 reading to each target, turning the small angle between the two targets. We then rotate the lower base about 120° and make F1/F2 reading on each target, this time turning the large angle between targets. The two angles are then compared and adjusted to 360° if the difference is within acceptable limits. The procedure is as follows.

With the instrument on point A, and Reflectors at points B & C, we first determine the *small* angle between B and C.

- Make a F1 reading to point B
- Turn through the small angle between B & C
- Make a F1 reading to point C
- Turn through the small angle between B & C
- Make a F2 reading to point B
- Turn through the small angle between B & C
- Make a F2 reading to point C

Average the F1 and F2 readings to each point, then find the difference in angles. This is the small angle between B & C.

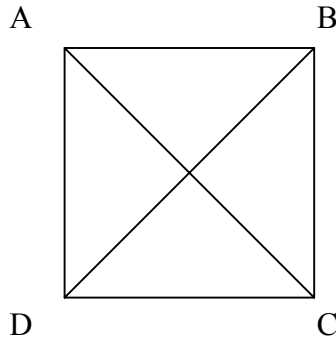
Now loosen the LOWER clamp on the horizontal circle and turn the instrument through 120°

Now repeat the above procedure, but this time turning through the large angle.

The two angles you have obtained should sum to 360°. You can sum the angles, take the difference from 360°, and then adjust each angle by ½ this amount, so that they will sum to 360°

Quadrilateral survey

The corners of the quadrilateral should be labeled A, B, C, D, in a clockwise direction. That is, if you are standing at A, looking at the opposite corner – C – , D will be on your right, and B on your left.



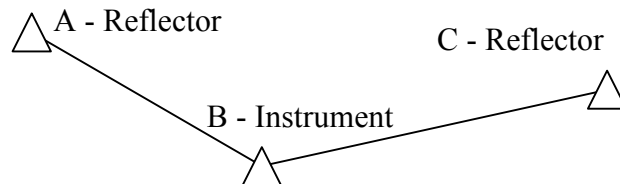
- 1) Make a sketch of the quadrilateral in your notebook. Record project, time, date, names of the survey crew. All of this is important. Since we are looking for changes in angles and lengths over time, we need to know when the readings were made.
- 2) If you are using a SDR33 notebook, you should still make a sketch in a notebook. You should record the point numbers used in the SDR for each round of readings. I suggest that you do not use the point averaging in the SDR33 — that is, never change a point number, only change the label. The more advanced users of SDR33 notebooks may wish to use the set collection program.
- 3) Set the instrument at A
 - Check that B,C, & D are level and over the benchmarks
 - Measure the height of all tripods
 - Take a F1 reading to B – check that the label and tripod height are correct
 - Take a F2 Reading to B – check that the label and tripod height are correct
 - Take a F1 reading to C – check that the label and tripod height are correct
 - Take a F2 reading to C – check that the label and tripod height are correct
 - Take a F1 reading to D – check that the label and tripod height are correct
 - Take a F2 reading to D – check that the label and tripod height are correct
 - On the first cycle record the readings in your notebook. You can use this to check your other readings as they are taken. You should also use the first set of readings to check that the sum of the angles is correct for the various triangles in the quadrilateral. This may help you detect a bust.
 - Repeat the above procedure two more times (for a total of 9 *pairs* of readings)
- 4) Move the instrument to station B. Make measurements to A, D, and C as described above. Before starting, make sure that all reflectors are level and exactly over you points.
- 5) Move the instrument to station C. Make measurements to D, A, and B as described above. Check reflectors are level and over the points.
- 6) Move the instrument to station D. Make measurements to A, B, and C as described above. Before starting, make sure that all reflectors are level and exactly over you points.
- 7) When done you should have eight angles and six lengths.

Geophysical Line (Traverse) Survey

This is perhaps the hardest type of survey to have confidence in since you will not get to close your survey to see how well you did. The best way we have available to check the survey is to use GPS to anchor both ends of the line. You can then start and end your survey at a known point. Afterwards you can translate and rotate your survey coordinates so that your final point is as close as possible to the coordinates of the end point as determined using GPS. You should survey in any benchmarks in your area – these will be needed for elevation control.

Since there are numerous station setups it is important to maintain orientation control along the line. This process is made easier if you are using a SDR33 electronic notebook, since it will prompt you for backsights, etc. In the SDR33 I suggest you use single digit numbers to refer to survey stations, and use numbers greater than 1000 for the geophysical observation points.

The basic geometry will be the current instrument station (Station B) with a reflector at the next instrument station (Station C) and a reflector at the previous instrument station (station A). The geometry will be a little different for the first and last instrument stations.



- 1) Record project name, time, date, names of survey crew in a notebook. All of this is important since it can be used to help find and correct errors.
- 2) Make a sketch of the current geometry in your notebook. Even if you are using a SDR33 electronic notebook, you should still make a sketch in a notebook. You should record the point numbers used in the SDR for each round of readings. Make sure the SDR33 is configured so that it will combine F1/F2 readings
- 3) Set the instrument at B and orient the instrument
 - Check that A, B, & C are level and over the benchmarks
 - Measure the height of all reflectors. Writing the current height on some flagging and attaching it to the tripod is a good idea.
 - Enter the current station number (for B) into the SDR33 as the instrument point. Change any other fields as needed.
 - For the backsight enter the station number of A. The SDR33 will now prompt you to take a backsight to station A. This will orient the instrument. At this point enter the temperature and pressure corrections for the EDM (if you do it earlier the SDR33 will clear the entry from the Total Station).
- 4) Determine the orientation to the next instrument station
 - Take a F1 reading to A – check that the label and tripod height are correct. Remember to override the default point number with the station point number.
 - Take a F2 Reading to A – check that the label and tripod height are correct
 - Take a F1 reading to B – check that the label and tripod height are correct
 - Take a F2 reading to B – check that the label and tripod height are correct
 - Repeat the F1/F2 reading to A and C.
 - Take single F1/F2 reading to each of the geophysical stations.
 - When done, move to station C and repeat this procedure.

The first instrument station

In surveying we need to tie our survey to the outside world. For us the best thing to do is to use GPS to tie down the location and orientation of the end points of the line. You should, however, survey in all benchmarks that you can. This is especially important for orientation control. Perhaps the best case is to start and end on a benchmark of known elevation, and use GPS to get the coordinates of the benchmarks.

I have found it useful to set the zero direction of the instrument in the direction of the final station. This way you can use your intuition to check your readings, *i.e.*, are you pointing to the left ("W") or right ("E") of the final point.

A more advanced procedure for line surveying

The accuracy you have in your line depends on how accurately you can measure the angle between the line segments A-B and B-C. The procedure above is a simple one, and works well with the SDR notebooks, and you will leave the field with the coordinates of the geophysical stations. This is because the procedure keeps the same coordinate system throughout your survey

A way of getting more accurate angles on a traverse is as follows:

- a) Take F1/F2 readings to A and C, turning the instrument through the smaller angle between A and C. Correct each angle, and determine the change in angle (You may want to do this procedure two or three times and average the result).
- b) Loosen the LOWER clamp of the Total station and rotate the station about 60° .
- c) Tighten the lower clamp
- d) Take F1/F2 reading to A and C, turning the instrument through the larger angle. Correct each angle, and determine the change in angle (You may want to do this procedure two or three times and average the result).
- e) The sum of the angles from steps (a) and (d) should be 360° . If it is not, then adjust the angles by the same amount so they sum to 360° . This will give a better measurement of the angle between the two line segments

Because the lower clamp was loosened and the instrument rotated you do not have a consistent orientation in the instrument along the line. Although you can use the SDR33 to store data you will have more processing to do by hand later.

Download SDR33 Jobs to a Windows PC

In these instructions we use Microsoft Windows Terminal Program (Windows 3.1) or HyperTerminal Program (Windows 95/NT) to download the data. Any communications program (for DOS, Mac OS, or Windows) can be substituted. The programs used in this handout come with Microsoft Windows, so will be universally available.

1. Connect SDR33 to PC

Connect the SDR33 to one of the computers serial ports. This requires a special cable. Currently this cable is attached to “Pope & Talbot” in the Geology Department computer lab. If you are going to be using another computer for downloading, please sign out a cable from the Geology Department Office. **DO NOT REMOVE THE CABLE FROM “Pope & Talbot”.**

We will assume that the SDR33 is connected to COM2 (many computers, such as the ones in the Geology Department Computer Lab use COM1 for the mouse, COM2 is then available for connecting devices such as the SDR33 or GPS units).

2. Setup the SDR33 for communications

- Go to the main function menu
- Select the Communications menu
- Select the SDR data format. Other formats available are MOSS; ICS; Binary File ; Printed; Plotted. To import the data into Microsoft Excel you should use the SDR format. Details on these other file formats can be found in the SDR manuals.
- Select the data you want to download. Use the OPTNS softkey. Download the current view (*usually OBS. This is set in the *Configure Reading* menu during the Job setup). Select other views you may want. For “Plane Table” mapping you will want to select “POS”. This will download the E,N,Z position of points.
- Under the COM softkey, set the following fields
 - Port: Top*
 - Modem: No*
 - Baud rate: 9600*
 - Word Length: 8*
 - Parity: Not set*
 - Stop bit: 1*
 - Output delay: 0*
 - File: No*
- After setting the above settings, use the SEND softkey
- Select jobs
- Highlight the job
- Press the ALL softkey

At this point you are ready to download the data.

Pressing OK will start the process.

Before you press OK you need to configure the computer to collect data.

Use either (3a) or (3b) depending on the version of windows you are using.

The default windows directories and program groups are assumed.

3a) Windows 3.1 and Windows NT 3.1 to 3.51: Terminal Program

- Start MS Windows
- Open the Accessories Group
- Double-Click on the Terminal icon
- Windows Terminal should now be running
- Select the Settings ... Communications... menu item
 - Baud Rate: 9600*
 - Data bits: 8*
 - Stop bits: 1*
 - Parity: None*
 - Flow Control: Xon/Xoff*
 - Connection: COM2*
- Click on the OK button when these settings are set.
- Choose the Transfers ... Receive Text File ... menu item and specify a filename to store the data in. Use a file extension of SDR. Make a note of which directory the file is going into!
- Press the OK button on the SDR to start the download process.
- You should see the contents of the file scroll past you on the screen
- Once all the data has been transferred, select the Transfers ... Stop menu item to close the file.
- You can now exit the terminal program

3b) Windows 95 and Windows NT 4.0: Hyper-Terminal Program

- Click on the Start Icon
- Programs
- Accessories
- HyperTerminal
- HyperTerminal Program *OR* the SDR33 Download Icon (this assumes someone saved a Hyper-Terminal Profile with the suggested settings. It is still wise to check the communications parameters though)
- HyperTerminal should now be running. If there is not a SDR33 profile, you will be asked about a "New Connection". Assign a name to the connection (e.g., SDR 33) and click OK
- Select COM2 (if that is the port to which the SDR33 is connected)
- Fill out the COM2 properties page
 - Baud Rate: 9600*
 - Data bits: 8*
 - Parity: None*
 - Stop bits: 1*
 - Flow Control: Xon/Xoff*
- Select OK
- Select the Transfer ... Capture Text menu item
- Press the OK button on the SDR to start the download process.
- You should see the contents of the file scroll past you on the screen
- Once all the data has been transferred, select the Transfer ... Capture Text ... Stop menu item to close the file.
- You can now exit the HyperTerminal program

Work with the data in Microsoft Excel

You can now use Microsoft Excel to read the SDR file. This can only be done if you have added the SDR33 add-in developed at Portland State University. See the SDR33 Excel Add-in handout for more information.

Other downloading options

The SDR33 (Expert) comes with software for downloading Binary Files. Unfortunately this only downloads the raw data stored by the SDR33. It does not download positions. For this reason you may want to use the SDR format.

You can also download a human readable version of the data in the SDR. This is the Printed output. Use the same instructions as above, but set “Printed” in step 2.

Microsoft Excel Add-in to load Sokkia SDR format files

- Download the add-in from the Total Station course home page (<http://www.geol.pdx.edu/Courses/TotalStation/>).
- Save the add-in the Excel\Library directory.
- Start Excel
- Select the Tools ... Add-ins menu
- If the SDR-import add-in is not listed, select Browse, and locate the add-in
- Make sure there is a check mark next to the SDR-Import add-in
- Exit this menu.
- To run the Add-in, use the Tools...Sokkia SDR Import menu item
- The File Open dialog box should appear. It will list all files with an SDR extension. Find the file you wish to import, and select OPEN
- You will be asked what data you want to import: Angles only, Coordinates only (assuming you downloaded the POS view), or Angles and Coordinates. Select which one you want.
- The macro will insert a sheet with the same name as the job name in the SDR file. If a worksheet with this name already exists then you will be asked if you want to replace the existing sheet or add in a new sheet. The new sheet will have the job name followed by a number.

Adjusting a traverse

A traverse is a survey where you have occupied each station and measured each angle and distance between points. The quadrilateral you surveyed in the park block is an example of a traverse.

Once you have adjusted each pair of F1/F2 readings, and averaged several F1/F2 combinations for each station you will have 12 angles (8 vertical and 4 horizontal) and four distances.

- Fix one corner of quadrilateral, say the SW corner. This will have coordinates of (0,0,0). Assign the direction from the SW to the SE corners to be “east”. Use your data to calculate the coordinate of the SE corner.
- From the SE corner, use the angle between lines from the SE to SW corner and SE to NE corner to calculate the coordinates of the NE corner.
- From the NE corner, use the angle between lines from the NE to SE corner and NE to NW corner to calculate the coordinates of the NE corner.
- From the NW corner, use the angle between lines from the NW to NE corner and NW to SW corner to calculate the coordinates of the SE corner. The difference between this calculated coordinate and (0,0,0) is your error of closure.

Since we know that the shape should have no error and we have convinced ourselves that there is no obvious bad data in our data set we can adjust the angles and distances so that our shape will close. There are several methods for adjusting traverses. The most complete method uses least-squares to adjust angles and distances so that you make the smallest possible changes. One method for quadrilaterals is given by Smith & Varnes (1987, Least-squares adjustment of triangles and quadrilaterals in which all angles and distances are observed: *Surveying and Mapping*, v. 47, no. 2, p. 125-142.). Copies of FORTRAN programs for making these corrections are given on the course web page. Note that the programs require ISML routines.

For this exercise you should use a coordinate adjustment method. Even for this adjustment there are two options:

Coordinate Adjustment: Compass Rule

In this method the coordinate error is distributed in proportion to the length of traverse lines. The assumption is that the greatest error will come from the longest shots.

$$\text{Northing adjustment} = \frac{\text{Length of traverse line to point}}{\text{Total length of traverse}} \times \text{Northing closure error}$$

$$\text{Easting adjustment} = \frac{\text{Length of traverse line to point}}{\text{Total length of traverse}} \times \text{Easting closure error}$$

$$\text{Elevation adjustment} = \frac{\text{Length of traverse line to point}}{\text{Total length of traverse}} \times \text{Elevation closure error}$$

Coordinate Adjustment: Transit Rule

In this method, the coordinate error is distributed in proportion to the amount that various coordinates change between points.

Northing adjustment =

$$\left| \frac{\text{Change in Northing for traverse line to point}}{\text{Sum of absolute values of all changes in northing for all traverse lines}} \right| \times \text{Northing closure error}$$

Easting adjustment =

$$\left| \frac{\text{Change in Easting for traverse line to point}}{\text{Sum of absolute values of all changes in easting for all traverse lines}} \right| \times \text{Easting closure error}$$

Example Map

The following is an example of the kind of map you can produce in Surfer. From the SDR data file I generated the following files

- *TopoDat.dat*. Contains (e,n,z) coordinates of all points. Used by the *Grid* menu to create a grid file (TopoDat.grd)
- *TopoDat.grd*. File produced by Surfer from TopoDat.dat
- *Corners.dat*. Coordinates of corner points (same as quadrilateral points)
- *Lines.bln*. Contains lines for grass areas.
- *Boundary.bln*. Contains coordinates of corner points. Used in the *Grid...Blank...* menu option to blank the part of the grid outside the quadrilateral. This essentially removes the contours from the edges of the map. The boundary.bln file operated on the TopoDat.grd file to produce TopoDat2.grd.
- *TopoDat2.grd*. Blanked Surfer grid file

Copies of the files (excluding the grid files) are attached.

The above files were then combined to produce a map as follows:

- 1) Use the *Map ... Contour* option to open TopoDat2.grd
- 2) Use the *Map ... Overlay* option to plot Corners.dat. This gives the corner positions.
- 3) Use the *Map ... Load Base Map* option to plot the Lines.bln file on the map
- 4) Use the mouse to select all the above layers, then use the *Topo ... Overlay maps* option to overlay and align all the map layers.
- 5) Print the final map

Surfer File Formats

Grid files

The first step to producing a Surfer map is to make two worksheets in Excel. One should contain (E,N,Z) coordinates for all your points. This file will be used by Surfer to generate a grid file that will then be contoured. There should be three columns in this worksheet: E, N, and Z. The first line should contain a column label. Save this worksheet as an ASCII text file. You can add as many columns as you like in this file, and they can be in any order. Do make sure that you use the first line as column labels!

The second worksheet will contain coordinates of lines. There are two possible formats you can use: the *Boundary Line File* or the *Atlas File* format. Details are given below.

In Surfer you will first create a grid file from the (E,N,Z) data, and then contour the resulting grid file. The line files can then be overlaid onto the contour map.

Boundary Line Files

We will use this line type to plot lines on the map. The format is outlined on p. 9-8 to 9-10 in the Surfer manual. These files should be ASCII text, and use an .BLN file extension

The format is simple:

Number of points in line 1, flag

e_1, n_1

e_2, n_2

$e_3, n_3,$

.

.

.

e_n, n_n

Number of points in line 2, flag

e_1, n_1

e_2, n_2

$e_3, n_3,$

.

.

.

e_n, n_n

If you make $e_n = e_1$, and $n_n = n_1$ then you will have a closed shape. Normally you will want to set the flag to 0. This will blank inside the boundary.

You can create this format on an Excel worksheet and use the “Save As...” command to save the sheet as a comma delimited text file.

Atlas files

We will use this line type to plot lines on the map. The format is outlined on p. 9-6 to 9-7 in the Surfer manual. These files should be ASCII text, and use an .BNA file extension. This format is similar to the BLN format. The ID names are used to identify objects in Surfer. Using the Object ID you can fill objects with different attributes.

“Primary ID name”, “Secondary ID name”, curve type (a single number)

e_1, n_1

e_2, n_2

$e_3, n_3,$

.

.

e_n, n_n

“Primary ID name”, “Secondary ID name”, curve type (a single number)

e_1, n_1

e_2, n_2

$e_3, n_3,$

.

.

e_n, n_n

There can be multiple objects in a single file. The curve type is the number of (e,n) points that define the line. If you leave the number as a positive integer then it is interpreted as a polygon (a closed shape). If it is a negative number then it is a polyline. The difference is that a polygon will always draw a line from the last to first points. In the case of the polyline the absolute value of the number is the number of vertices.

Examples of Surfer Files

TopoDat.dat

```
"Name", "Number", "Easting", "Northing", "Elevation"  
"BS-Point", 1000, -0.004304, 35.51018, 98.30226  
"line1", 1001, -4.805739, 29.88262, 98.22028  
"line1", 1002, -11.35918, 25.34923, 98.41533  
"line1", 1003, -11.76833, 22.79258, 98.5062  
"line1", 1004, -16.88055, 19.26647, 98.61948  
"line1", 1005, -19.41705, 19.67862, 98.57703  
"line1", 1006, -26.11094, 15.12753, 98.74338  
"line1", 1007, -21.9202, 9.082759, 98.81189  
"line1", 1008, -1.952017, 0.4794111, 99.97485  
"line1", 1009, -0.4093112, 1.533964, 99.99229  
"line1", 1010, -1.481919, 25.24327, 98.3056  
"line2", 1011, 3.818055, 23.98207, 98.33434  
"line2", 1012, 4.802134, 2.001531, 99.97575  
.  
.  
.  
"topo", 1085, 3.449535, -20.68444, 100.9283  
"topo", 1086, -4.438947, -19.30832, 100.728  
"topo", 1087, 1.403334, -11.35189, 100.2917  
"topo", 1088, -7.554019, -9.8283, 100.119  
"topo", 1089, -8.021962, -0.5889005, 99.63486  
"topo", 1090, -16.92247, -2.763579, 99.48798  
"topo", 1091, 8.335228, -13.02091, 100.3145  
"topo", 1092, 7.837219, -19.83388, 100.8761  
"topo", 1093, 13.2805, -12.6579, 100.5711  
"topo", 1094, 22.04708, -15.48218, 101.3903  
"topo", 1095, 9.424007, -4.370037, 100.2025  
"topo", 1096, 13.52819, -48.87768, 102.5  
"ts2", 1047, -34.96098, 18.15217, 98.74827  
"ts3", 1048, 47.01132, -30.70967, 102.3399
```

Corners.dat

```
"Name", "Number", "Easting", "Northing", "Elevation"  
"tt", 1096, 13.52819, -48.87768, 102.5  
"tt", 1048, 47.01132, -30.70967, 102.3399  
"tt", 1047, -34.96098, 18.15217, 98.74827  
"tt", 1000, -0.004304, 35.51018, 98.30226  
Lines.bln  
11, 0  
-4.81, 29.88  
-11.36, 25.35  
-11.77, 22.79  
-16.88, 19.27  
-19.42, 19.68  
-26.11, 15.13  
-21.92, 9.08  
-1.95, 0.48  
-0.41, 1.53  
-1.48, 25.24  
-4.81, 29.88  
10, 0  
3.82, 23.98
```

4.80,2.00
5.72,2.03
12.63,-7.99
12.28,-8.81
15.28,-10.11
22.65,-13.30
31.38,-17.04
31.99,-16.61
3.82,23.98

...

(Data for two other lines omitted)

Boundary.bln

5,0
-34.96098,18.15217
-0.004304,35.51018
47.01132,-30.70967
13.52819,-48.87768
-34.96098,18.15217

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Manuals Available

- SET 2B_{II}/3B_{II}/4B_{II} Electronic Total Station Operator's Manual
- Series B_{II} Electronic Total Station Two-way communications functions, Command Explanations
- SDR33 Quick Reference Card
- Atmospheric Correction Card
- Series B_{II} Field guides
- SDR33 Reference Manual
- SDR33 Reference Manual addendum
- SDR33 Getting Started

List of Surveying Equipment

The following is a list of equipment available in the Geology Department. You can use this for planning the equipment you may need for field work. See Gene Pierson about making arrangements to use the equipment. You should have had proper instruction on care and use of the instrument before taking it to the field.

GPS

- Trimble 12 Channel Community Base Station
- Trimble GeoExplorer II
- Trimble Pathfinder software (for differential correction)
- II Morrow 6 Channel Handheld GPS receiver, with software for differential correction (others are available from the Geography and Environmental Sciences Departments)
- Garmin GR-45 handheld receiver with GBR-21 receiver with 6' antenna for real-time differential correction (see Curt Peterson. Best for Coastal work).
- 5 Magellan GPS 2000 receivers.

Total Stations / Theodolites / Plane Tables

- 1 × Sokkia SET 5A Total Station (5-second theodolite)
- 6 × Sokkia SET 4BII Total Stations (5-second theodolite, 5 mm + 3 ppm EDM, Single prism range: 1.2 km)
- 1 × Sokkia SET 2BII Total Station (1-second theodolite, 3 mm + 2 ppm EDM, Single prism range: 2.4 km)
- 6 × SDR-33 Expert Electronic Field Notebooks (640 Kb)
- 1 × SDR-33 Standard Electronic Field Notebooks (256 Kb)
- 1 × Wild T-2 1 second theodolite
- 5 × K&E Alidades / Tripods / Plane tables / rods (feet)

Distance Meters

- 1 × Sokkia RED-2 EDM.
- 1 × Pentax EDM

Level

- 1 × Sokkia B21 Level (1.5 mm / Km using double-run methods)
- 2 × 7.6 m fiberglass level rods

Prisms/Prism Mounts

- 11 × Sokkia AP-01 -40mm prisms
- 7 × WA Tribracs
- 7 × Tribrac adapters with optical plummet for mounting reflectors
- 9 × Sokkia AP-01 tilting prism holders with targets
- 1 × AP-03 Triple Prism mount
- 2 × Triple Prism assemblies with -30mm offset reflectors
- 1 × -30mm / 0mm offset single prism with target

Tripods / Prism Poles

- 12 × Wide wooden tripods
- 1 × Fiberglass Tripod
- 12 × Adjustable prism poles

Surveying Equipment Checklist / Sign-out List

Please fill out this form. We use the forms to track the use of equipment so we can make reports to the NSF. It is part of the justification for investing in this type of equipment. The only reason we ask for a name and phone number is to contact you if the equipment is urgently needed by someone else. Please report any problems with the equipment so that it can be fixed.

Date Out: _____
 Expected Return date: _____
 Date In: _____
 Name/Phone Number: _____
 Project: _____
 Any problems with equipment? _____

Number		Out	In
	Total Station (Contents of Carrying Case)		
	Sokkia Set 4BII (record serial numbers)		
	Lens cap		
	2 Rechargeable BCD 25 battery packs		
	BCD 19 battery module		
	BCD 27 battery charger (120 v DC)		
	Tubular compass		
	Plumb bob		
	Sun Hood		
	Tools		
	Vinyl cover for total station		
	Silicon cloth for cleaning optics		
	SET B _{II} Short Instructions		
	SDR 33 Short Instructions		
	PPM tables		
	Bag of silicon gel		

	SDR 33 Equipment		
	SDR 33 notebook (record serial number)		
	Padded case for notebook		
	Two 9 v Alkaline batteries		
	Two Lithium Backup batteries		
	Rotating bracket for SDR33		
	SDR33 Mounting bracket holder		
	Cable adapter (6 pin to 9 pin RS 232)		

	Prisms / Prism Mounts		
	Single prism mounts (in padded bag)		
	Triple prism mounts (in padded bag)		
	-30 mm Triple Prism Assemblies		

	Other Equipment		
	Wooden Tripods		
	Tribrac		
	Target mounting posts w/ optical plummet		
	Large carrying cases for tribracs & posts		
	Prism Poles		
	Metal tripods for prism poles		
	Sokkia Umbrella		
	Brunton		
	Cloth tapes (15, 30 m)		
	Steel measuring tape (metric)		
	Thermometer (°C)		
	Barometer (analog or digital?)		

	Total Station Manuals		
	SET 4B _{II} Manual		
	SDR33 - Getting Started		
	SDR33 - Reference Manual		
	SDR33 - Reference Manual Supplement		

	Level		
	Sokkia B2 _I Self-adjusting level		
	Toolkit		
	Cover		
	Instruction Manual		
	6.7 m Level Rods		

Instrument Station Setup Checklist

Project name: _____

Instrument operator: _____

Rodman No. 1: _____

Rodman No. 2: _____

Station No: _____

Description of instrument location: _____

Item	Value	Entered to Total Station
Instrument Height: To Ground		
To BM		
Station Elevation		
Station Easting		
Station Northing		
Orientation Control		
Temperature (°C)		
Pressure (InHg)		
ppm (from chart)		
Starting Block Number		
Starting Point Number		
Height of Rod No. 1:		
Height of Rod No. 2:		
Prism Constant, Rod No. 1	mm	
Prism Constant, Rod No. 2	mm	

Total Station Data Sheet

Station number: _____ Date: _____ Page ____ of ____
 Station elevation: _____
 Station coordinates: _____ E _____ N Location: _____
 Instrument height: _____
 Reflector height: _____
 Orientation: _____
 Instrument operator: _____
 Reflector operator: _____ Comments: _____
 PPM correction: _____
 Units: (ft) (m) (cm) (mm)

Point Number	Point Code	Coordinates			Angle		Slope distance	Comments
		East (E)	North (N)	Elevation (Z)	Vertical (ZA)	Horizontal (HAR)		

