GEOM20015
Sensing and Measurement

Assignment 2

Traversing

25 July 2024

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Definitions

Let us start with definitions necessary to understand Assignment 2 and the field procedures associated with the process of traversing:

Directions	Simply that, a direction (over there).
Bearings	A direction relative to a datum.
Angles	The arithmetic difference between two directions or bearings.
Total Station (TS)	An instrument used for measuring angles (directions) in the horizontal and vertical planes and distances using Electronic Distance Meters (EDMs).
Prism	A reflector that reflects the EDM beam of a total station.
Tribrach	A plate for attaching an instrument or a prism to a tripod.

Objective

Assignment 2 forms the second part of your project. With the temporary CPs established and their heights determined through levelling, your group must now determine the horizontal coordinates (X,Y) of temporary CPs (establish horizontal control). You will do this by performing a closed traverse, traverse calculations, and adjustments. You will use a total station in this assignment. Familiarise yourself with the total station through the self-learning Equipment Module E5 on Canvas before heading out in the field. A detailed instrument guide for the total station used in this assignment is provided as a supplementary material on the Assignment 2 page on Canvas.

A traverse is a sequential series of total station set-ups used to determine the coordinates of points along a path (polyline or polygon) by measuring distances and angles. Different types of traverses and methods to set up the station exist. In this assignment, you will learn to use the most common ones. Note, levelling provides a higher accuracy to determine heights of points required in this project for the stormwater harvesting system.

Your team must perform a closed traverse. In your case, the traverse forming a polygon is already formed by the closed loop of CPs set by pegging in the previous assignment. However, this polygon integrates only one permanent CP of known horizontal coordinates while traversing requires at least two permanent CPs. So, your team must choose a second permanent CP, which can be any permanent CP within the line of sights from the first one. An example polygon is shown in Figure 1, where CP 3002 is included as the second permanent CP.

Why do we need two CPs of known horizontal coordinates for a traverse? The horizontal coordinate system is 2-dimensional, which means it has 3 degrees of freedom (2 translations and 1 rotation). By placing the total station directly above a CP, we have resolved (fixed) 2 degrees of freedom. The most common way of resolving the 3rd degree of freedom, rotation, is by simply setting a backsight towards a second CP of known horizontal coordinates. This orients the totals station, which is now properly set up.

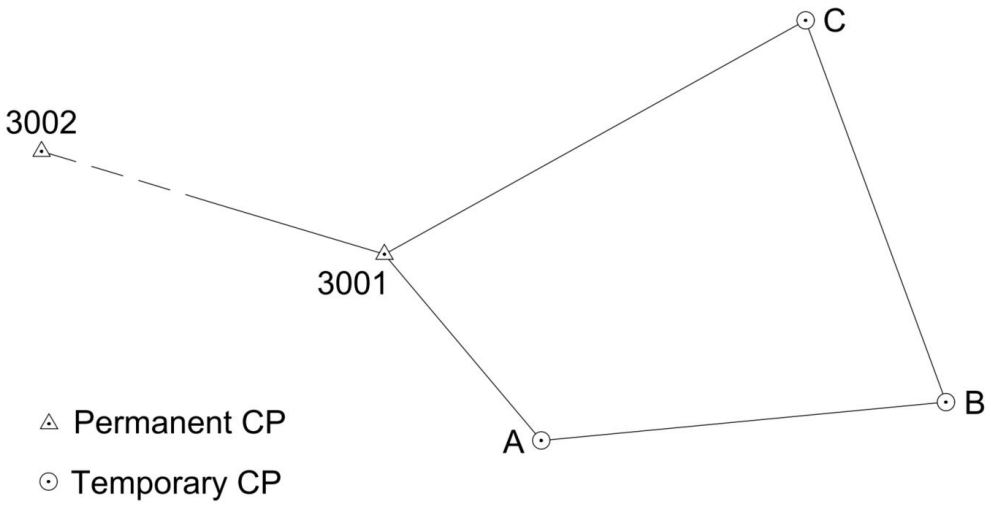

Figure 1. *Example traverse polygon.*

Forced centering

Your group should use forced centering to perform the traverse. Forced centering is a traversing method used to minimise the errors associated with the setting up of targets and instruments. Forced centering makes use of tribraches, Figure 2, which are attached to the base of the tripod and which are used to fix either a total station or a prism on top. Once the tribrach is set up, the instruments can be removed from the tribrach and interchanged.

Figure 2. *A tribrach and a prism fixed into a tribrach.*

This allows traversing using three tripods, one total station, and two prisms, as shown in Figure 3. In this example, the total station is first set up on top of point A, the backsight prism on top of point 3001, and the foresight prism on top of point B. Once the directions and distances are measured and we want to move the total station to the next point, point B in the counterclockwise direction, the total station on A and the prism on B are swapped by releasing them from tribraches and locking them in their new place, while keeping their tripods in place. The second prism is moved from point 3001 prism to point C with the tripod. In other words, when moving along the traverse two points are similar, which means two out of three tripods are kept in place, which reduces errors and increases the accuracy.

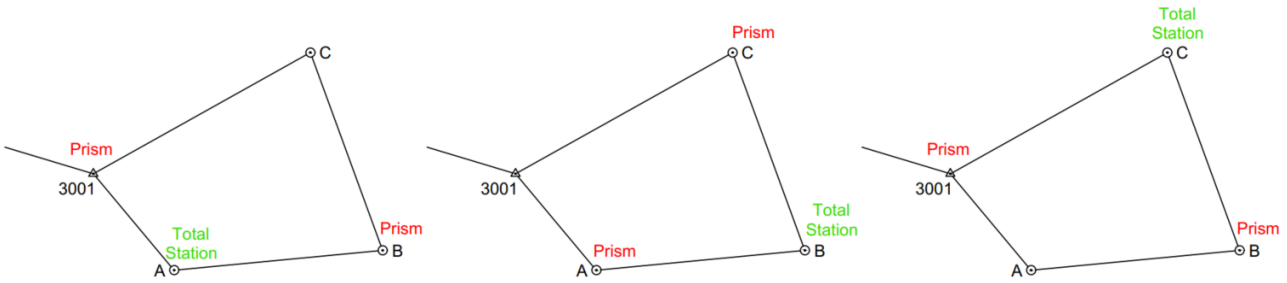

Figure 3. *Forced centering example. Diagrams from left to right show locations of the total station and prisms when moving in a counterclockwise direction.*

Recall levelling, where we "transfer" a height from a point of a known reduced level to a point of an unknown reduced level using a measured height difference. In a sense, in traversing we "transfer" the horizontal coordinates from a known to an unknown point using bearings and distances.

Tasks

Assignment 2 consists of two main tasks. A detailed numerical example of these tasks, with figures, planning of field measurements, booking, reduction and adjustment, is provided as a supplementary material on Canvas.

Task 1: Traversing

You must perform a closed traverse by measuring directions and distances of all sides of the polygon.

Consider the following:

1. Plan the field measurements before you begin to ensure all necessary data has been gathered. This includes all internal angles of the polygon, lengths of all polygon sides, and setting the baseline. See the numerical example for more information.
2. When using forced centering, subsequent instrument stations always have two similar points between them. This means only one tripod is moved between the subsequent stations.
3. After swapping the prism and the total station, do not forget to lock the tribraches. Forgetting to lock them means the instruments are loose, which is bad for the measurements and may also cause the total station to drop to the ground and gets damaged.
4. You should measure directions with at least two repetitions (two sets). See the numerical example for more information.
5. Make sure the prism constant set in the total station matches the offset of prisms you are using. An incorrect prism constant will cause all measured distances to be incorrect (longer or shorter by a constant offset).
6. Make sure the prisms are exactly vertically above the CP by checking the spirit bubble is level and the optical plummet aims to the middle of the CP.
7. Make sure the total station is exactly vertically above the CP by performing the centering and levelling (this will be demonstrated in practicals):
    a. Adjust the length of tripod legs and set it above the point.
    b. Level the coarse physical spirit bubble using the tribrach footscrews.
    c. Level the fine digital bubble using the tribrach footscrews.
    d. Check the optical plummet (or laser plummet in some total stations) constantly to make sure it aims to the middle of the CP.

    Aim to get as close to 0" levelness of the digital bubble. Anything below 10" is acceptable. Do not get alarmed by this number slightly changing over the course of measurements – the digital bubble is very sensitive and small movements due to the wind and the instrument being used are normal (everything below 30" is normal).
8. Make sure the tripods are secure in the soil and the total station and prisms remain fixed. Bumping or moving them will cause errors. If this happens, set up the instrument again and repeat all measurement on this point. Any of the following might indicate a total station or the prism might have been moved:
    a. The total station digital bubble levelness 30" or more.
    b. Face left and face right readings more than 1' different.
    c. Distances to the same point more than 1 cm different.
9. Read the **horizontal** distances to 1 mm and the directions **(horizontal angles)** to 1".

Although you are not reading vertical angles in this assignment, keep in mind they are still being used by the total station internally to convert the measured slope distances into horizontal distances.

Task 2: Data processing

Beginning and ending a traverse on the same point or two points with known coordinates allows us to calculate misclosures. In general, we first calculate average distances and internal angles, then calculate the angular misclosure and adjust the angles, calculate the linear misclosure and adjust the distances to calculate coordinates.

In order to satisfy the 3rd order traversing standards, the maximum allowed angular misclosure is:

$$12.0''\sqrt{n}['],$$

where n is the number of internal polygon angles.

In addition, a linear misclosure accuracy must be better than 1:8000 for a 3rd order traversing.

If your misclosures (angles and distances) are higher than the maximum allowed misclosure, you must repeat the measurements. This is a hurdle. Failing to satisfy the misclosure requirement means the objective has not been completed, and such a report will not be considered (it will be marked with 0).

In this task, you are expected to perform the reduction of field measurements, adjustment of angles, Bowditch adjustment, and to calculate the final horizontal coordinates of your temporary CPs to be used in the next assignment, with all necessary steps and controls. You can use the supplementary numerical example and the lecture materials for guidance.

Data

Table 1. *Survey Control Points.*

Point number	Easting [m]	Northing [m]	AHD Height [m]
5005	320590.269	5814955.281	45.830
5006	320616.255	5815029.880	46.698
5007	320577.947	5815103.545	46.410
5008	320497.890	5815107.456	46.395
5009	320444.135	5815026.926	46.278
5010	320505.804	5814975.623	45.081

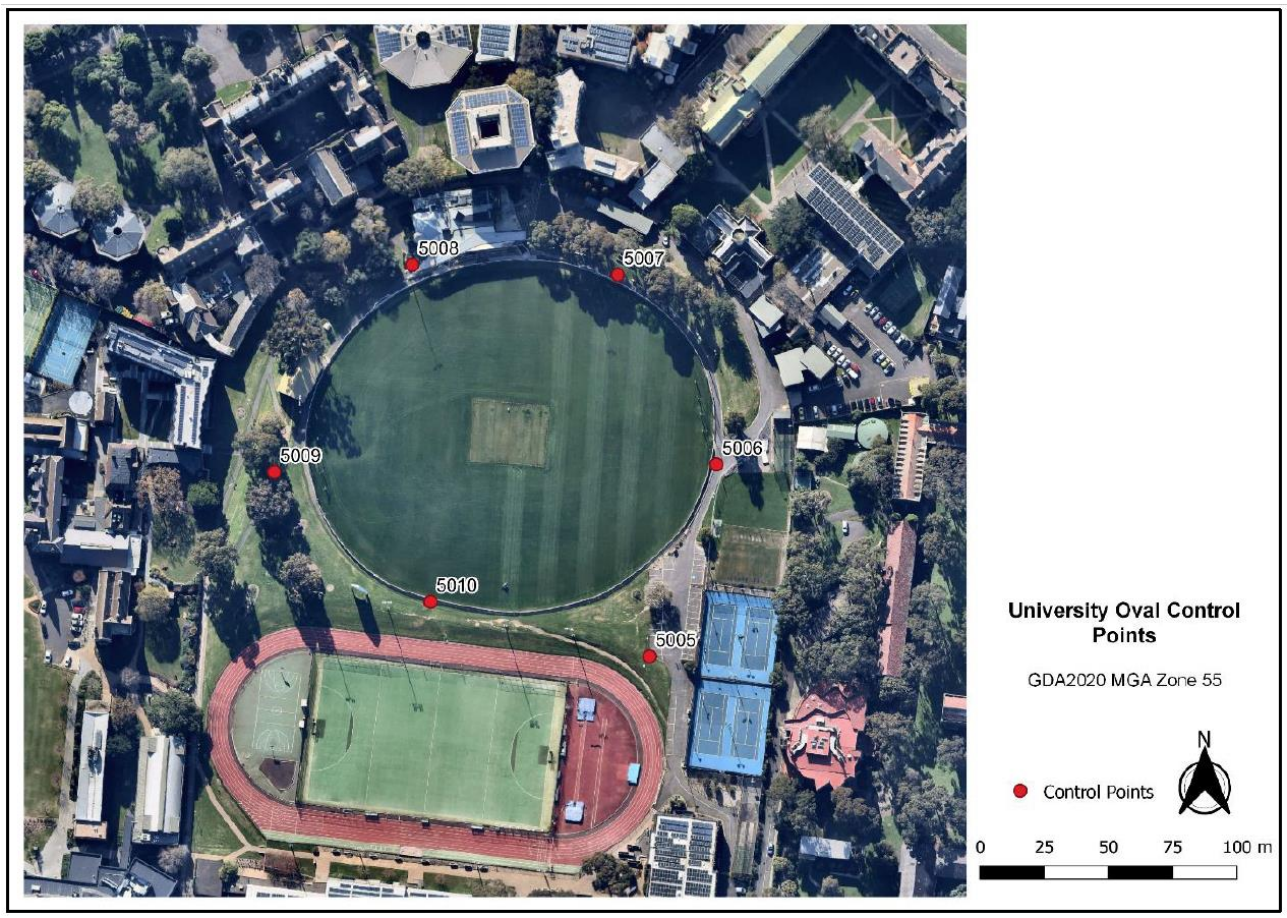

Figure 4. *University Oval Control Points*

Equipment

Total station, two prisms, three tripods. Use the same total station throughout the project as your job is saved inside.

Submission

Deliverable is a professional report covering the undertaken procedure and calculations.

The report should have a minimum of 1000 words and a maximum of 2000 words. Too short (below minimum) or excessively long (above maximum) reports will receive a penalty. The word count excludes the cover/title page, contents page, tables, table and figure captions, equations, references, and appendices.

The report should be written in an illustrated report format and include the following sections:

- **Aim** – Each lab assignment has an overall aim. This should be stated, e.g. "To become familiar with mobile mapping…"
- **Task** – The set task, e.g. "To prepare a map of the rubbish bins on Campus using a handheld GPS mapping device…"
- **Equipment** – Tools used to achieve the tasks, both software and hardware. Note the equipment number where available.
- **Procedure** – The steps the group undertook in order to undertake the assignment. Do not copy the steps from assignments. Illustrations (images, diagrams, etc.) can be helpful here.
- **Results** – The table of measurements made in the field, with all data reductions, adjustments, calculations and final results. Explain all steps. You can include any data that you believe will help explaining the undertaken steps, such as equations, images, maps or plans.
- **Discussion** - This is by far the most important part of the report where any problems encountered are analysed. This is also where the group shows their level of understanding of the exercise.
- **Conclusion** – A brief summary of the practical and whether the aim was met.
- **Group member contribution** – A group contribution table containing one row for each group member, as follows for a group of four people:

Name	Contribution to the assignment (max 50 words)	Percentage contribution
Hua Li	Write no more than 50 words to describe Hua's contribution to the project.	25%
Tim Fox	Write no more than 50 words to describe Tim's contribution to the project.	25%
…	…	…

The report is submitted per group, which means one digital submission per group, by any group member, into Canvas in PDF format. The details regarding the deadline and consequences of late submission can be found on Canvas.

Original work - Please make yourselves aware of the definition of, and University policy towards, plagiarism:

https://academicintegrity.unimelb.edu.au/

For citation style and reference type, we recommend APA or Harvard. Choose one and make sure it is consistent throughout the report:

http://library.unimelb.edu.au/recite

Evaluation

This assignment is worth 10 points. The assessment criteria is divided into the following four categories:

- **Organised and coherent scientific report** on the practical work carried out (1 point)
- **Procedure and Conclusion.** A clear description of the procedure and an explanation of why this procedure was carried out. Brief summary of the results and statement as to whether the practice was successful. If not successful, why not? What would you do differently next time? (2 point)
- **Fully documented and elaborated results** (4 points)
- **Discussion and analysis** of the results, in particular the necessary checks for evaluating the overall work. Discuss the size of misclosures and what may have caused it. Any problems? (3 points)

In a case of grossly unequal contribution reported in the Group member contribution section of the report, the individual marks received by group members will be adjusted based on their contribution. Otherwise, all group members will receive the group report mark.

The detailed rubrics for each criterion are outlined below. As the report might not meet all the criteria in one category, the markers will choose the best fitting category using the rubric as a guideline.

Organised and coherent scientific report (0-1)	
1	Professional
	- An appropriate scientific structure has been used - There are no spelling or grammatical errors - Excellent diagrams, tables, charts etc. - Report flows logically from start to finish, is clear, concise, and readable
0.75	Adequate
	- An appropriate scientific structure has been used - One or two spelling and/or grammatical errors - Appropriate use of diagrams, tables, charts etc. - Report flows logically from start to finish but glosses over some topics and/or rambles on others
0.5	Needs Improvement
	- Missing one or two key structural elements (e.g. Aim, Objectives, Procedure, Results, Analysis, Conclusion) - Numerous spelling and grammatical errors - Non-existent, poor, or inappropriate diagrams, tables, charts etc.
0.0	Inadequate
	- No organization or structure. Missing a number of key structural elements (e.g. Aims, Objectives, Procedure, Results, Analysis, Conclusion) - Chronic spelling and grammatical errors - No use of diagrams, tables, charts etc.

Procedure and Conclusion (0-2)	
2	Professional
	Procedure: - The procedure is complete and contains sufficient detail to allow the work to be duplicated - A correct explanation of why the procedure was used is provided Conclusion: - Statement that the practical was successful (or not, explanation provided) - Summary of the results or findings - Suggestions for what might be done better next time
1.5	Adequate
	Procedure: - The procedure is complete and contains sufficient detail to allow the work to be duplicated - A basic attempt (successful or otherwise) has been made to explain why the procedure was used Conclusion: - Statement that the practical was successful (or not) - Summary of the results or findings
0.75	Needs Improvement
	Procedure: - Basic details on the procedure are provided but they are insufficient to allow the work to be duplicated - No explanation of why this procedure was used Conclusion: - Summary of results or findings
0	Inadequate
	- No details on the procedure nor conclusion were provided

Fully documented and elaborated results (0-4)	
4	Professional
	- Completed booking sheet - All checks - Misclosure calculation and acceptability - All steps elaborated - Correct adjustment
3	Adequate
	- Completed booking sheet - All checks - Partly elaborated steps - Adjustment attempted, but there are arithmetic errors
1.5	Needs Improvement
	- Completed booking sheet - Some checks - Partly elaborated steps with some errors - Adjustment attempted, but there are errors of logic (e.g. not proportional to number of setups)
0	Inadequate
	- Partially completed booking sheet - No attempt at elaboration of steps - No adjustment attempted, or adjustment grossly incorrect

Discussion and analysis (0-3)	
3	Professional
	- All key issues are addressed in the analysis, critical thinking and additional discussions included.
1.5	Adequate
	- An attempt at an analysis has been made, addresses a few key issues.
0.75	Needs Improvement
	- An attempt at analysis has been made but addresses no key issues.
0	Inadequate
	- No analysis of the results is provided.

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