Instructions for the tacheometer exercise

April 3, 2020

Meeting point: the Elissa Plaza on the North side of the Bachelor Centre, at exit U! Consult a map.

The tacheometer exercise (2 h outdoors)

In the exercise we model a road using points measured by tacheometer. In this instruction guide, we present the stages of the exercise in detail. It would be a good idea for the student to carefully read this guidance before the start of the outdoor part. If things remain unclear in this guide, you may and should contact the course assistant. As always, helpful critique is always welcome as the course is under continuous development.

Learning outcomes: After completing the instrument and calculation exercises, the student understands the principles of operation of a tacheometer and is able to carry out the geodetic post-processing for the points mapped. Furthermore, the student masters the basics of 3D modelling using the Matlab calculation software. In the exercise, we try to avoid the use of dedicated geodetic calculation software, to better allow the student to internalize the principles of geodetic computation.

1 Preparations

1.1 Preparatory materials

On the MyCourses pages of the course, there is preperatory material for the exercises, which the student should become familiar with before doing the exercises.

For the tacheometer exercise, the student should watch on MyCourses the videos

- "Pisteelle pystytys: Kolmijalan ja pakkokeskistysalustan", which instructs how to set up a tripod over a point and how to level the forced-centring device,
- "Takymetrimittaukset", in which is the workings of a tacheometer are explained, and how to handle it in a measurement situation.

In addition to the videos, there is material on setting up and levelling in the documents "Setting up a tripod on a point" and "Tacheometer measurements, general".

Furthermore, on MyCourses one can read the instrument specific instructions for the Sokkisha and Nikon instruments that we shall use.

1.2 Instrumentation

1. *Work-safety vests for all students (also the assistant!)*
2. Tripod: familiar from the video "Toiminta mittauspisteellä"
3. Forced-centring device: known from the videos "Toiminta mittauspisteellä" and "Takymetrimittaukset". In the case of tacheometers the forced-centring devices come generally attached to the tacheometer, i.e., the are inside the tacheometer's carrying case.

4. Tacheometer: inside an orange (or yellow) tacheometer case.

5. Measurement rod: known from the video "Takymetrimittaukset". A measurement rod is usedto measure the instrument height, i.e., the distance from the point over which the tacheometer is being set up, to the horizontal-axis mark on the side of the tacheometer.

6. Round prism and staff: known from the video "Takymetrimittaukset". The target prism is used to as a signal that the tacheometer is targeting when carrying out measurements. In this exercise, the prism is screwed onto the top of the staff, which is placed on the point. Furthermore, round prisms are also used when measuring between known points, on tripods.

7. The observation form: we use a form in which we write up, i.a., the instrument height as well as all measured observations. The form is found on MyCourses and will be printed on paper by the assistant in preparation for the exercise.

At the start of the exercise, the group as instructed by the assistant goes to the instrument repository to fetch all instrumentation needed, after which transfer on foot to the nearby measuring site.

2 In the terrain

Because of the number of groups and in order to achieve the learning outcomes, we measure using three tacheometers at the same time. In the real world, a road mapping of this type would be undertaken using a robotic tacheometer with only one human worker.

We thus have three tacheometers in total, from which each group picks one:

Tacheometer no.	Name
1	Nikon DTM-A20
2	Sokkisha SET 2C
3	Sokkisha SET 3

The mapping exercise is thus carried out on Elissa Plaza. In figure 1 is depicted the measurement area and known points.

The progress of the measurements:

1. *Every student dons the safety vest. Although there isn't a whole lot of traffic on Elissa Plaza, accidents can and do happen too easily...*

2. Every group carries out the setting up of a tripod over one GNSS point and levels the foirced-centring device.

3. Group 2 sets up the tacheometer on point GNSS-2 and the groups 1 and 3 set up tacheometers on points 1 and 3. Remember to measure both the instrument and the target height, and write them down! Group 2 measures horizontal and vertical angles and well as horizontal and slant ranges to the points GNSS-1 and GNSS-3. *The measurements between GNSS points are done in both faces, face left and face right, i.e., the instrument is turned about both the horizontal and vertical axes by* 200 gon. Remember to write down all observations! In figure 2 the measurement situation described is visualized.

4. Groups 1 and 3 do in turn the angle and distance measurements to point 2. *Measurements between GNSS points (base or starting points) are done in both faces.* In figure 3 this stage of the measurement is depicted.

5. All groups start mapping the road, at least the part of the road that is readily mappable from that tacheometer. *The mapping measurement is done only in face left.* The prisms are mounted on the mapping staff, and the target heights of the staffs are measured. In

Figure 1: Known points for the measurement, GNSS 1–3.

Figure 2: Measurement situation for points GNSS-1 ja 3.

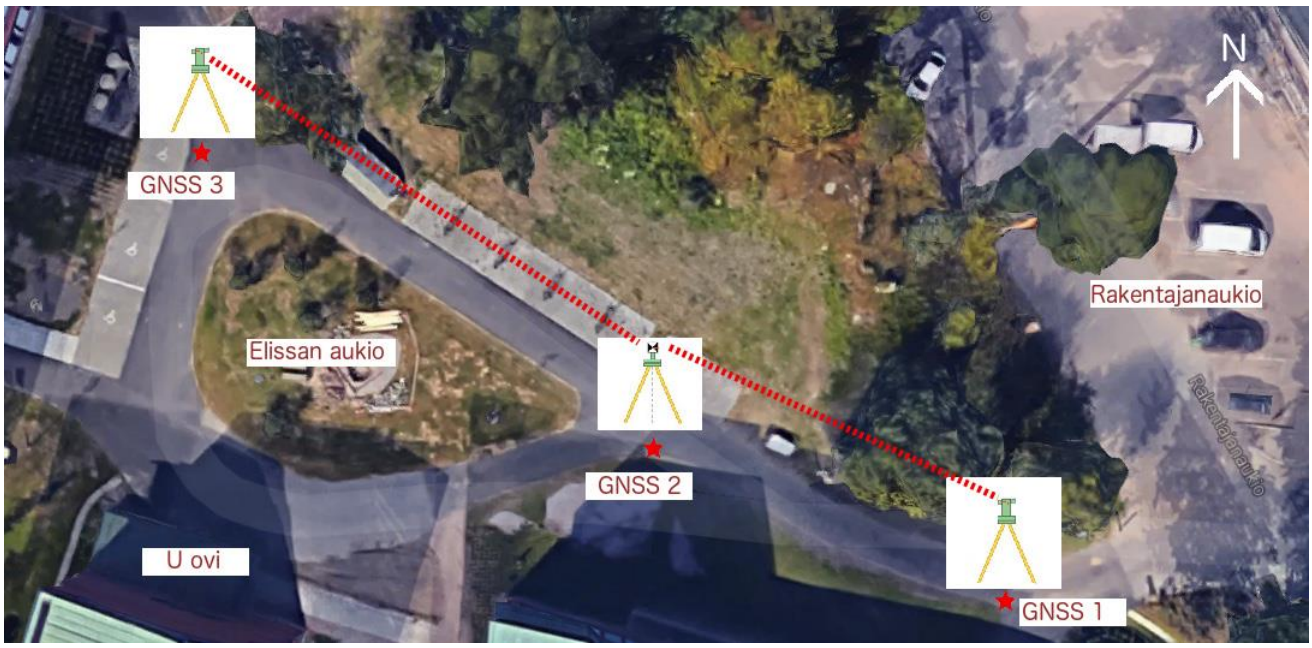

Figure 3: Station determination for points GNSS 1 and GNSS 3.

figure 4 this measurement situation is visualized, in which all tacheometer stations have been determined and we proceed to measure with tacheometers to mapping staffs. Aim first at the tip of the staff, which is on the ground. Then, turn the telescope around the vertical axis to find the prism.

6. The mapping of the road is done in this way, that we measure the edges of the road and the midline. The edge is measured next to the edge stones; the midline you end up estimating yourself while walking with the prism staff. The measurements are spaced 10 m (paces) apart. *Note: write down if the line measured was the edge on the side of the building, on the side of the trees, or the midline!*

   Example: 1 = side of building, 2 = side of trees, 3 = midline. This is essential for successful road mapping, so the lines will go correctly in the Matlab mapping.

7. When the mapping has been done from the stations, the groups trade places in such a way, that the group on point GNSS 1 moves to GNSS 2, the group on GNSS 2 moves to GNSS 3, and the group on GNSS 3 to GNSS 1. In figure 5 is depicted this moving around of the groups. *Note, only human beings move, the tacheometers remain in place!*

8. We now go back to item 5 in this guide, and repeat the work as instructed, until all groups have been at all stations and thus mapped the whole road in the area.

9. When the measurements have been completed, the equipment is moved back to storage as instructed by the assistant, and the batteries are connected to chargers in order to re-charge for the next exercise group. After this, we proceed to recording the measurement data, next section. *The observations are so far only on paper, and therefore it is important to get them copied into digital form.*

3 Recording the measurement data

When the field measurements have been carried out, all data recorded on the observation forms must be stored into digital form. This will be done in a computer classroom, where the students write the data from the observation forms into Notepad. *Alternatively*, students do this on their

Figure 4: All tacheometer stations have been determined, the mapping can start.

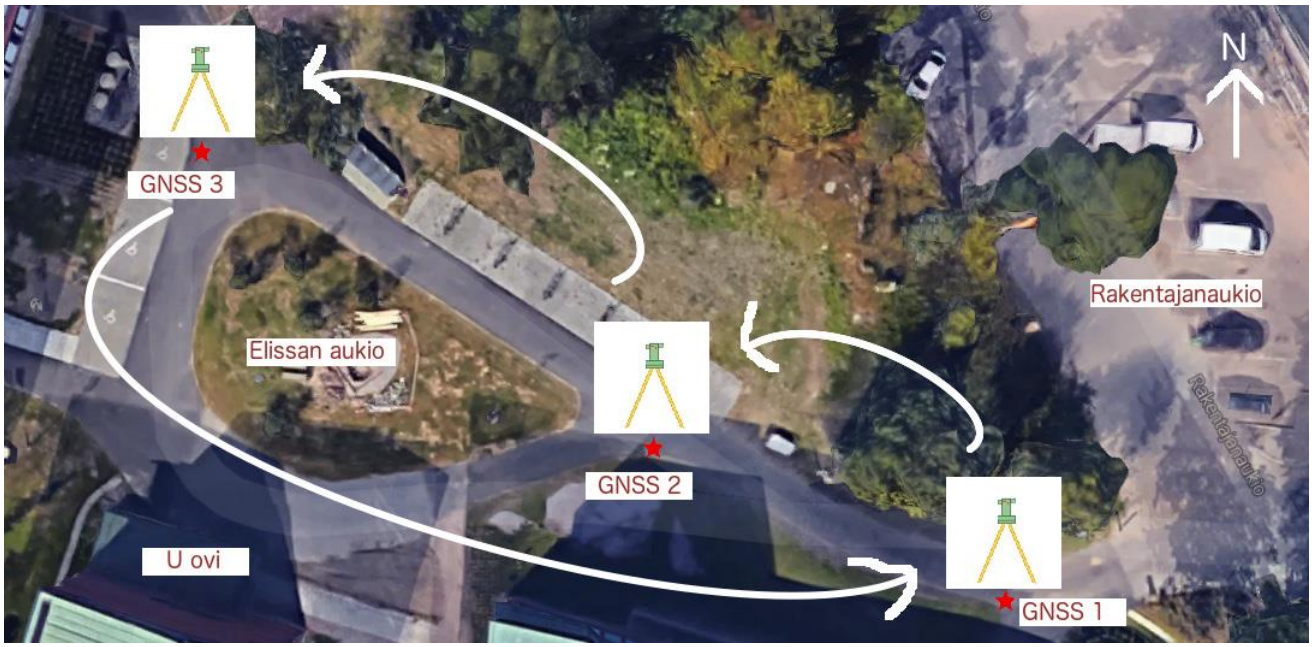

Figure 5: Changing around of groups.

Figure 6: Data from the observation form is fed into the computer.

own if the exercise takes so long that no time remains for doing it together. The file thus created will be needed in the calculation exercise, so *please do share it with all the members of your group.*

In figure 6 it is shown how data from the form can be fed into the computer. The first three lines in the figure are so-called header lines, not containing actual data but rather general information related to the measurements that were carried out, or to the formatting of the data. Write here the measured instrument height, the names of the members of your group, and the date. On the last header line you should write the titles of the columns, i.e., what a number under that title means. After the header, type in all the data measured by you from the observation form, in the same order as they appear on the form, separated by TABs between the columns.

4 Post-processing and 3D modelling

In the calculation exercise belonging to the tacheometer exercise, co-ordinates are calculated for the points by means of the *forward geodetic problem.*