Quick manual for measurement and processing of kinematic GPS data

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Kinematic GPS measurements are made with two GPS receivers, one which is fixed (*base station*) located over a known fixed point and one which may be moved around (*rover*), and which is made for the actual positioning measurements. The data collected by the rover may be processed and corrected after the measurements have been made, *post-processing*, to achieve very high precision (1cm±1ppm). This correction is possible because the base station is located over a stationary point with known coordinates and any deviations from this position can be considered noise and can be removed. The difference in coordinates between the base station may then be analyzed together with data from the rover to obtain an accurate positioning of the rover relative to the base station.

In practise, measurements are made by installing the base station over a known fixed point and setting up the rover anywhere desirable. The rover must remain perfectly still for 15–20 minutes to gather enough data to make the differential correction possible in the post-processing stage. this is referred to as *initialization*. Once initialization has been achieved, the rover may be moved around to make position measurements while the base station remains fixed over the known fixed point. The GPS system controls sampling so that all receivers collect data simultaneously, there is no need to worry about timing of measurements except that both base station and rover must both be logging data simultaneously to achieve dGPS.

This quick manual describes collection of *kinematic* data with a Trimble 4600LS with associated handheld computer (TSC1) as a rover and a Trimble 4000ST as base station. The manual also summarizes the postprocessing and transformation of results into Swedish Grid system riket nät (RT-90) coordinates.

Different menu choices in the handheld computer and software is denoted by ***italic bold text***. Messages of different kinds are denoted by *italic text*. So-called "soft keys" on the handheld are marked by a **box**. "soft keys" are determined by the function keys on the handheld.

1 Collection of kinematic GPS data

1.1 The base station

1.1.1 Permanent base station

Tarfala has a permanent base station (Trimble 4000ST) located in Forskarhuset. The following describes how the base station is set-up to collect data for dGPS measurements.

1. Start the base station by pressing the green power button (if it is not already on). Check that the memory is free from previous measurements by entering the menu ***Controller/Survey data files***. The number and size of existing files are shown on the screen. If files exist press ***Delete files*** and confirm by pressing ***Delete it***. **NOTE! check that files are downloaded to the so-caled GPS computer before you delete them on the base station. Download them if you are uncertain.**. item Start the base station through the menu ***Survey/Start pre-defined kinematic survey***. Make sure the fixed base station is in contact with satellites and that it starts to store information. This can be seen as a counter on the display.

2. After completing a set of measurements with the rover, you need to stop the base station data collection by choosing ***End Survey*** and reply ***Yes*** to the question "*End survey?*". You can then enter the antenna height as (default) 0 m followed by ***Accept***. You are now done with the base station.

1.1.2 Local base station

If you are not using the Tarfala base station a separate base station (4600LS) must be set up in the field over a known fixed point. This can be made by doing the following.

1. Set up the intended base station receiver over a known point. Attach an external battery and the handheld computer to the GPS receiver through the dedicated Y-cable.

2. Measure and write down the correct antenna height for the base station by measuring the height to the fixed point on the ground with the dedicated Trimble tape measure.

3. Start the handheld computer by pressing the green button. Turn on the GPS receiver by pressing a corresponding green button on the GPS receiver. Check that the green diod next to the power button on the receiver is lit.

4. Select ***Files/Job management*** in the main menu on the handheld. Press **New** and fill in ***Jobname*** and finish by pressing **ENTER** twice.

5. In the subsequent menu (***Select coordinate system***) choose ***Select from Library/RT90 2.5gW*** and press **OK**. Go back to the main menu by pressing **ESC**

6. Choose ***Survey/Survey style:Tarfala*** in the main menu and select ***Start base station***. At start-up you will receive the following message: "*Warning: Receiver is currently logging data. Stop it?*", choose **Yes**. You then receive a message stating: "*Disconnect from the basstation*"

7. Disconnect the handheld from the base station and turn the computer off. Disconnect the battery from the Y-cable and the Y-cable from the base station receiver. Then connect the battery directly to the base station receiver. It is now logging base station data that will be used for post-processing your rover data to dGPS.

1.2 The rover

The start-up varies depending on which base station that is used. If a new local base station was set up, a new job should be created on the handheld when the roving receiver is started. Instead the job created when starting the local base station should be used.

1. set-up the rover over an arbitrary point (e.g. a stake). Connect an external battery to the handheld computer and the rover receiver by the dedicated Y-cable. Be careful with the Y-cable, it is delicate (and very expensive as well as hard to replace very quickly).

2. Measure the correct antenna height for the initialization using the dedicated Trimble tape measure and and write it down in a note book.

3. Start the handheld computer bu pressing the green power button. Turn on the GPS receiver by pressing the corresponding green power button. Check that a green diod next to the power button is lit. If a local base station will be used, skip item 1, 2, 4 and 5, for measurements with the fixed Tarfala base station, follow all items.

4. Select ***Files/Job management*** in the main menu of the handheld computer. Press **New** and enter the ***Jobname*** and end by pressing **ENTER** twice. [**NOTE!** this step is skipped when using a local base station.]

5. In the following menu, (***Select coordinate system***), select ***Select from Library/RT90 2.5gW*** followed by **OK**. Go to the main menu by pressing **ESC** [**NOTE!** this step is skipped when using a local base station.]

6. Select ***Survey/Survey style:Tarfala*** in the main menu. If you use a local base station, you will not be able to select ***Survey Style*** since this was already chosen when you started the base station. Select ***Continuous topo***. This results in the ***Initialization*** menu. At start-up you receive the following message: "*Warning: Receiver is currently logging data. Stop it?*". Choose **Yes** to continue.

7. In the initialization menu choose: ***Initialization method: New point*** and fill in the ***Point name*** as well as the measured antenna height under ***Antenna height***.

8. Press **Start** or **ENTER**. This starts the initialization procedure of a kinematic measurement. The handheld computer starts to count down time remaining of the process. Wait until the count-down is completed, you will receive a message stating "*Initialization has been gained*".

9. Press **Store** when the initialization is completed. The rover is now ready for making measurements.

10. Press **Measure** to start a measurements. Make the measurement, e.g. the location of a stake by letting the rover sit perfectly still on a stake and temporarily end the measurement (e.g. for moving the rover to the next point of interest) by pressing **End**. Commence measurement by pressing **Measure**, and so on. **NOTE! It is important that the GPS receiver is located in its upright position at all times and that is is not covered at any time, it is e.g. not permissible to move a receiver in a back pack.**. Not following this rule may disrupt the contact between the receiver and the GPS satellites and necessitate a new (20 min) initialization and possibly also loss of data. Successful fixed initialization is indicated by the word ***PPK: Fixed*** at the bottom of the hand held screen. If ***PPK*** reads ***float***, a new initialization is necessary. ***PDOP*** shows how well satellites are distributed in the sky and the ***PDOP***-value must not be higher than 6. If that happens a flashing warning text is shown stating "*Poor PDOP*". Check that nothing is obstructing "the view" from the receiver to the sky and wait until the satellites have moved to a more favorable position in the sky. This could take 10–60 minutes.

11. When all measurements have been completed, press **ESC** followed by ***End survey***. You receive a question "*Power down receiver?*", reply **Yes**

12. Turn off the handheld computer, disconnect all cables and stow away the GPS equipment for transport.

1.3 Reinitialization

If you lose the initialization you receive a message stating "*Initalization have been lost. Re-initzialize now?*". Reply **Yes** and you will be brought to the initialization menu. There are now two alternatives: to repeat item 7–9 at an arbitrary point *or* to return to the point where the first initialization took place and choose ***Initalization method: Known point***. Enter the name of the initialization point under ***Point name*** or press **List** to select the point from a list of saved initialization points. Follow item 8–9 to continue. The advantage to reuse an old initialization point is the the time for reinitialization is shortened significantly to perhaps one or a couple of minutes.

2 Downloading GPS data

Connect the handheld computer or the base station to the serial port of a computer with the GPload v2.75 software installed using the dedicated cables. The cable can be connected to any of the ports on the handheld computer.

2.1 Handheld computer

1. Start the handheld computer by pressing the green power button. Select ***Files/'Import/export'/'Send/Recieve from PC'*** in the main menu. you will see a message stating "*waiting for connection*".

2. Start the GPLoad software and select the appropriate serial port to which the cable from the handheld is connected from the ***Port*** list. Select ***Survey Controller v4/5/6/7*** from the ***Device***-list in order to obtain the correct communication protocol for the handheld.

3. Select the communication (COM) port to which the handheld is connected from the ***ports***-list.

4. Select ***Connect*** to connect to the handheld computer. GPload shows "*Connected to Survey controller v6.5*" in its status field at the same time as the ***Available files*** filed is updated. The message on the handheld computer will change to read "*Connected to PC*". This may take a few seconds.

5. Mark all files in the field ***Available files*** that should be downloaded and click on ***Add***. The files are then also shown in the field ***Selected files***. Click on ***Destination Directory*** to select where the fiels should be saved on the computer.

6. Click on ***Transfer*** to start the transfer of data. When the transfer is complete, click on ***Disconnect*** to terminate the connection and turn off the handheld computer.

2.2 Base station

1. Ensure yourself that the logging session on the base station is closed. If the base station is still collecting data, press ***End survey***, and accept the default (0 m) antenna height. If the memory of the base station has been filled, and the base station has automatically stopped logging, just press ***accept*** to accept the default antenna height.

2. Start the GPload software. Choose ***GPS receiver*** in the ***Device***-list to obtain the correct communication protocol for the base station.

3. Select the communication port (COM) to which the base station is connected from the ***ports***-list.

4. Select ***Connect*** to connect to the base station. The GPload status field shows "*Connected to 4000ST*" or "*Connected to 4600LS*" depending on to which base station you have used. The connection procedure may take a few seconds.

5. Mark the files to be downloaded in the ***Available files*** field and click on ***Add***. The fiels are then also shown in the ***Selected files*** field. Click on ***Destination Directory*** to select where the files should be saved on the computer.

6. Click on ***Transfer*** to start the transfer of data. When the transfer is completed, click on ***Disconnect*** to terminate the connection and turn off the base station.

3 Post-processing of GPS data

Here follows a description of post-processing of kinematic GPS-data collected according to the methods described above. Processing is performed with the GPSurvey 2.35 software. GPSurvey is built around survey projekts. A project contains a data base with, perhaps, several days of work and it is possible to select parts of the data base for processing.

3.1 Processing

1. Start GPSurvey and select ***Project/New***. Provide a name for the new survey project for dGPS processing. Also fill in the operator name in the field ***Supervisor***. Click on ***Create***.

2. Add the downloaded files to the project data base by selecting ***Load/From DAT-file***. Locate the folder to where you downloaded your files in the ***Directories*** field (use **..** to move upwards in the folder structure and the ***Drives*** list to read from a different hard disk). Mark all fiels that should be included in the processing in the ***Files Found*** field and click on ***Add***. Alternatively, you can click on ***Add all***. There are typically two files, one from the base station and one from the rover, but if reinitializations have been made there may be more files from the rover. Click on ***OK***.

3. You will now encounter a run-through of antenna heights of all files in the files, where you can specify the antenna height (if different from what you originally entered in the field) and the exact coordinates for the base station etc. This can, however, be made also later in the processing. Choose the ***Interactive*** check-in and continue with ***OK***. Now you will see information on the fiels and also get a second chance to change different parameters. Change as appropriate or simply click on ***OK*** to accept the given parameters and continue. **NOTE! This must be repeated for each data segment. For an entire day of measurement, this may be up to 100 segments, so hang on and click away.**

4. To choose what GPS-data to process choose ***Process/Baselines***. Mark the files you have just read in and add them to the processing by clicking on ***Add***. Alternatively, you can click on ***Add all***. Continue by clicking on ***OK***. Now a new window opens called WAVE where the settings for the processing itself can be set. From this point all menu choices etc. are made in this window. You can now change antenna height and coordinates for the base station as well as antenna heights for all measured points.

5. Choose ***Edit/Station Position*** to change the values for the base station. Select which station is the base station from the ***Station Name*** list. Change coordinates and elevation for the base station to the exact coordinates for the fixed point over which the base station was located. Check that ***Enable Precise Coordinates*** is marked and that ***Fixed***

Control is set in the ***Point Quality*** list. All other stations should be left empty unless they have known coordinates. Click on ***OK*** to continue.

6. Antenna height for the base station and other stations (their initialization points) can be changed in ***Edit/Occupations***. Choose station in the field and click on ***Edit*** to change antenna height. Several or all points can be changed simultaneously by marking several points and then clicking on ***Edit***. Finish by clicking on ***OK***.

7. Select ***Edit/Continous Segments*** to edit the antenna height for all surveyed points. Mark the points and select ***Edit*** to change the values. Several or all points can be changed simultaneously by selecting points and clicking on ***Edit***. Finish by clickking on ***OK***.

8. The processing is started by selecting ***Process/Baselines***. The calculations can take quite som time to be performed so be patient.

9. When the calculations are finished, information on the results are shown in a new window called SOLUTION SUMMARY. It is important that the ***Solution Type*** is ***L1 Fixed***. This indicates that the processing was successful and that the differential positions are of good precision. If the ***Solution Type*** is ***L1 Floating***, the processing must be redone or, in the worst case, the entire survey redone.

10. save the processing calculation by selecting ***File/Save*** and click on ***OK***. The fiels are automatically saved in a folder under the main project folder. Close the WAVE window. The processing is now finished.

3.2 Show and export the results

1. To show the obtained results select ***View/Network Map*** in GPSurvey. This shows a raw map of the processed results included in the current project. It is possible to print this map.

2. To export a text-file containing all positions, choose ***Utilities/Coordinate Transformation***. This opens a new window called GPTRANS. select ***File/From/SSK-file*** to get the files to be exported. The dialog that opens automatically shows the folder where the calculations were saved. select all `.SSK` files that are shown and click on ***OK***.

3. select ***Use local Time format*** in the following dialog and click on ***OK***. You now obtain a list of all processed surveyed points in WGS-84 coordinates.

4. Export the list of all coordinates by choosing ***File/To/ASCII File***. Provide a file name and select a folder to export the coordinate file and then click on ***OK***.

3.3 Transformation from WGS-84 to RT-90

In order to obtain coordinates in the Swedish Grid rikets nät (RT-90) from the exported coordinates, use the MAPTRANS software.

1. First, the exported file must be supplied with a file header containing all coordinate specifications required by MAPTRANS. Open the exported file in a text editor (e.g. UltraEdit, Notepad). Make sure the file looks as the following example:

```
MAPTRANS:[WGS84 Lon/Lat](dd)[WGSH](m)
18.5622330   67.8996593     1428.999
18.5622330   67.8996593     1429.009
18.5622330   67.8996593     1429.010
    ...          ...           ...
```

   save the file as a text dokument.

2. Start MAPTRANS. Choose ***GPS modulen*** and click on ***OK***. Choose the file to be used in the ***Data från*** dialog, click on ***OK***. Find the text file with the added MAPTRANS header.

3. Choose to which coordinate system you wish to transform the WGS-84 data (in Tarfala we use RT90 2,5gV). Click on ***OK***. Provide a file name and a location to where you wish MAPTRANS to store your Swedish Grid output. click on ***OK*** to save the file.

You now should have a file with your measurements in RT90 coordinates and elevations in m a.s.l. in three plottable columns.