
# High-Precision Positioning Unit 2.1 Summative Student Assignment: Measuring Topography with Kinematic GNSS

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*This assignment assesses your ability to plan, execute, and analyze positions from a survey you design. Refer to the Kinematic GPS/GNSS Survey Methods Manual and your notes from previous exercises for guidance. This survey should answer a specific scientific question. You will need to justify why local, high-resolution topography is needed and how it helps measure something that was previously undetectable.*

*This survey will take a minimum of 2–4 hours, depending on the number of points collected and the time needed for processing the base station position. Your sampling design should be appropriate for the time you have been allotted by the instructor.*

Note: The items to be turned in at the end of this project are listed on the last page. Review them.

## Preparing for the Survey

Time spent planning and preparing for a survey can dramatically decrease time and energy spent in the field later. It is important that a clear plan for the survey is in place and that all members of the team understand the operations before going into the field. Some aspects of the survey may need to be adjusted as field conditions change, but having a basic idea beforehand will make this process easier.

### *1. Site Selection and Survey Plan*

You will be given a general field site by your instructor. Sites with LiDAR work best for this exercise. Review maps or images of the area and discuss as a large group what features you wish to measure. With this decided, break into small groups and discuss sampling design for the area. This could include base station location, features to be measured, and paths in and out of the site. It may help to visualize this data by sketching it on a paper map. After a few minutes, come back as a group and propose your sampling design, its pros and cons, and justify why you think it is the most appropriate. As a group, quickly convene and make a final plan.

### 2. Logistics

Use the *Kinematic GPS/GNSS Survey Methods Manual*, Section 3.2, to account for logistical needs for equipment on the trip. You are responsible for initial packing of equipment and use of the equipment checklist. Decisions will be made as a group, but each of you is responsible for your own checklist.

## Executing the Survey

Utilize the *Kinematic GPS/GNSS Survey Methods Manual*, Section 4, RTK/PPK Setup, and your own notes to set up a base station and rover(s). Make sure you actively participate in the physical setup and take notes as needed. You are responsible for taking field notes. An example of a field book setup is provided.

After setup is complete, begin recording points around the area. Follow the plan as a group, deciding how you will subdivide work. Make certain that you have a naming convention for the locations in place before starting. You may wish to use a group identifier followed by the points

number. Numbers at the end of a point ID typically increment automatically. For example, GroupA1, GroupA2, GroupA3 would be the first three points collected by group A.

When complete, make sure that files are saved and then pack up the equipment. Use the equipment you list you started with to make sure all equipment is returned.

## Processing Data

Data should be retrieved and backed up as soon as possible after the survey is complete. Downloading and completing a quick processing of the data on a field laptop can be a great step for ensuring success in fully processing the data later. If you are limited by lack of computers, processed GNSS point data can be redistributed to students for analysis. Remember, it may take a day or two to get a quality base station position from OPUS if you set up over an unknown point. Your instructor should provide you with a pre-processed solution if this is the case. Otherwise, you can use points that are accurate relative to the assumed position of the base station.

Work in groups or as a class to process the data. Follow Section 5.3 in the *Kinematic GPS/GNSS Survey Methods Manual*, Data Processing, for OPUS base station solutions. Once you have a solution or position for the base station, process the baselines to correct the rover positions.

## Analyzing Topography

Use skills and workflow found in the Unit 2.1 Student Exercise Creating Topographic Surfaces to interpolate a topographic surface using the geospatial data collected in the survey.

1. Run ArcPro and open a new map document and geodatabase. Save them with an appropriate name.
2. Add a basemap DEM to your map. This can be done 2 ways:
    a. **Map > Add Data > Data > ArcGIS Online** and search for the dataset for your state/area.
    b. Use an established DEM (LiDAR is great). **Map > Add Data > Data > Filename.**
3. Add your GNSS points. **Map > Add Data > XY Point Data.** Select your file and the appropriate fields for *x, y,* and *z* data and set the Coordinate System to the system you exported your original points in. Check your table in a spreadsheet program if errors occur. Make sure data is in the proper system and that there are no erroneous points.
4. Check your coordinate systems and make sure the DEM and your GNSS points are in the same system. If not, project the DEM to the correct system. **Analysis > Toolbox > Data Management Tools > Projections and Transformations > Raster > Project**
5. Interpolate a topographic surface using your GNSS points. **Analysis > Toolbox > Spatial Analyst > Interpolation > Kriging** (or your method of choice).
6. You may try various settings for Kriging or other methods, but the defaults are usually appropriate. Input = GPS points; *Z* Value = height; Output raster = name of the new layer; Kriging Method = Ordinary; Semivariogram model = Spherical or Linear
7. Compare your surface map to the DEM by subtracting the values of one from another using the raster calculator (search for this tool). Your equations should look something

like **Diff("YourTopograhyMap","DEM_Map")** or **"YourTopograhyMap" - "DEM_Map"** Note: the order you select your maps will change the sign of the difference. The resulting map shows you the difference between your high-resolution interpolation and the DEM.

8. Create two maps including Title, Legend, North Arrow, Scale Bar, and appropriate symbols for different features (**Insert > New Layout > Pick Layout Size and Add Appropriate Features)**. One map should show your topographic surface and the second map should show the difference between it and the DEM map.

## Discussion Questions

After you have completed your topographic analysis, answer the following questions:

1. Describe your scientific objective. What did you intend to measure? How did your survey design aim to accomplish this?
2. How would you improve your survey design and technique next time?
3. If you were to return and survey this field site 10 years from now, do you think you would be able to detect a change in the surface?
    a. Be explicit regarding the accuracy of the kinematic GNSS technique (what you can resolve) and the scale of topographic change that might occur.
    b. Also be sure to comment on how the interpolation method changes the uncertainty of the surface. Is it less or more certain than the measured points?
4. Discuss the societal relevance of high-resolution topography generated through a survey like yours. How can this data benefit the general public? Give two specific examples.

## Final Deliverables

The final list of deliverables should include:

1. Survey design sketch map and activity plan
2. Equipment list and field book survey log
3. Final maps (topography and DEM difference) with annotations
4. Answers to discussion questions

## Rubric

| Component | Exemplary | Basic | Nonperformance |
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| **General Considerations** | Exemplary work will not just answer all components of the given question but also answer correctly, completely, and thoughtfully. Attention to detail—as well as answers that are logical and make sense—is an important piece of this. | Basic work may answer all components of the given question, but some answers are incorrect, ill-considered, or difficult to interpret given the context of the question. Basic work may also be missing components of a given question. | Nonperformance occurs when students are missing large portions of the assignment, or when the answers simply do not make sense and are incorrect. |
| **10 pts**<br>**Survey Design** | **9–10** points:<br>Student actively participated in discussion and formulation of the plan.<br>The survey plan is reasonable and effective design for the area and accounts for potential obstacles.<br>The survey map effectively illustrates the design components. | **5–8** points:<br>Student participated in discussion and formulation of the plan.<br>The survey plan is reasonable but may not be the most effective design or account for potential obstacles.<br>The survey map illustrates most of the design components. | **0–4** points:<br>Student did not participate in discussions or formulations of the plan.<br>AND/OR<br>Is missing various components of a reasonable survey design.<br>Is missing several critical map components |
| **10 pts**<br>**Field Book and Equipment List** | **9–10** points:<br>Field book contains well-organized, concise notes on the setup, field survey, and results.<br>Metadata is well kept and includes all appropriate components.<br>An equipment list was kept and utilized. | **5–8** points:<br>Field book contains mostly organized notes on the setup, field survey, and results. May be missing 1 or 2 parts.<br>Metadata is kept and includes most critical measures.<br>An equipment list was kept but may not be well utilized. | **0–4** points:<br>Field book contains some notes, but may not be organized or is missing several components.<br>Metadata is missing several critical components.<br>An equipment list was not kept or utilized. |
| **10 pts**<br>**Final Map** | **9–10** points:<br>Map includes all parts of the GNSS survey, including the base station, measurement positions, and topography or other features. | **5–8** points:<br>Missing 1–2 of the listed characteristics for an exemplary map.<br>AND/OR | **0–4** points:<br>Missing 2–4 of the sketch components.<br>AND/OR<br>Most characteristics are present (1–2 missing) but are incorrect, |

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| | Maps include normal map elements such as titles, north arrow, scale, and legend.<br><br>Difference map is labeled properly and uses an effective color/grayscale range. | All characteristics are present but lack detail or are incorrect, showing a lack of comprehension. | showing a lack of comprehension. |
| **10 pts**<br><br>**Write-Up or Discussion** | **9–10** points:<br><br>The discussion is well written and includes all of the following components:<br><br>Justification of survey design<br><br>Challenges and future solutions<br><br>Discussion of future map and discernable changes is correct<br><br>Two good examples of societal benefits of GPS-derived topography<br><br>Should answer all of the questions. | **5–8** points:<br><br>The discussion is moderately well written and includes all of the components.<br><br>OR<br><br>The discussion is well written but missing 1–2 components or fails to answer some of the questions. | **0–4** points:<br><br>The discussion is poorly written discussion and is missing several components.<br><br>AND/OR<br><br>The discussion fails to discuss more than 2 critical components or fails to answer questions. |