High-Precision Positioning Unit 3 Summative Assignment: Leveling-Line Analysis with Static GNSS

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This assignment assesses your ability to plan, execute, and analyze positions from a survey you design. Refer to the Static 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 long-term, high-precision positioning is needed and how it helps measure something that was previously undetectable.*

Introduction

Static GNSS surveys are effective tools for capturing movement in the earth's surface. They record positional observations of fixed points over long periods of time and then compare these movements with other known positions from static stations such as CORS. This data produces a time series of points, which can represent many things such as tectonic motion, land subsidence, or slow-moving geomorphic features such as some landslides. One application of this technique is to produce leveling lines, a series of monuments that are placed across a feature, such as a fault, and measured periodically to determine how one portion of the line is moving relative to the others.

A GNSS time series is composed of many positional observations, which represent the movement of a fixed location. You will design a survey, collect positions, and analyze a new observation within a time series of historical measurements of a campaign site or leveling line. You will then analyze and deduce the geologic (or other) process that is driving these movements.

Project Description

Site Selection and Reconnaissance

Your instructor will select a site that has a pre-existing campaign deployment with established benchmarks. This may likely include multiple locations that need to be observed. Review satellite images of the site and make a plan with your team on how to reach and survey each location. Tools such as Google Maps can help you visualize the area. The site should also be analyzed for potential obstacles and complications such as sky view, line of sight, and overhead obstructions, although these were likely accounted for in the initial survey. Locate the descriptions for the benchmarks or monuments you will be visiting. These descriptions often have useful details on site location, monument type, and access instructions.

Survey Design

Consider how you will approach and access each site. Keep realistic expectations for the number of positions that can be surveyed and how long you need to occupy the location to produce high enough precision data to capture the intended change since it was last surveyed. Think carefully and then write up a **design proposal** 5–7 sentences long that includes:

1. A hand-drawn map of the study area with points of interest and survey locations
2. The question you will be approaching for the study
3. A quick summary of techniques used and why they are the best choice for this study

Execute the Survey

Pack all appropriate equipment, travel to the study area, and begin the survey. Remember to use the *Static GPS/GNSS Survey Methods Manual* and your personal notes from the introductory survey for any questions on equipment setup and methods. Make certain to collect good notes in the field, collecting all pertinent metadata. Metadata is paramount to precision on static surveys. Once the survey is complete, ensure your data is secure, pack all of the equipment, and return to the classroom.

- Keep a log of all necessary metadata including but not limited to the example provided. Use a personal field book if available. All individuals must record this.

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. Remember, it may take a day or two to get a quality position solution from OPUS. Your instructor may provide you with a pre-processed solution if this is the case. Otherwise, you can process points that are accurate relative to a known position or base station.

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

- Note the precision of your measurements indicated by the OPUS solution. You will need this later to determine if you can detect change in the series.

Collecting Previous Campaign GNSS Data

The GPS Velocity Viewer is an application hosted by EarthScope that visualizes GNSS data from NOTA and CORS sites. Use the GAGE Velocity Viewer, DAI 2, or the NGS Data Explorer to collect campaign data from the locations you surveyed, along with several surrounding stations. This will be used to analyze your data in a time series and to visualize the movement in a broader geologic context.

1. Visit the Nation Geodetic Survey (NGS) webpage at https://www.ngs.noaa.gov/NGSDataExplorer/.
2. Use the map to navigate to your area of interest and select the series of stations you will analyze. Right click in the center of your area of interest, then "Center map here."
3. Under Map Layers on the left side, select a radius, ex. 5 miles, then "Find Marks."
4. View the list of sites you selected and download the specified datasheets or retrieve them from your instructor.

Analyze Campaign Positions

Take your processed positions and plot them with the historical leveling-line data, which was either collected in the last step or provided by the instructor.

1. Open the leveling-line position in Excel or another spreadsheet program.
2. Insert the new positions you acquired, making certain that metadata is correct.

3. For the leveling line, make plot with stations' horizontal distance from each other (you may need to calculate this) and the vertical height of the station. Create a new data series for each campaign occupation of the leveling. (See example.)
4. Choose several sites that categorize different locations on the leveling line and then plot the time series of data for that site. Make at least three plots for each site for North, West, and Vertical movements, such as in the Time Series assignments.

Analysis and Discussion

Write at least a 500-word report on the analysis of your data and your findings. This should include the *associated error*, and any relevant information on *techniques*, *projections*, etc, that has been asked above. The bulk of report should focus on the summary of findings.

Answer the following questions in your report.

1. Were you able to detect a difference in your campaign measurements from the series?
2. What was the direction of the movement as indicated by the time-series plots? Was movement instantaneous, episodic, or continuous? How would you know?
3. What was the magnitude of movement detected and was it greater than the estimated error and precision of your measurements? If not, can you say that any change occurred?
4. Is a static GNSS system appropriate for this survey, given the results and your experience. Why or why not? Your claims must be justified by your evidence and measurements of accuracy, precision, and uncertainty of the technique.
5. How did the survey design highlight the feature that you were trying to observe?
6. How would you modify this design in the future to produce better results?
7. What are the societal benefits of this research? Write three sentences in plain English that would communicate this benefit in some public medium like a newspaper.

Submit:

1. The original **survey design** sketch and proposal
2. Your **field book** or a filled out log sheet
3. The leveling line plot
4. At least one station's Horizontal and Vertical movement time-series plot
5. The analysis and discussions **report** described above

Component	Exemplary	Basic	Nonperformance
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.	Nonperformance occurs when students are missing large portions of the assignment, or when the answers simply do not make sense and are incorrect.
Survey Design **(10 points)**	**9–10** points: A well-written survey design that accurately assesses change and accounts for potential sources of error Map is well designed and contains all requested components. It illustrates the written survey design including points to be collected, station locations, and notations on features to be measured.	**5–8** points: Missing 1–2 of the listed characteristics for an exemplary report and may be poorly written/unclear; AND/OR All characteristics are present but lack detail or are incorrect, showing a lack of comprehension.	**0–4** points: Missing 2–4 of the characteristics, may be poorly written and unclear; AND/OR Most characteristics are present (1–2 missing) but are incorrect, showing a lack of comprehension.
Survey Execution and Notes **(10 points)**	**9–10** points: Students execute the survey and keep a detailed log of events. Students track equipment used, metadata, and other necessary field observations.	**5–8** points: Missing 1–2 of the listed characteristics or poorly written/unclear; AND/OR All characteristics are present but lack detail or are incorrect, showing a lack of comprehension.	**0–4** points: Missing 2–4 of the characteristics, may be poorly written and unclear; AND/OR Most characteristics are present (1–2 missing) but are incorrect, showing a lack of comprehension.
Final Maps and Discussion **(10 points)**	**9–10** points: A well-written summary that accurately assesses the survey design, potential errors, interpretation of results, and discussion of broader impact of technique. Societal benefit is clearly articulated using nontechnical language. Plots are well designed and contain all requested components. It illustrates the change detected and associated error. Should	**5–8** points: Missing 1–2 of the listed characteristics for an exemplary report and may be poorly written/unclear. Societal benefit is listed but not clearly justified. AND/OR All characteristics are present but lack detail or are incorrect, showing a lack of comprehension.	**0–4** points: Missing 2–4 of the characteristics, may be poorly written and unclear; AND/OR Most characteristics are present (1–2 missing) but are incorrect, showing a lack of comprehension.

	minimally include station locations and error bars.		