# GPS REPORT, GROUP 1

## Introduction

On March 5th, 2006, four groups from the AT-329 class conducted differential GPS surveys within Sassendalen. Each group's goal of surveying Sassendalen was to acquire a practical knowledge of using differential GPS systems, which would then be used during their GPR surveys. On March $7^{th}$, Group 1 used the techniques learned on March $5^{th}$ to accurately locate the position of our GPR survey.

## Data and Methods

Data was collected by using two Leica GPS system 500 receivers. In both the March $5^{th}$ and March $7^{th}$ surveys, one of the Leica GPS receivers was mounted to a tripod and used as a permanent base station, while the other Leica GPS receiver was attached to a rod and used to perform either kinematic or stop-and-go surveys. During the surveying process, the base station acquired data using a static survey at an interval of 2 seconds. For the kinematic survey, the roving Leica receiver was attached to a snow scooter traveling 10-30 km/hr and recorded data at a 10 second interval. During the stop-and-go survey, the roving receiver must remain stationary for a period of time while the data is being collected. The time required is directly related to the number of available satellites and their respective geometries. In most instances, it took at least five minutes to accurately locate your position.

Following the surveys, each group processed the data using the computer program Leica Ski-Pro. Leica Ski-Pro allowed us to analyze and view the GPS data both numerically and graphically. The exported data was converted from EUREF89 datum to UTM, zone 33, by using the computer program, WSKTrans.

## Results

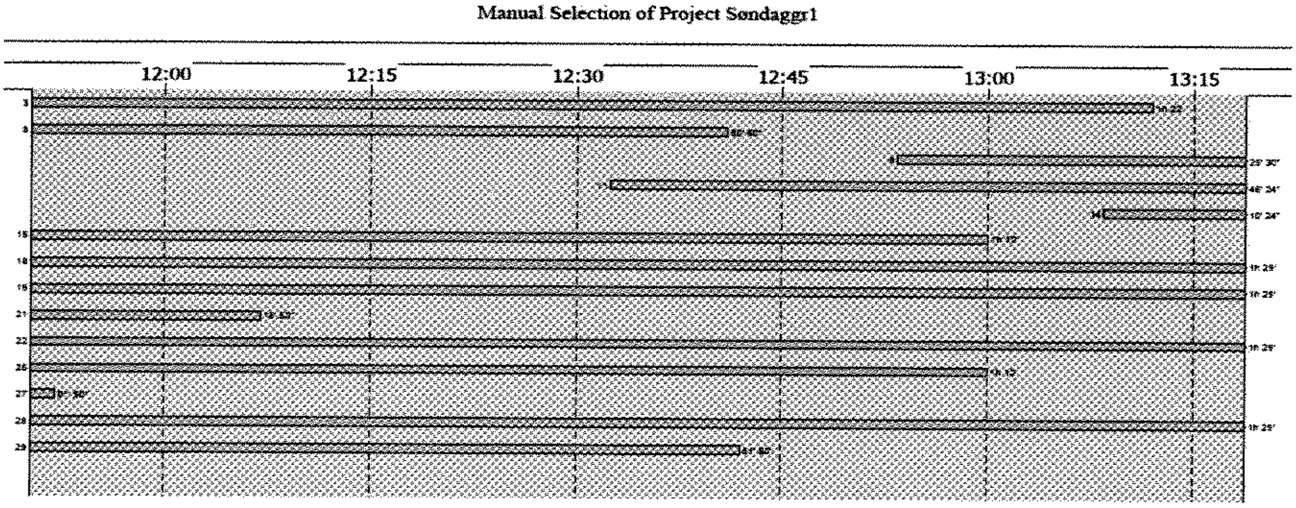
MARCH $5^{th}$, 2006

Many factors influence the quality of your GPS survey, from the physical collection of data while in the field to the post processing of the data in the computer lab. In either case, a good understanding of the inherent GPS pitfalls is needed to accurately asses the quality of the data. While in the field, the largest influence on data quality is tied directly to the number of available satellites and their respective geometries. For even the most basic survey, you need at least 4 available satellites. Related to the number of satellites and their respective geometries to one and other are the values of Position and Geometric Dilution of Precision, PDOP and GDOP respectively. PDOP is a quantitative measure of the accuracy of your measured position relative to satellite geometry. The higher dilution of precision in position measurements, the less accurate your results are. GDOP is a measure of the quality of satellite geometry, or arrangement, to one and other. The higher the GDOP value, the more concentrated the satellites are which overall decreases the quality of measured data.

During our March $5^{th}$ survey, we had a range of 8 to 11 satellites, which is quite good when working on Svalbard, Figure 1. This then translated to relatively low PDOP and GDOP values. The PDOP range measured during our survey was within 2.0 to 3.0, ensuring good position measurements in relation to satellite location. The same was true for GDOP with a range of values from 2.5 to 3.2, overall confirming a broad arrangement of satellites and increasing our recorded accuracy.

Given our location and limited time, we were not able to set up a receiver on a known base station, i.e. NP124 benchmark. This would have increased our recorded accuracies, but given the premise of the exercise, it was not needed. Overall, the results from the March $5^{th}$ survey are quite good.

Figure 1: Satellites available through the survey (March 5, 2006).




The survey conducted on March 5th was done so by attaching a GPS receiver to a snow scooter and then using the scooter to drive in a straight line for about 600 meters. Figure 2 graphically depicts the survey, as well as the relative locations of the base station and the two stop-and-go measurements conducted at the beginning and the end of the survey. The survey seems quite good and straight, but to accurately asses the quality of the survey, a profile view is needed. Figure 3 shows the two scooter passes performed over the survey. At most we see differences in the elevation of around 10cm, which is good, especially given the bumpy ride associated with a snow scooter. This suggests that the overall quality of the differential GPS survey is quite good.

Figure 2: Group 1 Survey Profile

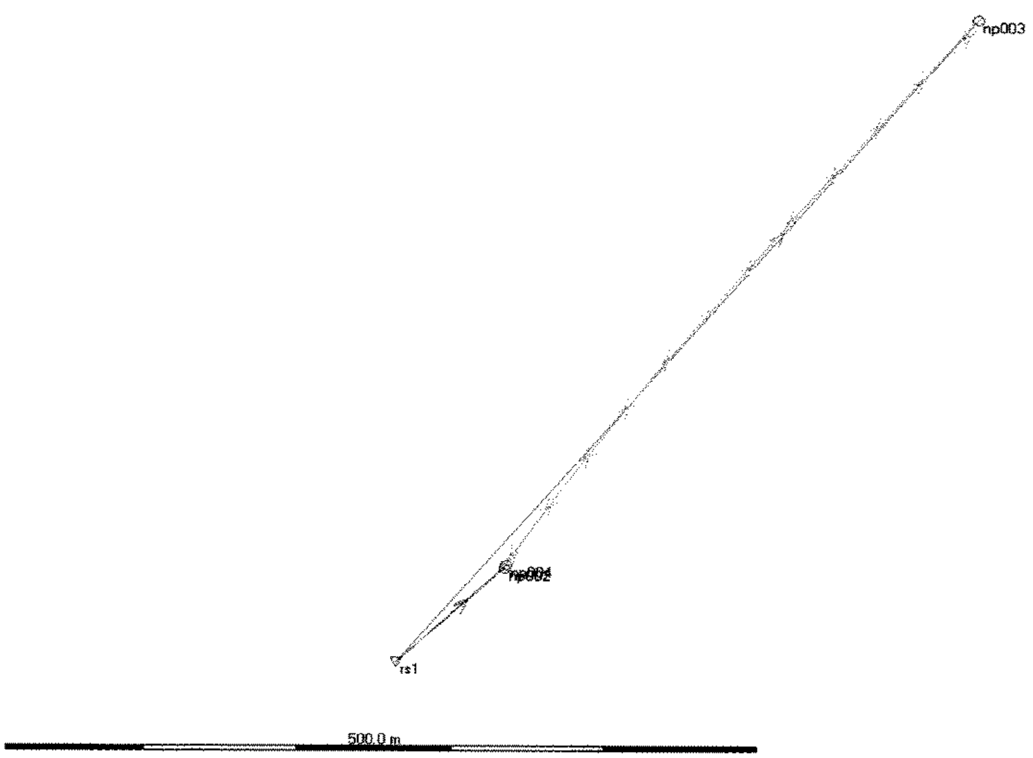
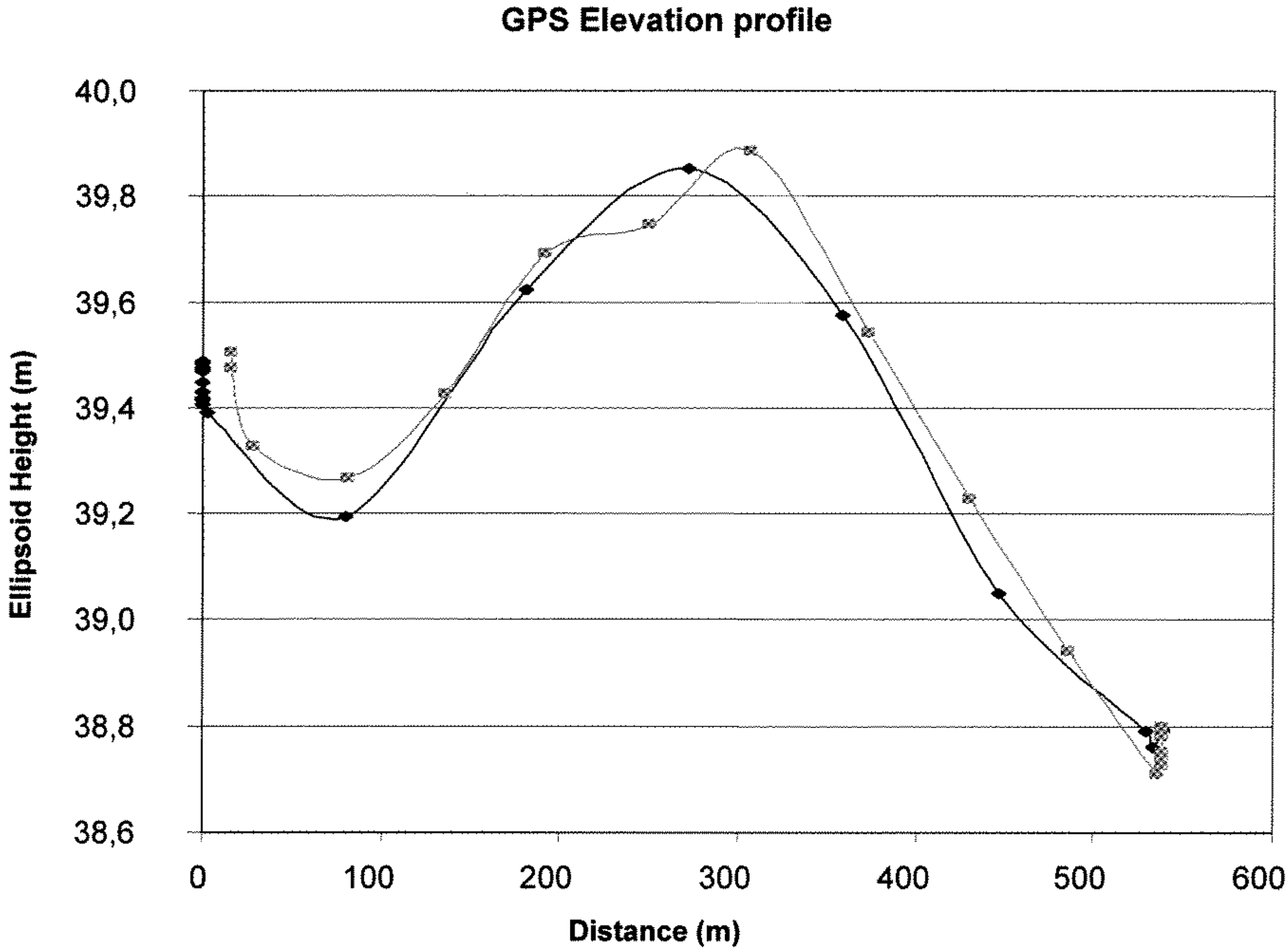


Figure 3: Elevation profile comparison from the March 5th Kinematic Survey




MARCH 7th, 2006

Our goal for conducting the GPR survey was to detect a buried object, which in this case is a utility pipe running through a culvert beneath a road. Even though we were conducting this survey in the middle of town, it is always essential that you have a good understanding of your location, so we conducted a GPS survey using the techniques learned on March 5th. Initially we set up a Leica receiver as a base station which would collect data every 2 seconds while we were performing the GPR survey. Then using a second Leica receiver, we measured our starting and ending points of the GPR survey. Once the GPR survey was complete, we drove to bench mark NP124 and collected data using the roving Leica receiver. This way we measured our two survey points in relation to a temporary base station and then tied all three in by surveying a known reference point.

As with our March 5th survey, the accuracy of your survey depends on the number of satellites and the measured DOP values. Figure 4 depicts the number of satellites available during our survey, which ranged from 6 to 10. Although we had a good number of satellites, we measured a large range in DOP values. The PDOP had a range of 5 to 14, as did the GDOP with 5 to 14. This suggests that the accuracy of our survey is not as good as it can be, but again, given the fact we used a known base station, our overall survey is quite good.

Figure 4: Number of Satellites available during survey on March 7th, 2006

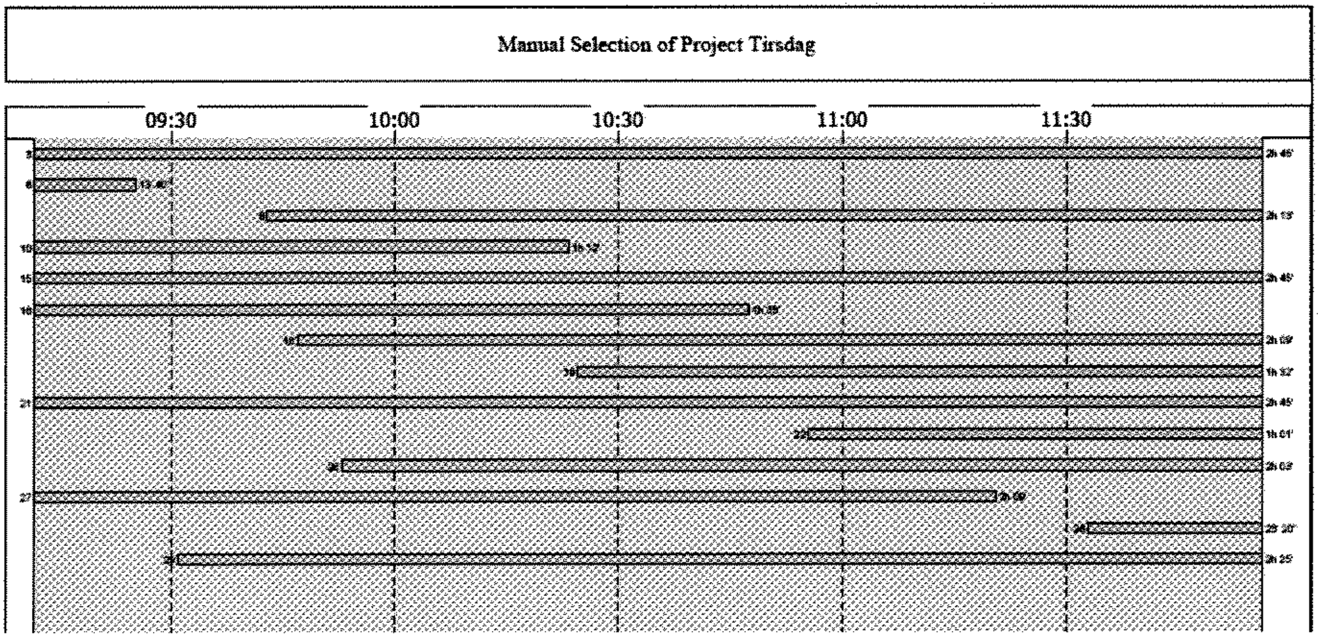



Figure 5: GPS profile of March 7th GPR Survey

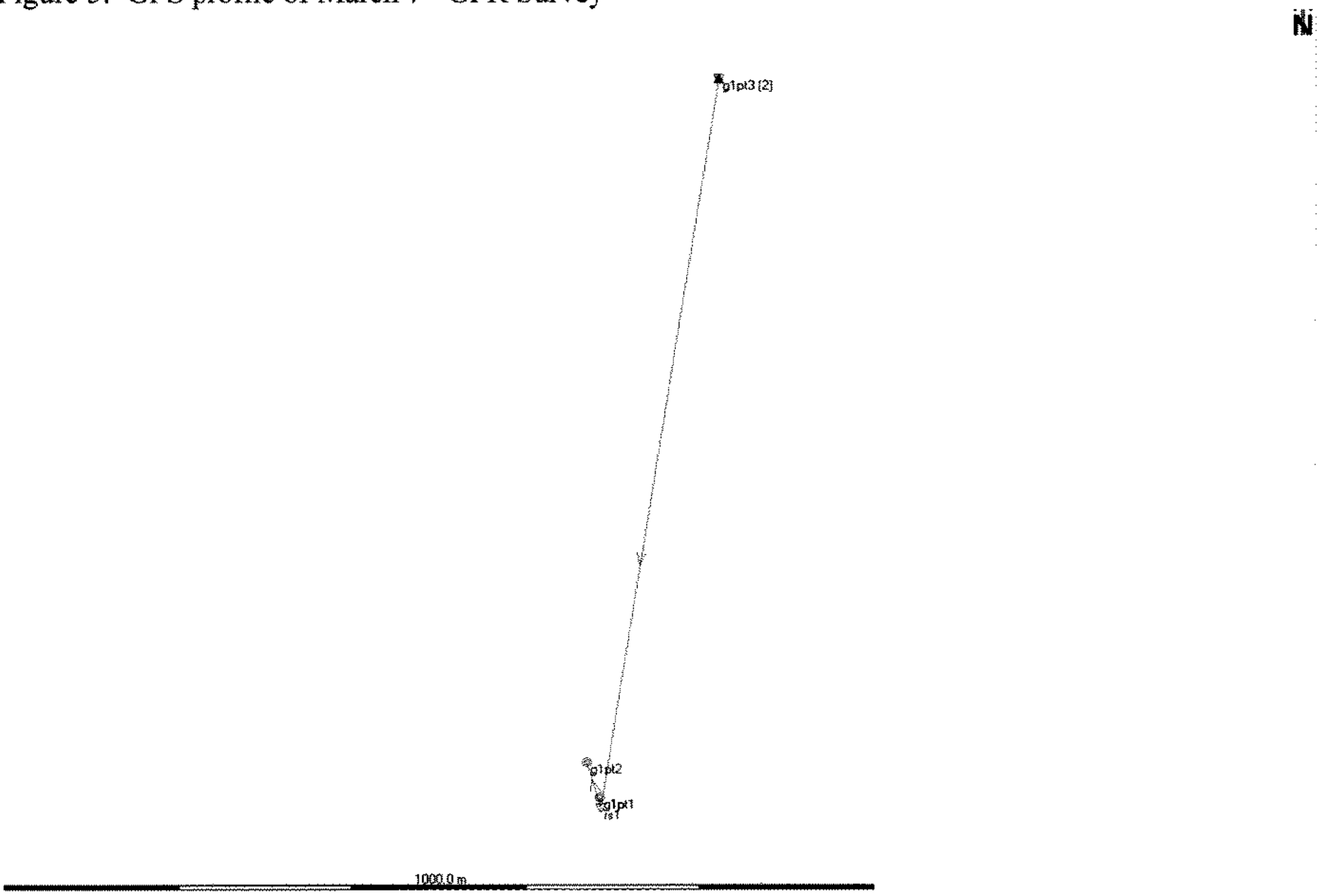


Figure 5 is a plan view of our GPS survey, in which it depicts the temporary base station, the two measured GPR survey points and the known reference point, NP124. The data collected in the field was then analyzed and processed in the computer lab. Table 1 shows the collected data and the subsequent conversions and transformations. The first conversion was to take the measured ellipsoidal heights and convert them to geoid heights. This is done by one of two conversion factors. The first is the NTNU Geoid Model, Figure 6, and the second is a scale factor to the known reference point, NP124. The two constants are 33 and 31.901 meters respectively. The next conversion was to take the Euref89 coordinates and convert them to ED50. This could be done with either the computer program WSKTrans or by using a scale factor form the NP124 reference point. The last two columns of Table 1 show the difference between using the WSKTrans program and NP124. This difference is because WSKTrans is made for use on the mainland Norway only, and therefore has some inherent inaccuracies.

Figure 6: NTNU Geoid Model

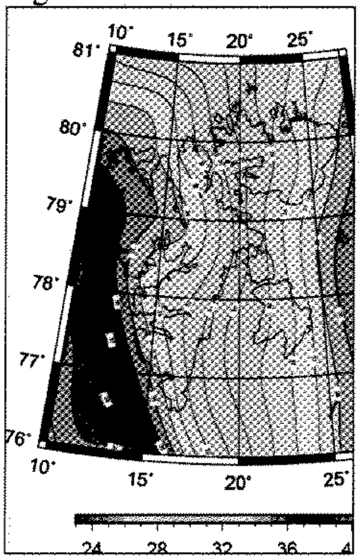



Table 1: GPS data

| Points | Height | NP124 diff | geoid model | ED50 N | ED50 E | EU89 N | EU89 E | ED50 fra NP124,N | ED50 fra NP124,E | Diff, N | Diff,E |
|---|---|---|---|---|---|---|---|---|---|---|---|
| g1pt2 | 71.3155 | 31.901 | 33 | 8682544 | 514205.5 | 8682336.103 | 514141.615 | 8682538.613 | 514216.975 | 5.053 | -11.518 |
| g1pt1 | 72.7782 | 31.901 | 33 | 8682499 | 514220.8 | 8682291.692 | 514156.918 | 8682494.202 | 514232.278 | 5.052 | -11.517 |
| rs1 | 73.8034 | 31.901 | 33 | 8682486 | 514221.5 | 8682278.099 | 514157.659 | 8682480.609 | 514233.019 | 5.052 | -11.517 |
| g1pt3 | 66.8010 | 31.901 | 33 | 8681551 | 514364.5 | 8681342.978 | 514300.640 | 8681545.488 | 514376.000 | 5.049 | -11.514 |

**Discussion**

Our field work incorporated three different GPS surveying methods; static, stop-and-go and kinematic. All three require the use of at least two GPS receivers and will produce accuracies of around 10-20 mm. Static surveys can have accuracies of less than 10mm, but they require a stationary receiver, located at a known point, collecting data for a long period of time with optimal DOP conditions. Kinematic allow you to survey large areas while on the move by setting a time step for data collection. Stop-and-go surveys require you to be stationary while collecting data, but you are able to move from point to point. Each have their advantages and should be used accordingly to make the most efficient and accurate surveys. In setting up each survey, you must adjust for certain parameters that will affect the data collection. One of the more important ones is the cut-off angle, which is the angle at which satellites below that angle will not be used. This is due to the atmospheric noise associated with signals passing through such amounts of atmosphere. You also need to determine your logging time interval, which governs how often you collect data. This will affect your resolution during kinematic surveys and will help determine your initialization time period during stop-and-go surveys.

As seen in the March 7th surveys, post processing is a critical step in performing a good GPS survey. Given that we are working on Svalbard, which still uses the ED50 reference system; we have to take that into account. If we do not, our survey can be off in all directions by upwards of tens of meters. That is why it is critical to use and reference a known point, such as NP124.

**Conclusion**

Both the March 5th and March 7th GPS surveys were quite successful with accuracies of around 10-20mm. Our surveys pointed out the importance of understanding the factors influencing GPS data as well as the importance of knowing which reference system you are in. If we had assumed that Svalbard used the WGS84 coordinate system, than our locations would have been off by upwards of 10's of meters. Ultimately, both surveys provided a practical understanding in performing and processing differential GPS surveys and also allowed us a means to accurately locate our GPR survey.