GNSS-INS Processing

Description of Project

The purpose of this lab is to process the GPS-INS from the airborne LiDAR that is covering an area located just outside of Kona, Hawaii.

The following information is a little back ground and can be found on page one of the Lab 4 GPS-INS Processing under the overview section.

"GPS aided inertial navigation systems have been available for commercial mapping applications for over twenty years, pioneered by Canadian-based Applanix Corporation with their POS (Position and Orientation System) technology. The impact on the aerial survey and remote sensing industry brought about a re-assessment of traditional photogrammetric methodology and the potential elimination of two fundamental mapping components, the ground control survey and corresponding aerotriangulation process.

By merging GPS and inertial navigation technologies, accurate position and orientation of the airborne imaging sensor with respect to the Earth, can be determined directly. Such an approach is referred to as Direct Georeferencing. This approach is opposite to that of aerotriangulation, which requires accurate control points to be surveyed on the ground and then identified in the stereo imagery. These are then used to "back-out" the position and orientation of each photo through a geometric adjustment. One main advantage of Direct

Georeferencing is that it can be used with any type of airborne imaging sensor, such as an aerial camera, hyperspectral scanner, Synthetic Aperture Radar or LiDAR. This method of calculating airborne position and orientation data is now a proven and reliable technology that is becoming more robust and accurate every year with the ongoing development in GNSS and inertial equipment. Integration of GNSS and INS is the enabling technology behind LiDAR, SAR, and IfSAR. "

Methodology

This methodology section is going to go through all the steps and processes involved to achieve the goal set for this project.

The first thing that was done for this project was create a new project through the project wizard. The first screen you will be asked to create a project , for this project the project was called Day269f1 (Day 269 stands for the Julian day and f1 stands for flight 1 since there are two flights for this project).

The second thing that was done for this project was import the GNSS data file (this file could be a GPB, Raw GNSS or Raw SPAN IMU). The first import that goes into this window would be Span01_269.gpb file and then make sure you have the **I have IMU data file in Waypoint (IMR) format** box checked and then the second spot to import a file should automatically fill (this file should be Span01_269.imr).

The next window that pops up is the **Base (Master) Station Information.** Some of the information that has already been filled out in this window is not correct. The **Northing** should read **19 43 42.64707** , the **Easting** should read **-156 02 28.70589**. The **Ellipsoidal Height** needs to be changed so it reads **35.773 (m)**. The Datum needs to be changed from WGS84 to **NAD_83(PA11)**. Then final thing that needs to be changed/imputed is the **Measured Height** this should read **1.423**. After clicking finish you should see something like the image to the right, titled **Day 269 Flight 1**.

Once you have got the base station and rover data into Inertial Explorer, the next step is to process our GNSS. This is done by clicking on the **Process GNSS** button, which looks something like this , when this window pops up make sure that **Differential GNSS** is selected under Processing Method; also make sure that **Both** is selected found under Processing Direction. Then under Processing Settings, make sure the Profile is set to **GNSS Airborne**, then select the **Advanced** button. Once you have verified that all of the processing settings are correct click the **Process** button, this will process the GNSS data and spit out a solution.

Once you have gone through the Processing GNSS steps, the next thing is to **Plot** those results. The way you plot the results of the pervious steps is by clicking the **Plot Results** button which looks something like this , the plots that were looked at for this lab were the following: **Estimated Position Accuracy, RMS Carrier Phase, Combined Separation, Combined Separation with Fixed Ambiguity, Float/Fixed Ambiguity Status, Number of Satellites, PDOP, Quality Factor,** and **Satellite Lock – Cycle Slips.**

The next step is to fix/omit any cycle slips that are causing errors. This is done by going back into the process gnss window and click on the advanced button again and under the **General** tab at the bottom where it says **Satellite/Baseline Omissions** click the **Add** button. Then when the **Omit Satellite Info** window pops up make sure that **Only specified satellite is checked** and that **GPS** is selected from the drop down menu and then plug in the satellite number you wish to omit, in this case it was satellite number 29. Then make sure that **Omit satellite for all baselines** is selected, then make sure that **Use specified time range** is selected, and put in **69242** in the first **Range** box and **69267** in the other (***NOTE* you can do this more then once and on different satellites)**.

Image Description

The image above show where the base station is located in comparison to the flight paths that were flown. This image is being shown in Google Earth.

The image to the right is showing the Epochs and their Quality. This image is being shown in Google Earth. The legend found under this image came from Inertial Explorer.

- GPS Time: fixed field width = 9, number of decimals = 2
- Latitude: fixed field width = 16, number of decimals = 5
- Longitude: fixed field width = 16, number of decimals = 5
- Orthometric Height: fixed field width = 12, number of decimals = 3
- Roll Angle: fixed field width = 9, number of decimals = 4
- Pitch Angle: fixed field width = 9, number of decimals = 4
- Heading Angle: fixed field width = 9, number of decimals = 4
- North Velocity: fixed field width = 9, number of decimals = 4
- East Velocity: fixed field width = 9, number of decimals = 4
- Up Velocity: fixed field width = 9, number of decimals = 4
- Latitude: fixed field width = 14, number of decimals = 10
- Longitude: fixed field width = 14, number of decimals = 10

The next step in the data processing is to process the INS data. For this lab we will be using the **Process Loosely Coupled** tool which looks like this , once the process loosely coupled window pops up there are two things you need to change. The first thing that needs to be changed is the **Update Data** , change to drop down so it says **GNSS Combined (OK)**. The second thing that needs to be changed is the **Profile**, and you change that drop down so it says **SPAN Airborne (FSAS)**. Then instead of clicking the process button, click the drop down menu for it and select **Solved Lever Arm**. A window, similar to the images to the right (under image description), should pop up and the **Current Values** lever arm should read all zeros. Once this window pops up highlight **Forward Estimate** and click ok. The process loosely coupled window should pop back up and you want to re-do this solve lever arm process a couple times until the values are looking similar to one another, the second image to the right on the bottom is what the values look like after running through the previous step four times. After you have those values looking similar to one another you click the **Process** button and that will apply the final values for the lever arms to the project/the data.

Once you have completed solving for the lever arms you need to run the **Combine Solutions** and the button looks like this , and the only thing that needs to be changed in this window is the **Solutions To** and you change the drop down so it says **LC Solutions**, then hit the **Combine** button. After that is the **Smooth Solutions**, which looks like this , and just make sure the drop down menu says **LC Solutions** again.

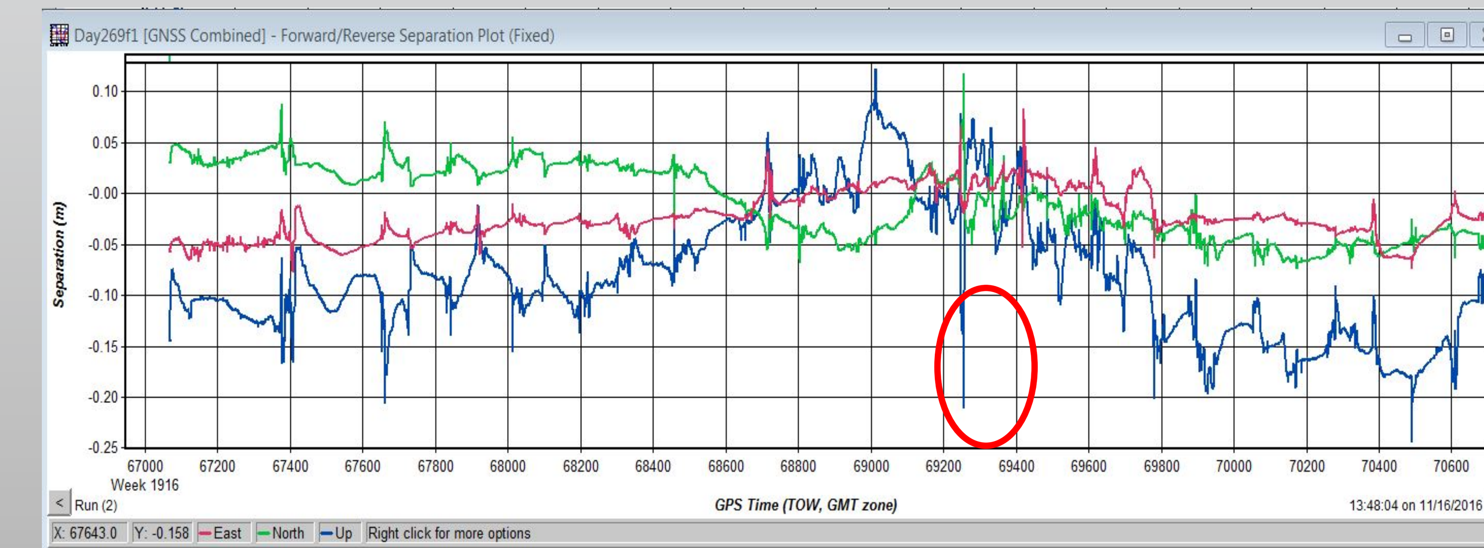
The next thing that needs to be done is to take a look at the **IMU Plot Results**, just to double the quality of the data after it has been processed.

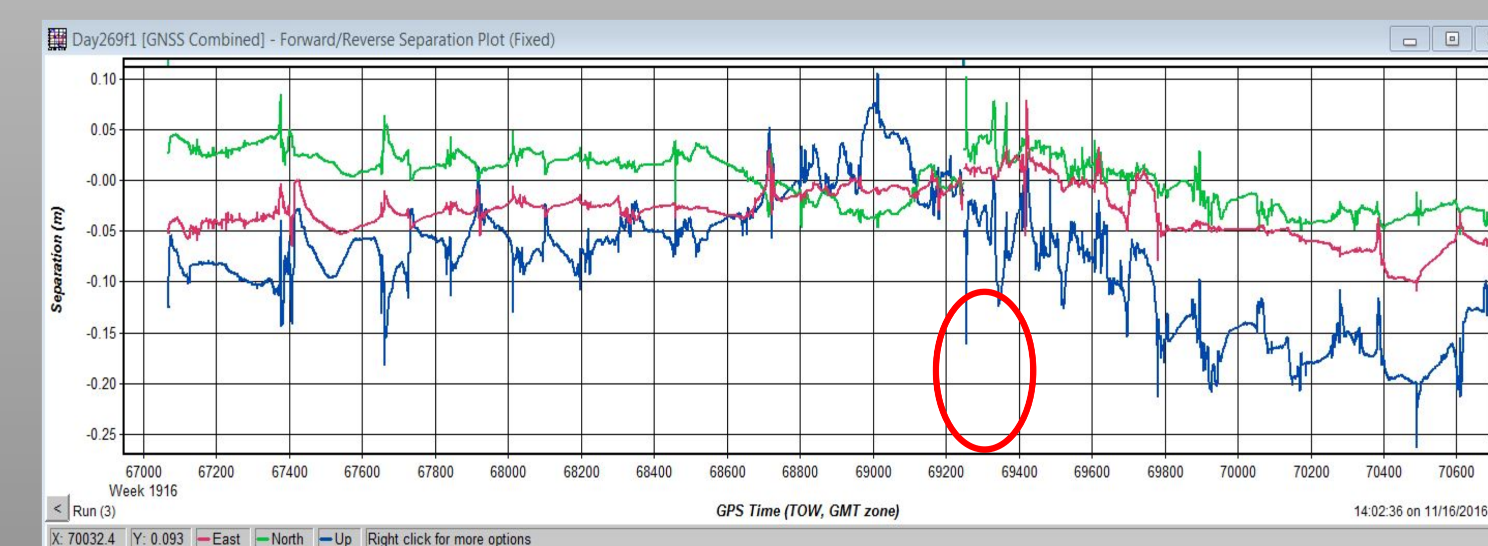
Then the final thing that needs to be done is **Export to SBET (Smoothed Best Estimate of Trajectory)**. This is found under the **Output** tab at the top and then click export to SBET. The window that pops up allows you to name the file you are exporting, Day269f1_sbet.txt was used for the first flight data. Make sure **Epochs** is selected and then click the new button at the bottom, a second window should pop up and this is where we choose the variables that will create our SBET profile, a list of the variables that were used to create the SBET for this lab can be found above. Once you have all those variables click next in the wizard and make sure that **Binary trajectory interval** is set to **0.0050 (s)** and also make sure **Time Interval** is selected and it says **0.0100 (s)** and finally make sure **Applied lever arm (IMU to Sensor)** is checked and then hit the **Finish** button. Then once you have exported your SBET text file just open it up to make sure everything looks like it should **(*Please note I would have put a screen shot of the SBET output for this lab, but it was too large to fit)**.

Precision/Accuracy Analysis

Well going through the GPS-INS processing steps I have come to the conclusion that the errors that were found through out the lab could have occurred due to a couple of factors. One being the pilot rolling the plane too steeply during the turn and the second being a loss of satellite or a cycle slip.

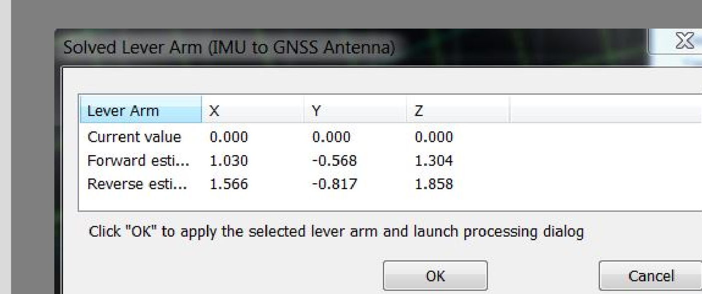
For an example the two graphs that you see below are showing a spike in the combined separation plot, highlighted by the red circle. Since this section has been selected from an epoch which was recorded during one of the aircraft's turns, from this I can come to the conclusion that this spike was caused due to the pilot rolling the plane too steeply in a turn.





What have I learned about GPS-INS

I knew nothing about GPS-INS processing, everything that I know now is because of this lab. I now know how to omit satellite information when it is necessary to do so. I now know how to use the solve lever arms function, found within Inertial Explorer, if I forget to take the measurements out in the field. Also I now know more about the software Inertial Explorer itself, due to the fact that I have never worked with the software before I can now say that I am comfortable working with the software.

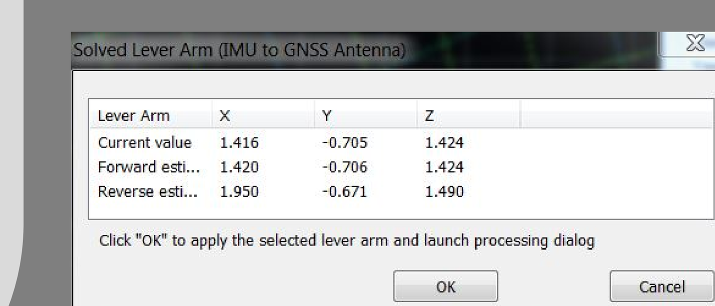


Solved Lever Arm (IMU to GNSS Antenna)

Lever Arm	X	Y	Z
Current value	0.000	0.000	0.000
Forward esti...	1.030	-0.568	1.304
Reverse esti...	1.566	-0.817	1.858

Click "OK" to apply the selected lever arm and launch processing dialog

OK Cancel



Solved Lever Arm (IMU to GNSS Antenna)

Lever Arm	X	Y	Z
Current value	1.416	-0.705	1.424
Forward esti...	1.420	-0.706	1.424
Reverse esti...	1.950	-0.671	1.490

Click "OK" to apply the selected lever arm and launch processing dialog

OK Cancel

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Course: Introduction to Advanced Positioning Systems (REMT 3030)

Date: November 18th, 2016
Date Due: November 22nd, 2016
Datum: NAD_83(PA11)
Projection: UTM zone 1
Geoid: GEOID12B (HAWAII)
Data Reference: Can found below with the Airborne GPS-INS (Rover) and also Base Station Data (Base).

Airborne GPS-INS Data (Rover)

The GPS-INS data was acquired by DigitalWorld Mapping Inc. on September 25th, 2016 (Julian Day 269) over an area just outside of Kona, Hawaii. DWM's system consisted of an integrated NovAtel SPAN IMU, and a Riegl LMS Q-280i ALS.

Base Station Data (Base)

The base data was submitted to OPUS for an adjusted final coordinate to be used for post-processing. Please see the OPUS solution text file (located in the Base folder with the base station data) for horizontal and vertical datum information. Remember, it is very important that the proper coordinate, HI, and antenna model be used in post-processing.