***Assessing Image Accuracy using GNSS***

This exercise introduces formal evaluation of data source accuracy. We collect much of our data from aerial images in this class, and many other projects. The positional accuracy of our data is limited by the quality of the source materials. With UAVs/drones making it easy to collect high-resolution images, we often need to estimage the positional accuracy of those images before using them. Here we'll evaluate the horizontal positional accuracy of the 2017, leaf-off drone image collected over the St. Paul Campus. The image may be found in the class L drive, in the Campusimages folder.

Our broad workflow is:
- Identify three of the five Larpenteur avenue NGS points for which we have highly precise coordinates.
- Download/record the "truth" NGS coordinates for your chosen points, using the UTM, zone15 N, NAD83 1996/2007/2011 system.
- Collect GNSS/GPS data for those points, differentially correct them, and export x and y coordinates using the Trimble software to the same UTM system as the NGS control. Andy will demonstrate use of the hardware after the GNSS intro lecture. We will be in lab to help with the processing, but you should strive to collect at least one point the first day, leaving time to return to the lab while we're there to help with correction/processing/export.
- Create an NGS/GNSS spreadsheet using the (too few) NGS points as truth, and GNSS points as test.
- identify a set of 8 or more features in your study area which can be precisely identified to within an inch or so (e.g., sidewalk/curb corners, stable paint marks, small pipes), visible on the aerial image.
- Digitize those points on the image, extract geometry/coordinates x and y coordinates for those "test" features using ArcGIS Pro.
- visit those points in the field and collect GNSS data, return to the lab, differentially correct, and export "true" coordinates using Trimble hardware and software (Pathfinder Office, or PFO)
- Calculate the image coordinate error using an NSSDA spreadsheet
- Create a map with insets for the image accuracy points
- Turn in data and maps to Canvas

***Part 1: Learning to Use GPS/GNSS, Comparison to NGS Coordinates***
There are five NGS control points along the south side of Larpenteur Ave., east of Cleveland Ave. "True" coordinates for these points are on the NGS sheets available from the main class website, resources for this week.

You will collect data from three of these points using Trimble hardware and software, and fill out the standard NSSDA spreadsheet, mostly for practice, and to ensure you can effectively use the GNSS/GPS technology.

In this first part of the exercise, you consider the NGS coordinate locations as "truth," and the GNSS/GPS coordinates you collect as "test" in the NSSDA spreadsheet.

Andy will go over use of the hardware and software, and key points on correctly correcting and exporting the GNSS data. It is key on export to use the correct datum and projection file. In all calculations we will be using the Zone 15N UTM coordinate system, and the NAD83 1996/2007/2011 datum.  The 1996/2007/2011 versions of the NAD83 datum are functionally equivalent in ArcGIS. DO NOT use the NAD83 1986 version.

Complete the NGS/GNSS spreadsheet provided in the resources column. This IS NOT the NSSDA spreadsheet provided in the resources column, make sure you use the correct excel spreadsheet here. Remember, NGS sheet coordinates are truth, your collected/extracted coordinates are test. Three points are too few to accurately assess the accuracy of the GNSS/GPS measured coordinates, but I will combine these later, this spreadsheet is to check for major errors, practice with GNSS, and get familiar with the spreadsheet. If you have errors above 20 cm, please see Andy or I.

Zip the following together, and turn in on Canvas:
1) GNSS/GPS files (.ssf and .cor),
2)  your NGS/GNSS spreadsheet as an electronic document, and
3) an exported pdf of your spreadsheet.

### Part 2: Image Accuracy Assessment Using GNSS
Find and familiarize yourself with eight suitable test points in your study are on the 2017 leaf-off image. It is surprising how much detail you can see, and many suitable test features are visible on your image. Select features that are well distributed across your study area, are not under trees or right next to buildings, and for which you can safely collect data (careful near roads).

For this exercise, you want to GPS features that are very distinct on the images, e.g., sharp corners at sidewalk intersections, the base of very distinct poles where you can clearly identify the ground surface, or the corners of rectangular concrete pads in grassy

fields (see the image for three examples).



These points are too close together, you would want them well-distributed throughout your area, but they are examples of the kind of points we'd like to identify.

It would be prudent to select one or two extra points on images while in the lab, because a point in the field might not suit. They might not be easily identifiable, or have changed since the image was created. Having a few extra points means you don't have to come back to the lab and then return to the field because some of your initial points were impossible to find, or had been altered by construction.

Create a geodatabase/feature layer, digitize the point locations in the NAD83(CORS96) UTM zone 15 coordinates we've been using, and extract the x and y values for each point.

Use the provided GNSS equipment to visit and collect data for each of your points. Use carrier phase collection, and collect until the predicted accuracy stabilizes, generally in the 5 to 20 cm range if you have it set on horizontal positional prediction.  This should take from 30 seconds to several minutes for each point.

You may have to collect GPS data for a bit longer at your first point, up to 10 minutes with the high-resolution GPS. The field software shows an estimate of accuracy, if it is set to display correctly, it should decrease with occupation time to below 10 cm for most units.  It is good practice to collect your first point twice, once until you get carrier lock, then closing that point, and then a second in which you capture a point over the

same first location.  The initial data aren't as good as the GNSS equipment is capable of collecting because the estimate improves the longer you have lock on satellites. By collecting twice at the first point, while maintaining lock, you get better results. As noted before, you may reduce the time at the second or third points if you can maintain carrier lock, you will see the estimated positional uncertainty start lower and decrease faster at later points.

From the previous paragraph, it should be clear that you should try to maintain carrier lock. This means you should close the feature, but not the file, between points, and carefully walk with the pole/tripod upright and above your head from one point to the next. It helps if you don't pass under any obstructions, e.g., narrow gaps between buildings, under dense canopy. The expected accuracy shown in Terrasync may spike to a larger number for a bit, but if you maintain lock on most of the satellites, it will decline quickly and you may be able to collect for only a few minutes at each point until the expected accuracy converges on a low value.

Once done in the field, use the Pathfinder Office software in the lab to differentially correct and export the data, then extract the x and y coordinates for this GNSS "truth," and complete the NSSDA spreadsheet.

Turn in to Canvas the following files for your image accuracy assessment, all zipped into one archive file:
1) the NSSDA spreadsheet (as an .xls or .xlsx),
2) a pdf of the NSSDA spreadsheet
3) the GPS files (.cors and .ssf)
4) feature class/layers of both the truth points exported from GNSS, and the test points digitized from the image(as a geodatabase or zipped shapefiles) for your test points layer, and
5) a pdf map of your truth and test points, with your project area and the 2017 image as a background. Include and inset map that focuses on one of the test/truth points and feature.  Also include an appropriate legend, title, and other map elements.