



GIS3: USING GNSS AND UAS TO MONITOR A STREAM RESTORATION SITE

INTEROPERABILITY

When working on projects that involve GIS, we often need to share data among organizations that use different GIS applications (ArcGIS vs. QGIS vs. MapInfo) or, for example, that use a GIS application made by one company, a GPS application made by another company, and a geoprocessing model that was developed in-house with Python. To do so, we rely on *interoperability*.

Interoperability is a mindset that allows data to be exchanged easily; that prevents the loss or corruption of data during exchange; and minimizes the cost of handling data exchanges. Technologically speaking, interoperability is made possible by adopting standards. Culturally speaking, interoperability is made possible by understanding our clients' and customers' needs and helping them to reach their goals.

Required reading: [Bolstad \(2016: p619-624\)](#)

HORNBAKER WETLAND

The *Burd Run Stream Channel, Riparian Zone, and Wetlands Restoration Project* (Jaymes and Woltemade, 2000) restored all those things on the 21-acre “Hornbaker Wetland” property next to campus (Britton Rd @ Foldersonger Rd). Since restoration, the Hornbaker Wetland has been undergoing natural change. The site is now used to provide SHIP students with opportunities for field training related to hydrology, geology, biology, and geographic data collection; and for using the data accumulated over the last 20 years to support student-faculty research. A recurring need exists to collect new digital snapshots of this evolving wetland and to document progress and change since restoration.

Research question: *What are the current site and situation characteristics of the Hornbaker Wetland?*

GEOTECHNOLOGY

Georeferenced aerial photography is commonly used to capture before and after conditions at disaster, stream restoration, dam removal, or brownfield sites. High-resolution aerial photography is easy to interpret and provides analysts with the raw data needed to scout future fieldwork, digitize vector features that represent important entities, or evaluate landscape change over time.

Until recently, collecting aerial photography was a relatively expensive process because it required planning a flight mission that will achieve the desired coverage and image resolution, putting a plane into the sky, and, if the site footprint is small (like 21 acres small), waiting until you had enough small footprints to make a full day of work for the pilot. That's largely why past airphotos of the Hornbaker Wetland have been collected episodically.

We're going to use three different geotechnologies to help us answer our research question, and we need these technologies to interoperate.

1. Unmanned Aircraft System (UAS)

A UAS (a.k.a. “drone”) is a class of geotechnology that can be used to acquire aerial imagery quickly and cost effectively. Small UAS can overcome the scale gap between collecting data in the field manually and collecting air-borne data in bulk with planes or satellites (Meyers, 2014; Jordan, 2015; Kelleher et al., 2018). In this lab, we are going to learn how to plan a UAS mission for collecting vertical aerial photography AND we're going to deploy a small drone to collect images over the Hornbaker Wetland.



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2. Global Navigation Satellite Systems (GNSS)

A GNSS is a class of geotechnology that is useful for measuring time, location, and elevation; for recording attributes; and for assisting navigation and tracking. In this lab, we are going to use GNSS in three ways: (1) to geotag photographs taken in the field using mobile device cameras; (2) to conduct coordinate surveys of ground control points using a differential grade GNSS device; and (3) to auto-navigate a small UAS during flight.

3. ArcGIS Online (AGOL)

As you learned earlier this semester, AGOL is a nifty cloud-based mapping tool. It allows people and organizations to collaborate and to share geographic information, geoprocessing services, and media within the familiar browser environment. In this lab, we're going to use AGOL to build a map application that highlights the Hornbaker Watershed.

GNSS devices come in one of three grades: recreational, differential, and survey:

1. Recreational devices (e.g., mobile phones and pocket receivers) are typically small hand-held computers that can be used for place finding, waypoint marking, and geotagging media; under the very best conditions, they can make repeated horizontal coordinate measures with ± 5 meters of precision.
2. Differential grade devices have larger antennas, better hardware, and better software than recreational devices. When coupled with data-cleaning techniques during post-processing, differential grade devices can deliver repeated horizontal coordinate measures with sub-meter precision.
3. Survey grade devices are the state-of-the-art and tend to be very expensive. They can make repeated horizontal coordinate measures with ± 1 centimeter of precision in real time.

OBJECTIVES

In the office, we are going to:

1. plan a UAS mission for collecting vertical aerial photography over the AOI;
 - a. perform GNSS mission planning to identify the blocks of time when GNSS satellite-receiver geometries are optimal for measuring coordinates;
 - b. monitor the local weather forecast to identify the blocks of time when atmospheric conditions are suitable for flying a small UAS (clear visibility for 3NM, no precip, wind speed < 12 MPH);
 - c. setup an automated flight plan for the small UAS;
2. prepare a few mobile and GNSS devices for collecting data;

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In the field, we are going to:

3. layout conspicuous Ground Control Point (GCP) markers in the field;
4. use a mapping-grade GNSS device to measure the positions of the GCP markers;
5. deploy a small drone to collect vertical aerial images (with all the GCP markers in place);
6. take mobile photographs while working in the field;

Back in the office, we are going to:

7. post-process the GNSS data collected at the GCP markers;
 8. post-process the aerial imagery collected over the site;
 9. perform an accuracy assessment of the resulting image mosaic – how well do the coordinates of the image agree with the coordinates obtained with GNSS?
- and
10. build an interactive map that allows non-GIS users to interact with the wetland data we collected.

To accomplish our objectives, we need to develop a workflow that assures the data we collect and share are accurate, consistent, and complete.

FLIGHT PLANNING

Planning an aerial mission is an optimization problem. On the one hand, you want to fly as high as you can to capture a lot of ground in each image. The FAA has established a 400 feet AGL ceiling for small UAS, so that's as high as they may go. On the other hand, you want to fly as low as you can to capture a lot of detail. The tallest tall obstacles on the ground (e.g., trees, buildings, powerlines, etc.) will, however, limit how low you can fly safely. And then there's fuel (in this case, battery life); you gotta have enough juice to execute the plan AND to return home safely.

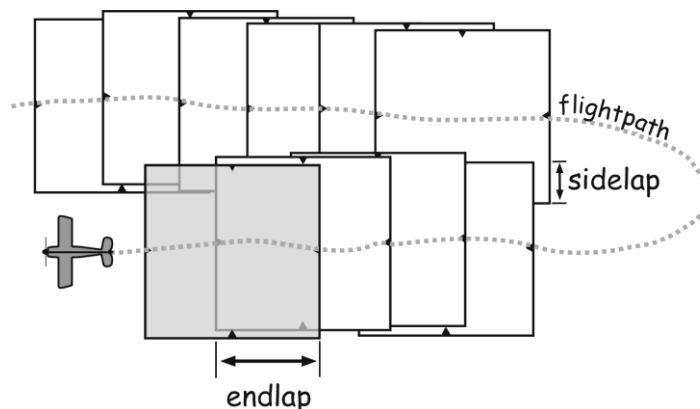


Figure 1. A good flight plan provides you with wall-to-wall coverage and a lot of overlap. This image (Figure 6-20 in Bolstad, 2017) shows a flight path with about 66% endlap and 20% sidelap.

Required reading: [Bolstad \(2016: p247-256, 258-265, 269-271\)](#)



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Step 1. Flight planning with DroneDeploy.

DroneDeploy is an online flight planning and photo processing service that works with a variety of drone brands and models. DroneDeploy charges \$300 per month to use its professional services, but they do offer a free 14-day / 10-mission trial. Sign up for a free DroneDeploy account using your Google credentials.

<https://www.dronedeploy.com/signup.html>

DroneDeploy is fairly intuitive to use. Missions (including 2 “test” missions) are listed in your table of contents on the left. The map view is on the right. Feel free to play around with the 2 “test” missions to get a feel for how to examine the flight plan properties for each and to make changes to each.

When you’re ready to plan a mission over the Hornbaker Wetland, visit the DroneDeploy’s App Market and **Install** the app called **KML and SHP Import**.

Next, **Plan a Flight Map (+)**. If DroneDeploy doesn’t recognize your location, then search for Shippensburg University. DroneDeploy will zoom to the university and create a square-shaped AOI with an initial flight path.

Change the default AOI using the **Import KML or ZIP** tool. Submit the Hornbaker shapefile I gave you.

Use the Advanced settings to ensure we get **70%** endlap and **70%** sidelap.

Adjust the flying **Altitude** to achieve “1 inch resolution,” which should be high enough to avoid any trees but not too high that we forfeit detail unnecessarily.

Next, use the Advanced settings again to change the **Flight Direction** property. Rotate the flight path to **minimize** total flight time.

Give your mission a name and save it.

Question 1: Build a table in your report that presents all your flight mission properties.

Question 2: What effect(s) does changing the flying Altitude (+100 ft, -100 ft) have on your mission?

METHODS FOR USING TRIMBLE DEVICES – PART 1: MISSION PLANNING

Step 1. Perform GNSS mission planning. Bolstad (2016: p203-213)

Anyone who has used a car navigation system or a mobile device knows that your ‘blue dot’ can be plotted large or incorrectly on your mobile map. That’s because most devices are setup to measure positions quickly under any satellite constellation rather than to wait until satellite conditions are good enough for measuring positions reliably. GNSS mission planning is the process of predicting when the satellite constellation above your work site will be suitable for collecting reliable data.

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Use John Deere's NAVCON's *Satellite Predictor* application to plan your GNSS mission and to identify blocks of time when satellite-receiver geometries will be optimal above Shippensburg University.

<http://satpredictor2.deere.com/lookup>

1. Page 1
 - a. Choose **Your location**: Either type in “Shippensburg University” or use the map to choose a spot in the AOI. [\[Continue\]](#)
2. Page 2
 - a. Choose the right **Time Zone**. If you're planning field work in Pennsylvania between March and November, then you want Eastern Daylight Saving Time (EDT). If you're planning fieldwork in Pennsylvania between November and March, then you want Eastern Standard Time (EST).
3. Page 3
 - a. Choose the **Date** we expect to be in the field.
 - b. Review the expected satellite **Visibility** at our designated place and time. Take notes about when 6 or fewer satellites are expected, for those blocks of time could yield less-than optimal data. [\[Print report\]](#)
 - c. Review the expected **DOPs**. A DOP value works like a golf score – lower numbers are better (see Table 1 and [Figure 5-12 in Bolstad, 2016: p213](#)). [\[Print report\]](#)

Table 1: Meaning of DOP values (H = 2D horizontal, V = vertical, P = 3D positional)

| DOP Value | Rating | Description |
|-----------|-----------|---|
| < 1 | Ideal | Highest possible confidence level to be used for applications demanding the highest possible precision and accuracy at all times. Suitable for in-route navigation. |
| 1-2 | Excellent | Positional measurements are likely accurate enough to meet all but the most demanding needs. Suitable for in-route navigation. |
| 2-5 | Good | Good enough for making many business decisions. Positional measurements are likely good enough to make reliable in-route navigation suggestions to the user. |
| 5-10 | Moderate | Approximate results likely. A more open view of the sky is recommended. Use with skepticism. |
| 10-20 | Fair | Positional measurements should be discarded or used only as rough estimates only. |
| >20 | Poor | Garbage in, garbage out. |

Question 3: Report any and each ‘good’ block of time (from start time to end time) when the HDOPs and VDOPs are expected to be less than or equal to 2.0. This is important because we want to avoid doing any GNSS work during bad blocks of time. Attach copies of your NAVCON reports to your lab report.

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Steps 2 and 3. Thinking about what needs to be mapped and what needs to be observed.

Begin a session of **GPS Pathfinder Office** and setup a **New...** project named *Hornbaker*. Point the **Project Folder:** to your **GIS3/labs** folder, your **T:** drive; or the **C:\Geotemp** folder.¹

Next, use Trimble's **Utility > Data Dictionary Editor** tool to help you prepare for data collection. When the tool opens, create a data dictionary called **Hornbaker-<your initials>.ddf** and save it. Set up your data dictionary as follows:

1. Name: *Hornbaker-<your initials>*
2. Comment: *September 2018*
3. Version: TerraSync v5.00 and later
4. Create a **New point Feature...** called *GCP* with the following settings and symbol:
 - a. Default setting
 - i. Select a 1-second position logging interval;
 - ii. Use a minimum of 90 raw positions to support each GCP;
 - b. Symbol
 - i. Choose 20-pt benchmark-looking symbol of any color.
 - ii. **[OK]**
 - c. Next, create **New Attributes...**
 - i. Numeric attribute
 1. Name: *GCPID*
 2. Comment/Alias: *Which GCP?*
 3. Decimal places: 0
 4. Minimum: 1
 5. Maximum: 20
 6. Default: 1
 7. On Creation: Normal
 8. On Update: Normal
 9. Auto-Incrementing:
 - a. Increment
 - b. Step Value: +1
 - ii. Menu attribute
 1. Name: *Blocked*
 2. Alias: *Is your horizon blocked?*
 3. Menu Attribute Values:
 - a. **[New...]**
 - i. Attribute value: *Yes*
 - ii. Default: unchecked
 - iii. Code Value 1: 1
 - iv. **[Add]**
 - v. Attribute value: *No*
 - vi. Default: checked
 - vii. Code Value 1: 0

¹ You need to change the default project path because you don't have permission to write in the IT Administrator folders, which were mistakenly set as the default folders during installation.

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- viii. [Add]
 - 4. Display in Field As: Radio Buttons
 - 5. On creation: Required
 - 6. On update: Normal
- iii. Numeric attribute
 - 1. Name: PerBlock
 - 2. Comment/Alias: What percent of your local horizon is blocked?
 - 3. Decimal places: 0
 - 4. Minimum: 0
 - 5. Maximum: 100
 - 6. Default: 0
 - 7. On Creation: Normal
 - 8. On Update: Normal
 - 9. Condition: [Change]
 - a. Enable condition: checked
 - b. If this condition is true, "Blocked is No", then:
 - i. On creation: Not Visible
 - ii. On Update: Not Visible
- iv. Text field
 - 1. Name: Comments
 - 2. Comment/Alias: Open ended comment.
 - 3. Length: 50
 - 4. Feature Repeat: Omit from Repeat
 - 5. On Creation: Normal

Save your data dictionary file and compare your setup against Figure 2. If everything looks good, then close.

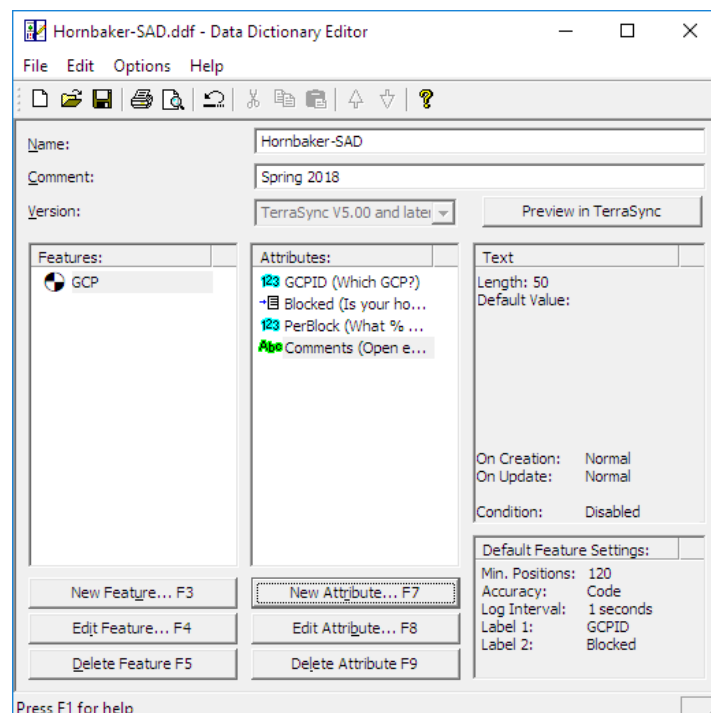


Figure 2. Snapshot of a complete data dictionary.



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Next, obtain a Trimble device and insert it into the grey cradle (GeoExplorer 3000 series) or connect it via USB (GeoExplorer 6000 series). Turn on the device (green button). On your workstation, Microsoft's Mobile Device software should recognize the Trimble device and open a connection. When prompted, "Connect without setting up your device" (we're not trying to sync music libraries or anything like that, just connect).

Next, open Trimble GPS Pathfinder Office's **Data Transfer** utility and connect with the *GIS Datalogger* on *Windows Mobile* device (if it hasn't already done so).

Next, add your data dictionary file to your **send** list, then **transfer** everything on the send list to the Trimble device. **Close** and **Exit** the utility.

METHODS FOR USING TRIMBLE GPS DEVICES – PART 2: COLLECTING DATA

Before beginning any fieldwork, make sure you are prepared with suitable clothing, boots, water, and sun protection (e.g., a hat, sunscreen). Expect to be outside and working in a wetland.

When you are in the field and ready to start your survey, start **GPS / TerraSync** (Professional). *TerraSync* is data collection software that reads satellite signals and calculates time and position. It can take several minutes to 'lock' onto all the satellite signals that are above your local horizon, so be patient.

On start, TerraSync will display its **Status** window. Think of yourself as standing at the center and the circle. The circumference of the circle represents the 360° local horizon around you. Each box symbol represents a satellite that is in the space dome above your local horizon.

Next, choose the **Data** option from the pull-down menu, which will let you use your data dictionary **Hornbaker-XYZ** as a template for creating a new data file.

Data file names are auto-generated. The prefix is usually the letter "R" (R for rover); the next two characters indicate the month ("03" for March); the next two indicate the day of the month; the next two indicate the hour of the day (on a 24-hour clock); and the suffix is usually a letter that auto-increments (from A to Z) during the hour. Be sure to choose your data dictionary before you **Create** your data file.

When prompted, enter the height of the antenna above ground (**2.0 m**).

Next, if you followed all the directions above correctly, then you should now see 4 buttons: [GCP] and the three default feature classes: [Point_generic], [Line_Generic], and [Area_generic].

Go to the field, collect data, and take pictures. **Bolstad (2016: 227-233)**

When you're finished with all your field work, **Close** the data file, **Menu > Exit** TerraSync, and power down the device by holding the green power button until the device turns off.

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Back at the office, turn the device back on and insert it into its cradle (or connect it via USB). Microsoft's Mobile Device software should open a port for communication. When prompted, "Connect without setting up your device" and minimize the Mobile Device Center window.

Next, start a new session of **GPS Pathfinder Office**. Re-open your *Hornbaker project*.

Next, open the **Data Transfer Utility**. Add your data file to your **receive** list, then **transfer** all the items on the receive list to your project folder. **Close** the Data Transfer utility.

Question 4: How did Mission Planning and building a data dictionary change the typical way you do fieldwork?

METHODS FOR USING TRIMBLE GPS DEVICES – PART 3: POST-PROCESSING

All that mission planning you did was to ensure you collected data when optimal conditions were expected. Working to plan does not guarantee, however, that field conditions were actually optimal, that you actually collected good data, or that your dataset is actually complete.

Your raw data are likely infected with some errors. Tall buildings or trees may have blocked some of the available satellites, thus increasing your DOPs (see Figure 2), or worse, they may have caused a satellite signal to bounce before arriving at your device (see Figure 2). A GNSS receiver cannot distinguish a direct signal from a longer multipath signal. See Figure 5-31 in Bolstad (2016, p231). And then there's human error on top of all that. These errors are just some of the reasons why you never want to give raw data to a client.

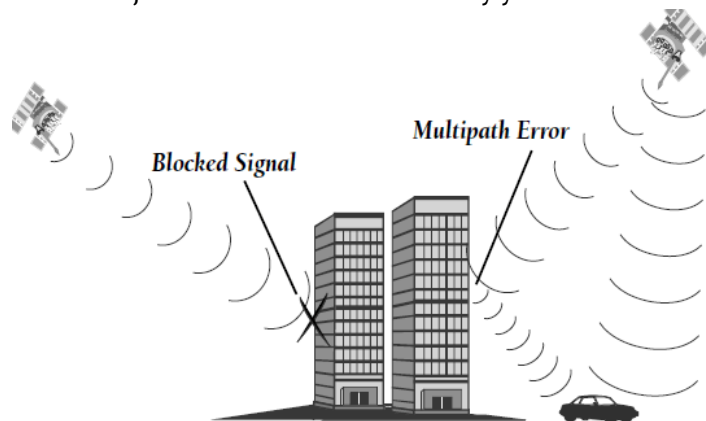


Figure 2. Actual field conditions can be different than predicted field conditions. This image shows buildings blocking some satellite signals and causing others to bounce indirectly toward a car with SatNav. The same can happen to you near hills or under tree canopies.

Before post-processing, make a copy of your data file (e.g., **copyR0*.ssf**). Working with a copy will let you practice and play with impunity. The original *.SSF file will serve as your back-up.

Start another session of **GPS Pathfinder Office** and re-open your *Hornbaker project*. Make sure you can see the *Map*, *Time Line*, *Feature Properties*, and *Position Properties* windows.



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Next, set the **Options > Coordinate System...** to *US State Plane 1983, Pennsylvania South 3702 (NAD83)*. Set your vertical datum to be *Mean Sea Level* (via the latest available GEOIDxx model). All coordinate values should be displayed in **meters**.²

Next, **File > Open...** your data file (**copyR0*.ssf**). If you setup your data dictionary correctly, then you should see *where* your features were measured (*Map window*) and *when* they were measured (*Time Line window*). You can use your cursor to select a feature in either window and the corresponding symbol will become selected in the other window. Notice how the *Feature* and *Position* attributes change with selection.

Question 5: How many GCPs did we layout and how many GCP features are in your feature class?

Exploring your raw data

Use your cursor to select a feature. The *Feature Properties* window lets you review feature attributes. Meanwhile, the *Position Properties* window reports the average of *uncorrected* Easting, Northing, and Altitude values derived from your raw sample of 150 positions.

Change the **View > Layers > Features... > Not in Feature > Symbol...** properties so they have a dark color and a thick width.

Next, use the *Feature Properties* window to **Delete** your selected feature. Relax, deleting a selected feature doesn't do harm (unless you hit "save"). Deleting a feature allows you to see the raw sample of single-fix positions that support your feature. Change map scale and pan to focus on your supporting sample.

Question 6: How many raw single-fix positions (repeated measures) were used to support the average coordinates for your feature?

Next, use your cursor to select raw positions, one-by-one, and examine their coordinates and DOP values. Use the *Position Properties* window to see how your measuring method changed over time as satellites entered or left the constellation above your local horizon. Notice how the DOP values can jump.

Question 7: Where and when was the best (lowest) PDOP observed? The worst (highest)? In each case, how many satellite signals were used to measure the position at that moment in time?

² Remember, all GNSS receivers spatially reference positions to the WGS84 ellipsoid model only. These settings do not change the actual geographic coordinates $\{\lambda, \Phi, h\}$ that you measured; rather, they simply tell your desktop software which spatial reference system you want to use for display purposes only.

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Question 8: Change map scale and look at the entire pool of supporting positions.

- Does your pool of raw positions have a dense central cluster? If so, how wide is it? (Use the Measure tool.)
- How far apart is the most distant pair of raw positions? (Again, use the Measure tool.)
- Interpret your answers above to characterize how consistently your equipment/method produced the same result during repeated measures? In other words, use the two distances you just measured to describe the precision of your measuring method.

Return to your Feature Properties window and **[Un-delete]** your selected feature.

Applying differential corrections to your raw data. Bolstad (2016: p215-220)

As described in your textbook, differential correction techniques require at least two proximate GNSS devices to receive satellite signals simultaneously. One receiver is installed at a fixed and known point; this receiver is called the “base station” (e.g., a National Geodetic Survey CORS site, see Figure 3). The other receiver is mobile and used for fieldwork; this receiver is called the “rover.”

The “base” is installed at a known spot and it measures its known self over-and-over again. Any observed difference between the measured coordinates (obtained via GNSS) and the already-known coordinates (thanks NGS CORS) can be blamed on the atmosphere.

$$Difference_{base @ time_x} = Actual_{base} - Measured_{base @ time_x} \quad \text{Eq. 1}$$

If we assume that your rover used the same satellites AND suffered the same atmosphere as the base station suffered, then any observed “differences” at the base can be used, in turn, to “correct” the data obtained by the rover; hence the term *differential correction*. Differential corrections are applied to the raw sample of single-fix positions, which will subsequently adjust each average feature.

$$Correct_{rover @ time_x} = Raw_{rover @ time_x} - Difference_{base @ time_x} \quad \text{Eq. 2}$$

Trimble software performs differential correction swiftly. Speed is great for the professional, but speed makes it difficult for students to watch what is happening and learn. So, follow these directions and you’ll be able to watch the process and get a better sense of how differences measured at the nearest CORS are used to correct your rover data.

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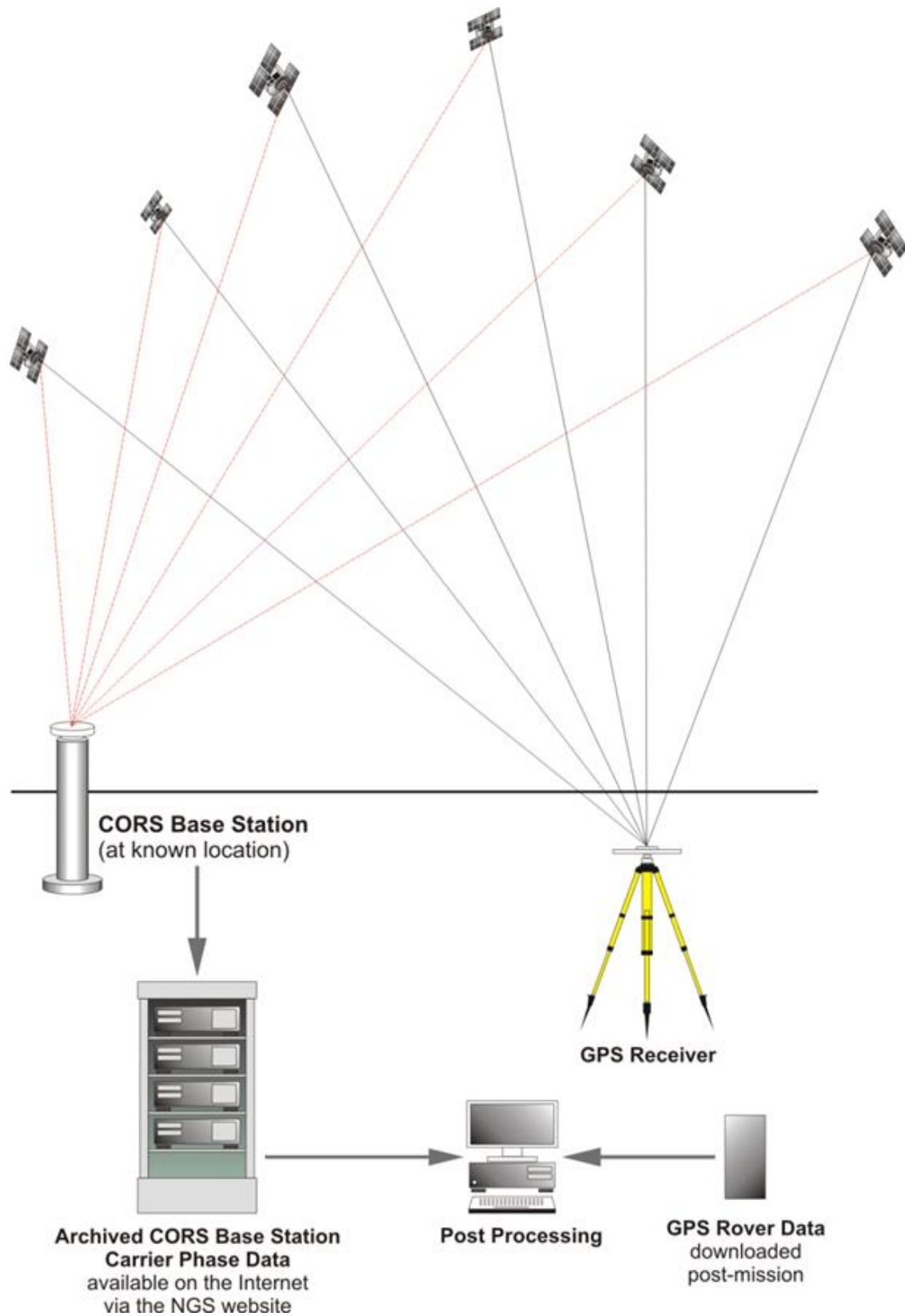


Figure 3. An illustration of the differential correction system.

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1. Open the **Utilities > Differential Correction...** utility. You might be prompted to save your file if you made any changes: the choice is yours to make.
 - a. Select the SSF file(s) you wish to correct.
 - i. [Next]
 - b. Processing type
 - i. *Automatic Code and Carrier Processing* (Recommended)
 - ii. Use a single base provider
 - iii. [Next]
 - c. [Change...] the Correct Settings
 - i. Output positions:
 1. Corrected only
 - ii. Use new GPS Filtering settings:
 1. Elevation mask = 10°
 2. Minimum Signal-to-Noise ratio = 33
 3. Maximum PDOP = 10
 4. DO re-correct real-time code positions
 5. [OK]
 - iii. [Next]
 - d. Base Data
 - i. Use *Base Provider Search* and **Select...** the closest base station (e.g., CORS, MCCONNELLSBURG (PAFM), PENNSYLVANIA). Choosing this option instructs the software to access the CORS server over the Internet and request base station data.
 - ii. DO use the position from the downloaded base files.
 - iii. DO Confirm base data and base position before processing.
 - iv. [NEXT]
 - e. Output folder
 - i. Use the same folder as the input file
 - ii. Create a unique filename ...
 - iii. [START]

Question 9: How many base files, if any, did the software download for you?

Question 10: How much coverage (amount of temporal overlap, expressed as a percent) exists between your rover data and the base station data?

iv. [CONFIRM]

Question 11: Knowing that satellites-receiver geometry can change over time, it is likely that you measured some raw positions during better conditions than others. How many (#) and what share (%) of your corrected positions fell into each “range” of uncertainty?

See Bolstad (2016) Figures 5-11, 5-12, and 5-31

v. [CLOSE]



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2. **File > Close** your uncorrected data file (*.SSF).
3. **File > Open** your corrected data file (*.COR).

Question 12: Did you lose any features after differentially correcting your raw positions? (#,%)?

Exporting your corrected data

Follow these directions to export your corrected GCPs to delimited text *.CSV format.

1. Open the **Utilities > Export...** tool.
 - a. Select your corrected (*.COR) data file as input for export.
 - b. Choose your output folder (where the outputted CSV file will be saved).
 - c. Choose the *Sample Configurable ASCII Setup* option.
 - d. [Properties...]
 - i. Data
 1. “Export all Features”
 2. Uncheck “Include Not in Feature Positions”
 - ii. Output
 1. “For each input file create output file(s) of the same name.”
 2. System File Format: Windows.
 - iii. Attributes (for the output attribute table)
 1. Export menu attributes as *Attribute Value*
 2. All features (check all of the following)
 - a. PDOP
 - b. HDOP
 - c. Correction status
 - d. Receiver type
 - e. Date recorded
 - f. Time recorded
 - g. Data File Name
 - h. Total positions
 - i. Filtered positions
 - j. Data Dictionary Name
 3. Point features (check at least the following)
 - a. Vertical Precision
 - b. Horizontal precision
 - iv. Units
 1. Use Current Display Units
 2. Latitude/Longitude Options: *DDD.dddddd*
 3. Time format: *24 Hour clock*
 - v. Position Filter
 1. Position Filter Criteria
 - a. Minimum Geometry = 3D (5 or more)
 - b. Maximum PDOP = 6
 - c. Maximum HDOP = 6

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2. Include positions that are:
 - a. Check every option except *Uncorrected positions*
- vi. Coordinate system
 1. Use Export Coordinate System [Change]
 - a. System: Lat/Long
 - b. Datum: WGS 1984
 - c. Altitude units: Meters
 - d. Altitude reference: MSL
- vii. Configurable ASCII
 1. File Options: One Set of Files per Feature Type
 2. Template List
 - a. [Delete] any templates that are there (e.g., pos, att, etc.)
 - b. Make a [New...] template called CSV
 - i. Output file extension: csv
 - ii. Apply to: Points
 - iii. Field format: Delimited
 - iv. Delimiters
 1. Field: Comma (,)
 2. Text: Double Quotes (“)
 3. Decimal: Dot (.)
 - v. Template Worksheet (see Figure 2 below)
 - vi. {Feature ID} {Longitude} {Latitude} {MSL} {Attributes} ~ [New Line]
3. [OK]
- e. [OK]

ASCII Export Template Editor: CSV

Output File Extension: Apply to: ☒ Points ☐ Lines ☐ Areas

☐ Use Template as Heading

Field Format: ☒ Delimited ☐ Fixed Column

Delimiters: Field: Other: Text: Decimal:

Macro Palette

| | | | | |
|-------------|------------|----------------|----------------|------------|
| {Latitude} | {Northing} | {Feature ID} | {Header Start} | {GPS Time} |
| {Longitude} | {Easting} | {Feature Name} | {Footer Start} | {Text: } |
| {HAE} | {MSL} | {Attributes} | {Hdr/Ftr End} | New Line |

Template Worksheet

{Feature ID} {Latitude} {Longitude} {MSL} {Attributes} [Newline]

OK Cancel Clear Template Help

Figure 4: ASCII Export Template Editor: Your output CSV file template.

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Question 13: How many of your features survived the export filter (see 1.d.v.1 above) and were exported?

Close your file and exit *GPS Pathfinder Office*.

METHODS FOR POST-PROCESSING OUR AERIAL PHOTOGRAPHS

You will receive a link to a ZIP archive containing all the aerial photographs we captured. After extracting them from the archive, you're going to geoprocess them in two ways:

Post-processing aerial photographs in ArcGIS

If you haven't already done so, create a geodatabase for this project. Next, create a set of point features representing the centroid of each photograph (see Table 2).

Table 2: Parameters for the **GeoTagged Photos To Points** tool (Esri 2017a).

```
GeoTaggedPhotosToPoints_management(Input_Folder, Output_Feature_Class, {Invalid_Photos_Table},  
    {Include_Non-GeoTagged_Photos}, {Add_Photos_As_Attachments})
```

| Parameter | Explanation | Data Type |
|--|---|---------------|
| Input_Folder | The folder where your photo files are located. | Folder |
| Output_Feature_Class | The output point feature class. | Feature Class |
| Invalid_Photos_Table (Optional, in this case, Yes) | An output table that will list any photo files in the input folder with invalid Exif metadata or empty GPS coordinates. | Table |
| Include_Non-GeoTagged_Photos (Optional, in this case, ONLY) | <ul style="list-style-type: none">ALL_PHOTOS — All photo files will be added as records to the output feature class. If a photo file does not have GPS coordinate information, it will be added as a record with null geometry. This is the default.ONLY_GEOTAGGED — Only photo files with valid GPS coordinate information will have records in the output feature class. | Boolean |
| Add_Photos_As_Attachments (Optional, in this case, ADD) | <ul style="list-style-type: none">ADD_ATTACHMENTS — Photo files will be added to the output feature class records as geodatabase attachments. Geodatabase attachments are copied internally to the geodatabase. This is the default.NO_ATTACHMENTS — Photo files will not be added to the output feature class records as geodatabase attachments. | Boolean |

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Next, sort your airphoto centroids by datetime and recreate the flight path in shapefile format (see Table 3). The reason why we're writing to Esri shapefile format is because we want to ZIP the output for upload and use in ArcGIS Online.

Table 3: Parameters for the **Management > Points to Line** tool (Esri, 2017b).

```
PointsToLine_management(Input_Features, Output_Feature_Class, {Line_Field}, {Sort_Field}, {Close_Line})
```

| Parameter | Explanation | Data Type |
|---|---|---------------|
| Input_Features | The point features to be converted into lines. | Feature Layer |
| Output_Feature_Class | The line feature class which will be created from the input points. | Feature Class |
| Line_Field (Optional) | Each feature in the output will be based on unique values in the Line Field. | Field |
| Sort_Field (Optional, in this case sort by DateTime) | By default, points used to create each output line feature will be used in the order they are found. If a different order is desired, specify a Sort Field. | Field |
| Close_Line (Optional, in this case, NO) | <p>Specifies whether output line features should be closed.</p> <ul style="list-style-type: none">CLOSE —An extra vertex will be added to ensure that every output line feature's end point will match up with its start point. Then polygons can be generated from the line feature class using the Feature To Polygon tool.NO_CLOSE —No extra vertices will be added to close an output line feature. This is the default. | Boolean |

Post-processing aerial photographs in DroneDeploy

Return to DroneDeploy.com and log into your trial account.

Visit Drone Deploy's App Market again and, this time, **Install** the app called **ArcGIS Online Web Tile Layer**. You'll use this app too share your geoprocessing results at DroneDeploy with AGOL. But first, you need to derive a mosaic from the raw input images.

Next, ignore your flight plan and **Upload images (+)**. Give your mosaic a user friendly name and upload all the JPGs we collected.

DroneDeploy will send you an email when your geoprocessing is finished, at which time you can return, review your results, and **Export** the mosaic for download and use in the ArcGIS Desktop environment.



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REVIEW

At this point, you should have:

- One geodatabase containing point features representing aerial photograph centroids.
- One zipped shapefile of our flight path, which was derived from the points above.
- One CSV file containing the differentially corrected positions and attributes of our GCPs
- One folder of raw aerial photographs
- Two copies of your aerial mosaic:
 - One downloaded and ready for use with ArcGIS for Desktop
 - One available at DroneDeploy.com and ready for sharing with ArcGIS Online.

ARCGIS ONLINE

Together, we'll build two simple web maps and one map application in-class to highlight the Hornbaker Watershed. Just make sure you have everything listed above.

DELIVERABLES

Complete a well-written report of the lab exercise. Include the lab title and your name and date on the first page. Your report should include six sections and headings: Purpose, Objectives, Methods and Data, Results and Answers, Summary, and References. Provide a brief introduction with purpose and concise objective statements using your own words. Describe the important methods and input data you used. In the Results and Answers section, address any issues or questions prompted during the lab. Include tables and figures in the same order you refer to them. In the Summary section, describe how you accomplished the purpose of the lab (i.e., how well did you answer the research question); then identify anything that you learned, or anything that remains problematic. I encourage you to share your "lightbulb" moments. Your References section should list any resource that you used to borrow facts, figures, or quotes.

All lab reports should be typed and printed on 8.5" by 11" stock. Before drafting your report, set your left and top margins to 1.2" and set the others to 0.7".

For the body, set the normal font face to be Candara, Bookman Antiqua, Bookman Old Style, or Georgia; never use Times New Roman or any kind of decorative font. Set the normal font size to be 11 points. Use 1.5 line spacing. Include page numbers on every page. Major section headings should be in bold face. All tables and figures must be inserted into the body of your report and conform to the formatting and margin requirements. Regarding tables: (1) columns containing text should be left justified; (2) columns containing numbers should be right justified; (3) values in a column should be presented using the same level of decimal precision; and (4) your table records should be sorted meaningfully, especially if the purpose of the table to help the reader find highest and lowest values.

Also, attach the two reports you generated during GNSS Mission Planning as appendices.



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