Desktop, Cloud, or Open Source? : Comparison of UAS Imagery Processing Tools

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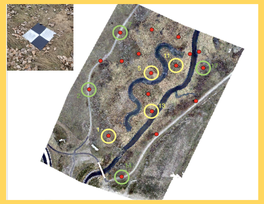
PROJECT OVERVIEW

Our project focused on learning how to collect and process UAS aerial imagery. The drone imagery processing industry is still nascent, but is growing rapidly with more professional and consumer-grade products coming out every day. We decided to use this opportunity to perform our own data collection, and then used this data to compare several emerging drone data processing software products on the market. For each of these software products, we focused on weighing the pros and cons of their feature sets, along with conducting a rough accuracy assessment for each.

Ground control point (GCP) collection

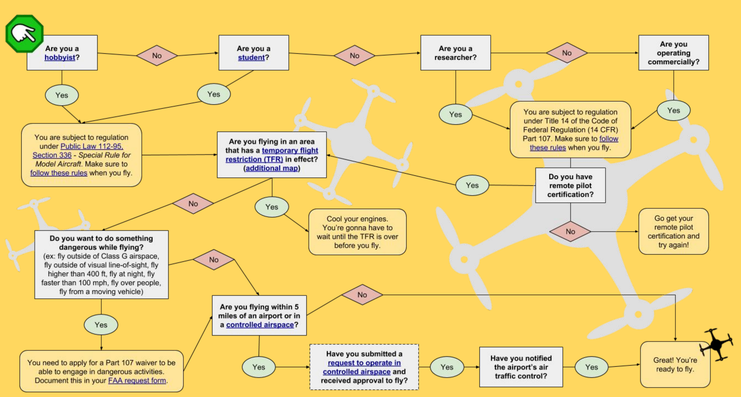


We laid out 2' x 2' black-and-white checkered targets with roughly even spacing throughout the study site. We then surveyed the location of each of these targets using a survey-grade, real-time kinematic (RTK) GPS unit. Using a wifi hotspot, we connected to the MNDOT base station, so we received real-time corrections on all survey points without having to set up a base station or post-process our GPS data. Surveyed coordinates were captured in NAD 83, corresponding to the datum used by the MNDOT base station.

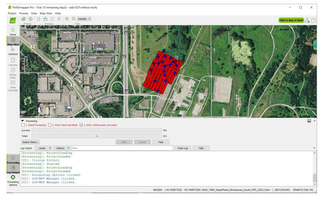
UAS data collection

For 2D mapping and 3D model reconstruction, we collected a total of 414 geotagged images using a DJI Phantom 4 UAS and the Pix4DCapture app installed on an iPad connected to the UAS's remote control unit. We flew at a height of approximately 170 ft, as this allowed us to clear trees and other obstructions while also collecting the highest resolution imagery feasible on limited battery life. It was also well under the flight height restrictions in effect for the area.

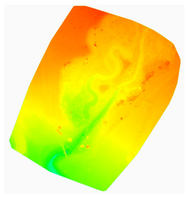
FAA REGULATIONS



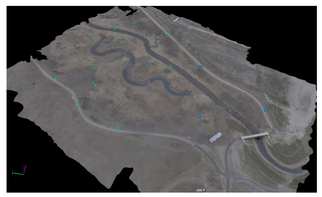
Pix4D - Desktop High Performance Platform



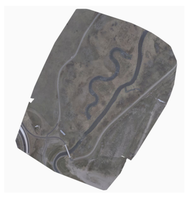
Captured Points and GCPs



DEM Product



3D Model with GCP Rectification

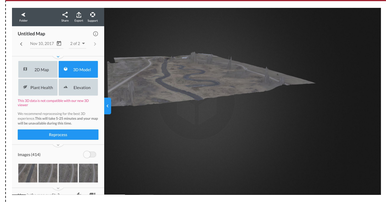


Orthophoto Product

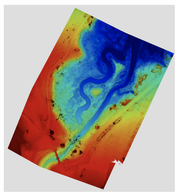
We would recommend this software if a project has enough budget to commit to purchasing the software, along with higher-end hardware. Pix4d is particularly **good for users who need a highly customizable and highly accurate UAS map**. Because Pix4D offers a self-contained desktop processing software option, it may also be useful for mapping projects that involve field work with limited internet access or sensitive data that is not appropriate for cloud processing and storage. In addition, Pix4Dmapper also contains volumetric measurement and surface classification functions that may be helpful for specialized use cases. Among all three types of platform we have tired, Pix4Dmapper is the only one where we applied GCP rectification, resulting in relatively high accuracy results.

	RMSE (in ft)
Center control points	0.929
Edge control points	1.309
All control points	1.135

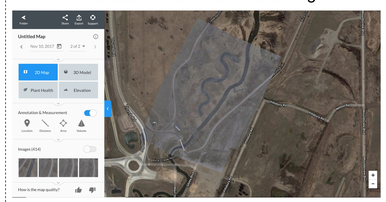
Drone Deploy - Cloud-Based Processing Platform



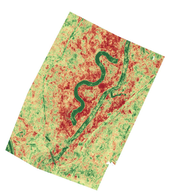
Interface with 3D Model Showing



DEM Product



Interface with 2D Model Showing

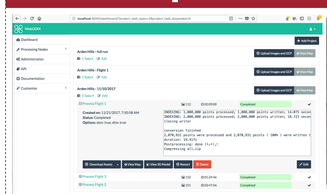


NDVI Product

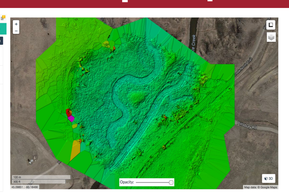
We would recommend this service for projects that don't require centimeter or millimeter accuracy, and for users who don't have or need much knowledge or control over what goes in between the image upload and final product. This tool also doesn't require the user to have access to high-end hardware to perform data processing. If the user wants to avoid paying for the premium service, the resulting products from the software need to be georeferenced to surveyed GCPs by hand using ArcGIS or another tool with georeferencing capabilities. The other drawback of using this software is that **many of the reliable/workable product formats cannot be accessed by the free trial user.**

	RMSE (in ft)
Center control points	10.379
Edge control points	10.430
All control points	10.405

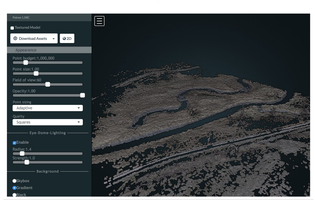
Open Drone Map - Open Source Platform



Processing Interface



DEM Product



Display Interface

Orthophoto Product

We would recommend this software for use on **low-stakes or experimental projects**, where the purpose is to obtain a low-cost introduction to drone imagery processing. For example, this could be a great product for educational organizations on tight budgets, and could be an approachable teaching tool. OpenDroneMap could be deployed on an in-house server and essentially act as an in-house cloud processing tool with an end-user experience that would likely feel somewhat similar to Drone Deploy's cloud environment. OpenDroneMap could thus be a great fit for small-scale projects, and projects with data privacy constraints that would be inappropriate to send to a cloud provider for processing.

	RMSE (in ft)
Center control points	6.126
Edge control points	9.759
All control points	8.147

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COMPARISON

	Pix4D	Drone Deploy	Open Drone Map
Type(s) of software	• Collection app to manage data collection missions • High-end image processing software that can run locally (offline) • Cloud-based processing also available	• Collection app to manage data collection missions • Cloud-based processing	• Open source image processing software that can run locally (offline) via command line • Web app UI available that can be run locally on a laptop via Docker or installed on a server
Cost	15-day free trial $3,500 USD per year	Free (limited features) $99 - $299 USD per month (full features)	Free
Processing time	Initial processing: 16 min Point cloud densification: 1 hour 18 min 3D textured mesh generation: 1 hour 30 min DSM generation: 50 min Orthomosaic generation: 52 min DTM generation: 14 min **Total:** 5 hrs **Hardware used:** Windows 2.80GHz Intel i7-7700HQ 8GB RAM	Uploading time: 2-3 hrs Processing time: 5 hrs	Flight 1: 2 hours 9 min Flight 2: 2 hours 47 min Flight 3: 1 hour 24 min **Total:** 6 hours 20 min **Hardware used:** Mac 2.9 GHz Intel Core i5 8GB RAM
Pros	• Allows manual rectification using GCPs • Detailed accuracy report is provided • Output is customizable in terms of content, resolution, format • Process comprises three steps, which can be executed separately	• Processing is cloud based and can work on any kind of system. • Can use the time for other part of project since we don't have much to do after uploading the images.	• Very user-friendly for an open-source project. Much of that seems to be thanks to Docker, which automates a lot of the installation and setup tasks. • Nice web-based user interface that allows user to view final 2D and 3D products in a web browser
Cons	• License is expensive • Relies on heavy computational power	• "Add GCP" is disabled for free users • False NDVI • All the images need to be uploaded to the cloud which does consume a lot of time • Post processing the outputs requires some knowledge of raster tools	• Relies on heavy computational power; errors out if processor and RAM aren't sufficient • No collection app available, but it looks like this is on the project roadmap

LESSONS LEARNED

- Drone **battery life** can be critical to the success of a project. Be careful on cold and windy days! You may need access to extra batteries that results in breaking your flight into several segments to capture the target area.
- FAA regulations require the UAS to be within **line of sight** from the pilot at all times. Plan your flight so that you can stand in the middle of the capture area to maintain better line of sight.
- **Altitude detection** in DJI drones seems to have some glitches (geoid and ellipsoid); it is best to use ground control points to register the location of final data products to correct for any confusion in altitude.
- Process all captured images together in **one workflow**. Do not break images into separate processing chunks, because this can lead to discrepancies and mismatches at the boundaries of the final processed products.
- During data processing it is important to **understand the effects that datum choices may have** on the final data product. We encountered consistent distance offsets in the orthomosaics from DroneDeploy and OpenDroneMap when comparing the final products to our ground control points. This may be due to datum discrepancies between the UAS's GPS, which captured coordinates in WGS84, and our survey GPS unit, which captured coordinates in NAD83.