UAV/S in GIS

Brookhaven College
1st Flight Operation &
Evolving Plans

Summer and Fall 2016

Can we fly the campus?

- July 2016 Used COTS $2000 UAS
  - DJI Phantom 3 Pro
  - 12 mp camera
- This is turn-key; everything is integrated
  - Sensor and lens
  - Gimbal and mount
  - Flight control and positioning
  - Remote Control

Resources Needed

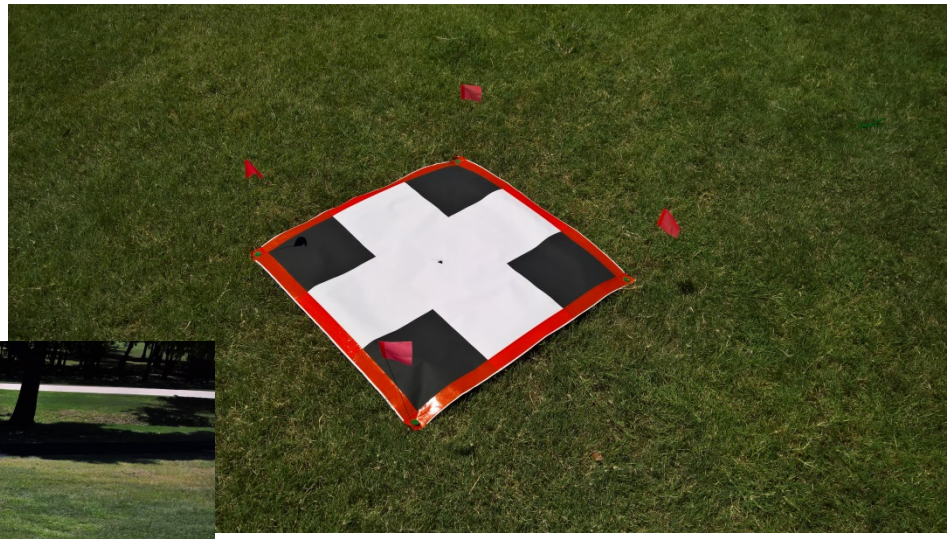
- To Fly
  - Aviation Consultant (licensed pilot, liaison to local controllers/airports)
  - UAS
  - Mission Planning app
  - Viewing device (tablet)
- To have accuracy
  - AOI with group control points
- To result in useful data
  - Solid computing capability
  - Image Processing capability

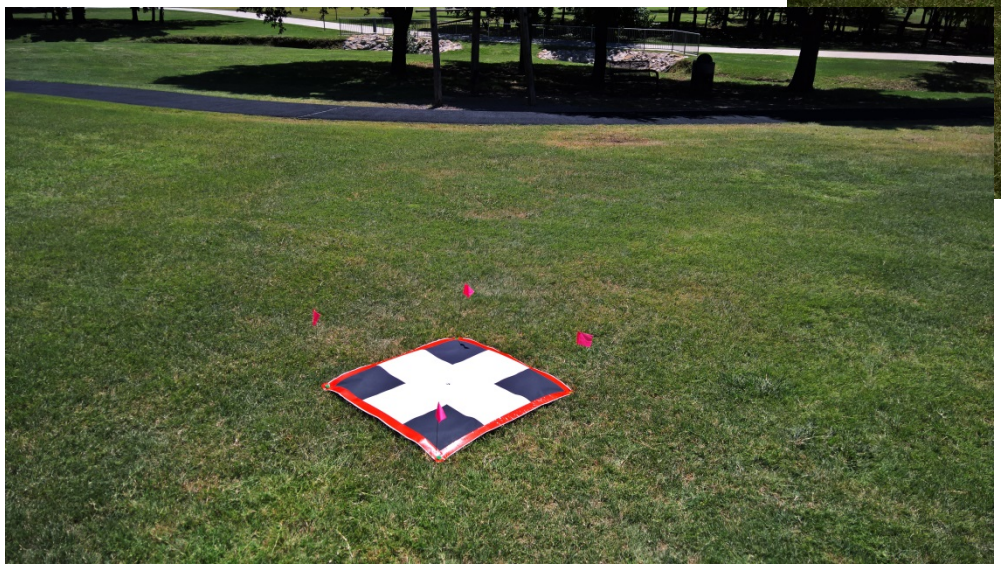
How we spent 3 days.

- Day 1 – Ground Control Points (GCPs)
  - Create the targets
  - Place the targets
  - Capture location coordinates for targets
- Day 2 – Flying and Photography
  - Visually plan the missions
  - Flight operations and team
- Day 3 – Processing imagery
  - Create data products

Targets are fast, easy and cheap

Sq. Meter
Reinforced Edges
Staked
Flagged
Coordinates Captured





Plotter
GPS

The GCPs

4 hours to plot and prep targets

8 hours to place and capture

1 hour to pick them up later

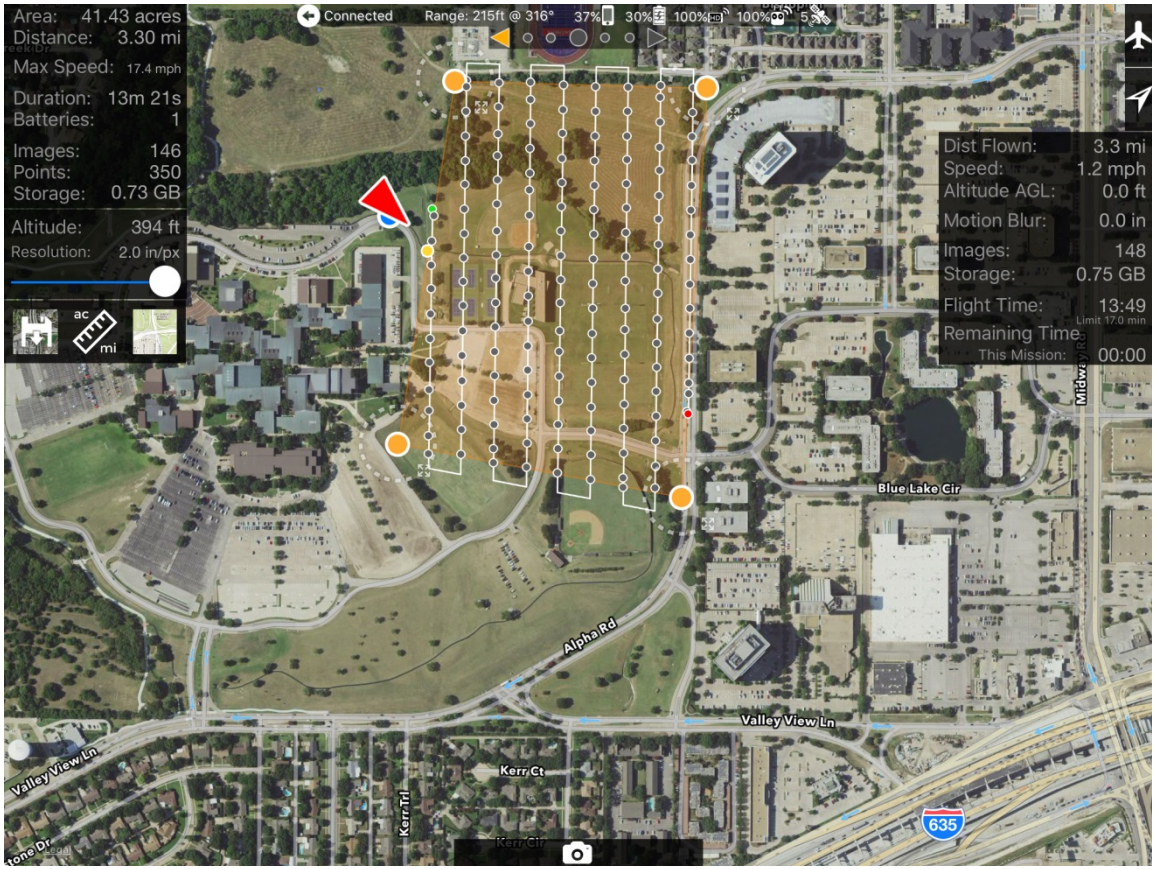
Mission Planning

Map Pilot for DJI $10 app on the Apple Store

Easy to use

Plan Flight area relative to telemetry

- Battery life,
- Elevation,
- Wind



The Actual Flight

1. Plan Mission / set the ‘fence’ (area of interest)
2. Check telemetry
3. UAS take off
4. Eyes on / monitor flight
5. Autonomous image capture
6. UAS returns to start / land
7. Replace battery & check equipment
8. Move to new location

Repeat it all

How did we cover the campus?

- 7 missions
- 400 feet elevation
- Yielded 650 images
- 5 member team
  - PIC – pilot in command
  - PAC – pilot at controls
  - VO – visual observer (3)

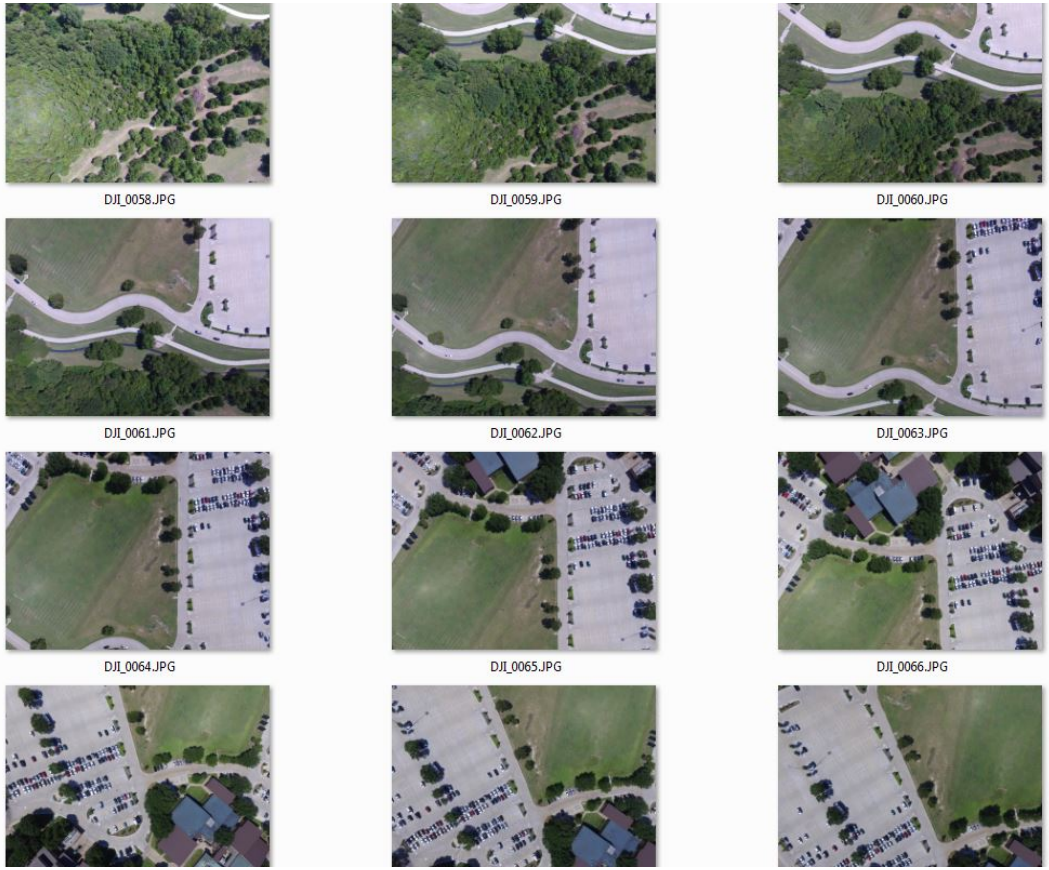
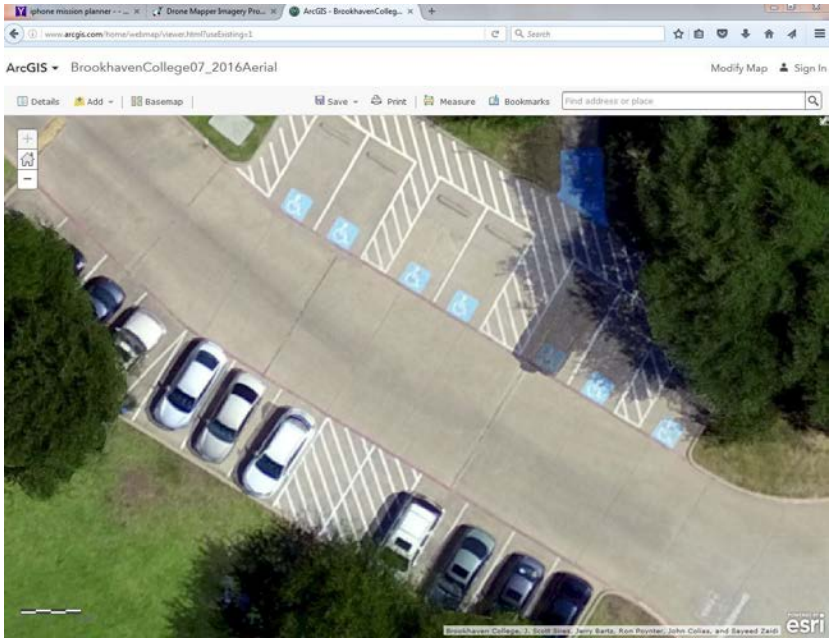


Image processing

- Esri's Drone2Map
- 3-hour process to stitch together 650 photos
- Result is a 192 acre orthomosaic
- 2.25" pixel resolution
- Search 'BHC UAV' in ArcGIS Online



Recent Changes / August 29, 2016

- Part 107 – Remote Pilot License
- Required for using drones in business
- Age 16 or above
- Drivers license
- Pass a TSA background
- Cost $150.00
- Pass an online knowledge test (40% pass rate)

New Operating Limits

- Must maintain line of sight
- Approval required to fly in any airspace other than class ‘G’
- Flight ceiling of 400’ above structure or terrain
- No flight at night
- No payload for delivery
- No operation from a moving vehicle

New Operating Limits (continued)

- License renewal every 24 months
- No operation of more than 1 drone
- No flight over people unless participating or under cover
- 55 lb. loaded weight limit

- Waivers available for most every limitation

Coming Soon from the FAA

- NEXTGEN airspace plan
- Defined drone air routes
- 2nd and 3rd tier license options

Next Steps at BHC

- DIY / BYO
  - Hexacopter (Fall 2016)
  - Marine vessel (Fall 2017)
- Active courses with UAS technology
- Small robotics (air, land and sea)
- Pre-engineering skills
- Spring 2017 Festival
- More course content throughout

Fall 2016 GIS Course

- Refining and Enhancing
  - COTS vs. BYO/DIY
  - SOP Development
  - Additional missions
  - Data Processing

$3000 BYO UAS

Function	Item No	Quantity	Unit Cost	Aggregate Price	Weight(g)
24 MP Sensor	SOA5100BK	1	$598.00	$598.00	399
Gimbal	Airy-LE-0203	1	$599.00	$599.00	550
Camera Trigger	Seagull #MAP2	1	$42.00	$42.00	12
Camera Cable	Seagull Sony S2	1	$16.00	$16.00	0
Frame	Flame Wheel 550 (F550)	1	$48.00	$48.00	478
Flight Controller	9387000081-0	1	$191.00	$191.00	312
2nd GPS (primary)	572000003-0	1	$30.00	$30.00	35
Motors x6	9536000005-0	8	$36.86	$294.88	558
ESC x6	DYS - XS30A	6	$16.99	$101.94	52
Pull Propeller	LP10047SF (APC 10x4.7)	2	$3.06	$6.12	36
Push Propeller	LP10047SFP (APC 10x4.7)	2	$3.06	$6.12	36
2.4ghz transmitter	Radiolink-Acc-AT9-R9D	1	$119.00	$119.00	0
Charger	UP120AC DUO AC/DC Charger - 120W	1	$99.00	$99.00	0
Landing Gear	PFG-CGCRLG	1	$200.00	$200.00	320
Battery	912700004-0	8	$43.68	$349.44	1286
Media card	IM1RR4698	2	$43.99	$87.98	0
				$2,788.48	4074

Student built UAV

Built by
Seth Bullis

Class-developed SOP

Standard Operating Procedure (SOP) for

Unmanned Aerial Vehicles / Systems in GIS

Objective/Explanation/Description/Notation:

A Real estate company can use UAV technology to survey land for real estate development. Here is a sample scenario that an investment partnership between GoodLife Real Estate Investors and BetterLife Development Co. LLC recently purchased a 250-acre land in Frisco for developing an amusement park. The company needs to survey the land at the beginning of development stage. Instead of conventional land survey, the company decided to use UAV for the survey to get more detailed geographic information of the land. This new technology also gives an edge on the time to finish the survey significantly.

How UAVs are changing the surveying industry - https://news.3dr.com/how-uavs-are-changing-the-surveying-industry-52845b90f66#.h0u24ur75

	Traditional Surveying	Aerial LiDAR	UAV/UAS
Accuracy	2 cm	4 cm	3 cm - 6 cm

Traditional Surveying has higher accuracy, and UAS has similar accuracy to LiDAR.

	Compare to Traditional Surveying	Compare to Aerial LiDAR
Cost Savings using UAS	30% - 75%	15% - 80%

The cost depends on specifics and size of the sites.

Comparing to traditional methods, UAV/UAS has the following advantages:

- Cheaper
- Similar Accuracy
- Faster Deliverable

Required Equipment ($2,000 budget):

- UAV - DJI Phantom 4
- RGB Camera - This UAV comes with the camera
- UAV Case (optional)

<Drone Comparison>

	DJI Phantom 3 Pro	DJI Phantom 4	Yuneec Q500 Typhoon	3DR Solo	3DR X8	Chroma with 4K
Price	$1,259	$1,429	$1,450	$800	$1,350	$1,200
Number of Rotor	4	8	4	4	8	4

Control System	Remote Control Phone/Tablet	Remote Control Phone/Tablet	Remote Control Phone/Tablet	Remote Control Phone/Tablet	Remote Control	Remote Control
Applications	Film & Photography	Film & Photography	Film & Photography	Film & Photography Surveying	Film & Photography	Film & Photography
Max flight time	23 min	25 min	25 min	25 min	15 min	30 min
Operating range	2,000 meters	5,000 meters	800 meters	500 meters	300 meters	n/a
Still Camera Resolution	12 megapixels	12 megapixels	12 megapixels	14 megapixels	doesn't come with camera	12 megapixels
Max video resolution	4k	4k	4k	1080		4k
Body color	White	White	Black	Black	Black	White
Max speed	16 m/s	20 m/s	8 m/s	15 m/s	30 m/s	n/a
Max flying altitude	6,000 meters	6,000 meters	122 meters	n/a	100 meters	n/a
Flight planning	Yes	Yes	No	Yes	Yes	No
Auto landing	Yes	Yes	Yes	Yes	Yes	Yes
Return to home	Yes	Yes	Yes	Yes	Yes	Yes
Collision avoidance	No	Yes	No	No	No	No

Reference: http://drones.specout.com/

Assembly:

If you decided to buy ready-to-use UAV (DJI Panthom 4 is optimal for the budget as mentioned above), you don't need assembling process any further. However, you will get much more options and cost savings if you select each part and assemble them by yourself. You can purchase most of the parts listed at www.hobbyking.com

- Parts List

1. The frame (body) - Quadcopter or Hexacopter
2. Motors
3. Propeller
4. Electronic Speed Control (ESC)
5. Battery - 5000mAh 11.1 volt 3 cell LiPo battery (30 minutes flight time)
6. Charger
7. Power distribution board (PDB) - PDB allows one battery to power all 4 motors at once.
8. Transmitter and receiver - At least 4 channels(throttle, yaw, pitch and roll) are required, and will need additional channel for autonomous functionality or control LED lights if you want to do.
9. Microprocessing board (flight control board) - This controls every function in the quadcopter from moving to staying stable while hovering.
10. GPS (GPS & GNSS)

11. Sensor
12. Gimbal
13. wire & connector

Flight Planning:

Manual control is generally more useful for inspections that need to react to information in real time, while autonomous control is more useful when one is trying to fly in a systematic pattern to create a map. To acquire good quality results, you have to consider the image overlap, flight height, resolution etc. As the drone flight planning software is developed, the flight planning gets much easier. It reduces ton of your times for calculating the flight route based on your expected quality of the result, and also it is considered safer. So in this project, I decided to use an autonomous flight software on the market.

	General rule of Image Overlap	
	Min.	Max.
Forward	75%	80%
Lateral	60%	80%

- Ground Control Points

GCPs are used for absolute position information. They are points of known coordinates in the area of interest, and will increase significantly the absolute accuracy of the outputs. The GCPs should be placed homogeneously in the area of interest, and 5 to 10 GCPs are usually enough because more GCPs do not contribute significantly to increasing the accuracy.

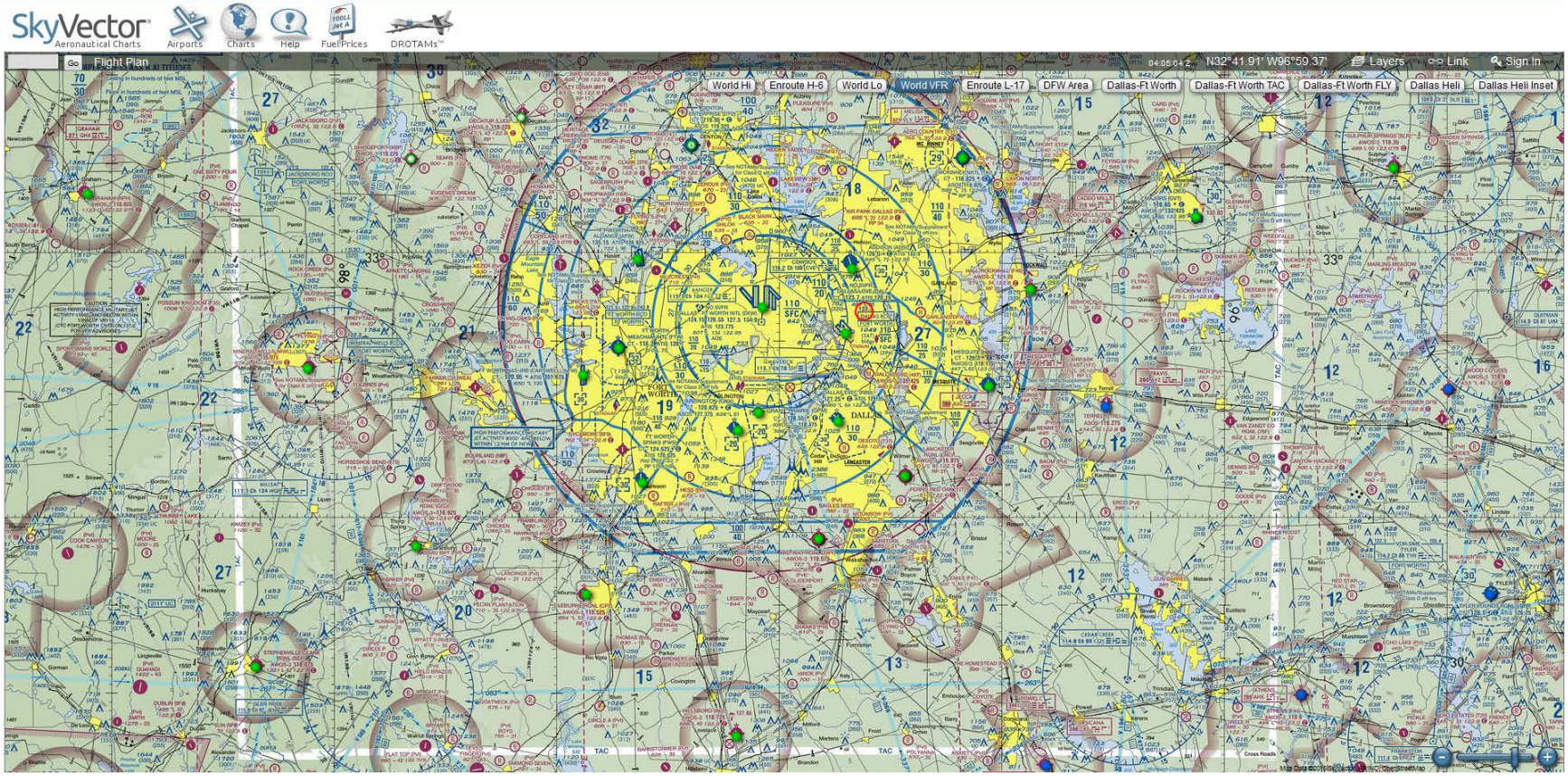
- Applications for autonomous control (Available at 'App Store', under $10)

- Android Apps: Data Mapper, Droid Planner, DroneDeploy
- iOS Apps: Skycatch Commander, DroneDeploy, Map Pilot from DronesMadeEasy

Post Capture Processing:

- Pix4D
- Esri Drone2Map - Data processed by Drone2Map can also be rendered in Esri's ArcGIS online web service and integrated into ArcGIS for further processing.
- 3DR Site Scan
- DroneMapper

Skyvector.com for planning



D2M

Experience reveals ease of use

Processing Report

esri

Generated with Drone2Map for ArcGIS

Summary

Project	BHC_DSM
Processed	2016-12-01 02:46:36
Average Ground Sampling Distance (GSD)	5.39 cm / 2.12 in
Area Covered	1.1022 km^2 / 110.224 ha / 0.4258 sq. mi. / 272.511 acres
Time for Initial Processing (without report)	06h:23m:06s

Quality Check

Images	median of 28479 keypoints per image	✓
Dataset	688 out of 691 images calibrated (99%), all images enabled	✓
Camera Optimization	0.4% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 8388.67 matches per calibrated image	✓
Georeferencing	yes, 2 GCPs (2 3D), mean RMS error = 19.218 m	⚠

Preview

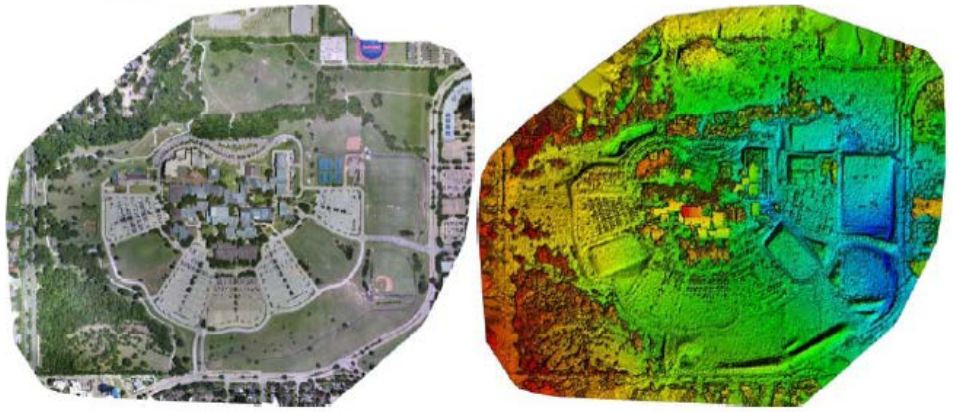


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Practice Datasets

https://www.sensefly.com/drones/example-datasets.html

https://cloud.pix4d.com/download/

Fall 2016 GISC1391 Special Topics in GIS (UAV and GIS)

Resources to get started

Find your own resources - Search online for 'ArcGIS UAV'

2014 article explaining the broad application of UAV in GIS.

http://www.esri.com/esri-news/arcuser/spring-2014/uav-and-gis-an-emerging-dynamic-duo

Some common initial questions:

https://geonet.esri.com/thread/162697#comment-580358

1) What are the requirements for the UAV camera and GPS/INS system?
2) What metadata is required to process still UAV images? Does it have to be FMV military standard?
3) Is the new application going to be integrated with Mosaic Dataset/ Image Service/ ArcGIS Desktop and ArcGIS Runtime?
4) Can I do the following with the new UAV mapping application?
    a. Create orthorectiefied image?
    b. Measure a height?
    c. Other functionalities?
5) According to the video, the point cloud can be produced from images. What is the output of the process? Is it LAS dataset? Is there any automatic algorithms for change detection and feature detection/others?
6) What are the time frames for the app release?

What's new regarding developing rules and regulations over the use of UAV?

http://geospatial-solutions.com/category/technology/uasuav/

How in-demand are UAVs in GIS?

http://mappingstats.maps.arcgis.com/apps/MapJournal/index.html?appid=a58b39a0b284418cb56e23f67f0fad6f#map

UAV flight planning tool

http://www.arcgis.com/apps/Viewer/index.html?appid=021e985e6e2d42a694db71ce4ba54312#!

DroneMapper solution

https://dronemapper.com/guidelines

DroneMapper examples

https://dronemapper.com/blog

More Examples, Uses and Case Studies

https://www.gislounge.com/using-unmanned-aerial-systems-uas-for-remote-sensing-of-archaeological-sites/

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Learn More:

This information (these links) found at: http://voices.nationalgeographic.com/2014/03/05/so-you-want-to-shoot-aerial-photography-using-drones/

Drone & Pilot sUAV Logbook

Kike Calvo´s Drone Collections

Drone / UAV Dictionary: Includes 300 Commercial UAV Applications

Cool stuff for Drone and Unmanned Vehicle enthusiasts

Drone Entrepreneurship: 30 Businesses You Can Start

Small Unmanned Aircraft: Theory and Practice

Introduction to Unmanned Systems: Air, Ground, Sea & Space

UAV Fundamentals Executive Course

How to Start an Unmanned Aircraft Vehicle (UAV) Business Course on DVD

Small UAV Construction

Getting Started with Hobby Quadcopters and Drones: Learn about, buy and fly these amazing aerial vehicles

Military Robots and Drones: A Reference Handbook (Contemporary World Issues)

The Media Source Presents Drones: Are They Watching You? Magazine

Introduction to Unmanned Aircraft Systems

Drone Pilot (Cool Careers)

Fly by Wire Aircraft: Fighters, Drones, and Airliners

Introduction to Remote Sensing, Fifth Edition

Build Your Own Drone

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Thank you

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