The Evolving Use of Drone Technology for Environmental Applications

City of Jacksonville Environmental Symposium

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Presentation Contents

- Federal Government Policy
- Flying small Unmanned Aircraft Systems (UAS) in National Air Space (NAS)
- UAS Environmental Applications

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Federal Government Policy

Congressional Directive

- **February 2012: Congress directed Federal Aviation Administration (FAA) to accelerate integration of small, civil Unmanned Aircraft Systems (UAS) into National Airspace (NAS) by September 2015 ***
  - Small UAS: < 55 lbs

- **Impediments to implementing directive** (GAO-12-889T; 7/2012)
  - No sense-and-avoid capability to detect other airborne platforms
  - Command and Control (C^2) vulnerability
  - Lack of technical operational standards
  - Lack of regulation to ensure safe integration into NAS
  - GPS spoofing and jamming
  - Privacy

* ***FAA Modernization and Reform Act 2012 (Public Law 112-95)***

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FAA Action Plan

- Issued “Integration of Civil UAS in the National Airspace System (NAS) Roadmap”, Feb 2013
- Issued “UAS Comprehensive Plan - A Report on the Nation’s UAS Path Forward”, Sep 2013
- Designated six sites to assess UAS technologies, Dec 2013
- Issued Notice of Proposed Rulemaking (NPRM), Feb 2015
- **Final rules issued in June 2016 (aka, Part 107)**

- Selected 10 projects nationwide, as part of Integration Pilot Program (IPP), Apr 2018
  - Lee County Mosquito Control District, Fort Myers will advance integration through development of low-altitude applications to mosquito populations

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Flying UAS in National Air Space

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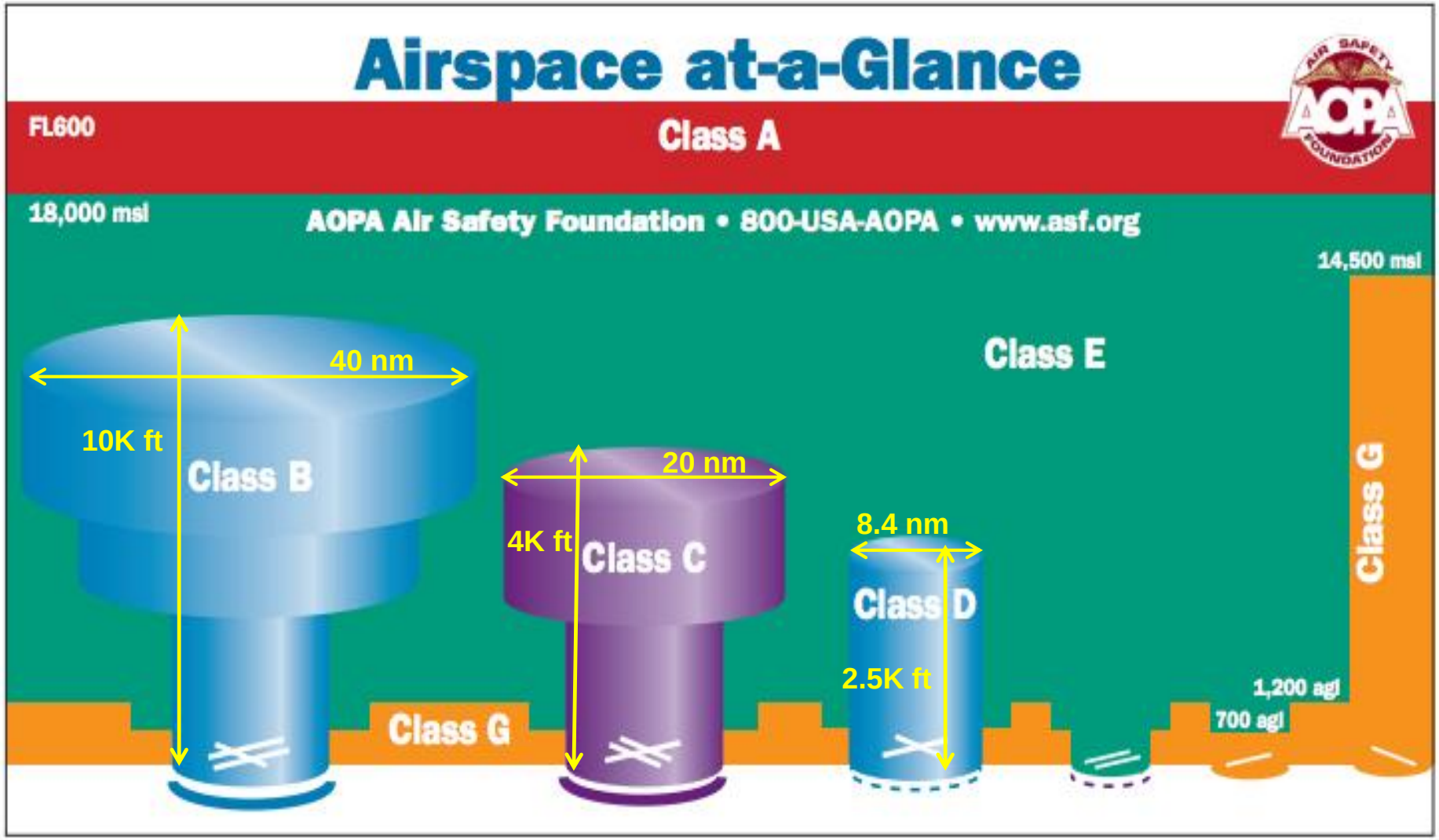
National Airspace



- Classes A, B, C, D, and E are controlled airspaces
- Class G is uncontrolled

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Flying UAS in NAS -- Commercial

FAA determines sUAS use on case-by-case basis issuing either certificate of authorization (COA), airworthiness certificate, Section 333 exemption, or now, Part 107

1. **Certificate of Waiver or Authorization (COA)**
   - Issued to Federal, State, and local Government agencies
   - Specifies times, location, and permissible flight operation

2. **Airworthiness Certificate – Experimental Category**
   - Issued to commercial companies operating UAS as part of business (e.g., Boeing)

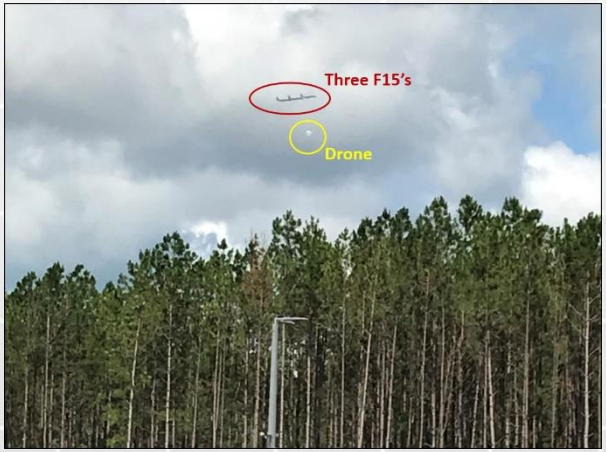
3. **Section 333 Exemption***
   - Operator petitions FAA for Section 333 Exemption
   - Like COA, requires manned flight training and visual observer

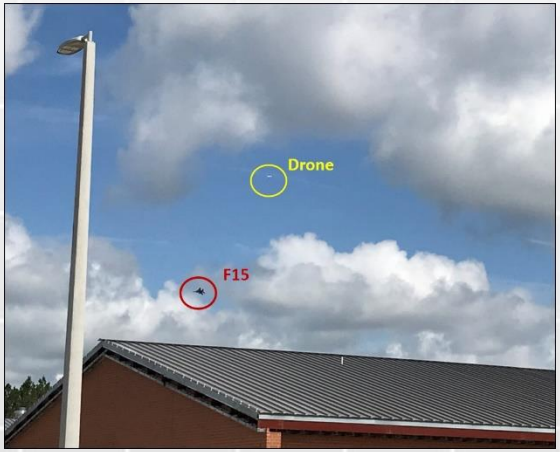
4. **Part 107**
   - Rule adds Part 107 to Title 14 Code of Federal Regulations (14 CFR)
   - Allows routine civil operation of small UAS in the NAS
   - Provides safety rules for those operations
   - Took effect 29 August 2016 (see Next Chart)

* Section 333 of Public Law 112-95 grants Secretary of Transportation authority to determine whether an airworthiness certificate is required for UAS to operate safely in NAS

Part 107 – Key Rules

- Requires Remote Pilot Certificate, contingent on the following:
  - Be at least 16 years old. Pass a three-hour aeronautical knowledge test at FAA Knowledge Test Center (Fee: $150). Certificate valid for two years.
- Maximum operating altitude 400 feet AGL, or 400 feet AGL from a structure (e.g. building, roof).
- UAV must weigh less than 55 pounds; fly less than 100 mph; Daylight-only operations
- Can’t fly over anyone who is not participating in the operation and not under a covered structure.
- Can pilot UAV from moving vehicle (except from another aircraft) in “sparsely populated” areas.
- Pilot must maintain VLOS (visual line of sight) of UAS at all times
- Operations in Class G airspace are allowed without air traffic control (ATC) permission. Operations in Class B, C, D and E airspace need ATC approval.





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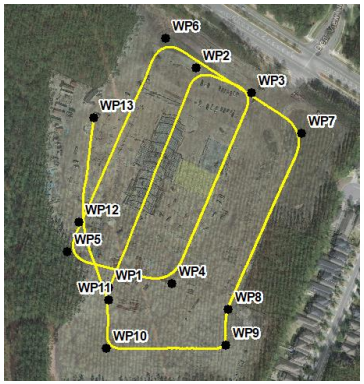
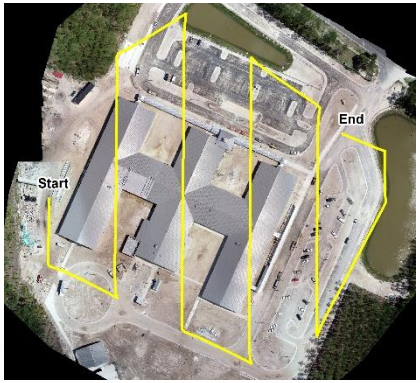
Benefits of Drone Aerials

- Ease of data acquisition
- Expedited data delivery
- Reduced cost compared to manned aerials
- Map difficult areas or small projects
- Ideal for dull, dirty, dangerous (D^3) jobs
  - Roof/powerline inspections, mining operations, HAZMAT incidents

Waypoint (WP) Route



Survey Grid



Manned

Drone

Small Project Site (0.3 acre)

Environmental Applications

Drone Environmental Applications

- Invasive plant & animal species monitoring
- Site surveys – 3D models, topography mapping
- Forest inventory
- Crop monitoring -- vegetation health
- Route planning for canals, pipelines, roads, powerlines
- Surface mining assessments
- Conservation easement & mitigation bank inspections
- Monitor prescribed burns
- Volumetric Calculations
- Hurricane/flooding damage assessment
- Waterway dye tracing
- Fauna/flora habitat mapping, identifying animal territories and ranges
- Thermal water plume detection
- Beach erosion, coastal monitoring
- Document construction progress

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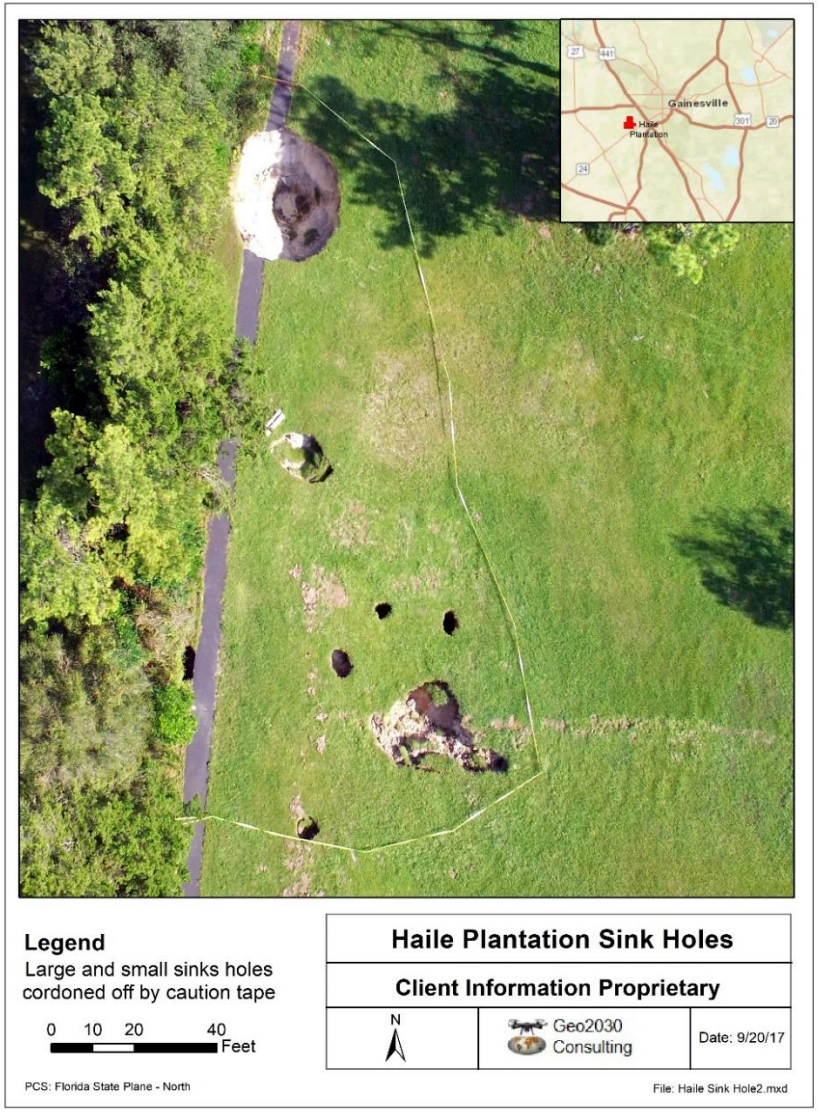
Environmental Applications

Sink Hole Volumetric Calculations

Sink Hole Volumetric Calculations

- Rains from Hurricane Irma caused several sink holes to open in subdivision SE of Gainesville
- 36 photos taken directly above largest sinkhole to compute its surface area and volume



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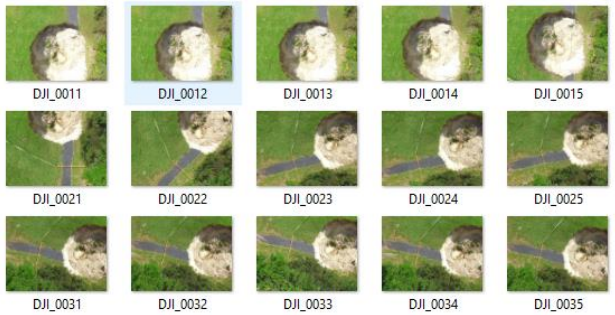
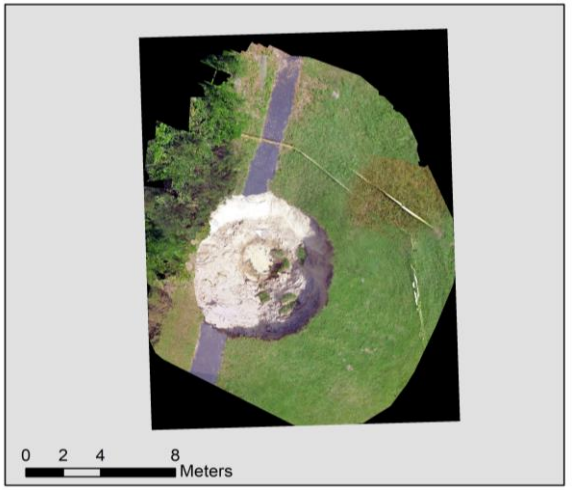
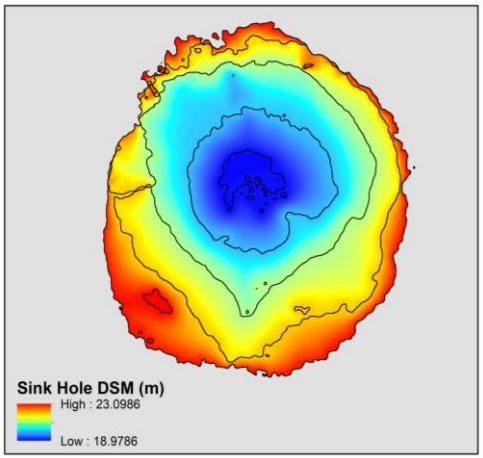
Sink Hole Photo Processing



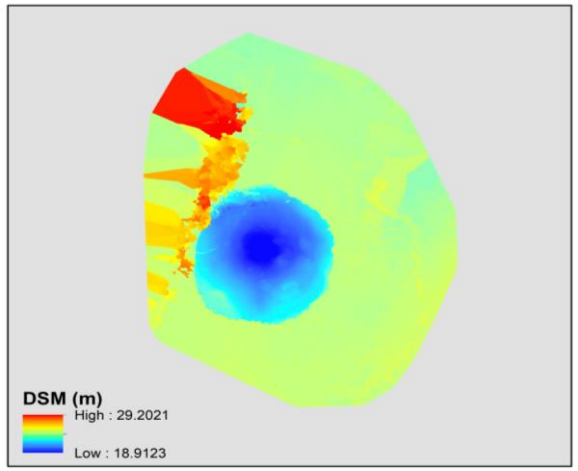


- Process 36 overlapping photos to yield orthomosaic, DSM, 3D point cloud, 3D textured mesh
- Import DSM into ArcGIS to perform volumetric calculations using assortment of spatial analysis tools
- Same methodology to calculate volume of aggregate stockpiles

Sink Hole DSM with 1-meter Contours



- **Surfaced Area Affected: 47.1 m^2**
- **Volume: 97.8 m^3**



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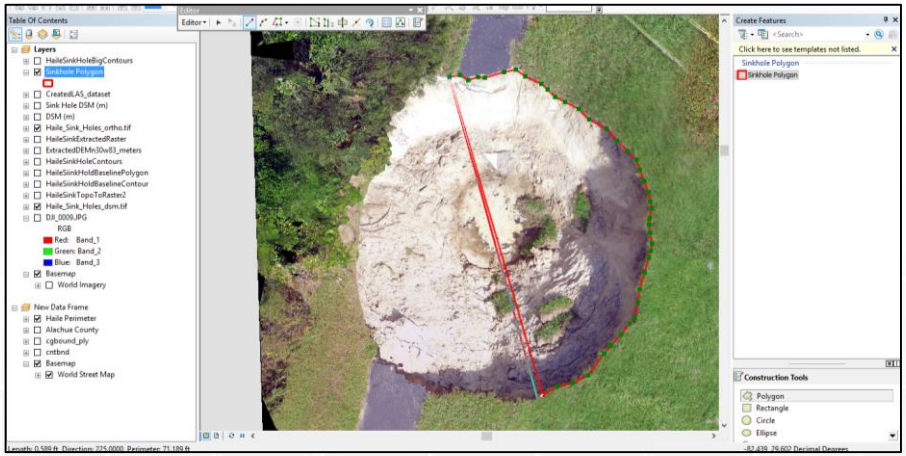
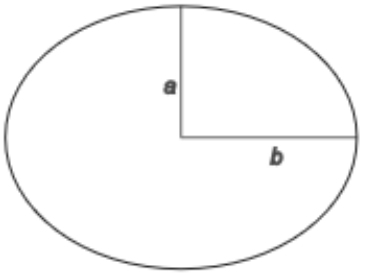
Validating Volumetric Calculations

Validating Surface Area (2 methods)

1. Digitize sink hole polygon feature in ArcGIS to render area attribute; result 49.3 m^2
2. Approximate 2D sink hole as regular ellipse



$$A = \pi ab$$

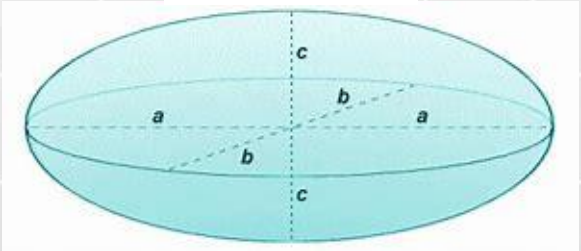


$$A = \pi(3.8)(4.1) = 48.95\ m^2$$

Validating Volume

1. Approximate 3D sink hole as bottom half of ellipsoid

$$V = \frac{4}{3}\pi abc$$



$$V = \tfrac{1}{2}\left(\frac{4}{3}\pi(3.8)(4.1)(4.0)\right) = 130\ m^3$$

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Sink Hole 3D Point Cloud

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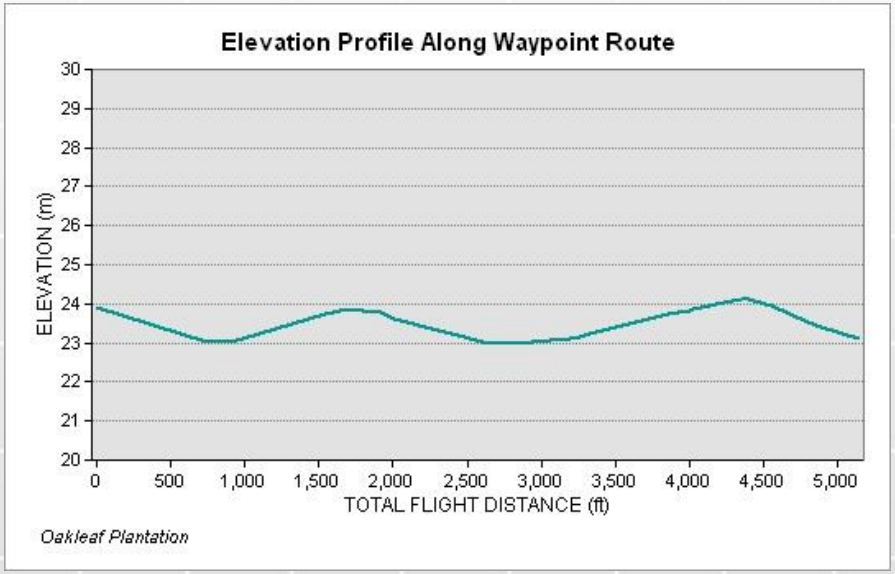
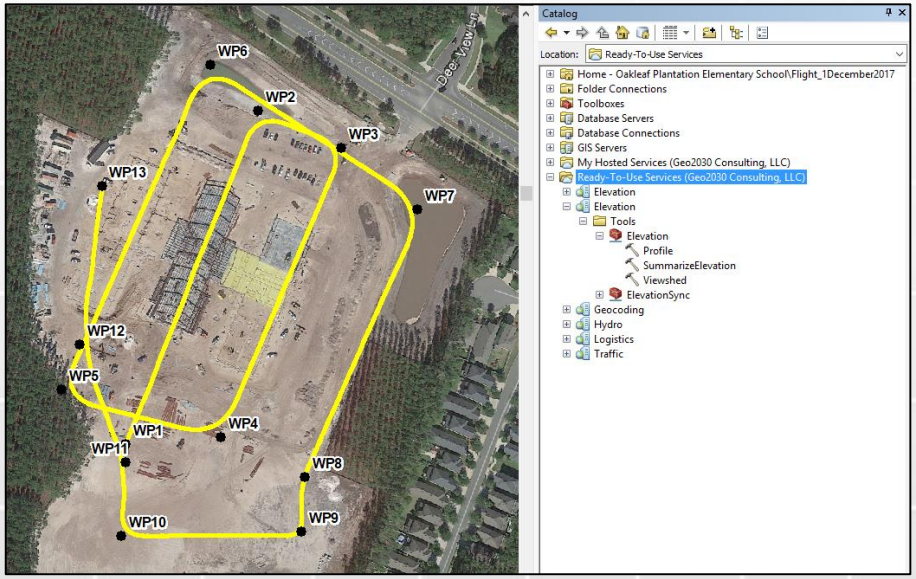
Environmental Applications

Elevation Profile Along Flight Path

Elevation Profile Along Flight Path

- Import drone flight data (lat/lon) into ArcGIS as *.csv file and save as Line feature class
- Log into ArcGIS Online and access ready-to-use service Elevation Profile tool
- Tool functionally-maps USGS 3DEP data to each lat/lon coordinate along flight path
- Select 3D Analyst → Profile Graph





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Validating Elevation Profile

1. Access USGS 3DEP 'Elevation Point Query Service'

USGS science for a changing world | The National Map — Your Source for Topographic Information

USGS Home | Contact USGS | Search USGS

The National Map - Elevation Point Query Service

The **Elevation Point Query Service** returns the elevation in international feet or meters for a specific latitude/longitude (NAD 1983) point from the USGS 3DEP 1/3 arc-second layer hosted at the NGTOC. If unable to find data at the requested point, this service returns -1000000. Input parameters: **x** (*longitude*), **y** (*latitude*), **units** (*Feet, Meters*), **output** (*XML, JSON*). Latitude and longitude must be specified in decimal degrees with southern latitudes and western longitudes represented as negative values. The 1/3 arc-second dataset covers nearly all the U.S. states and territories, though Alaska has only partial coverage. For additional information, such as for 3DEP metadata, projection, horizontal/vertical datum, and vertical accuracy, go to FAQs:

- https://www.usgs.gov/faqs/what-metadata-are-available-3dep-products
- https://www.usgs.gov/faqs/what-are-projection-horizontal-and-vertical-datum-units-and-resolution-3dep-standard-dems
- https://www.usgs.gov/faqs/what-vertical-accuracy-seamless-3dep-dems

Parameter	Value
X:	-81.843406
Y:	30.161052
Units	Meters
Output	XML

Get Elevation

```
- <USGS_Elevation_Point_Query_Service>
  - <Elevation_Query x="-81.843406" y="30.161052">
      <Data_Source>3DEP 1/3 arc-second</Data_Source>
      <Elevation>23.8</Elevation>
      <Units>Meters</Units>
    </Elevation_Query>
</USGS_Elevation_Point_Query_Service>
```

2. Corroborate with On-Site Survey

Surveyor indicated point elevation (MSL) = 77.78 ft (≈ 23.71 m)

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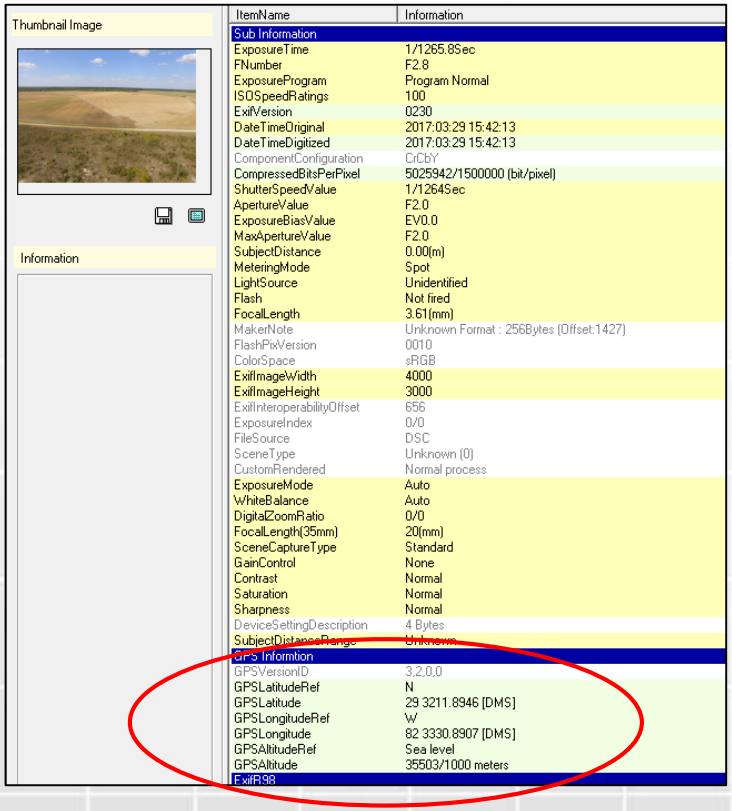
Environmental Applications

Video Flight Data Overlay

Video Flight Data Overlay



* Exchangeable Image File (EXIF)

- Drone photos store camera and GPS data in JPG file header (EXIF metadata*)
- Unlike drone photos, drone videos typically lack spatial information

Consequently…

- Video location and drone heading are indiscernible

Where is this flight?

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Video Flight Data Overlay (cont.)

- During post-flight processing, drone flight data (lat, lon, & heading) can be overlayed on video
- Provides often-beneficial georeference information when flying over large-acreage sites such as wetlands, conservation easements, timberlands, etc.

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Questions?

- **River Dye Tracing:** https://youtu.be/CsbyQmj0eb4
- **Monitoring Prescribed Burns:** https://youtu.be/rO0wxv0iu4M

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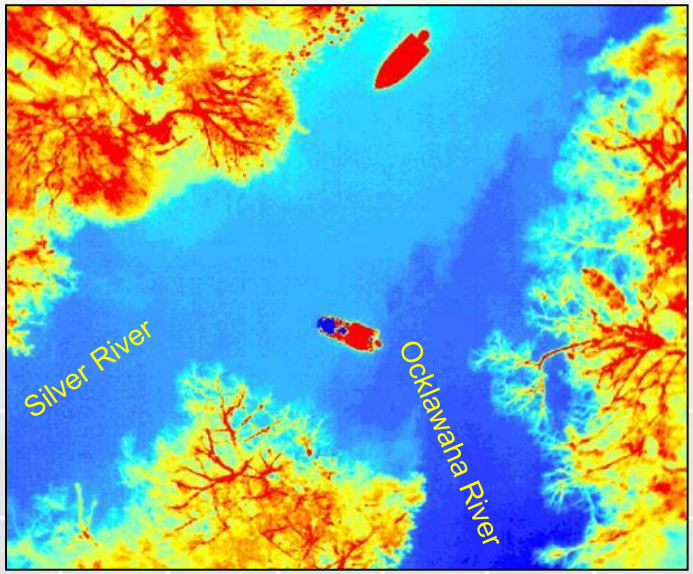
Thermal IR Camera

- Thermal (LWIR) cameras measure radiant surface temperatures
- Ideal for heat mapping applications:
  - Soil moisture
  - Geothermal detection
  - Wildlife inventory
  - Thermal water plumes (upwelling; ground water discharge)
- Image illustrates water temperatures at confluence of Ocklawaha and Silver Rivers*



* *Courtesy of SJRWMD*