UAS for Large Area Surveying and Site Assessments

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Es²

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Introduction

- Advances in Unmanned Aerial Systems (UAS) technology have provided the ability to accurately survey and assess large areas with high precision and detail.
- This presentation will discuss the utilization of UAS for large area solid waste management, site investigations, and assessments.
- UAS case studies will be presented for landfill topography and volumetrics, phase 2 site assessments, and wetland vegetation assessments.

About Es²

- Established in 1996
- Corporate headquarters in Denham Springs, LA
- Registered engineering firm in TX, LA, MS, FL
- Provide a wide range of environmental, engineering, and geospatial services for industry, government, and private sector clients
- Two Certified FAA Part 107 Small UAS Pilots on staff
- Certified SBE, DBE
  - SBA 8(a)
  - LA Hudson
  - LADOTD DBE

Andrew Milanes, PE, GISP

- President and founding partner of Es²
- BS in Civil Engineering – LSU (1992)
- MS in Geomatics Engineering & GIS – UC Denver (2022)
- Registered professional engineer (TX, LA, MS, AL, FL)
- Certified GIS Professional (GISP)
- Pix4D Certified (UAS photogrammetry software)
- 25+ years surveying, mapping, and photogrammetry experience

Small UAS Regulations

Small Unmanned Aircraft Regulations

- Regulated by the Federal Aviation Administration (FAA)
- Applicable to Aircraft Under 55 lbs (small UAS)
- Two Options to Legally Fly Small UAS by the FAA:
  - Special Rule for Model Aircraft (Section 336)
  - Small UAS Rule (Part 107), August 2016

FAA Small UAS Rule (Part 107)

- Fly for recreational OR commercial use
- Register your drone https://registermyuas.faa.gov
- Get a Remote Pilot Certificate from the FAA
- Fly a drone under 55 lbs.
- Fly within visual-line-of-sight*

* These rules are subject to waiver.

FAA Small UAS Rule (Part 107)

- Don't fly near other aircraft or over people*
- Don't fly in controlled airspace near airports without FAA permission*
- Fly only during daylight or civil twilight, at or below 400 feet*

* These rules are subject to waiver.

FAA Small UAS Rule (Part 107) Revised April 2021

- Allows for flights at night, over people, and moving vehicles
- Waiver not required
- Must meet specific conditions
- Provisions for Remote ID
  - Fully integrate UAS into the National Airspace System

FAA Small UAS Rule (Part 107) Revised April 2021 Operations Over People or Moving Vehicles

- Risk-based approach
- Small UAS divided into 4 categories
  - Category 1 – 0.55 lbs or less and no exposed rotating parts
  - Category 2 - >0.55 lbs, no exposed rotating parts that would lacerate human skin, and will not cause injury ≥11 foot-lbs of kinetic energy upon impact from a rigid object
  - Category 3 - >0.55 lbs, no exposed rotating parts that would lacerate human skin, and will not cause injury ≥25 foot-lbs of kinetic energy upon impact from a rigid object
  - Category 4 – does not meet requirements for 1-3; requires an FAA airworthiness certificate and flight manual

FAA Small UAS Rule (Part 107) Revised April 2021

Operations Over People				
	Category 1	Category 2	Category 3	Category 4
Directly Participating	Allowed	Allowed	Allowed[2]	Allowed
Not Directly Participating	Allowed[1]	Allowed[1]	Must be on Notice[2,3]	Operating Limitations

[1] Sustained flight over open-air assemblies prohibited, unless Remote ID compliant.
[2] Sustained flight over open-air assemblies prohibited.
[3] Transit only, no sustained flight for open or non-restricted access sites.

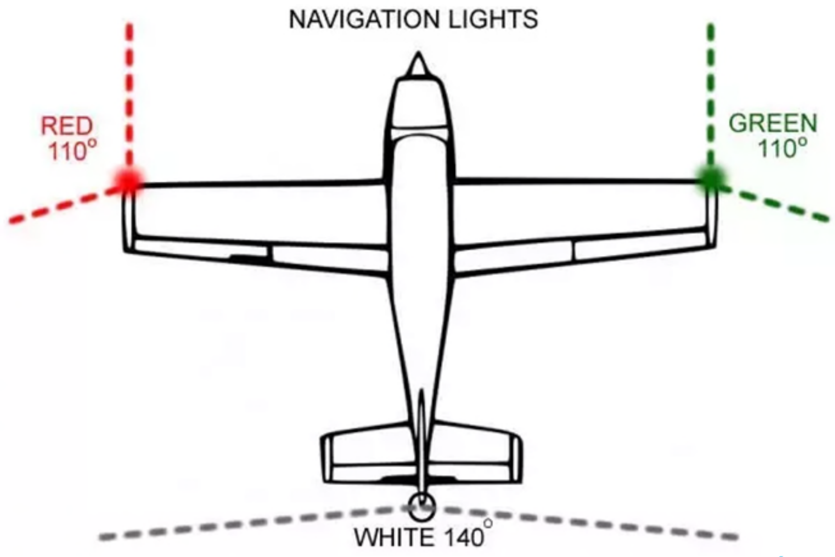
FAA Small UAS Rule (Part 107) Revised April 2021

Operations Over Moving Vehicles				
	Category 1	Category 2	Category 3	Category 4
Directly Participating	Allowed	Allowed	Allowed	Allowed
Not Directly Participating	Must be on Notice[1]	Must be on Notice[1]	Must be on Notice[1]	Operating Limitations

[1] Transit only, no sustained flight for open or non-restricted access sites.

FAA Small UAS Rule (Part 107)
Revised April 2021
Night Operations

- Small UAS must have anti-collision lighting
- Visible for at least 3 miles
- Flash rate to avoid collision



FAA Small UAS Rule (Part 107)
Revised April 2021
Remote ID

- Ability of a drone in flight to provide identification and location information
- Helps FAA, law enforcement, and other federal agencies locate the control station when a drone is flying in an unsafe manner or unauthorized location
- Drones without Remote ID will only be allowed to operate at FAA-recognized identification areas sponsored by community-based organizations or educational institutions.
- Compliance date: **September 16, 2023**

Don’t be this person:

UAS Mapping Engineering / Surveying Laws
Louisiana Professional Engineering and Land Surveying Board

- Surveying and mapping functions that must be performed by or under the responsible charge of either a professional engineer or professional land surveyor include:
  - Topographical surveys
  - Quantity and measurement surveys
  - Profiles and cross-sections
- Laws are the same no matter the data acquisition method

Types of Small UAS and Sensors

Types of Small UAS

- Multi-Rotor
  - 4 rotors (quadcopter) – most common
  - 6 rotors (hexacopter)
  - 8 rotors (octocopter)

Types of Small UAS

- Fixed-Wing
  - “Flying Wing” design
  - “Conventional Airframe” design

Types of Small UAS

- Vertical Take Off and Landing (VTOL)
  - Multi-rotor / fixed wing hybrid
  - Uses rotors for vertical take off and landing
  - Transitions to fixed-wing mode for flight
  - Tail Sitter or Tilt Rotor

Comparison of Small UAS Types

Type	Pro	Con
Multi-Rotor	Ease of use	Short flight times
	VTOL and hover flight	Slow speed
	Good camera control	Small area coverage
	Can operate in a confined area	
	Larger payload	
Fixed-Wing	Long endurance	Launch and recovery needs additional space
	Large area coverage	Harder to fly, more training needed
	Fast flight speed	Small payload
Fixed-Wing Hybrid	VTOL and hover flight	Not perfect at either hovering or forward flight
	Long endurance	Still in development
	Medium payload	

UAS Sensor Options

- Prosumer aircraft equipped with non-interchangeable camera system
- RGB sensor (up to 1”, 20MP)
- Fixed focal length lens (non-interchangeable)
- 3-axis stabilized gimbal
- Good for general photography

UAS Sensor Options

- Digital SLR
- Full-frame RGB sensor (up to 42MP)
- Fixed focal length lens (interchangeable)
- 3-axis stabilized gimbal
- Good for high-accuracy mapping

UAS Sensor Options

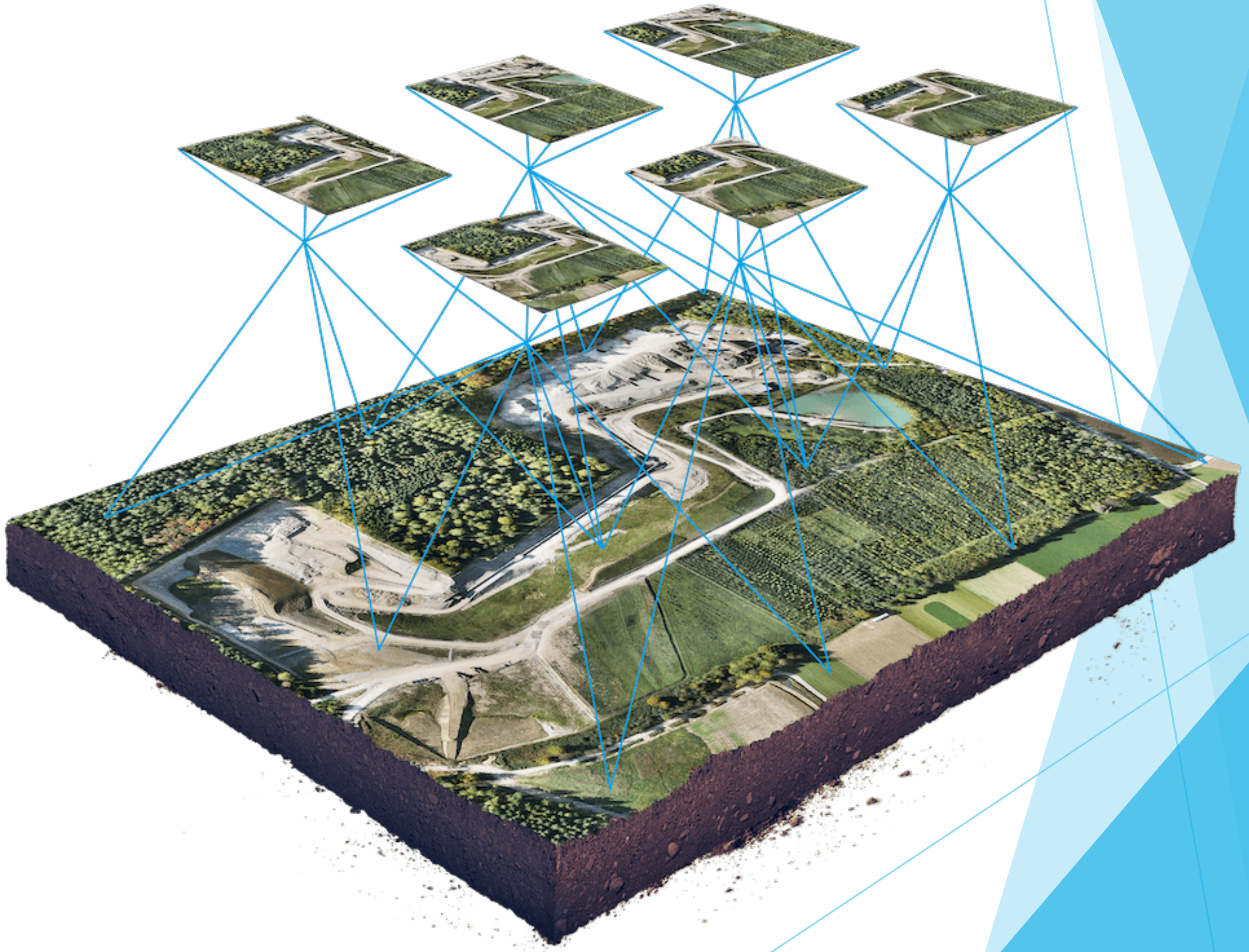
- Light Detection and Ranging (LiDAR)
- Detailed point cloud
- Captures fine details such as power lines
- Good for topographic mapping in vegetation

UAS Sensor Options

- Multispectral
- 5 Bands: Red, Green Blue, NIR, Red Edge
- Vegetation mapping
- Image classification
  - Land/water
  - Vegetation type
  - Vegetation health
- Calibrated sensors for repeatable results

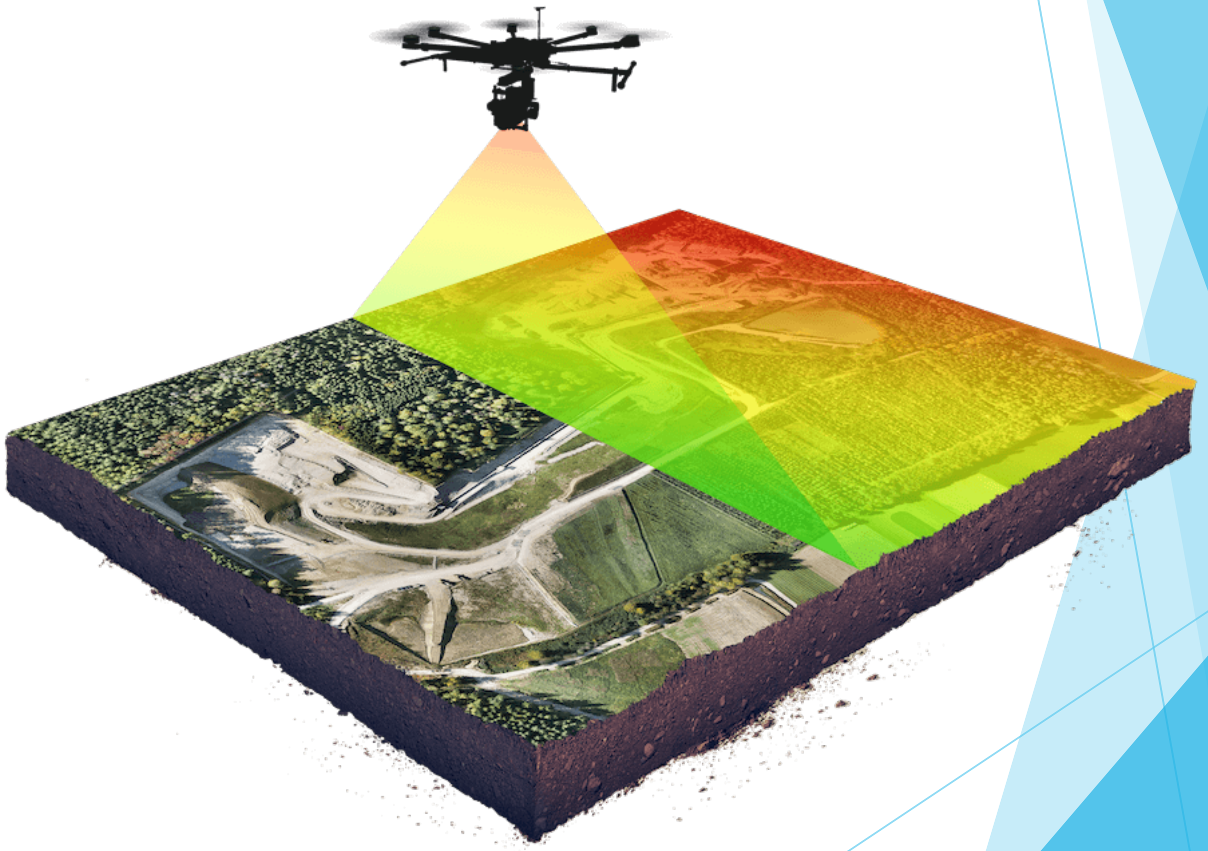
Photogrammetry vs LiDAR

- Photogrammetry:
  - Large number of high-resolution photos are captured over an area.
  - Images overlap such that the same point on the ground is visible in multiple photos and from different vantage points.
  - Photogrammetry uses these multiple vantage points in images to generate a 3D map.

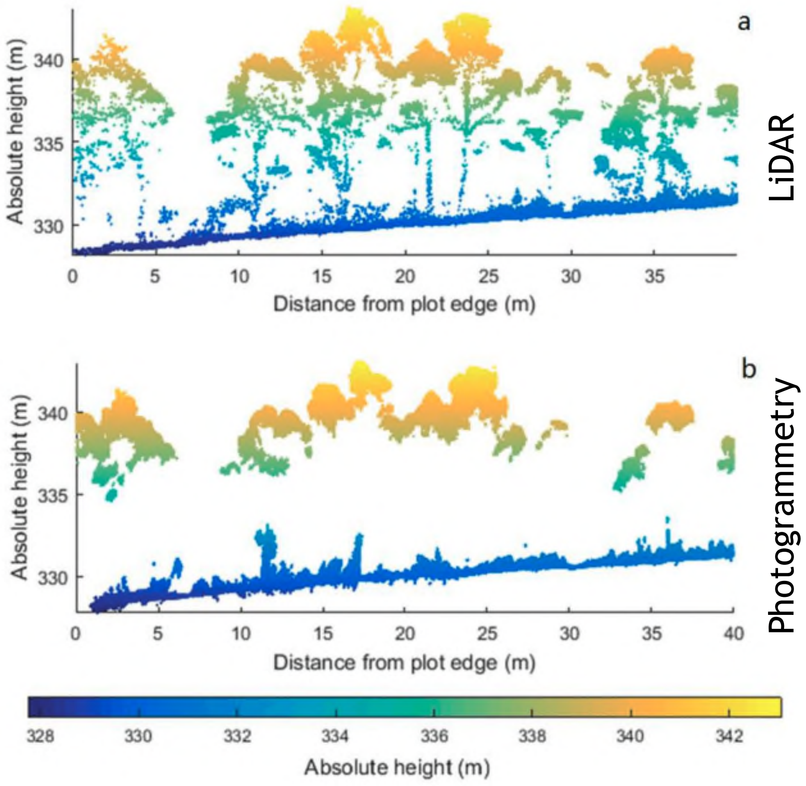


Photogrammetry vs LiDAR

- LiDAR:
  - Uses oscillating mirrors to send out laser pulses in many directions to generate a "sheet" of light as the drone moves forward.
  - Through measuring the timing and intensity of the returning pulses, it can provide readings of the terrain and of points on the ground.



Terrain Modeling Underneath Vegetation



- In some specific situations, a terrain model below vegetation is needed as an output.
- Photogrammetry can be used to effectively create 3D models in areas with sparse vegetation.
- Higher cost and complexity of LIDAR may be worth it when dealing with areas of relatively dense vegetation.
- LiDAR light pulses can filter through small openings between the leaves and reach the ground below.

Note: LIDAR pulses don't go through vegetation canopy; they go around it.
I.e., mapping terrain under very dense vegetation is still not possible, even with LIDAR.

Cost Factors

- Project size (acres)
  - Multi-rotor up to ~300 acres
- Vegetation present?
  - LiDAR required for bare ground of vegetated site
- Required accuracy
- Existing survey control monuments present?
- Deliverables
  - Raw data
  - Processed data
  - Web maps
  - Hardcopy prints

Additional Challenges for Large Projects

- Multiple takeoff/landing locations
- Maintain visual line of site of UAS
- Data storage
  - ~35gb per 100ac
- Processing time
- Computer hardware / software limitations
- Data dissemination

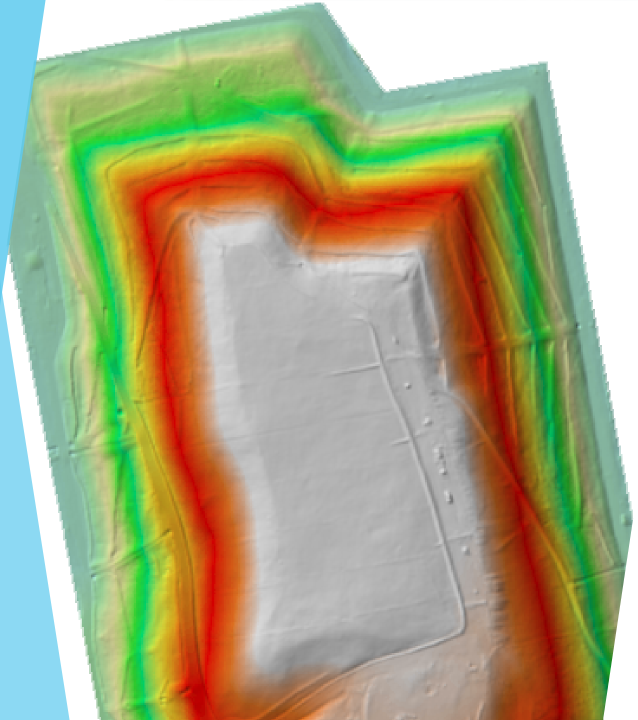
Case Studies

Case Study
Waste Management Woodside Landfill

- RDF disposal facility in Walker, LA
- Opened in 1987 with a projected life remaining of 36 years
- Facility acreage: 527 ac
- Topographic data obtained annually using manned aircraft photogrammetry
- Engineer needed more frequent data for air space calculations
- Flight area varied depending on need
  - Entire landfill
  - New cell construction
  - Hurricane debris green waste processing area

Case Study
Waste Management
Woodside Landfill

- Entire Landfill
  - Two flights
  - 400 feet above ground level
  - 3,500 images
  - 1.5 hours flight time
- WingtraOne UAS
  - VTOL tailsitter
  - Sony RX1RII 42mp DSLR camera
  - Ground sample distance – 0.05 feet
  - PPK GNSS



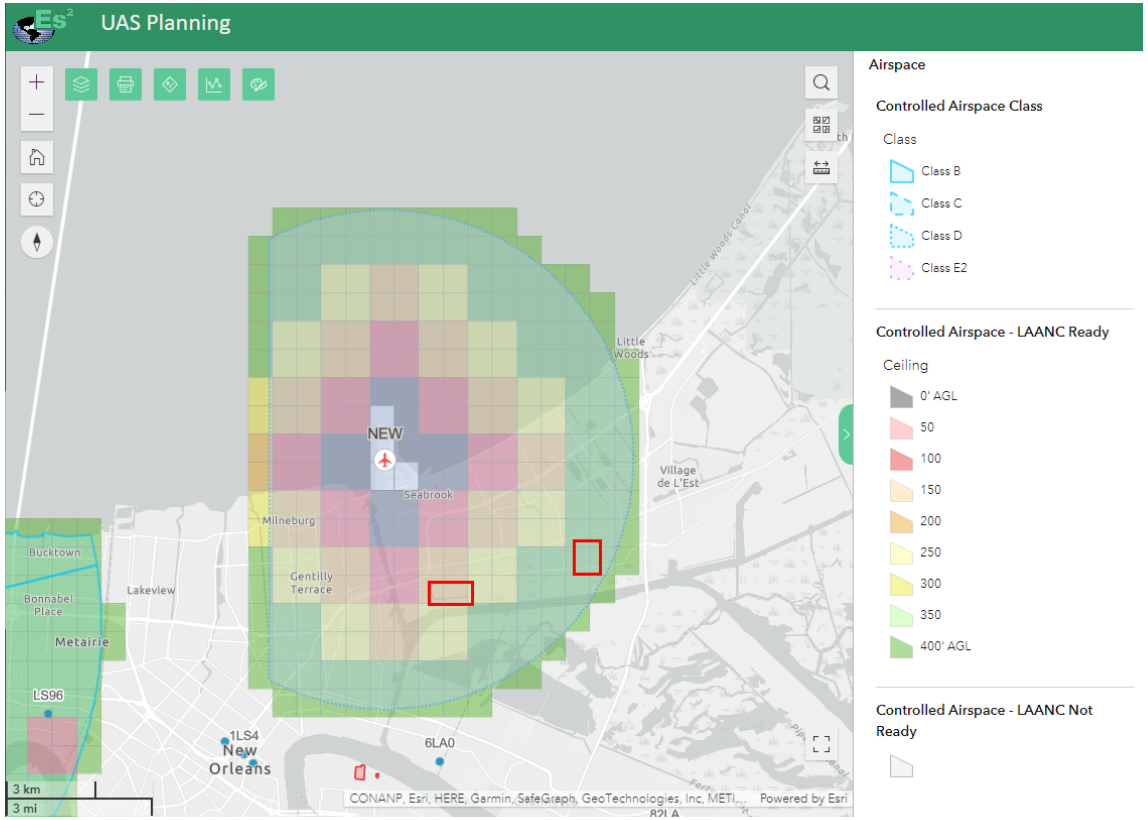
Case Study
Waste Management
Woodside Landfill

- 35 existing control monuments used as check points
- No additional ground surveying performed
- Pix4DMapper utilized for photogrammetry
  - Orthophoto mosaic
  - Digital terrain model
  - 3-inch contour lines
- Vertical Accuracy: 0.12 feet
- Data Delivery: 1 week
- Data also delivered via web application

Case Study
Site Assessments – Port of New Orleans

- Port NOLA contracted ERM to conduct site assessments
- Two properties located in New Orleans East
- ERM contracted Es^2 to conduct UAS flights to aid in the site assessments
- Properties were difficult to access on-foot
- Utilize UAS imagery for a first-look

Case Study
Port NOLA
Site Assessments

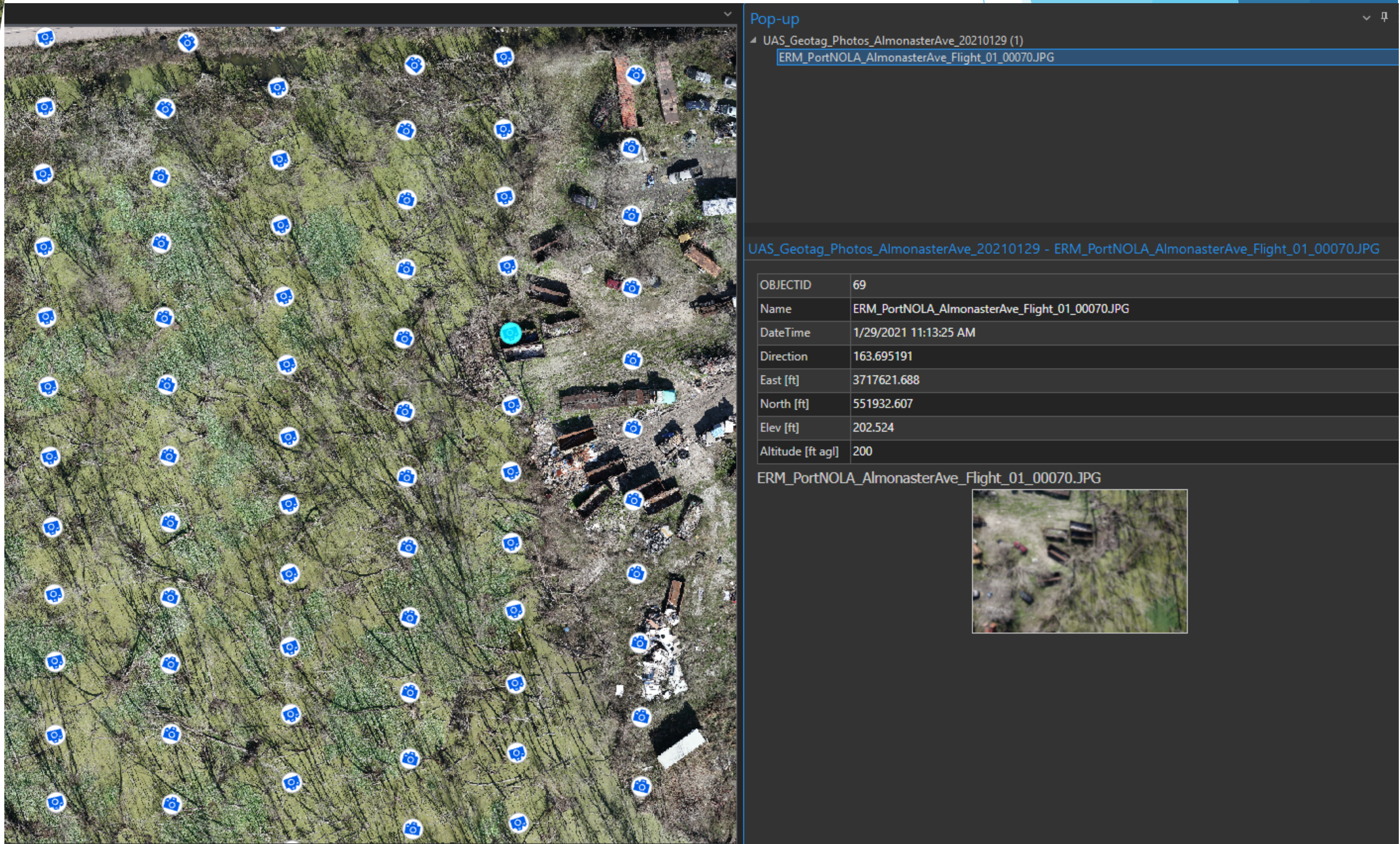


- Within Lakefront Airport Class D Airspace
- Restricted to 200 feet agl
- WingtraOne UAS
  - Sony RX1RII 42mp DSLR camera
  - 2,200 images

Case Study
Port NOLA
Site Assessments

- Pix4DMapper utilized for photogrammetry
  - Orthophoto mosaics
- Esri File Geodatabase with point layer of individual photo locations and link to image
- Data Delivery: 1 week

Case Study
Port NOLA Site Assessments



Case Study
Wetland Vegetation Assessment
Rockefeller Wildlife Refuge

- Marsh creation monitoring survey
- 107 acres
- Cameron Parish, LA
- Subcontractor to HDR
- UAS utilized to collect natural color and multispectral imagery for use in image classification

Case Study
Wetland Vegetation Assessment
Rockefeller Wildlife Refuge

- WingtraOne UAS
- Sony RX1RII 42mp DSLR camera
  - 400 ft agl
  - 0.6 in/px
- Micasense Altum multispectral sensor
  - RGB, NIR, RedEdge
  - 315 ft agl
  - 1.6 in/px

Case Study
Wetland Vegetation Assessment
Rockefeller Wildlife Refuge

- Ten ground control targets for check points
- Pix4DMapper utilized for photogrammetry
  - Natural color orthophoto mosaic
  - 5-band multispectral reflectance map
- Horizontal accuracy: 0.08 ft
- Data Delivery: 1 week

Case Study
Wetland Vegetation Assessment
Rockefeller Wildlife Refuge

Case Study
Wetland Vegetation Assessment
Rockefeller Wildlife Refuge

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