Drones, a New Tool for Chemical Engineering Applications

Mike Allison
Raptor Aerial Services LLC

South Texas Section of the AIChE
(American Institute of Chemical Engineers)

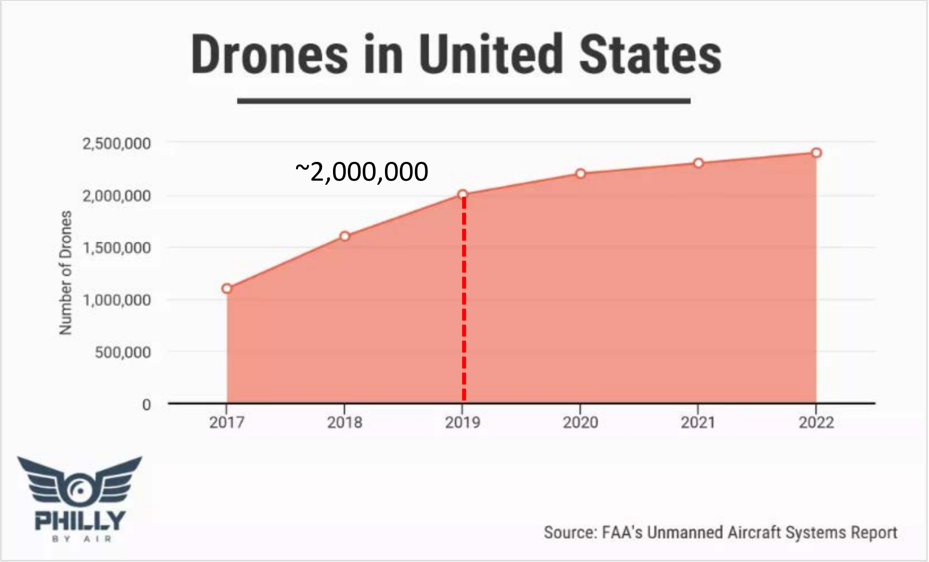
Dinner Meeting

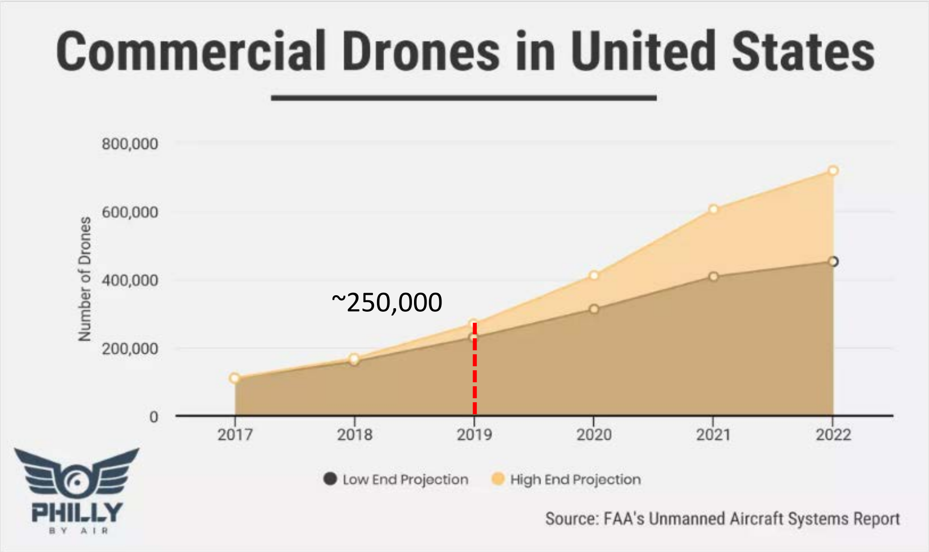
January 10, 2019

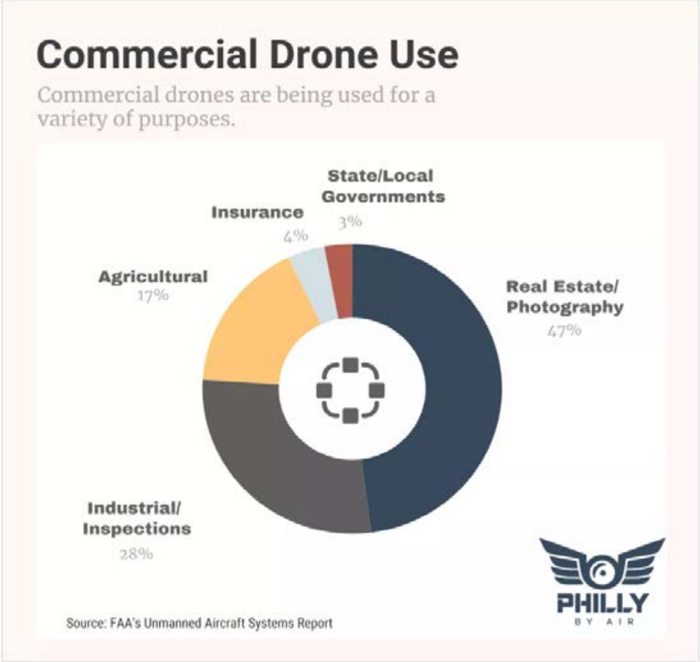
Presentation Outline

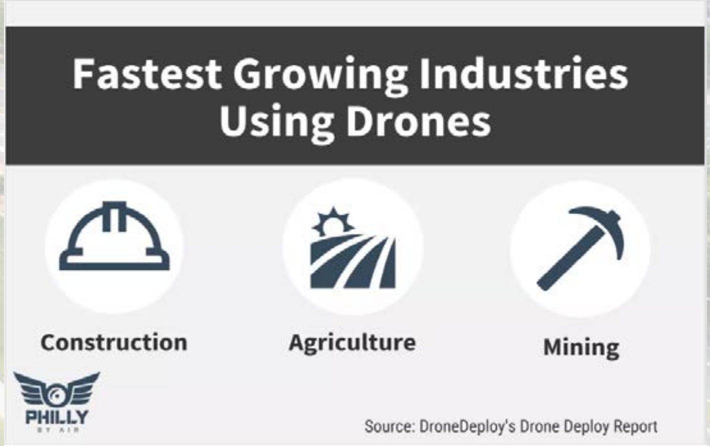
- Growth of the Drone Industry
- FAA Rules for Operating a sUAS
- Basic Components of a Drone System
- Types of Drones
- Drone Energy Sources
- Drone Sensors
- Software
- Ground Control Points (GCPs)
- Photogrammetry and Elevation Modelling
- Drone Aerial Survey Workflow
- Processing Imagery From Drones
- Examples of Aerial Survey Projects
- Inspection Drones
- Online Resources

Growth of the Drone Industry









FAA Rules for Operating a sUAS

Small UAS Rule (Part 107) Operating Rules

- Small Unmanned aircraft (sUAS) must weigh less than 55 pounds, including payload, at takeoff
- UAS must be registered with the FAA
- Operations in Class B, C, D and E (controlled) airspace are allowed with the required ATC permission. Operations in Class G airspace are allowed without ATC permission.*
- Keep the unmanned aircraft within visual line-of-sight (VLOS) ~ ½ mile*
- Fly at or below 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure*
- Fly during daylight or civil twilight with appropriate anti-collision lighting*
- Fly at or under 100 mph*
- Yield right of way to manned aircraft*
- Do not fly directly over people*
- Do not fly from a moving vehicle, unless in a sparsely populated area*
- FAA Reauthorization Act of 2018, became Public Law No. 115- 254 on October 5, 2018
    - o An aeronautical knowledge test and new requirements are in store for hobby flyers

*Exceptions may be approved by requesting a waiver

Basic Components of a Drone System

Drone with camera

SD Card to store Images/Videos

Phone/Tablet (Apps)

Controller

Rechargeable Batteries

Quadcopter Drones

DJI Phantom 4 Professional

Weight – 3.1 lbs (including battery and props)
Diagonal Size – 14 inches
Operating Frequency – 5.8 GHz
Max Operating Distance – 4 miles
Max Speed – 45 mph
Max Flight Time – 30 min (20 min)
Battery – LiPo 4S, 5870 mAh, 15.2V
Camera – Fixed, 1” CMOS Sensor, 20 MP

DJI Inspire 2

Weight – 7.58 lbs (including batteries and props)
Diagonal Size – 23.8 inches
Operating Frequency – 5.8 GHz
Max Operating Distance – 3.1 miles
Max Speed – 58 mph
Max Flight Time – 27 min
Battery – LiPo 6S, 4280 mAh, 22.8V
Camera – Zenmuse X4S, X5S & Sentera Double-4K

DJI Matrice 210

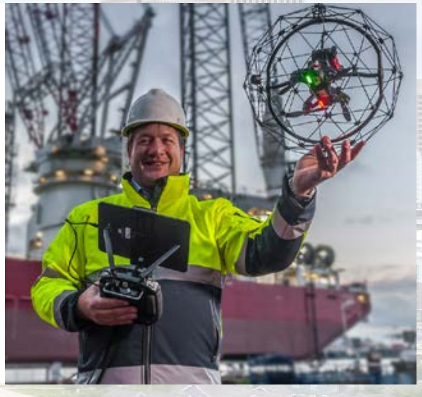
Weight – 11 lbs (including battery and props)
Dimensions – 34.9×34.6×16.1 inch
Operating Frequency – 2.4 GHz, 5.8 GHz
Max Operating Distance – 2-3 miles
Max Speed – 51 mph
Max Flight Time – 27 min (25 min)
Max Payload - ~3.5 lbs (1.6 kg) to 5 lbs (2.3 kg)
Battery – LiPo 6S, 7660 mAh, 22.8V
Camera – DJI Zenmuse X4S, X5S, Z30 and XTR
Operating Temperature - -4° to 113° F
IP Rating – IP43

Quadcopter Drones

DJI Wind 4

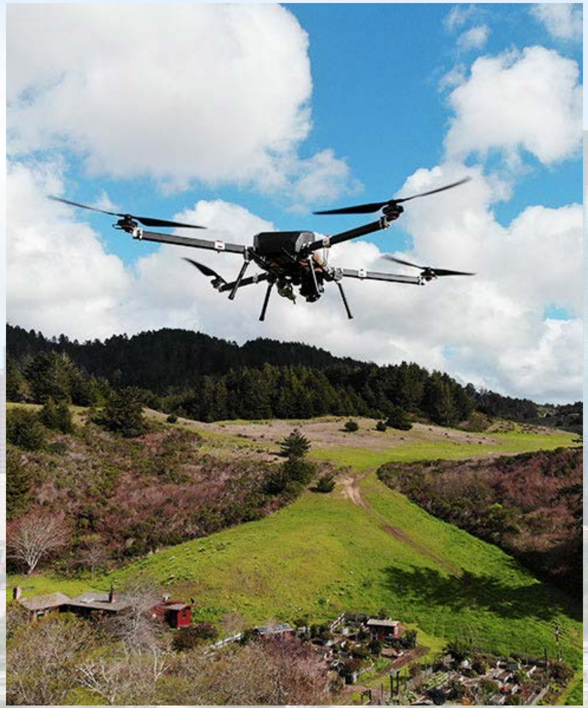
Weight – 24 lbs (including battery and props)
Dimensions – 42 inch diagonal length, 34 inches x 34 inches x 21 inches
Operating Frequency – 2.4 GHz, 5.8 GHz
Max Operating Distance – 2-3 miles
Max Speed – 40 mph
Max Payload – 22 lbs
Max Flight Time – 25 min with 9 lbs payload (with 2 DZ-12000mAh Batteries)
Battery – DZ-12000mAh
Camera – ZENMUSE X3/Z3/XT/X5/X5R/Z30
Operating Temperature 14° F to 122° F
IP Rating – IP56 Water and Dust Resistant

Other Types of Drones



Hybrid VTOL Fixed-Wing Drone

Drone Energy Sources



Hybrid Gas-Electric Multicopter Drone

THE PERIMETER DRONE

OPERATING SPECIFICATIONS	
Maximum Speed	36 mph (57 km/hr)
Cruise Ground Speed	22 mph (35 km/hr)
Maximum Endurance*	5+ hours without payload 2+ hours with 5.5 lb (2.5 kg) payload 1+ hour with 7.7 lb (3.5 kg) payload
Maximum Expected Range (at cruise speed)	No Payload – 110 miles (177 km) 5.5 lb (2.5 kg) payload – 70 miles (112 km)
Maximum Tested Wind Speeds	25 mph (35 km/hr)
Maximum Payload Capacity	8.8 lb (4 kg) (45 minute flight time)

Gas-Powered VTOL Drone

Our V2 airframe can travel nearly 500 kilometers on 3.8 liters (1 us gallon) in optimal weather conditions. This opens up its coverage area to nearly 5 times that of typical electric powered planes, dramatically increasing the number of people and places we can reach.

Drone Energy Sources

Solar-Power Fix Wing UAV

Types of Cameras/Sensors

Zenmuse X4S

Zenmuse X5S

Zenmuse Z30

Zenmuse XT2

Sentera Double 4K RGB/NDVI

Snoopy A-Series Scanner mounted on a DJI Matrice 200
- 100 meter max range (328 ft)
- 4-5 cm Accuracy
- Tactical grade L1/L2 IMU
- Weight: 1.63 kg (3.59 lbs)

LiDAR USA

M200 Series Snoopy LiDAR Package

FAST-LIGHT-ACCURATE

The M200 Snoopy Series LiDAR Package is designed specifically for the ever popular DJI M200/M210 UAV.
Custom designed for the Velodyne A-Series Scanner and weighing only 1.63kg, the M200 Snoopy Series is Light, Fast and Easy To Use. With deployment from an easy to carry case with just a click of a button on your smartphone you are ready to scan. The M200 Snoopy Series is a smaller, evolved version of our Snoopy system.
This unit is designed to be an affordable yet extremely accurate solution. Delivering improved performance with strong ROI results allowing its user to provide state of the art LiDAR solutions to their clients. Making it the
"WORLDS FIRST M200/M210 LiDAR System"

Specifications

System Accuracy: 4.6cm x y +/- @ 50m

- Weight: 1.63 kg
- LWH: 11.75 in x 4.375 x 3.5
- Weight Balanced

- Power Consumption: 25 Watts
- Voltage Input: 10-30 VDC
- 2250mah powers 30+ minutes

- INS Snoopy L1/L2 GPS+GLONASS

Velodyne VLP-16 or LITE
- 50 Points per square meter @ 50m AGL
- 300,000 points/sec
- 16 individual lasers
- +/-15 degree Vertical FOV
- 360 degree Horizontal FOV
- 100 m range (max AGL 60m)
- Single Antenna

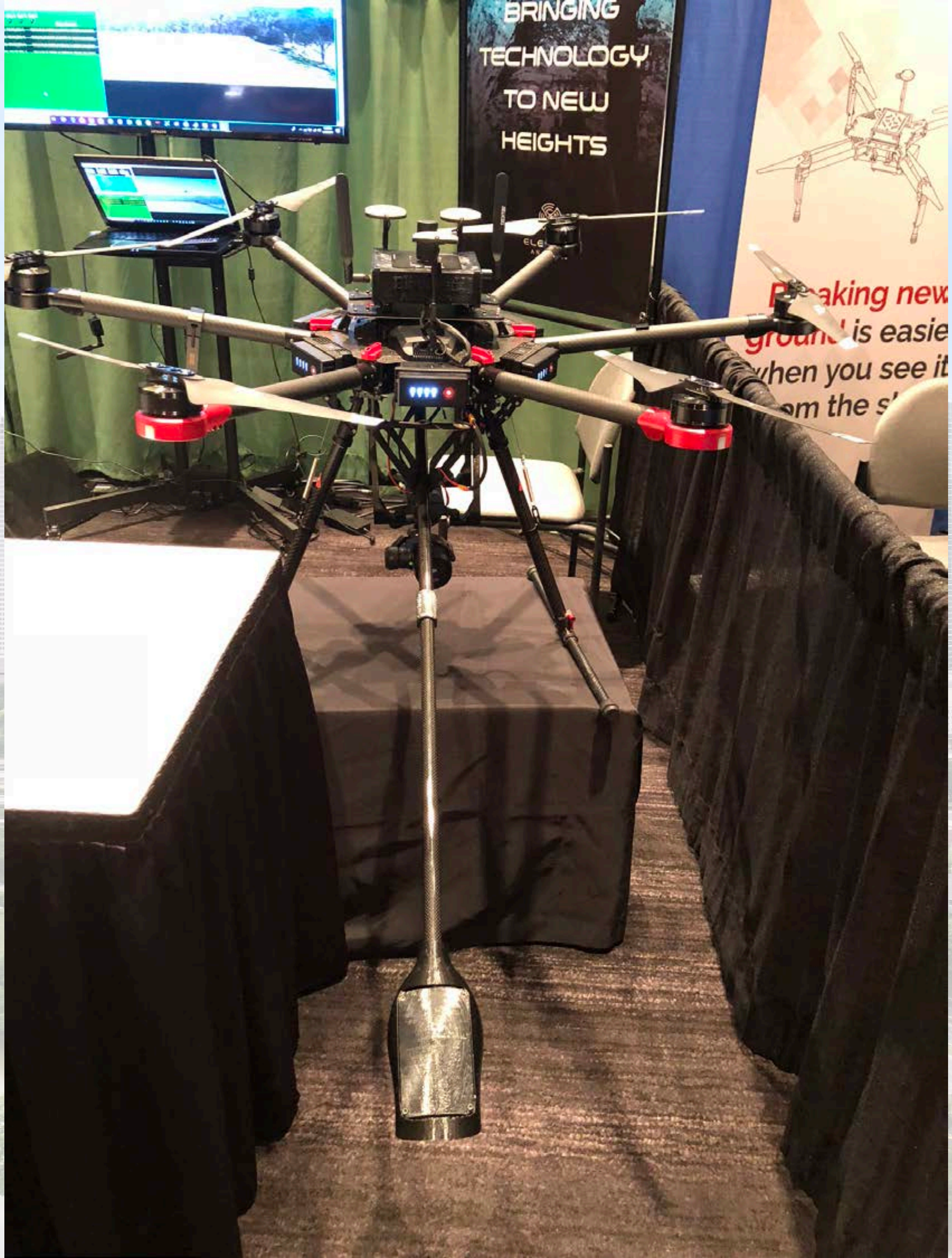
- Internal Storage: Lasts several days
- Virtually Unlimited Removal Storage

- Quick Release Mount
- Easy Transport
- Airline Friendly Transport

Software
- Supports All coordinate systems
- LAS/LAZ and other file format outputs
- Point cloud filtering
- Strip-to-Strip Matching
- Control point adjustment tool
- Easy to use size
- Classification

WE ARE LiDAR

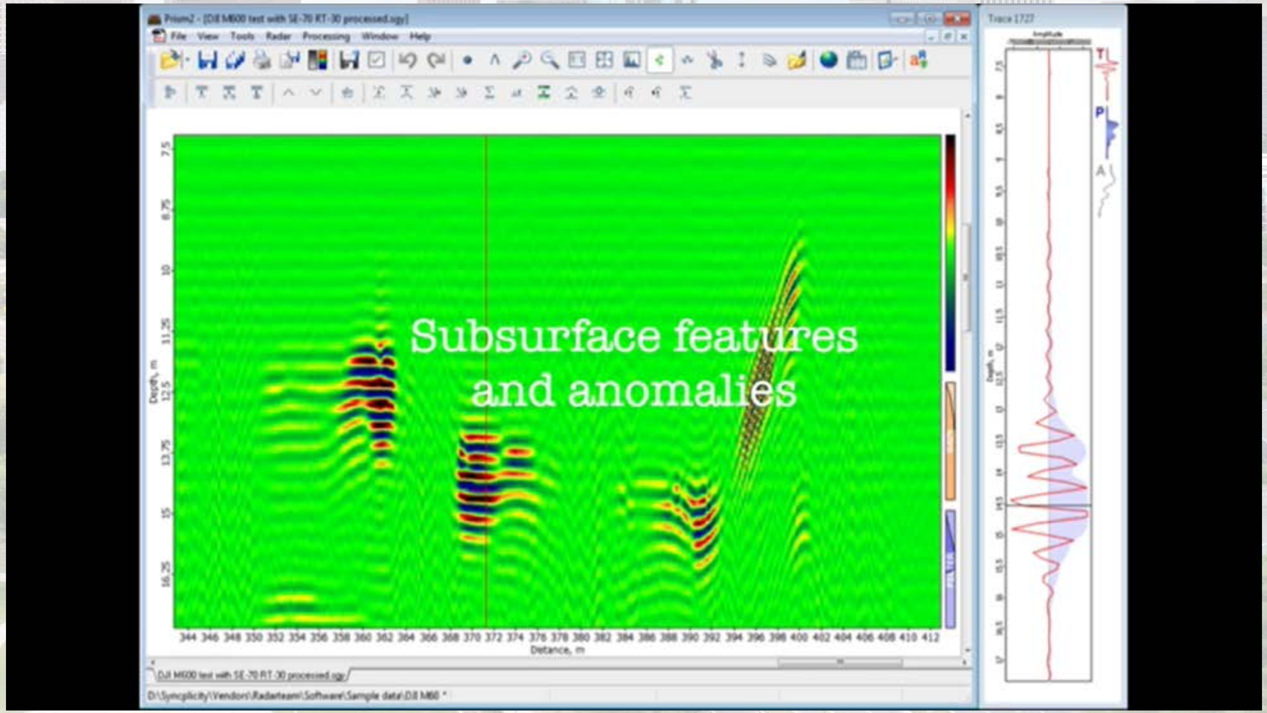
WWW.LIDARUSA.COM
1-833-LiDAR4U


BRINGING
TECHNOLOGY
TO NEW
HEIGHTS

RAPTOR AERIAL SERVICES
Increase Sales, Reduce Costs, Save Time, Improve Safety

Drone Sensors

Airborne (UAV) Ground Penetrating Radar (GPR)



Drone Sensors

UAV Aeromag Surveys

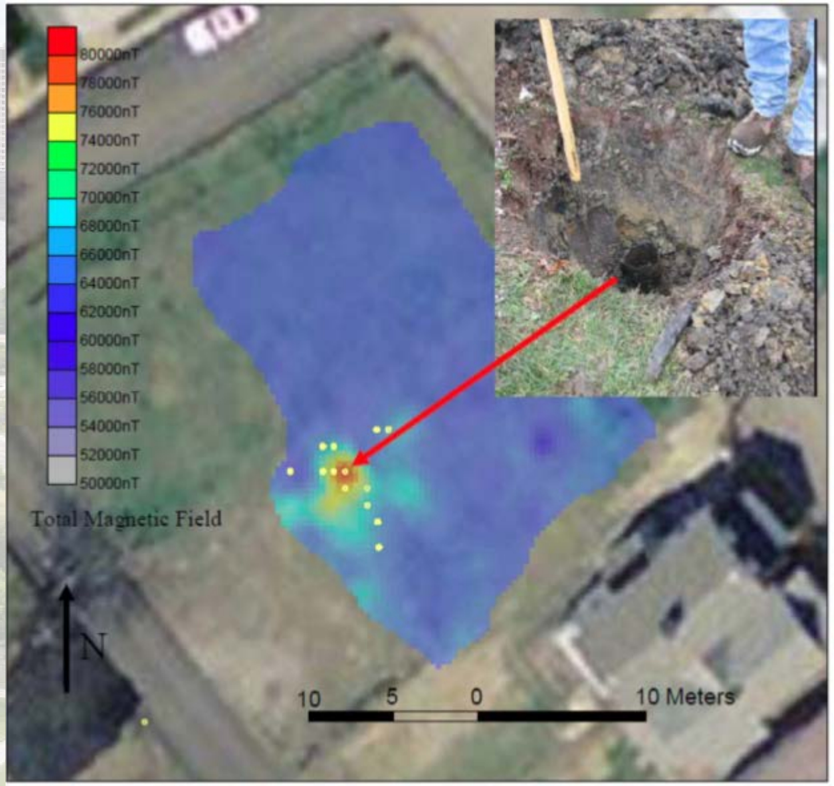


Figure 8: Color-scale magnetic map containing a strong monopole anomaly that denotes the location of an abandoned gas well. Yellow circles indicate locations where CH_4 levels exceeded 100 ppm. Inset is a picture of the gas well casing excavated at this location.

NETL - Methods for Finding Legacy Wells in Residential and Commercial Areas 16 June 2016

Types of Sensors Used on Drones Today

- RGB (Photographic) Cameras of All Types and Sizes
- Multispectral and Hyperspectral Imaging
- Radiometric Thermal IR Imaging
- LIDAR
- Ground Penetrating Radar (GPR)
- Magnetometers
- Methane (Gas) Leak Detection and Gas Sniffing
- Air Sampling (Air Quality, Hazardous Sources, Flare Plumes, Chemical)
- Others

Software

- Google Earth Pro (Aerial Survey Planning)
- DroneDeploy (Mission Planning and Flight Automation)
- DJI GS Pro (Mission Planning and Flight Automation)
- DJI GO 4 (Drone Settings, Compass Calibration and Photography)
- DJI Pilot (Inspection)
- GPS Tracks/EOSToolsPro/ICMTGIS PRO (GCP Positioning)
- SimActive Correlator3D (Processing)*
- Blue Marble's Global Mapper GIS (General Mapping)
- Virtual Surveyor (Visualization, 3D Measurements including Volumes)
- FLIR TOOLS (Thermal Imagery)
- Others –Microsoft Office Suite, Snagit, Camtasia, Zoom, TeamViewer

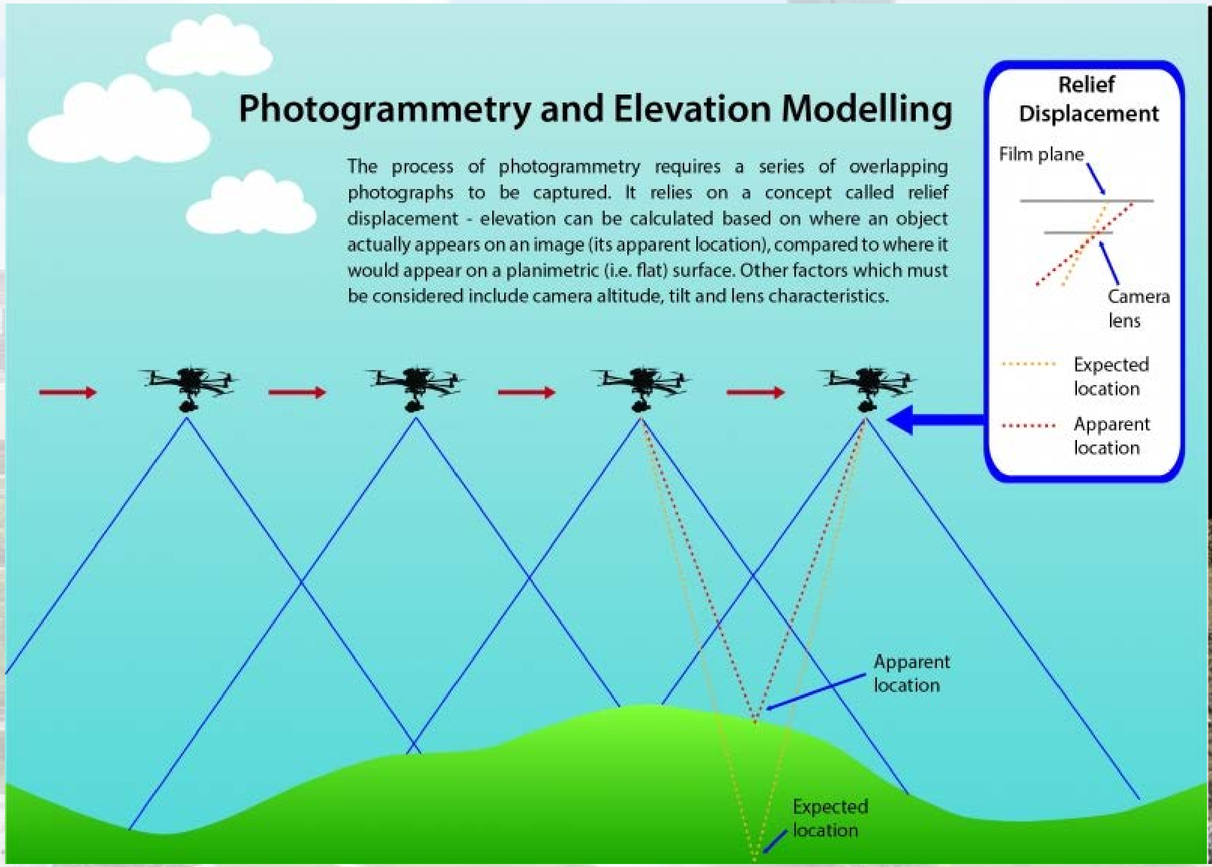
***Pix4D**, **Agisoft PhotoScan**, Maps Made Easy, Datumate Suite …

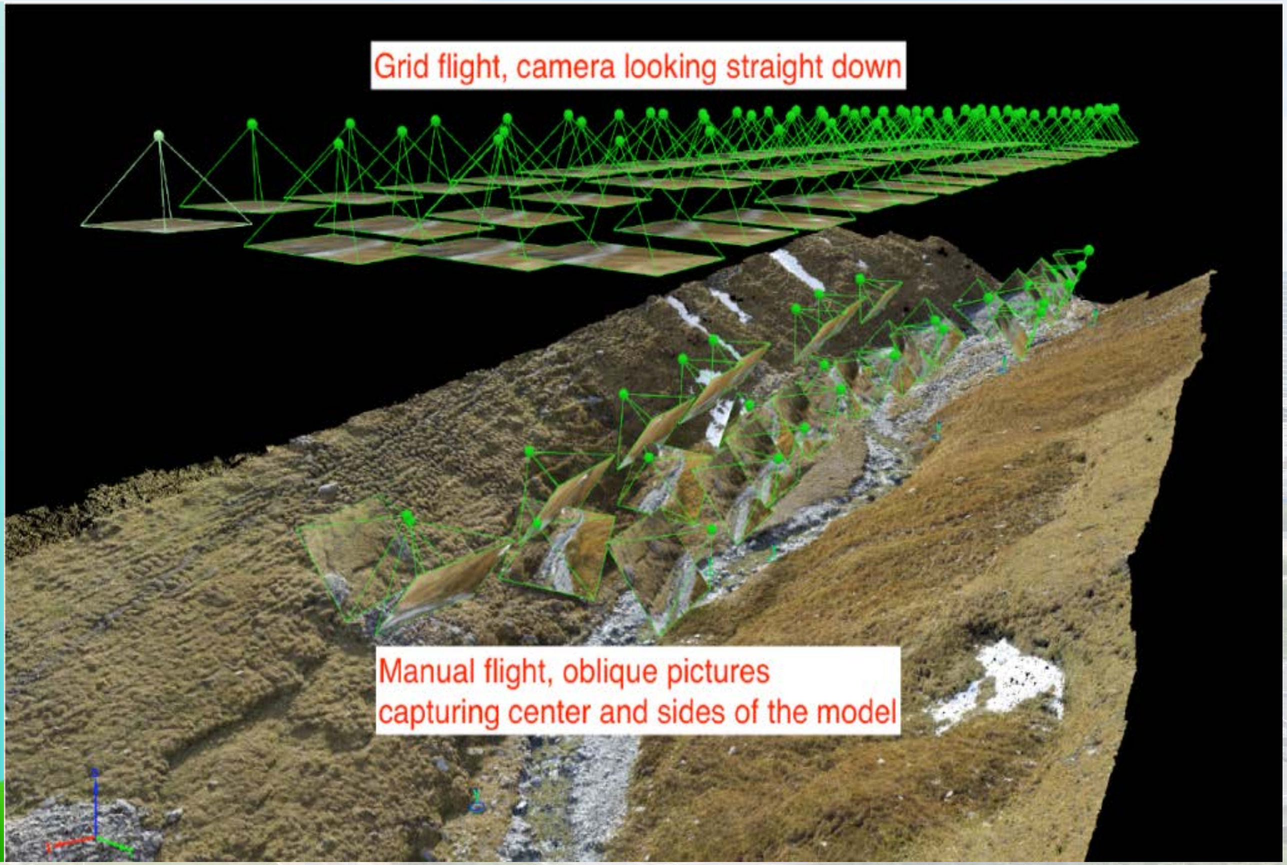
Ground Control Points (GCPs)

- GCPs are large marked targets on the ground, spaced strategically throughout your area of interest.
- The GCPs and their coordinates are then used to help drone mapping software accurately position your map in relation to the real world around it.
- Recommend at least 5 GCPs located in the 4 corners and the center of your map.
- Use an RTK GPS system for the most accurate reading.

Ground Control Points (GCPs)

Photogrammetry and Elevation Modelling





Understanding Elevation Data

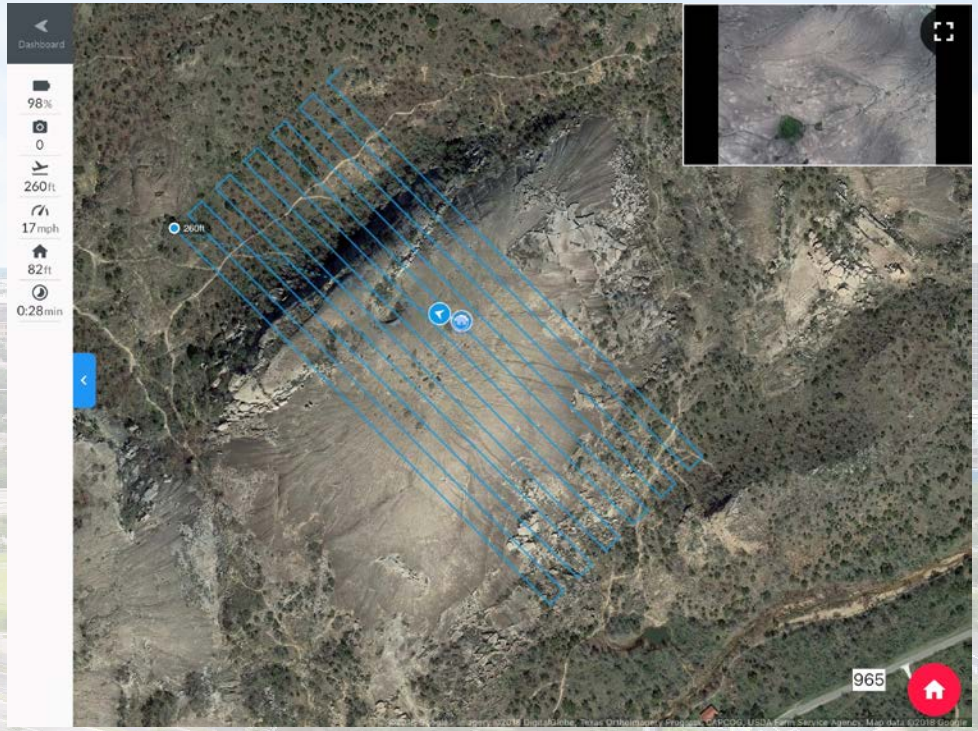
- Elevation maps are created using standard geo-referenced information embedded in your drone imagery.
- By applying some advanced math, you can figure out the elevations by looking at differences in perspective between two or more overlapping images.
- By default, maps show elevation data relative to your drone's take-off location.
- If you want to view elevation data expressed in height above average mean sea level (MSL) or relative to your project coordinate system, you can either add Ground Control Points (GCPs) to your map or you can use the elevation calibration tool to easily adjust the elevations in your map in just a few clicks.

Drone Aerial Survey Workflow

- Pre-Flight Meeting (Survey Objectives)
- Flight Planning (Google Earth, GIS and Customized Maps)
- Laying Out and Positioning of GCPs
- Drone Aerial Survey Data Acquisition (< 1 Hour – Days)
- Process Images (Desktop or Cloud Computing)
- Generation of Orthomosaic, Elevation Models, 3D Model
- Ancillary Products – Contours, Profiles/Cross Sections, Volumes
- Large Format Hardcopies

Mission Planning & Piloting

DroneDeploy Web App Main Mission Planning Screen



DroneDeploy iOS App Main Mission Pilot Screen

Other Mission Planning Apps - Pix4DCapture, Maps Made Easy, DJI Ground Station Pro

Cloud vs Desktop Processing

- Cloud Processing (DroneDeploy, Pix4D, Maps Made Easy, Datumate Suite)
  - Pros
    - More simplified process
    - Lower learning curve
    - Less expensive subscription service
    - Less powerful personal desktop computer/laptop required (processing performed on the servers)
    - Fairly responsive support
  - Cons
    - Less options available (fewer parameters to choose)
    - Requires high speed internet connection to upload images

- Desktop Processing (Correlator3D, Pix4D, Agisoft PhotoScan)
  - Pros
    - More options available (more parameters to select)
    - Generates better overall results
    - High speed internet connection less important (no uploading images)
  - Cons
    - Higher learning curve
    - A more powerful desktop computer/laptop required (Dell XPS 8920 w/ 64GB RAM)
    - More expensive subscription service

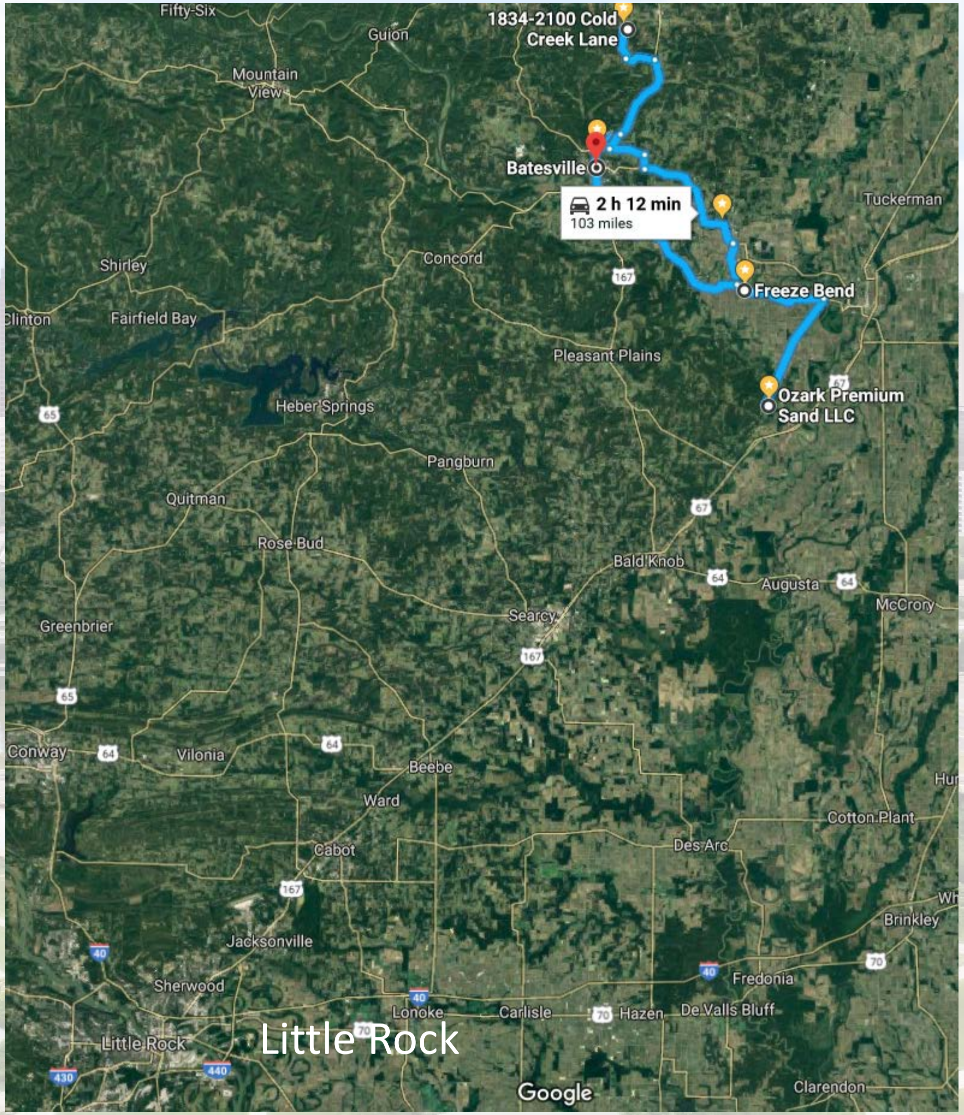
Summary of Actionable Data Products from Drones

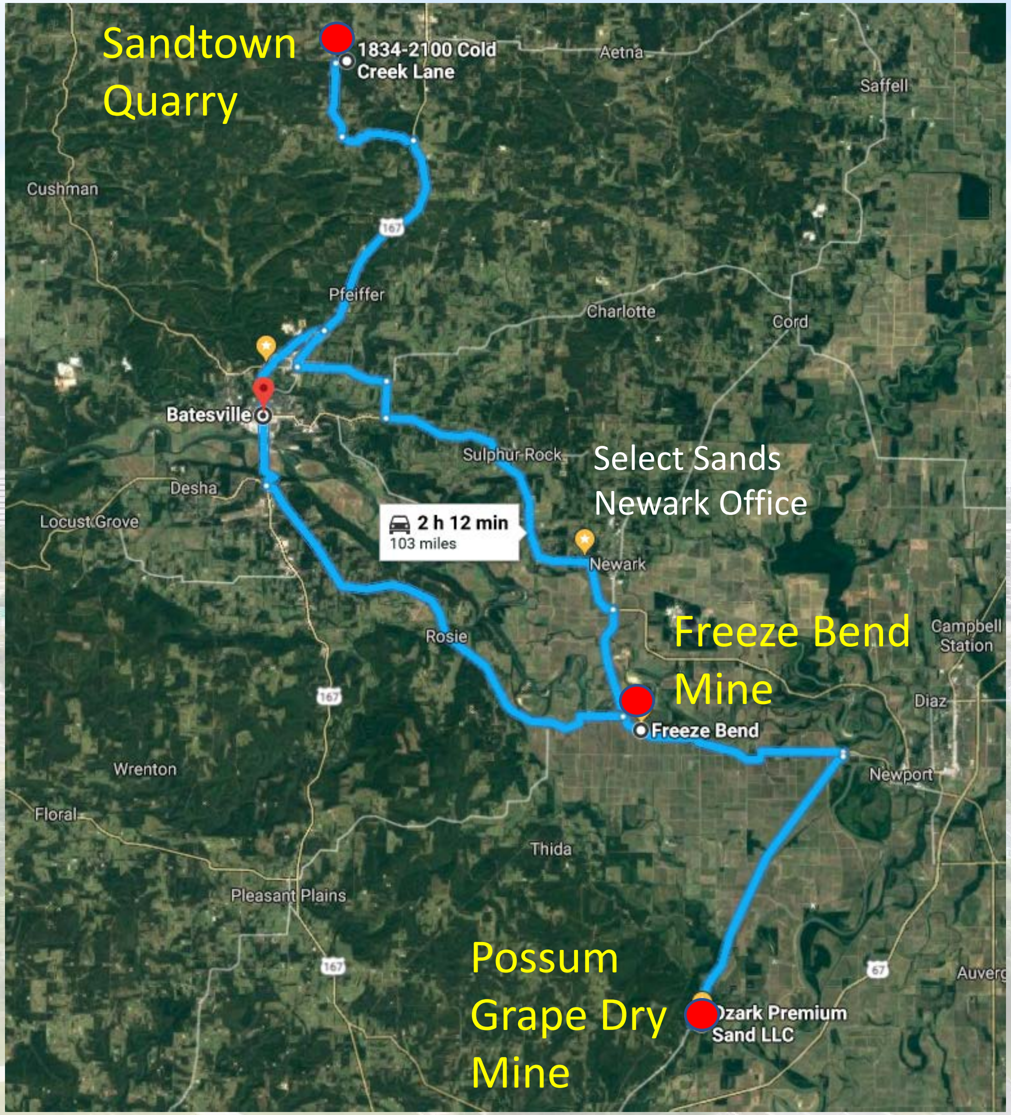
- High Resolution Aerial Photos and Videos
- 2D Orthophotomosaics (Photo Maps)
- Digital Surface Elevation Models
- Digital Elevation Models (DEM) - less structures and vegetation
- 3D Point Clouds
- 3D Surface Models
- Surface Contours and Topographic Maps
- Length, Area and Volume Measurements
- Surface Profiles and Cross Sections
- Multispectral and Thermal IR Maps
- Geophysical Surveys (Magnetic, Gravity, GPR, etc..)
- Methane (Gas) leak detection and gas sniffing
- Air sampling (hazardous sources, flare plumes, chemical)

Example of Aerial Survey Project

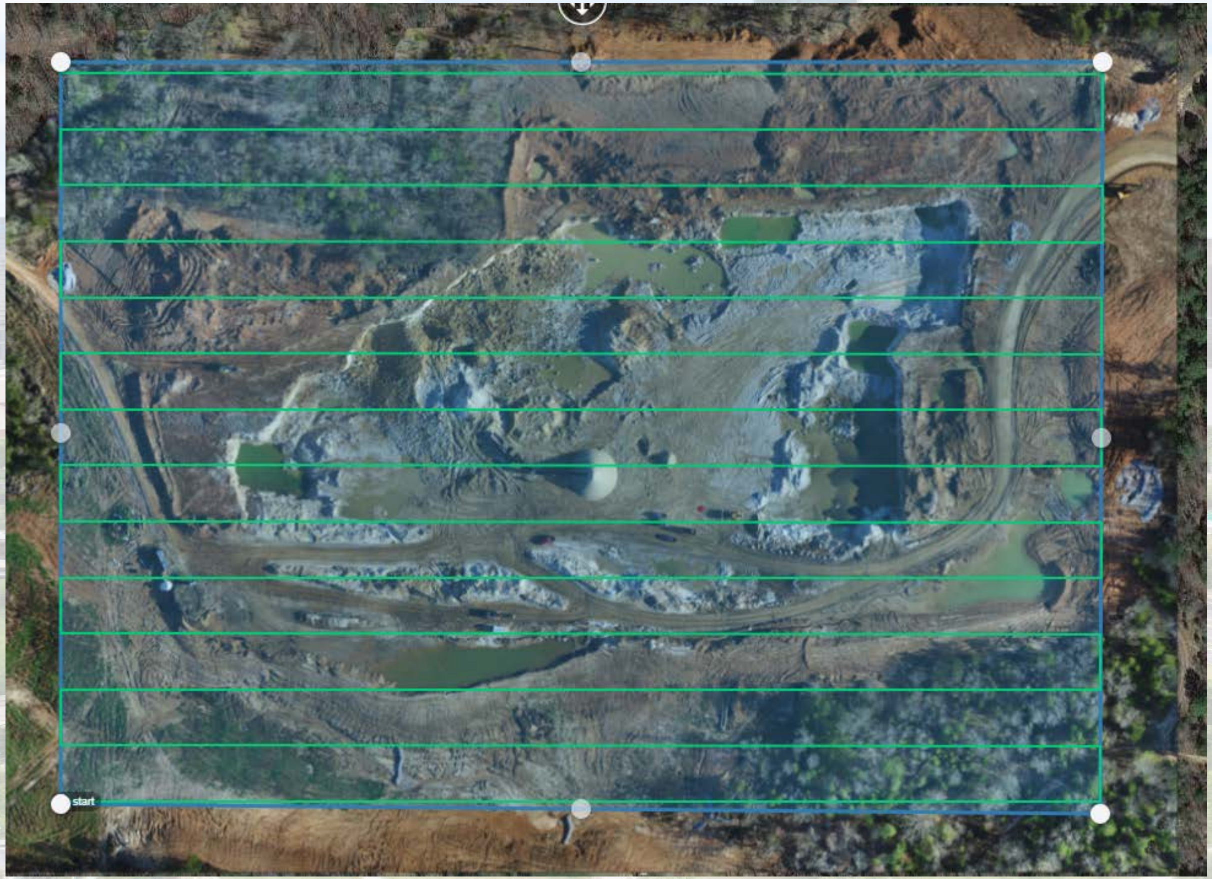
Select Sands Corp
Ozark Operations, Arkansas

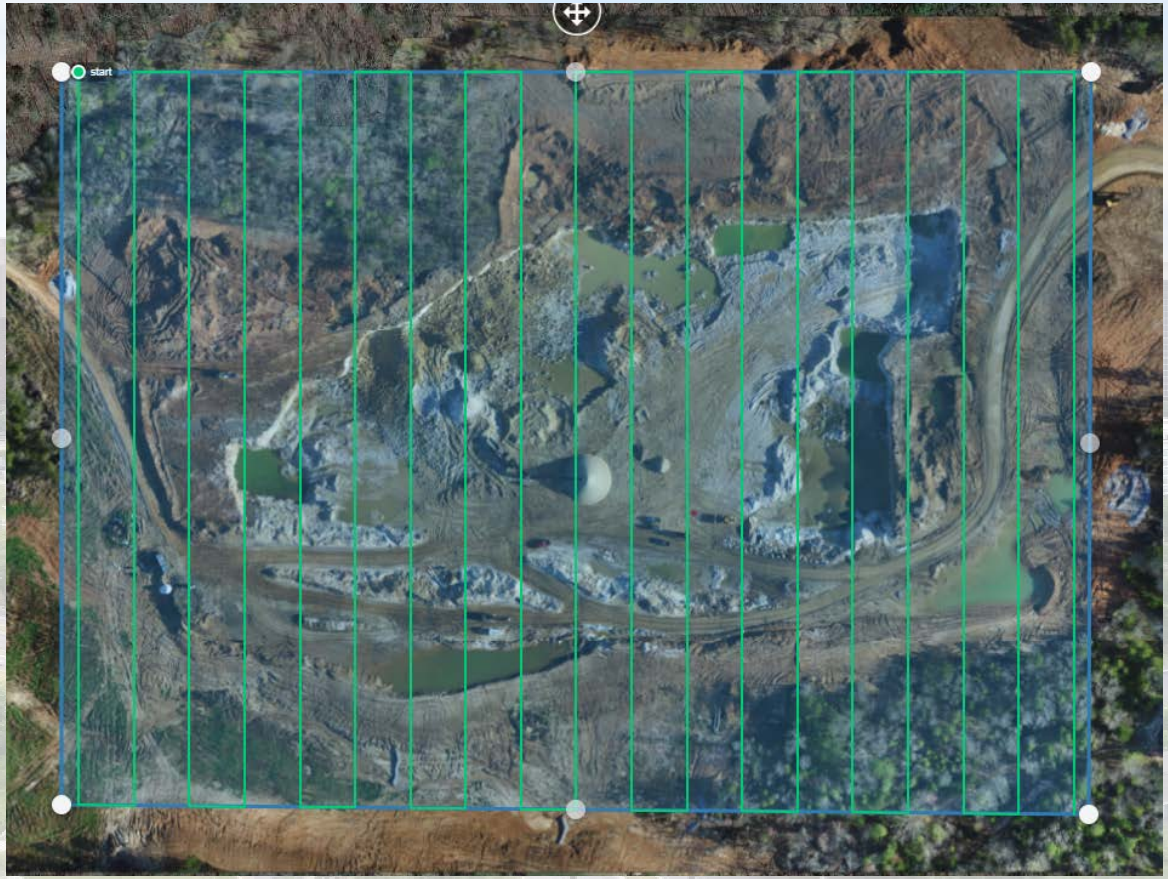
Select Sands Mine Sites





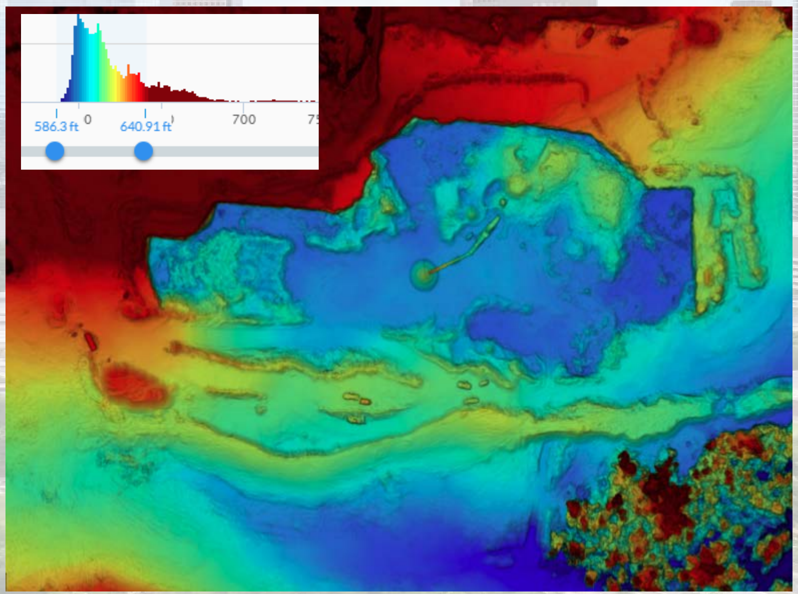
2 Passes, Perpendicular Grid Pattern



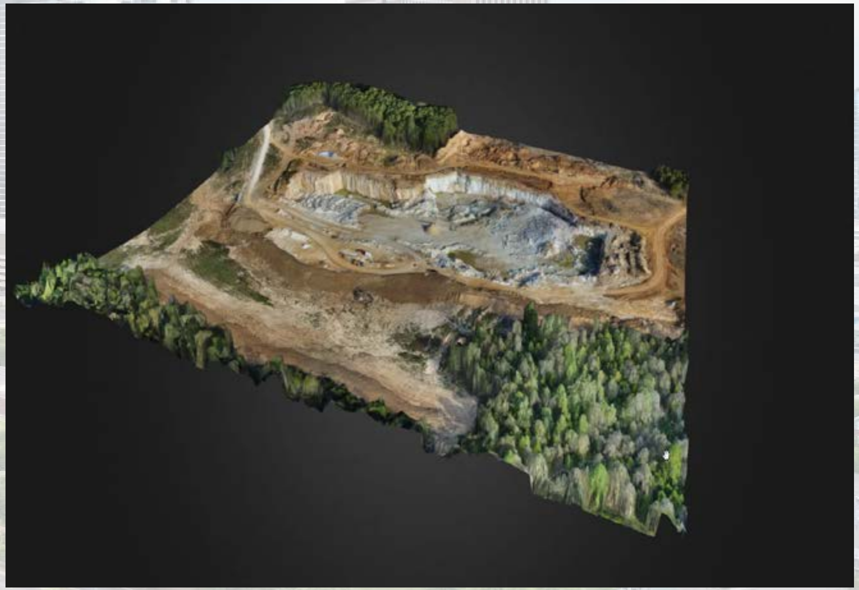


Sandtown Quarry (30 Acres)

Orthomosaic Photo



Digital Surface Elevation Model



3D Model

Construction Site Monitoring (e.g., Well Pad, Production Facility)

Orthophotomosaic – 09/17

Orthophotomosaic – 12/17

Orthophotomosaic – 03/18

Orthophotomosaic – 06/18

Quarterly Stockpile Volumes Report

Stockpile	Area (sq. ft.)	Volume (cu. Ft.)	Volume (cu. yd.)	Tons	Reference	Totals
100 Mesh #1	8,065.00	59,898.00	2,218.44	2,839.61	Flat 234	
100 Mesh #2	4,659.00	38,485.00	1,425.37	1,824.47	3D Polygon	
100 Mesh #3	28,285.00	300,798.00	11,140.66	14,260.04	3D Polygon	
100 Mesh #4	26,584.00	209,555.00	7,761.29	9,934.45	3D Polygon	
100 Mesh #5	14,729.00	102,148.00	3,783.26	4,842.57	3D Polygon	
100 Mesh #6	3,854.00	25,926.00	960.22	1,229.08	Flat Minimum	
100 Mesh #7	3,042.00	10,824.00	400.89	513.14	3D Polygon	35,443.35
40-70	18,832.00	228,076.00	8,447.25	10,812.48	3D Polygon	10,812.48
Overs Waste	9,288.00	61,665.00	2,283.89	2,923.37	3D Polygon	2,923.37
Raw Feed #1	22,397.00	175,959.00	6,516.99	8,341.75	3D Polygon	
Raw Feed #2	3,375.00	16,190.00	599.63	767.53	3D Polygon	9,109.28

Traditional Stockpile Inventory Method

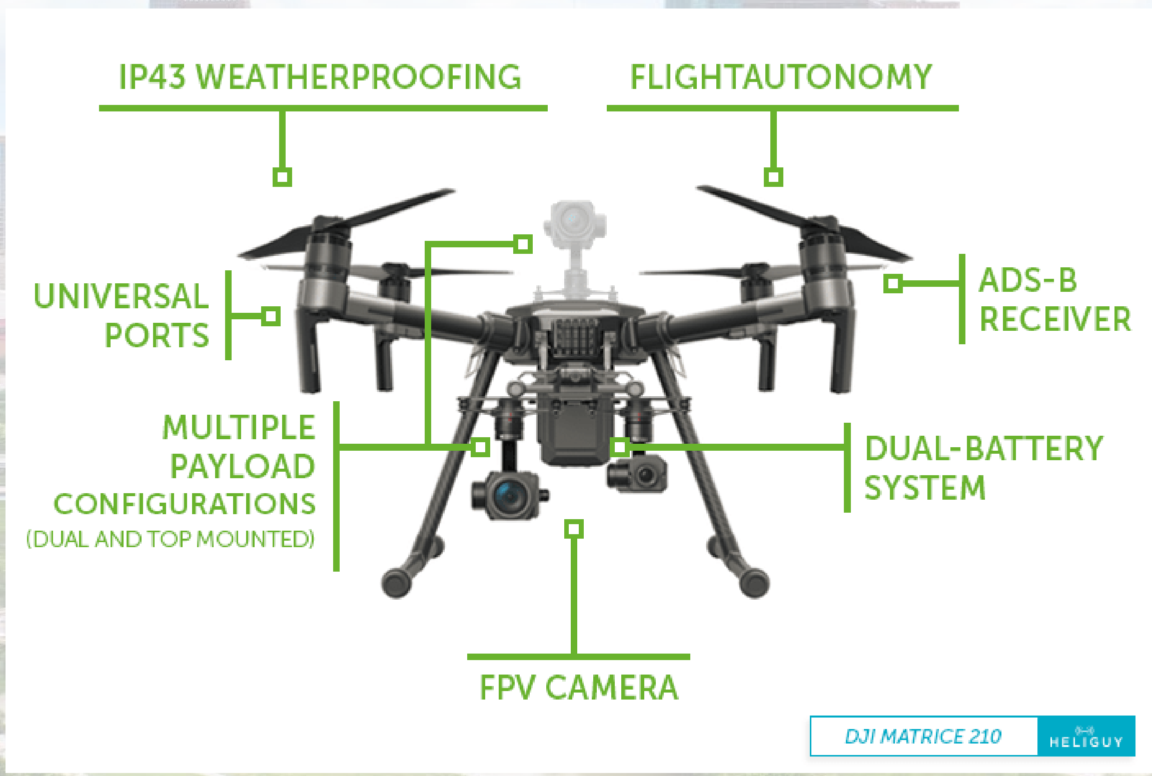
- Performed Annually
- Time Consuming and Labor Intensive Resulting in Higher Costs
- 1-2 Weeks Turnaround from Start to Finish
- Safety Risks with Survey Team Climbing on Stockpiles
- Summarized Final Report for Each Site

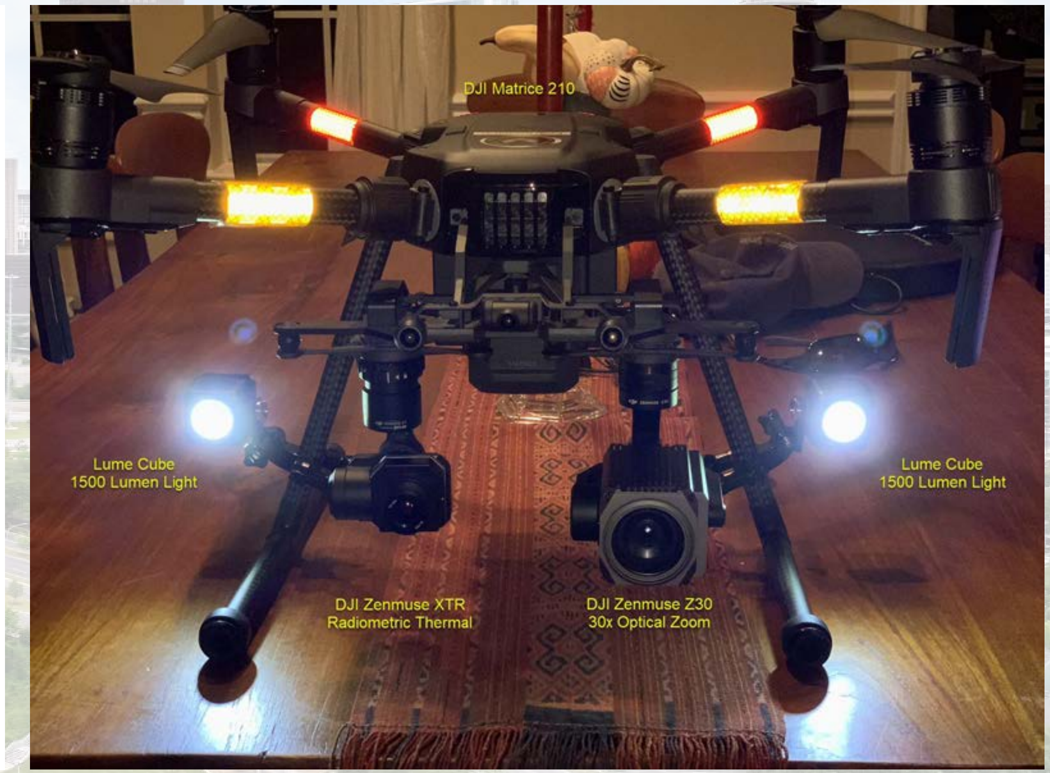
Drone Stockpile Inventory Method

- Performed Quarterly
- 7 Days or Less Turnaround from Start to Finish
- Digital Data delivered via Dropbox including Georeferenced Orthomosaic Photo, Digital Surface Elevation Model and 3D Model for Each Site
- Stockpile Polygons for Each Site Visually Confirmed Collaboratively
- Detailed Final Report
- 34”x44” (ANSI E) Scaled Hardcopy Plots Provided for Each Site

Inspection Drones

DJI M210 – External Inspection Drone





Close-up Inspection Work

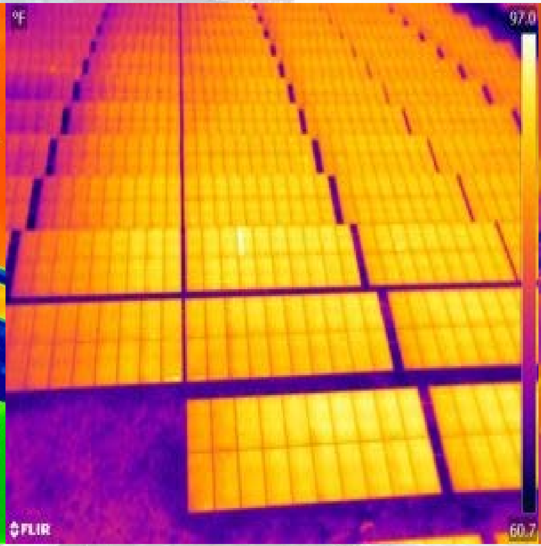
SKY
-FUTURES
Unmanned System Solutions

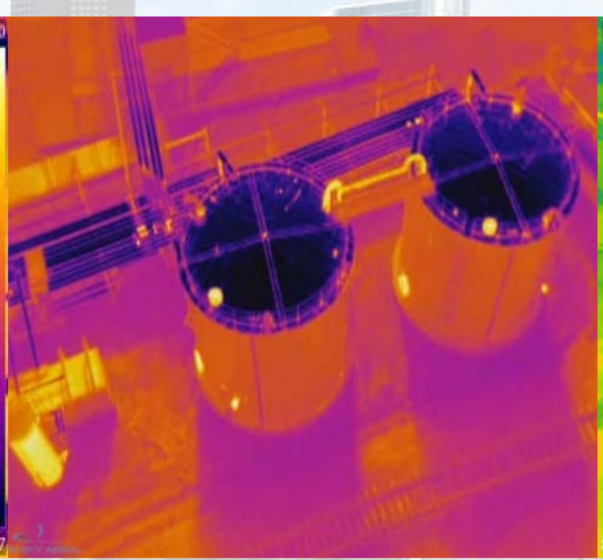
Single Man UAV Team

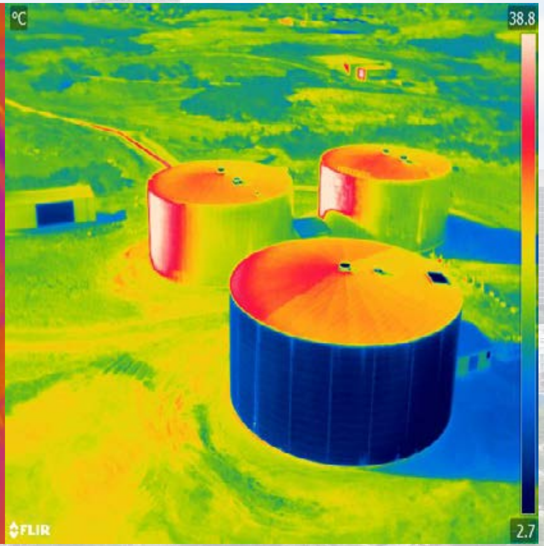
Live Flare Inspection

35km/h Winds

Thermal Inspection

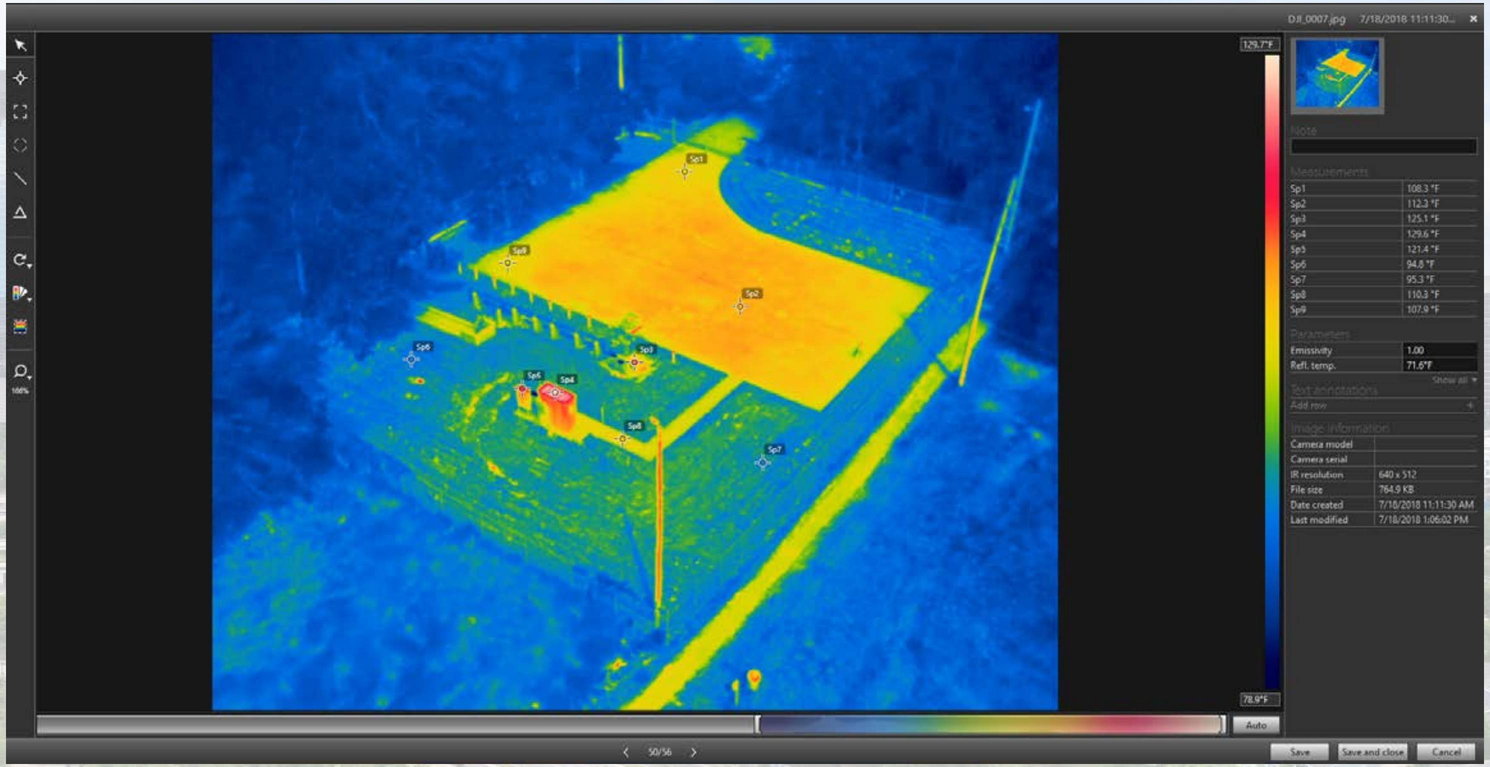






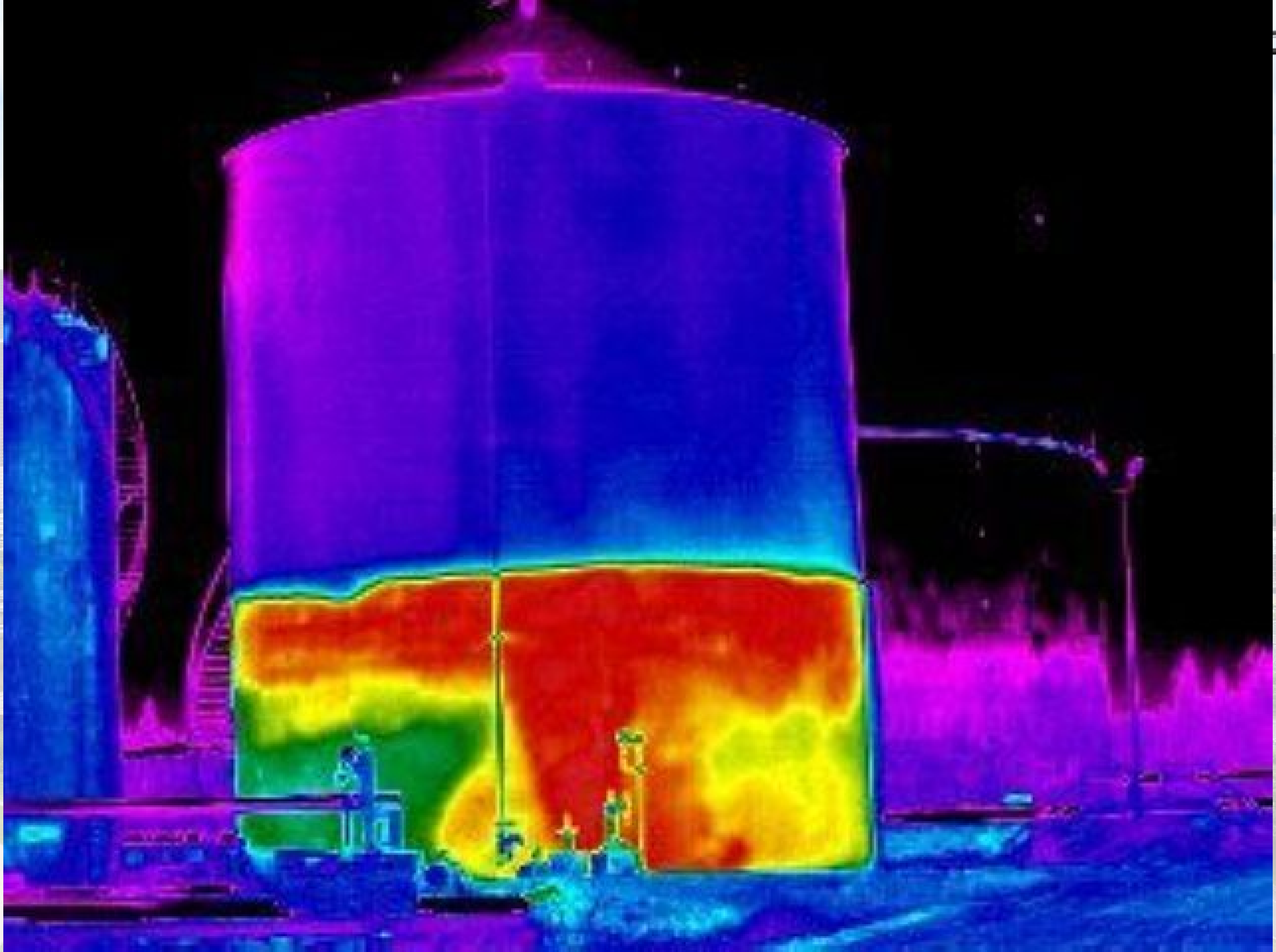
Radiometric Thermal Imagery

Gray Palette

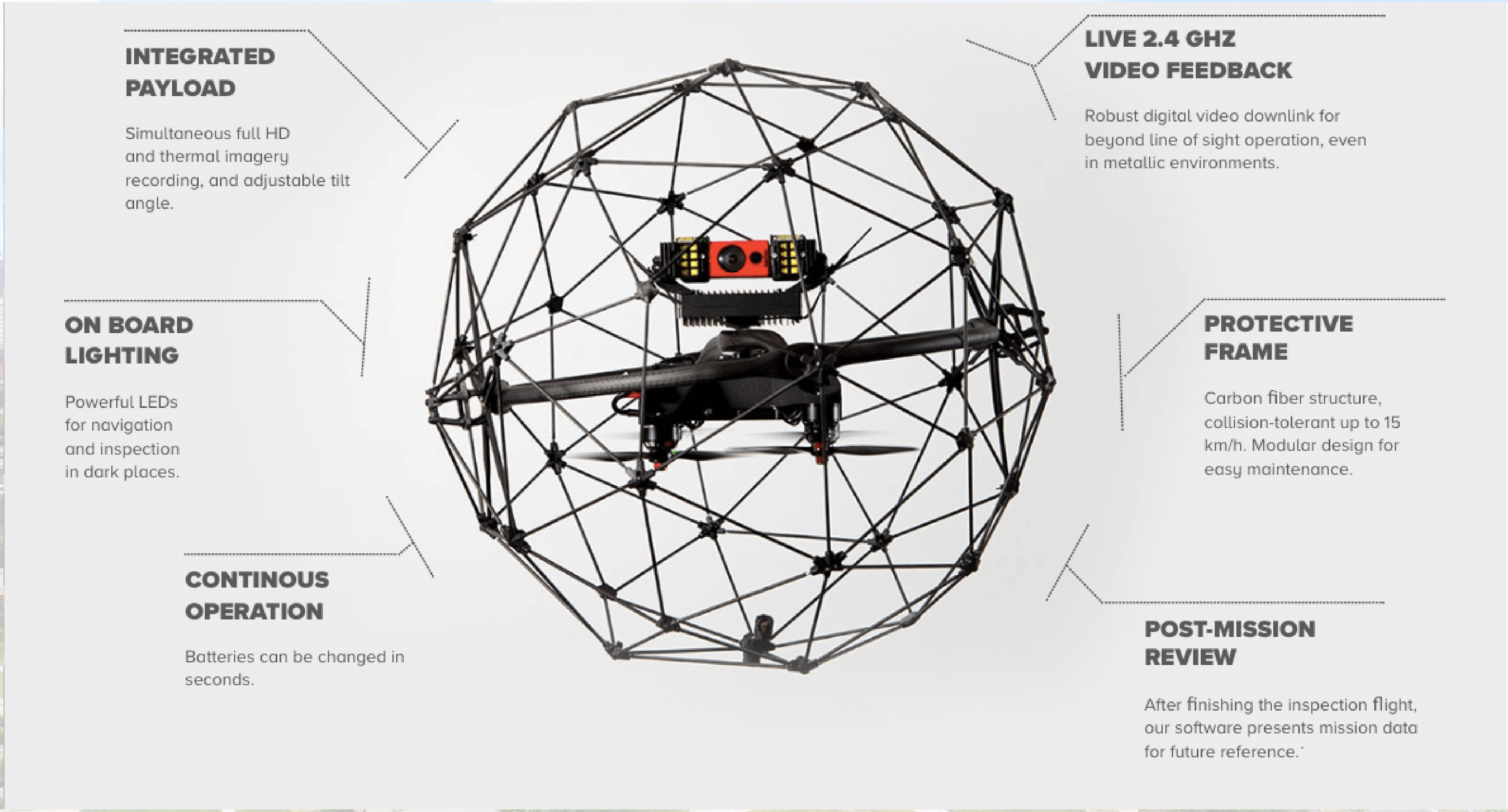


Rainbow Palette

RAPTOR AERIAL SERVICES
Increase Sales, Reduce Costs, Save Time, Improve Safety



Flyability Elios – Internal Inspection Drone




Flyability presentation - Elios, the collision-tolerant drone for industrial inspection
FLYABILITY
SAFE DRONES
FOR INACCESSIBLE
PLACES
Play


RAPTOR AERIAL SERVICES
Increase Sales, Reduce Costs, Save Time, Improve Safety
Drone Boiler Inspection
conEdison
EVERYTHING
MATTERS
Play
0:00 / 1:40
Scroll for details

Drone Inspection Resource Efficiencies

Table 1: Case Study Resource Efficiencies

Flare Inspection (unplanned)	60% resource savings
Flare Inspections (2)	80% resource savings
Electrical Substation Thermal Imagery	90% resource savings
Confined Space Inspection	80% resource savings
Unit Transformer Inspection	90% resource savings
Two-dimensional top-down photos of units and oblique angles	80% resource savings

Figure 6. Case Study Confined Space and Flare Mission Pictures

"Unmanned Aircraft Systems (UAS): Case Study that Highlights Challenges and Opportunities"

by Robert Shirley, Damien Parson and Florine Vincik. Presented at the GCPS in Spring, 2018.

Drone Inspection Cost Savings

- Onshore Oil and Gas Drone Inspection Saves Client $4m in Egypt
- North Sea offshore structural drone inspections saved Oil & Gas client 80% cost

Using of Drones To Investigate Major Industrial Accidents

- Assessing damage to ensure investigation team safe access to the incident site;
- More accurate recording of the incident site via aerial stills and videos; and
- Easier-and-earlier assessment of the extent of damage for the purpose of recovery and business resumption.

Drone Inspection Advantages and Disadvantages (Offshore Oil Platform)

Advantages:

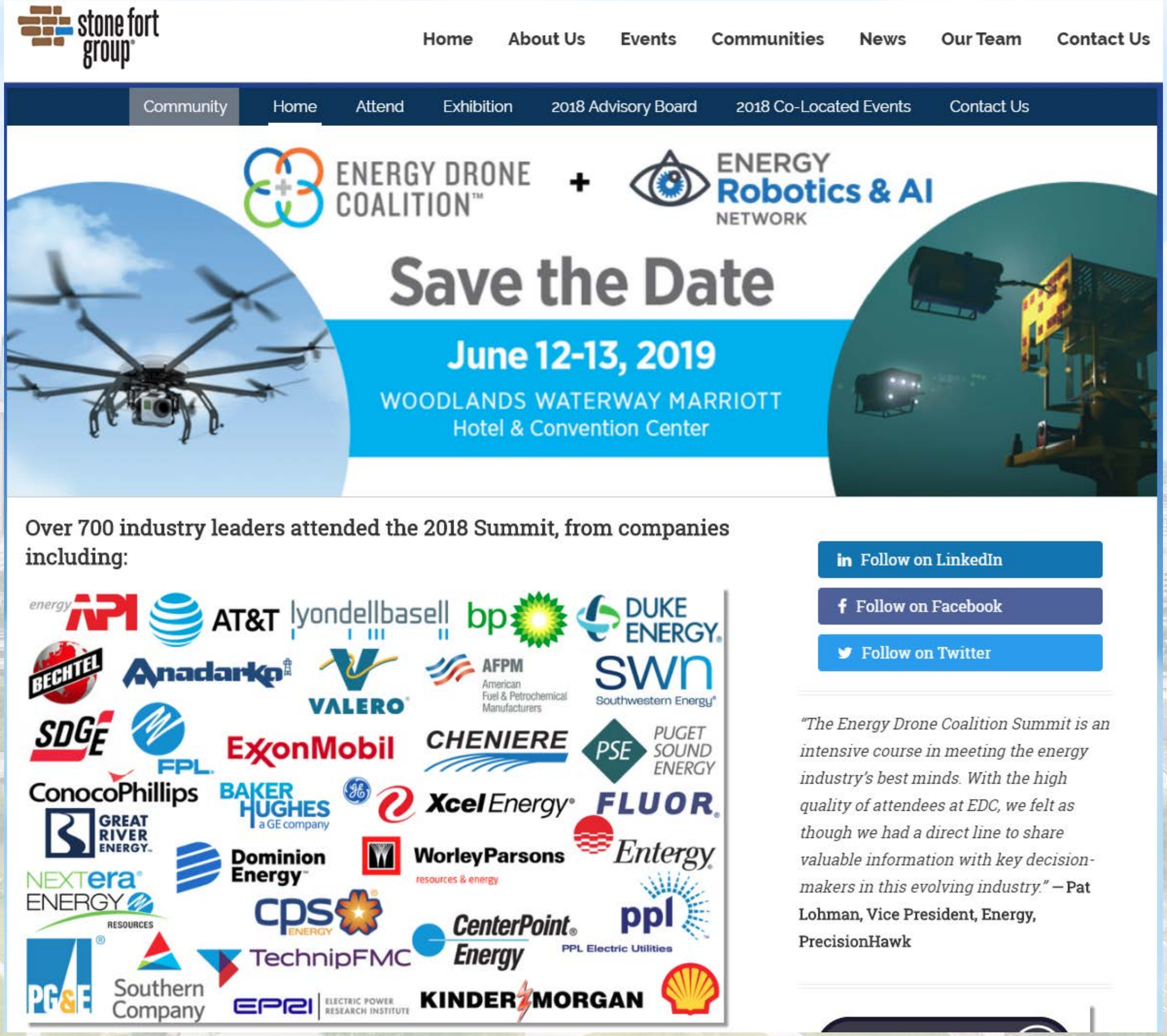
- **Safety** – UltraHD 4K quality up close image without a man's presence onto the inspected objects,
- **Cost saving** – Drone inspection is cheaper than using a helicopter while also maintaining the same image quality,
- **Time saving** – The system's mobility and its ability to rapidly analyse gathered data reduces the time of defect detection and repair to a minimum,
- **High productivity**– Low costs and short time of taking photos make for the most effective way of the offshore oil platform's inspection,
- **High quality inspection**– our trained pilots are able to fly very close to the inspected object. Together with our engineers' knowledge we are able to rapidly locate and diagnose even a thermal related problem.
- **The best thermal imaging equipment** – using highest quality thermal imaging cameras we are able to detect, among others, corrosion, consumption and breakage of the inspected objects.

Disadvantages:

- **Short flying time** – short flying time due to low battery durability requires coming back to the starting point every 15-25 minutes. However, we have a lot of batteries as well as a mobile recharging station to ensure the consistency of inspections,
- **Weather restrictions** – considering relatively low weight of the drone and considerable amount of electronic elements we must not fly when the wind's speed exceeds 18 m/s, when it's raining or snowing.

Online Resources

- FAA/UAS – http://www.faa.gov/uas
- FAA Federal Drone Registration - https://registermyuas.faa.gov/
- Know Before You Fly - http://knowbeforeyoufly.org/
- UAS Pilot Knowledge Test Prep - https://www.faa.gov/uas/getting_started/fly_for_work_business/becoming_a_pilot/
- Remote Pilot 101 - https://remotepilot101.com/
- UAV Coach - https://uavcoach.com/
- Dronepedia - https://dronepedia.xyz/


stone fort group
Home
About Us
Events
Communities
News
Our Team
Contact Us
Community
Home
Attend
Exhibition
2018 Advisory Board
2018 Co-Located Events
Contact Us
ENERGY DRONE COALITION™
+
ENERGY Robotics & AI NETWORK
Save the Date
June 12-13, 2019
WOODLANDS WATERWAY MARRIOTT
Hotel & Convention Center
Over 700 industry leaders attended the 2018 Summit, from companies including:
Follow on LinkedIn
Follow on Facebook
Follow on Twitter
"The Energy Drone Coalition Summit is an intensive course in meeting the energy industry's best minds. With the high quality of attendees at EDC, we felt as though we had a direct line to share valuable information with key decision-makers in this evolving industry." —Pat Lohman, Vice President, Energy, PrecisionHawk

Q&A

Any additional questions or comments?

Thank you!!

Thanks To The AIChE South Texas Section for the Opportunity To Provide You an Overview of Drones, a New Tool for Chemical Engineering Applications

Bio

- B.S and M.S in Geology
- 34 Years Working in Oil & Gas – Gulf, Chevron, Halliburton, Devon Energy, Fieldwood Energy
- Various Geology and IT Leadership Positions
- Purchased 1st Drone in 2015
- Started Raptor Aerial Services LLC in February, 2017
- FAA Part 107 sUAS (Drone) Exam/License in March, 2017
- >450 flights logged in several different States
- Attended Drone-related Conferences and Workshops
- Networking and Business Development
- Technical Presentations and Courses on Drones

Mike Allison

Raptor Aerial Services LLC

www.raptoraerialservices.com

mike@raptoraerialservices.com

832-242-4406

Backup Slides

FAA Rules for Operating a sUAS

LAANC is the Low Altitude Authorization and **N**otification **C**apability, a collaboration between FAA and Industry. It directly supports UAS integration into the airspace.

It provides access to controlled airspace near airports through near real-time processing of airspace authorizations below approved altitudes in controlled airspace.

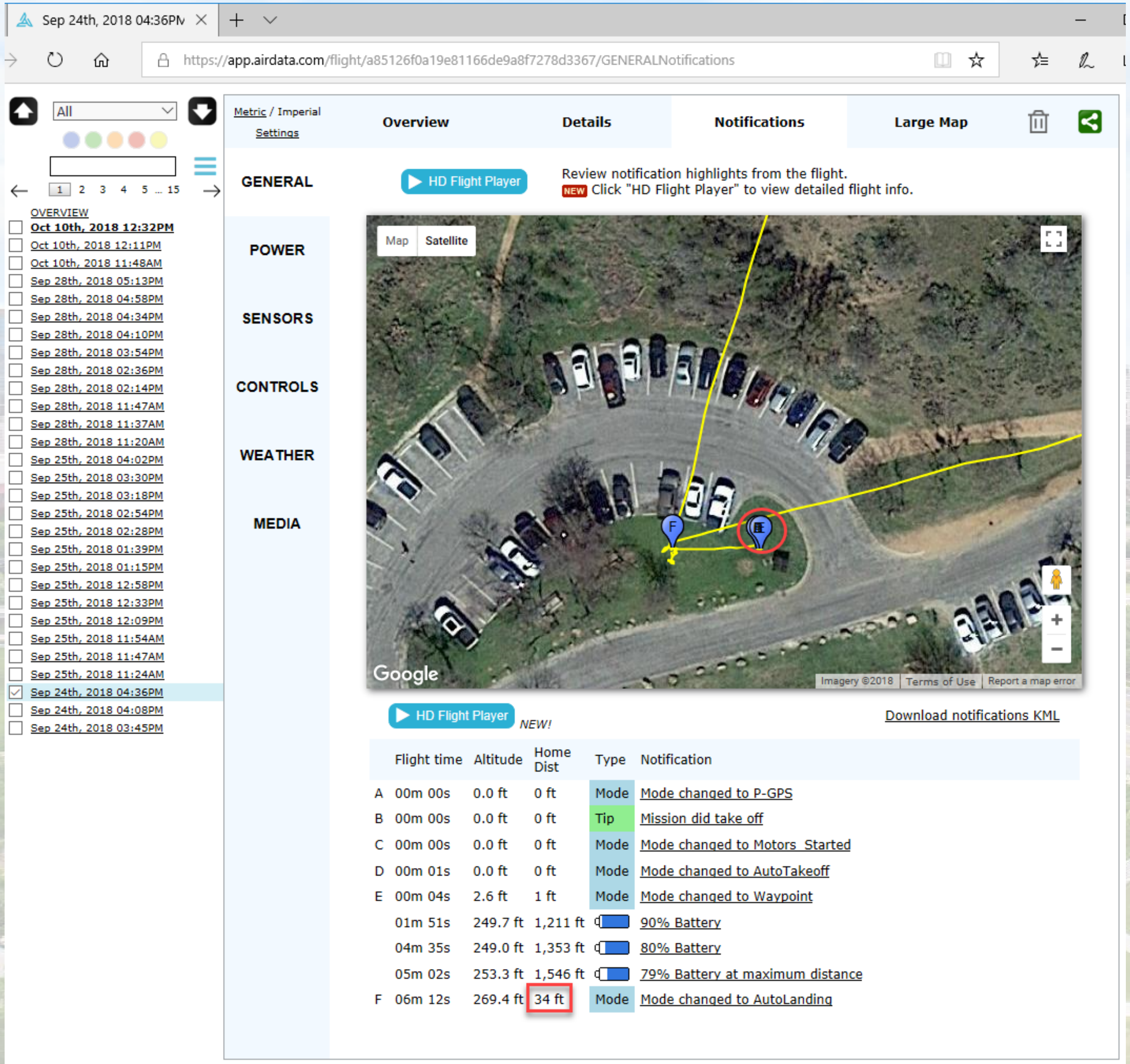
LAANC is available at nearly 300 air traffic facilities covering approximately 500 airports. If you want to fly in controlled airspace near airports not offering LAANC, you can use the manual process to apply for an authorization.

The capability is in beta throughout 2018, and seeks to test the capability nationwide; the results will inform future expansions of the capability.

Houston area airports covered by LAANC

IAH-George Bush Intcntl/Houston	HOUSTON	TX
DWH-David Wayne Hooks Mem	HOUSTON	TX

Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)



DJI Phantom 4 RTK


New DJI Phantom 4 RTK Drone


New DJI Phantom 4 RTK Remote Controller


New GS RTK Flight Planning App


D-RTK 2 HIGH PRECISION GNSS MOBILE STATION

- Announced October 15th
- Long Battery Life up to 30 Minutes.
- Fewer GCPs Required.
- RTK Horizontal Positioning Accuracy: **1cm**+1ppm*.
- RTK Vertical Positioning Accuracy: **1.5cm**+1ppm*.
- Absolute Horizontal Accuracy of Photogrammetric Models: **5cm** (When flying at 100m height, 2.7cm GSD, sunny.)
- Available Now. Total “Estimated” Cost with Base Station: **Under $10,000**

*When using D-RTK Base Station

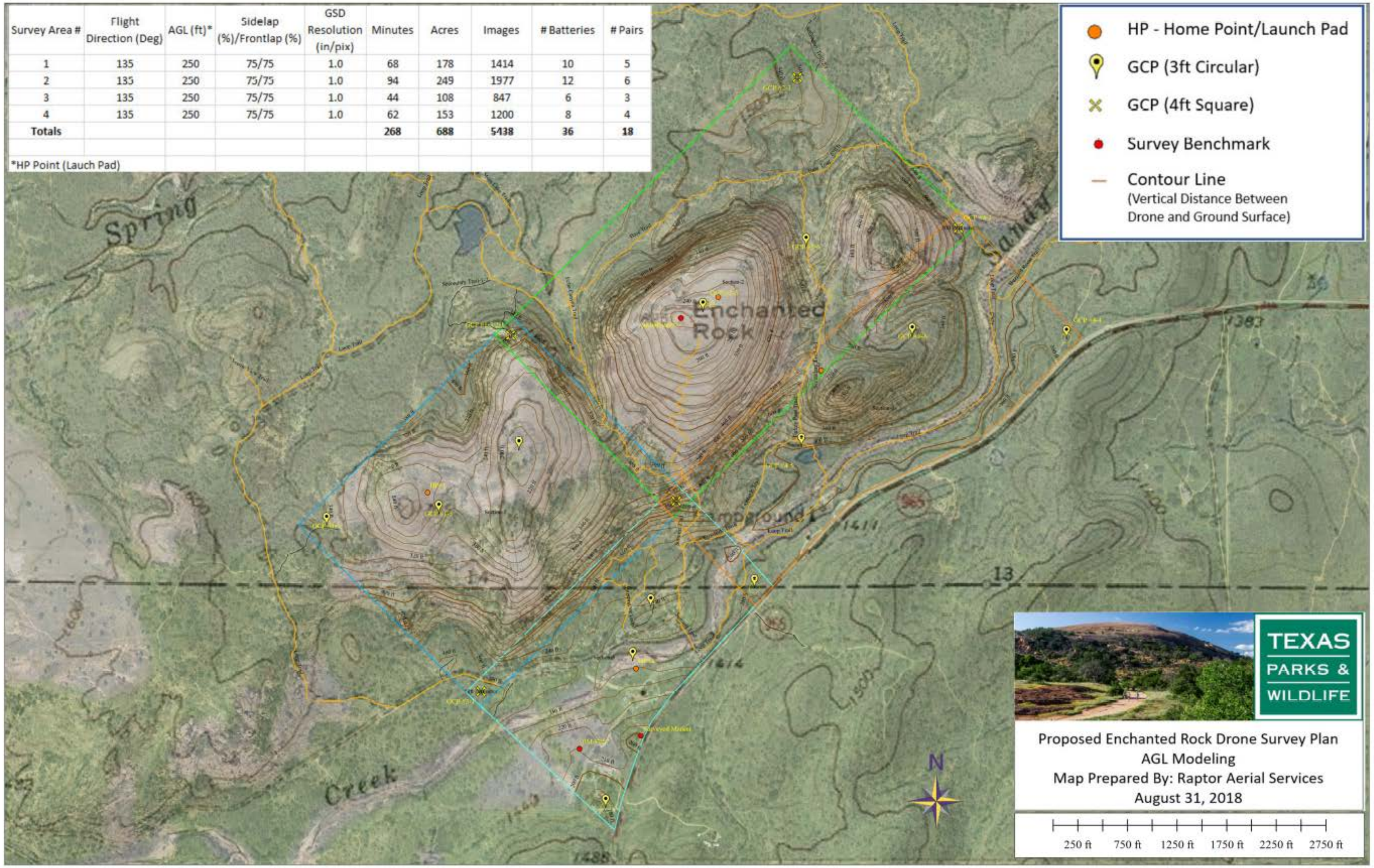
NEW! DJI Mavick 2 Enterprise (Dual)

- Announcements on October 29th and December 20, 2018
- 31 Minute Flight Time
- 12MP 1/2.3 CMOS sensor with 24-48mm optical zoom function and 3x digital zoom
- Accessories include a 2,400 lumens **spotlight**, **speaker** with a 100-decibel projection power and Beacon, a **strobe light** designed to be seen up to almost five kilometers away
- **Dual: FLIR MSX®, Spot Meter, Area Measurement and Isotherm**
- Available Now. Starting Cost: **$2,000-$2,700**

Texas State Parks & Wildlife
Enchanted Rock SNA
Fredericksburg, TX

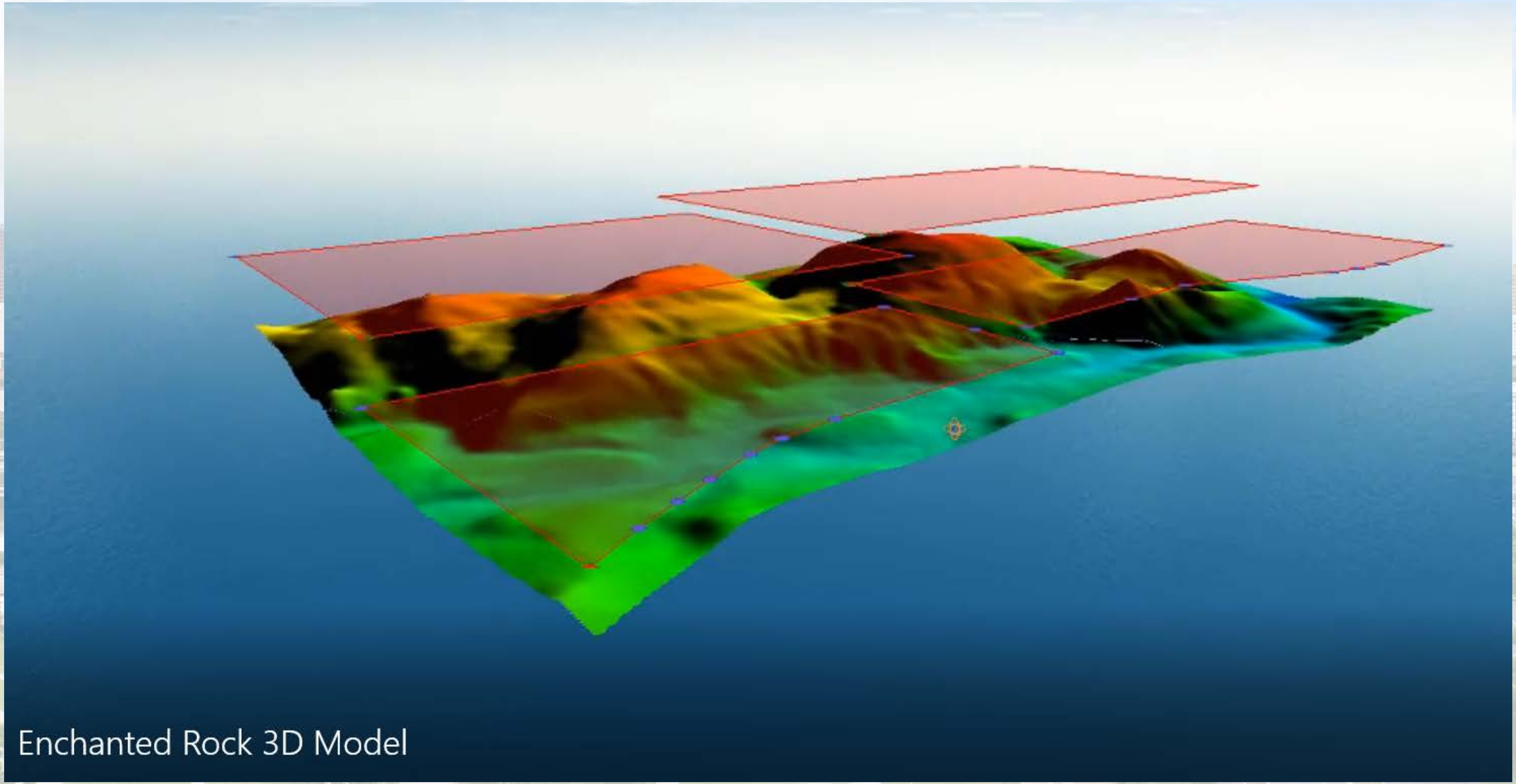
Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)

Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)



Survey Area #	Flight Direction (Deg)	AGL (ft)*	Sidelap (%)/Frontlap (%)	GSD Resolution (in/pix)	Minutes	Acres	Images	# Batteries	# Pairs
1	135	250	75/75	1.0	68	178	1414	10	5
2	135	250	75/75	1.0	94	249	1977	12	6
3	135	250	75/75	1.0	44	108	847	6	3
4	135	250	75/75	1.0	62	153	1200	8	4
Totals					**268**	**688**	**5438**	**36**	**18**
*HP Point (Lauch Pad)									

Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)



Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)

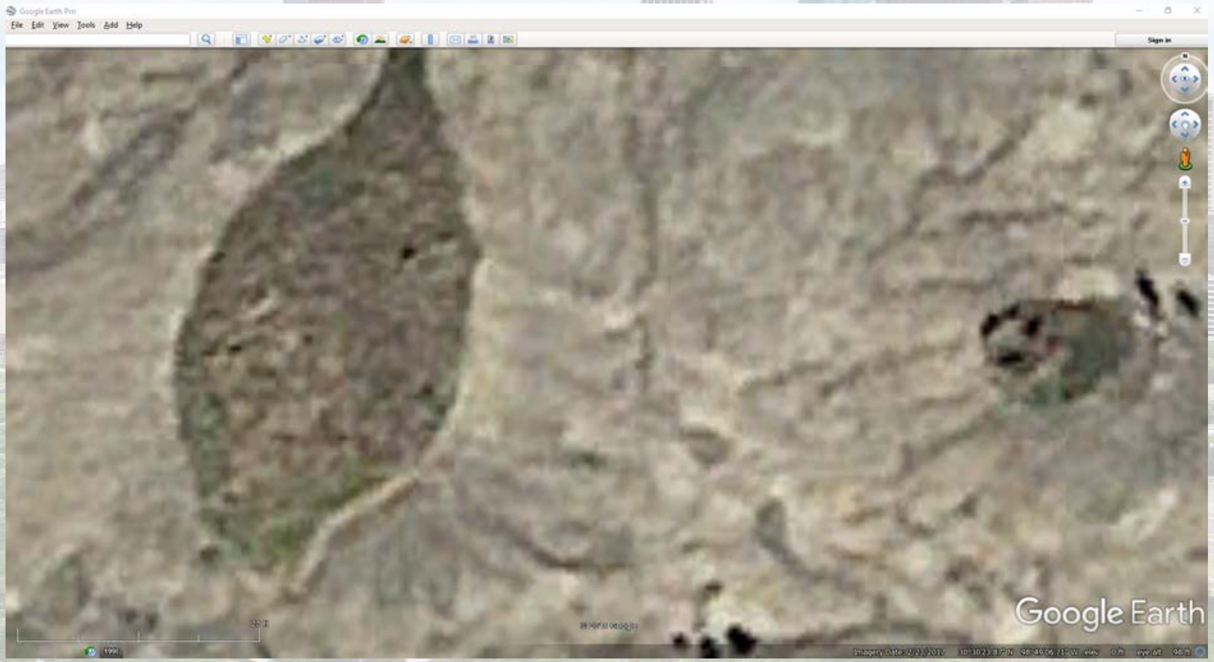
Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)

Enchanted Rock State Natural Area
Fredericksburg, TX (~700 Acres)

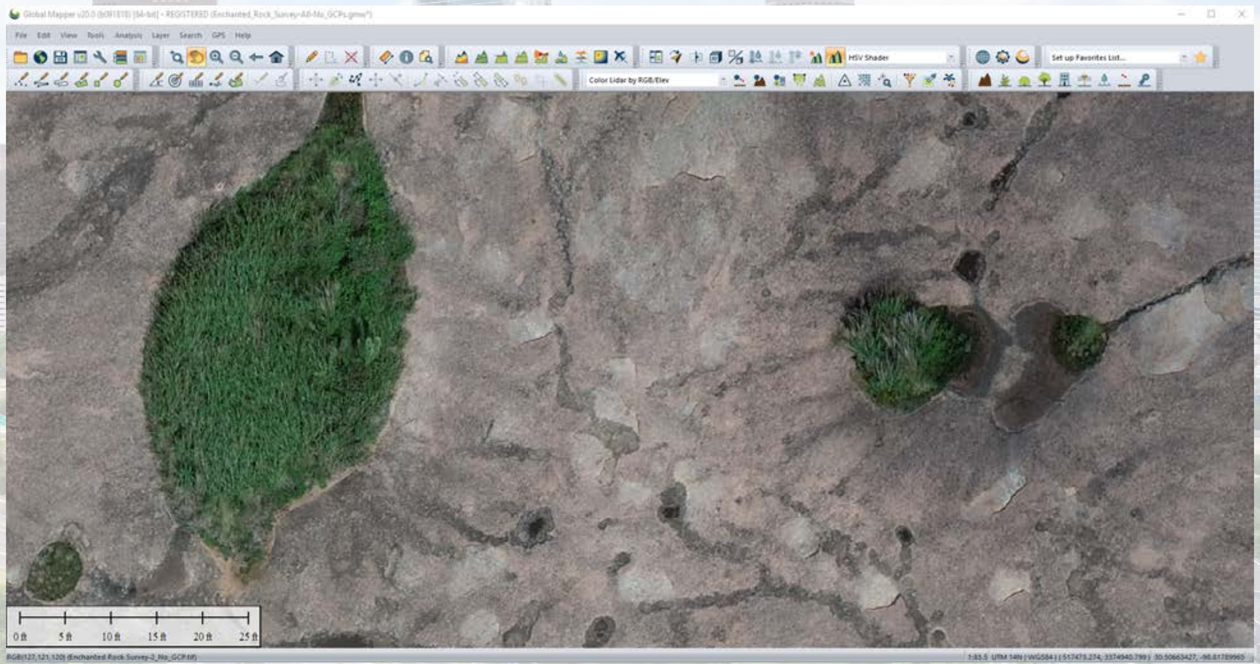
Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)

Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)

Enchanted Rock State Natural Area Fredericksburg, TX (~750 Acres)



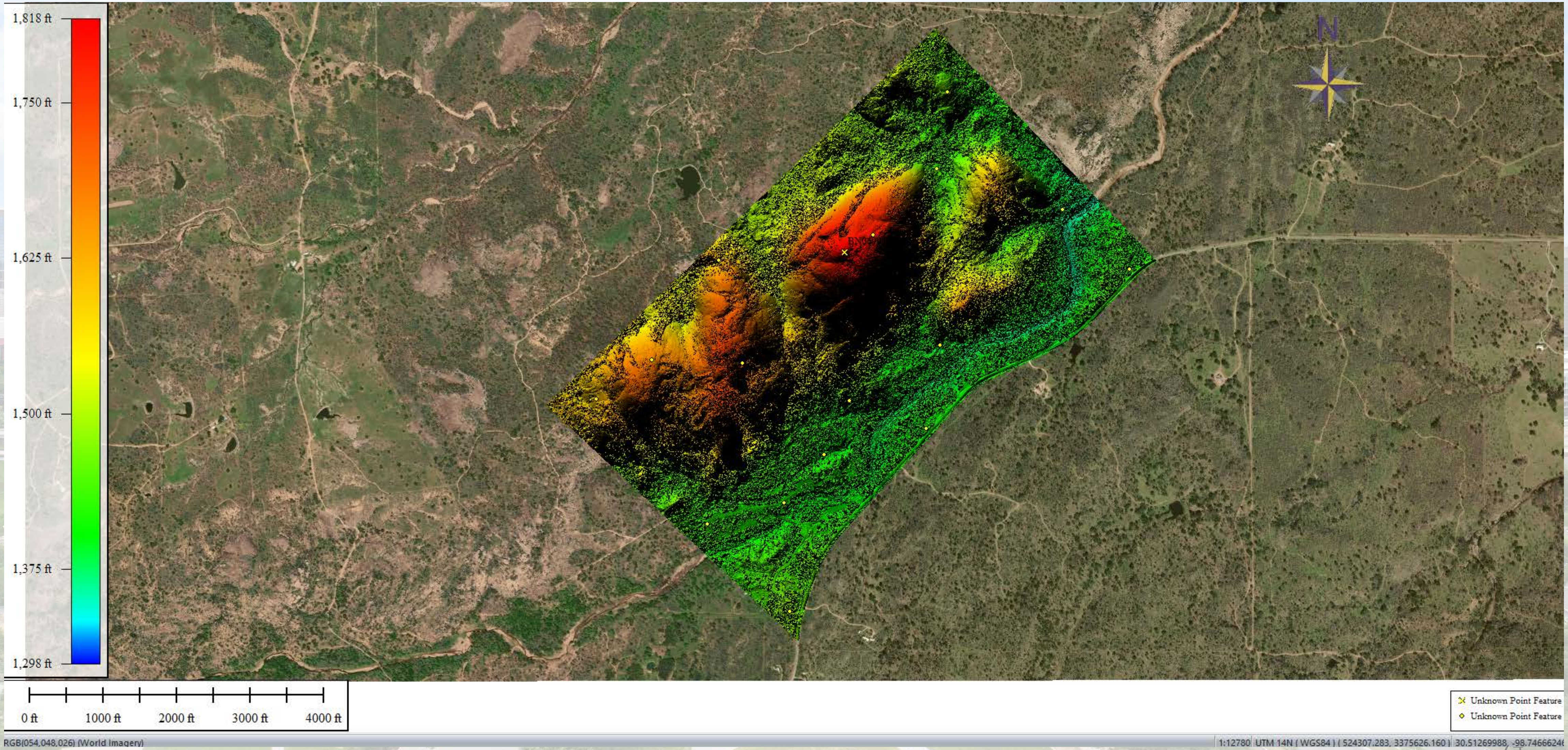
Google Earth Pro: Imagery Date: 2/23/2017



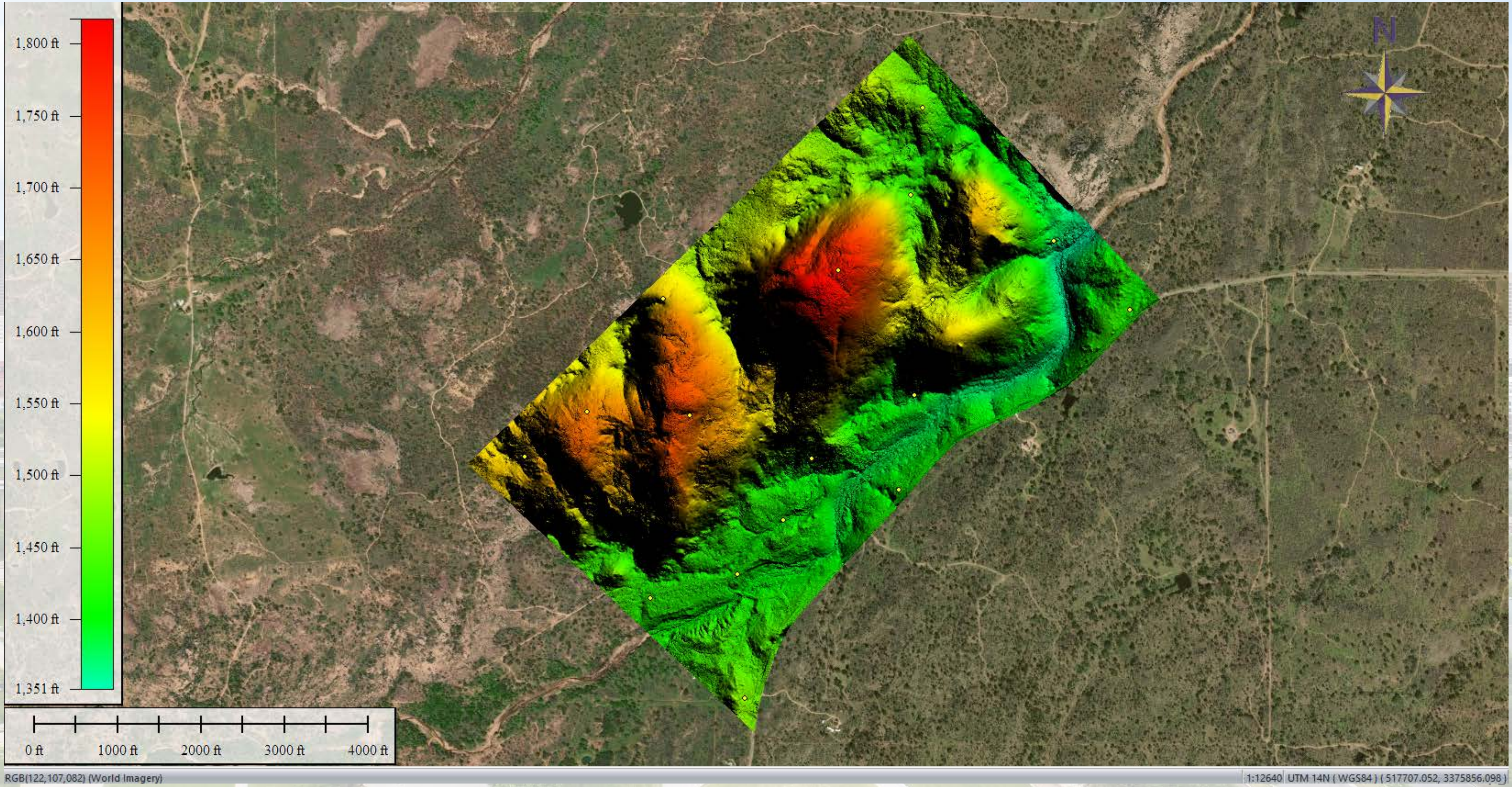
Drone Survey: Imagery Date: 9/25/2018

Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)

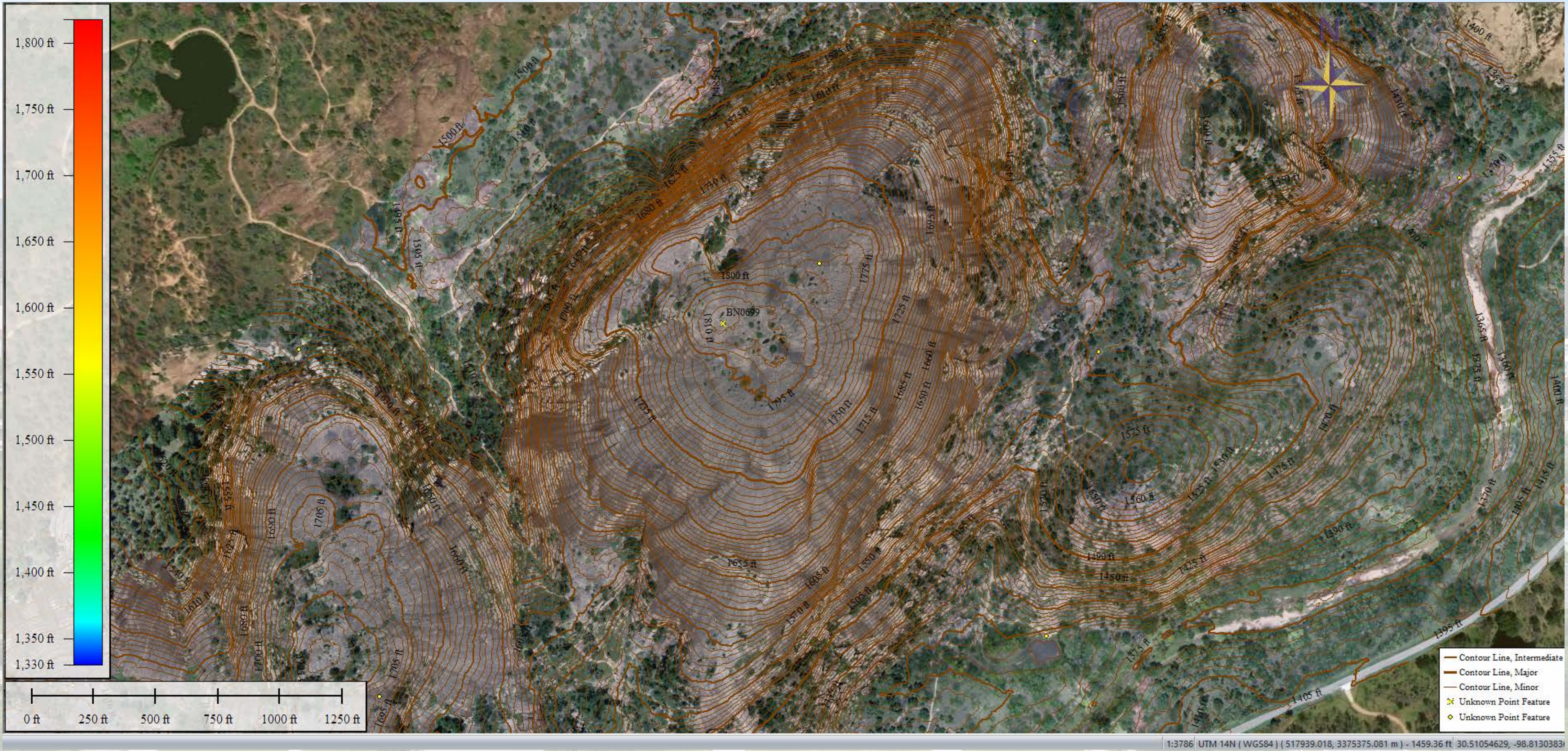
Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)



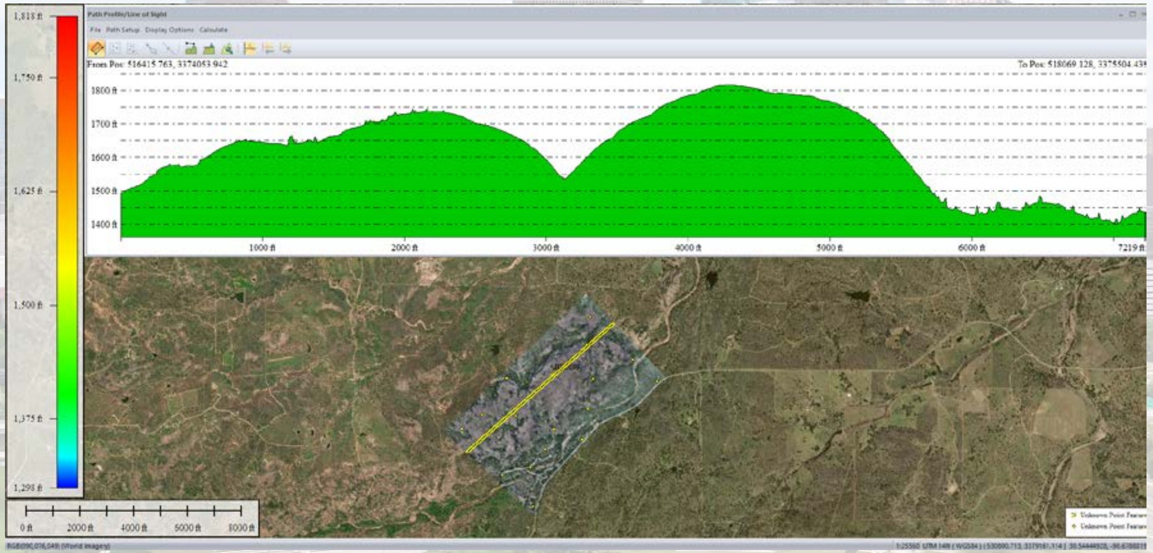
Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)

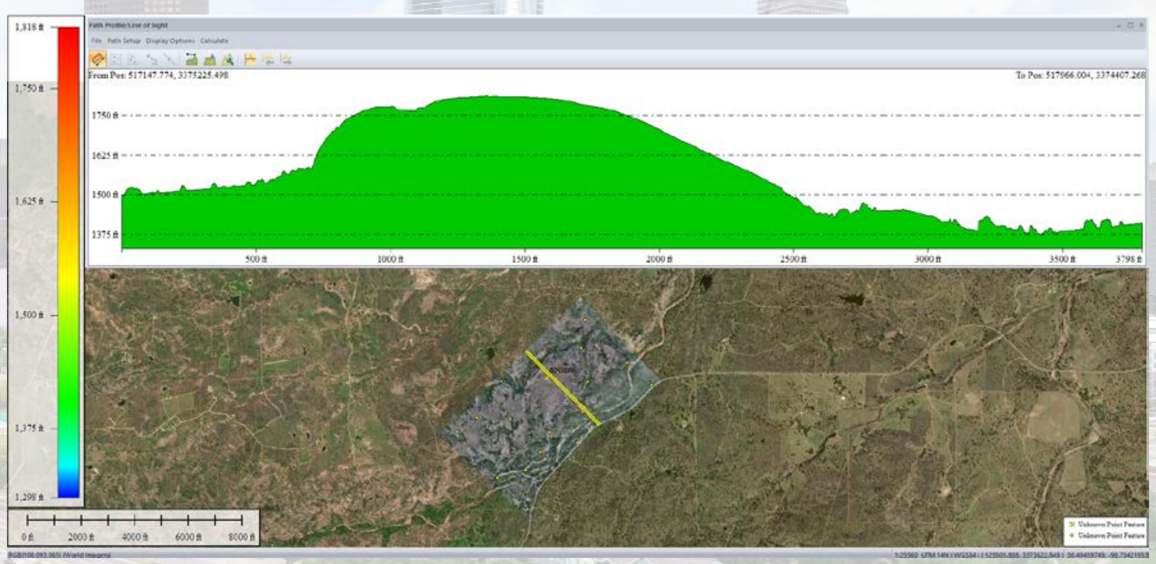


Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)



Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)





Enchanted Rock State Natural Area
Fredericksburg, TX (~750 Acres)

Results

Data has been provided to the Texas Parks & Wildlife and University of Houston Geophysics Department.

- The Park plans to use this Data for Biological Impact, Training and Planning.
- UH holds an Annual Geophysics Field Camp at Enchanted Rock. The Data will be used by Students during the Field Camp.