



# USGS - Unmanned Aircraft Systems National Project Office

[uas.usgs.gov](http://uas.usgs.gov)

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Denver, Colorado USA  
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# Outline

- **Background**
- **Current United States (FAA) UAS Aviation Policies**
- **Interest in UAS Technology**
- **Data Acquisition and Processing**
- **Missions**
- **Future**

# Department of the Interior

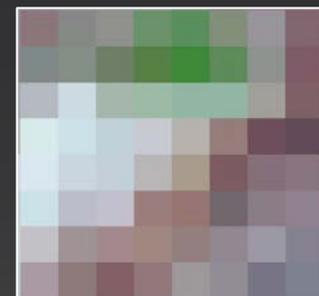
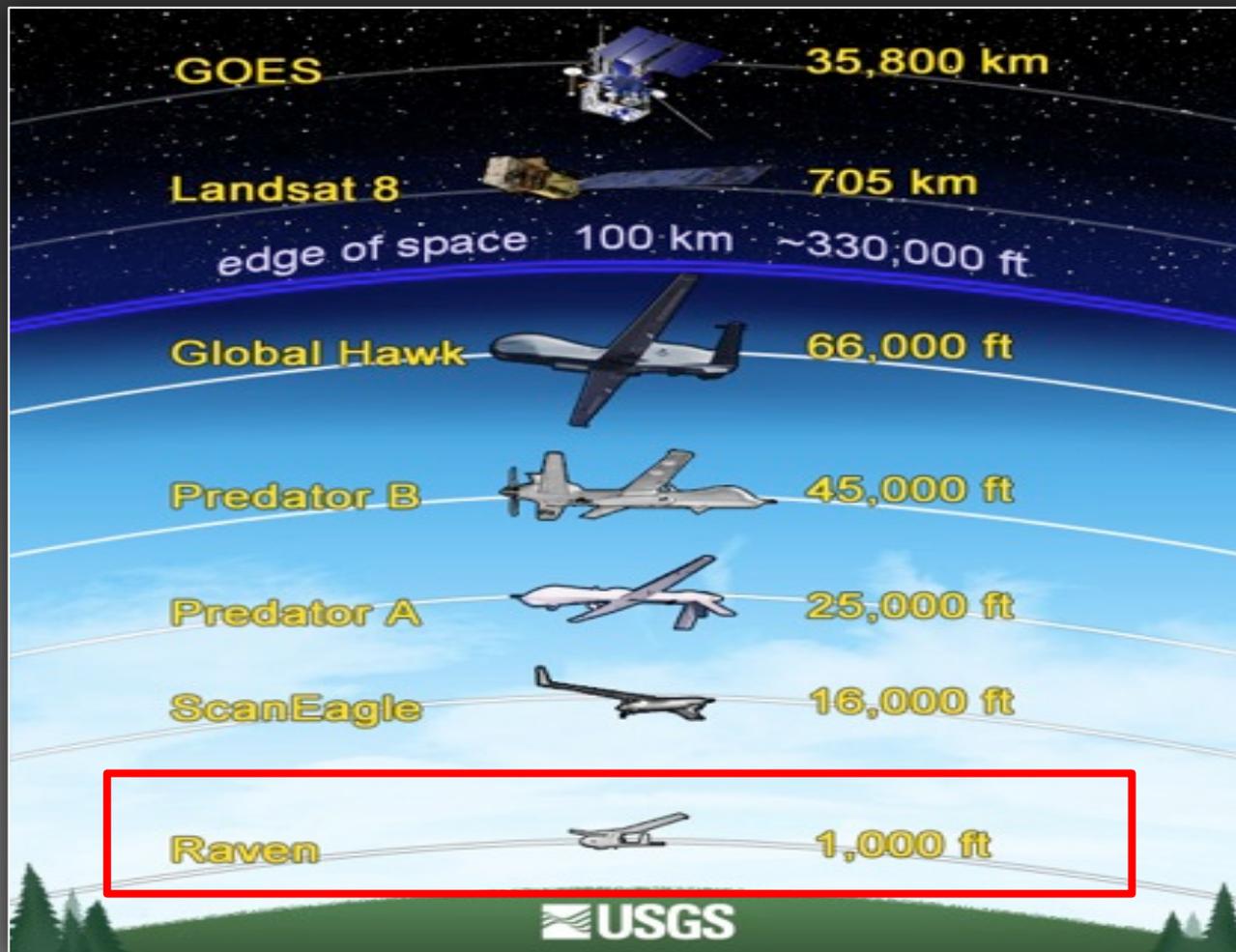


507 million acres of land - 1 out of every 5 acres in U.S. is the Dept. of the Interior's management responsibility

U.S. Geological Survey, Bureau of Land Management, Bureau of Indian Affairs, Office of Surface Mining Reclamation and Enforcement, Bureau of Reclamation, National Park Service, U.S. Fish & Wildlife Service



# Sources of Remote Sensing Data



Landsat 8 (30 meter)



NAIP 2010 (1 meter)



UAS at 400 ft (5 cm)



UAS at 200 ft (2.5cm)

Low altitude role of small UAS in data acquisition



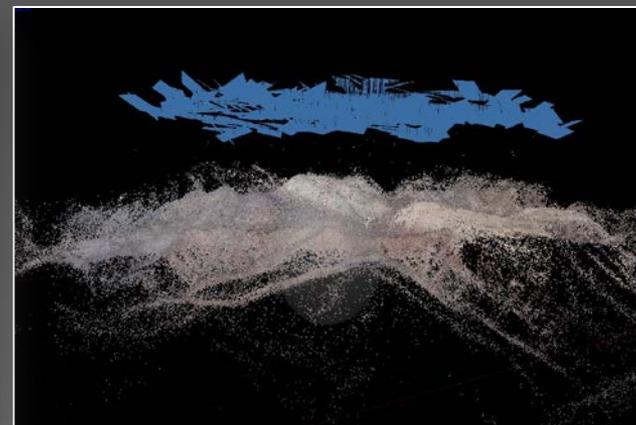
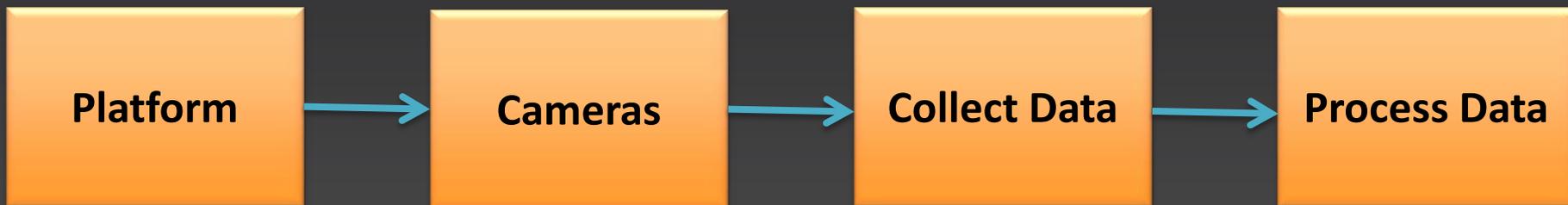
# USGS UAS Implementation Timeline

- Emerging Technology Investigations.....2004-2008
- USGS UAS National Project Office Created.....May 2008
- First Systems (Raven) Acquired.....Dec. 2009
- Operator Training.....2009-2010
- Operations in the National Airspace.....March 2011

# Why So Much Interest in UAS Technology?

- U.S. Universities involved with UAS related Programs ..... 175
  - Countries involved with UAS manufacturing..... 65
  - U.S. UAS related manufactures ..... 200
  - Global UAS related manufactures ..... 715
  - Global UAS platforms..... 2,400
- 
- AUVSI predicts 3 years after NAS integration of UAS 70,000 U.S. jobs could be created and more than \$13 Billion into the U.S. Economy

# UAS Production Process



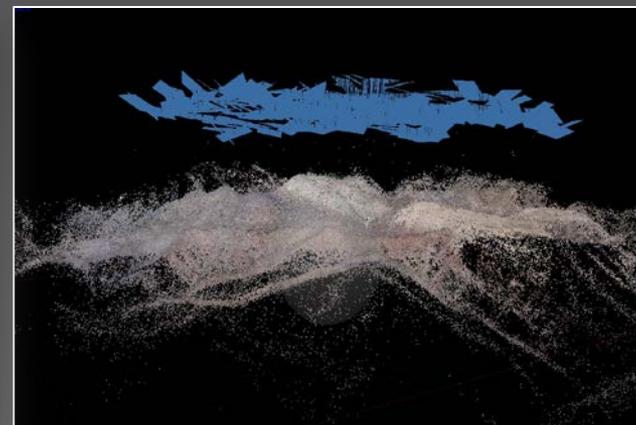
# UAS Production Process

Platform

Cameras

Collect Data

Process Data



# Policies: Who Can Operate a UAS in the United States - National Airspace System?

- Can a civilian company operate an UAS as part of a business?

Currently, civilian companies may not operate a UAS as part of a business without obtaining a Special Airworthiness Certificate - Experimental Category (SAC-EC). However, this SAC-EC is very limited in scope of operational use.  
FAA Order 8130.34

- Who can receive a Certificate of Authorization (COA) to fly a UAS in the NAS?

Only public agencies operating an unmanned aircraft.

- What is a “Public Agency”?

Any agency that operates a public aircraft (14 CFR Part 1.1)

If you receive funding from the federal government at some level, you are probably a “Public Agency.” A public agency cannot operate under the guidelines of Advisory Circular 91-57 (Model Aircraft)

# Policies: How to Operate in the United States National Airspace

- **Certificate of Authorization (COA):**
  - Authorization issues by the Air Traffic organization to a public operator for a specific UAS activity on a case-by-case basis.
- **Memorandum of Agreement (MOA):**
  - Signed Dec. 24, 2013 between the FAA and DOI-OAS
  - Information Bulletin No. 14-04
    - under 400'
    - line of sight
    - 5 miles from an airport
- **Dept. of the Interior - UAS Operational Procedures (OPM) No. 13-11:**
  - DOI-OAS outline procedures of how to operate UAS in the NAS

# Policies: How to Operate in the United States National Airspace

- **Spectrum:**
  - Currently on military frequencies
  - Future: On a civilian government frequencies or encrypted public freq.
- **Range or private owner approvals:**
  - Dept. of the Interior guidelines ask that we get the range (refuge, park management agency) and/or private land owner approvals
- **Airworthiness:**
  - Annual check of the systems by DOI-OAS for individual aircraft airworthiness
  - American Society for Testing & Materials (ASTM) International (Committee F38) [www.astm.org](http://www.astm.org)
  - NASA testing

# Policies: How to Operate in the United States National Airspace

- NOTAMs & Notices:

- Must issue a Notice to Airmen at least 48 hrs. in advance (COA or MOA)
- Contact the nearest Air Traffic Control Tower and Military Base if necessary

- UAS Operators

- Currency – have flown or been on a simulator in the past 90 days
- Proficiency – must be checked by an OAS instructor once a year
- Class 2 Medical – good for one year as issued by FAA approved physician

# Current U.S. Dept. of the Interior UAS Platforms

## AeroVironment – Raven RQ-11 A



Wing Span	55 inches
Air Vehicle Weight	4.2 lbs
Range	10+ km (LOS)
Airspeed	27-60 mph
Altitude	>400 AGL
Endurance	90 min Lithium Battery
Payload	EO/IR Full Motion Video
	GPS- Radio uplink & down link
GCS/RVT	- Combined Weight – 14 lbs

## Honeywell – T-Hawk RQ-16



AV Weight	18 lbs
UAS System Weight	51 lbs
Range	10 km
Endurance	47 minutes - Gas Powered
Payload	EO/IR Sensor
Max Speed	45 mph
Flight Characteristics	Hover and Stare Capable

# Cameras/Sensors

## Existing:

- Natural Color Video
- Thermal IR Video



## Current Enhancements:

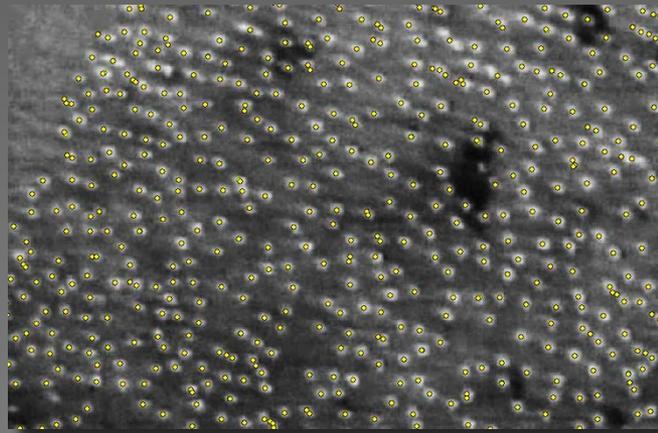
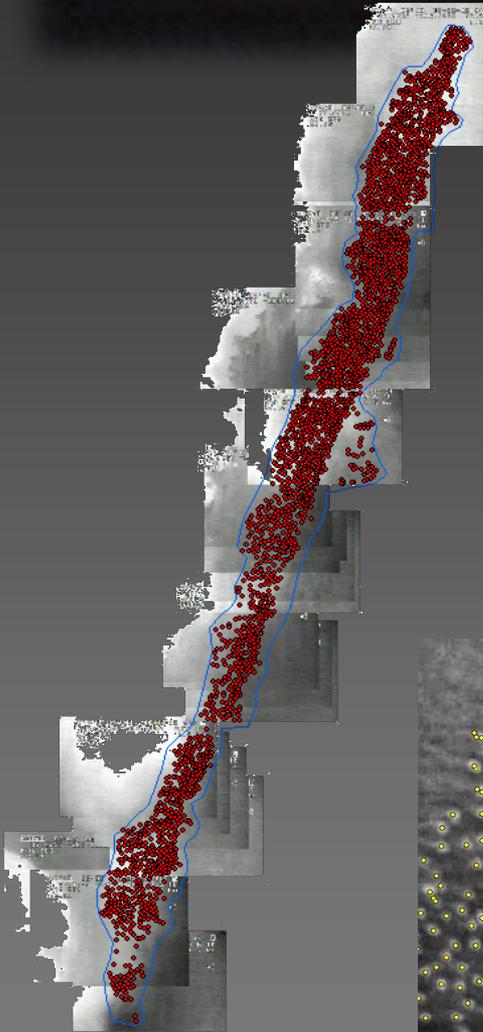
- GoPro Hero 2 & 3 - 1080P HD camera (still frame and video)
- Canon SX260HS & S100 – GPS enabled (RGB and IR) – CHDK
- Sony ActionCam – GPS enabled



# Sandhill Crane Population Estimates

Monte Vista, Colorado – First UAS Mission in NAS

March 2011



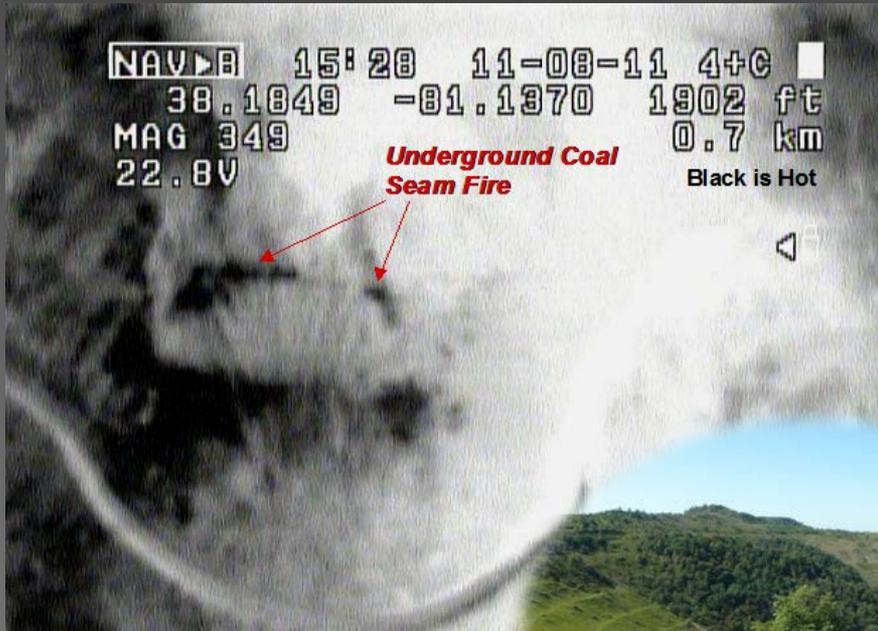
Developing methods to estimate Sandhill Crane abundance for natural resource management.



Execution of this UAS mission cost \$2,645, compared to similar fixed wing manned aircraft surveys that cost \$4,310 up to \$35,000 if contracted privately.

# Mine Inspections

West Virginia



Raven Thermal IR

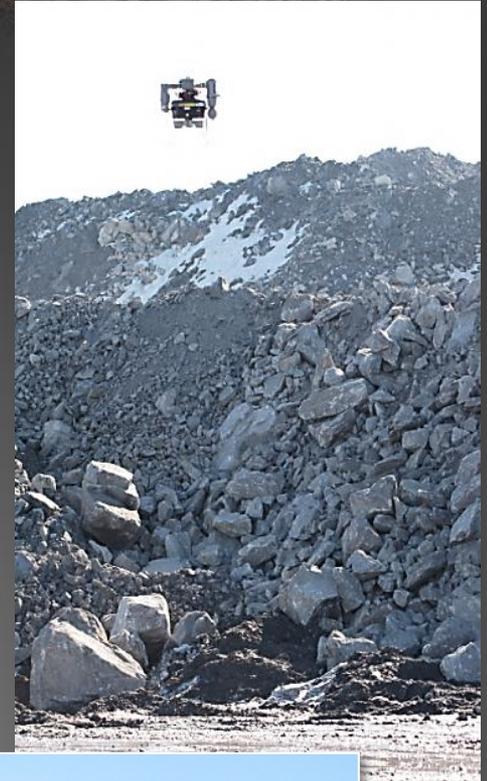


Raven video natural color

# Mine Inspections

West Virginia – First T-Hawk Mission in the NAS – Nov. 2012

Mine permit inspections monitoring a range of topics:  
water quality, hazardous conditions, terrain topology, wildlife  
habitats, erosion, check dams, and post mining land use





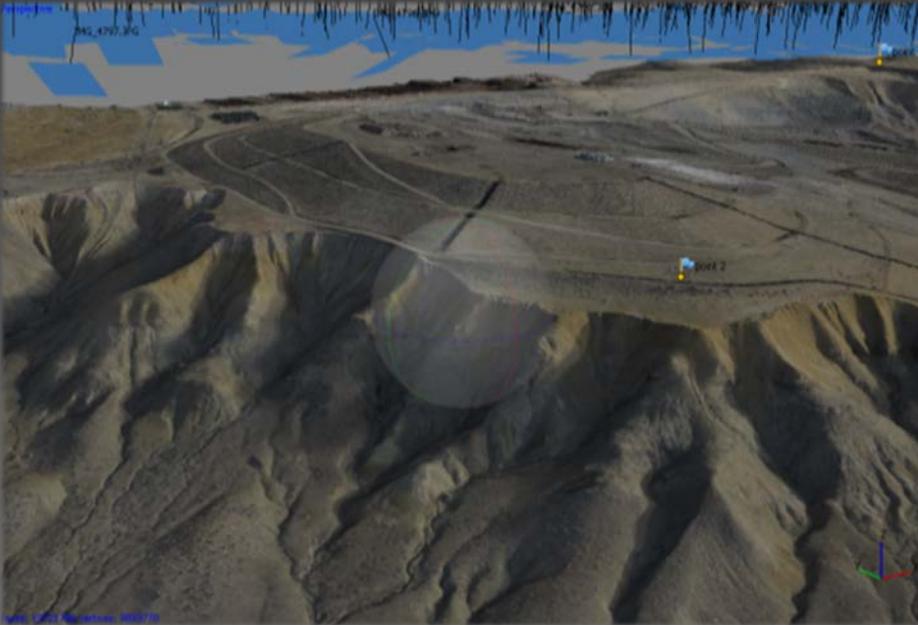
# Gravel Pit & Landfill Operations

## Volumetric Compliance Inspections

Grand Junction, Colorado – 2013



Falcon-UAS



Photogrammetric derived dense point cloud with RGB values



Orthophotography derived from 360 feet (110 m) above ground level

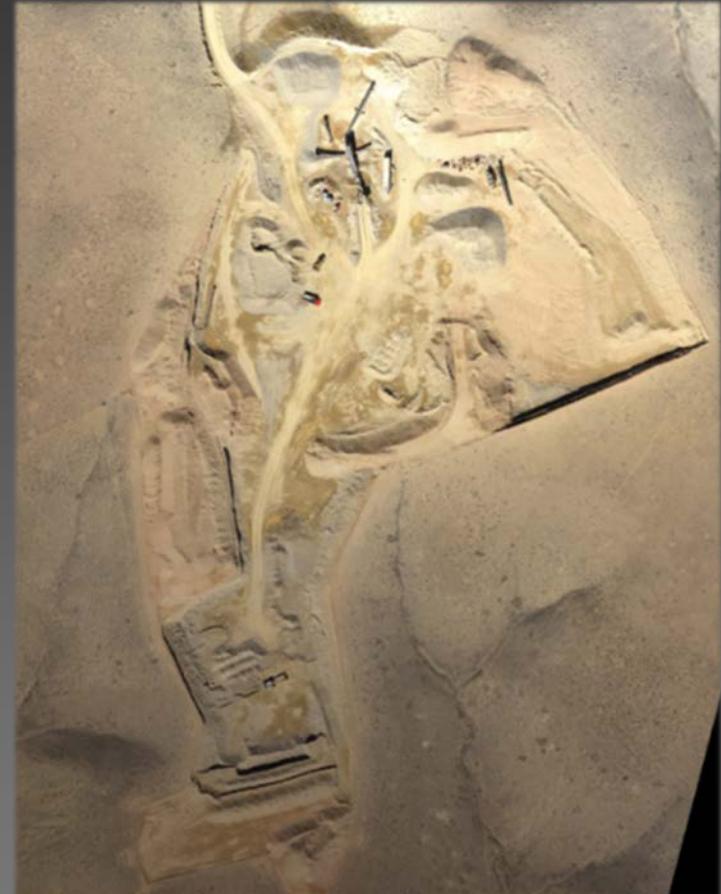
# Gravel Pit & Landfill Operations

## Volumetric Compliance Inspections

Grand Junction, Colorado – 2013



Digital Elevation Model Hillshade



Orthophotography

(3.2cm resolution – 481 images)



### Cost Effectiveness:

Traditional Aerial Photography.....\$10,000

UAS Mission.....\$300

# Debeque Landslide

Debeque, Colorado



June 2013



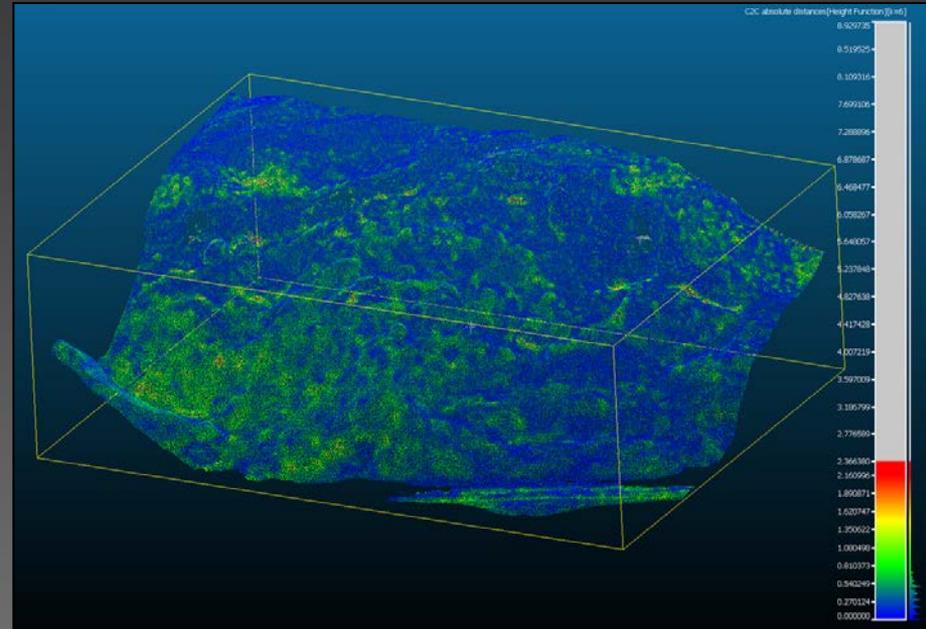
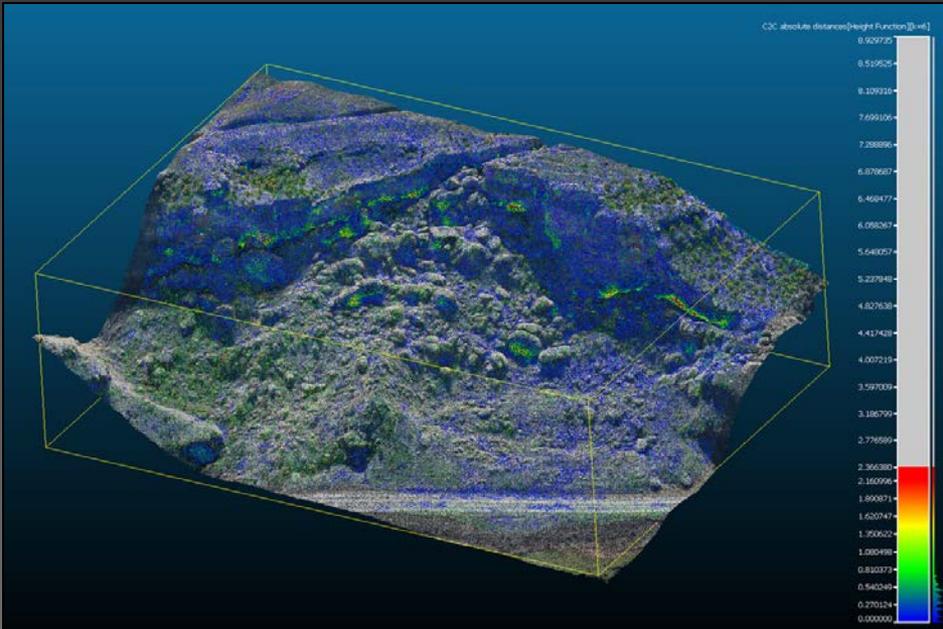
October 2013

Temporal series of Landslide models monitoring geomorphic processes.



# Debeque Landslide

Debeque, Colorado



Point cloud comparison and calculations (using Cloud Compare)

Green indicates possible movement

# Pleistocene Trackway Mapping

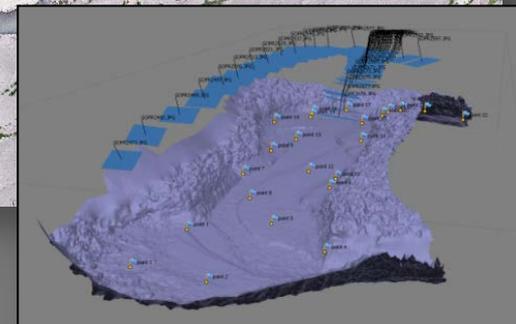
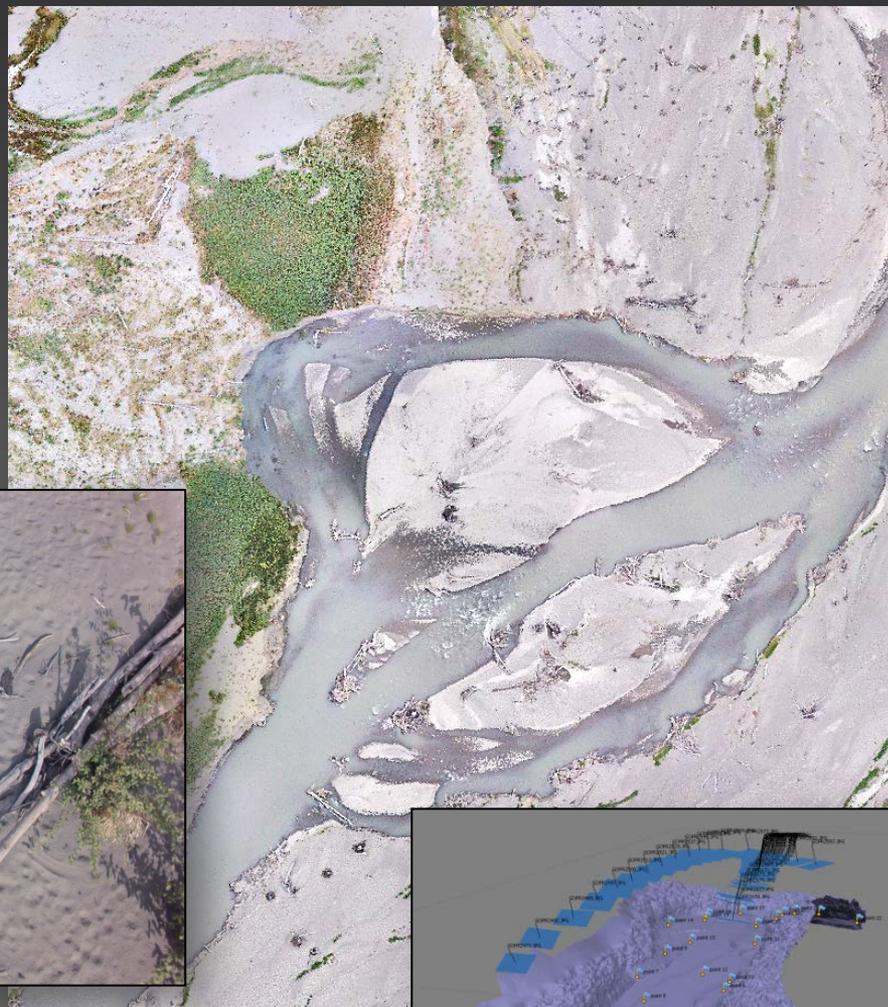
White Sands National Monument, NM January 6-10, 2014



Photogrammetric documentation using a UAS to aerial survey extremely fragile fossilized footprints from the late Ice Age.

# Elwha Dam Removal and River Restoration

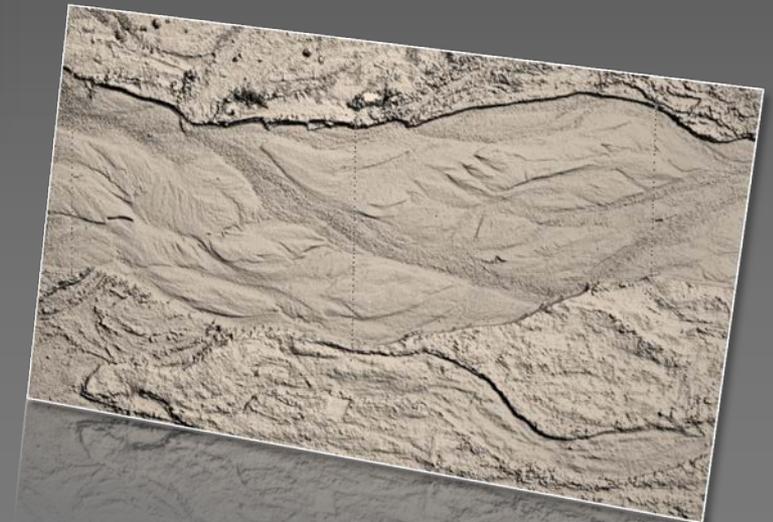
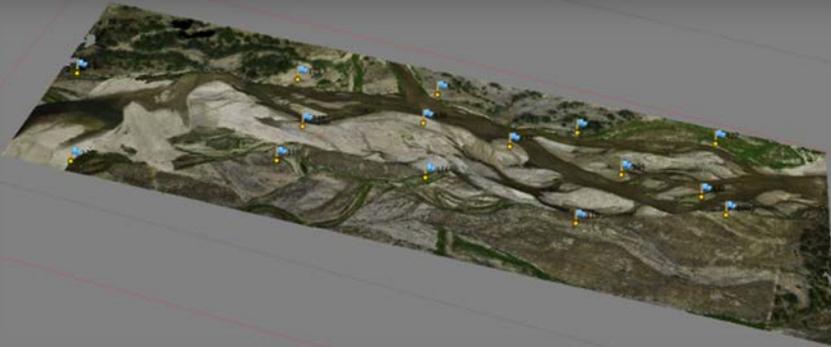
Olympic National Park, Washington



Monitoring sediment volumes eroded from the reservoir and deposited downstream, where the mobile sediment can potentially affect salmon habitat.

# Emergent Sandbar Habitats

Platte River, Nebraska



Mapping the spatial extent and elevation of emergent sandbars along two reaches of the Platte River for endangered or threatened nesting birds (least terns and piping plovers)

# Boundary/Fenceline Inspections

Haleakala National Park, Maui



Infrastructure inspections maintaining 65 miles of fence line to exclude pigs, axis deer, predatory mammals, and invertebrate threats to the native resources



# Elk Population Surveys

## Carrizo Plain, California



Elk



Raven UAS individual images from the Sony ActionCam (2mp) from 150 ft. AGL

# Pelican Nesting Habitats

Chase Lake, North Dakota June 9-13, 2014

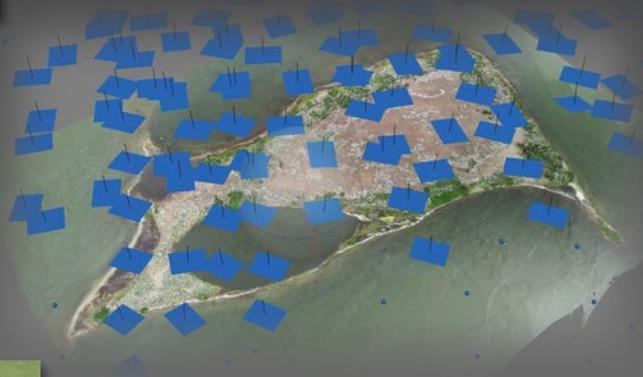


# Census of Ground-nesting Colonial Water Birds

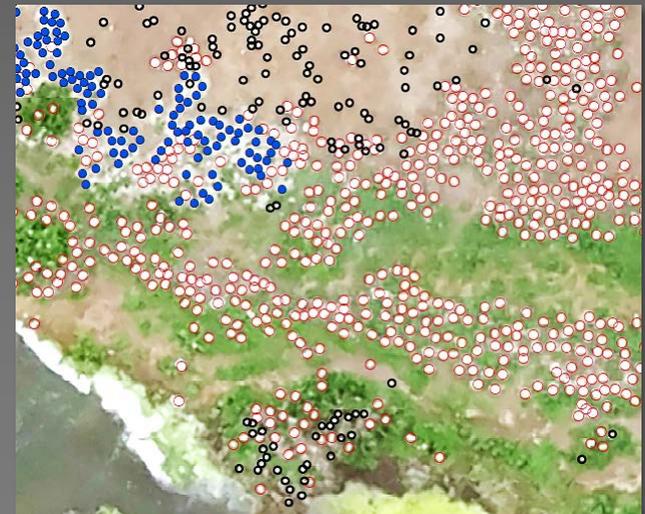
Chase Lake National Wildlife Refuge, ND June 11-12, 2014



Using UAS to aerial survey American White Pelicans, Double Crested Cormorants, Gulls and other ground nesting water birds.



Other applications included landscape change and power line surveys for bird strike detection.

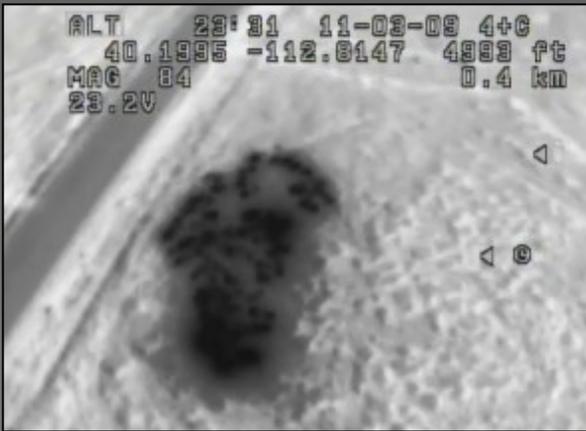


# Wildfire – Prescribed Burn

UAS Training - Dugway Proving Grounds, Utah



Electro-Optical Video of Prescribed Burn



Infrared Video of Prescribed Burn

# Geospatial Product Creation

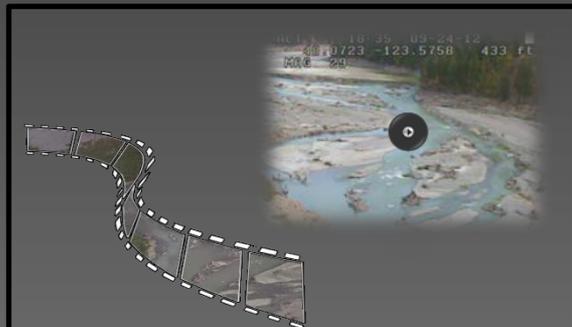
## WITH DATA ACQUIRED FROM UAS



STILL FRAME IMAGES CAPTURED ON-BOARD THE UNMANNED AIRCRAFT



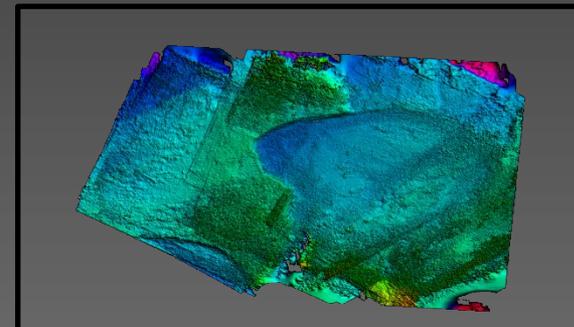
GoPro Hero2 - 11 megapixel (compressed)



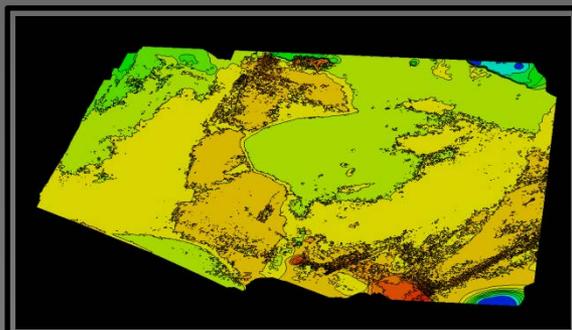
FULL-MOTION VIDEO



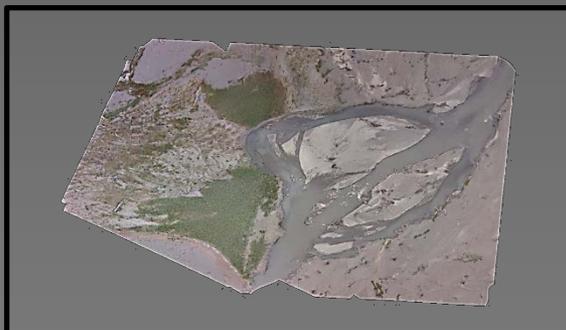
3-D POINT CLOUD DATA



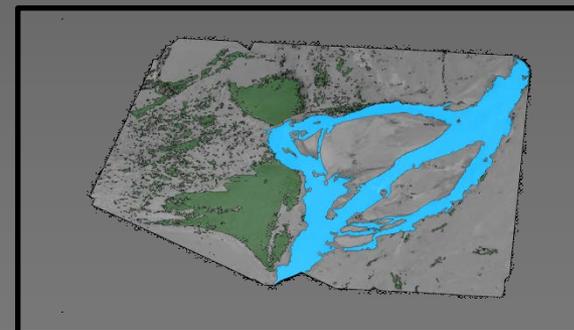
ELEVATION MODELS



ELEVATION CONTOURS



ORTHOIMAGERY

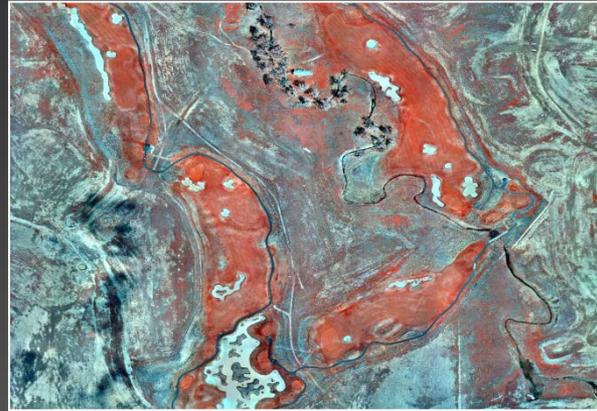


SEGMENTATION AND CLASSIFICATION

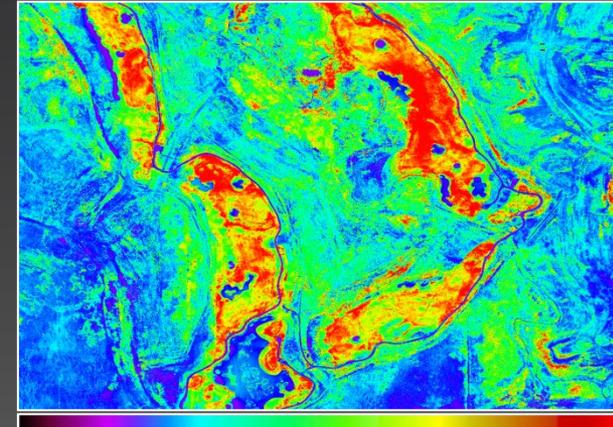
# UAS Color Infrared



2011 NAIP



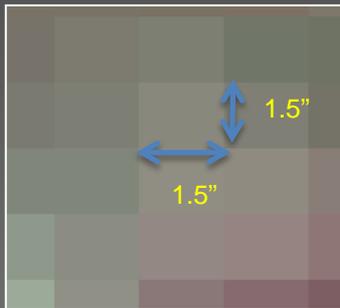
2013 UAS CIR



NDVI Low

2013 UAS NDVI

NDVI High



1.5 inch ground sample distance  
from 400 feet above ground level

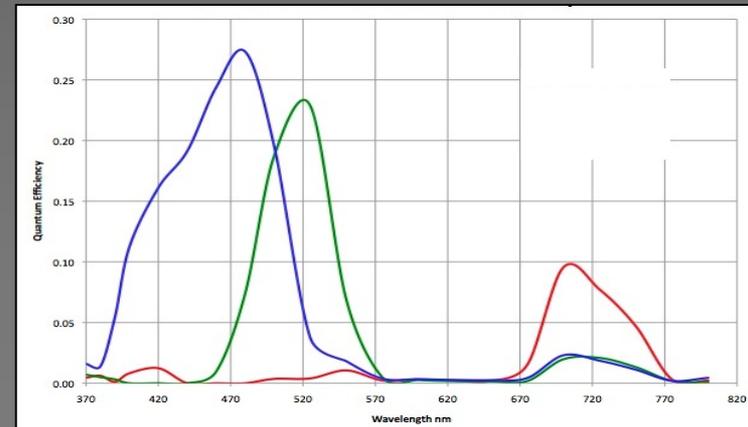


Camera	Canon Powershot SX230 						
<b>Camera Inputs:</b>	FL (mm)	Img wtdh (pix)	Image hgt (pix)	Sensor wtdh (mm)	Sensor hgt (mm)	Pix Size (wtdh)	Pix Size (hgt)
	5	4000	3000	6.17	4.55	0.0015	0.0015
<b>Calculations:</b>	GSD wtdh (cm)	GSD hgt (cm)	GSD wtdh (inches)	GSD hgt (inches)	Photo wtdh (ft)	Photo hgt (ft)	
100 ft	0.94	0.92	0.37	0.36	123.4	91.0	
200 ft	1.88	1.85	0.74	0.73	246.8	182.0	
300 ft	2.82	2.77	1.11	1.09	370.2	273.0	
400 ft	3.76	3.70	1.48	1.46	493.6	364.0	



Canon Powershot SX260 and S100

$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$



# UAS Data Processing

Color Infrared & Normalized Difference Vegetation Index (NDVI)

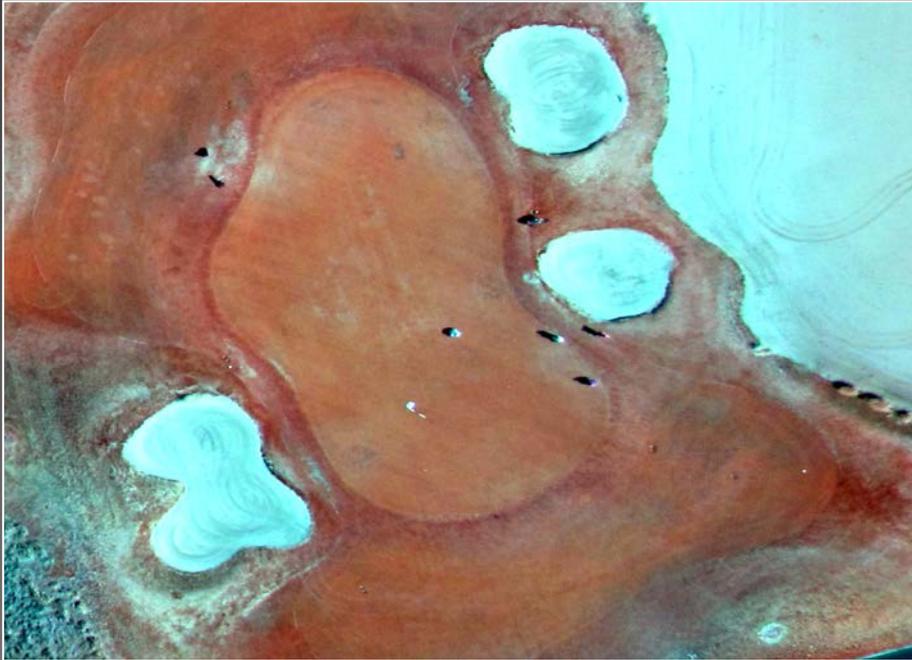
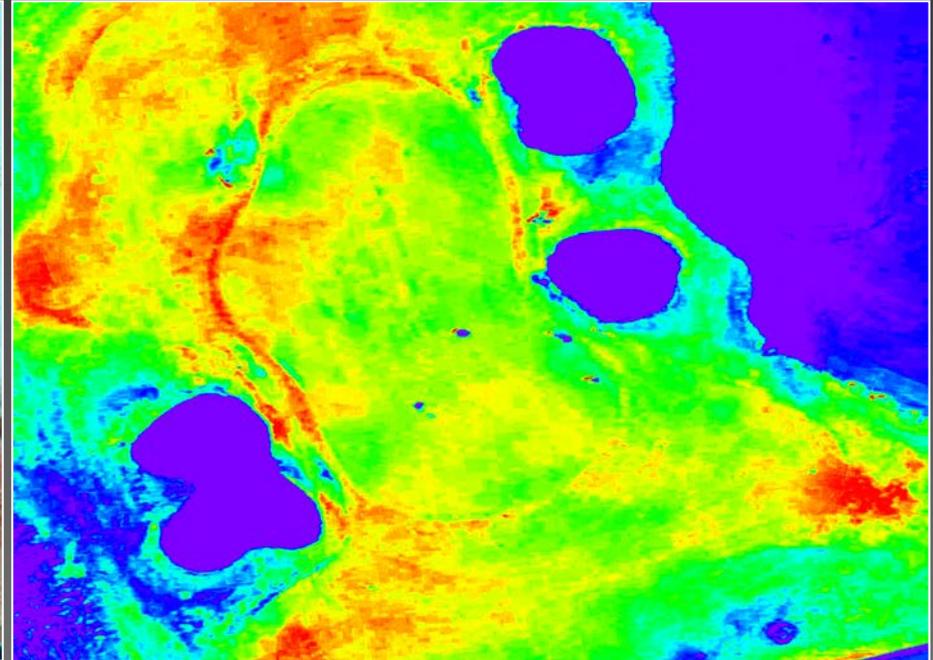


Image collected from UAS – Canon SX230 HS – 400'



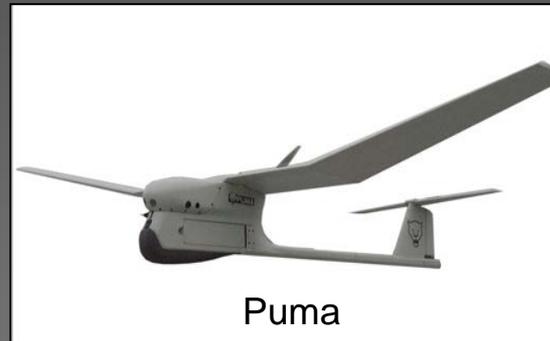
$$\text{NDVI} = \frac{(\text{NIR} - \text{VIS})}{(\text{NIR} + \text{VIS})}$$

# Possible New Platforms

## VTOL



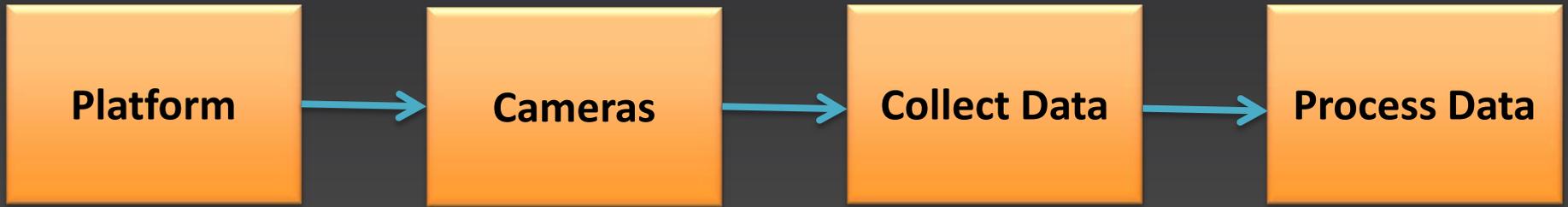
## Fixed Wing



## Micro



# UAS Production Process



\$1,000



\$20,000



\$30,000-\$50,000



\$300



\$2,000 - \$25,000



Collect Data

\$25 - \$75/hr

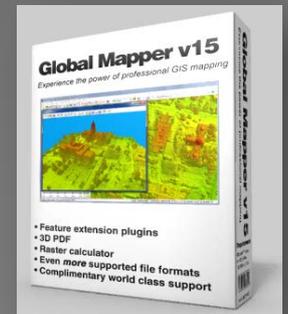


Process Data

\$3,000



\$400



# Future

- Updated RoadMap (Published Open File Report)
- New, better, more versatile, lower cost UAS platforms
- Work on airworthiness standards acceptable to FAA and OAS
- Working with Universities to stay up on latest technology
- Would like a DOI contract mechanism for tapping other UAS technology
- Continue to support proof-of-concept missions
- Continually looking at new sensors
- More emphasis on the end data products vs. the platforms

# USGS UAS National Project Office Contacts



## Our Team

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