



# USGS - Unmanned Aircraft Systems National Project Office

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

Jeff Sloan  
USGS-Geosciences & Environmental Change Science Center  
UAS National Project Office  
Denver, Colorado USA  
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# Outline

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

# Department of the Interior

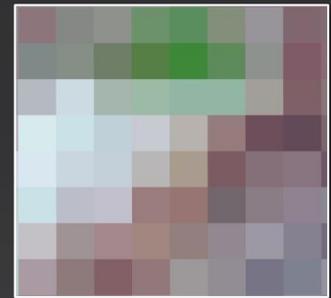


507 million acres of land - 1 out of every 5 acres in U.S. is the Dept. of the Interior's management responsibility

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

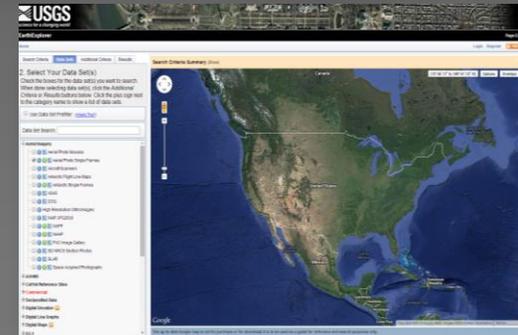
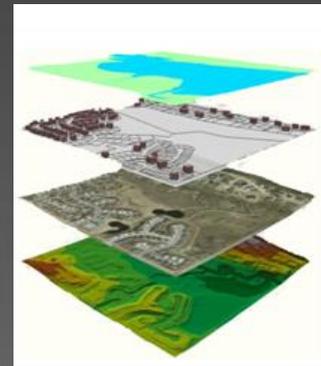
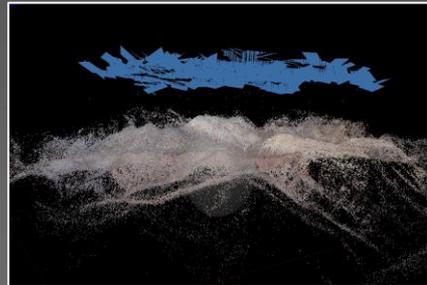
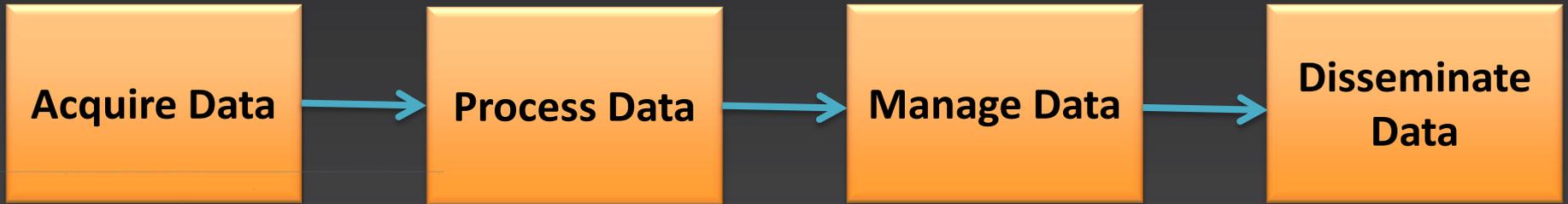


# USGS UAS Implementation Timeline



- 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

# UAS Production Process



# 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
  - ASTM International (Committee F38) [www.astm.org](http://www.astm.org)

# 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
- Ricoh GR – no GPS



# Wildfire – Prescribed Burn

UAS Training - Dugway Proving Grounds, Utah



Electro-Optical Video of Prescribed Burn

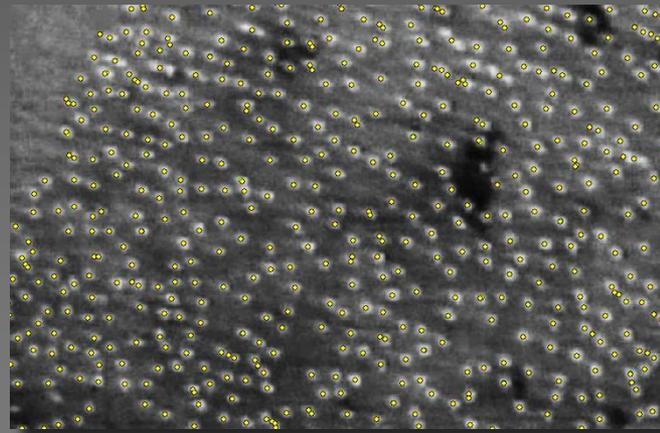


Infrared Video of Prescribed Burn

# Sandhill Crane Population Estimates

Monte Vista, Colorado – First UAS Mission in NAS

March 2011



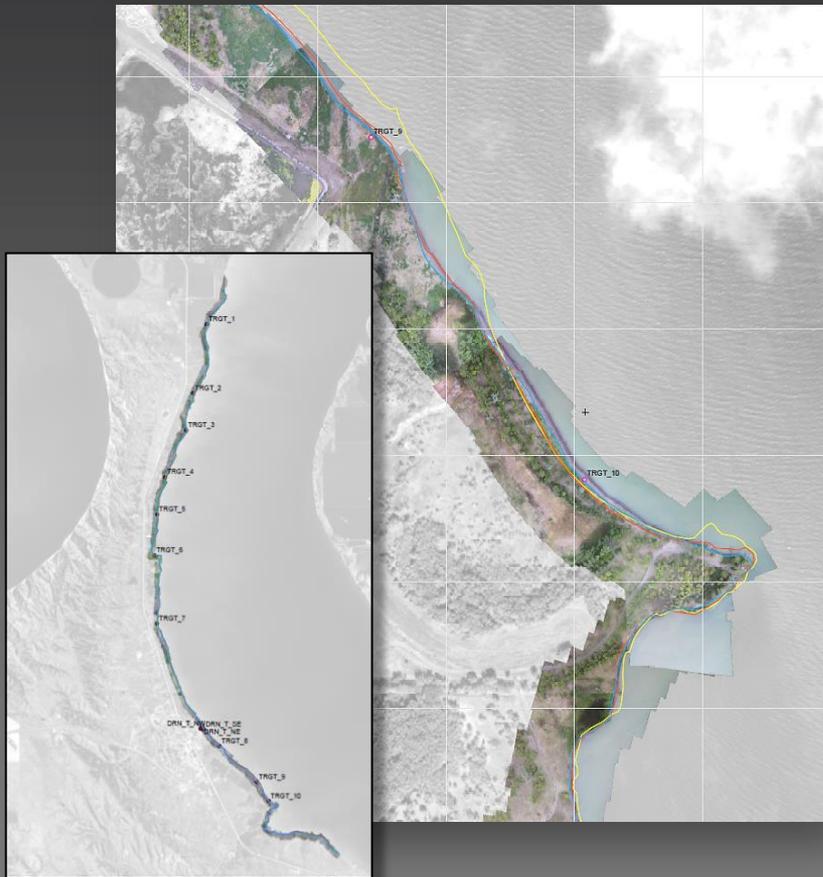
Developing methods to estimate Sandhill Crane abundance for natural resource management.



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.

# Missouri River Erosion

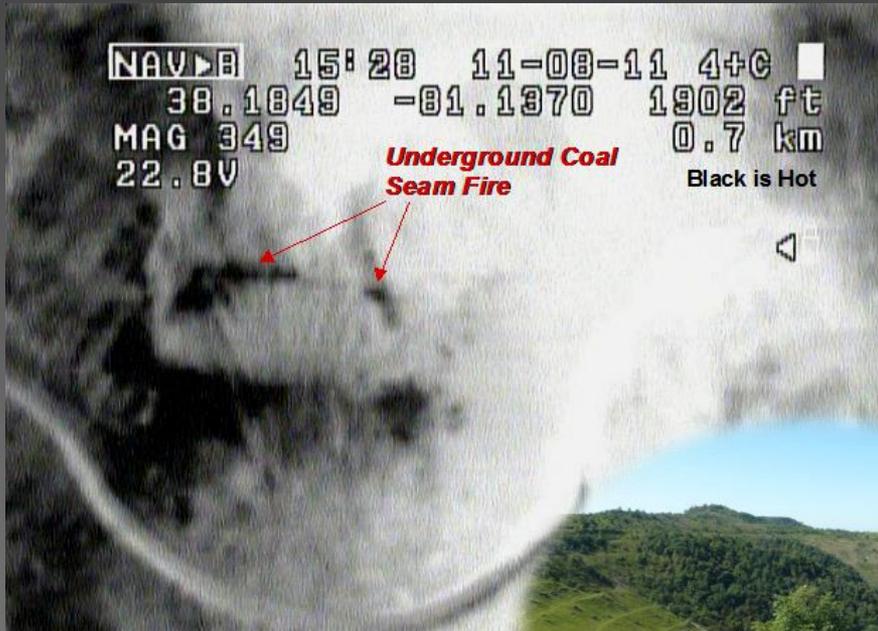
Lower Brule, South Dakota



Monitoring erosion rates of the Missouri River over a 7 mile stretch near Lower Brule. Stretches of the river have seen high rate of bank loss of up to 8 feet per year.

# Mine Inspections

West Virginia



Raven Thermal IR



Raven video natural color

# Abandoned Mine Land Surveys

Pitkin County, Colorado - Sept. 2012

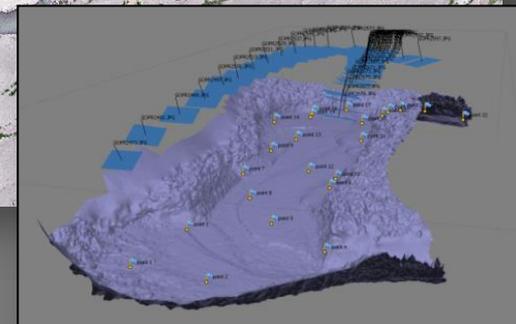
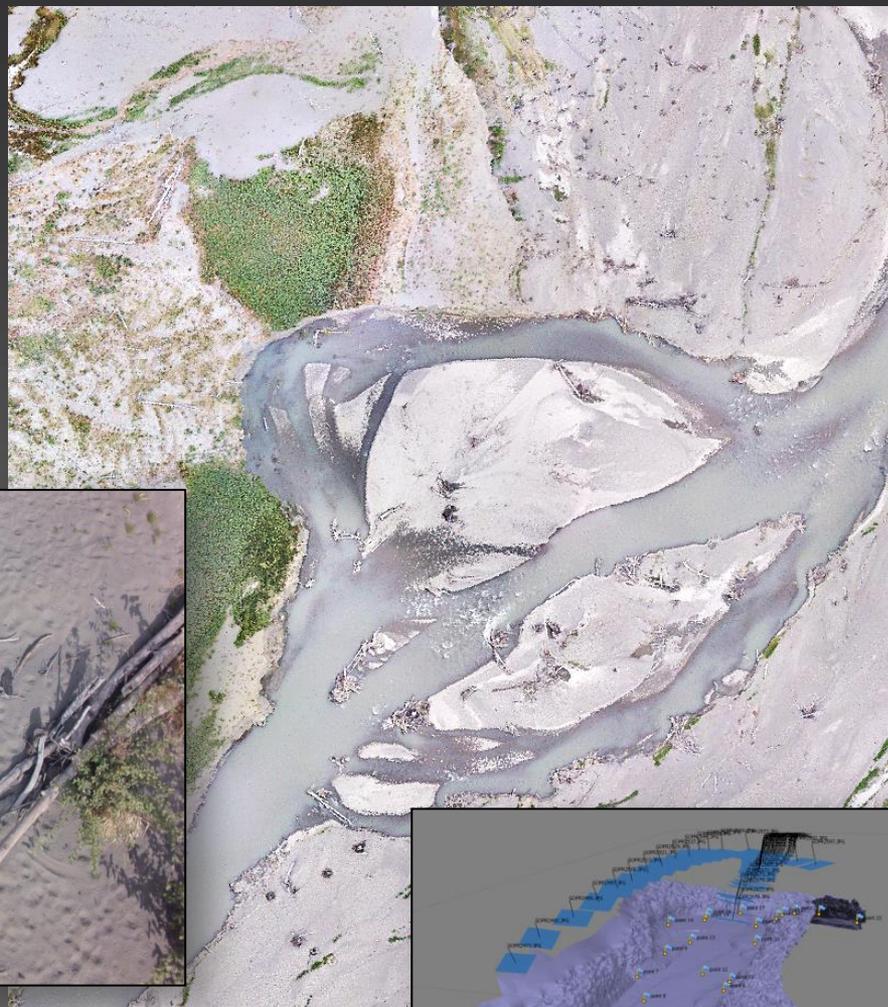
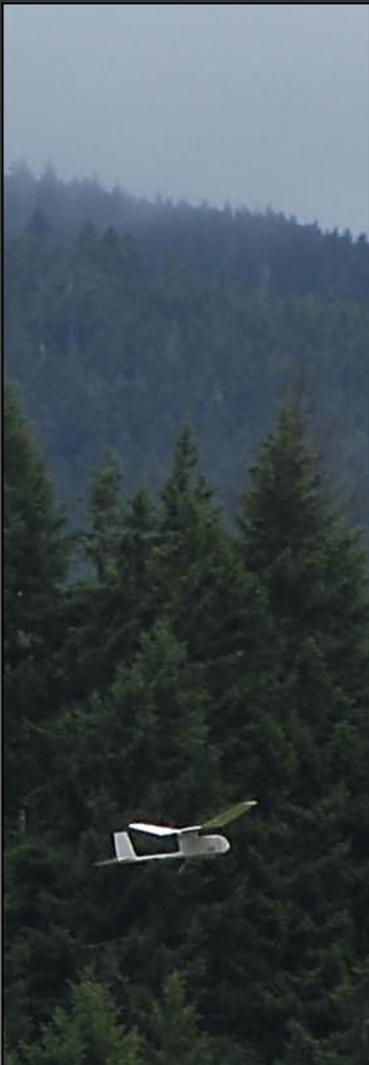


Inspecting abandon mine lands (AML) for Safety, hazards, erosion, and surface instability.



# 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.

# Boundary/Fenceline Inspections

Haleakala National Park, Maui

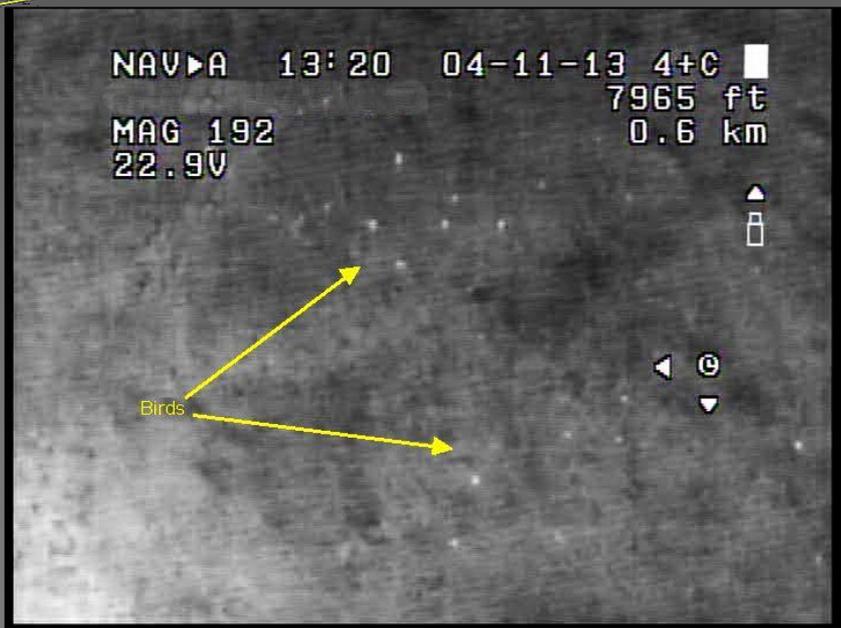
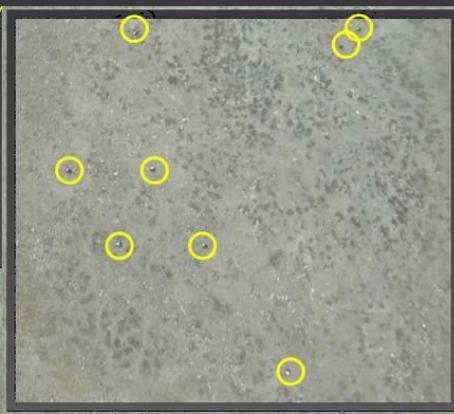


Infrastructure inspections maintaining 65 miles of fence line to exclude pigs, axis deer, predatory mammals, and invertebrate threats to the native resources



# Sage Grouse Population Estimates

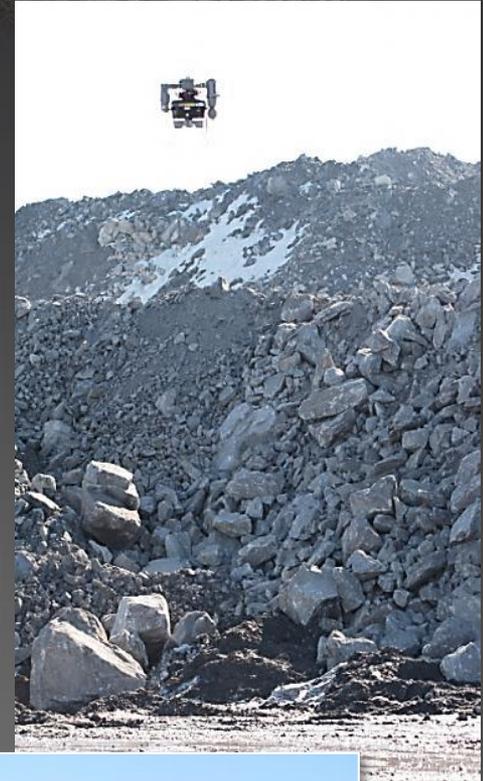
North Park, Colorado



# Mine Inspections

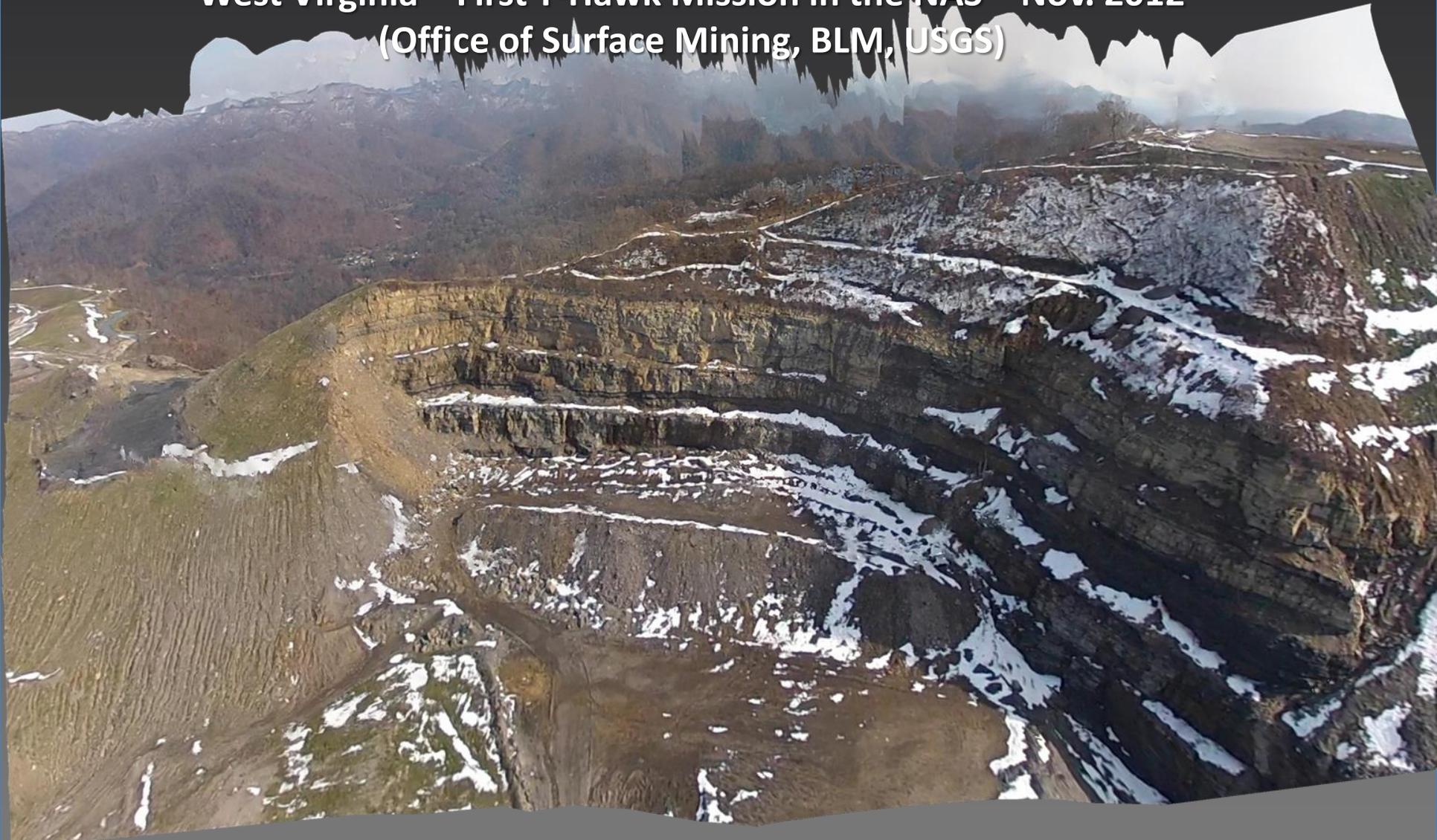
West Virginia – First T-Hawk Mission in the NAS – Nov. 2012  
(Office of Surface Mining, BLM, USGS)

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



# Mine Inspections

West Virginia – First T-Hawk Mission in the NAS – Nov. 2012  
(Office of Surface Mining, BLM, USGS)



# Debeque Landslide

Debeque, Colorado



June 2013



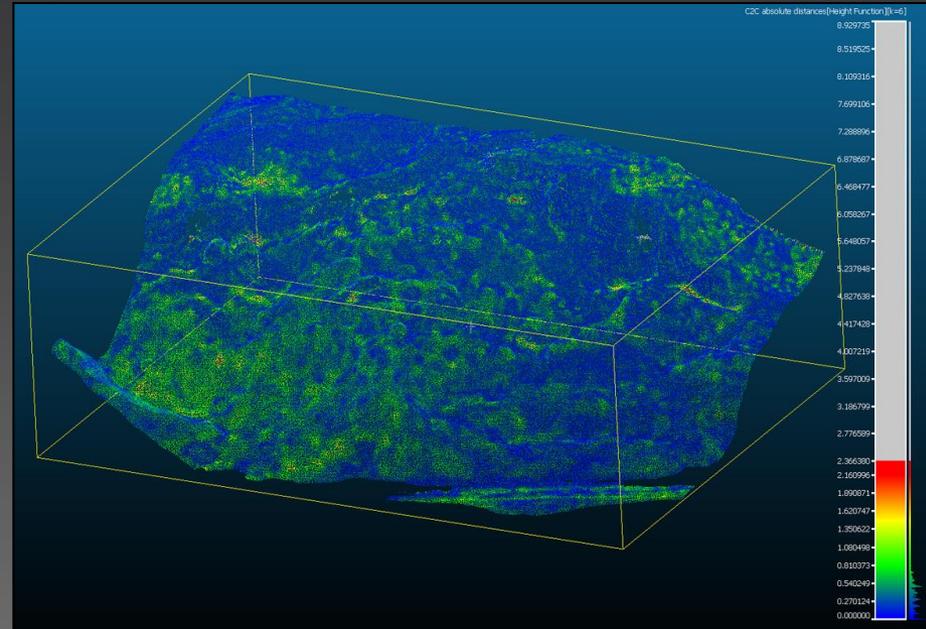
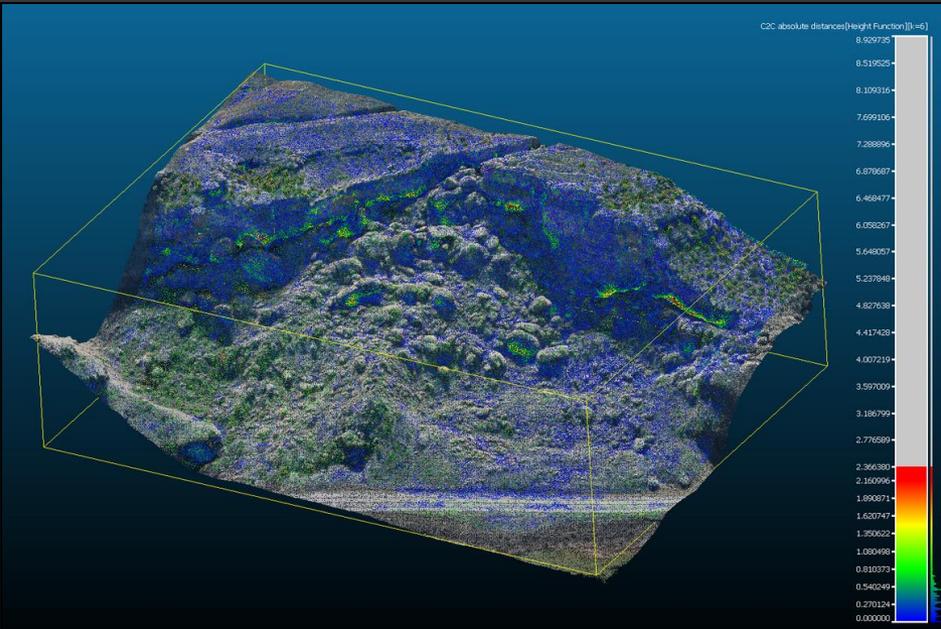
October 2013

Temporal series of Landslide models monitoring geomorphic processes.



# Debeque Landslide

Debeque, Colorado

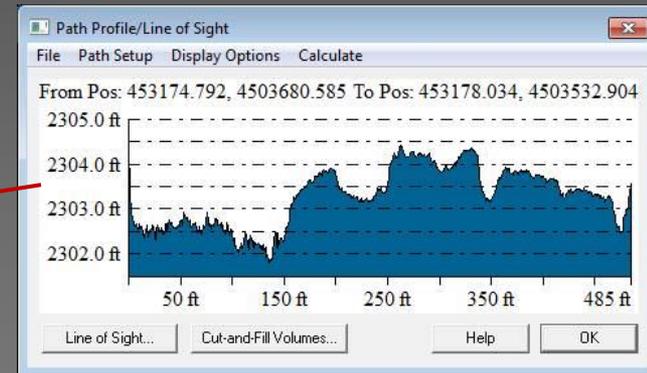
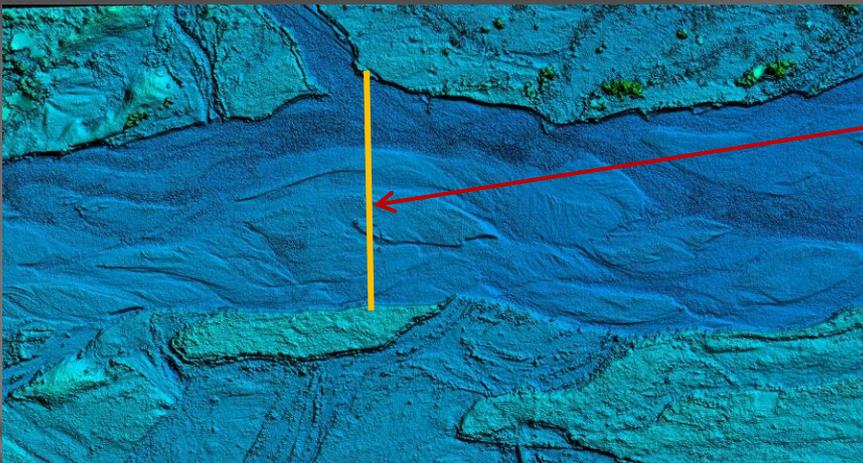


Point cloud comparison and calculations (using Cloud Compare)

Green indicates possible movement

# 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)

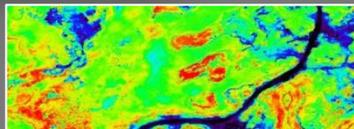
# Waterfowl & Habitat Surveys

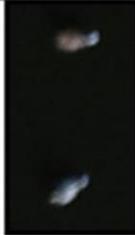
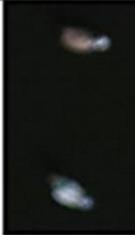
Ruby Lake, NV – Kern/Pixley, CA – Tomalas Bay, CA



Generating a census for waterfowl populations and determining individual species. Developing an UAS image library for waterfowl identification and mapping habitat.

From 1937 to 2000, 66% of all field biologist fatalities in DOI were aviation-related.



15 cm ZOOM					
Elevation (MASL)	158	138	120	102	85
M above ground	90	70	52	34	17
Ft above ground	295	229	170	112	56
Mallard					

# Pleistocene Trackway Mapping

White Sands National Monument, NM January 6-10, 2014  
(BLM & NPS)



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

# Elk Population Surveys

## Carrizo Plain, California



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

# Pelican Nesting Habitats

Chase Lake, North Dakota June 9-13, 2014



# Pelican Nesting Habitats

Chase Lake, North Dakota June 9-13, 2014



Power Line – Pelican - Bird Strike



Pelicans, Egrets, Cormorants

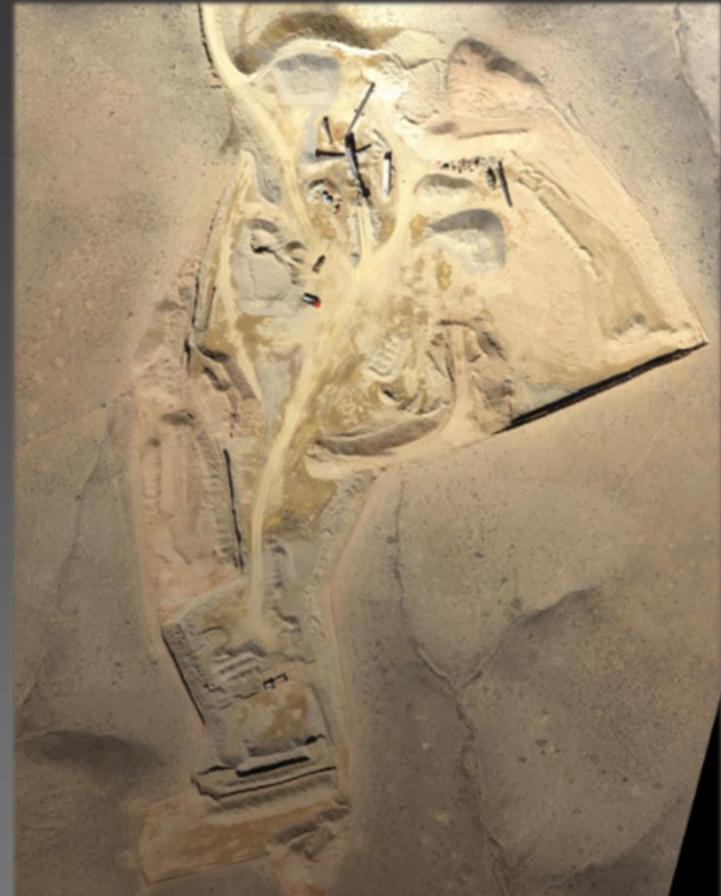
# Gravel Pit & Landfill Operations

## BLM Volumetric Compliance Inspections

Grand Junction, Colorado – 2013



Digital Elevation Model Hillshade



Orthophotography

(3.2cm resolution – 481 images)



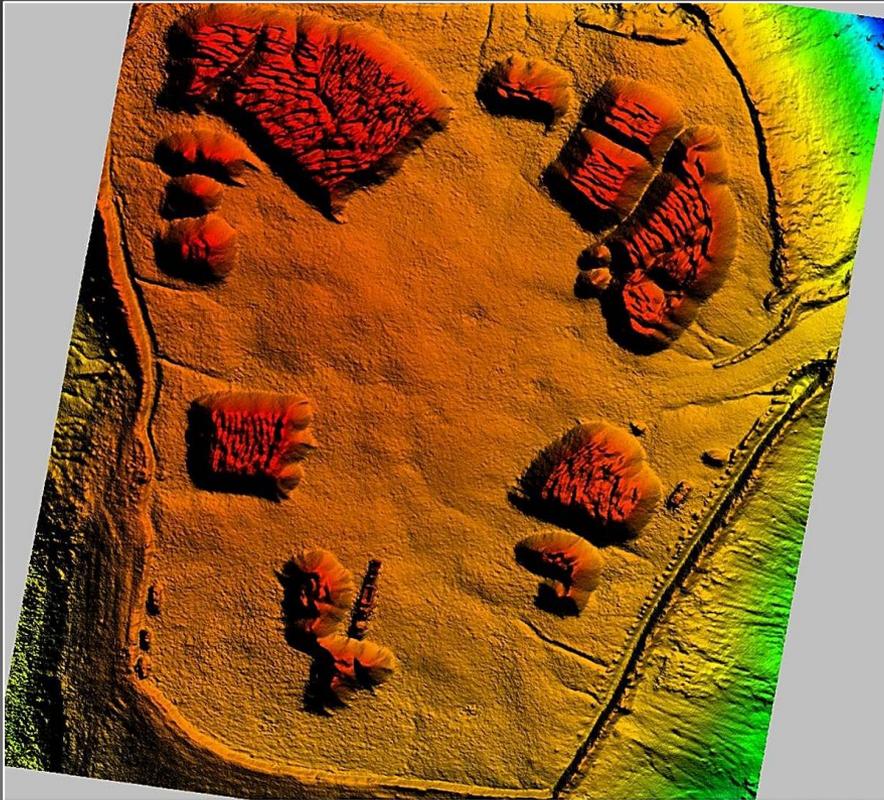
### Cost Effectiveness:

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

UAS Mission.....\$300

# Mining Stockpile Volumetric Measurements

## Kentucky – 2014



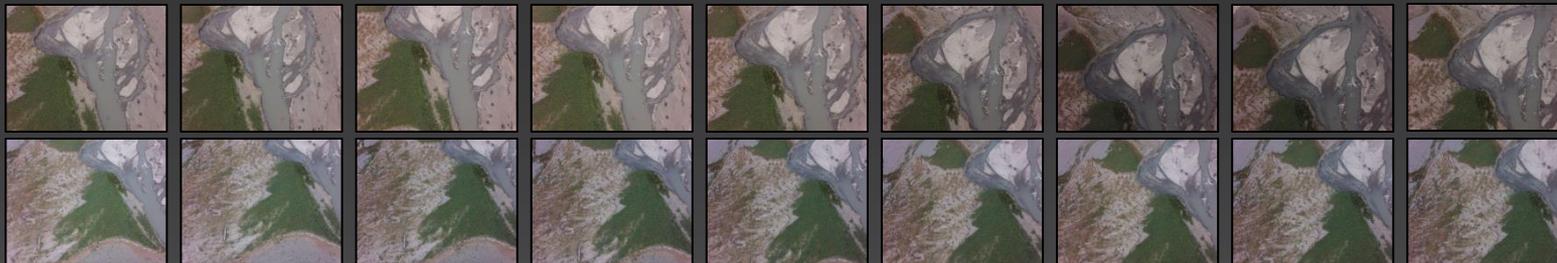
Digital Elevation Model Hillshade



Volumetric Measurements  
(Cubic Yards)

# Geospatial Product Creation

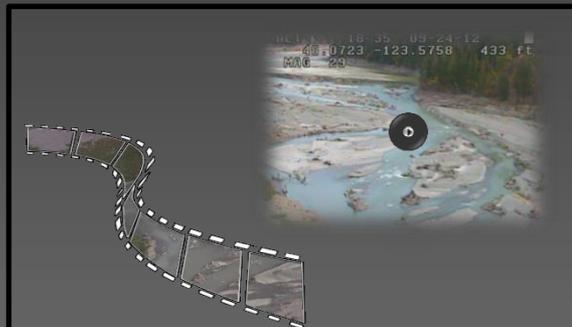
## WITH DATA ACQUIRED FROM UAS



STILL FRAME IMAGES CAPTURED ON-BOARD THE UNMANNED AIRCRAFT



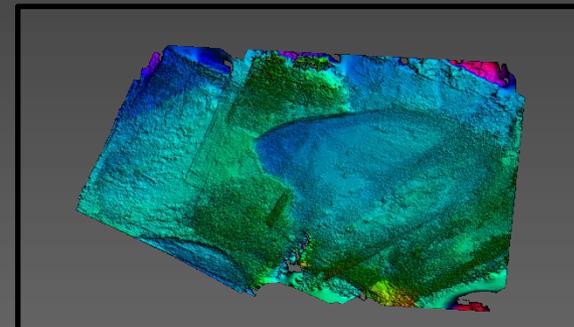
GoPro Hero2 - 11 megapixel (compressed)



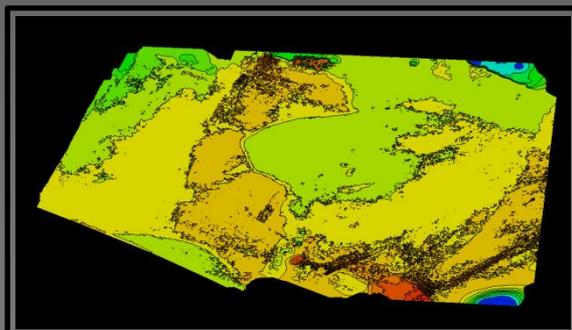
FULL-MOTION VIDEO



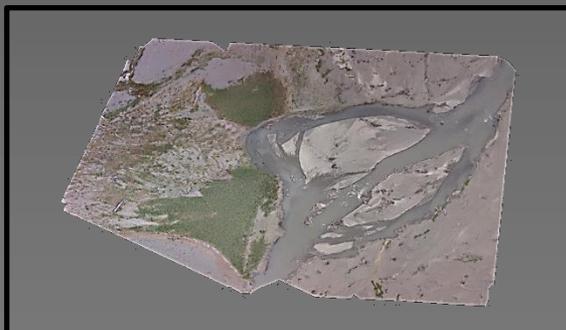
3-D POINT CLOUD DATA



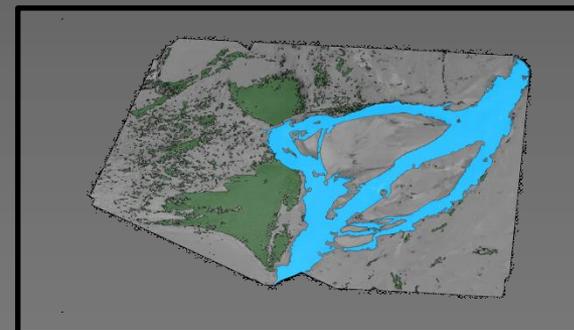
ELEVATION MODELS



ELEVATION CONTOURS



ORTHOIMAGERY

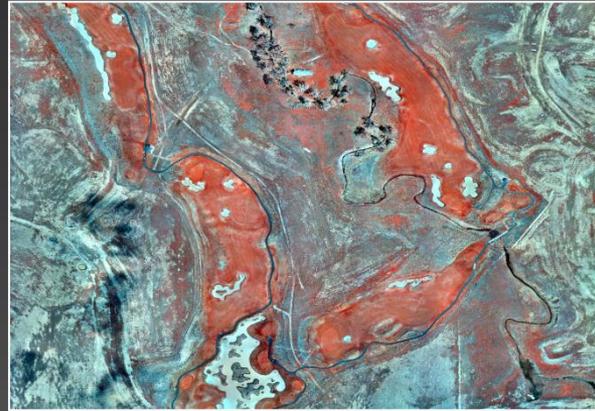


SEGMENTATION AND CLASSIFICATION

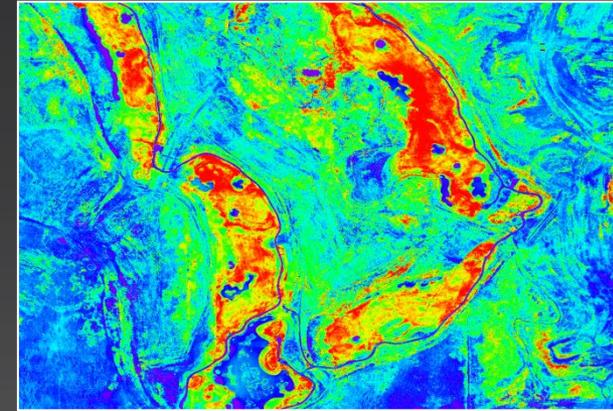
# UAS Color Infrared



2011 NAIP



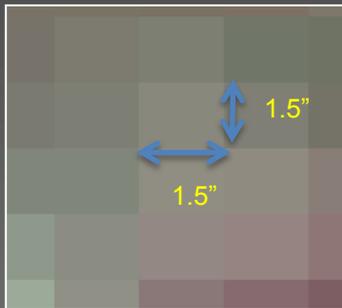
2013 UAS CIR



NDVI Low

2013 UAS NDVI

NDVI High



1.5 inch ground sample distance  
from 400 feet above ground level

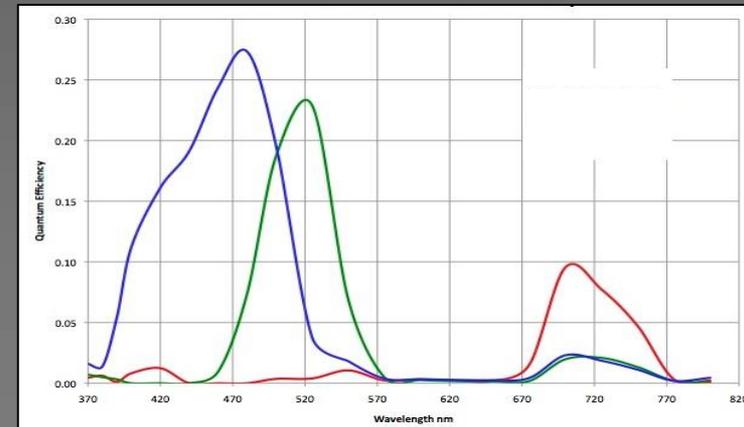


Camera	Canon Powershot SX230 						
<b>Camera Inputs:</b>	FL (mm)	Img wtdh (pix)	Image hgt (pix)	Sensor wtdh (mm)	Sensor hgt (mm)	Pix Size (wtdh)	Pix Size (hgt)
	5	4000	3000	6.17	4.55	0.0015	0.0015
<b>Calculations:</b>	GSD wtdh (cm)	GSD hgt (cm)	GSD wtdh (inches)	GSD hgt (inches)	Photo wtdh (ft)	Photo 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)

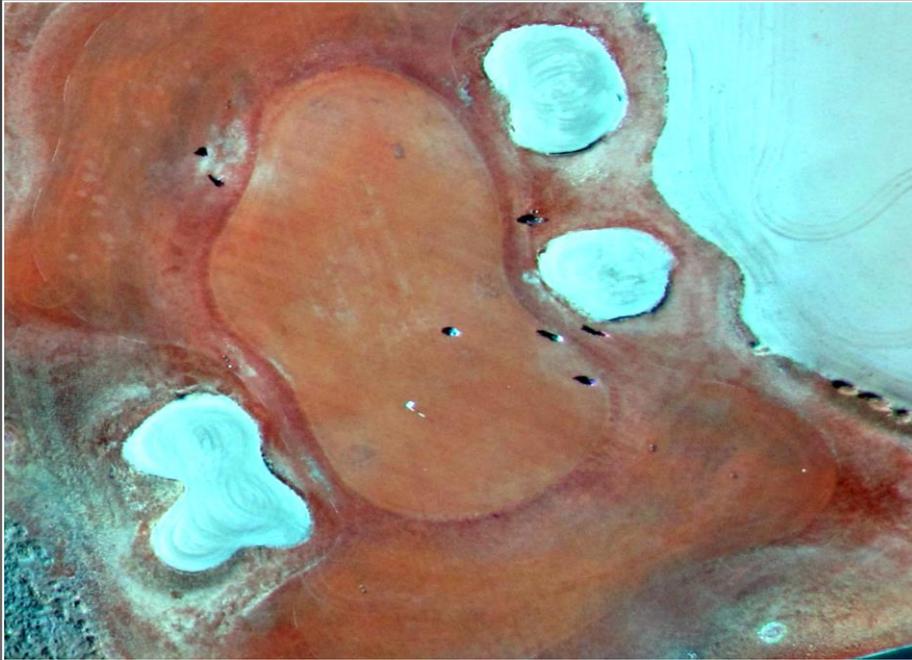
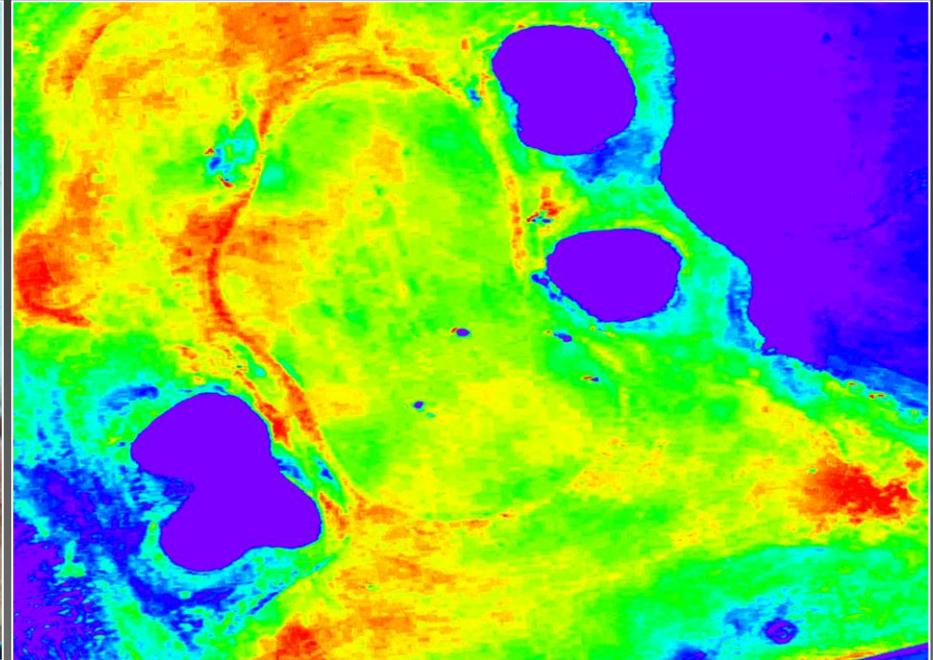


Image collected from UAS – Canon SX230 HS – 400'

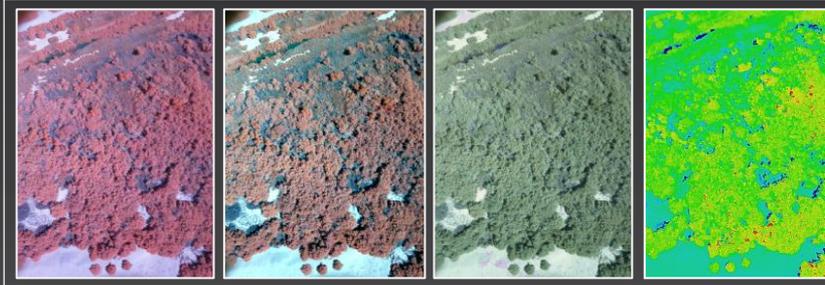


NDVI Low

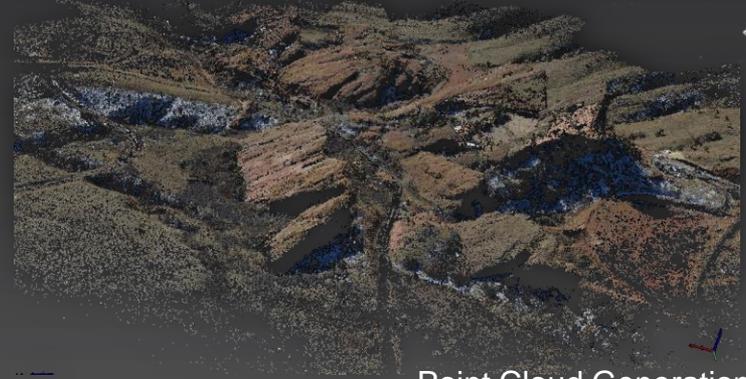
NDVI High

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

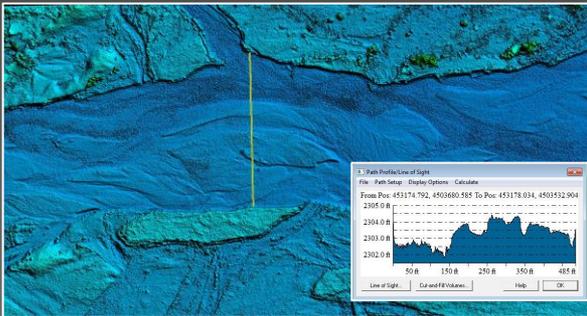
# UAS Derived Product Examples



Color Infrared - NDVI



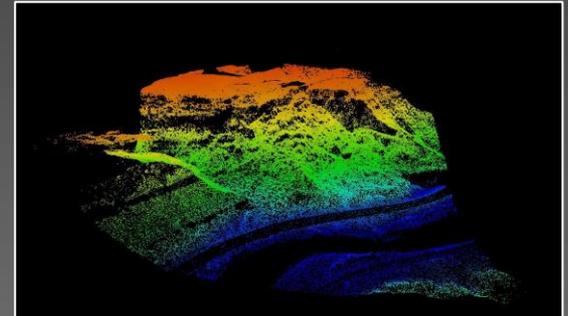
Point Cloud Generation



Elevation Models



Feature Extraction



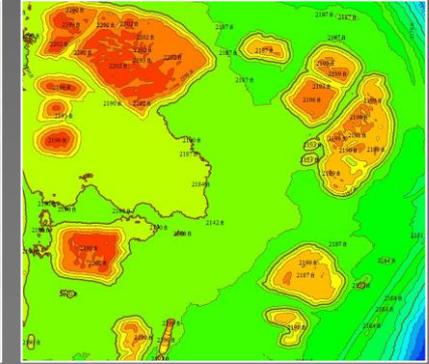
KML - 3D Modeling



Orthophotography



Volumetric Measurements



Contour Generation

# Future

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

# Possible New Platforms

## VTOL



## Fixed Wing



## Micro



DJI Phantom

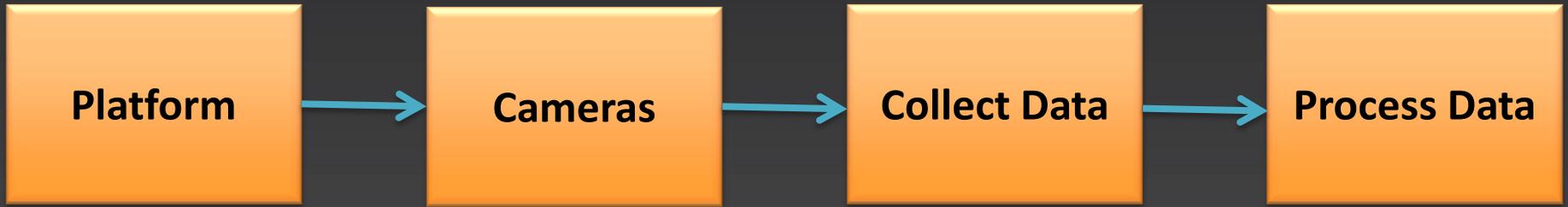


SkyJib



DJI S1000

# UAS Production Process



\$1,000



\$20,000



\$50,000



\$300



\$2,000 - \$25,000



\$25 - \$75/hr



\$3,000



\$400



# USGS UAS National Project Office Contacts



## Our Team

Name	Title	Phone	Agency	Email
Jeff Sloan	UAS Project Manager, Mission Operator and Data Analysis	303-236-1308	USGS	jlsloan@usgs.gov
Mark Feller	Mission Operator and Data Analysis	303-236-1302	USGS	mrfeller@usgs.gov
Mark Bauer	Mission Operator and Data Analysis	303-236-1247	USGS	mabauer@usgs.gov
Todd Preston	Mission Operator and Data Analysis	406-994-5034	USGS/Parallel	tmpreston@usgs.gov
Lance Brady	Mission Operator and Data Analysis	303-236-5507	USGS	lbrady@usgs.gov
Issac Anderson	Mission Operator and Data Analysis	303-236-5020	USGS	ianderson@usgs.gov
Jill Cress	Coordination and Software Development	303-236-1248	USGS	jjcress@usgs.gov
Susan Goplen	COA Coordinator and Software Development	303-236-1231	USGS	segoplen@usgs.gov
Bill Christiansen	USGS Aviation Management	303-236-5513	USGS	wdchrist@usgs.gov



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