Unmanned Aircraft Systems (UAS) Activities in the Department of the Interior

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U.S. Geological Survey

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Topics

- Unmanned Aircraft System or UAS
  - How, Why & Why Now
- FAA – Policy and Privacy
- Department of the Interior
  - Strategy
  - Technology
  - Applications and Products
- Summary

T-Hawk Ground Station, Charleston, West Virginia

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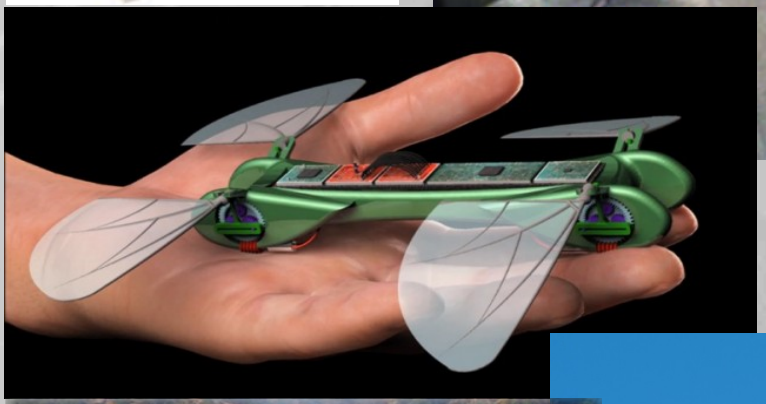
What is a UAS and the Different Types of "Drones"

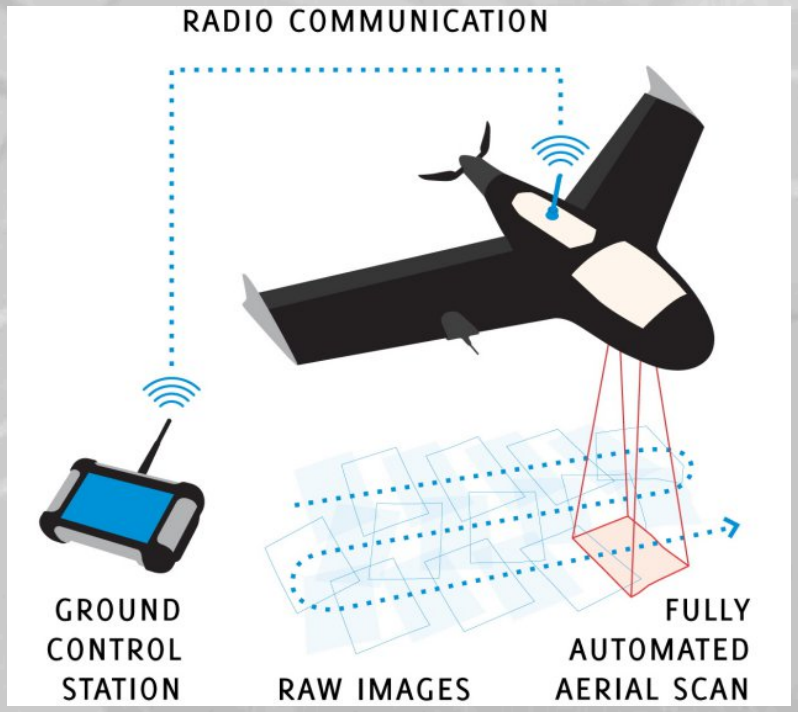






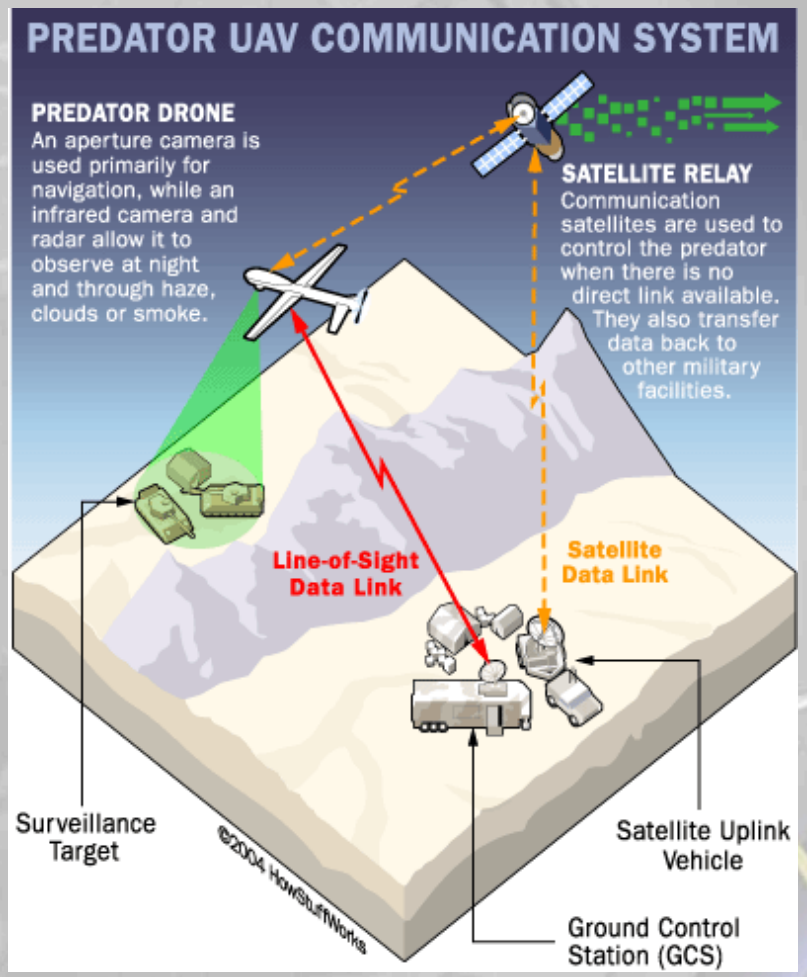



How a UAS Works



Line-of-Sight (LOS)

DOI mode of operation



Beyond-Line-of-Sight (BLOS)

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Factors in Increased UAS Usage

UAS technology is developing at extraordinary rates

- U.S. Universities involved with UAS related programs- 165
- Countries involved with UAS manufacturing- 80
- US UAS related manufactures- >800
- Global UAS related manufactures- 715
- Global UAS platforms- 2400

Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 establishes a 2015 deadline for integration of UAS into the National Airspace System (NAS)

Economic forecasts

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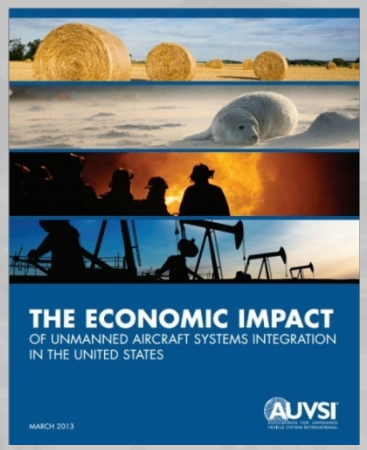
UAS Economic Potential

Association for Unmanned Vehicle Systems International (AUVSI) 2013 Economic Report

- The UAS **global market** is currently **$11.3 billion**
- Over the next 10 years, the UAS **global market** will total **$140 billion**
- The economic impact of U.S. airspace integration will total over **$13.6 billion** in the first three years and will grow sustainably for the foreseeable future, cumulating to over **$82.1 billion** between 2015 and 2025
- Every year that airspace integration is delayed will cost the U.S. over **$10 billion** in lost potential economic impact, which translates to **$27 million** per day



(www.auvsi.org/econreport)

FAA and UAS

Congress included language and milestones requiring the integration of UAS into the National Airspace System (NAS) in the FAA Modernization and Reform Act of 2012

Exemptions, Section 333, for commercial UAS operations, over 400 submitted, 29 approved (film, oil and gas, real estate, agriculture)

NPRM for "Operation and Certification of small UAS", released February 15, 2015, 60 days for comments, final rule late 2016/early 2017, highlights

- UAS < 55 lbs
- Visual line of sight only, autonomous ops allowed
- No observer required
- Operators required to pass "knowledge" test
- No airman medical certificate
- No operations over people
- Daylight only, maximum altitude 500 ft AGL
- No airworthiness certification
- No Certificate of Authorization (COA)

Agreement between FAA and DOI supports "file and fly", streamlines COA process

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Where you can fly tools – https://www.mapbox.com/drone/no-fly/

Presidential Policy

"Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights and Civil Liberties in Domestic Use of Unmanned Aircraft Systems", February 15, 2015, for all Federal agencies:

- **Examine their UAS policies and procedures related to collection, use, retention and dissemination of information obtained by UAS prior to using UAS and at least every 3 years to ensure privacy, civil rights and liberties are protected, focus on PII (Personally Identifiable Information)**
- **Difficult to observe PII from UAS, but it does require agencies to establish or update their policies and procedures, such as:**
  - **Procedures to receive, investigate and address complaints**
  - **Procedures to authorize UAS use in response to requests from Federal, State, local, tribal or territorial governments**
- **ALL UAS data must be maintained in a "system of records" or can't be disseminated**
- **Require that grant recipients have policies and procedures addressing privacy, civil rights and liberties**
- **Keep the public informed on UAS operations, UAS changes and annual summary of UAS operations**
- **Provide report by August 14 on implementation status of policies and procedures**
- **NTIA led "multi-stakeholder" process, including private sector for privacy, accountability and transparency**

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Outstanding Issues

Issues that need to be addressed:

- **Standards (ASTM F-38 and RTCA SC-203, now SC-228)**
- **Definitions**
- **Secure command and control links (C2)**
- **Aircraft certification/registration**
- **Operator training/certification/registration/licensing**
- **Air traffic requirements/procedures**
- **Spectrum allocation**
- **Detect and Avoid (DAA)**
- **Secure GPS**
- **Lost link procedures**
- **Safety analysis/risk acceptance**
- **Insurance**
- **Liability**
- **Public perception**
- ***Privacy……***

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Privacy Concerns

Fourth Amendment provides protection against unreasonable searches and seizures and requires search warrants to be based upon probably cause

The U.S. Courts have repeatedly held that data from airborne technology, in public airspace, observing anything in "plain view", without using "sense enhancing technology" will be admissible without a warrant

- **United States v Causby, Dow Chemical v US, California v Ciraolo, Florida v Riley**

Helicopter or manned aircraft vs. UAS

- **UAS are harder to see, hear, fly lower, and are cheaper**

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Privacy Concerns (cont.)

Legislation – protecting 4th amendment, State vs. Federal, see map

- **Data clause in legislation restricting access and setting deletion dates**

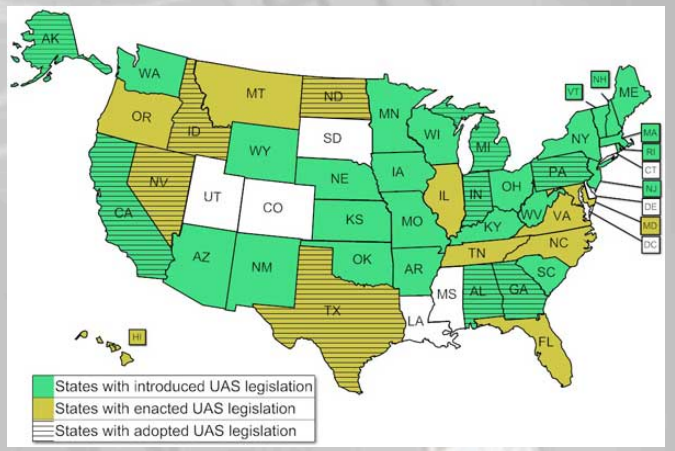
Law firms are developing UAS expertise

Guidelines

- **International Association of Chiefs of Police**
- **AUVSI**

Is it a technology or data issue?

- **Internet, GPS/phone, license plate readers**



National Conference of State Legislatures

DOI policy – "ensure the property owners have advance notice prior to the proposed" mission

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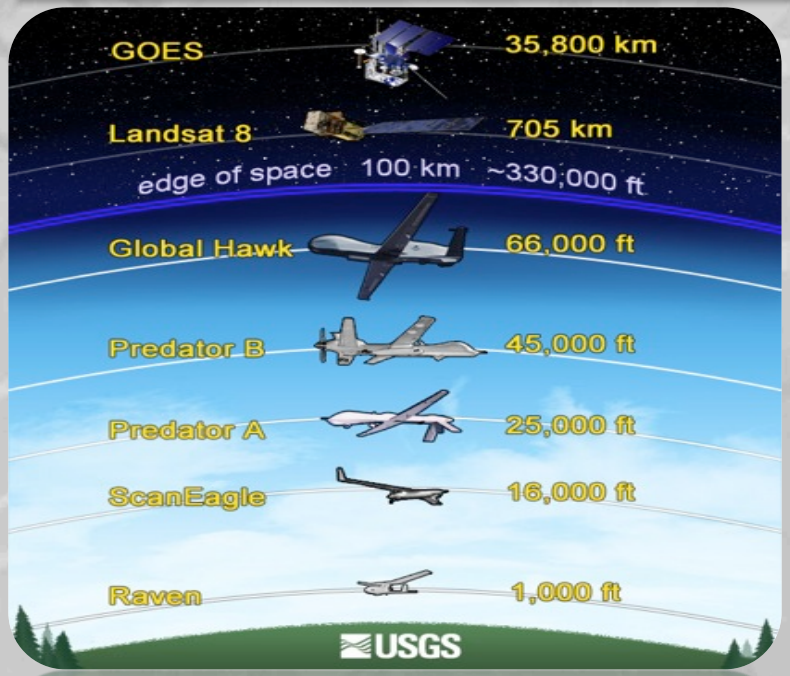
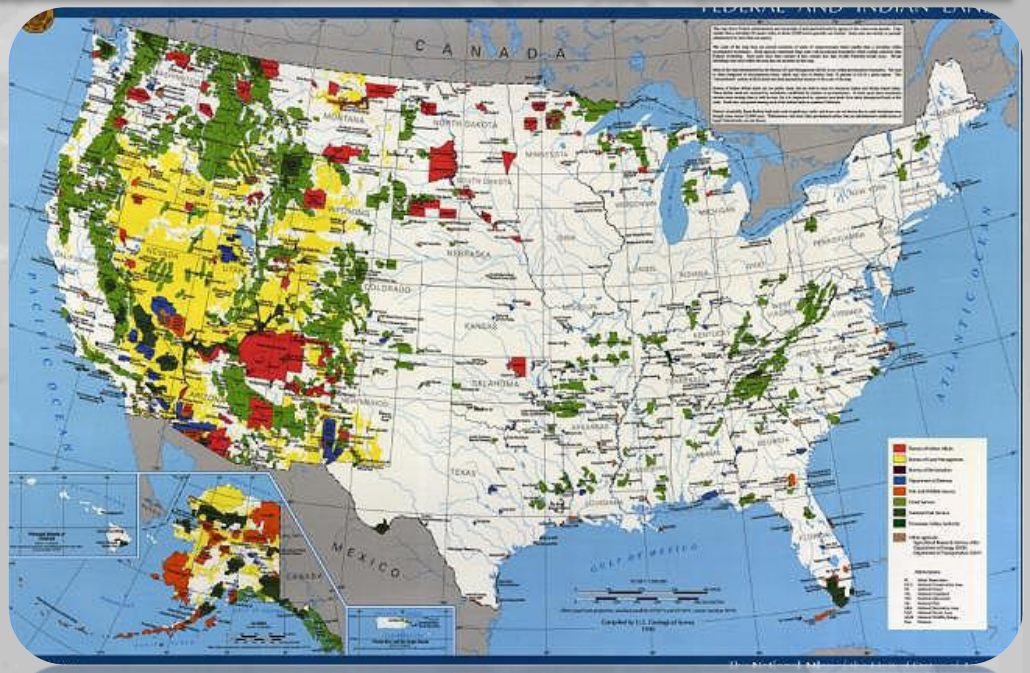
DOI Remote Sensing Data Sources





Department of the Interior (DOI) manages more than one-fifth of U.S. land

- Satellites provide periodic observations over regional/continental areas at low spatial resolutions
- Manned aircraft can collect data over large spatial areas with a variety of sensors
- Field surveys acquire many types of information over small spatial areas
- UAS facilitate science driven remote sensing data acquisitions and compliment the other observations

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What is the DOI UAS Strategy

DOI's UAS program strategy is tailored to the mission, funding, personnel, and infrastructure levels of the Department and is summarized as:

- **Focus on small UAS (sUAS), which are more aligned with DOI's decentralized mission execution strategy and more supportable by the Department's funding, personnel and infrastructure levels.**
- **Leverage available excess DOD sUAS to minimize procurement, training, and support costs.**
- **Establish partnerships with Federal departments who possess UAS capabilities beyond DOI's to support DOI missions that require more extensive UAS capabilities.**
- **Conduct operational tests and evaluations of various UAS technologies to support the development of long-range UAS requirements and strategy for the DOI UAS activities.**
- **Based on the requirements and strategy developed above, procure (buy or contract) for UAS capabilities that cannot be met either through excess DOD sUAS or those available through partnerships with other Federal agencies.**

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NPS closes parks to launching, landing or operations of UAS, may use for administrative purposes (SAR, fire ops, scientific studies), June 2014

USGS National UAS Project Office

Supports the technology transfer of UAS capabilities to enhance the informed decision making across the Department

- **Established in 2008**
- **Collaborates on operational test and evaluation missions with other DOI bureaus and Office of Aviation Services (OAS)**
- **Evaluates emerging technologies**
- **Develops new products and capabilities**

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Current 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

19 systems, 3 aircraft per system,
57 total, 30 operational
39 Raven B, none fielded

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

22 systems, 2 aircraft per system, 44 total, 42 operational, 1 with new radio

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UAS Technology - 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
- I-buttons (temp. & humidity)

Future Investigations

- Multispectral, Hyperspectral
- LIDAR, RADAR, Thermal
- Chemical/Air Sampling
- Radio Relay/Tracking

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UAS Applications

Wildlife Management

- Migratory Birds (Sandhill Cranes, Trumpeter Swans)
- Pygmy Rabbit Landscape Habitat
- Grizzly Bear Monitoring
- Elk Population Survey
- Sea Turtles
- Sage Grouse Inventory

Public Safety

- Abandoned Mine Lands Survey
- Coal Seam Fire Detection
- Wildfire Incident Support
- Monitor Volcanic Activity
- Monitor Landslides
- Flood Mapping
- Law Enforcement Support

Inspections-Mapping

- Fence, Pipeline, Power lines
- Mine Reclamation
- Vegetation - Invasive Surveys
- Archeological Site Surveys
- Environmental Survey - Palmyra Atoll
- Damage Assessments
- Easement Verification
- Volumetric Calculations

Research

- Assess Impacts of Dam Removal
- Hydrographic Survey
- Fire Science Research
- Monitor Forest & Rangeland Health
- River Bank Erosion Studies
- Geologic Resource Mapping
- Sensor & Imaging Processing

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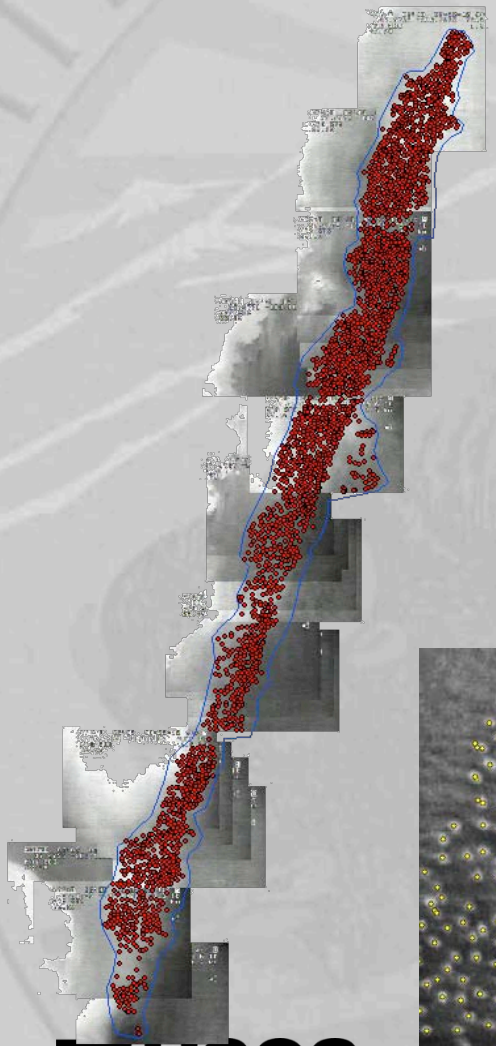
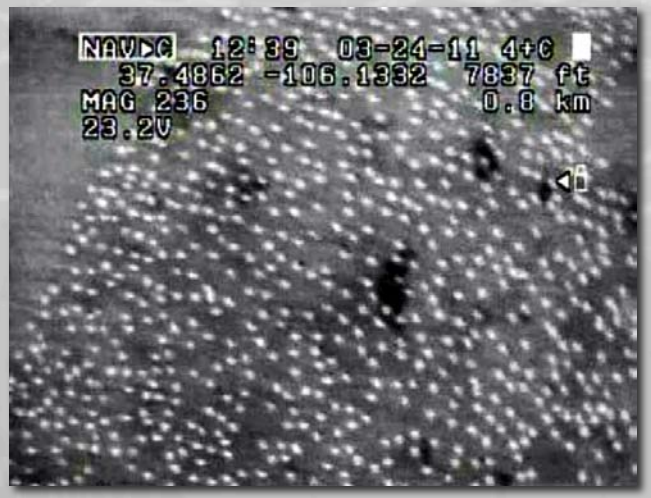
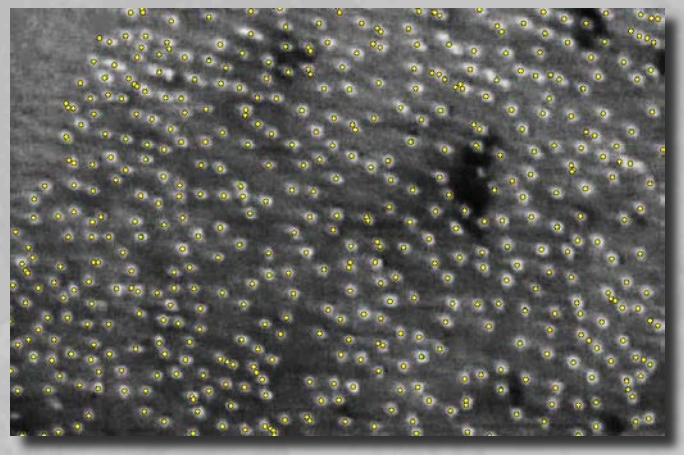
Sandhill Crane Population Estimates

Monte Vista, Colorado







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

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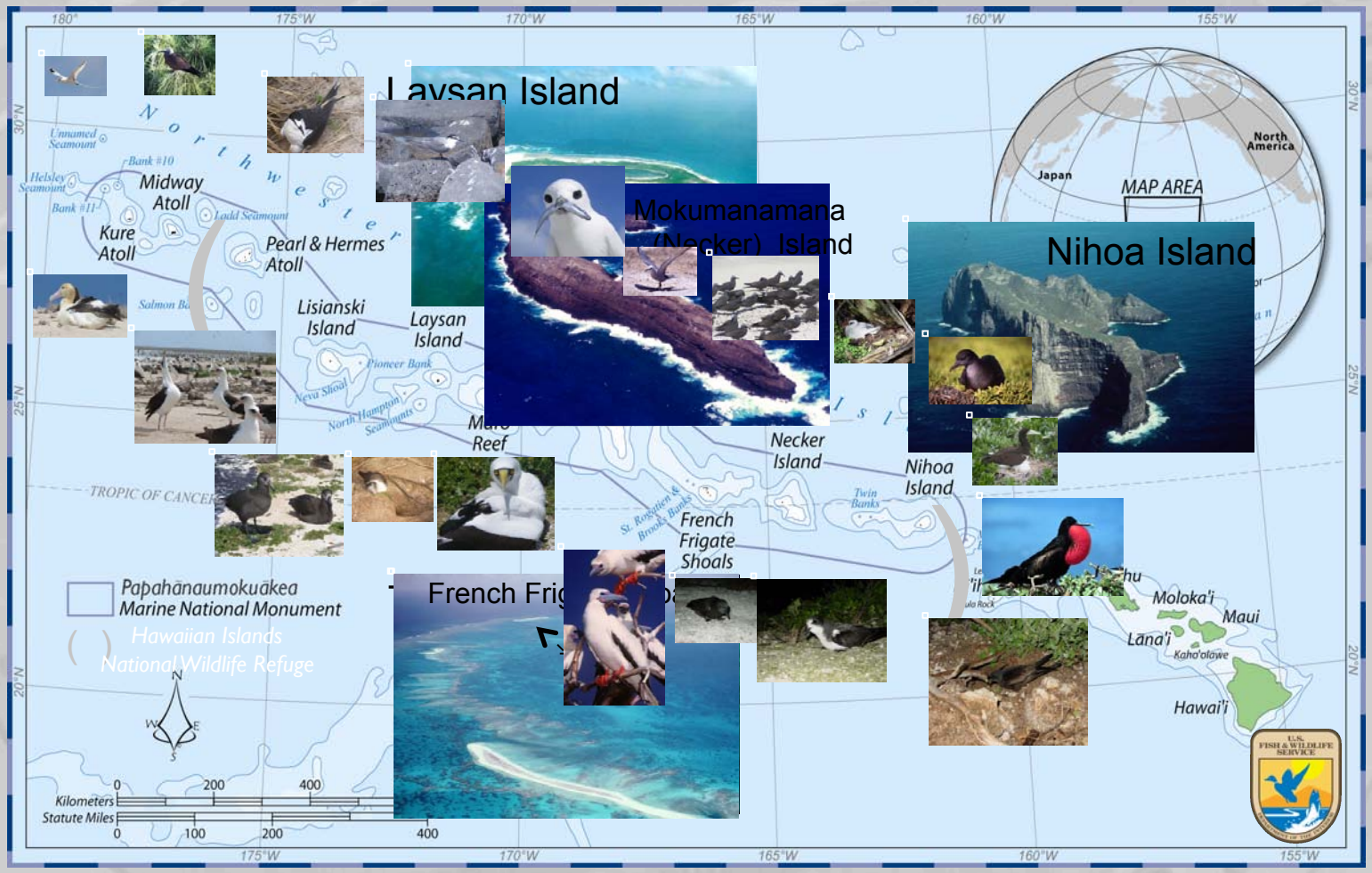
Seabirds and Vegetation

Determine feasibility of using aerial imagery for seabird and vegetation surveys in the HINWR

Cooperative activity with NOAA (Puma flights) and NASA (Ikhana flights) to collect imagery (EO and TIR) over specific islands and over all locations



Seabirds and Vegetation - Imagery Analysis

Seabirds – Visual Assessment

Count Individuals

Differentiate

Understand Limitations

Vegetation – Remote Sensing

Classify

Soil Moisture

Paleontological Resource Documentation

Previously used at White Sands NM – Pleistocene Megatrack ways

- **Used T-Hawk flown by USGS**
- **Without UAS, tracks would have been difficult to photograph**

Additional NPS areas could benefit from mapping with UAS

- **Pliocene vertebrate track ways in Copper Canyon at Death Valley National Park**
- **Dinosaur tracks on cliffs along Lake Powell shoreline in Glen Canyon National Recreation Area**

Geologic Hazards

UAS usage for photo-documenting rockfall or landslides

- Reduces exposure of staff to unstable areas
- Combined with photogrammetry can quickly and safely model a recent failure – remote volumetric analysis
- Potential to track small changes in source areas to assess future events

Images from UAS vs. ground based images

- Provides improved coverage
- Potentially much faster
- Reduced employee exposure to risk

Fluvial Geomorphology

UAS images can be used for channel change assessment

- Assess dimensions of channels and bars

Repeat data sets from UAS platforms

- Provide qualitative and quantitative data on channel dynamics
- Estimate incision or aggradation rates

Eliminates the need to physically perform transects

- Increased safety and precision of measurement
- Quick, safe assessment for decision making when dealing with bank erosion

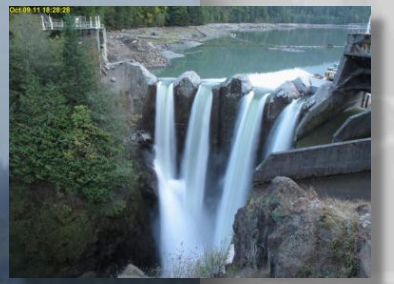
Gulf Islands National Seashore

UAS cooperator mission with US Army Corps of Engineers to evaluate deposition of sands in Gulf Islands National Seashore

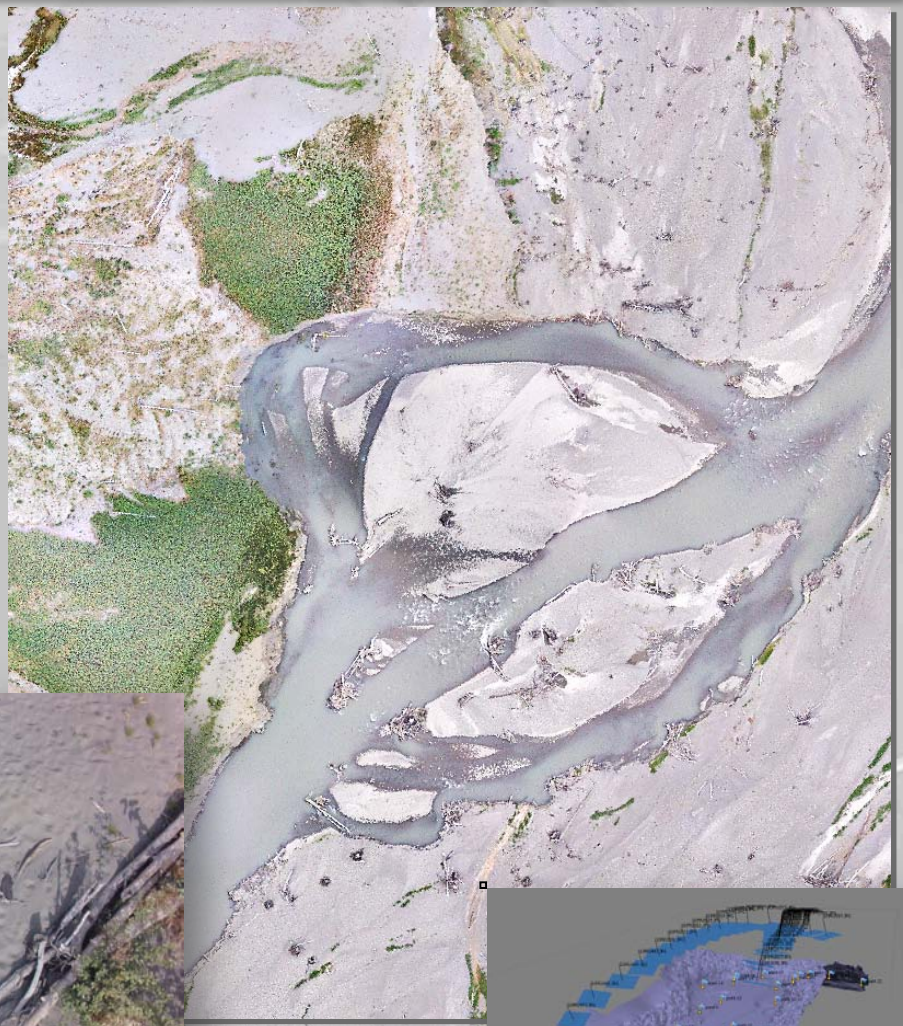
Park benefited from aerial imagery and land mass data

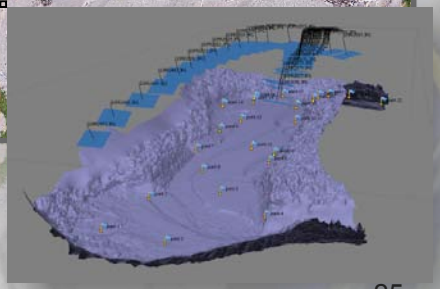
Elwha Dam Removal and River Restoration

Olympic National Park, Washington



Monitoring sediment volumes eroded from the reservoir and deposited downstream, where the mobile sediment can potentially affect salmon habitat and flood-stage elevation





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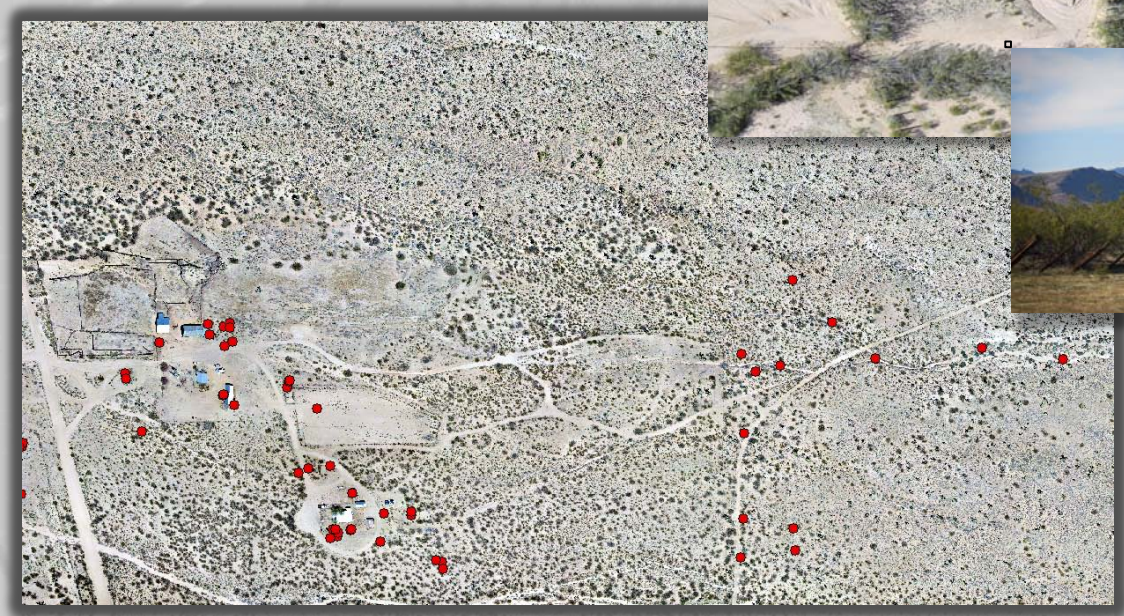
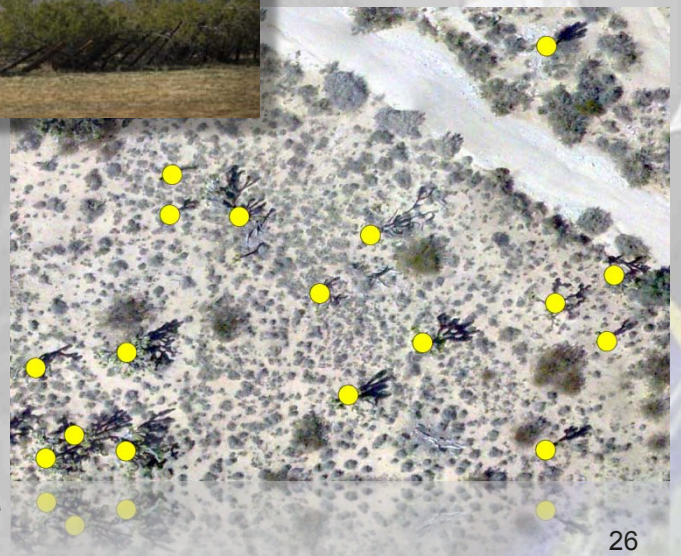
Abandoned Material Inventory

Mojave National Preserve, California





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Geo-locating abandoned materials and Joshua Tree mapping

Developing Intelligent Autonomous UAS for Geoscience Research

Multisensor UAS Platform

For the past two years we have been developing UAS technology for performing airborne geoscience. The next step is to develop a multisensor platform that will take advantage of ***Payload Directed Flight*** and ***Swarm technology*** to greatly expand the versatility of these aircraft for resource (energy, water, mineral), and hazard (volcano, earthquake, landslide) studies that require **high-resolution mapping**, as well as **rapid deployment** and **monitoring under dangerous conditions**.

Onboard Sensors

- **Magnetometer**
- **Gas (CO_2, SO_2, H_2S)**
- **LiDAR**
- **Thermal IR (1.5-13µm)**
- **Hyperspectral (400-2500nm)**
- **Gamma ray**
- **Aerosols**

The SIERRA UAS developed in 2012 for airborne magnetic surveying

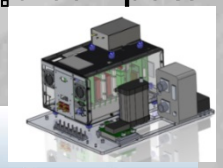
Viking 400 UAS planned for multi-sensor missions

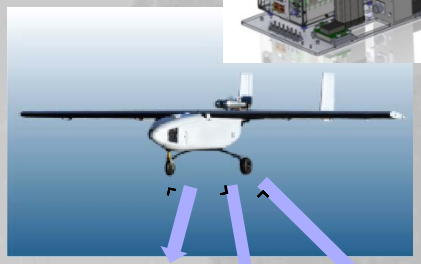
Intelligent Autonomous Adaptive Surveying

Payload Directed Flight (PDF)

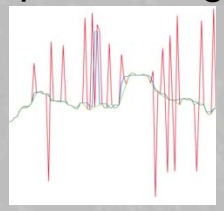
PDF involves 'intelligent' flight control where the onboard computer monitors and responds to data it is collecting from its onboard sensors (payload). A UAS that utilizes PDF can autonomously respond in real-time to incoming data and adapt its flightpath to collect data where its most needed.

Onboard computer

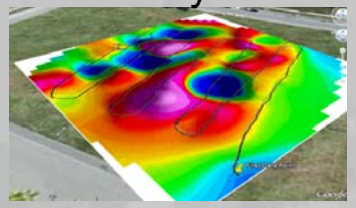




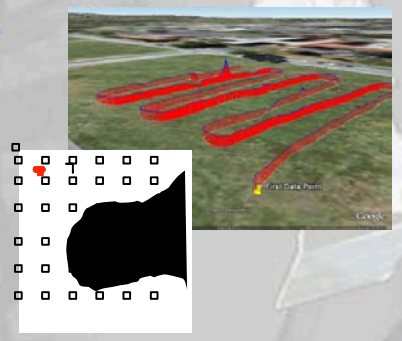
Onboard real-time data processing



Real-time mapping & analysis



Real-time trajectory planning and control

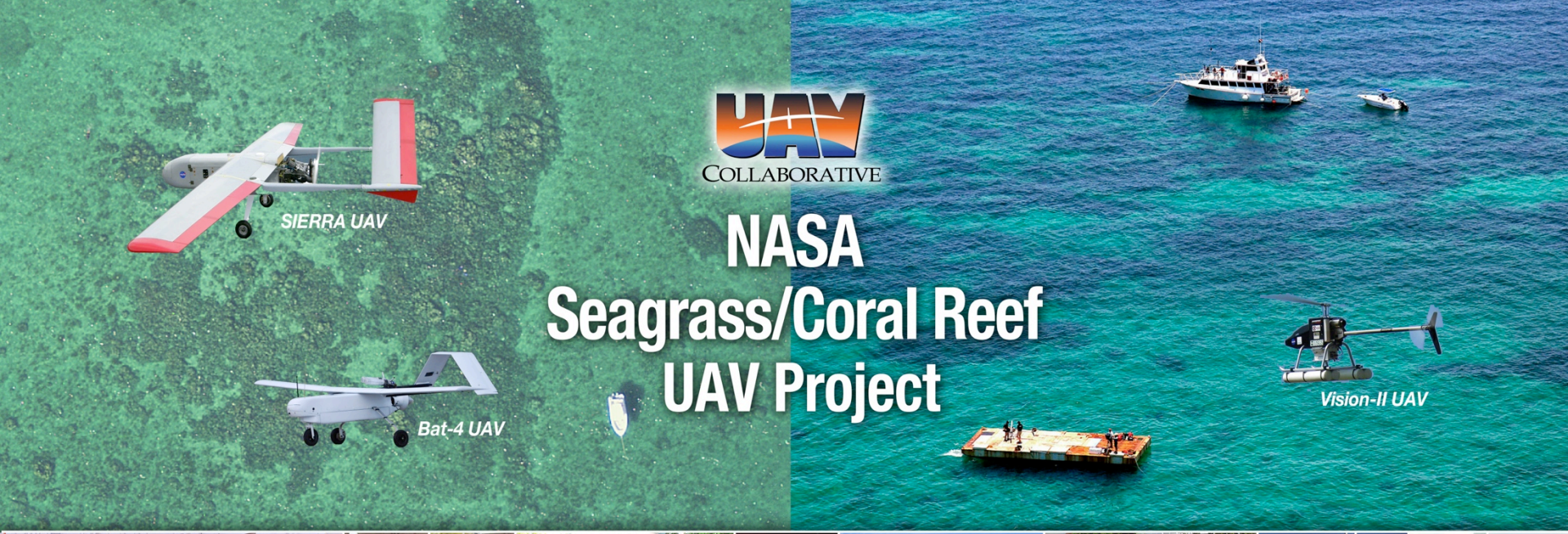


'Mothership' sends updated flight commands to swarm

Swarm technology

We also plan to simultaneously deploy a 'swarm' of smaller single-sensor UAVs that will communicate data to, and receive flight commands from, the multisensor platform, allowing for instantaneous measurements to be made over a broad spatial extent.

- terrain avoidance
- anomaly-seeking
- maximizing data return…



UAV COLLABORATIVE

NASA Seagrass/Coral Reef UAV Project

NASA Ames Research Center

Florida Fish and Wildlife Conservation Commission

USF UNIVERSITY OF SOUTH FLORIDA

Optical Oceanography Laboratory
College of Marine Science
University of South Florida

Institute for Marine Remote Sensing

USGS St. Petersburg Coastal and Marine Science Center

MLB www.spygrass.com

XTREME Aerial Concepts

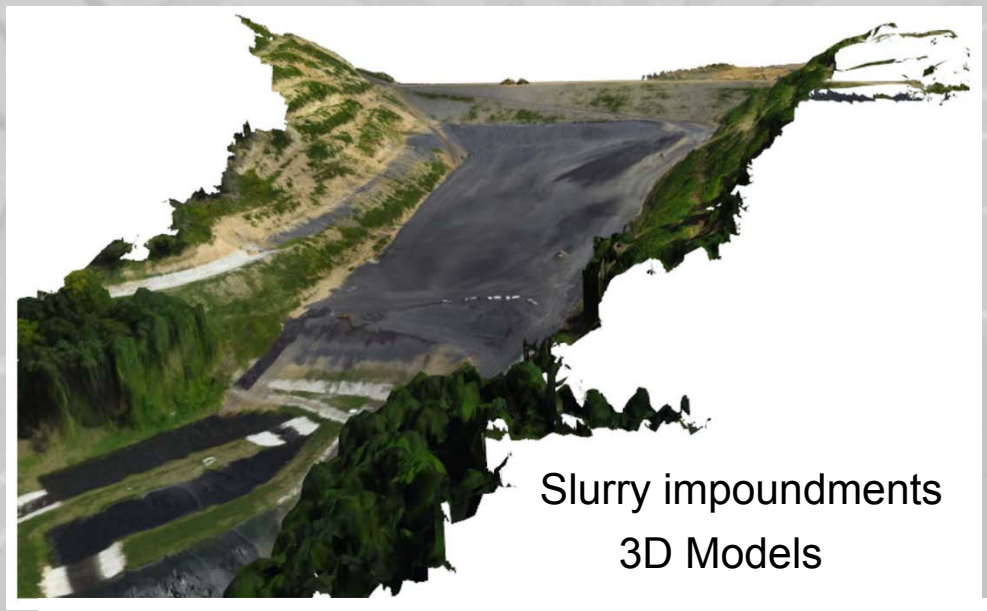
JAKADOFSKY JET ENGINES

NOVASOL

SEA TOW

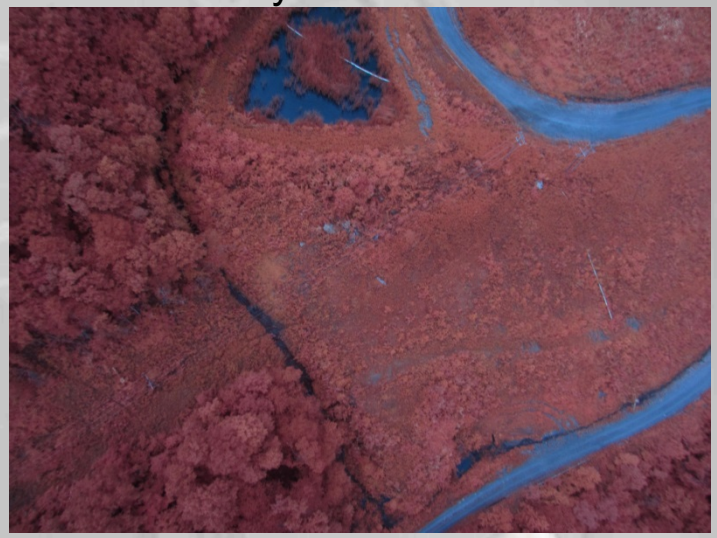
Observing Surface Coal Mining Activities

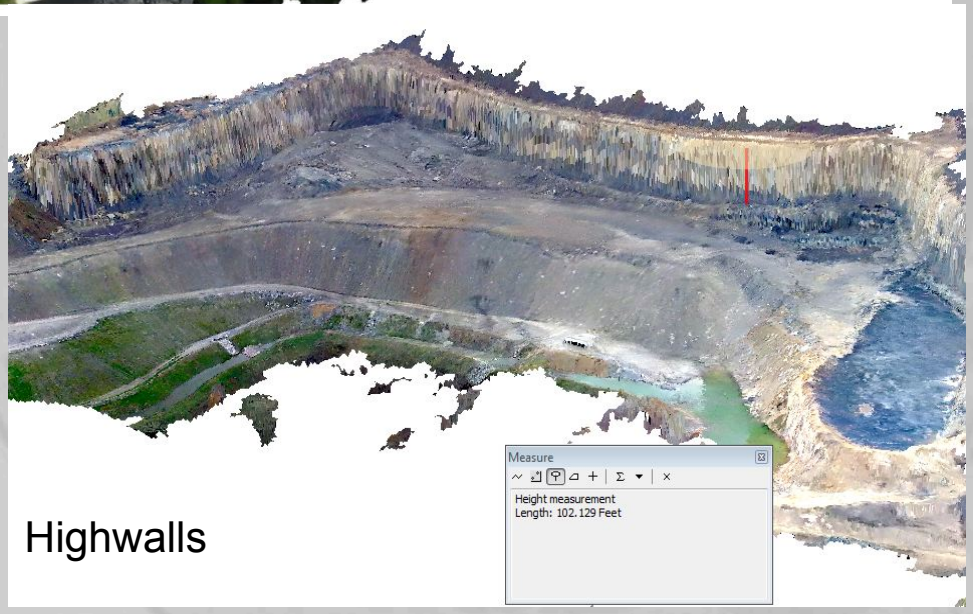
Geospatial Products



Slurry impoundments
3D Models

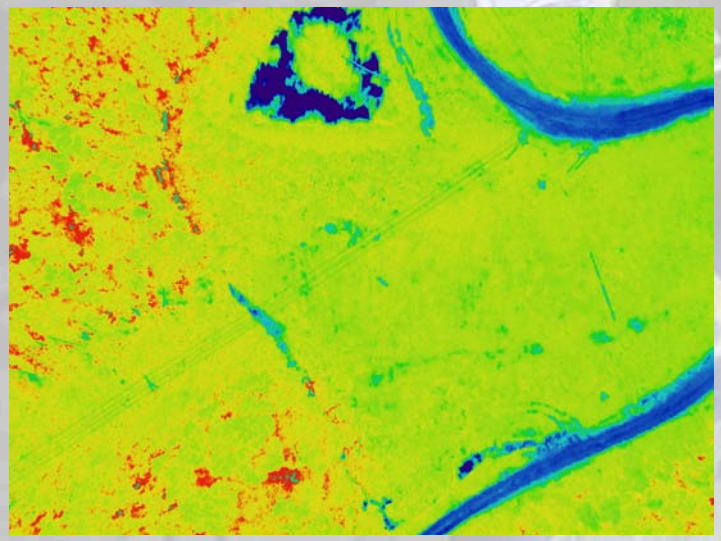
Surface analysis



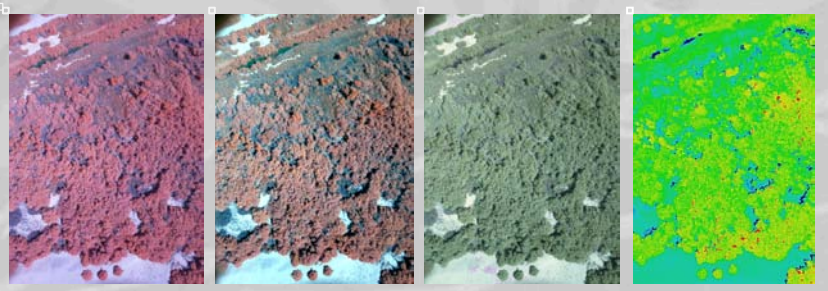


Highwalls

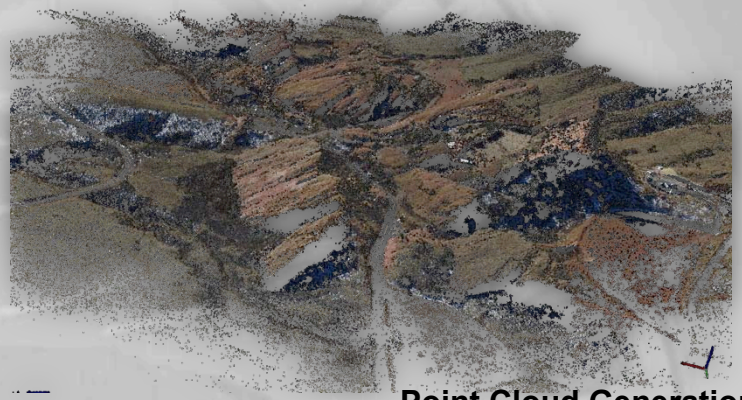
Color Spectrum Analysis



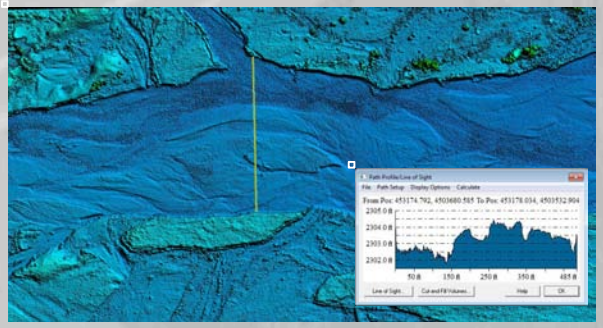
Geospatial Data Products



Color Infrared - NDVI

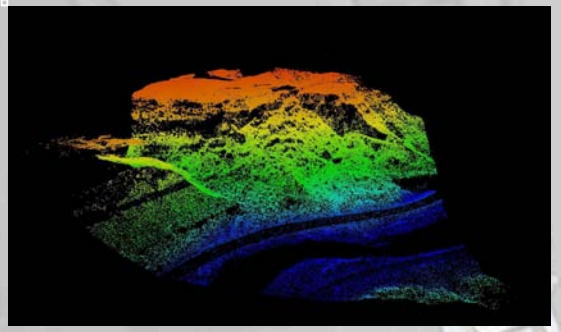


Point Cloud Generation



Elevation Models

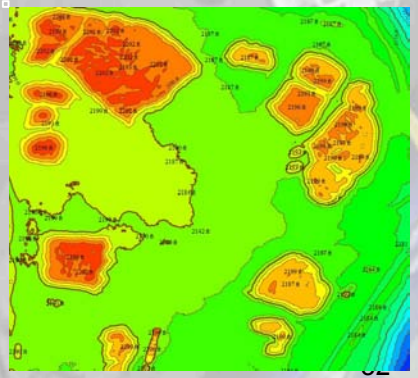
Feature Extraction



KML – 3D Modeling

Orthophotography

Volumetric Measurements



Contour Generation

Tangible Benefits

The tangible benefits of the Department's UAS activities can be summed up in three words: Science, Safety, and Savings.

Science

- **UAS are far less disruptive to sensitive animal species than manned aircraft. They carry high tech sensors and possess the ability to transmit real-time data that can also be recorded for future analysis. These unique characteristics enable UAS to gather repeatable, scientifically valid observations. Better science leads to better policy decisions, which benefits all Americans.**

Safety

- **DOI missions often expose personnel to significant safety hazards. From 1937 to 2000, 66% of all field biologist fatalities in DOI were aviation-related. UAS have also been used to replace ground personnel in certain missions, reducing their risk to injury. UAS is one tool DOI is evaluating as part of its program to improve safety.**

Savings

- **The cost to operate sUAS, under 55 pounds, currently employed by DOI is less than 10 percent of the cost to operate manned aircraft. FWS and USGS estimated the Sandhill Crane UAS mission costs at $2,500. Estimates to fly a similarly equipped manned aircraft were over $25,000.**

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Carpe Caelum

The Department requires timely, high-quality, affordable data to meet its mission

- **Remote sensing is a key source of these data and we are using remote sensing data acquired from both satellite and aircraft**
- **UAS provide a flexible, low-risk and low-cost alternative – scientists can get the data they need, when they need it**

Continue operational testing and evaluation (many new ides), but will start to transition some activities to operations

Key issues

- **Collaboration/partnerships are important to meeting our goals**
- **Ability to take coincident measurements with multiple sensors**
- **Leading to data integration with *in situ* and satellite data sets**
- **3 Ds – data management, data access and data policy**
- **New UAS this spring!!**

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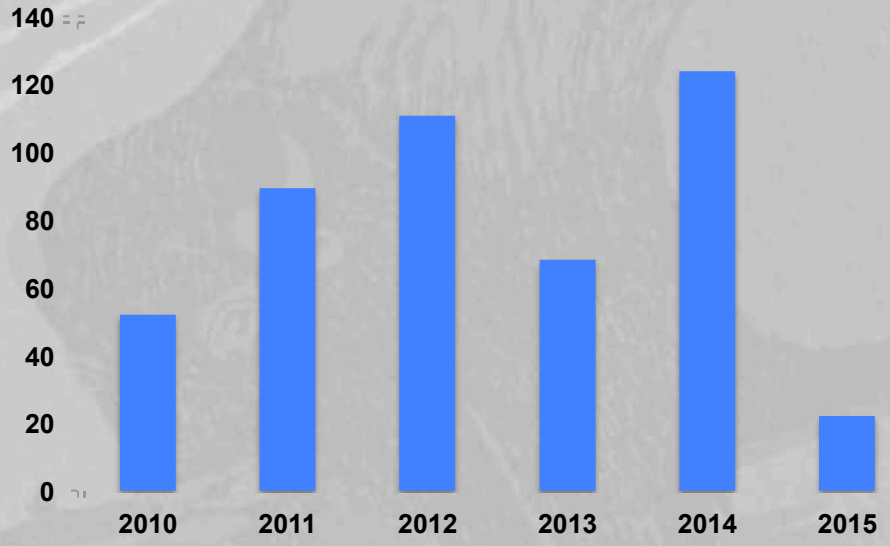
Questions?

UAS Workshop, May 19-21, 2015 in Reston

http://geography.wr.usgs.gov/ICES/UASworkshop.html

Websites:

USGS – http://uas.usgs.gov/
Office of Aviation Services – http://oas.doi.gov/
FWS - https://sites.google.com/a/fws.gov/region-1-unmanned-aerial-systems-uas-resource-guide/



DOI UAS Mission Hours by Fiscal Year

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