USGS- UAS for Research and Applied Science

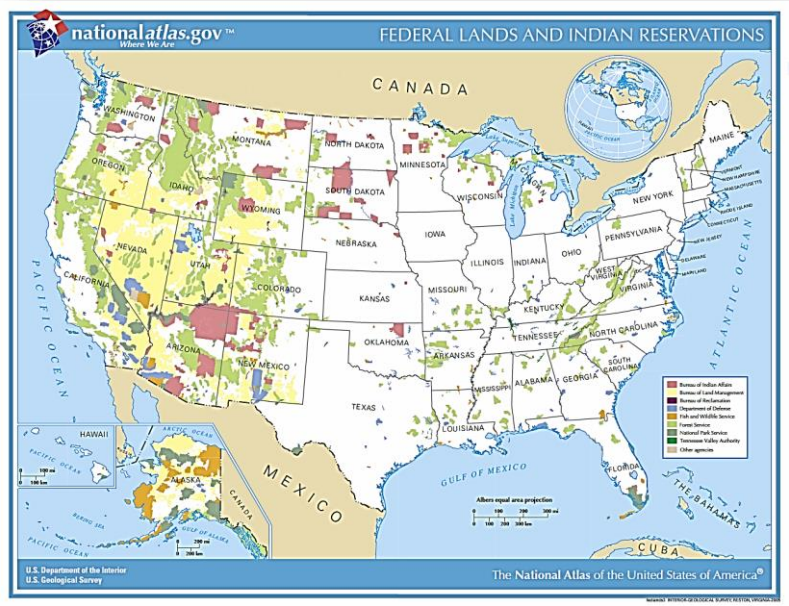
Lance R. Brady
Department of the Interior
United States Geological Survey (USGS)
National UAS Project Office

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme
of the European Union

HARMONIOUS
uas for environmental monitoring

USGS Mission and Land Imaging Capabilities



The USGS is the Science Agency for the Department of the Interior

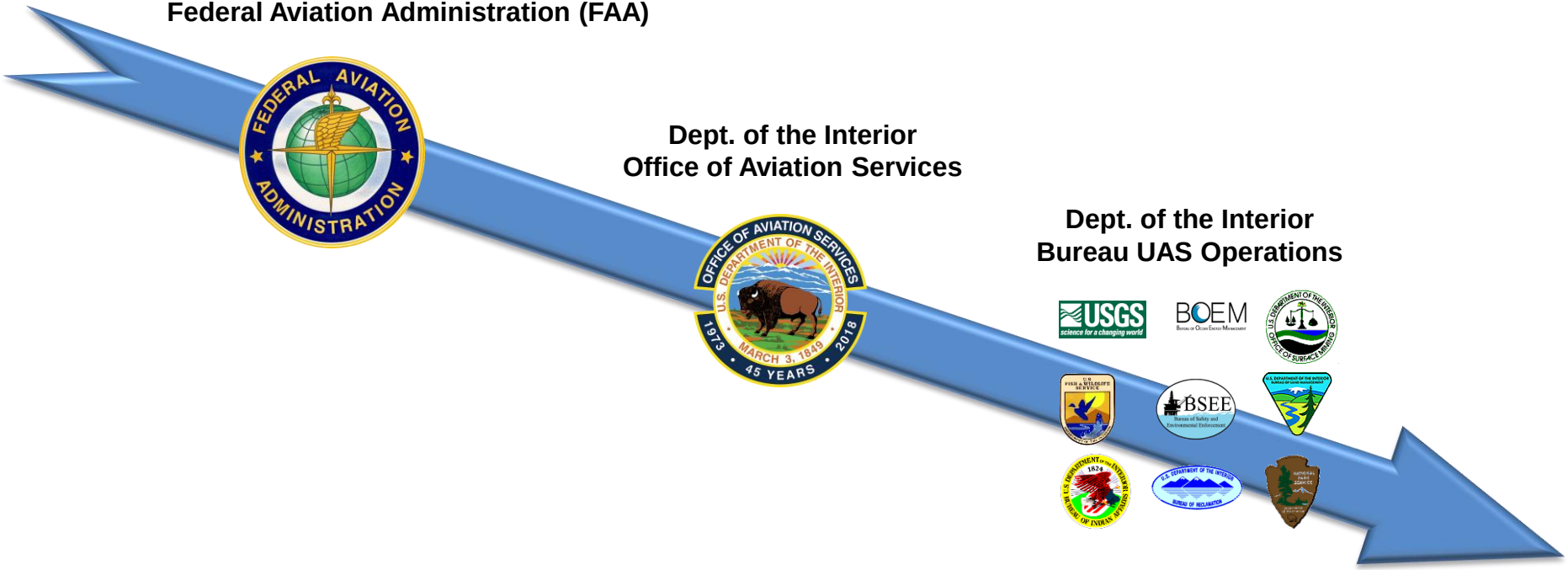
The USGS provides reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life

USGS National Unmanned Aircraft Systems Project Office

USGS UAS Implementation Timeline

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

Department of the Interior – UAS Implementation



USGS – Current UAS Platforms


DJI Matrice M600 Pro


BirdsEyeView FireFly 6 Pro


3DR Solo with MicaSense Sensor


DJI Mavic Pro


Parrot Anafi

USGS UAS Inventory (Oct. 2019)

DJI Matrice M600 Pro 13
BirdsEyeView FireFly 6 Pro 8
3DR Solo 115
DJI Mavic Pro 14
Parrot Anafi 26
Pulse Vapor 1

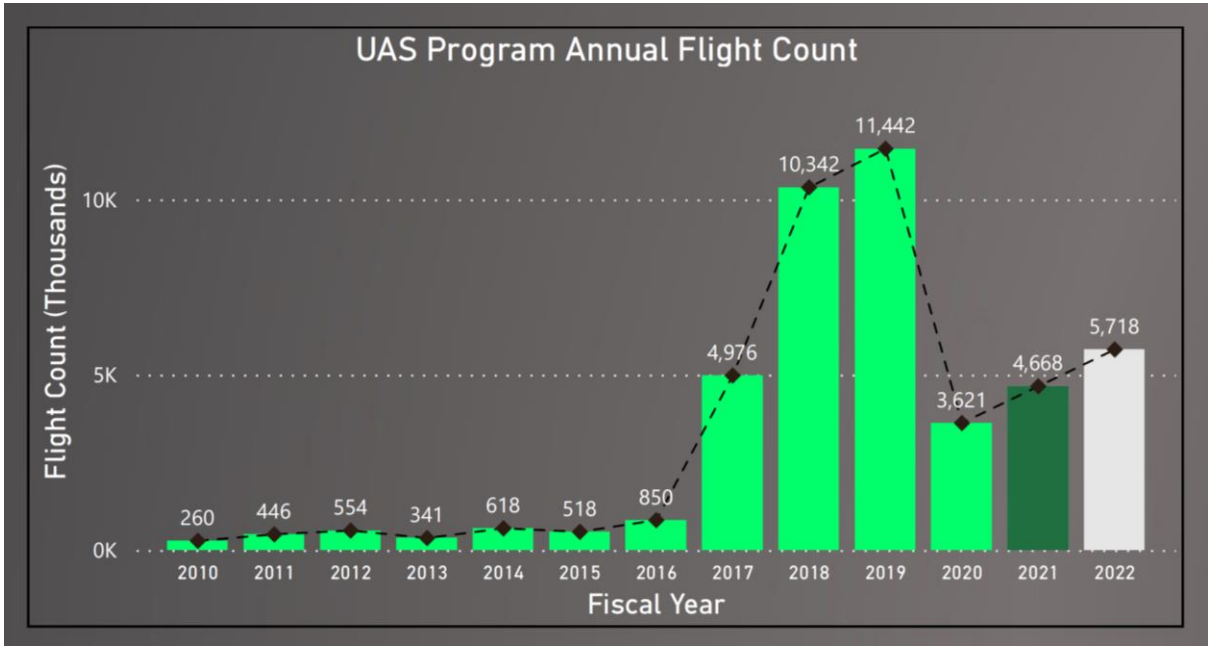
Total UAS @ USGS 177

USGS (DOI) – UAS Training

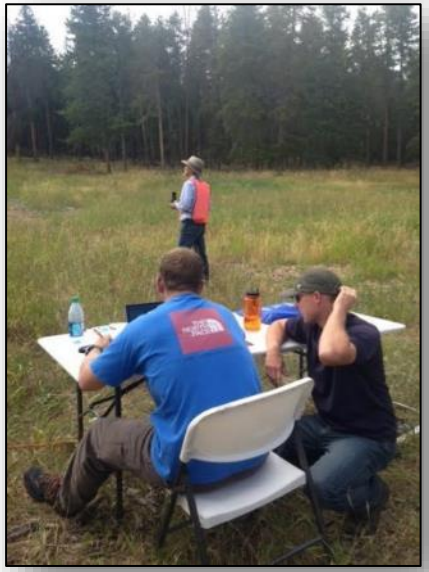
- FAA - Part 107 Certification
- Procure Aircraft Systems
- A-450 Basic Small UAS Course
- Currency (every 90 days)
- Proficiency (refresher – 2yrs)
- FAA Part 107 (recurrent-2yrs)

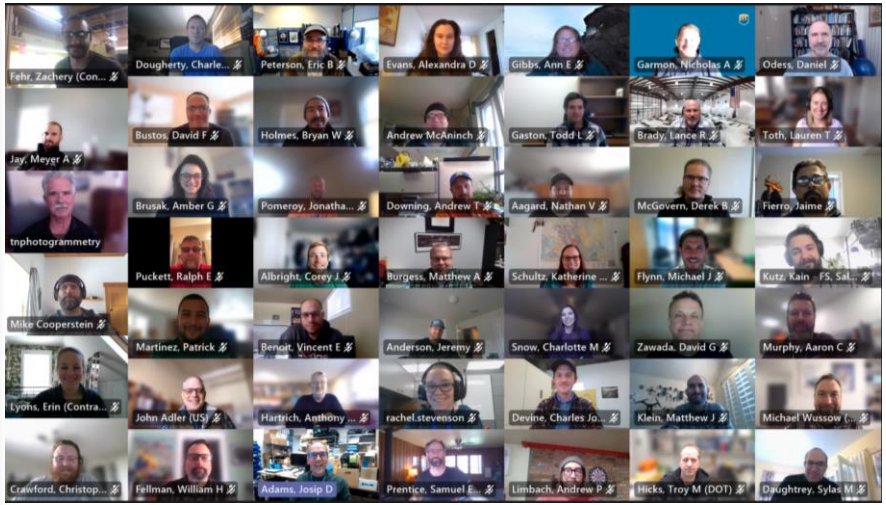
USGS National UAS Project Office

DOI Annual Flight Use



Department of the Interior – Advanced Training





- Advanced Operating Courses
- Data Processing Courses

UAS Existing Sensors Approved for DOI Use

High Definition Video

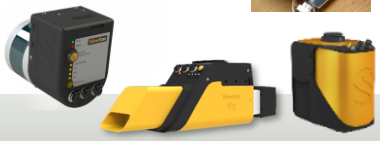
Point & Shoot Cameras

DSLR Cameras

Thermal Sensors

Multispectral Sensors

Doppler Radar



Lidar

- GoPro Hero
- Kodak Pixpro SP360
- Ricoh GR II
- Sony RXIRII
- Sony A6000, A7R
- FLIR Vue Pro/Pro R/Dual Pro
- MicaSense RedEdge 3, M, Altum, Dual
- Slantrange 3P, 4P
- Parrot Sequoia
- MAPIR Survey3
- Doppler Radar
- YellowScan VeloDyne Surveyor Lidar
- Riegl MiniVUX-1UAV
- HydraSleeve Water Sampler

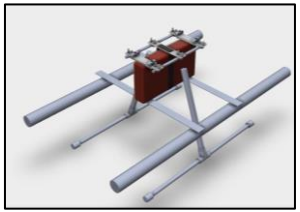
… and others

Sensors are developed in-house, through leasing and contracting agreements, or acquired on a competitive bidding process in accordance with U.S. Government purchasing thresholds. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

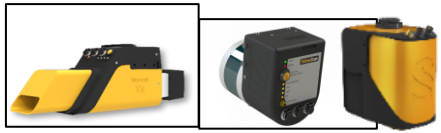
https://www.doi.gov/aviation/uas/fleet

USGS UAS Sensors Currently Being Integrated and Tested

Gas Sensors



Ground Penetrating Radar (GPR)



Lidar

PhaseOne
(medium format metric camera)

Hyperspectral

Geomagnetic

Telemetry

Sensors are developed in-house, through leasing and contracting agreements, or acquired on a competitive bidding process in accordance with U.S. Government purchasing thresholds. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

USGS UAS Sensors – Ground Penetrating Radar (GPR)

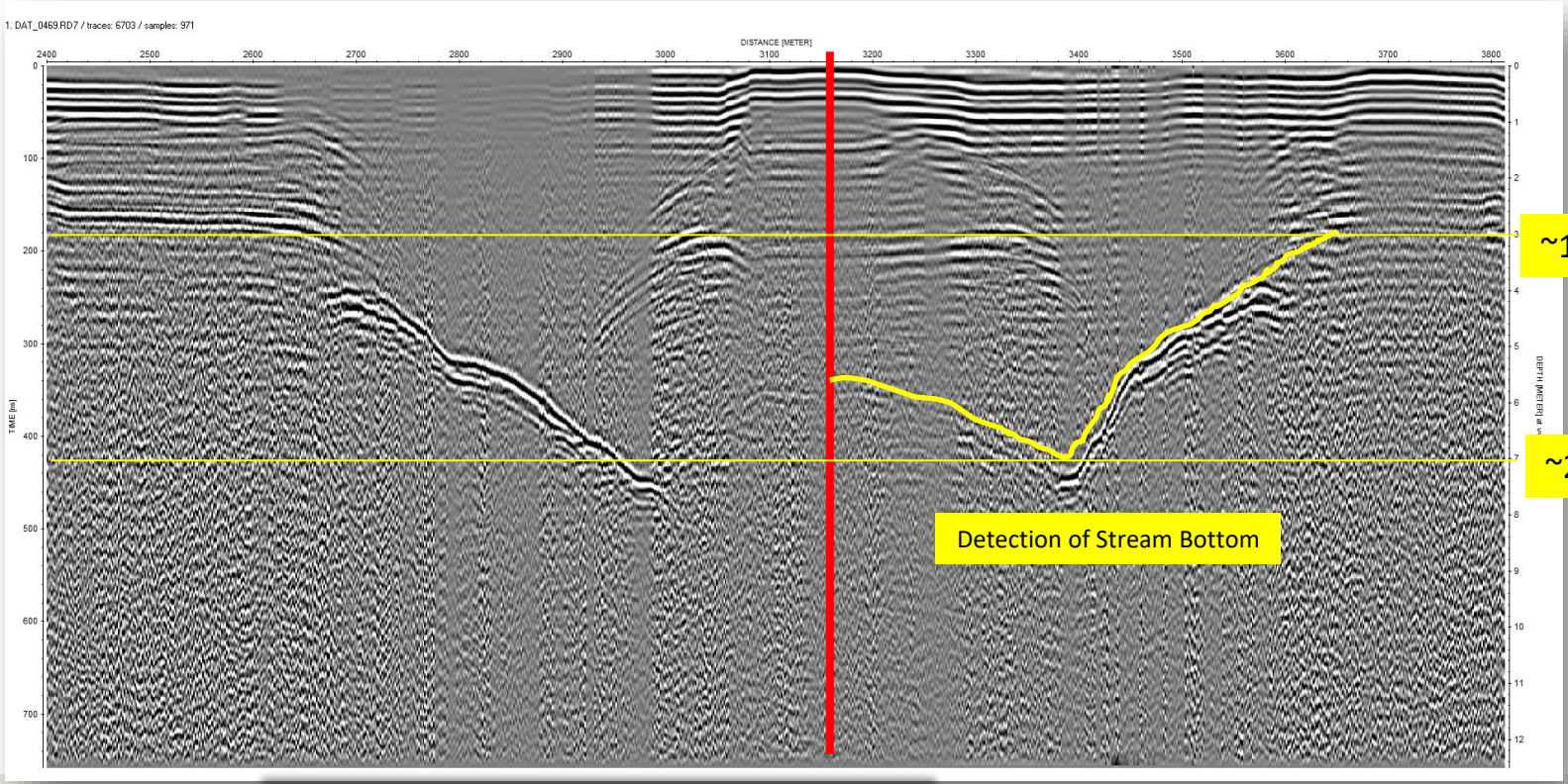
John Fulton & Cian Dawson, NUPO, - USGS

Juniper Unmanned & Mala Guideline Geo

Photo & Video Courtesy of Cian Dawson

USGS science for a changing world

USGS GPR UAS– Test Flights
Androscoggin River, May 2019



Experimental test data for information purposes only

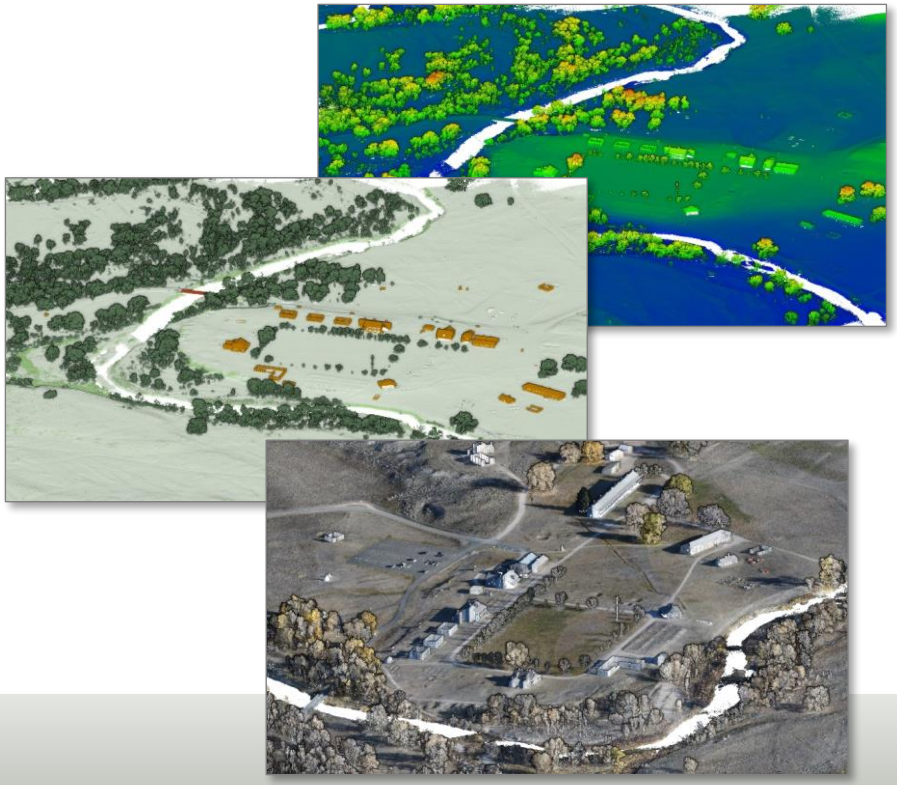
Note:

- *Profile is out and back.* Frequency 160 MHz bow-tie
- *Red line indicates approximate turn-around point.*
- *X-axis distance is actually trace time in nanoseconds*

USGS UAS Sensors – Lidar

USGS UAS Lidar Sensor Integration and Test Flights and Derived Data from YellowScan (VeloDyne Puck VLP-16) Lidar

Ft. Laramie National Historic Site, WY

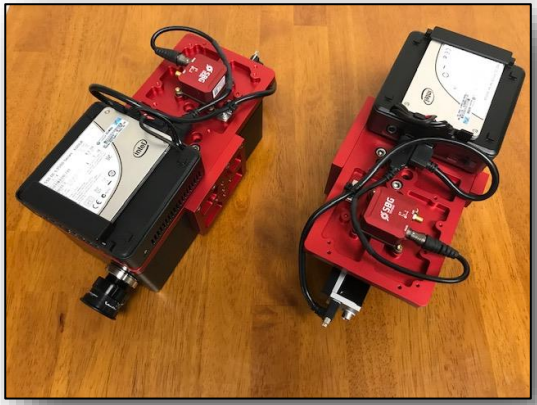


Lidar data is experimental test data for information purposes only
Imagery data is archived and publicly available

USGS National UAS Project Office – Sensor Integration

Headwall Nano Hyperspec

Resonon Pika XC2



Spectral Range (*nm*)	400 – 1000
Spectral Resolution (*nm*)	1.3
Spectral Channels	447
Spatial Channels	1600
Max Frame Rate (*fps*)	165
Bit Depth	12
Weight (*lb/kg*)	4.9 / 2.2
Dimensions (*cm*)	10.1 x 27.5 x 7.4
Connection Type	USB 3.0
Operating Temperature (°F/C)	41-104, 5-40
f/#	2.4
Pixel size (*µm*)	5.86
Avg. RMS Spot Radius (*µm*)	6
Smile (peak-to-peak) (*µm*)	4
Keystone (peak-to-peak) (*µm*)	5

Sensor integrations are presently still in development

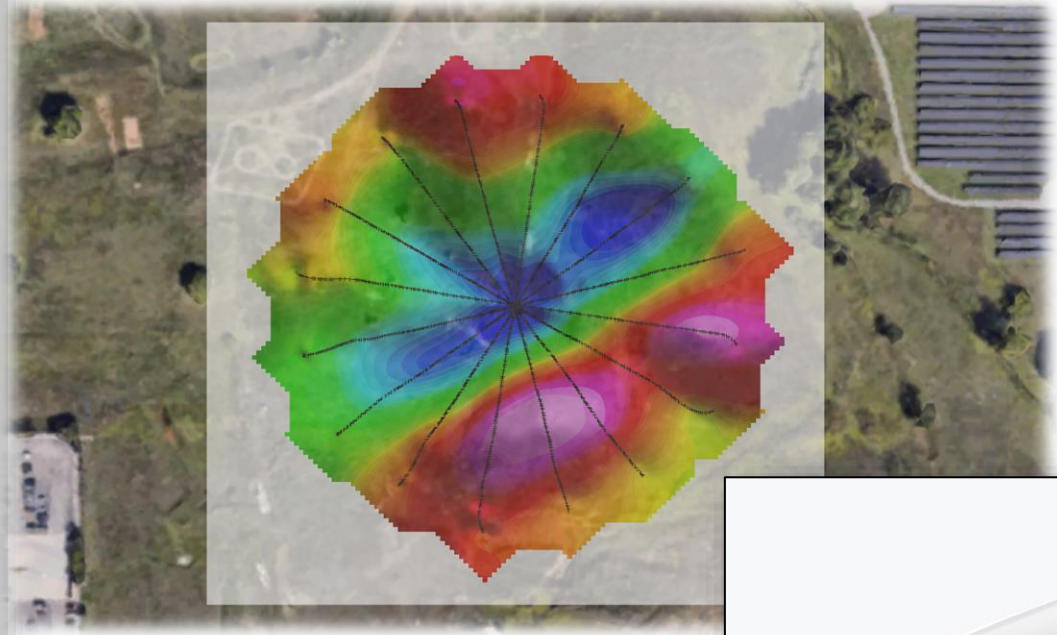
USGS National UAS Project Office – Sensor Integration

Palo Alto, California Biofilm Resonon Pika-L Project (May 2021)

Sensor integrations are presently still in development

USGS National UAS Project Office – Sensor Integration (2018)

Test Flights AeroMagnetics



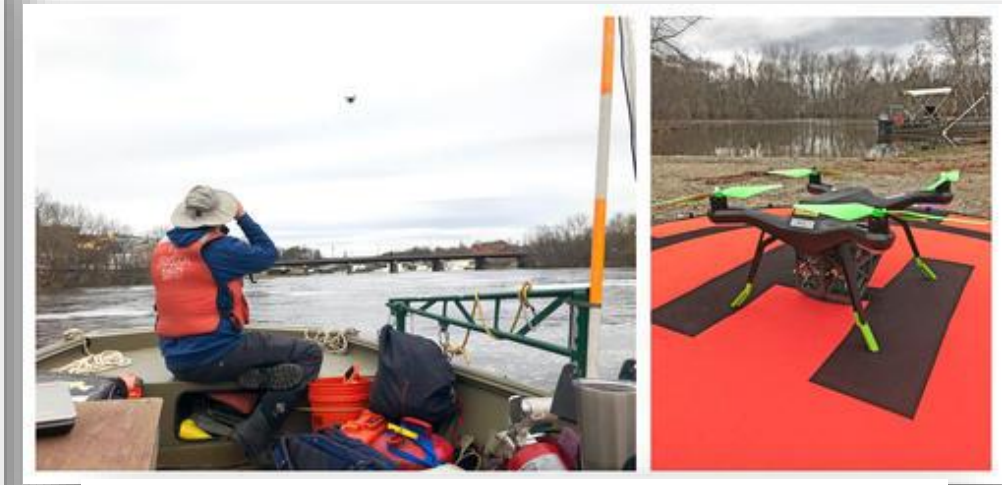
GeoMetrics - MagArrow

Data acquired via contract with Juniper Unmanned

USGS National UAS Project Office – Sensor Integration

Sensor developed by Sommer Messtechnik (Austria) and integration by USGS

QCam



remote sensing

MDPI

Article

QCam: sUAS-Based Doppler Radar for Measuring River Discharge

John W. Fulton [1,*], Isaac E. Anderson [1], C.-L. Chiu [2], Wolfram Sommer [3], Josip D. Adams [1], Tommaso Moramarco [4], David M. Bjerklie [1], Janice M. Fulford [1], Jeff L. Sloan [1], Heather R. Best [1], Jeff S. Conaway [1], Michelle J. Kang [1], Michael S. Kohn [1], Matthew J. Nicotra [1] and Jeremy J. Pulli [1]

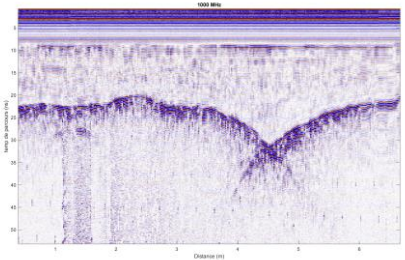
USGS science for a changing world

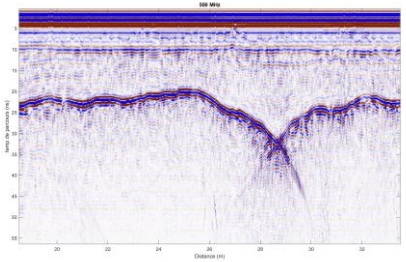
USGS Innovation Center Proposals – UAS Radar Snow Water Equivalent

Assess avalanche risk and measure *in situ* snow water equivalent in high-altitude basins

(Oct 2020)
Near Eisenhower Tunnel, CO

Dr. John Fulton, USGS
CO Dept. of Transportation
USGS NUPO





Credit: Jonah Bartrand (Graduate Research Assistant) and Dr. John Bradford (Professor and Department Head, Geophysics), Colorado School of Mines

USGS Innovation Center Proposals – Software Defined Radar

(Sept 2020)
Winter Park, CO

Dr. John Fulton, USGS
Mr. Sam Prager, USC
USGS NUPO

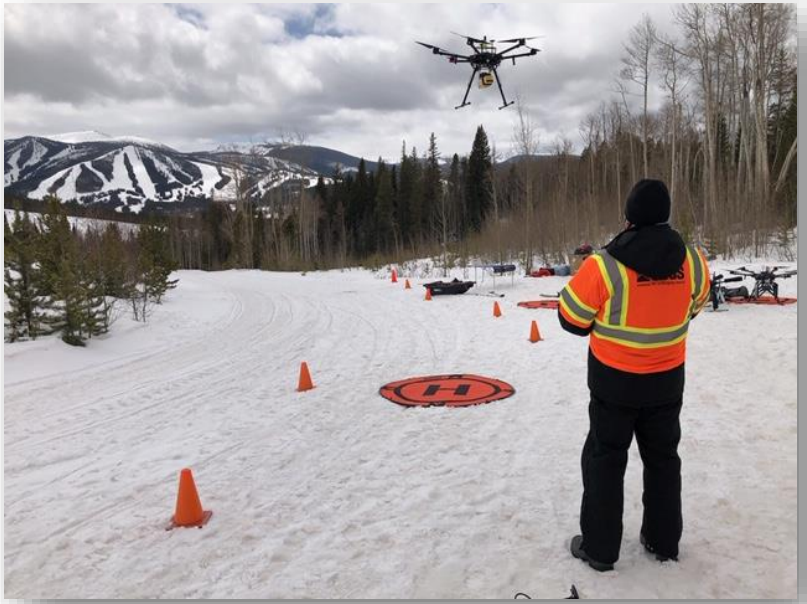
UAV-based software-defined radar sensors for environmental monitoring

USGS Innovation Center Proposals – Software Defined Radar

(April 2021)
Winter Park, CO

UAV-based software-defined radar sensors for environmental monitoring

Dr. John Fulton, USGS
Mr. Sam Prager, USC
USGS NUPO



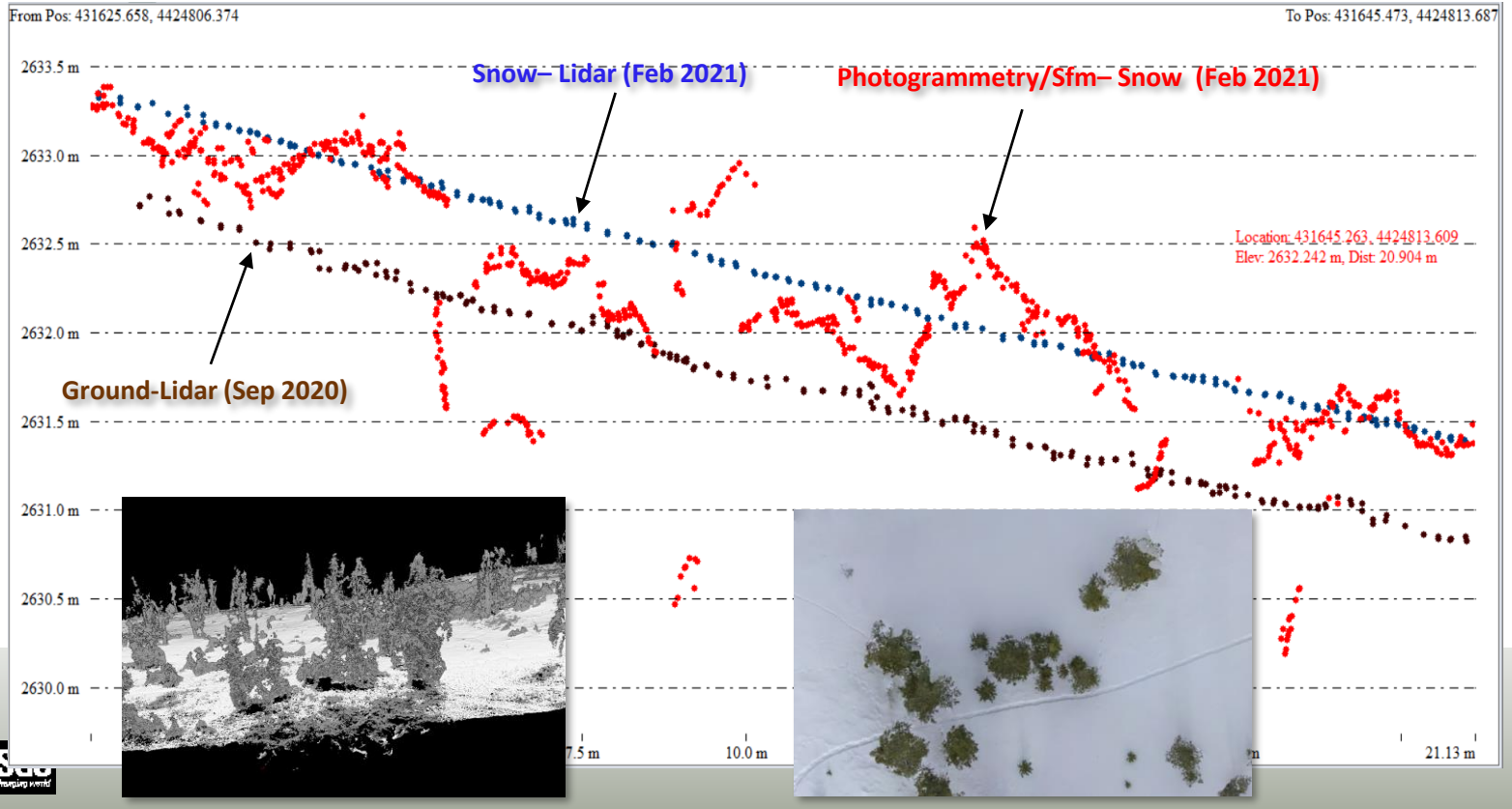
Simultaneous Lidar Data Collection

Four separate systems to collect imagery, radar and lidar

USGS Snow Water Equivalent Project – UAS Lidar

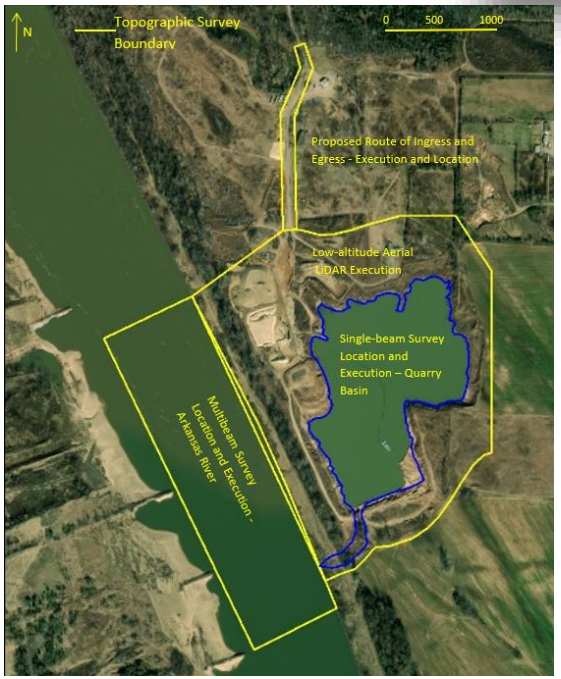
Devils Thumb Ranch - Lidar vs Sfm a Snow Depth Comparison

From September 2020 to February 2021



USGS – Slackwater Harbor Analysis (2021)

Corp of Engineers/USGS – Dardenelle Arkansas



- Collection at 5 m/s at 61m AGL
- QA/QC RMSE 0.03m based on photogrammetric point cloud and 12 Aeropoint GCP's corrected to Trimble R8 Base
- Photogrammetric collection used for colorization and QA/QC of the lidar point cloud

Technology for Analysis

- **Ricoh photogrammetry**
- **Yellowscan VX-20 lidar**
- **Multibeam sonar bathymetry survey**

USGS science for a changing world

Experimental test data for information purposes only

USGS National UAS Project Office

Stratospheric Micro Balloon Remote Sensing Pilot

URBANSKY.COM

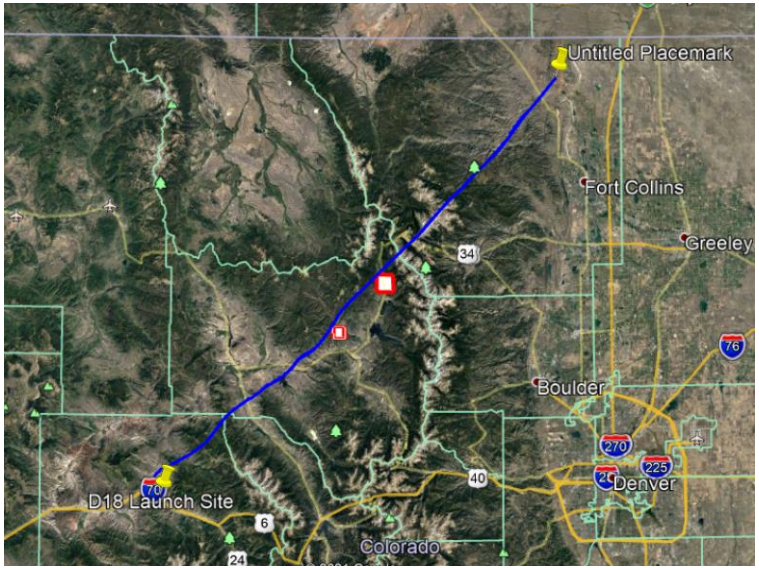
- Mission Objectives
  - Accurate pre-flight trajectory modeling
  - Remote, mobile flight system launch with minimum personnel
  - Targeted, broad-area, gap-free ~10cm GSD imaging from the stratosphere, ~16 sq. km AOI within East Troublesome Burn Scar 2020
  - Active and targeted termination, descent and soft landing of the flight system
  - Post-processing of the data per the USGS/NUPO Specifications
- Marketing
  - Starting at $5 per sq.km for new tasking
  - ~10cm GSD 3-band aerial imagery
  - Working on multispectral and thermal payloads

Graphics and Photographs Courtesy of Urban Sky

Experimental test data for information purposes only

USGS National UAS Project Office

Stratospheric Micro Balloon Remote Sensing Pilot



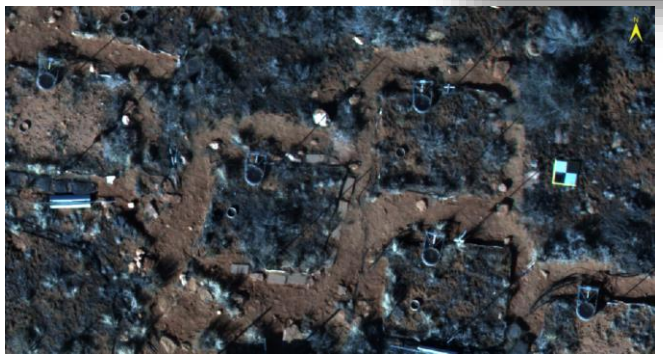
URBANSKY.COM

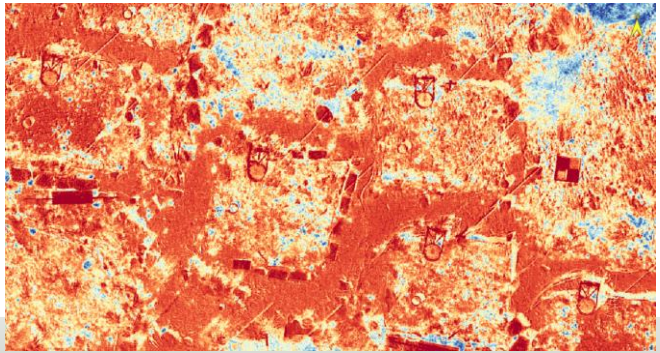
- October 11, 2021 USGS Flight
  - Launch Time: 7:48am MT
  - Launch Location: A public, dirt road on BLM land just north of Wolcott, Colorado
  - Total Flight Duration: ~3 hours and 8 minutes
  - Distance Covered: ~177km (~109 miles)
  - Amount of area we ***would've*** imaged (if payload was functional): ~2,000 sq. km
  - System Landing Time: ~10:55am MT
  - System Landing Location: In a remote, unpopulated area ~10km (~6 miles) North of Livermore, Colorado (commanded and controlled, targeted descent).
  - Hardware Status after Mission: The payload was recovered with no noticeable damage.

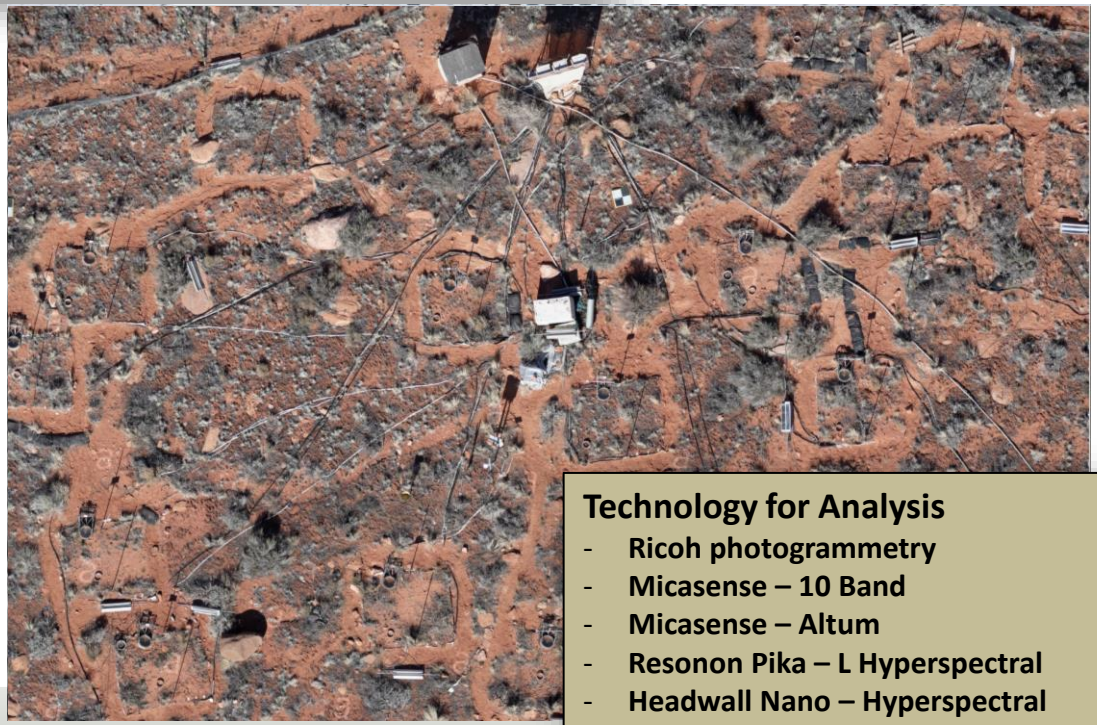
Graphics and Photographs Courtesy of Urban Sky

USGS – Moab Biocrust (2022)

USGS/University of Arizona – Moab, Utah







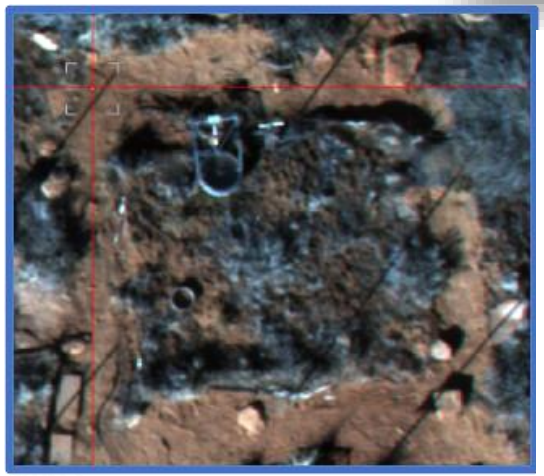
Technology for Analysis

- **Ricoh photogrammetry**
- **Micasense – 10 Band**
- **Micasense – Altum**
- **Resonon Pika – L Hyperspectral**
- **Headwall Nano – Hyperspectral**
- **XT2 EO/IR**

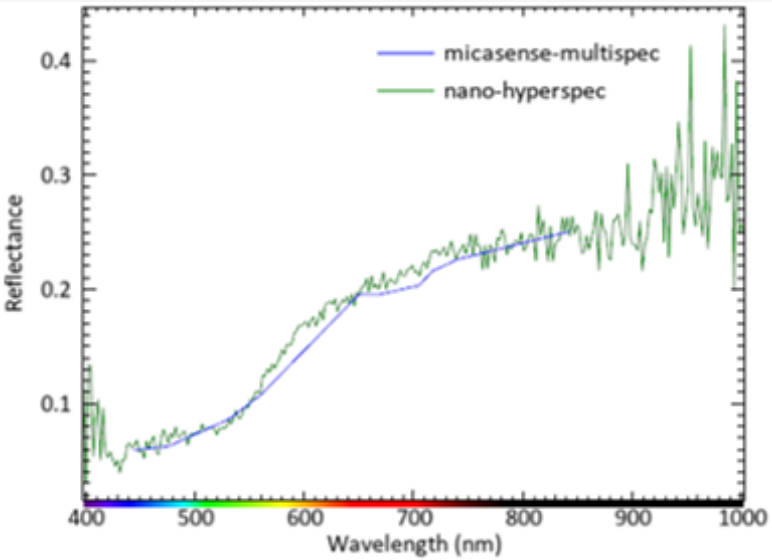
Experimental test data for information purposes only

USGS – Moab Biocrust (2022)

USGS/University of Arizona – Moab, Utah



10-band Micasense



274-band Headwall Nano

Comparing multispectral and hyperspectral reflectance profiles

USGS Innovation Center Proposals – Wildfire Smoke Plume Sampling (EPA)

(April 2021)
Konza Prairie, KS

Kolibri Sensor

USGS Innovation Center Proposal - Environment Protection Agency

USGS – Post-Wildfire Fire Severity (2021)

Office of Wildland Fire – East Troublesome Fire Colorado

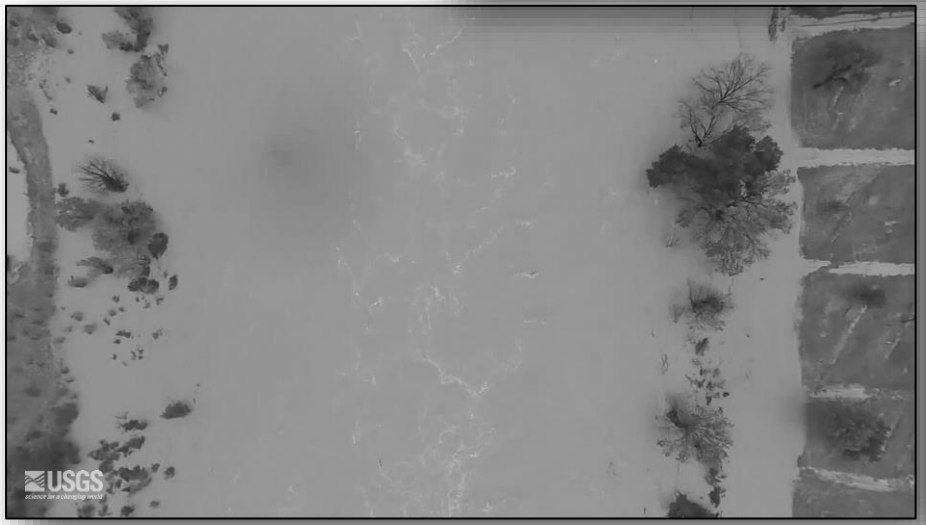
Technology for Analysis

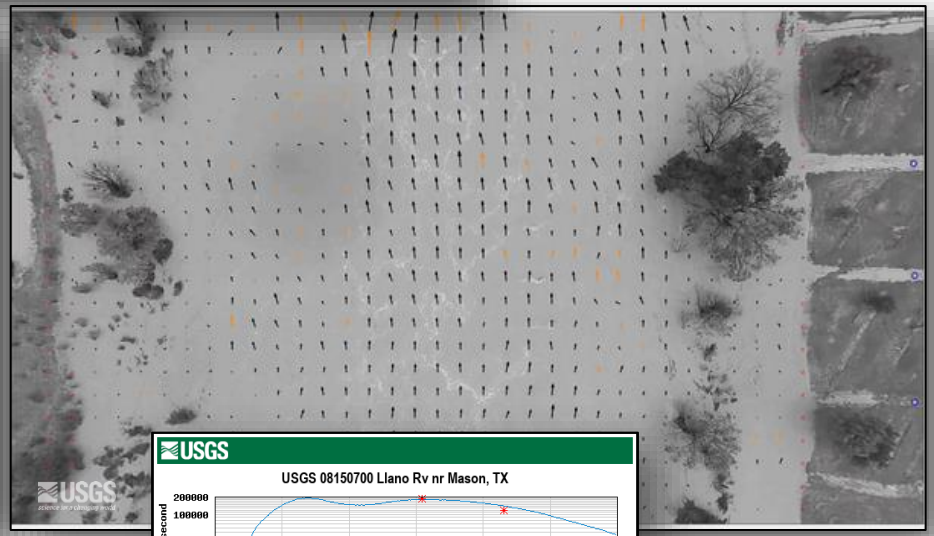
- **Ricoh Photogrammetry**
- **Yellowscan VX-20 Lidar**
- **Micasense 10 band MS**

Experimental test data for information purposes only

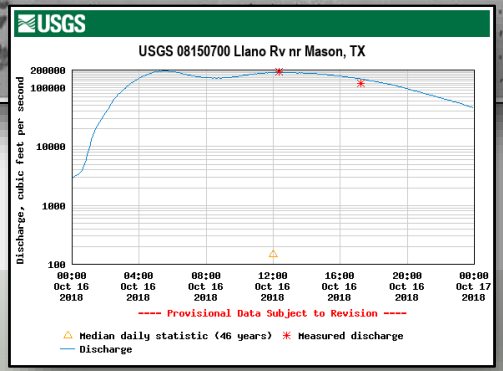
USGS – Natural Hazards Response

LSPIV – Large-Scale Particle Image Velocimetry





Courtesy: USGS, F. Engel - 2019



Computer vision used to:

- **Stabilize video**
- **Remove lens distortion**
- **Execute image velocimetry**

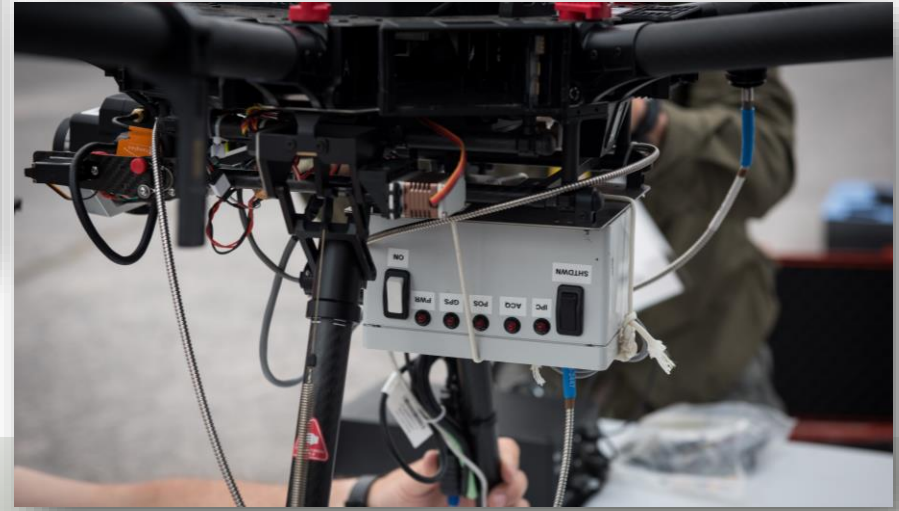
USGS science for a changing world

Experimental test data for information purposes only

Hawaii – Kilauea Volcano Eruption - 2018

USGS science for a changing world

USGS UAS Sensors – Volcanic Gas Sensors (2018)



Sensors developed and integrated by the USGS

USGS National UAS Project Office – Sensor Integration (2019)

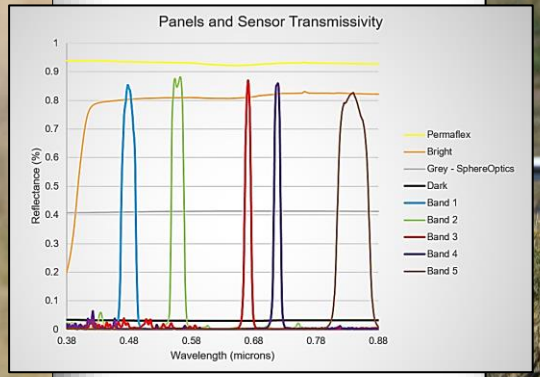
Water Sampling - HydraSleeve

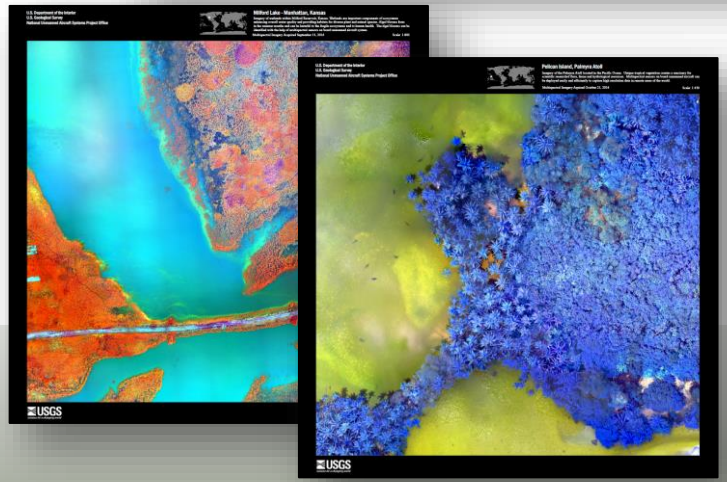
USGS National UAS Project Office – Sensor Integration (2019)

Water Sampling - HydraSleeve

Experimental test data for information purposes only

USGS National UAS Project Office – Sensor Calibration & Best Practices





USGS – Lidar and Validation

Our UAS LiDAR Systems

Yellowscan Surveyor
(Velodyne VLP-16)
Acquired 2016

Yellowscan VX20-100
(Riegl mini-Vux-1UAV)
Acquired 2019

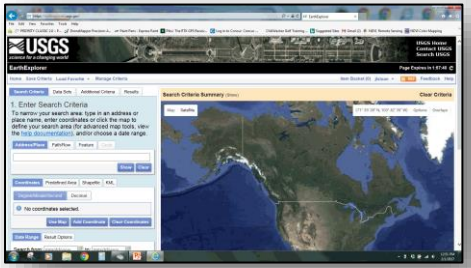
Yellowscan Mapper
(Livox Horizon)
Acquired 2021

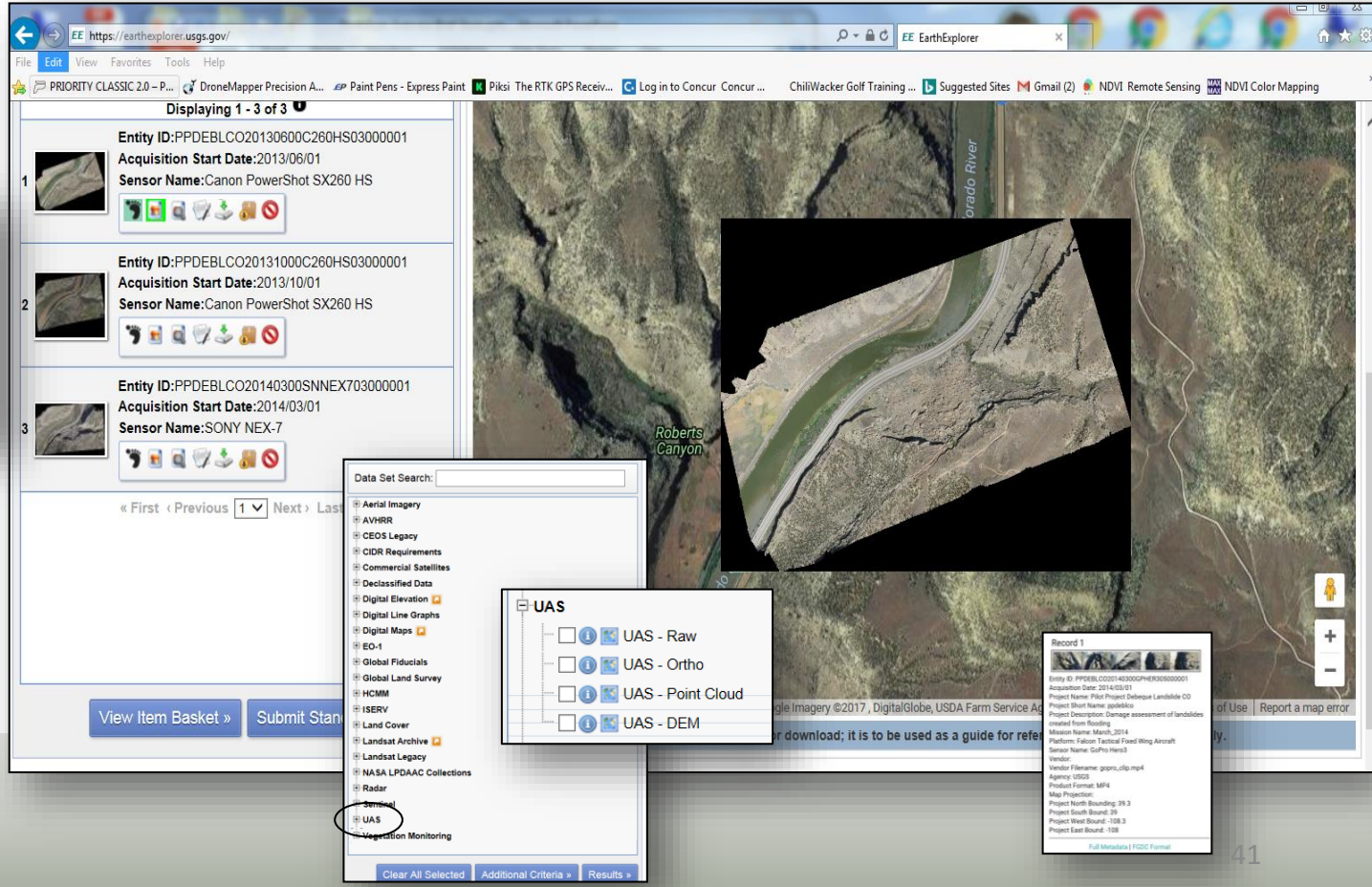
Experimental test data for information purposes only

Metadata, Archiving, and Distribution

USGS – EROS Data Center
EarthExplorer

earthexplorer.usgs.gov





2021 - USGS National UAS Project Office

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