Topics

• Unmanned Aircraft System or UAS
  o What & How
  o Why & Why Now
• FAA – Policy and Privacy
• International
• Department of the Interior and USGS National UAS Project Office
  o Technology
  o Applications & Products
  o Collaboration
• Summary
What is an Unmanned Aircraft System (UAS)

There is nothing unmanned about an unmanned system!

What to call it?

- Unmanned Aircraft System (UAS)
- Uninhabited Aircraft System (UAS)
- Unmanned Aerial Vehicle (UAV)
- Remotely Piloted Aircraft (RPA)
- Remotely Piloted Vehicle System
- “Drone” or Civil Drone
- Model Aircraft or Remote Controlled Aircraft

Public perception is skewed

- Predators/Drones
- Weaponized
- Autonomy
- Surveillance/privacy
Different Types of “Drones”
How a UAS Works

Line-of-Sight (LOS)
DOI mode of operation

Beyond-Line-of-Sight (BLOS)
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

USGS

science for a changing world
UAS Economic Potential

AUVSI’s 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)
UAS Economic Potential (cont.)

<table>
<thead>
<tr>
<th>State</th>
<th>2015 Total Impact ($M)</th>
<th>2015 Agricultural Impact ($M)</th>
<th>2025 Total Impact ($M)</th>
<th>2025 Agricultural Impact ($M)*</th>
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<tr>
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<td>$1.55</td>
<td>$1.43</td>
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<td>$3.48</td>
<td>$3.17</td>
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</table>

* estimated from 2015 percentages

The Economic Impact:
Where will drones be in 2015?

- Wildfire mapping
- Disaster management
- Thermal infrared power line surveys
- Telecommunication
- Weather monitoring
- Aerial imaging/mapping
- Television news coverage, sporting events, moviemaking
- Environmental monitoring
- Oil and gas exploration
- Freight transport

Produced by: Matthew Schroyer, DronesForGood.com, DroneJournalism.org
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

- Certificate of Authorization (COA) process
- Arctic – 1st commercial ops
- Six UAS test sites
- UAS Roadmap
- Small UAS Rule

FAA considers all UAS as “aircraft” and reaching integration by accommodation (COAs), integration (stds), and evolution (NextGen)

FAA 2012 aerospace forecast, estimated a fleet of 10,000 domestic UAS within five years. The 2011 forecast went so far as to predict that the fleet of domestic UAS could reach 30,000 by 2030

Very limited commercial UAS operations currently allowed, only public operations via COA – 52/82 in 2007, 423/492 in 2013, ~50% universities
FAA and UAS (cont.)

- Test site progress, see map, includes privacy policy for test sites
- Agreements with Federal agencies, including DOI, to streamline operations
- Small UAS Notice of Proposed Rule Making (NPRM), late 2014
- Several lawsuits
  - Raphael Pirker
  - Texas EquuSearch
  - Model aircraft hobbyists
  - Research universities
  - Commercial drone interests
FAA and UAS (cont.)

Commercial operations
• Arctic – over ocean (2013) and land (2014 pipeline inspections)
• FAA can grant exemptions under section 333 of the FAA Modernization and Reform Act
• Granted regulatory exemptions to 6 aerial photo and video production companies, the first step to allowing the film and television industry the use of UAS in the NAS, 9/25/14
• Exemptions – film industry, oil (flare stack and pipeline inspections), agriculture, as of October 2 received 57 requests, approved 6 (film)

Center of Excellence for Unmanned Aircraft Systems RFP, Aug 2014 from Congressional Consolidated Appropriations Act 2014
• Relationship to 6 test sites and FAA Technology Center UAS activities

Where you can fly tools – https://www.mapbox.com/drone/no-fly/
FAA and UAS (cont.)

- In general, model aircraft must be flown as a hobby, not weigh more than 55 pounds, not interfere with manned aircraft, not fly within 5 miles of an airport without prior permission and adhere to a set of community-based guidelines
- Over 25,000 comments
- Over 30 university researchers file complaint letter with FAA, August 2014
- The Academy of Model Aeronautics (AMA) is “extremely disappointed and troubled” by the approach the FAA has chosen to take in regards to this issue.

<table>
<thead>
<tr>
<th>Hobby or recreation</th>
<th>Not hobby or recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flying a model aircraft at the local model aircraft club.</td>
<td>Receiving money for demonstrating aerobatics with a model aircraft.</td>
</tr>
<tr>
<td>Taking photographs with a model aircraft for personal use.</td>
<td>A realtor using a model aircraft to photograph a property that he is trying to sell and using the photos in the property’s real estate listing.</td>
</tr>
<tr>
<td>Using a model aircraft to move a box from point to point without any kind of compensation.</td>
<td>Delivering a package for a fee.⁶</td>
</tr>
<tr>
<td>Viewing a field to determine whether crops need water when they are grown for personal enjoyment.</td>
<td>Determining whether crops need to be watered that are grown as part of commercial farming operation.</td>
</tr>
</tbody>
</table>

⁶If an individual offers free shipping in association with a purchase or other offer, FAA would construe the shipping to be in furtherance of a business purpose, and thus, the operation would not fall within the statutory requirement of recreation or hobby purpose.
“FAA is making some progress in meeting UAS-related provisions of the FAA Modernization and Reform Act of 2012, but the Agency is significantly behind schedule in meeting most of them, including the goal of achieving safe integration by September 2015. FAA has completed 9 of the act’s 17 UAS provisions, such as selecting 6 test sites, publishing a UAS Roadmap, and developing a comprehensive plan outlining FAA’s UAS plans in the near- and long-term. However, the Agency missed the statutory milestones for most of these provisions, and much work remains to fully implement them. FAA is also behind schedule in implementing the remaining eight UAS provisions. For example, FAA will not meet the August 2014 milestone for issuing a final rule on small UAS operations. FAA’s delays are due to unresolved technological, regulatory, and privacy issues, which will prevent FAA from meeting Congress’ September 30, 2015, deadline for achieving safe UAS integration. As a result, while it is certain that FAA will accommodate UAS operations at limited locations, it is uncertain when and if full integration of UAS into the NAS will occur.” DOT IG Audit Report June 26, 2014
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**
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
Privacy Concerns (cont.)

- Legislation – protecting 4th amendment, State vs. Federal, see map
- Law firms are developing UAS expertise
- International Association of Chiefs of Police guidelines for UAS use
- AUVSI voluntary code of conduct
- Privacy review – FAA, DoJ, DHS
- Is it a technology or data issue?
  - Internet, GPS/phones, cameras/buildings, email, license plate readers pose greater threats
  - Pilot on ground vs. plane
- Rumor of an executive order on UAS
In 2013, 43 states introduced 130 bills and resolutions addressing UAS issues. At the end of the year, 13 states had enacted 16 new laws and 11 states had adopted 16 resolutions. - National Conference of State Legislatures

Data clause in legislation restricting access and setting deletion dates
Canada has granted nearly 1,500 “Special Flight Operations Certificates” in the last three years

DHL has received authorization to start regular drone delivery flights to an island in the North Sea about 7.5 miles off the coast of Germany - DHL parcelcopter
Sato, Akira (2011, October). Civil UAV Applications in Japan and Related Safety & Certification. Presented at the 1st Annual Agricultural UAS Conference: Precision Agriculture, Atlanta, GA.
Remote Sensing Data Sources

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.
Secretary Sally Jewell oversees 70,000+ employees in 9 bureaus:

- Bureau of Ocean Energy Management (BOEM)
- Bureau of Safety and Environmental Enforcement (BSEE)
- Bureau of Indian Affairs (BIA)
- Bureau of Reclamation (BOR)
- U.S. Geological Survey (USGS)
- U.S. Fish and Wildlife Service (FWS)
- Bureau of Land Management (BLM)
- National Park Service (NPS)
- Office of Surface Mining, Reclamation and Enforcement (OSM)

USGS established by the Organic Act of March 3, 1879, which mandated "the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain."

NPS closes national parks to launching, landing or operations UAS, June 2014
What is the 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.
Tangible Benefits

The tangible benefits of the DOI UAS operational test and evaluation phase can be summed up in three words: **Science, Safety, and Savings.** Examples of these tangible benefits include:

- 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. Many offer greater airborne persistence and launch responsiveness than manned aircraft. These unique characteristics enable UAS to gather repeatable, scientifically valid observations. Better science leads to better policy decisions, which benefits all Americans.

- 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.

- 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.

New agreement between the FAA and Department supports “file and fly” approach to UAS flights
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
- Evaluates emerging technologies
- Develops new products and capabilities
UAS Technology – Aircraft

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 Raven A

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 T-Hawk
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
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

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

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

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
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.
Pleistocene Trackway Mapping
White Sands National Monument, NM

Photogrammetric documentation using a UAS to aerial survey extremely fragile fossilized footprints from the late Ice Age.
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.
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.
Developing Intelligent Autonomous UAS for Geoscience Research

Jonathan Glen (GMEG Science Center, USGS)
Corey Ippolito (NASA Ames)

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 (CO₂, SO₂, H₂S)
- 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
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
Abandoned Material Inventory
Mojave National Preserve, California

Geo-locating abandoned materials and Joshua Tree mapping
Geospatial Data Products

- Color Infrared - NDVI
- Point Cloud Generation
- Elevation Models
- Feature Extraction
- KML – 3D Modeling
- Orthophotography
- Volumetric Measurements
- Contour Generation
Geospatial Data Products (cont.)

1.5” Ground Sample Distance from 400 ft

Canon Powershot SX260 and S100

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

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<tr>
<th>Camera</th>
<th>Canon Powershot SX230</th>
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NOAA Collaboration

- Shoreline assessments
- Fisheries law enforcement
- Marine debris
- Wildlife surveys
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
- Declining budgets and increased acquisition costs have reduced the data from these sources
- UAS provide a flexible, low-risk and low-cost alternative – scientists can get the data they need, when they need it

The USGS will continue the operational test and evaluation phase, but will start to transition some activities to operations and investigate new sensors, products and applications

The USGS will continue to lead the evaluation and application of UAS technology in the Department and will continue working with the other bureaus, Federal agencies and universities

Website: http://uas.usgs.gov/
Back-ups