



USGS – National Unmanned Aircraft Systems Project Office

UAS Mission Planning

Jeff Sloan & Joe Adams

USGS-Geosciences & Environmental Change Science Center

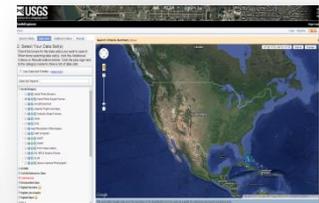
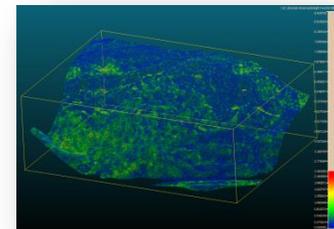
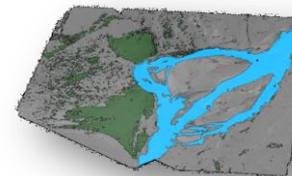
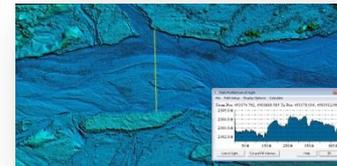
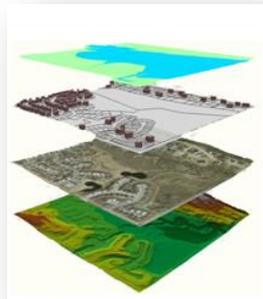
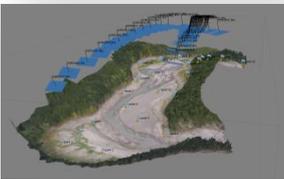
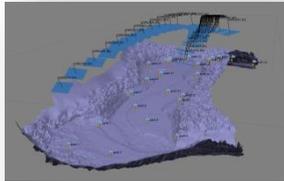
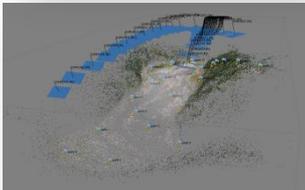
National UAS Project Office

Denver, Colorado USA

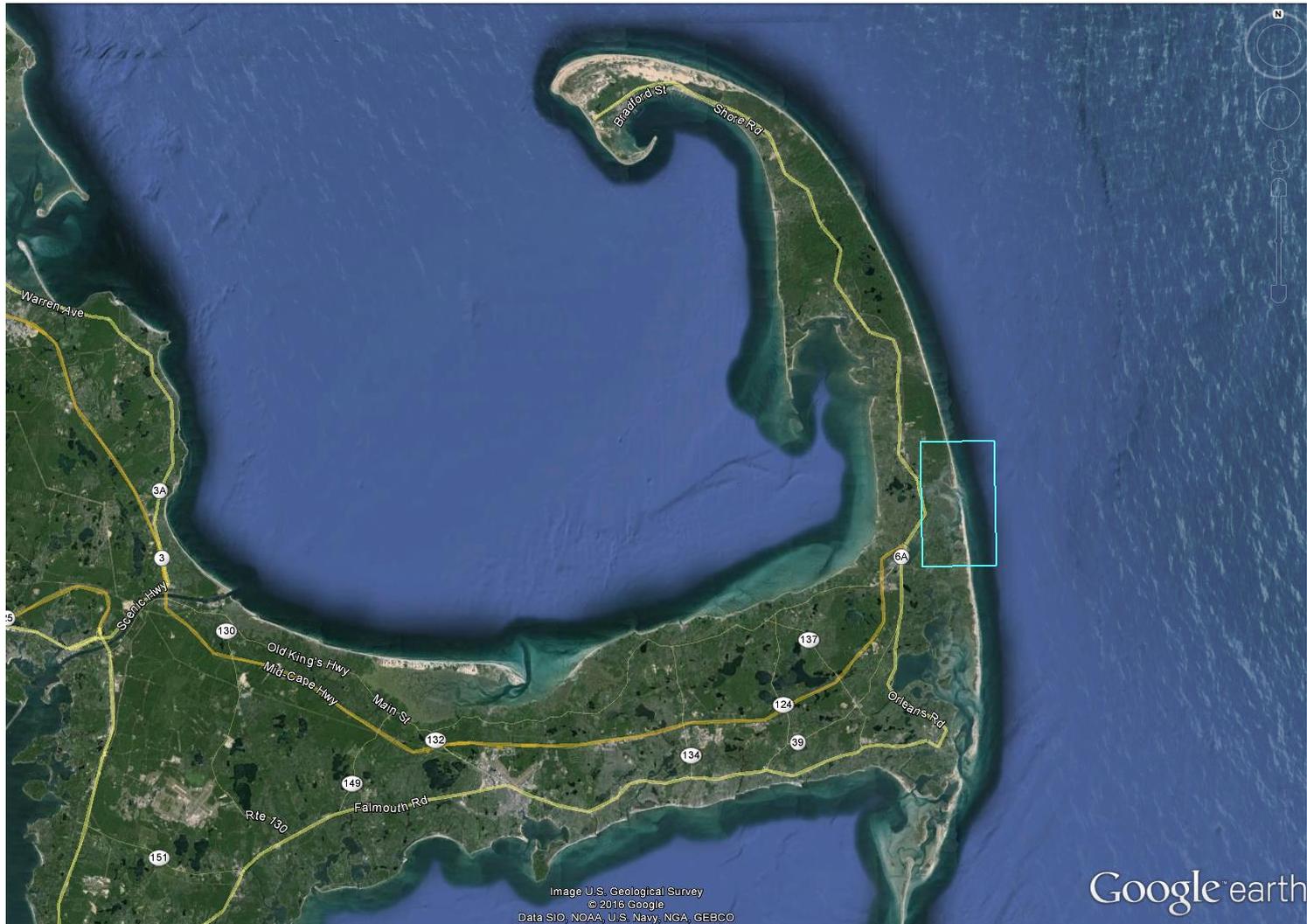
March 2016

uas.usgs.gov

UAS Data Production Process

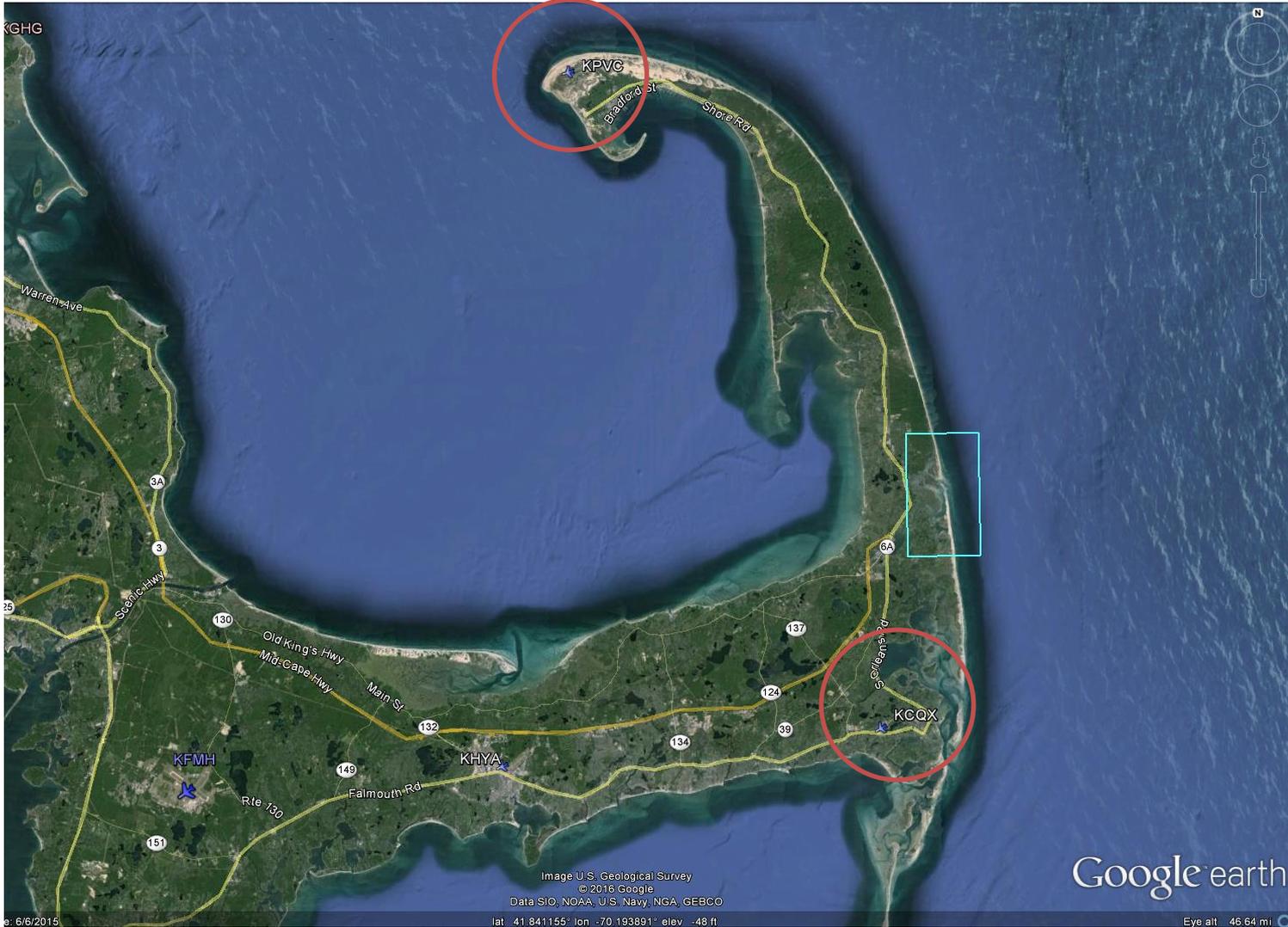


Cape Cod Project



Define the Area of Interest

Cape Cod Project



Identify Airports, Populated Areas, Obstacles, Hazards

Cape Cod Project

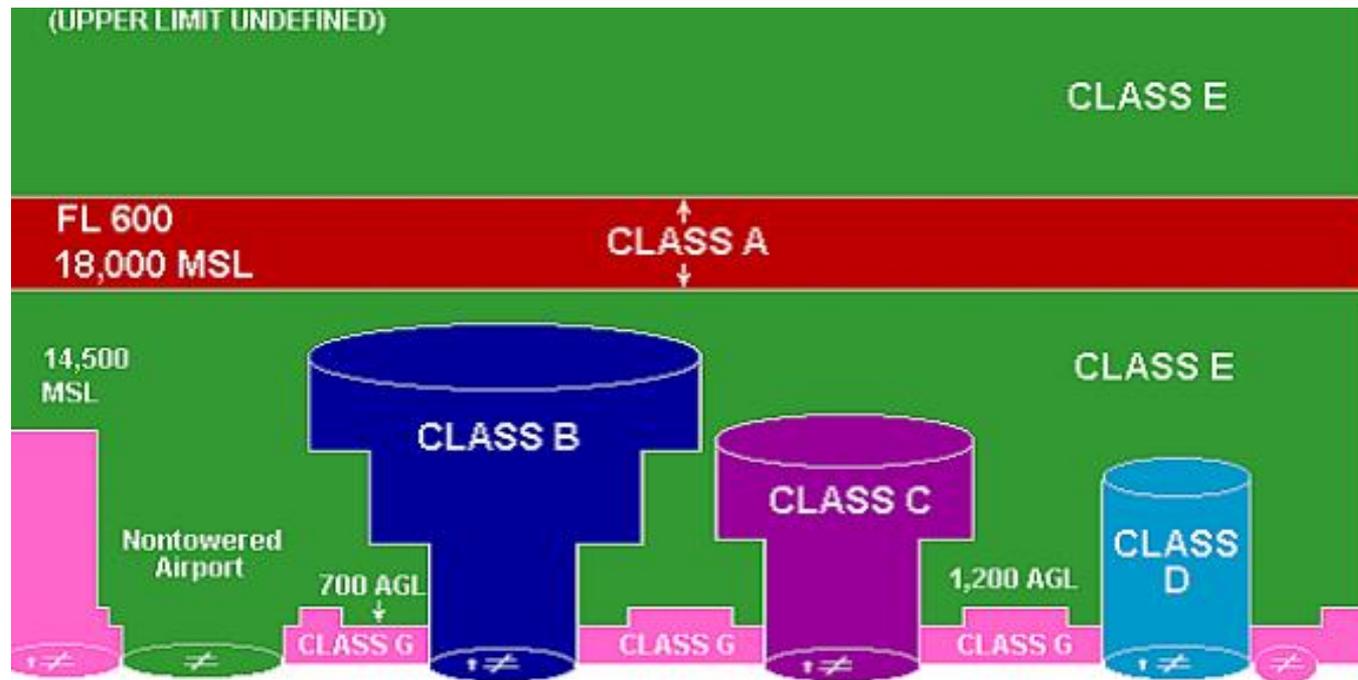


Identify Land Ownership (Public & Private)

Initiating a Project

- Class of airspace that the project will work in
- COA vs. MOA
- Specific Agency Operation Requirements
- Range approvals or Private land approvals
- Safety Plan
- Operational Procedures (OPM-11)
- Logistics
- Cost Considerations
- NOTAM
- MISHAP Procedures
- Sensors / Flight Planning
- Data Archiving

U.S. Airspace Classes at a Glance



Policies: How to Operate in the United States National Airspace

- **Certificate of Authorization (COA):**

Authorization or waiver issued by the Air Traffic Organization to a public operator for a specific UAS activity on a case-by-case basis

- **Memorandum of Agreement (MOA):**

- Originally signed Dec. 24, 2013 (updated Sept. 2015)

- FAA and DOI Information Bulletin No. 14-04

- Under 1,200'

- Visual Line of sight

- 5 nm from an airport (control tower)

- 3 nm from an airport (published instrument procedures)

- 2 nm from an airport (not having published instrument procedures)

- 2 nm from a heliport

- Not over people or urban settings

- NOTAM

- VFR weather minimums and allowed to fly at night

Specific Agency Operation Requirements



National Park Service:

- 1.) NPS UAS operations application form (one time operation or permanent)
- 2.) Safety plan (reviewed by NPS)
- 3.) NPS Research Permit and Reporting System (RPRS)
- 4.) Copy of the FAA Certif. of Authorization (COA)
or FAA/DOI Memorandum of Agreement (MOA)
- 5.) Approval letter or email from any private land owner that UAS will fly over



U.S. Fish & Wildlife Service:

- 1.) Special Use Permit (SUP)
- 2.) Safety plan (reviewed by USFWS)
- 3.) Range Approval Letter
- 4.) (If required) Animal Care and Use Letter
- 5.) Approval letter or email from any private land owner that UAS will fly over



Bureau of Land Management:

- 1.) Safety plan (reviewed by BLM)
- 2.) (If required by the property specialist) Range Approval Letter
- 3.) Approval letter or email from any private land owner that UAS will fly over

Specific Agency Aviation Contacts

Fish and Wildlife Service (FWS)

Anthony Lascano (National Aviation Manager)
4501 North Fairfax Dr., ms 4401
Arlington, VA 22203

E-Mail: anthony_lascano@fws.gov
Phone: (703) 358-2059
FAX: (703) 358-2203

National Park Service (NPS) / NIFC

Jon Rollens (Branch Chief of Aviation)
3833 S. Development Ave.
Boise, ID 83705-3833

E-Mail: Jon_Rollens@nps.gov
Phone: (208) 387-5227
FAX: (208) 387-5250
Cell: (208) 484-5186

Aviation Safety Managers:

NPS:

Jim Traub james_traub@contractor.nps.gov (208)-387-5931

USFWS

Brian Mullin – USFWS brian_mullin@fws.gov (208)-387-5515

Safety Plan

Small Unmanned Aircraft Project Aviation Safety Plan

Mission: Aerial Photography		Project Name: Rapid response mapping of coastal landscape change with UAS	Unit: Cape Cod N.S.
Anticipated Project Date: Feb 29, 2016 – Mar 4, 2016	Start Time: 0630	Ending Time: 1700	
Project Plan Prepared by: Christopher Sherwood/Jeff Sloan/Mark Bauer	Title: Research Oceanographer UAS Operators/Analysts	Date: Dec 29, 2015	
Note: Signature by the preparer verifies that all personnel have the required training for the mission. Attach Map, clearly showing areas to be flown; aerial hazards must be indicated.			
Project Plan Reviewed by:	Title: NPS Safety Aviation Manager	Date:	
Project Plan Reviewed by:	Title: NPS Chief of Law Enforcement	Date:	
Project Plan Reviewed by:	Title: NPS, IMR Reg. Aviation Manag.	Date:	
Project Plan Reviewed by:	Title:	Date:	
Project Plan Reviewed by:	Title:	Date:	
This Flight is Approved by: Jeff Sloan 	Title: Chief, National UAS Project Office	Date: Dec 29, 2015	

Project Description:

1) UAS flights - A series of UAS flights will be flown along overlapping flight lines over the survey area. Flights will be launched and landed from an open, unoccupied location (e.g., a beach, parking lot, or lawn) with good sight lines and no overhead obstructions (e.g., trees, power lines, towers). Flight levels will be limited to <400 feet above ground levels and kept within line-of-sight, and flights will be visually monitored by certified operators. Target regions to be mapped are sandy beach environments with sparse vegetation, bluffs and dunes, vegetated uplands, and wetlands, including vegetated marsh and unvegetated tidal flats. Portions of flights will be over water. The aircraft will be a FAA-approved rotary-wing (helicopter) or fixed-wing aircraft with camera, GPS, radio-control, and autopilot capabilities.

2) Ground-control markers

Ground-control markers will be deployed by project personnel and surveyed in with differential GPS. Each of the approximately 10-15 markers will be made of durable fabric and placed on the ground temporarily during overflights. They will be deployed by foot by (a) team(s) of two, who will also survey their location. Marker locations on Nauset Spit and marsh locations may be placed by trained and properly equipped personnel operating a 14' outboard.

3) Ground-truth surveys

Walking surveys with continuously recorded differential GPS data, photos, and field notes describing vegetation cover (including canopy height) and ground texture will be made during the overflights. These surveys will be conducted by the same team(s) that deploy and recover the ground-control markers.

4) Construction of orthophotomosaic, digital surface map, and digital elevation map.

Software will be used to mosaic the images, rectify the mosaic with the ground-control points, and construct a digital elevation map using structure-from-motion algorithms. These activities will take place at the USGS offices.

Organization:

- a. USGS Leads: Mark Bauer (USGS) and Todd Burton (USGS) and Jeff Sloan (USGS) - have go/no-go authority
b. USGS Coordinator: Christopher Sherwood (USGS)

c. Nearest Airport Manager:

ARTCC: Boston Logan International (KBOS), Freq, 124.725 118.250. Facility Manager: Ed Ereni Ph. (617)-567-5400
Chatham Municipal Airport (KCQX), attended 1300Z-dusk. Facility Manager: Timothy Howard Ph. (508)-945-9000
Barnstable Municipal Airport (KHYA). Facility Manager: Bud Breault. Ph. 508-775-2020
Provincetown Municipal Airport (KPVC). Facility Manager: Arthur Lisenby. Ph. 508-487-0241

d. NOTAM: 48 hours prior to start, contact Boston Center ARTCC (603)879-6655

- e. Plan approval authority: Mark Bauer or Todd Burton - USGS National UAS Project Office
f. UAS Flights will be coordinated with NPS Cape Cod National Seashore dispatcher.

Safety Provisions:

- a. All UAS flight activity will be within the defined FAA-DOIMOA boundary.
b. USGS or NPS visual observers will be utilized at all times.
c. UAS pilots will maintain a safe operating distance from manned and unmanned aircraft.

Other Airspace Deconfliction Procedures:

Flights will be coordinated with NPS Cape Cod National Seashore dispatcher located in Boston, 617-242-5659. The Eastham and Orleans Police and Fire Departments will be notified of flight times and locations.

Justification Statement for UAS flights:

The proposed project is directly related to Cape Cod National Seashore (CACO) enabling legislation to "preserve the natural and historic values of a portion of Cape Cod". According to the CACO General Management plan, the purposes of Cape Cod National Seashore are to:

- Preserve the nationally significant and special cultural and natural features, distinctive patterns of human activity, and ambiance that characterizes the Outer Cape, along with the associated scenic, cultural, and recreational values.
- Provide opportunities for current and future generations to experience, enjoy, and understand these features and values.

Coastal storms affect the park, reshaping natural features, changing habitats, and altering infrastructure and access to park features. The primary objective of the proposed UAS mapping is to explore methods for rapidly mapping coastal topography and habitat before and after storm events. The UAS system is expected to provide precise, accurate, and inexpensive geo-referenced images of topography and habitat in a non-intrusive manner. Once the initial maps have been made, subsequent mapping efforts will be conducted after significant storms to quantify changes, including erosion, deposition and changes in vegetation and habitat. Analysis of the initial maps and subsequent changes will be conducted by the USGS to improve quantitative models of response of natural coastal features to storms. This project will also provide an opportunity to formalize the permitting process for UAS research use in CACO and evaluate the role of UAS in the National Park system.

Special Instructions: Personnel should be prepared for field conditions and should take precautions for any possible inclement weather. Temperatures could range from 15-50 degrees F and rain/snow is possible. Caution should be taken to stay hydrated and under shelter from the various weather conditions.

Emergency medical attention and evacuation plan: Personnel certified in Advanced First Aid will be present during field operations. Any medical emergencies will be coordinated through emergency services (dial 911) and the Cape Cod dispatch (located in Boston), 617-242-5659. In the event of a medical incident, the medical incident commander for the USGS will be Sandy Brosnahan.

Risk Assessment Matrix

Likelihood	Severity			
	IV Negligible	III Marginal	II Critical	I Catastrophic
Frequent A	2	3	4	4
Probable B	2	3	4	HIGH
Occasional C	1	2	SERIOUS	4
Remote D	1	MEDIUM	2	3
Improbable E	LOW	2	2	2

Reference the Aviation Risk Mgmt. Workbook, JHAs, etc., to assist completion of Risk Assessment

Describe the Hazard:	Pre-Mitigation hazards rate out as:		
	Likelihood A-E	Severity I-IV	Risk Level
1. Mid-air collision with another aircraft	E	I	1
2. Collision with personnel or the general public	C	II	2
3. Collision with vehicles or boats	B	II	2
4. Operating A/C outside of approved area	B	III	1
5. Operating aircraft outside of manual limitations	B	III	2
6. Collision with birds	D	IV	1

Operational Procedures (OPM-11)



United States Department of the Interior
Office of Aviation Services
300 E. Mallard Dr., Ste 200
Boise, Idaho 83706-3991

DOI OPERATIONAL PROCEDURES MEMORANDUM (OPM) - 11

Subject: DOI Use of Unmanned Aircraft Systems (UAS)

Effective Date: January 1, 2016

Supersedes: OPM 13-11 dated October 20, 2014

Expiration: December 31, 2016

1. **PURPOSE.** The purpose of this OPM is to provide guidance on the operations and management of Unmanned Aircraft Systems (UAS).
2. **AUTHORITY.** This policy is established by the Director, Department of the Interior (DOI or Department), Office of Aviation Services (OAS) in accordance with the provisions of Departmental Manual 112 DM 12, 350 DM 1; Secretarial Order 3322 dated August 23, 2012, and the Presidential Memorandum on Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems, dated February 15, 2015.
3. **BACKGROUND.** Current Federal Aviation Administration (FAA) policy is provided in FAA Order 8900.1, Volume 16, Unmanned Aircraft Systems (UAS), dated June 23, 2014 and subsequent. This national policy document contains the following fundamental provisions.
 - A. Unmanned Aircraft are defined as "aircraft" flown by a "pilot" regardless of where the pilot is located. 14 CFR 1.1 defines "aircraft" as a device that is used or intended to be used for flight in the air.
 - B. Aircraft and pilots must demonstrate compliance with applicable sections of Title 14 CFR to operate in the National Airspace System (NAS). The FAA retains the authority to approve UAS operations within the NAS in Class A, B, C, D, E and G airspace.
 - C. When operating in Class A, B, C, D, E and G airspace, DOI UAS's must be operated with a FAA Certificate of Waiver or Authorization (COA).
 - D. COAs are not required in Restricted, Prohibited, or Warning airspace. However, UAS operations in these specific airspaces will be regulated and approved by the Controlling Authority (a.k.a. "Range Control").
4. **POLICY.** UAS by definition are considered aircraft regardless of size or weight. While their methods of control and airspace utilization procedures are different than manned aircraft, the overall

Cost Considerations

Equipment Costs:

Aircraft Type
Sensor Type
Equipment Shipment/Transfer
Size of Project Area

Labor Costs:

Project Management
COA
Scheduling
Approvals
Planning
Number of operators
Ground Control
Flying
Processing

Travel Costs:

Per diem
Hotel
Rental Car
Travel time to site
Weather Conditions

NOTAM



Unmanned Aircraft System Data Processing



Using SkyVector.com for Information for UAS FAA-Notice to Airmen (NOTAM)



Aeronautical Charts Displayed on the SkyVector.com Website

Vector display of direction and distance from Navigation Aid

Procedures for Finding Information for Input into issuing a NOTAM

Find the nearest Airport or Navigation Aide (navaid):

Zoom in on the map to the closest airport...double click on the airport or navaid and a cross will display...Right click and select 'Plan'

Move to the center of the COA boundary...double click to place a cross symbol...right click and select 'Plan'

A flight Plan box will display and a vector will be drawn on the map from the COA center point to the airport or navaid with a direction (degrees from North) from the airport or navaid to the COA center point. A distance in nautical miles will also be displayed.

Issuing a NOTAM (1-877-4-US-NTMS) :

Call the NOTAM number and they will ask for the following information:

- Who is submitting the NOTAM and contact information
- Current date and time
- Aircraft type: unmanned aircraft system (possibly size or weight)
- Approved FAA-COA number for the project
- Dates and times (zulu) of flights (beginning and ending)
- Flight Altitude (i.e.. 0-400')
- Affected Air Route Traffic Control Center (ARTCC)
- Flight Location (from the skyvector information including nearest airport or navaid, distance and direction) and the distance radius of the COA boundary center point

The FAA will give a NOTAM number that should be known when flying the UAS

Updated Nov. 2013 - J. Sloan USGS

Issuing a NOTAM (1-877-4-US-NTMS) :

Call the NOTAM number and they will ask for the following information:

- Who is submitting the NOTAM and contact information
- Current date and time - Aircraft type: unmanned aircraft system (possibly size or weight)
- Approved FAA-COA number for the project
- Dates and times (zulu) of flights (beginning and ending)
- Flight Altitude (ie. 0-400' AGL)
- Affected Air Route Traffic Control Center (ARTCC)
- Flight Location (from the skyvector information including nearest airport or navaid, distance and direction) and the distance radius of the COA boundary center point or launch site

MISHAP

UAS Aircraft Mishap Checklist:

1.) Notify the following entities in this order:

- a.) FAA ARTCC – as defined in the COA if the aircraft has flown away and not returned through loss-of-link automation
- b.) DOI 1-877-4-MISHAP (1-877-464-7427)
- c.) File an on-line SAFECOM www.safecom.gov Fax: (208-433-5007)
- d.) File an on-line DOI Safety Management Information System (SMIS) report <https://www.smis.doi.gov/>

2.) Documentation:

- a.) Document the crash site (photos, maps, gps locations)
- b.) Save all log files, video, still frame images, ground control laptop screen captures

Getting a UAS Capability in DOI

What is Needed to get a UAS Capability at a Center:

1. Money to purchase the systems and monthly/hourly fees
2. Bureau National Aviation Manager approval
3. OAS-13 agreement between the Center and OAS (SES level signature)
4. FAA Class 2 Medical Exam for designated UAS trainees
5. OAS Training Classes
6. Obtain access to the FAA COA on-line system via OAS approval

What is Needed to Keep the UAS Capability Active and Functional at the Center:

1. Keep the UAS operators current (fly at least once every 90 days or simulator)
2. Proficiency checks annually with OAS instructor
3. Class 2 Medical Exam annually
4. Money for monthly/hourly fees
5. Data Management capability and procedures
6. OAS and FAA Reporting
7. Annual air-worthiness approvals from OAS on center's specific UAS

DOI UAS Platforms

2009-2015

Raven



T-Hawk



PRESENT

Falcon UAS



Falcon Hover



Pulse Vapor 55



MLB Super Bat



Sensors

Point & Shoot or DSLR Cameras



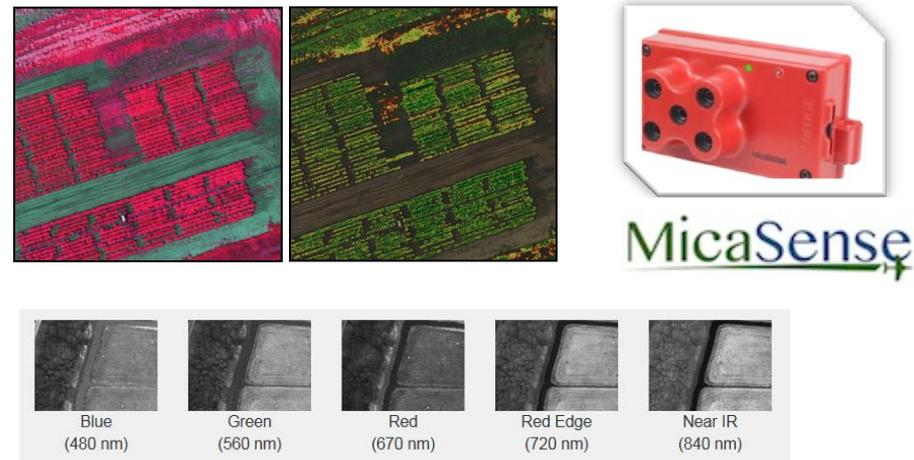
HD Video



Calibrated Thermal Sensor



Multispectral Sensor



Flight Planning

Unmanned Aircraft System Flight Planning

Camera	Sony A5100	
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<i>Camera Inputs:</i>	FL (mm)	Img wdh (pix)	Image hgt (pix)	Sensor wdh (mm)	Sensor hgt (mm)	Pix Size (wdth)	Pix Size (hgt)
	20	6000	4000	23.50	15.60	0.0039	0.0039

<i>Calculations:</i>	GSD wdh (cm)	GSD hgt (cm)	GSD wdh (inches)	GSD hgt (inches)	Photo wdh (ft)	Photo hgt (ft)
50 ft	0.30	0.30	0.12	0.12	58.8	39.2
100 ft	0.60	0.59	0.24	0.23	117.5	78.0
200 ft	1.19	1.19	0.47	0.47	235.0	156.0
300 ft	1.79	1.78	0.71	0.70	352.5	234.0
400 ft	2.39	2.38	0.94	0.94	470.0	312.0
500 ft	2.98	2.97	1.18	1.17	587.5	390.0
600 ft	3.58	3.57	1.41	1.40	705.0	468.0
700 ft	4.18	4.16	1.65	1.64	822.5	546.0
800 ft	4.78	4.75	1.88	1.87	940.0	624.0
900 ft	5.37	5.35	2.12	2.11	1057.5	702.0
1000 ft	5.97	5.94	2.35	2.34	1175.0	780.0

<i>Flight Planning:</i>	Speed (mph)	Speed (kts)	Flt Hgt (ft.-AGL)	Dist. Side Transect (ft)	Dist. Forelap (ft)	Cam. Interv. (s)
50 ft			50	29.4	23.5	1.07
100 ft	15	13	100	58.8	46.8	2.13
200 ft			200	117.5	93.6	4.25
300 ft			300	176.3	140.4	6.38
400 ft			400	235.0	187.2	8.51
500 ft			500	293.8	234.0	10.63
600 ft			600	352.5	280.8	12.76
700 ft			700	411.3	327.6	14.89
800 ft			800	470.0	374.4	17.01
900 ft			900	528.8	421.2	19.14
1000 ft			1000	587.5	468.0	21.27

UAS Data Archiving

LTA-UAS-DMP-1.0
Version 1.0

Department of the Interior
U.S. Geological Survey

USGS UNMANNED AIRCRAFT SYSTEMS DATA MANAGEMENT PLAN

Version 1.0

October 2015



UAS DATA MANAGEMENT FLOW

Figure 1 illustrates the end-to-end data flow from the initial acquisition of data to the final archival and distribution of products to the end user community.

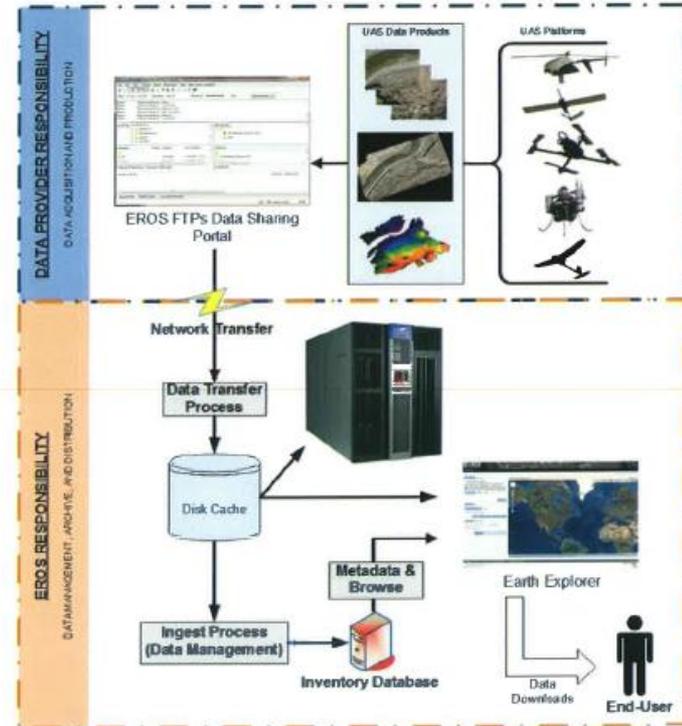


Figure 1 Data Flow Overview

UAS activities will be project or program driven. Projects may schedule several UAS missions to capture the required data. Missions are normally over different geographic areas. Each mission may include a single or multiple UAS collects. A UAS collect is defined as the specific collect (or flight) that is flown for its data collection. The data

Contracting and Cooperation

- Cooperative agreements with other agencies
- Cooperative agreements with universities
- Contracting (Section 333 exemptions)



COOPERATIVE ECOSYSTEM
STUDIES UNITS
NATIONAL NETWORK



United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Geosciences and Environmental Change Science Center
National USGS Project Office
Denver Federal Center - Box 25046, MS 980
Denver, Colorado 80225

Scope of Work

Requested by: Jeff Sloan
USGS - National Unmanned Aircraft System Project Office
Denver, Colorado 80225
email: jsloan@usgs.gov
ph. (303)-236-1308

Contractor: Raptor Maps Inc.
Mr. Nikhil Vadavkar
Boston, MA
email: nikhil@raptormaps.com
ph. (617)-286-6466

Services Requested:

The contractor shall furnish all personnel, equipment, supplies and services to accomplish the following:

- 1.) Overlapping natural color images of a portion of the Cape Cod National Seashore encompassing an area outlined in the boundary area of as designated on the attached map. A 70% overlap in the forward moving flightline, and 50% on the sidelap between transecting flightlines. Preference would be for a fixed focal length on the camera with the lowest ISO and F Stop, as well as, shutter speeds adjusted to the lighting that will best capture clear images. Preference is also for the GPS locations embedded into the individual image EXIF header information.
- 2.) Work will be performed the week of March 1-4, 2016 within the timeframe of daylight hours and in coordination with the land owner/manager.
- 3.) Photos should be delivered to the USGS Scientist that is the Principal Investigator of the study area within a 7 day time period via an online download mechanism or on a physical hard drive.
- 4.) The digital images should be no less than 12 megapixel in resolution and delivered in a standard image format (.raw, .jpg or .tif).
- 5.) The desired end product is a set of color digital still frame images with sufficient resolution able to derive a ground sample distance of 10 cm (1 meter) and to be able to derive a digital surface model with a horizontal accuracy of 10 cm and vertical accuracy of 10-30 cm (1 to .3 meters) from structure-from-motion (sfm) techniques.

Obligations of the Contractor:

- 1.) The contractor shall comply with all applicable federal, state and local regulations, including FAA certification and Section 333 exemptions, as applicable. In advance of fieldwork, the contractor shall obtain all necessary permits.

- 2.) Before commencement of work, the contractor shall prepare a safety plan and implement the plan in carry out this scope of work. The contractor must be able to produce a copy of the plan at any time at the request of the USGS or other federal oversight.
- 3.) The contractor shall coordinate site access with the land owner or land manager and notify that entity within 24 hours if weather conditions or other circumstances require the mission to be cancelled or rescheduled. If appropriate, the USGS representative can be the point of contact to relay information on cancellation or rescheduling.
- 4.) The contractor is responsible for all equipment, and for any associated damage that might be caused by the equipment or other acts in implementing this scope of work.
- 5.) The contractor will provide proof of insurance from a responsible company or companies.
- 6.) The contractor has sole authority over initiating, conducting or terminating a flight.
- 7.) The contractor shall accept payment via a credit card end product purchase.

Obligations of the USGS:

- 1.) The USGS will provide information detailing the desired data specifications.
- 2.) The USGS will pay the contractor a sum of \$3,500 for the scope of work outlined above using a credit card payment method.
- 3.) The USGS will provide the ground control points necessary to reach the desired level of end-product accuracy.

Site Access and Scheduling:

- 1.) The equipment shall be launched from and returned to locations designated ahead of time and approved by the land owner/manager.
- 2.) The equipment will operate entirely within the boundaries outlined in the approved area within the Cape Cod National Seashore defined area.
- 3.) The USGS or National Park Service retains the authority to cancel or alter the use of equipment on the site at any time.

Ownership of Products:

General: The contractor shall vest title to all documents produced under or as a direct result of this procurement to the USGS.

- 1.) All materials prepared by the contractor or the USGS personnel under this scope of work shall be and remain the exclusive property of the USGS.
- 2.) The USGS reserves the right to utilize, revise or modify these documents or to have these documents used, revised or modified by others, in any way it deems necessary.
- 3.) The contractor may not utilize or share any products created from this scope of work without the explicit written permission from the USGS.

The contractor has read and agrees to the above terms.

Signature: _____ Date: _____
Raptor Maps Inc.
Mr. Nikhil Vadavkar

Companies with Section 333 Exemptions

(As of Feb. 2016)

