

RECLAMATION

Managing Water in the West

Exploring Potential Uses of Unmanned Aerial Systems to Support Reclamation's Mission

Research and Development Office
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Final Report 2014-013734



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Bureau of Reclamation
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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Executive Summary

The Department of the Interior manages approximately 20% of the land and water in the United States, much of it in remote, sensitive, and dangerous areas. It is the Department's mission to preserve and protect these assets. Remote sensing is used extensively to survey these resources. As part of Interior, Reclamation shares these commitments, but also manages enormous amounts of water and power infrastructure which is essential to the economic health of the 17 Western United States. This infrastructure, too, must be surveyed and monitored on a regular basis, often with the use of remote sensing technology. Unmanned aerial systems (UAS) have shown promise for use in monitoring small areas such as reservoirs and power facilities on a frequent basis and at a substantial cost savings when compared to conventional aerial photography.

To coordinate research and development of UAS technology in Reclamation, the Research and Development Office provided funding for the creation of a UAS Community of Interest to support bureau-wide information exchange concerning unmanned aerial systems (UAS) technology (and related laws), inter-agency collaboration, project development, flight and data processing training, briefings of senior management, and conducting needs analysis.

By the end of the project the community contained more than 80 members; had a dedicated SharePoint site; conducted multiple training sessions; briefed directors of Policy and Administration, Management and Services, Safety Security and Administration, Technical Services, and various senior Regional managers about the feasibility of using UAS technology to conduct mission remote sensing activities. Team members participated in DOI work groups and analyzed Departmental needs surveys which will be used to help develop a DOI UAS roadmap.

Recommended next steps include development of a UAS best practices manual and provision of continued support for testing the feasibility of using this technology for a variety of new uses such as dam face analysis, emergency management, security, topographic mapping, and boundary encroachment monitoring.

Contents

Executive Summary 1

Contents..... 3

Purpose 5

Tasks 5

Results..... 5

Future Work..... 14

 Data Sets that support the final report15

Purpose

This research and development project sought to provide a clearinghouse for unmanned aerial systems (UAS) activities in Reclamation. Many science, engineering, and security efforts go on in isolation. Creation of a single point of contact can facilitate information exchange.

Surplus UAS equipment have moved from the military to the Department of the Interior (DOI). It is desirable that research and development of water resource applications of these technologies occur in a coordinated fashion to maximize investments and to avoid duplication.

The overall goal of this effort was to build a community of interest in Reclamation for the exploration of potential uses for these technologies to advance Reclamation's mission. The project coordinated Reclamation-wide efforts to learn what niches these new technologies might fill. It also explored various platforms and sensors, investigated Federal Aviation Administration (FAA) and DOI regulations governing the use of UAS, developed relationships with other agencies, conducted training activities, and encouraged project development. It also sought to learn what training requirements exist for the use of UAVs. It asked, "How can we best pair people willing to research these technologies with those who have a need for the data they produce? And how can we coordinate scientific, engineering, and research and development efforts?"

Tasks

There were twelve tasks associated with this research and development project:

1. Build a UAS community of interest and foster communications within it.
2. Build relationships with other DOI agencies using UAS technology
3. Conduct training sessions and encourage training in the use of UAS technology.
4. Explore technological developments.
5. Conduct UAS reviews and assessments.
6. Encourage UAS project development.
7. Participate in interagency work groups.
8. Conduct and analyze UAS needs surveys.

Results

Community of Interest

The Reclamation UAS Community of Interest now has more than 80 members across all five regions. Members include managers, engineers, physical scientists, biologists, geologists, hydrologists, security personnel, emergency management specialists, real estate staff, planners, and policy analysts. Several times each month communications are exchanged amongst these personnel regarding developments both in UAS technology and

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

in related flight regulations. In addition, to further foster communication the team developed a UAS SharePoint site:

<https://dosp/TECHRESC/TR/TSC/UAS/Pages/default.aspx>

Relationships with Other Agencies and Training Sessions

The Reclamation UAS team primarily developed relationships with the DOI Office of Aviation Services (OAS), The U.S. Geological Survey (USGS), and the Bureau of Land Management (BLM). Representatives of these agencies have flown missions, processed data, produced reports, and provided educational sessions for Reclamation staff. The training sessions have dealt with subject such as:

- Mission planning
- FAA requirements
- OAS requirements
- Data processing
- UAS history
- Mission summaries
- Future prospects for UAS

The research team also briefed USBR senior management in Safety, Security, and Law Enforcement; Property Management; Policy and Administration; and various Regional Offices concerning the potential uses of UAS. The briefings included summaries of current capabilities, potential applications within Reclamation, legal requirements, and the strengths and limitations of this technology.

The research team surveyed UAS literature and websites, visited university research facilities, and participated in vendor demonstrations in an effort to keep abreast of UAS developments. It has also made periodic visits to the USGS UAS laboratory to receive briefings on that bureau's activities. Finally, it has participated in monthly DOI-wide calls hosted by Bruce Quirk, where we have seen presentations from the University of Florida, the Department of Defense, the National Aeronautics and Space Administration, the Federal Aviation Administration, among others. We have passed summaries of these meetings on to the community of interest.

Project Review

In addition, team members conducted reviews of potential UAS projects and initiatives. Douglas Clark and Kristin Swoboda attended the Center for Unmanned Aerial Systems meeting in Salt Lake City, UT to assess the desirability of becoming a member of that organization. They gathered pro and con data and submitted a report to Reclamation's Research and Development Office. It peer reviewed an analysis of T-Hawk hover craft capabilities for Dr. Jade Soddell. Members of the team also peer reviewed R&D UAS research proposals.

The team assisted with the development of UAS projects and research on T-Hawk usage, Predator usage, sedimentation studies, and dam face applications of UAS. Reclamation's PN Office team members are currently developing UAS missions for that region, including flights for wildfires.

Inter-Agency Work Groups and Surveys

Team members have participated in DOI work groups. Douglas Clark participated in the DOI Executive Aviation Subcommittee (EAS) Work Group which is producing a road map for the adoption of UAS within DOI bureaus. Issues under discussion include the following:

- Maintenance of the current fleet of UAS aircraft
- Inventory of bureau requirements for new UAS aircraft
- Contracting with vendors for new aircraft
- Determining the airworthiness of new aircraft
 - Determining what criteria will be used to certify airworthiness.
 - Determining if vendors certify airworthiness.
 - Examining the feasibility of using a third party such as a UAS test facility or NASA to certify airworthiness.
- The organizational arrangements for the implementation of UAS. Specifically, would individual bureaus be allowed to manage their own UAS programs?

One of the actions of the EAS was to conduct a survey of the DOI bureaus to determine their individual UAS needs. Clark evaluated the Reclamation results. There were 26 respondents in Reclamation, insufficient for a high level of statistical significance, but still possibly suggestive. Most of the Reclamation respondents were either members of the geospatial community or managers (Figure 1). Other areas of expertise included biologists, a budget analyst, a contract specialist, a hydrologist, a mechanic, a natural resources specialist, a project manager technician, a real estate specialist, and a surveyor.

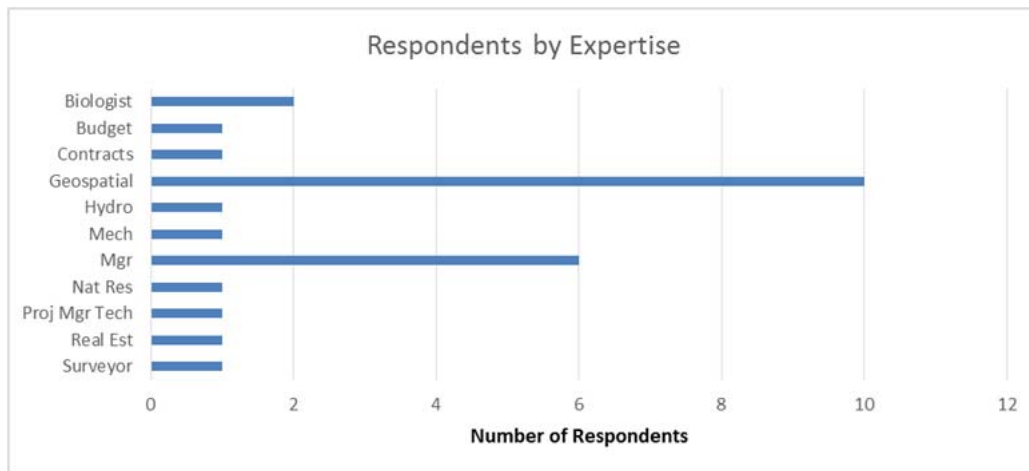


Figure 1: Expertise of respondents

The Pacific Northwest Region in Boise, Idaho, where the Office of Aviation Services is also located, had the highest number of respondents (Figure 2), followed by the Mid-Pacific Region, the Denver Office, and the Lower Colorado Region.

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

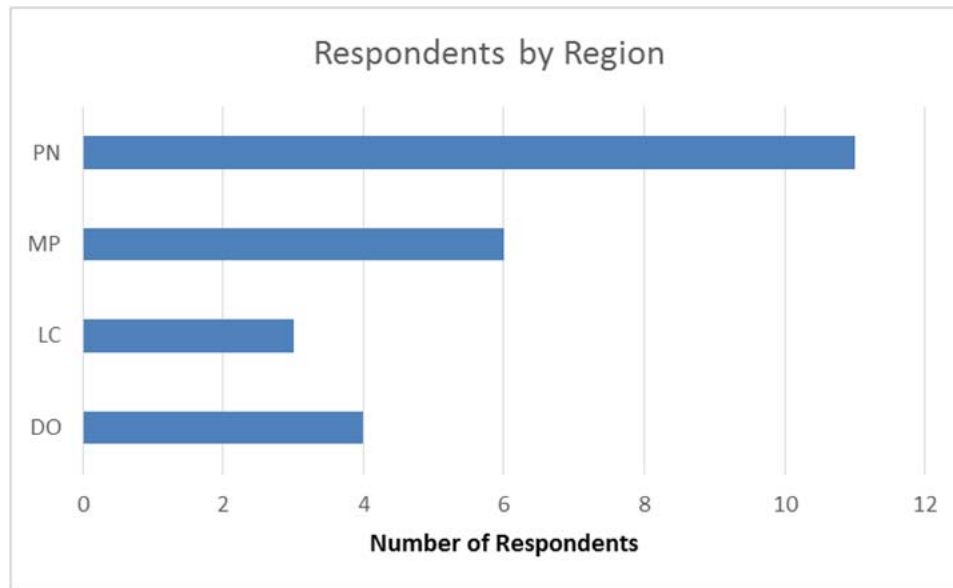


Figure 2: Geography of respondents

Questioned about using UAS for unmet data gathering requirements, Reclamation personnel mentioned operations and maintenance (O&M) surveys, vegetation surveys, and reservoir surveys most prominently (Figure 3). Other areas of interest included agricultural surveys, archeological surveys, change detection analyses, habitat surveys, high definition photography, encroachment/trespass detection, monitoring inaccessible areas, and telemetry surveys. Other areas of interest included various types of monitoring activities including endangered species, water flow, flood control, boundary, ineligible lands, restoration, regulatory compliance, water management, water quality, and wildlife. Finally, mention was also made of requirements for using UAS for areas needing frequently repeated monitoring and those that might require thermal imagery (perhaps to detect canal leaks).

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

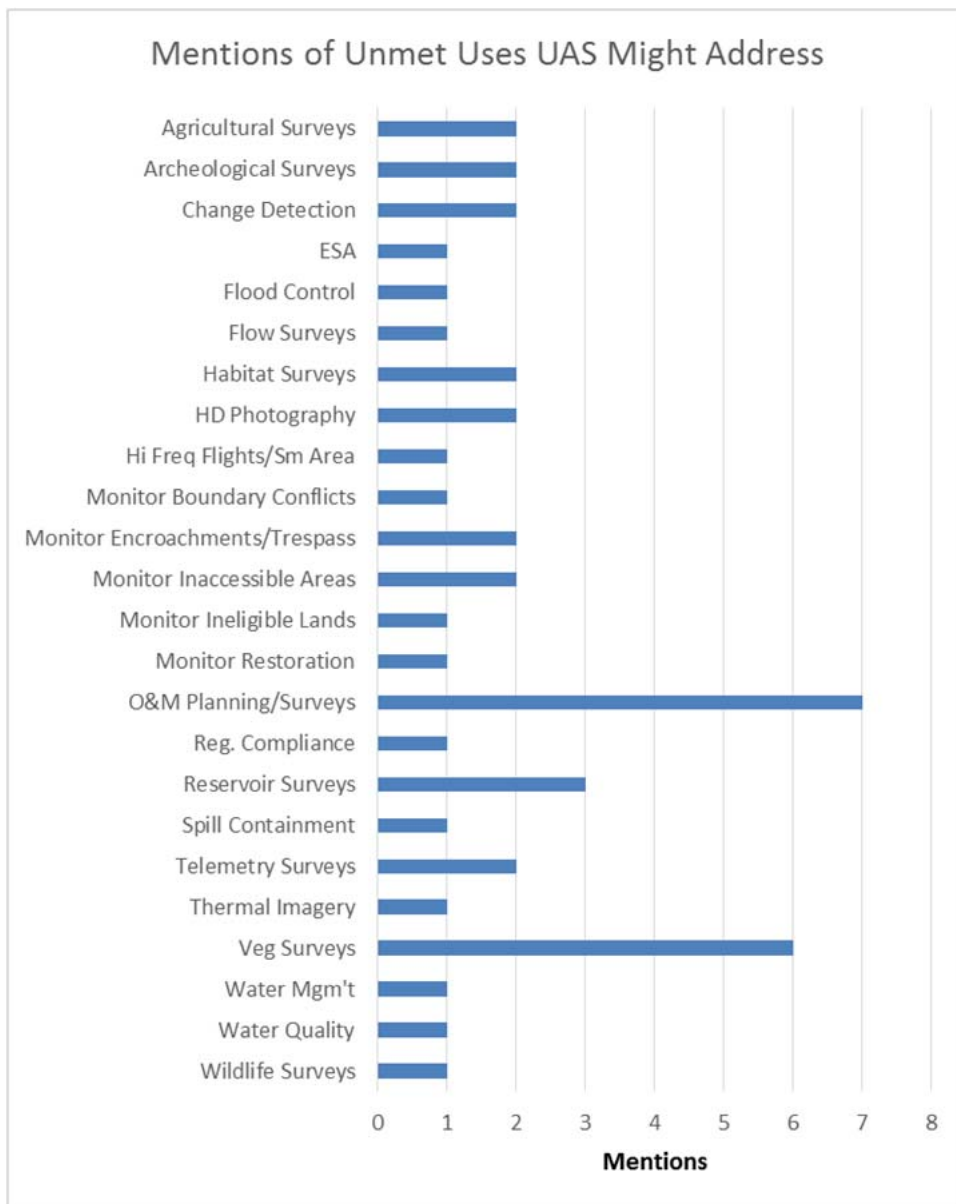


Figure 3: What unmet data requirement needs UAS might address

There were survey questions about both required flight and mission durations. The most prominently mentioned flight durations were in the range of 4 or more hours, followed by 1 to 3 hours (Figure 4) and mission frequencies ranged from multiple days to a single day (Figure 5). The aerial extents of missions were most frequently less than 10 square miles (Figure 6). Linear distances ranged from 1 to 60 miles. Particular features were also mentioned as the focus of particular missions. These included dam sites, shorelines, and rivers.

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

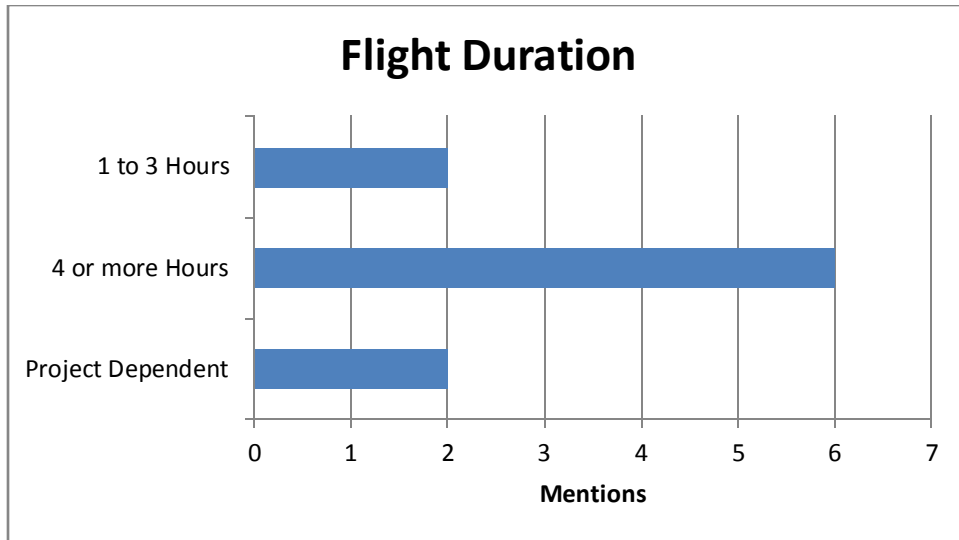


Figure 4: Flight duration requirements

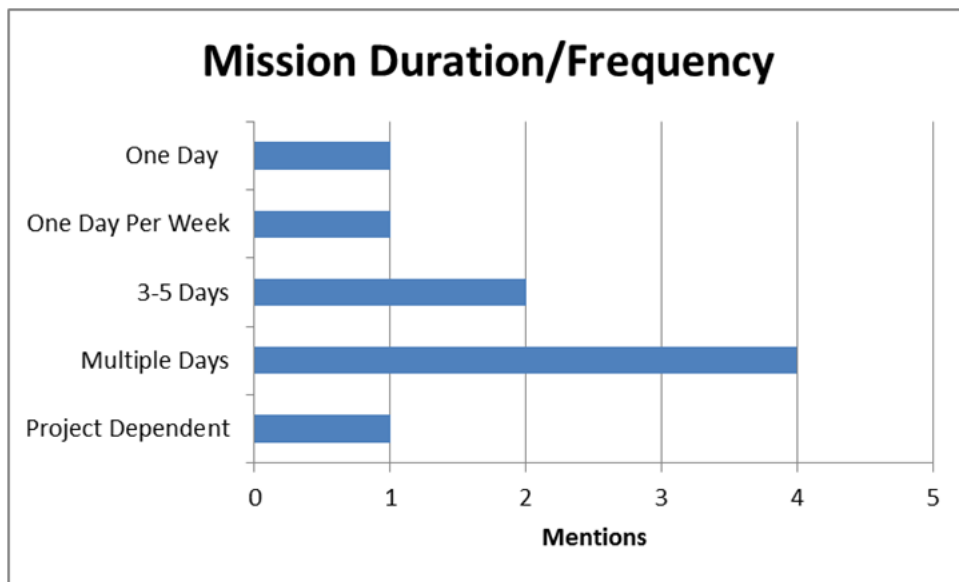


Figure 5: Mission Duration Requirements

When asked what sorts of missions might be improved using UAS, Reclamation respondents reported most interest in aerial photography (traditional, multispectral, IR, and CIR) and LiDAR (Figure 7). Others included dam inspections, topographic surveys, aquatic surveys, O&M inspections, reservoir surveys, collection of IR and CIR imagery, snow surveys, telemetry surveys and the like. Interestingly, using UAS as replacement of some field surveys was also mentioned. Field surveys are expensive and repeated ones are obviously even more expensive. The view amongst some respondents was the UAS might be used to replace some of these in certain cases. In the event that this was possible, certain numerical extrapolations for missing data might be avoided.

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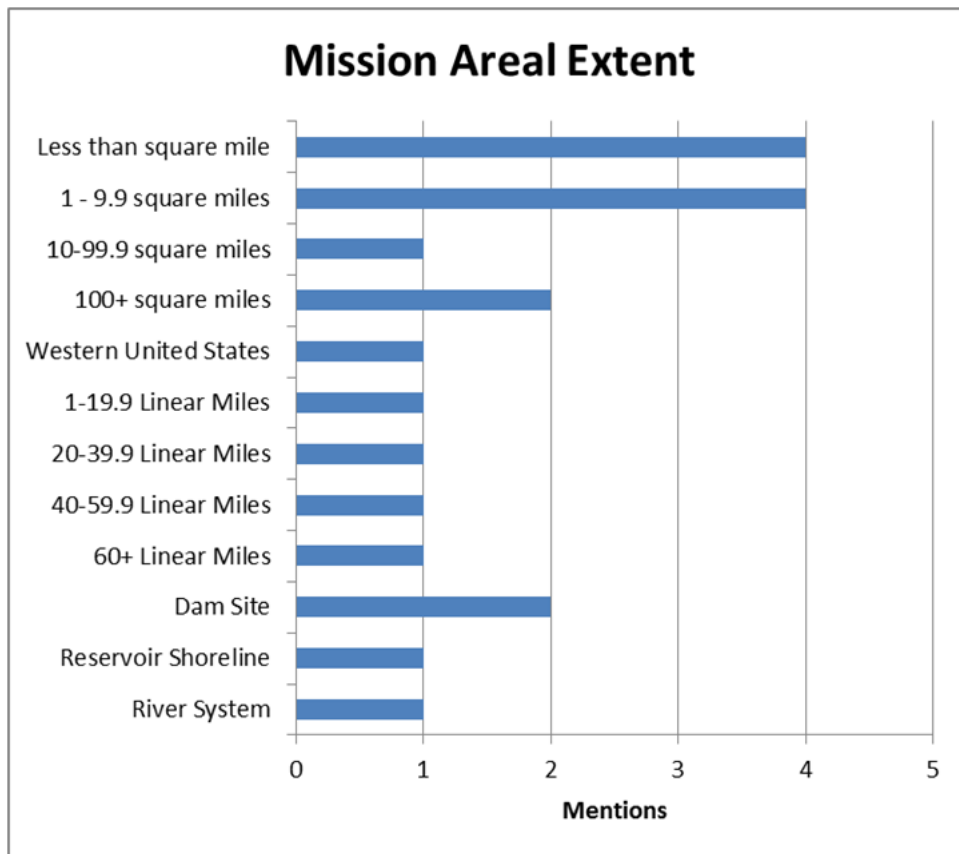


Figure 6: Mission area requirements

Overall, the survey respondents indicated that unmanned aerial systems hold promise for making it possible to conduct frequent missions to gather high resolution imagery over small areas.

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

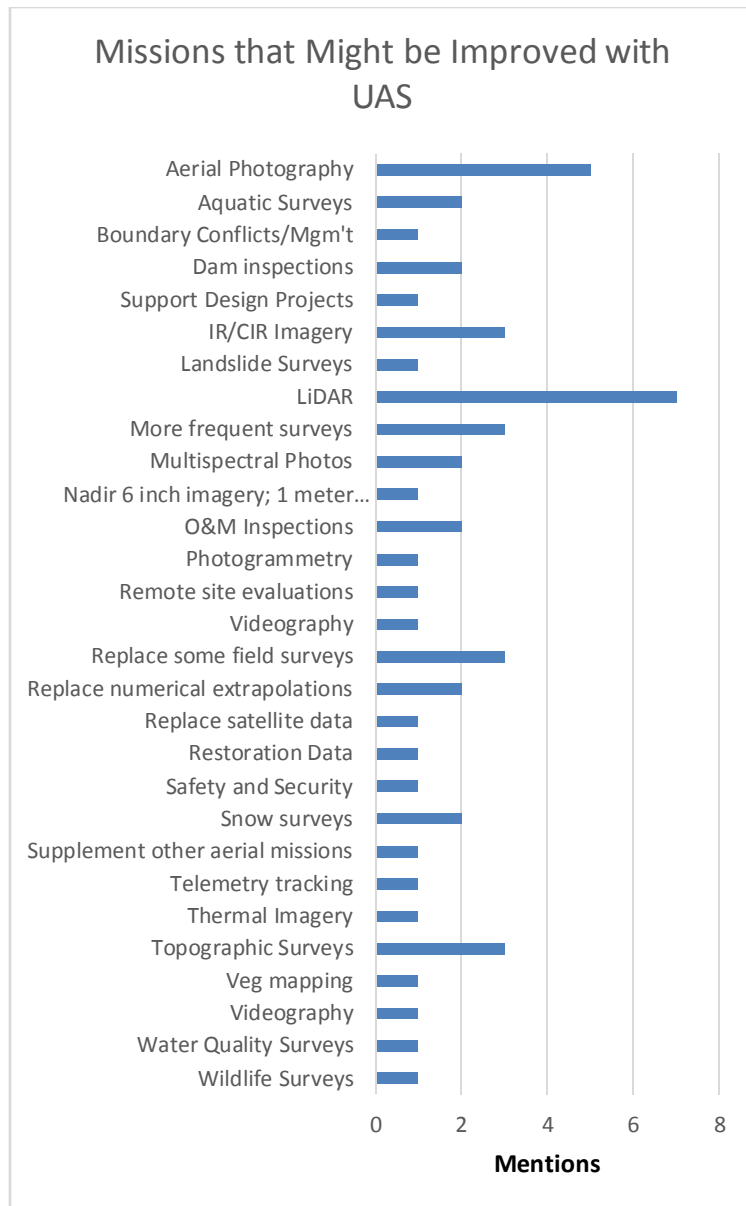


Figure 7: Missions that Might be Improved with UAS

After this initial survey, as a next step, the DOI Executive Aviation Subcommittee Work Group requested that the bureaus conduct a subsequent survey of possible users and report back respecting the following items:

- Each bureau's basic concept of operation of unmanned aerial systems
- Whether in-house operators or contract operators would be used
- Contracting requirements for UAS services
- The internal bureau management structures for UAS
- The probably mix of aircraft requirements, e.g. hover craft, fixed wing, etc.
- UAS program funding

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

The research team undertook this assignment. Survey results were consolidated for Reclamation respondents. A summary report was approved by John Brynda, USBR Aviation Director, and was subsequently submitted to the EAS. The results of the survey are listed below:

Defining the Scope of Bureau Unmanned Aircraft Programs

1) For your Bureau, describe the basic concept of operation for unmanned aircraft.

Does your bureau plan on having trained operators, contracting for service or a mix?

It depends on the type of UAS platforms & sensors that DOI makes available to the Bureaus, or if the Bureaus will be allowed to own/operate their own UAS. It will likely be a mix of trained operators and services contracts. Larger project areas will likely be serviced via contracting, while smaller project areas, or those that demand quick turnaround, will be serviced by in-house operations.

2) If your Bureau plans to contract for services, what do you anticipate them to be generally?

Services primarily would be for imagery/data acquisition and delivery. In some cases data processing and/or surveying services may be required. It would be more feasible to fly contract services for larger project areas. Pricing is anticipated to be very competitive the first couple years and develop into a more structured standard over time. As costs are unknown at this point, comparisons to surveying and manned flight contracts could be used as for comparison.

3) For your Bureau describe the internal management structure that would be needed to support your UAS program.

Any needed FTE's? Percent of time existing employees would be involved in UAS?

It depends on UAS use over time. Initially, perhaps a team of 3 FTE's working part-time UAS projects per Region. Most all of Reclamation's labor requirements are project-driven. If UAS projects prove popular and demand increases, more resources will flow towards UAS related things. As demand increases over time, the need for personnel will increase. It is likely that Remote Sensing and GIS groups across the bureau will be heavily involved with and manage UAS operations, since they are already in the business of acquiring imagery and processing it into mapping products. At present, in Reclamation, the office of Safety, Security, and Law Enforcement oversees UAS policy, but flight operations are largely the domain of remote sensing and GIS shops.

4) If your bureau intends on having "in-house" operators, how many would you anticipate? How/where would they be located (not the specific locations but the general concept of employment)?

It all depends on whether Reclamation management supports in house or contracted UAS. Technical staff will want to exploit cost savings and timeliness that UAS offers as compared with using commercial contractors who work for profit. For offices interested in acquiring UAS imagery, a team of 3 in-house operators per office seems reasonable. By October 1, 2015, depending on what happens with respect to FAA law and OAS regulations, Reclamation may have anywhere from 3 to 30 operators, based in cities like Boise, Denver, Sacramento, Boulder City, Albuquerque, and smaller cities like Provo, Grand Junction, Coulee City, Page & Yuma, Arizona, etc.

Another option would be to have a centralized DOI pilot cadre in places such as Boise or Denver where DOI bureau offices congregate. The establishment of OAS flight "districts" would make management and oversight of UAS activities simple and transparent. **(Continued on next page).**

Exploring Uses of Unmanned Aerial Systems to Support Reclamation's Mission

5) What mix of aircraft would your bureau need to complete 80% of its mission set?

(small rotorcraft, small airplane, mid-size airplane, large UAS etc...)

A) Small Hexacopter type that is capable of carrying a high quality digital SLR camera payload (Nikon D800 type) that will acquire vertical, oblique, right-angle imagery/data. Multi-bladed copters are generally more imagery acquisition stable than single/double bladed helicopter type UAS. These are ideal for hovering-inspection type projects and for mapping smaller project areas.

B) Fixed wing/airplane type UAS with a high quality digital camera/optics that is capable of capturing photogrammetric quality, high resolution images suitable for hi-res digital elevation model (DEM) and orthophotography production.

C) Aerostat for location critical (areas that cannot be serviced by UAS because of FAA restrictions), or site specific monitoring or surveillance.

D) If smaller sensors are developed, higher resolution multi-spectral (false-color IR), thermal, hyperspectral, and 'AR' (LiDAR, Radar, InSAR, IFSAR) type sensors) may become available. These could be flown on either fixed wing or hover craft.

6) For your Bureau, how would the UAS program likely be funded? (national, regional, local, project, mix)?

Most likely UAS work will be project funded. National or regional funds would be welcome. R&D funds have been used in the past to explore new airframes and sensors.

In brief, Reclamation primarily expressed an interest in both a small fixed wing craft and a hexacopter. These would be flown by a mix of both Federal and contract personnel for primarily small area missions. Projects would be funded on a fee for service cost basis for each project.

Clark also participated in the monthly DOI UAS call hosted by Bruce Quirk, USGS UAS Liaison. During one of these calls, he made a presentation to the Department about Reclamation UAS initiatives including the community of interest, experimental missions, management briefings, outreach activities and the like.

Future Work

The Reclamation Community of Interest will continue support projects designed to explore the feasibility of using UAS to conduct remote sensing and surveillance activities in a more efficient and cost effective manner.

Team members Douglas Clark and Alan Bell of the Emergency Management and GIS Group at the TSC have applied for Policy and Administration funds to develop a Directives and Standards manual for small unmanned aerial systems usage in Reclamation. This document will describe the major types of platforms and sensors that exist. It will explain which types should be used for various data gathering activities such as terrain generation, dam face analyses, vegetation mapping, etc. Other subjects that will be discussed include mission planning, ground testing, pre-flight and inflight testing, emergency procedures, record keeping, aviation safety, crew resource management, navigation, Federal Aviation Administration requirements, training requirements, medical requirements, and data processing.

Data Sets that support the final report

Share Drive folder name and path where data are stored:

<https://dosp/techResc/TR/TSC/UAS/Reports/Forms/AllItems.aspx?RootFolder=%2FtechResc%2FTR%2FTSC%2FUAS%2FReports%2FCommunity%20of%20Interest&FolderCTID=0x012000F4D84E1CC0A371499017EDF32B963366&View={3CB561AC-7850-4ECE-9BA3-B307F00CE9AF}&InitialTabId=Ribbon%2EDocument&VisibilityContext=WSSTabPersistence>

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Short description of the data: (types of information, principal locations collected, general time period of collection, predominant files types, unusual file types.)

DOI Survey to determine bureau UAS requirements. Collected as an electronic survey. Excel spreadsheets.

Keywords: Unmanned Aerial Systems, UAS, remote sensing, communities of interest.

Approximate total size of all files: (folder size) 500 KB