U.S. GEOLOGICAL SURVEY
UNMANNED AIRCRAFT SYSTEMS PROJECT OFFICE
LESSONS LEARNED AND OPPORTUNITIES

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Abstract: The U.S. Geological Survey Unmanned Aircraft Systems (UAS) project office is leading the implementation of UAS technology in anticipation of transforming the research methods and management techniques employed across the Department of the Interior. UAS technology is being made available to monitor environmental conditions, analyze the impacts of climate change, respond to natural hazards, understand landscape change rates and consequences, conduct wildlife inventories and support related land management missions. USGS is teaming with the Department of the Interior Aviation Management Directorate (AMD) to lead the safe and cost effective adoption of UAS technology by the Department of the Interior Agencies and USGS scientists. Recently, DOI-USGS sponsored our second UAS training session. Each student received instruction in basic and advanced flight skills, airspace management, aviation safety, emergency procedures, crew coordination, and mission planning.

INTRODUCTION

The mission of the U.S. Department of the Interior is to protect America's natural resources and heritage, honor our cultures and tribal communities, and supply the energy to power our future. The U.S. Department of the Interior uses sound science to manage and sustain America's lands, water, wildlife, and energy resources, honors our nation's responsibilities to tribal nations, and advocates for America's island communities. As keepers of our nation's legacy, we manage the resources in our care to benefit Americans now and in the future. Interior employees are developing and implementing the cutting-edge science and expert management techniques that make this possible. We are also taking actions to help America transform the challenges it faces today into opportunities for tomorrow. The Department employs 70,000 people, including expert scientists and resource-management professionals, in eight technical bureaus:

- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Ocean Energy Management, Regulation and Enforcement
- Bureau of Reclamation
- National Park Service
- Office of Surface Mining, Reclamation and Enforcement
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

Since Congress created the Department of the Interior in 1849, it has become the steward for managing over 500 million acres of surface land, or about one-fifth of the land in the United States. The Department has responsibility for managing a variety of water and underwater resources. The Bureau of Reclamation manages nearly 500 dams and 350 reservoirs that deliver irrigation water to one of every five western farmers and provides water to over 30 million people. The Bureau of Ocean Energy Management, Regulation and Enforcement has jurisdiction over approximately 1.76 billion acres of the Outer Continental Shelf, on which it manages approximately 9,000 active oil and gas leases on 44 million acres. The Department hosts over 460 million visitors to nearly 5000 recreational sites including wildlife refuges, parks, monuments, seashore sites, battlefields and other cultural and recreational sites on a yearly basis. The energy projects on federally managed lands and offshore areas provide about 30 percent of the nation's energy production. The Department's law enforcement workforce is one of the largest in the Federal Government. [i]

The U.S. Geological Survey (USGS) serves the Nation as an independent fact-finding agency that collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. The value of the USGS to the Nation rests on its ability to carry out studies on a national scale and to sustain long-term monitoring and assessment of natural resources. Because it has no regulatory or management mandate, the USGS provides impartial science that serves the needs of our changing world. The diversity of scientific expertise enables the USGS to carry out large-scale, multi-disciplinary investigations that build the base of knowledge about the Earth. In turn, decision makers at all levels of government-and citizens in all walks of life- have the information tools they need to address pressing societal issues. As an unbiased, multi-disciplinary science organization that focuses on biology, geography, geology, geospatial information, and water, we are dedicated to the timely, relevant, and impartial study of the landscape, our natural resources, and natural hazards. [ii]

Beginning in Fiscal Year 2005, the U.S. Geological Survey, Land Remote Sensing Program (LRS) sponsored the Rocky Mountain Geographic Science Center to conduct an Emerging Technology Investigation on Unmanned Aircraft Systems (UAS). The goals of the Emerging Technology Investigation Projects are to monitor promising technologies and determine their potential to support the USGS and DOI mission. Often the investigations

involve the creation of Cooperative Research and Development Agreement **(**CRADA**)** or similar agreements with academia, private industry or governmental entities. The LRS program has supported investigations into sensor web, hyperspectral imaging, data compression and similar geospatial technologies. The findings of the unmanned aircraft investigation included:

- Military use of UAS technology was increasing at an exponential rate,
- U.S. investments in UAS technology for 2009-2013 were projected to be between $25 - $30 Billion,
- The Department of Defense, NOAA, NASA, DHS, and the FAA had or were in the process of establishing UAS Program Offices,
- 60 Universities in the U.S. were offering UAS related programs,
- There were over 150 vendors of UAS technology,
- A wide variety of platforms (aircraft) and sensor packages were available,
- Substantial momentum existed in industry, academia and government to develop civil applications of UAS technology,
- UAS technology could contribute to the safety of DOI aircraft crews & field staff,
- UAS provided large area coverage (compared to ground observations),
- UAS provided long dwell times over areas of interest,
- Readily available technology- minimum DOI/USGS research and development cost,
- Ability to operate in hostile environments (smoke, ash, active volcano, etc.),
- Relatively low costs to operate (sUAS) compared to manned aircraft,
- Provided a archive of images for future use and analysis,
- Puts technology in the hands of the scientists,
- New observations = new science = more informed decisions

These finding led to the USGS announcing the creation of a UAS Project Office on May 8, 2008. Many of the goals and objectives described in the announcement of the office still serve as guidance and direction for our current activities:

> *In dangerous and remote areas, such as polar regions, volcanic islands, and expansive deserts, remote-controlled unmanned aircraft can provide more detailed, more timely data about the status of natural resources and environmental conditions than would be feasible by any other means. That is why the U.S. Geological Survey - long known as an authoritative source of aerial photography and satellite-based imagery - today announced that it is establishing a new program for earth observation using Unmanned Aircraft Systems (UAS).*

"This exciting approach to earth observation gives scientists a way to look longer, closer, and more frequently at some of the most remote areas of the Earth, places that were previously too dangerous or too expensive to monitor in detail," said Barbara J. Ryan, (former) USGS Associate Director for Geography. "The flexibility and relative low cost of unmanned aircraft systems will enhance our ability to track long-term landscape change. In addition, we can quickly assess landscape altering events, such as wildfires or volcanoes, in areas with challenging logistics."

In many cases, UAS technology is simply the most cost effective way to gather earth observation data for a wide variety of applications: managing federal lands; investigating climate change; mapping and charting; conducting environmental risk assessments; responding to and recovering from natural and human-induced disasters.

Even in less remote areas, manned aircraft flights may not be feasible at times due to long flight durations, hazardous weather conditions, and associated operations cost. Satellite-based observations can be hindered by coarse image resolution, limited sensor capabilities, and repeat orbiting cycles of days or weeks. The use of UAS technology allows flexibility in delivering timely data. Furthermore, data collection by UAS can be specifically tailored to the required resolution and radiometric parameters of individual investigations.

An important focus of the USGS UAS Program, a component of the USGS Land Remote Sensing Program, is to leverage the commitment that the defense and intelligence communities have made in supporting UAS research. Working in partnership with many other Federal agencies, academia, and industry groups, the USGS will promote UAS technology for civil, domestic applications. Offices for the new program will be located at the USGS facility in Lakewood, Colo.[iii]

OPPORTUNITIES:

A focus of USGS Unmanned Aircraft Project Office is to maintain and enhance our ability to leverage the substantial commitment private industry, academia and the Defense Communities have made supporting advanced UAS research, technology and applications development. A project goal is to encourage industry and academic colleagues that have previously developed UAS technologies for national defense applications to support the evolution of a dual use capability that will benefit the DOI and USGS missions. The USGS UAS Project Office, is actively working with mission partners such as the National Oceanic and Atmospheric Administration **(**NOAA**),** National Aeronautics and Space Administration **(**NASA**),** United States Northern Command (NORTHCOM), Department of Homeland Security (DHS), United States Army, United States Forest Service (USFS), academia (notably- New Mexico State University, University of Alaska- Fairbanks, University of Colorado, Virginia Tech. University, North Dakota State University, John Hopkins University, University of Florida, and the U.S Air Force Academy).

The Department of the Interior, National Business Center, Aviation Management Directorate (AMD) is a valued partner of the U.S. Geological Survey Unmanned Aircraft Project Office. While the USGS UAS Project Office worries issues such as sensor research and collecting project requirements, the AMD is working tirelessly to ensure that the Department establishes, maintains and enforces safe aircraft operations. AMD provides the Department with several UAS related services including: Aviation Safety Programs, Aircraft Management Services, and User/Operator Training. After an exhaustive review of existing standards and participating in the sUAS operator training session, AMD recently issued guidance- *DOI AVIATION MANAGEMENT OPERATIONAL PROCEDURES (OPM) MEMORANDUM NO. 09-11, DOI Use of Unmanned Aircraft Systems (UAS).* The OPM establishes UAS operational procedures, aircraft maintenance criteria, aircrew qualifications and maintenance personnel credentials for use across the Department of the Interior. A link to the OPM is available at: http://rmgsc.cr.usgs.gov/UAS/ [iv]

Other AMD program responsibilities and goals include increasing the efficiency and promoting the economical operation of aircraft, including UAS, for the Department of the Interior. AMD provides the Department with expert technical assistance in specialized and emerging aviation technology areas such as UAS integration into the National Air Space. The USGS UAS Project Office is working closely with AMD on determining the appropriate avenue to obtain UAS capabilities and services including: procuring unmanned aircraft, establishing commercial UAS aviation services contracts, and coordination of utilization of UAS assets with other governmental entities.

UAS capabilities have demonstrated the potential to effectively fill the current observation gaps that are critical to gaining a better understanding of the complexities and scientific knowledge related to climate change research, water resources forecasting, ecosystem monitoring and management and natural hazards. These information gaps in our observations frequently exist over the remote, scarcely populated and often volatile lands managed by the Department of the Interior (North Slope of Alaska, Volcanic Islands, Everglades, the vast, desolate areas found in the intermountain West) and other remote reaches of the Earth. Manned aircraft flights are problematic in these areas due to long flight durations, unpredictable weather conditions and associated operations cost. Satellite based observations are hindered by course resolutions, limited sensor capabilities, weather conditions and acquisition cycles that can often be several days or weeks. The use of UAS technology allows flexibility in delivering timely data, for longer durations (persistent staring), tailored to the required resolution and radiometric parameters and expands the ability to obtain remotely sensed data to inventory and monitor dynamic landscape altering events and conduct impact analysis over previously logistically challenging areas. The use of UAS technology will enhance our ability to provide unbiased scientific information to better enable decision makers to make informed decisions.

Unmanned Aircraft Systems (UAS) will transform the methods and techniques employed across the Department of the Interior (DOI) and the United States Geological Survey (USGS) in support of our mission to serve the Nation by providing 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. Cost effective UAS technology is currently available to support a wide variety of applications including: managing federal lands; monitoring environmental conditions and natural resources use; analyzing dynamic earth processes to support global and climate change investigations; generating mapping, charting, and geodesy products; conducting environmental risk assessments; and preventing, preparing for, responding to, and recovering from natural and human-induced disasters.

Collaboration across government, commercial entities, and academia are essential for the U.S. Geological Survey Unmanned Aircraft Project Office to efficiently and effectively evaluate and develop UAS capabilities that support and/or serve as:

- Augmentation of Satellite and Aircraft observations
- Verification and validation of remotely sensed observations
- Strategic Awareness in support of Incident Command Operations
- Wildland Fire Tactical Support
- DOI Law Enforcement (crowd control, Border Patrol, counter drug operations)
- Monitoring DOI assets (archeological sites, areas of critical habitat, critical infrastructure)
- Mapping (Digital Elevation Models, Image Collection)
- Land Management (monitoring rangeland and forest health conditions)
- Climate Change (monitoring carbon exchange)
- Logistical Support (instrumentation of seismic/ GPS sensors; material resupply)
- Communications and Broadcast Services (enhanced radio communications)
- Search and Rescue operations
- Environmental Research
- Wildlife Inventories
- Air quality measurements (volcanic gas and ash emissions, wildfire smoke plume gasses)

Recently, the U.S. Geological Survey obtained several sUAS Raven Systems. The systems have provided us with the ability to compare our current baseline of capabilities (i.e. flight duration, sensor packages) against our mission requirements. This analysis will be critical as we move forward in our use of UAS technology. The systems have also presented us with the opportunity to work with AMD and the FAA on the definition of operational (crew training, airworthiness criteria, etc.) requirements and Certificate of Authorization (COA) process. The AeroVironment produced Raven is a small unmanned aerial systems (sUAS) that are primarily designed as a reconnaissance and surveillance tool. The system transmits near real time airborne video images, compass headings and location information to a ground control unit (GCU) and remote video terminal (RVT). The Raven aircraft is hand launched without the need of special equipment or landing areas. The system employs a self-stabilizing aircraft configuration with stability augmentation avionics and provides ease of control and steady video imagery. The optics package includes an electro-optical (EO) color camera nose payload (side and forward looking) on the same payload and two infrared (IR) thermal nose payloads (a side

look payload or a forward look payload). The Raven system is typically operated by a two person team consisting of a Pilot and Mission Controller. The systems are proving invaluable in promoting and developing sUAS technology for civil and domestic applications.

The USGS UAS Project Office, plans to utilize this technology to support various scientific studies which include; analysis of wildfire and environmental impacts; monitoring land change; examining the affects of the mountain pine park beetle of the western states; tracking wildlife; completing ecosystem surveys; improving natural hazard forecasting and mitigation; and to aid and assist in GIS mapping & remote sensing projects within the department. The USGS and AMD have sponsored sUAS- Raven training sessions at Dugway Proving Grounds and Ft. Bliss. The two week courses, mirrored after training developed for the U.S. Army, have been attended by students representing USGS, NPS, BLM, AMD, FAA and USFS. Information on the course is available at: http://oneinterior.doi.net/oneinterior/News/nbc-usgs-unmanned-aircraft-system-training.cfm

CHALLENGES

The Project Office is representing USGS interest and supporting initiatives designed to implement UAS capabilities as a viable, cost effective and regulated alternative to existing land imaging resources. A partial listing barriers and areas that need further investigation:

- Operations Costs (compared to manned aircraft)
- Lack of commercial (contract) availability of UAS service providers
- Sensor familiarity and data exploitation tool availability
- Frequency availability to support Civil/ Commercial Operations
- Operator Training Certification Programs
- Data Archive- Dissemination policies and capabilities
- Concern with proliferation of "one of a kind systems"
- Lack of airspace available to maintain operator training and currency requirements
- Lack of airworthiness standards, especially for sUAS
- Few opportunities to document "real missions"
- Definition of "accident or incident"
- Liability for Civil Operations
- FAA National Air Space Regulations[v]

The most notable of the current restrictions and concerns is directly related to the Federal Aviation Administration Certification of Authorization process. The release and adoption of formal rules and regulations governing UAS operations in the National Airspace is eagerly anticipated by the USGS and our partners. It is hoped that the proposed rules recognize the high potential value of operating "program of record" sUAS as public aircraft, by trained operators and the relatively small risk associated with operating sUAS over the lands managed by the Department of the Interior. The majority of our remaining concerns will be rectified as systems and applications evolve and as we gain experience with this rapidly evolving technology. [vi]

CONCLUSION

The USGS UAS Project Office is dedicated to leading and coordinating the USGS efforts to promote and develop UAS technology for civil, domestic applications while not compromising risk to the public's safety. A key task, currently underway, is to develop a report that will serve as a roadmap for the development of these applications by the Department of the Interior and USGS. The document will be updated annually and used to evaluate the feasibility of future research, application developments, and mission support. In addition, it will help influence budget requests, plans and allocations. The report will:

- Provide an overview of the present state of the platforms and sensor capabilities,
- Provide a foundation for development of a comprehensive DOI/USGS UAS roadmap
- Determine and document technologies necessary to support future missions
- Document requirements for UAS and related technologies
- Determine and document future civil missions for UAS based on user-defined needs

The ultimate goal of the USGS Unmanned System Project Office is to support informed decision making that will directly benefit the Nation by creating the opportunity for USGS and our partners gain access to an increased level of persistent monitoring of earth surface processes (forest health conditions, monitoring wildfires, earthquake zones, invasive species, etc.) in areas that have been difficult or impossible to obtain information before. Much like the use of internet technology and global positioning systems, unmanned aircraft systems have the potential of enabling us to be better stewards of the land by:

- improving natural hazard forecasting and the analysis of the impacts;
- improving our understanding of climate change to better plan for the likely impacts;
- developing precipitation and evaporation forecasting to better manage water resources;
- monitoring Arctic ice change and its impacts on ecosystems, coasts, and transportation;
- increase safety and effectiveness of wildland fire management;
- broaden our abilities to monitor and enforce land use regulations;
- better understand and protect ecosystems

> Harry Kieling, AMD Alaska Regional Director and student in the first Department of the Interior Unmanned Aircraft System class said: *"A big segment of the future of aviation will include Unmanned Vehicles. They will not replace manned aviation, but a lot of DOI missions will be better and more safely performed by UAS. This Raven training is a big first step for DOI toward that goal."*

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APPENDIX

Below is a cross sample of requests related to potential applications of UAS technology provided by Department of the Interior employees. The list is provided to illustrate the ground swell of interest (including scientific, managerial and operations staffs) across the Department related to this emerging technology. To further illustrate the growing interest in UAS technology, over 100 Department of Interior employees have expressed an interest in being trained as sUAS operators.

"Our scientists have expressed interest in the capabilities of this system to collect low-altitude aerial imagery used for bird and habitat studies."

"although the FAA rules and regulations are covered in the course, it would be useful to have some general idea what these are to be able to pass along to prospective students. Water Centers in parts of the country where use of the sUAS may be problematic would be less likely to take advantage of this opportunity."

"I've been saying for years that USGS needed a capability like this one appears to have, for stream geomorphology and riparian ecology work, detailed high-res imagery of surface conditions in small watersheds, and for flood or ice-jam monitoring. I see good use of this platform for a variety of uses… flood monitoring, spill detection and monitoring in rivers, coastal spill detection and monitoring."

"Our team supports post-earthquake scientific investigations following large earthquakes in the US and, on occasion, internationally. These investigations require rapid assessment of the extent of surface faulting, earthquake- induced landslides and liquefaction, and the damage area, and effective deployment of field teams to record critical scientific observations before many of the subtle features are destroyed by natural or man-made processes. Use of small unmanned aircraft by our field teams may have the potential to complement existing reconnaissance methods that we currently employ, by possibly reducing the amount of time-consuming ground-level reconnaissance that typically occurs during these investigations, or to access areas that otherwise would be impossible or unsafe for our field crews and scientists to enter."

"To combat multinational drug traffic organizations engaged in cultivation of large marijuana plantations on public lands. I am interested in UAV/UAS programs as a way to conduct pre-raid reconnaissance of routes and locations, assess damage to natural resources as a result of cultivation activities and aid in the collection of geospatial data on impacted lands."

"I'm leading wetland restoration programs in San Francisco Bay and on Puget Sound. We've been experimenting with aerial photography to document wetland change."

"One of our technical interests is the interaction of surface water and groundwater. In places where groundwater flows into surface waters, and a temperature difference exists between the waters, such locations can be identified by temperature. One way in which this is done is with fiber-optic cable. The combination of camera and thermal imager of the sUAS would provide another way to evaluate the location of groundwater flow to surface waters, as well as providing clues about where deployment of continuous recording devices such as the fiber optic cable, or other measurement techniques would be most effective. The surface waters of interest include streams, rivers, lakes, wetlands, estuaries and coastlines."

"I would like to conduct video or photo surveys for pelagic birds on the Great Lakes using some sort of line transect sampling scheme. Altitude of flight would depend on the optical equipment. Pelagic bird surveys on Great Lakes can be accomplished with a small unmanned aircraft vehicle."

"I have discussed the potential applications of aerial surveillance and we feel that this tool could improve the quality of the science we provide to our cooperators and the public. North Dakota is prone to flood events due to limited topographic relief (especially in the Red River Valley) and the rapid release of water from a melting snow pack in the spring. We had a historic peak with widespread flooding this past spring in both the Western and Eastern sides of the state simultaneously that threatened North Dakota's largest population centers. Aerial surveillance wouldn't mitigate flooding but it would allow the USGS to document and better respond in real-time to ice jams, overland flooding, and levee failures. This spring saw all of these events and the use of an aerial surveillance system would have allowed the USGS to provide better science to our sister agencies and cooperators as they attempted to mitigate flood damage. My time with the ND USGS has enabled me to lead on the use and application of developing technologies in the hydrologic field. The use of real-time aerial surveillance to capture hydrologic events has the potential to improve our science and I would like to be a part of this developing technology."

"If this resource becomes available, I may be able to use it in conjunction with a small hyper spectral sensor to collect imagery over Fossil Butte National Monument as part of a project to collect spectral signature information for a couple of at-risk plant species. There is concern that these species may be threatened by the growing elk population "

"I would be interested in using this for glacier monitoring using LIDAR and digital photography."

"Our uses of UAS would include: Bird population counts in wilderness or non-accessible terrain, fire ecology mapping, swan signature, population and nesting sites"

"Global Change - Habitat and marsh detection / thermal ground water discharge (brine / geochemistry) detection."

"We would like to determine the chemical composition of materials in smoke plumes, especially fires that occur in the wildland- urban interface."

"We are interested in evaluating the potential of a UAS to monitor wildland fire and disseminate the information to the field crews (using PDA technology), incident command center, Geographic Area Coordination Centers and National Interagency Fire Center."

"I am very interested in the potential for thermal imaging of streams and wetlands to assess groundwater influxes and thermal dynamics. I am also interested in low-cost documentation of canopy changes from close range. We would be able to deploy the instrument locally in VA over public (conservation reserve and/or National Park) lands to gain experience. I could then see us deploying the system in the Everglades and some other areas of the southeast where surface/subsurface water interactions are of great interest."

"Potential applications of interest would be post-fire severity assessment and high spatial/temporal resolution monitoring; characterization and monitoring of other disturbances at high spatial/temporal resolution, incl. for ephemeral targets/phenomena (e.g., pests/pathogens); field data augmentation and plot supplementation."

"We are interested in using high resolution remote sensing to map changes in vegetation type, cover and stress as well as temporal changes and spatial distribution of water quality. Our group specializes in measuring water color in situ to study biogeochemical aspects of water quality parameters (ancillary and dissolved and particulate organics and inorganics). We would like to evaluate the utility of using the RAVENS highly resolute, visible + IR (and spectral if possible) images to extend the reach of our in situ water quality (limited to point) measurements. Specifically, we hope to use the RAVEN to map the accretion of carbon in experimental farmed wetlands in the Sacramento Delta and to map the extent and evolution of riparian zones of a model agricultural watershed. "

"Wild horse population estimates of the herds on BLM lands near Cody, WY"
"We want to integrate collected imagery and data into existing GIS/GoogleMaps databases (with the help of USGS GIS programmers and geographers) so that the information will be easily shared with both fellow USGS colleagues and regional cooperators. We have many more applications in mind, too many to list here right now, but hopefully we can discuss them soon"

"The UAS would be used for river corridor flights along the upper Colorado River (Upstream of Williams Fork) and Fraser River in Grand County. Fly the river to track habitat conditions and potential changes over the years as more water is removed and transported to the Front Range. This project would be repeated on some time interval (every 3 to 5 years)."

"The UAS would be used to monitor two-dimensional river hydraulics and habitat mapping on the Cache La Poudre River near Fort Collins. USGS has a long-standing study site in the Poudre River Canyon, just below the State Fish Hatchery between Kinikinik and Idylwilde, CO. The additional imagery would add to our project looking into hydraulic model sensitivity to various data sources and densities which impact the final habitat maps we create for resources managers. We have been discussing creating a second study site along the river near Greeley in order to begin looking at how the stream bed morphology plays a part in our model sensitivity. Basically, the UAS would help compare a steep gravel bed channel within the Poudre River Canyon to the flat sand bed channel on the Plains."

"The UAS would support moose inventory flights using the infrared camera. It is difficult to locate moose via manned aerial flights due to the trees and the dark color of the moose. It may be possible to pick moose up with the infrared camera. Possible locations for these flights would be the Williams Fork, and the Willow Creek drainages and areas near Grand Lake."

"Sage grouse lek location flights- There are several areas in Grand County that we know or believe to know that there are sage grouse leks however due to access difficulty (snow or mud) we are not able to thoroughly search. We would like to visit some of these areas with the UAS to try and locate the leks. Possible locations include the Parshall Divide, Granby and the Muddy Creek drainage."

"Colorado Forest Health Project – USGS would like to fly the Raven A UAS system in support of mountain pine bark beetle tree mortality (mapping) classification work. The imagery would help sampling selection, applied throughout the various datasets the USGS uses for defining dead tree cover. Flight imagery could also help identify the extent of blow down trees in support of fuels treatments. Additional flights of fuel treatment areas could provide updates of the changes for landfire and other fuels related datasets."

"There are two current projects at UMESC where we would like to see if UAVs and remote sensing would be useful. I am conducting a study of sandhill crane habitat use in and near Horicon NWR in Southeast Wisconsin. I'd like to use UAVs to pinpoint roost and feeding locations and perhaps actually count the birds. We are also involved with surveys of pelagic birds in the Great Lakes during fall-spring. I think there may be some major hurdles with FAA for flying missions over the Great Lakes? Folks in the Geospatial Sciences branch also fly to collect aerial photography data to generate periodic land use/cover GIS. A lot of this work is done all along the Upper Mississippi River. We feel that video streaming can be handy along with the standard airplane platform, frame based aerial photography."

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