

**MONTANA UNIVERSITY SYSTEM RESEARCH INITIATIVE**  
Autonomous Aerial Systems for Wildfire Management in Montana  
*Quarterly Report - April 11, 2016*



**Submitted by:**

Carl Seielstad, Project Lead and Principle Investigator  
FireCenter – The University of Montana – Missoula  
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<http://www.umt.edu/aaso/DroneFire/>

## Executive Summary and Highlights

Activities in quarter one have focused on: 1) developing project oversight , coordination, and communication; 2) outreach and partnering with Montana UAS companies; 3) establishing relationships with natural resource science and UAS university partners; 4) evaluating UAS platforms and sensors; and 5) applying for exemptions, COAs, and aircraft tail numbers. It has quickly become evident that there is enormous interest in UAS from Montana students, faculty, and the private sector. Our drone fly-in on the UM oval attracted more than 120 people, mostly students, and our science team of MUS faculty has grown to ten researchers. Despite the Federal Aviation Administration’s continuing delays in developing coherent regulatory structures, the UAS industry is growing at astonishing speed. Six additional Montana companies have submitted 333 applications since January. New platforms, sensors, and software appear weekly- almost none of it proven technology. Separating fact from fiction in the UAS marketplace has necessarily become a major focal point of the project. Success in the latter endeavor is reliant on effective collaboration with commercial, research, and recreational UAS partners. Expanding the collective knowledge and capacity of the project team and its partners is fundamental to future success of UAS-related business in Montana as markets develop.

We have identified two factors that are changing how the project unfolds relative to the original proposal. First, the majority of businesses wish to protect their interests through non-disclosure agreements. This means that the proposed industry ‘fly-ins’ will occur with individual companies over several days rather than in larger collaborative groups. Second, the regulatory strictures of the FAA combined with those of UM are more onerous than anticipated. It has become necessary to anticipate every possible system, application, and activity and to pre-emptively apply for permissions, permits, and contracts associated with them whether we ultimately use them or not. Overcoming regulatory obstacles will be a major contribution of this project.

Following, we describe activities and accomplishments in the first quarter of the project. Activities are organized by objectives and milestones, as reported in the Project OTOs. Expenditures and photos are included at the end of the document. Highlights include:

- *Comprehensive Administrative and Science Teams have been organized*
- *We have added ten science team members in forest inventory and health, wildland fire, hydrology, meteorology*
- *We are engaged in active negotiations/discussions with five Montana UAS companies.*
- *We have partnered with a Missoula company (Skyyfish) on platform/sensor integration and flight control*
- *A Washington state based UAS company has opened a satellite office in Hamilton, MT as a direct result of negotiations with our project*
- *We are working with peer institutions North Carolina State, Sinclair Community College, and North Dakota State Universities, including site visits and data exchanges*
- *Training has been completed for one FAA Pilot; two additional pilots are being trained*

- Two small training drones have been acquired and test flown; an array of remote sensing instruments are being examined that support the Science Team and that will exploit services from the private sector
- We have requested and received eight tail numbers from the FAA for UM aircraft; a COA application for the Lubrecht Experimental Forest and one COA application for flying over 12 Osprey nests in Western Montana has been submitted to the FAA
- We hosted a drone fly in at UM in March 2016, attended by 120 people
- A new UM class “Mapping/GIS Applications of UAS” is being offered
- We have hired two PhD and one MS student to work on fire and forest measurements

**Objective #1. Develop project management organization and workplan, prepare communications plans encompassing economic impacts, progress, and deliverables; develop strategy for end-of-grant transition to UM AASO**

Milestone 1) Develop project oversight organizational structure to manage functional areas: a) Administration, Compliance, Training; b) Technology and Operations; c) Research and Applications (end of year 2015)

***DroneFire Organizational Structure***

<b>Project Component</b>	<b>Component Lead</b>	<b>Objectives</b>	<b>Participants</b>
<i>Project Oversight and Management</i>	<i>Carl Seielstad</i>	<ul style="list-style-type: none"> <li>• <i>Coordination of Teams</i></li> <li>• <i>Budgets</i></li> <li>• <i>Communications</i></li> <li>• <i>Documentation</i></li> </ul>	<i>Jami Sindelar, Budget Analyst Niels Maumenee, IT Support</i>
<i>Autonomous Aerial Systems</i>	<i>Jenn Fowler, Jaylene Naylor</i>	<ul style="list-style-type: none"> <li>• <i>Complementary Systems</i></li> <li>• <i>Fly-In</i></li> <li>• <i>Training and Certification</i></li> <li>• <i>Client Development</i></li> <li>• <i>Best Practices/Operations</i></li> </ul>	
<i>Remote Sensing</i>	<i>Jim Riddering</i>	<ul style="list-style-type: none"> <li>• <i>Develop a field laboratory</i></li> <li>• <i>Alternative sensors</i></li> <li>• <i>Best Practices/Data</i></li> </ul>	
<i>Science Applications</i>	<i>Lloyd Queen, Carl Seielstad</i>	<ul style="list-style-type: none"> <li>• <i>Fuels Assessments</i></li> <li>• <i>Algorithm Development</i></li> <li>• <i>Work Flows and Data Management</i></li> </ul>	<i>Dave Affleck, Forestry faculty George Gaines, PhD student Chris Moran, PhD student Philip Williams, MS student</i>

- *We have established a comprehensive project management and accounting staff and strategy. This includes procedures, authorizations and documentation for the project in consultation with the UM Office of the Vice President for Research and Creative Scholarship.*
- *Science Teams have been rostered (see Objective #4 below) and are at work on research and application portfolios.*
- *One of the applications Teams, led by Dr. Andrew Larson from the College of Forestry, has added an investigation into snow cover mapping. This development adds a significant dimension to the project as this now ensures that the suite of platforms and sensors being developed will see year-around use.*
- *We are working to craft an “Advisory Panel” consisting of representatives from industry, science as well as from public and private land management agencies.*

Milestone 2) Develop Workplan, Milestones, and Timelines (end of January 2016)

- *Completed Project workplan with objectives, timelines, deliverables (OTOs).*
- *Science team members are completing project prospectus. Four draft plans have been received: videography, thermal infrared, mapping, meteorology.*

Milestone 3) Develop communications plan; economic impact plan; summary of deliverables; and progress to date (preliminary accomplishments Jan 2017 - final documents June 2017). 4) Develop strategy for hand-off through UM AASO.

- *An Outreach Team is at work on the website and they have opened an Instagram channel that allows us to reach a much broader audience and that is specifically targeted to students.*
- *We have hired an Integrated Communications undergraduate intern from the UM Journalism program.*
- *The project is being housed within UM AASO to ensure seamless transition to UM at project end. Success will be measured in part by continuation of activity in UAS-related research at UM after the MREDI project expires.*

**Objective #2. Establish contracts and coordinate flight operations with Montana’s UAS companies and FAA for fly-in/field campaign at Lubrecht Experimental Forest. Overall Purpose: Leverage and grow UM's research enterprise through private sector partnering.**

Milestone 1) Design and implement UM's Autonomous Aerial Systems Office (AASO) website to facilitate contracting and flight planning operations including a listing of current UAS platforms and payload technologies for existing 333 exemption holders in Montana. (January 29, 2016)

- *As noted above, a DroneFire website has been developed (<http://www.umt.edu/aaso/DroneFire/>) under the aegis of the AASO. By structuring the project within AASO, we ensure seamless continuity at project end. A list of current UAS platforms and technologies for existing 333*

*exemption holders who have agreed to collaborate with the project is included under the project partners tab of the website.*

Milestone 2) Contract template for Statement of Work needed from contractors as part of UM's procurement process, non-disclosure agreement template for contractors, and memorandums of understanding for field lab and training operations areas. (March 1, 2016)

- *A Non-Disclosure Agreement has been completed in consultation with UM Legal Council and has been signed by the Vice President for Research and Creative Scholarship*
- *We have developed mission specifications with SUATS company in Columbia Falls for UAS meteorology flights at their FAA approved airstrip.*
- *Contract templates are being set up in GrizMart.*
- *We have drafted a bid-template for partners with language to include 333 exemption numbers and liability coverages to allow for contracted services between private companies and UM scientists.*
- *Commander Navigation, a UAS development and services company based in Seattle, WA opened new MT Office (Hamilton, February 2016) specifically to partner with DroneFire. They are leaders in fixed wing, integrated systems that we will collaborate on multispectral mapping systems as a contractor/provider.*
- *We have developed a narrative with Commander that details the sensors currently offered on their long duration fixed wing platform. These include the MicaSense, Waldo Air visible and near IR cameras as well as Trillium and Resonon (a Montana based company) long wave infrared sensors. These sensor capabilities are within the specific sensor capabilities that the DroneFire science team will need to acquire and analyze.*
- *Site visits have been conducted with the following Montana Companies:*
  - *Big Sky UAV*
  - *Skyfish*
  - *Onebindingsystems, LLC*
  - *Resonon*
  - *Bridger Photonics*
- *Working with UM Offices of Risk management and Legal Services, we have completed institutional policies and procedures for UAS operations and acquisitions.*
- *Updated database of Montana 333 Exemption holders (from FAA); six new companies since January 2016.*

Milestone 3) FAA coordination for Lubrecht field campaign. (June 1, 2016); 4) Plan for potential second fly-in Spring 2017.

- *We have applied for a COA to fly at Lubrecht Forest and are working with project partners on applications that will allow them to fly at LEF.*
- *We continue to develop a written plan of activities to be submitted to the local Flight Standards District Office (FSDO) in Helena as well as the associated NOTAM covering all contracted flights.*

**Objective #3. Establish field laboratory for UAS research and development, where UAS can be deployed consistently to measure and monitor forest fuels. Overall Purpose: Grow emerging UAS field in MT by providing permanent R&D facility and demonstrating new instruments and technology.**

Milestone 1) Establish UAS launch site/airport adjacent to test areas at LEF; Identify forest stands across range of forest conditions; Complete MOUs, FAA documentation, and flight protocols; Coordinate/inform adjacent landowners as necessary

- *Three potential validation areas have been identified at Lubrecht Experimental Forest. Validation sites need to have a launch site, access to diverse forest conditions, and a vantage point to maintain line-of-sight with aircraft. The latter FAA-imposed requirement remains a significant limitation to operational flexibility in forested landscapes.*
- *Permissions to conduct flight operations at LEF have been secured from College of Forestry and Conservation.*
- *We have applied for a COA, as noted above.*

Milestone 2) Collect & integrate field and remote sensing validation data; Establish ground control - identify proximate GPS stations

- *Field reconnaissance is ongoing. Snow cover has restricted access to key areas.*
- *An independent airborne LiDAR data set has been processed for validation of UAS measurements.*
- *We have engaged in discussions with Missoula County Surveyors Office about the development of a Real-Time Kinematic Survey Network in western Montana that will aid in precision data collection by UAS.*
- *We are working to establish additional fire-related field sites on Kootenai and Lolo National Forests through collaboration with local land management partners.*
- *We have partnered with the USDA Missoula Fire Sciences Lab and established a shared sensor calibration facility and now have access to the USDA combustion chamber/wind tunnel in support of fire-based remote sensing. The geometry of flames affects the ability of sensors to accurately measure fire radiation. This facility allows us to test sensor (radiometer) performance in new ways.*
- *We are working with the Fire Sciences Laboratory to deploy UAS on prescribed fire to capture high resolution videography for use in model validation. These activities will be supported by a Research Joint Venture Agreement with the University of Montana.*

Milestone 3) Produce maps of test areas; Document activities, advertise, and post on website

- *A graduate student is compiling geospatial data of proposed Lubrecht test areas.*
- *Literature review on state-of-science on applications of UAS in forest inventory and assessment is underway – to be presented at the Inland Northwest Growth and Yield Cooperative meetings in Spokane, WA on April 19.*

- *Evaluated other UAS research centers and programs across the US and are sharing drone imagery with peers at North Carolina State University.*

**Objective #4. Develop a science cadre to test applications and conduct research; build infrastructure for data management; produce and test field-usable data products. Overall Purpose: Leverage MUS research enterprise targeted at private sector; build future customer base.**

*Milestone 1) Identify science cadre members and outreach to MUS partners (Jan-June 2016)*

*Science Team Members and Fields of Interest. Research prospectus are under solicitation.*

- *Affleck (Forestry) – tree regeneration survey*
- *Larson (Forestry) – snow accumulation and ablation*
- *Jensco (Forestry) – groundwater flow and water uptake by vegetation*
- *Woods (Wildlife Biology) – thermal entomology*
- *Allred (Range Management) – forage quality*
- *Queen/Seielstad (Fire Science) – fuels/ fire behavior*
- *Riddering (Fire Science) – visualization/virtual reality*
- *Vaillet (Wildlife Biology) – water flow/flooding*
- *McManigal (Geography) – mapping/GIS*
- *Fowler (AASO) – meteorology and lightning strike monitoring missions*
- *Gaines (Forestry) – forest inventory*
- *Moran (Fire Science) – lidar measurements of forest structure*

Milestone 2) Acquire data for test areas at LEF (June - Oct 2016; March - May 2017); Develop data processing streams including geometric corrections and calibrations (Aug 2016 - Feb 2017); Compare UAS-derived results to field metrics and data from other remote sensing data sources (June 2016 - end of project)

- *No significant accomplishments to report.*

Milestone 3) Develop a data management, archiving, and sharing system (continuous, beginning January 2016 with functional system by July 2016); Expand customer base.

- *Using NCLFA's compute cluster, we have put in-place a cloud-based shared drive for files, project reporting, and a data clearinghouse. The site is expandable to the full project scope, is redundant and secure.*
- *We have added project members to the NCLFA compute services cluster so that they can access GIS clearinghouse with data holdings which is supporting planning for test flights, definition of field and research plot locations and flight operations.*

**Objective #5. Procure and test two research UAS complementary to private sector systems. Overall Purpose: leverage overall enterprise in both public and private sectors.**

Milestone 1) Market research for COTS mapping system (Jan-March 2016). Identify Montana UAS manufacturers and available specifications on UAS. (March 1, 2016) Purchase will be made based on complementing private sector UAS platform options. Repeat for second UAS August 26, 2016.

- *Completed comprehensive review of COTS mapping systems. Sensefly Ebee and Trimble UX5 are most robust fixed-wing systems. DJI Inspire/Zenmuse and DJI Phantom are at the top of rotor-wing systems.*
- *Priorities (in order): 1. surveillance/intelligence gathering/virtual reality; 2. Optical, mapping, multispectral, frame-based; 3. Thermal Infrared; 4. Meteorology; 5. Lidar.*
- *Nearing completion of photogrammetric software evaluation, including: Agisoft, Pix4D, OpenDrone, ESRI Drone2Map.*
- *Initially, we propose to contract with two commercial data providers to collect imagery of forest stands at Lubrecht. One data acquisition will use a fixed-wing Sensefly Ebee and the other will utilize a rotor DJI Inspire. The purpose of these acquisitions is: 1) to test the operational limitations of the flight area; 2) examine data products from raw imagery with gps ephemeris, processed imagery (ortho-mosaics and 3-D point clouds; and 3) evaluate the entire workflow of each system (flight planning, data acquisition, processing).*

Milestone 2) Submit Certificate of Operation or 333 exemption application on new UAS (March 31st, 2016). Repeat for second UAS September 30, 2016.

- *Purchased two training rotor wing drones; a Matrice100 and Phantom3.*
- *Test flights in nets are underway, flight simulator software in-place.*
- *Are negotiating with a new MT company, Commander Navigation (Hamilton, MT), to explore fixed wing drone and alternative sensor technology. Commander is an industry leader in collecting long duration high resolution remote sensing data. We anticipate contracted services with Commander in order to acquire large format data for forest and vegetation mapping and inventory work.*
- *We have partnered with Skyyfish, a Missoula UAS company that is developing quadcopter hardware and flight planning and navigation software. We are collaborating to develop applications for various sensors they will include on their platform. We will also beta test software and provide consultation for natural resource applications. To date: our partnership has included five site visits, flight demonstrations, and training.*
- *We conducted a comprehensive review of UAS platforms and camera systems.*
- *We conducted a review of University UAS program nationwide.*
- *Partnered with Institute for Transportation Research and Education, North Carolina State University. NCSU established a UAS research and development center for the State of North Carolina in 2012. They are sharing data and expertise in UAS applications in transportation and agriculture, and providing inputs on software design and workflows.*



- *Applied for and received 8 tail numbers for UAS from FAA.*
- *Submitted UM 333 exemption application*

**Objective #6. UAS UM course development, training and certification. Overall Purpose: Develop more-capable workforce; grow emerging field of UAS applications.**

Milestone 1) Policies and procedures for UAS operations with the University of Montana (March 1, 2016)

- *Policies and procedures for UAS operations are available on the AASO website. The site is updated when new regulations and practices come online (e.g., frequently)*
- *Project staff attended five workshops, online-trainings, and conference sessions related to UAS procedures.*

Milestone 2) Training and certification program for UM UAS operators (January 29th, 2016); Conduct mid-project review and evaluation (Sept 2017)

- *Pilot training: Our lead pilot will have completed FAA currency requirements by the end of the reporting period. The FAA requires a certificated pilot to act as pilot-in-command (PIC) of any commercial/academic use of UAS. We have partnered with Choice Aviation (Hamilton, MT) to maintain Pilot currency requirements and will begin working towards currency on a second pilot soon.*
- *Flight simulators in-place for two UAS platforms (DJI Matrice100 and Phantom-3)*
- *Attended AGI Systems “Toolkit for UAS Programs” webinar, March 2016.*
- *Participated in UM’s “Tech Expo” on April 13, 2016. We set up a net enclosure and invited students, members of the public and other interested parties to pilot several drone platforms*
- *Three new graduate students in CFC, one MS and two PhD in remote sensing applications of drone-based forest mapping and fire behavior monitoring*

Milestone 3) UM Course for UAS operations and applications to serve as a template for best practices of UAS operations. This course will include information on private sector activities through lectures, course work, and guest speakers. (Fall 2017)

- *New UM Course offered through the Department of Geography in “GIS Applications of UAS”. Current course focus on the ‘how to’ more than best practices.*
- *A new drone photogrammetry module has been added to the Forestry “Environmental Remote Sensing” course, Spring semester 2016.*
- *Site visit to SUATS company in Columbia Falls to discuss UAS training for staff and students. SUATS is premier private training facility in western US. Currently negotiating agreement to train pilots at Kalispell facility.*

**Expenditures/Budget Summary in first Quarter**

		Initial Budget	Expense to Date	Amount remaining
Contracted Services		\$225,000.00	\$125.00	\$224,875.00
Supplies		\$45,000.00	\$7,149.73	\$37,850.27
Communications		\$0.00	\$0.00	\$0.00
Travel		\$60,000.00	\$0.00	\$60,000.00
Salary		\$334,930.00	\$11,906.33	\$323,023.67
Benefits		\$112,474.00	\$1,397.75	\$111,076.25
Tuition		\$32,596.00	\$6,145.44	\$26,450.56
Equipment		\$80,000.00	\$0.00	\$80,000.00
Other Services		\$10,000.00	\$662.50	\$9,337.50
TOTAL Expenses		\$900,000.00	\$27,386.75	\$872,613.25

*Current expenditures reflect the time-consuming but initially low-cost activities of: 1) developing project oversight, coordination, and communication; 2) outreach and partnering with Montana UAS companies; 3) establishing relationships with natural resource science and UAS university partners; 4) evaluating UAS platforms and sensors; and 5) applying for exemptions, COAs, and aircraft tail numbers. Expenditures will accelerate in Quarter Two.*



Recreational pilot flying DJI Phantom on UM oval at 'fly-in'.



Students work with DJI Phantom suspended below balloon at UM 'fly-in' highlighting some of the current regulatory absurdities in UAS flight operations- photo by Todd Goodrich (UM photographer).



Skyfish engineer assembling drone at Missoula facility. Skyfish is a project partner in hardware/software manufacturer and integration.



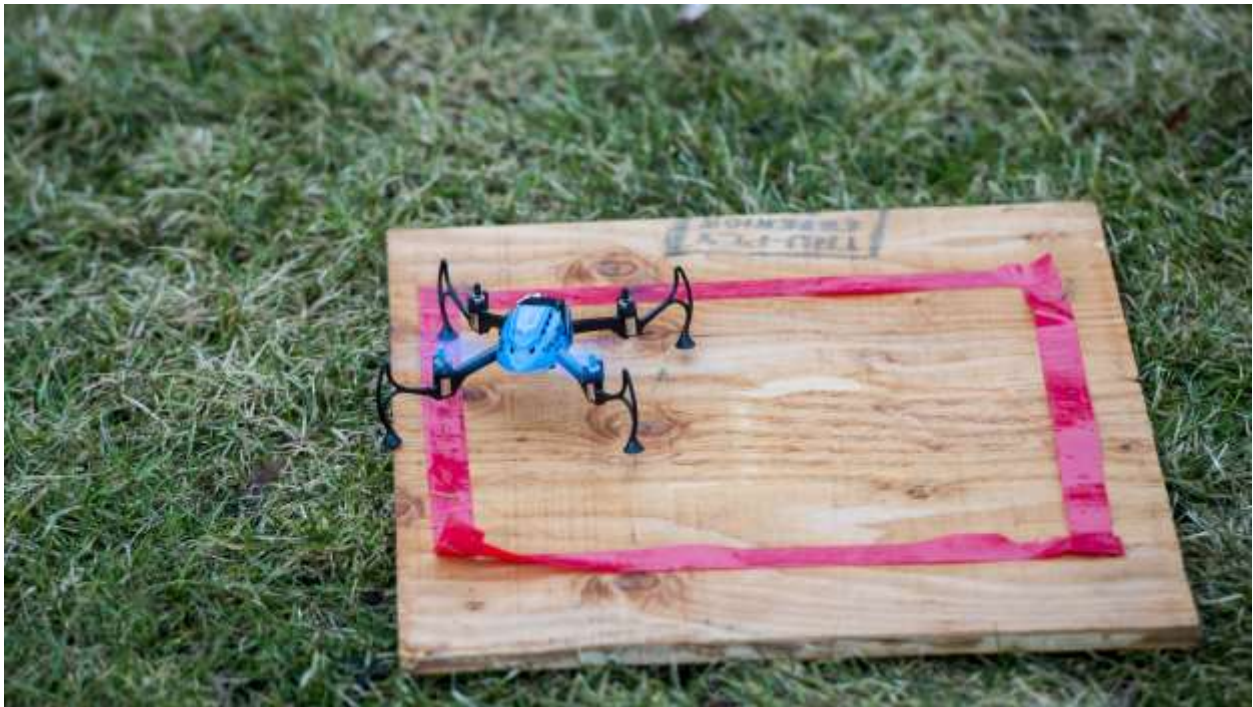
Configuring the cloud computing cluster at UM for DroneFire, March 2016.



Testing and flying in UM's Schreiber Gym.



Student test-flying drone in net on UM oval- photo by Todd Goodrich (UM photographer)



Student landing drone on target at UM 'fly-in'- photo by Todd Goodrich (UM photographer)





Student teaching citizen how to fly at UM 'fly-in'



The practice flying net set up on the UM Oval.



Assembling the Matrice100.



First Light- testing the DJI Matrice100 by lead pilot.



Steep learning curve - broken rotors after test-flight.