



UAS Applications in Arctic Remote Sensing

Dr. Michael C. Hatfield, University of Alaska, Fairbanks

MICHAEL C. HATFIELD, Ph.D. Assistant Professor, Department of Electrical and Computer Engineering University of Alaska Fairbanks; Fairbanks, AK 99775.5919 Email: mchatfield@alaska.edu; Office phone: 907.474.6098

1. PROFESSIONAL PREPARATION Ohio Northern University, Electrical Engineering (Math major), B.S. 1984 California State University Fresno, Electrical Engineering, M.S. 1987 University of Alaska Fairbanks, Electrical/Aeronautical Engineering, Ph.D. 1999 2. APPOINTMENTS 2013-present: Assistant Professor, Electrical/Computer Engineering, UAF Earth & Planetary Remote Sensing, UAF Geophysical Institute Associate Director for Science & Education, Alaska Center for Unmanned Aircraft Systems Integration 2009-2012: Director, Air Force Research Laboratory Air Vehicles Directorate 2006-2009: Deputy Director, Air Force Office of Scientific Research 1999-2003: Deputy Head, USAF Academy Department of Astronautics 1992-1996: Assistant Professor, USAFA Department of Astronautics 3. PUBLICATIONS 1. Cunningham, K., M. C. Hatfield, and R. Philemonoff, Unmanned Aircraft Systems in Alaskan Civil Research, 2014 Arctic Technology Conference, 2014 2. Hatfield, M. C., and J. G. Hawkins, Design of an Electronically-Steerable Phased Array for Wireless Power Transmission Using a Magnetron Directional Amplifier, 1999 IEEE MTT-S International Microwave Symposium Digest, 1999. 3. Hatfield, M. C., Characterization and Optimization of the Magnetron Directional Amplifier, Doctoral Thesis, University of Alaska Fairbanks, 1999 4. Hatfield, M. C., W. C. Brown, and J. G. Hawkins, Design of an Electronically-Steerable Phased Array for Wireless Power Transmission Using a Magnetron Directional Amplifier, IEEE Proceedings on MTTTS, 1998 5. Hawkins, J. G., S. Houston, M. C. Hatfield, and W. C. Brown, The SABER Microwave-Powered Helicopter Project and Related WPT Research at the University of Alaska Fairbanks, Space Technology and Applications International Forum, 1998, American Institute of Physics Conference Proceedings, 1998 4. SYNERGISTIC ACTIVITIES Serving in a newly established position with joint appointment to the Department of Electrical and Computer Engineering and the Geophysical Institute's Earth & Planetary Remote Sensing (EPRS) Group. Focus is on integrating existing academic and research efforts with UAF's Alaska Center for Unmanned Aircraft Systems Integration (ACUASI), leveraging opportunities for research into the characterization of volcanic plumes and wildfires, monitoring of glacial and sea ice, permafrost conditions, chemical sensors, forest biomass measurements, and arctic wildlife surveys. Academic emphasis includes study and development of UAV sensors and vehicles, and the application of these platforms in accomplishing remote sensing missions.

Dr. Keith W Cunningham

Mr. Samuel Vanderwaal

Mr. Eyal Saiset, University of Alaska Fairbanks

Unmanned Aircraft Systems (UAS) Applications in Arctic Remote Sensing as a Systems Engineering Design (SED) Tool for Student Learning

Michael Hatfield^{1,2}, Keith Cunningham^{1,3}, Samuel Vanderwaal¹, Eyal Saitet¹; University of Alaska Fairbanks (UAF) Geophysical Institute (GI) Alaska Center for Unmanned Aircraft Systems Integration (ACUASI)¹; UAF College of Engineering and Mines (CEM)²; UAF Scenarios Network for Alaska & Arctic Planning³

Abstract

There is need for strong partnership between pre-college Science, Technology, Engineering and Mathematics (STEM) programs and higher education that offers improved opportunities for developing our next generation STEM-related workforce. Our country is challenged by a lack of aerospace, electrical, mechanical, and computer engineering students, as well as high school and middle school STEM programs that often struggle to capture and connect students with opportunities in these fields. The health of our pre-college and higher education programs is linked, and neither can excel long term without support by the other. UAF has begun a holistic program to address deficiencies in both camps, using robotic vehicles like UAS as a primary means to achieve this.

Background

The University of Alaska Fairbanks (UAF) hosts the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI), a collaborative research program linking education in engineering, aviation, and remote sensing with real-world applications for geospatial data products collected by unmanned aircraft systems (UAS) ^[1]. As part of this mission, the center promotes STEM learning opportunities relevant to the burgeoning UAS field at high schools in Fairbanks and rural Alaska.

As a part of UAF and in partnership with the Federal Aviation Administration's (FAA) Pan Pacific Unmanned Aircraft Systems Test Range Complex, ACUASI is tasked with exploring the application of UAS to academic and scientific research, as well as evaluating the safety and practicality of operating practices needed to integrate unmanned aircraft into the National Airspace System. This construct provides an ideal opportunity to support the development of multidisciplinary engineering programs.

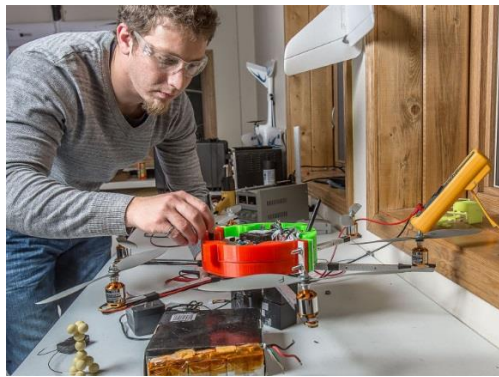
ACUASI was established in 2013 with a grant from the Alaska legislature. The center's mission is to promote the adoption of UAS technology, with the goal of spurring economic development by incorporating education and research into the real-world UAS applications already underway in Alaska. For over 13 years, UAF has been operating UAS in a variety of missions, ranging from public safety to supporting environmental research.

ACUASI's recently expanded education mission has funded a new, joint faculty position at UAF's Geophysical Institute (GI) and the College of Engineering and Mines (CEM) to teach UAS technology. The first classes took place during UAF's winter 2014 term; going forward, a foundation for UAS education and training has been established, and UAF has just approved plans for an undergraduate aerospace engineering minor beginning fall 2015. Faculty hired specifically for the center's STEM program are an integral part of the university's UAS technology courses.

Leveraging strong cooperation between ACUASI, CEM faculty and students, and GI research faculty and students, UAF has developed a synergistic methodology for simultaneously advancing capabilities in all areas. These include developing new UAS aerospace assets and sensors, accomplishing numerous arctic climate environmental monitoring missions previously not achievable via this means, and providing engineering students with valuable experience in aerospace technology. The combination of these factors has significantly benefitted all aspects of UAF's program, and has bolstered STEM opportunities for our local schools.

Through this partnership, numerous student-led/partnered initiatives have resulted in the development of sensors and systems to support the investigation of various arctic environmental phenomena, such as: 1) glacial/sea ice retreat and permafrost thawing; 2) detecting the presence of minerals in support of resource discovery and environmental remediation; 3) analyzing shoreline soil composition for coastal erosion studies; 4) sampling particulate matter in volcano or wildfire plumes; 5) surveying arctic land and marine wildlife; 6) providing new capability to monitor critical infrastructure; and 7) supporting state emergency management and law enforcement needs.

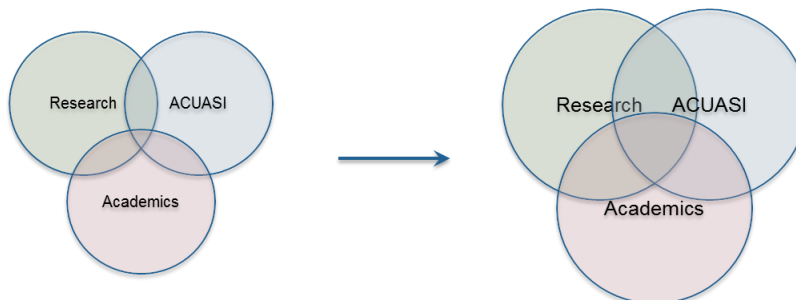
UAS systems developed through this teaming approach have greatly increased the ability of UAF to accomplish important arctic research, provide hands-on experience to our engineering and computer science students, and support STEM development in our local community.



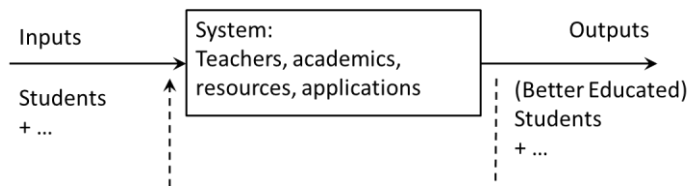
Construction of an early version multirotor at ACUASI

ACUASI Science & Education Focus

The focus of UAF/ACUASI's science and education partnership is to nurture and develop the integration of the university's UAS program with the GI's scientific research and CEM's academic program. By emphasizing shared interests of these entities, the program may be grown logically in a manner that supports the long term stability of each. In addition, this program also looks to provide opportunities and pathways to local STEM students.



Viewed from a system level, college engineering programs consist of an input (students), system (academics, resources, applications), and output (better educated/trained students).



Of course, one may also view other inputs as teachers, resources, and opportunities (+ ...) that feed into the program. All of these can be increased as a result of a successful program. Likewise, a vibrant program not only provides opportunities, such as jobs and further education to students, but also has the effect of growing the set of possible opportunities.

From this perspective, it is clear that all components must be considered in order to provide for the long term health and viability of the program. Colleges require robust STEM feeder programs to satisfy their constant need for technical students, as well as motivated high school and middle school teachers, knowledgeable of college opportunities who can inspire students to take advantage of these. Similarly, these students benefit immensely from having a program they can graduate to, which provides relevant opportunities and motivation for their hard work.

At UAF, synergy is accomplished through a combination of engineering and technical disciplines, along with aerospace assets (UAS, unmanned ground vehicles (UGV), or space systems) brought to bear on the solution of various remote sensing missions (environmental, infrastructure, disaster). The combined effect provides valuable opportunities and motivates students and faculty. Program success and public awareness provide increased interest and investment, resulting in additional opportunities.

Motivation

Given the right opportunities and modest resources, students can often tackle complex challenges in a fairly short period of time. This is particularly true when technology advances are made, opening up possibilities to apply that technology in new and exciting ways. We see dramatic examples of this around us all the time, and as educators, are continually challenged to re-scope the boundaries of what is achievable in the classroom and lab environment.

Student systems engineering design projects can be particularly noteworthy when given the synergistic combination of certain core elements: a challenging real-world mission with an identifiable user, an adequate, but not excessive amount of personnel and resources, an experienced mentor to guide the team and effort, and community awareness and support for the effort.

1. Challenging real-world mission. Students, like the rest of us, want to make a difference in their world. If they are going to buy-in to a project and give it their best efforts, they have to believe that they are tackling something worthwhile. Students don't want to be marginalized or left to work on 'story problems' until they have gained the 'requisite' skill set deemed necessary to tackle a project. The project may be related to technical accomplishment for its own sake, study of the environment, support a group of disadvantaged persons, or could be in support of critical infrastructure vital to our nation.

The project must be selected so that it may be completed by the group within the allotted period of time (generally a semester or two), but is challenging enough that the students will have to gel as a team in order to succeed. The project needs to have an intrinsic value that the students can believe in, and if possible, the students should have some choice in exact direction and scope of the project. Students need to understand not only the value of the project, but also the consequences of failure to the intended user or community. This provides the intrinsic motivation to the students (and instructor) to go the extra mile, as well as keeping the scope attainable, vice risk over reaching and failing to meet the project goals.

2. Adequate manpower and resources. Providing a challenging, yet attainable goal which maximizes student learning requires striking a critical balance with regards to resources. Resources include not only materials and funding, but also human capital, both in terms of student skill sets and their belief in their ability to achieve. Too few students or too few skill sets, and the project fails. Too few material resources and the project fails. On the other end of the spectrum, too many students can leave some unmotivated or break down the team. Too many material resources can result in simplistic solutions which don't challenge or motivate the students. A properly scoped project can be difficult to achieve and requires experience and judgment by the instructor. The end goal is to give the students just enough resources to make them work hard, be creative, and stretch their view of what is possible for them to accomplish.
3. Project mentor. The role of the instructor is vital, serving as subject matter expert in technical issues, mentoring the team in outlining possible approaches and risks, playing the role of group counselor when team personalities occasionally flare under pressure, and acting as advocate in securing necessary resources for the team. The instructor actively works to secure participation by the user throughout the project to ensure their needs are accurately captured and satisfied to the best of the team's ability within the constraints of time and resources available. In addition, the instructor takes steps to ensure the effort is documented and made known to the community of interest (the school, local community, or technical community, as appropriate).

When these elements are brought together in the right quantity and circumstances, students regularly surprise in their ability to create novel and well-thought solutions, often rivaling the quality of efforts seen in many research centers and small businesses. Through this process, it can be seen that the abilities of students are not something we wait until after graduation to bestow along with the degree, but an ever-improving capability we can and should leverage from the beginning.

UAF ACUASI Program

ACUASI's structure within the university is built upon this strategy and takes advantage of a mutually beneficial set of needs and capabilities. From a mission perspective, UAF researchers have need for ACUASI support to conduct their research in an effective, safe, and cost-efficient manner. In turn, as a lean university entity, ACUASI has need for affordable engineering support to satisfy these missions. Finally, UAF engineering students have need for meaningful projects and some nominal amount of material support. Each of these entities are complemented by and support the others, to the benefit of all. Finally, the success of these programs and an active STEM outreach program at UAF provide a strong link to our community, ensuring a continuous level of students and community support.

UAF's STEM program emphasizes the many facets and varied applications of UAS technologies. Beyond conventional aircraft systems, UAS also incorporate sensors to autonomously collect mission-specific data – a search-and-rescue drone, for example, may incorporate an infrared video camera.

Another key part of the “system” includes the two-way data communications required to pilot the aircraft, operate its sensors, and maintain the situational awareness needed for safe flight.

The data collected by UAS is typically used in two ways. First, real-time data from live video supports piloting and data-collection. Post-flight, data is processed and analyzed in such a way as to create geospatial products like image mosaics and three-dimensional surface models. These products can then be used to support research in fields such as biology, engineering, ecology, and many other areas of interest to scientists, professionals, and students alike. In these efforts, engineering students and faculty work hand-in-hand with scientific researchers and their students, building important bridges between the communities developing technology and those utilizing it.

An important component of this strategy is ACUASI’s ability to test a wide variety of sensors and integrate them into UAS platforms quickly in order to respond to academic and scientific research proposals. This approach has been applied to the development of aircraft such as the ACUASI Ptarmigan, an electric powered hexacopter which utilizes commercial-off-the-shelf components, combined with custom parts to create a modular, open architecture system. This gives ACUASI the ability to integrate sensors onto a platform without requiring vendor support to overcome proprietary, locked down systems, enabling a wide variety of remote sensing missions to be accomplished with a minimum of lead time and cost to research partners.

The Ptarmigan is a six-rotor platform capable of lifting over 1.5 kg payload, with a flight time approaching 30 minutes, depending upon payload and wind conditions. The Ptarmigan is based on the DJI S900 airframe and 3-D Robotics open-source autopilot (currently APM 4.2). The backbone of this system is a control board that communicates commands between the autopilot and the aircraft motor, landing gear, laser altimeter, and other payloads that may communicate directly with the autopilot in the future. By virtue of the open architecture design, this configuration also readily supports student involvement in development of system/sensor capabilities.

Examples of sensors integrated into the Ptarmigan hexacopter include: 1) a hyperspectral camera which supports analysis of numerous arctic environmental phenomena, such as vegetation health and regrowth after wildfires, presence of minerals in support of resource discovery and oil spill cleanup, and shoreline soil composition for coastal erosion studies; 2) multiple instruments designed to sample particulate matter for volcano and wildfire plumes (optical particle, impact drum sensor, and IR technologies); 3) IR cameras for survey of arctic land and marine wildlife, volcano and wildfire footprints, and monitoring critical oil pipeline/processing infrastructure; and 4) single and multiple camera configurations to precisely measure structural size of vegetation, and create digital elevation models of glacial and sea ice, roads, buildings, etc.



ACUASI Ptarmigan hexacopter

Sensors and payload components have been developed for other fixed-wing and rotary wing aircraft, including a methane sensor for sniffing gas leaks and numerous camera gimbal components and protective casings for camera payloads. Of note, all of these payloads have been developed or integrated by UAF students. One set of these has formed a university spin-off company to pursue commercial interests while finishing their education and supporting UAF UAS project development.

Student Engagement

ACUASI student engagement takes numerous forms. As UAF's educational effort has just begun, this initial phase has focused on building awareness between students, academic and research faculty, and ACUASI members. This framework has resulted in numerous opportunities for research with UAF's scientific community and engagement of students within the College of Engineering and Mines, both at the graduate and undergraduate levels. In addition, these programs and resources have provided valuable opportunities to engage the state's STEM population.

High School STEM and UAF

While our country places a high value on a technology, we have received mixed reviews on how well we are keeping pace with the international community with regard to STEM productivity. According to the 2014-2015 World Economic Forum (WEF) Global Competitiveness Report (GCR), the US currently ranks 35/144 countries surveyed, with respect to the Quality of primary education, and 51/144 in terms of Quality of math and science education for higher education and training ^[2]. Also, the 2012 Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) ranks the US as being 27th and 20th of 34 member countries in mathematics and science, respectively ^[3].

While UAF is primarily a research institution, its members broadly recognize that a strong STEM program is a vital component to the continued success of the university and our nation. As part of this vision, the university is working hard to achieve a stable and robust college UAS and aerospace program. The program's initial efforts have included building awareness of the UAS program, and educating research faculty on how they could become involved in the university's STEM outreach.

UAF is a committed partner in STEM education for our local K-12 programs, both in our cities and in the outlying rural communities. This takes the form of embedded UAS support within some local high schools, STEM competitions within the local community such as For Inspiration and Recognition of Science and Technology (FIRST) robotics, and science fairs in our local schools^[4].

As one example, the ACUASI program is teamed with a local high school, where graduate students in electrical engineering, computer engineering, and computer science mentor the high school STEM robotics class in UAS/UGV design and control system implementation. In this program, graduate students interact directly with high school students, supporting the teacher for some phases of the program and leading lectures and hands-on activities in later phases. The graduate students are in turn supported by undergraduate students, who help prepare lab materials and lesson plans.

In addition to the UAS program's STEM program, UAF has received a separate line of STEM funding to teach basic UAS operations in Alaska Native Villages.

Modern Blanket Toss. The Modern Blanket Toss is a STEM program administered by Alaska Upward Bound and the National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) program^[5]. The program teaches UAS technology at rural Alaska high schools, and primarily focuses upon mapping and monitoring in the vicinity of native villages. The term “blanket toss” comes from an Eskimo tradition of tossing a hunter into the air in order to scout distant game. Like the person being tossed, a UAS provides a higher, broader perspective of their community.

The Blanket Toss STEM program began in the spring of 2014 with \$750,000 in funding spanning three years. Students from the native villages attend Upward Bound classes at the UAF campus during the summer and learn to operate UAS at the Poker Flat Research Range. Later, during the academic year, students take part in UAS-centered learning activities structured into a "Challenge Series" that builds on a series of skills related to UAS operations and technologies.

In addition to promoting STEM learning, Modern Blanket Toss will develop mapping products that can be used in community projects, like monitoring coastal erosion. Students in the Upward Bound program are also encouraged to continue their educations at UAF; this may be an important means of promoting STEM education among underserved Alaska Native students.

Alaska Summer Research Academy. Each summer, the Alaska Summer Research Academy (ASRA) engages middle school and high school students in STEM opportunities^[6]. In 2015, the two-week summer academy will provide offerings in UAS, with a special focus on constructing vehicles and programming flight controls for unmanned blimps. This program involves UAF engineering faculty and students, as well as students in the scientific community as mentors and facilitators for the event. The topic selected for this year’s ASRA program was a direct result of outreach between UAF and local high schools and middle schools in the area, and coordination between ACUASI and the State of Alaska public K-12 school administrators.

Undergraduate STEM and UAF

Undergraduates are regularly exposed to UAS technology in variety of classes. These include programs in geography, geology, forestry, biology, and engineering, among others. This outreach is primarily conducted by faculty affiliated with the ACUASI mission.

Senior Design. Engineering students at UAF are required to take a senior design course that involves supervised team or individual research. In one such effort, a team consisting of one graduate electrical engineer and three mechanical engineers designed an IR camera payload with a color-wheel filter mechanism for a UAS allowing the study and characterization of volcanic plumes and wildfires.

Another team of graduating students tackled the development of a specialized UAS sensor that samples aerosols, such as ash from a fire. Last semester three seniors, two in electrical engineering and another in mechanical engineering, integrated this sensor onto a UAS for study of wildfires and volcanic plumes, as well as measurements of air quality and various pollutants. This sensor is being tested this spring for applicability in measuring airborne residue from various ordnance.

An additional project involved the design of a backpackable UAS to support front-line wildlands firefighters. As part of a senior design course, students interacted with members of Alaska’s wildlands firefighting community to understand their mission requirements and develop the preliminary design for a system that could be deployed with firefighting teams as a tactical asset, or be used as a sensor in building more accurate in situ pictures and assessments of wildfire behavior.

Individual Study. Several undergraduates have participated in individual studies that incorporate UAS technologies. Most of these studies have explored various geospatial data products that can be generated from UAS data, particularly still-frame images. This has included student research into digital ortho-mosaic products, as well as three-dimensional surface models generated from highly overlapping images.

One undergraduate student has assisted research faculty in building a business case for employing UAS to promote ecotourism. This particular student is a biology major with an interest in wildlife management. The research overlaps significantly with the UAF Cooperative Extension, which specializes in rural economic development.

Aerospace Engineering Minor. Our country is in need of aerospace engineers, based upon a confluence of factors, including previous cuts to the aerospace industry, the growth of international competition in secondary education (with resultant decrease in students coming to the US for an education and then staying), and the graying of our current aerospace workforce. Department of Labor projections predict an aerospace growth rate of over 7% for the period 2012-2022 ^[7]. Roughly 80% of the aerospace workforce is between the ages of 40-65 and over the next 20 years many are retiring or going to other industries. In addition, according to the Association for Unmanned Vehicle Systems International's (AUVSI) *Economic Impact of Unmanned Aircraft Systems Integration in the United States (March 2013)*, the UAS sector is expected to add 100,000 jobs and \$82B to our national economy by 2025. Alaska's share of the pie is projected to be 141 jobs and \$112M ^[8].

Formalizing a minor in aerospace engineering leverages the interest by students and the community in aeronautics and space systems engineering, including very popular UAS and UGVs. This minor will provide increased ability for UAF engineers to highlight their work in a critical engineering field, and will elevate the status of UAF in the aerospace community. The program will ensure a constant and growing stream of students for academics and research affiliated with UAF aerospace efforts, such as Alaska Space Grant Program (ASGP) and ACUASI. The undergraduate aerospace engineering minor is seen as the first step to an eventual degree granting program.

Graduate STEM at UAF

Graduate school participation in UAF's emergent UAS program has been an anchor point to the overall effort, with subsequent growth and focus occurring at the undergraduate level and HS/MS STEM programs. To date, graduate school participation in UAF's emergent UAS academic program has largely been in the area of providing project support to ACUASI efforts. As was previously mentioned, the two organizations naturally complement one another, with graduate students benefitting from meaningful projects and material support, and ACUASI increasing its organizational capability through an augmented workforce.

CEM Aerospace program. While UAF's UAS-centric engineering academic program has only existed for just over a year, it is quickly gaining traction within the student and faculty communities. Beyond the new aerospace minor and flavor this technology has brought to some undergraduate courses, UAF's graduate curriculum has also benefitted from this new emphasis area.

Starting fall 2014 semester, UAF began offering its first UAS-centric course in UAS Systems Engineering Design (SED). This course was an opportunity to offer graduate students (and some seniors) an experience in the understanding and design of UAS. Students learned about the systems engineering design process, as well as UAS subsystems functions and design considerations. In

addition, students formed small teams to complete a dissection and analysis of an existing UAS, then shared team briefings with the rest of the class. In this way, the students not only learned academic principles, but also gained a broad appreciation for UAS systems across the spectrum of science, hobby, commercial, and military uses.

As has been the general case with all of our efforts, this course was intended to be tightly integrated with ongoing operations and assets at ACUASI. Many of the missions and assets discussed in class were from ACUASI's wealth of experience. Some of the UAS systems analyzed in the case studies were systems ACUASI was considering for future purchase. The end result was a huge success. The class was very popular, drawing in virtually all eligible electrical engineering graduate students, as well as some students from outside the university.

As a result of student demand, during fall 2015 semester UAF will offer another UAS course for graduate (and selected undergraduate) students – this one focused on building up UAS platforms and sensors. As before, this course will be designed to both leverage and support ACUASI needs, developing platforms and sensor suites to accomplish upcoming missions. This course will serve as a springboard for developing a number of synergistic graduate projects in support of ACUASI needs and UAF's research community.

Outcomes

As a result of the combined efforts of UAF and ACUASI in providing new opportunities and leveraging the popularity of UAS (commonly referred to as unmanned air vehicles (UAV) or drones) in the news, we have seen a significant increase in interest at all levels, from our university graduate and undergraduate programs, down to local K-12 STEM students, parents, and administrators.

Graduate student participation. With the offering of UAS courses, graduate student participation and interest has peaked. Our first offering of a UAS course last fall recorded an all-time enrollment (over 2x the average), including a couple individuals from the local community that enrolled in the university for the sole purpose of taking this course. The course, which focused on the analysis and design of various UAS systems, was deemed a huge success, as measured by both enrollment and by student end-of-course critique comments. Our next graduate course to be offered in the fall focuses on building a UAS for accomplishing a local research mission. This has already had exceptional interest by both graduate students and seniors in the undergraduate engineering program.

In addition to academic course enrollment, several new graduate students have recently approached ACUASI regarding potential graduate projects. Since implementing the integrated approach to academics and research with UAS, graduate student involvement has soared by 500% in less than two years. Furthermore, this program has proven beneficial in providing a test bed of technology for other faculty to focus their own research outlets.

Aerospace engineering minor. Much progress has been made since the writing of the initial manuscript. Just last month, UAF leadership approved instituting a new minor in aerospace engineering, which will be a part of the university curriculum beginning fall 2015. Already, numerous students currently in mechanical and electrical engineering have expressed interest in enrolling in the new minor.

Technical conferences. As a result of the focused effort between UAF's Geophysical Institute, College of Engineering and Mines, and ACUASI over the last 18 months, participation in professional organizations and technical conferences has soared. Students and faculty have been successful in

submitting several science and engineering journal articles, conference proceedings, and numerous poster sessions for organizations such as the American Institute for Aeronautics and Astronautics (AIAA), the International Society for Electrical and Electronics Engineers (IEEE), the American Society of Engineering Educators (ASEE), and the American Geophysical Union (AGU).

STEM & Public Affairs. UAF's UAS program has been very popular with local K-12 students, parents, school teachers and administration. A recent UAF CEM outreach and recruiting event prominently featured several ACUASI aircraft, sensors, and 3-D printed components. The UAS display also included hands-on interactive stations, including a steerable video camera and infrared camera used on several ACUASI aircraft. This year's event was a huge success with the community, setting a new attendance record. This success was largely credited to the great publicity given the event, and inclusion of UAS assets. In addition, several recent news media interviews have focused on UAF's ACUASI programs, bringing valuable awareness of these opportunities to our community.

Summary

This integrated program has greatly increased the ability of UAF to accomplish important arctic research, provide hands-on experience to our engineering and computer science students, and support STEM development in our local community. By exploiting the utility and popularity of UAS/UGV systems, UAF stands poised to strengthen our state's education system and aerospace industry.

From a more global perspective, this program provides an example of what may be achieved when integrating popular new technology with engineering academics and real-world scientific/public safety needs. By harnessing our students' interest in the possibilities of this new technology and shaping academic curriculum around it, we can capture their attention at a critical age and have a better chance at keeping them motivated to excel academically at a challenging time in their lives.

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