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UAS Curriculum for Students Using an Active Learning Approach

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Abstract

Unmanned aircraft systems (UAS) offer an exciting opportunity to teach students about basic principles of aerospace engineering and instill valuable systems engineering design experience. The widespread popularity of UAS, an explosion of affordable and capable systems, and recent advances in policy by the FAA have created a permissive climate where these may be effectively used by students as either a new means to conduct scientific research or as the primary focus of a systems engineering design project. Whether a means or an end, UAS-based projects and courses provide stimulating and relevant learning opportunities many students are seeking today.

The University of Alaska Fairbanks (UAF) has broadly embraced the concept of active learning, supporting various initiatives to more effectively engage students, such as “flipped” classrooms where students take a more active role and responsibility for their education. In engineering, the university is proactively infusing UAS and aerospace materials into the curriculum, developing numerous aerospace courses and research opportunities for seniors/graduate students. UAF has also initiated a popular new aerospace engineering minor and has seen explosive growth in its new student chapter of the American Institute of Aeronautics and Aeronautics.

This paper discusses the implementation of one course at UAF which leads students though the process of analyzing the effects of subsystem design approaches and system trades impacting UAS overall performance and operational viability. The paper describes learning objectives, construction, activities, and lessons learned, as well as how this course fits into UAF’s academic and research efforts. It also outlines complementary activities offering students UAS-centric aerospace experience and briefly touches upon efforts to push related STEM opportunities down to local high school and middle school students.

Introduction

UAS Systems Design is a new multidisciplinary course intended to give students valuable experience in the field of UAS and aerospace engineering. Students are expected to: 1) conduct a systems analysis of UAS to include the air vehicle platform and sensors, ground station, and supporting infrastructure; 2) comprehend the complex interaction and interdependencies of UAS subsystems; 3) understand mission operational planning considerations such as flight planning and data requirements planning; and 4) demonstrate the ability to clearly and concisely communicate a UAS mission analysis in both written and oral form. In addition, due to student feedback from its inaugural offering, this second offering of the course included the design, construction, and flight of an actual UAS in support of a selected remote sensing mission.

While this 1-semester course was originally intended as a graduate class, its overwhelming popularity has resulted in it also being offered to seniors at UAF and now via video link to our sister campus in Anchorage (UAA). Structure of the course is intended to maximize the role of students in educating themselves and others through investigation, exploration, discussion, and hands-on activities. In addition to a limited number of traditional instructor lectures, students take an active role in their own education through a variety of means: 1) individual students lead discussions of topics relating to various UAS systems and aerospace fundamentals; 2) 2-person teams analyze an approved UAS (personal, commercial, or government) and provide a series of mini class briefings and papers detailing the design choices for subsystems and their effects on the overall UAS; and 3) small teams of 3-5 students design, build, and fly a UAS (quadcopter or hexacopter) to accomplish a small remote-sensing mission and discuss results.

Background

UAF's Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) serves as a collaborative research center linking education in engineering, aviation, and remote sensing with real-world applications for geospatial/science data products collected by UAS. As an integral part of UAF and in partnership with the Federal Aviation Administration's (FAA) Pan-Pacific UAS Test Range Complex (PPUTRC), 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 UAS into the National Airspace System (NAS). This construct provides an ideal opportunity to support the development of multidisciplinary engineering programs targeted to solve pressing real-world issues.

Leveraging the shared expertise and interests of ACUASI, UAF's engineering faculty and students, and its Geophysical Institute research faculty and students, the university has developed a synergistic approach for advancing capabilities in all areas. This focus has enabled UAF to simultaneously develop new UAS aerospace assets and sensors, accomplish numerous arctic climate environmental monitoring missions not previously achievable, and provide engineering students with valuable practical experience in aerospace systems engineering design.

UAF has instituted several educational activities supporting development of our local aerospace infrastructure. These include the incorporation of multiple new UAS/aerospace academic courses, implementation of several research projects for undergraduate and graduate students, and creating a new aerospace engineering minor (beginning AY2015-2016). Each of these efforts has proven popular with students and has brought positive awareness to UAF programs.

Motivation

As is broadly reflected in societal trends, UAF is also experiencing a huge increase in demand for UAS-related courses, training, and activities. UAS are currently in demand within virtually all sectors of society – federal, state, and local agencies, industry, small business, and entrepreneurs – all have growing interest in the application of UAS to their missions. For students and our education system, the impacts are obvious. Similar to yesteryear's information revolution which saw computers and cellphones move from a technical curiosity to a disruptive technology, and eventually to a mandate for participation in business and everyday life, there is now a growing expectation for students to possess some level of exposure to or awareness of UAS platforms, capabilities, and applications. Students understand this and they want on board.

Courses Implemented

To provide students with a foundational exposure to UAS/aerospace design principles while operating within the fiscal realities of a small developing program, UAF has instituted an initial modest 2-course sequence. These courses provide an opportunity for graduate and undergraduate students to gain valuable experience with UAS platforms, capabilities, and missions, as well as practical experience with the FAA's UAS flight regulations. The course also allows students to participate in design projects based upon real-world needs. The courses are designed so that they may be taken in either order, based upon student enrollment and program needs.

The first course, *UAS Systems Design*, is somewhat more foundational and theoretical in nature, providing basics of UAS subsystem technology and operations, insights into design choices and effects of subsystem trades, knowledge of popular UAS platform capabilities (past and present), and an awareness of UAS in use today. In addition, the course offers a limited exposure to building and flying relatively simple multi-rotor UAS. The second course, *Aerospace Systems Engineering*, is much more project-oriented, with a focus on learning the systems engineering design process (SEDP) in-depth and experiencing the realistic and challenging environment generally associated with team dynamics. These skills are then applied to design, build, and fly a complex UAS/sensor suite satisfying real-world operational requirements for UAF's ACUASI. This complementary course will be discussed briefly later in the paper.

UAS Systems Design

Overview. *UAS Systems Design* involves the investigation of UAS technologies and their impact on the design of existing UAS platforms. In this graduate/undergraduate level course, students conduct a systems analysis of a UAS, to include the unmanned air vehicle (UAV) platform and sensors, ground station, and supporting infrastructure. Focus of the course is for students to comprehend the complex interaction and interdependencies of UAS systems and understand mission operational planning considerations, such as flight planning and data requirements planning. As part of the course, students form small teams (generally 2-persons) to conduct the investigation of an existing UAS platform and general mission sets, and then provide a series of papers and class presentations on their findings. In addition, each student takes lead in delivering a classroom instruction module for a particular course topic.

Improvements. This course proved a huge success in its initial offering (fall 2014) and has been subsequently modified to accommodate its popularity and the desires of students. This year, student teams had the opportunity to apply the principles learned by building a simple multirotor UAS to conduct representative missions. After verifying a successful design and build, students also received some basic flight experience by piloting their UAS. In addition, the course was, for the first time, offered via video link to students at the University of Alaska Anchorage (UAA). This new paradigm was a huge success and proved of great interest in developing future courses, especially with respect to the hands-on UAS build and flight operations.

Organization. The course consisted of a mix of learning methodologies, with limited traditional classroom lectures provided by the instructor. Of the 43 course periods, 23 were dedicated to lectures, 2 to exams, 12 to small team UAS investigation and briefings, and 6 to team activities in building and flying a UAS. Lecture periods included both traditional instructor lectures, as well as a series of student-led discussions (generally lasting ½ period each). The textbook selected for this offering of *UAS Systems Design* and its complementary course, *Aerospace Systems Engineering*, was Designing Unmanned Aircraft Systems (2^{nd} Ed) by Jay Gundlach (AIAA Publishing, 2014).

The course outline is given below, with details of each major component provided in the discussion following.

UAS Systems Design Syllabus

Meeting	Date	Chapter	Topic	Assignments/Notes
1	August 29 Monday	1	L1: Course Admin; Overview	
2	August 31 Wednesday	1	L2: History of UAVs	
3	September 2 Friday	15	L3: Current Missions	
	September 5 Monday	Labor Day		
4	September 7 Wednesday		L4: Research at UAF, Intro to ACUASI	
5	September 9 Friday		A1: Visit ACUASI	
6	September 12 Monday		P1: Project Discussion	
7	September 14 Wednesday	2,12,15	L5: Classes of UAVs & Missions	
8	September 16 Friday	2,12,15	L6: HALE/MALE UAVs	Student Briefing 1
9	September 19 Monday	2,12,15	L7: µUAVs	Student Briefing 2
10	September 21 Wednesday	15,16	L8: UAV Systems	
11	September 23 Friday	19	L9: UAV Systems Trades	Student Briefing 3
12	September 26 Monday	5	L10: Basic Aerodynamics	Student Briefing 4
13	September 28 Wednesday	5,6	L11: Static & Dynamic Performance	Student Briefing 5
14	September 30 Friday	10	L12: Controls & Autopilots	Student Briefing 6
15	October 3 Monday		P2: Project Work	Student Briefing 7
16	October 5 Wednesday	8	L13: Propulsion Systems	Student Briefing 8
17	October 7 Friday	7	L14: Loads & Structures	Student Briefing 9
18	October 10 Monday		P3: Project Review 1	
19	October 12 Wednesday		P4: Project Review 1	
20	October 14 Friday		P5: Project Review 1	
21	October 17 Monday		L15: Electrical Systems	Student Briefing 10 Student Briefing 11
22	October 19 Wednesday		E1: Exam 1 (Midterm)	
23	October 21 Friday		L16: Mission Planning Considerations	Student Briefing 12
24	October 24 Monday		L17: Flight Planning, Data Collection	Student Briefing 13
25	October 26		L18: Ground Control Systems	Student Briefing 14

	Wednesday			
26	October 28 Friday		L19: Communications, Data Links	Student Briefing 15
27	October 31 Monday		L20: Payloads	Student Briefing 16
28	November 2 Wednesday		L21: Launch & Recovery Systems	Student Briefing 17
29	November 4 Friday		P6: Project Review 2	
30	November 7 Monday		P7: Project Review 2	
31	November 9 Wednesday		P8: Project Review 2	
	November 11 Friday	No Class		
32	November 14 Monday		A2: UAS Workshop – Introduction	
33	November 16 Wednesday		A3: UAS Workshop – Build	
34	November 18 Friday		A4: UAS Workshop – Build	
35	November 21 Monday		A5: UAS Workshop – Build/Test	
36	November 23 Wednesday		A6: UAS Workshop – Flights	UAF Location UAA Location
	November 25 Friday	Thanksgiving Break		
37	November 28 Monday		Review of UAS Workshop/Flight P9: Project Work	
38	November 30 Wednesday		L22: Makeup briefings	Student Briefing 18 Student Briefing 19
39	December 2 Friday		P10: Project Briefings & Reports	
40	December 5 Monday		P11: Project Briefings & Reports	
41	December 7 Wednesday		P12: Project Briefings & Reports	
42	December 9 Friday		L23: Course Wrap-up Course Surveys – bring laptop	
43	December 14 Wednesday		E2: Final Exam (10:15-12:15)	

43 Course Meetings = 23 Lectures (L) + 2 Exams (E) + 12 Project Days (P) + 6 Activity Days (A)

Student Discussion Topics

At the beginning of the semester, students submitted their top 4 choices for topics based upon the syllabus. Topics were meant to either directly address course topics or to complement these with case studies or topics of general interest. Students were responsible for conducting research on the topic, formulating an outline and briefing slides, and then presenting the materials to the class and leading a facilitated discussion. The instructor selected the topics based on relevance and the spectrum of student interests, and then worked with each student to ensure they were prepared for their presentation. Students submitted an initial outline shortly after topic approval, and then submitted draft slides in advance of the final presentation.

Objectives of this element included: Organizing and planning; communication (with instructor during planning, and with class during the presentation); facilitating lesson planning and group discussion; performing investigation to become expert in the selected topic; gaining a broad understanding of the other UAS topics through the presentations, and learning other techniques for speaking and teaching. Assessment was part of the Instructor Points for the course (10%).

Discussion topics for the 19 students included: Ground Control Stations; Loads & Structures; Aerodynamics; Fixed-Wing UAS Rapid Prototyping; Propulsion Systems; UAS Autonomy; Miniature UAS; UAS Command & Control; Electrical Systems; High Altitude Long Endurance (HALE)/Medium Altitude Long Endurance (MALE) UAS; Communications Systems; Sensors & Payloads; Systems Trades; Flight Planning & Data Collection; UAS Controls & Autopilots; UAS Energy Harvesting; Launch & Recovery Systems; Global Internet; and UAS Command & Control (C2) Security.

UAS Projects
At the beginning of the semester, students organized into 2-person teams (self-organized). Each team submitted their top 4 choices of UAS they wanted to study. The instructor reviewed the proposals and selected the best UAS for each team in order deconflict choices and ensure a wide spread of UAS types and capabilities (eg, fixed-wing vs rotary-wing, large commercial/military vs consumer Small UAS (sUAS), HALE/MALE vs (Micro Air Vehicle) MAV, super/hypersonic vs balloon/dirigible, exotic technologies or configurations). Throughout the semester, each team investigated their UAS and provided a series of 3 briefings to the class. In addition, teams provided a formal report to the instructor at the end of the semester (drafts submitted in conjunction with team briefings).

Objectives of this element included: Communication skills (written and oral); teamwork and planning necessary to tackle the multitude of subsystems and topics required; incorporating feedback from previous submissions. Assessments include 3 sets of papers and briefings:

- Report/Briefing 1 Topics: UAS Description, Missions, Performance Characteristics, Systems Trades, Airframe/Structures, Propulsion, AC Controls
- Report/Briefing 2 Topics: Computer/Controls, Electrical, Communications/Data Link, Payloads, Launch/Recovery Systems, Ground Station/Mission Planning
- Final Report/Briefing Topics: Comprehensive – all previous topics + Lessons Learned & Recommendations on UAS (shortfalls, improvements, applications)

All 3 briefings were graded. The first 2 reports were considered mandatory drafts – these were not graded, but provided opportunities for feedback prior to final report submission.

The 19 students were organized into 10 teams between the 2 campuses. Each team consisted of 2 members, with the exception of 1 carry-over team which had a single person (this was due both the individual student preference and breadth of topic selected). A good cross section of UAS types were examined by the teams, providing some measure of breadth to their experience.

<u>sUAS.</u> Study of these vehicles exposed the students to a small, but representative sample from the large and growing class of popular consumer/prosumer UAS that they are likely to encounter in the future. Small UAS investigated by the teams are shown in Figure 1.

Figure 1: DJI Phantom 4, Trimble UX5 HP

HALE/MALE UAS. Study of these platforms provided students with examples of work being accomplished in the area of highly efficient aerodynamic structures, materials, coatings, propulsion systems, and payloads. HALE/MALE UAS investigated by the teams are shown in Figure 2.

Figure 2: (clockwise beginning at upper left) Scaled Composites Proteus, Northrop-Grumman Global Hawk, General Atomics AltAir, Airbus Zephyr

Non-traditional configurations. Study of these assets exposed students to some examples of emergent technology and new UAS configurations taking advantage of these. Specific UAS investigated by the teams are shown in Figure 3.

Figure 3: (clockwise beginning at upper left) Raytheon Coyote, Martin UAV V-Bat, Arcturus Jump20, Urban Aeronautics Air Mule

Note that providing these academic reviews have also had the operational benefit of building a library of UAS and sensor information for ACUASI personnel to utilize for reference purposes.

UAS Workshop

Near the end of the semester, students were provided an opportunity to build, integrate, test, and fly a multirotor UAS. This occurred in a structured workshop environment which spanned a (nearly) 2 week period. Students formed teams of 4-5 to tackle the effort (self-organized). At UAF, 13 students formed 2 teams of 4 students each to build and fly DJI F450 quadcopters, and 1 team of 5 students to build a DJI F550 hexacopter. At UAA, a single team of 5 students built and flew a DJI F550.

Workshop agenda:

- Lesson 1: Overview. View completed example. Examine parts. Review provided instructions and on-line references. Formulate team plan.
- Lessons 2-3: Build UAS, integrate GoPro camera, begin testing.
- Lesson 4: Motor test, test radio controller, flight test UAS.
- Lesson 5: Conduct flight test of UAS.

Results. UAF flew all 3 UAS, with students getting the opportunity to personally 'fly' the UAS with a limited control tether, which allowed them to control the UAS roll/pitch/yaw commands, while the instructor pilot maintained control of motor commands and could override the student if necessary. Both UAF F450 quadcopters flew successfully for all students. The UAF F550 hexacopter also flew, but not all students were able to pilot the UAS as it eventually crashed due to lost rotor blade. (This is a known issue with the UAS motor design and precautions were taken, but unfortunately did not prevent this occurrence.) UAA was unable to fly as one motor was bad, and not discovered in time to secure another. Instead, the team was able to fly a commercial UAS (DJI Inspire) to achieve their UAS flight goal. Pictures of the teams building and flying their UAS are shown in Figures 4-5.

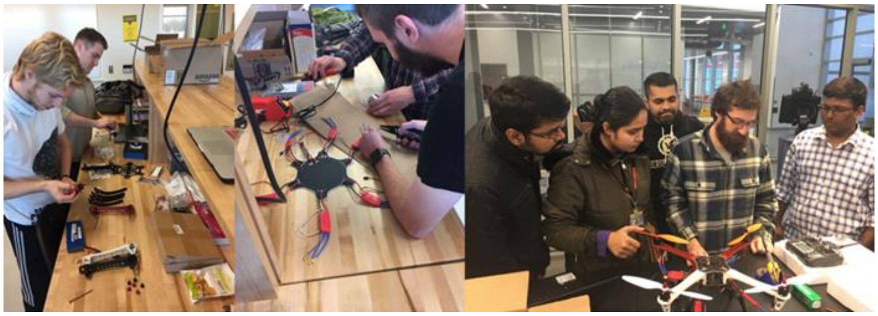

Figure 4. UAS Systems Design UAS Build workshop.

Figure 5. UAS Systems Design UAS Flight activity.

Lessons Learned

Overall, the course was a huge success, both locally at UAF and for the section offered remotely at UAA. Feedback from students was very positive with few complaints. Some of the lessons learned captured by the instructor, with inputs from students, are noted below:

- Schedule. The larger student population (19 this semester vs 11 the previous offering) made the schedule more challenging. This forced more days to present the 3 sets of UAS briefings and kept briefings shorter (3 days each set of briefings + 1 overflow briefing to another day). To accommodate this increase, it was necessary to truncate the number of lectures from the initial offering. It also cut into the days available for the UAS workshop.

- Student topics. This activity was rated as highly rewarding by students. Most of the students (undergraduate and many graduate) had not yet had an opportunity in their academic career to organize and lead a classroom discussion. Feedback from students was overwhelmingly positive. Students appreciated the opportunity to work through the process of organizing and leading a facilitated discussion and noted the boost in confidence this activity provided them for general public speaking skills. Students also noted value in the expectation that they were to provide questions of other student presentations. Students liked having the limits of a 30-minute period for the presentation and Q&A with a buffer for the instructor to fill in any needed materials or expand discussion.

- UAS Papers and Briefings. This activity was also rated as worthwhile by students. Students noted that their briefing skills and writing skills increased from participation in this effort. However, particularly with the larger classes, it may be worth reorganizing to reduce the number of briefings from 3 to 2 in the future, as this puts a time strain on other elements of the course which could have benefitted from additional time (such as the UAS Workshop). While eliminating one briefing would diminish the opportunity for students to apply what they've learned previously, it is expected that the impact to learning objectives could be lessened through the use of feedback mechanisms and careful instructor oversight.

- UAS Workshop. This was a new topic based upon previous course feedback (fall 2014). Student feedback was universally positive with this event being considered the most worthwhile (or at least the most fun). Many of the students had never had an opportunity to fly a UAS and all but a couple had never built any UAS or components. The biggest comment across the board was that we could have used a couple more days for the effort as the students were rushed and did not get an opportunity to fly/learn/fly again. It was also noted that we could make improvements in the quality of design instructions and supplementary UAS flight control software and materials, and how these are distributed to students.

- Video distance learning. This was a new teaching technique applied to this course. Based on student feedback and instructor impressions, this technique was deemed highly successful. For the most part, classroom interactions felt natural with the remote students participating equally within the extended classroom environment. It is likely that the subgroup environment on both ends aided significantly to student interaction, whereas it might have felt less natural with individual students dialed in. Some intermittent technical problems with video equipment made presentations difficult at times but did not take away from course overall. The UAS Workshop aspect of the course was made challenging by the remote section, requiring special coordination for design/build/fly facilities and travel by instructors/assistants for oversight. This would be lessened by having lab spaces with the same smart classroom connectivity in the future.

- Course content. While students had overwhelmingly positive feedback for the course content overall, many did note that this overview course was not able (and not designed to) tackle in-depth subsystem designs. However, many also indicated a desire to take follow on courses that would provide this detailed design experience. In addition, several students expressed interest in learning more about the systems engineering design process (SEDP) and tradeoff studies (the subject for the complementary course, *Aerospace Systems Engineering*).

Aerospace Systems Engineering

The complementary course in the series, *Aerospace Systems Engineering*, incorporates the application of UAS SEDP to satisfy operational needs of the ACUASI and associated research mission requirements. This is a multidisciplinary course structured for participation by both graduate and undergraduate students. This course is intended to provide students practical experience in aerospace engineering, and specifically provide new opportunities to learn about UAS (or traditional aeronautics or space systems design projects). Students learn first-hand about systems acquisition and the SEDP by forming a mock ‘company’ to solve a problem posed in the form of a contracting Statement of Work (SoW). The company forms its own organizational structure, schedule, and plan of attack for satisfying the SoW requirements.

The specific goals of last year’s course (fall 2015) were to retrofit an existing Lockheed Martin Stalker airframe with all new subsystems, including propulsion, electrical, communications, autopilot, and sensor packages. The operational requirements for the platform were intended to stretch capabilities of the original production aircraft, supporting a 2-kg payload for a flight duration of 2 hours and 1-kg payload for 4 hours. The team also leveraged numerous shared subsystem components to build out a DJI S900 hexacopter frame in order to increase ACUASI existing flight capabilities. Instead of an experimental ‘one-off’ design, each of these systems is considered to be the first airframe of a fleet of UAS to support operational mission requirements for ACUASI and UAF researchers. Steps highlighting design and construction of these UAS are shown in Figures 6-7.

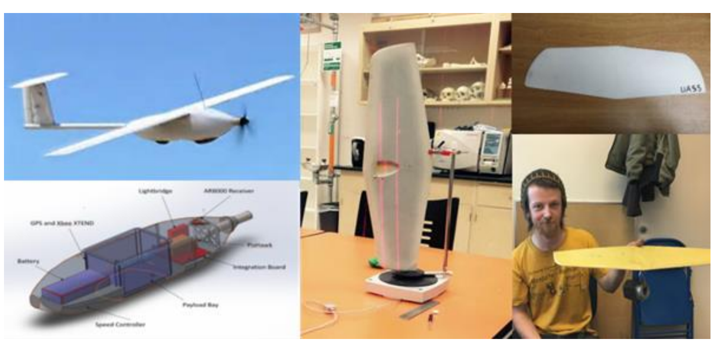

Figure 6. Aerospace Systems Engineering Lockheed Martin Stalker, Open Stalker fuselage design, vertical stabilizer.

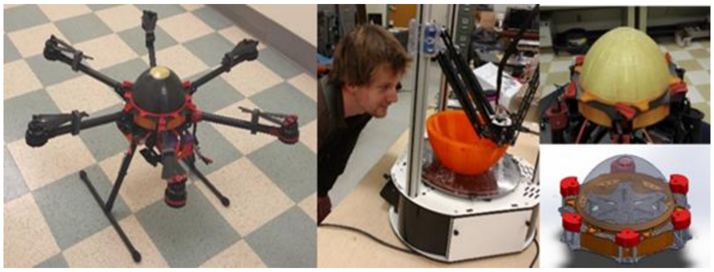

Figure 7. Aerospace Systems Engineering S900 vehicle #1, electronics bay design.

The next scheduled offering of *Aerospace Systems Engineering* will be fall 2017. Several potential project ideas are being considered, including development of an additional S1000 octocopter for UAF/ACUASI research and operations, or building a different fixed-wing electric motor aircraft. In addition, several payload suites are being considered, including a deployable pod for delivery of essential supplies to emergency responders, and a remote housing assembly to protect UAS from the harsh environmental conditions and deploy when needed. In addition, the course is being offered for simultaneous video link delivery to a section at UAA.

Complementary UAF Activities

Beyond traditional academic courses and classroom activities, student learning takes place in other forums such as graduate thesis projects and senior design projects. UAF graduate students had leveraged previous UAS course experiences and ACUASI research needs to develop several new UAS/sensor capabilities. UAF's operations/research/academics focus cultivates symbiotic organizational relationships to ensure this occurs. Some examples of graduate/senior UAS projects being used for operations/research include: the ACUASI's Ptarmigan hexacopter workhorse UAS, differential GPS payload, dual-camera precision photogrammetry package, atmospheric particulate matter sampler, and a lidar/laser UAS control system for indoor flight.

In addition, club activities and assets provide exciting new opportunities for students to learn UAS/aerospace principles outside of the classroom environment. These include UAS and robotics efforts being tackled by individual students and in support of club activities.

<u>AIAA Student Chapter.</u> UAF recently chartered a student chapter of the American Institute of Aeronautics and Astronautics (AIAA). Active since AY2015-2016, the AIAA student chapter participated in the AY2015-2016 Design/Build/Fly (DBF) competition with an extremely competitive design, making it just short of the final flight competition (Figure 8).

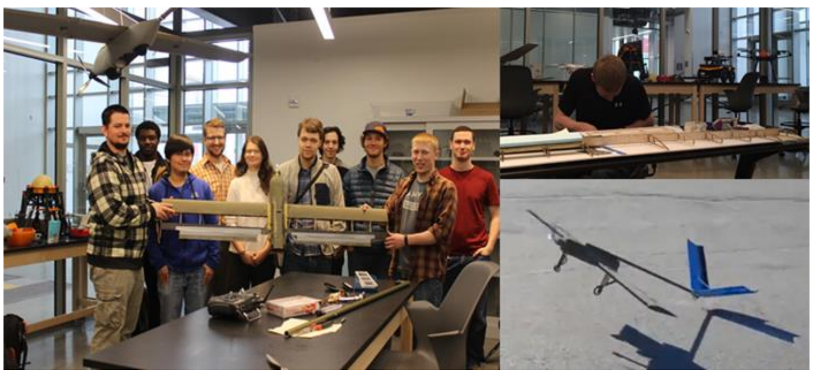

Figure 8. AY2015-2016 AIAA Club Design/Build/Fly effort

This year, the team reorganized to tackle the AY2016-2017 DBF challenge. Construction and flight test of the team's tube-stored UAS design is complete, and as of the writing of this paper, the DBF competition is underway. UAF's AIAA DBF team and prototype are shown in Figure 9.

Figure 9: AY2016-2017 AIAA Club Design/Build/Fly effort

Organic Fixed Wing Capability. Within the past 2 years, UAF has developed a significant in-house capability to build fixed-wing UAS. Stemming from its Fall 2015 *Aerospace Engineering Systems* course and AIAA DBF efforts, students have been rapidly expanding UAF's ability to construct various wing planforms and other components (fuselage, empennage…). The success of these projects and availability of design tools is bringing additional students to the program. Examples of this technology are shown in Figures 10-11.

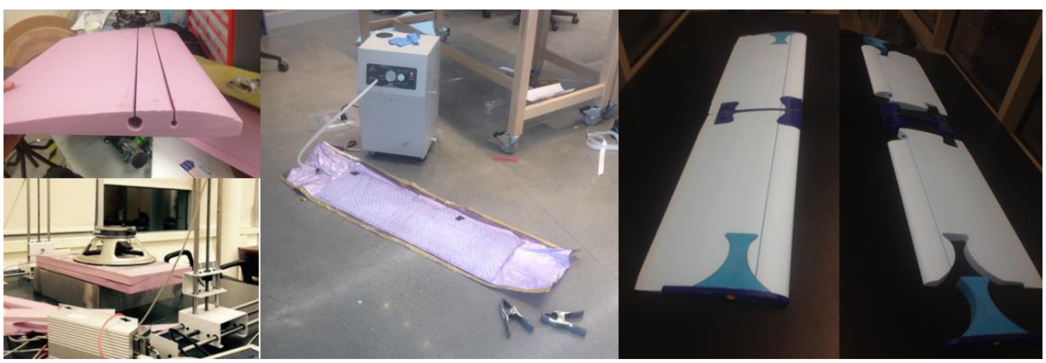

Figure 10: Foam core wing construction at UAF

Figure 11: UAF fixed-wing assets and components

STEM Activities
UAF is very active in STEM development and recruiting efforts. A couple noteworthy examples include the UAF's Upward Bound program and Modern Blanket Toss UAS project serving Alaska villages and native population, as well the Alaska Summer Research Academy (ASRA) providing opportunities for local high school and middle school students to participate in STEM-related activities. In addition, UAF is involved in developing several future activities, including a proposed effort to coordinate educational opportunities for K-12 teachers from across the state, as well as UAS competitions, such as popular drone racing events.

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. The program teaches UAS technology at rural Alaska high schools, and primarily focuses upon mapping and monitoring near native villages. The term "blanket toss" comes from an Eskimo tradition of tossing a hunter into the air 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. During the academic year, students take part in UAF-led learning activities structured into a "Challenge Series" that builds on a series of skills related to UAS operations and technologies. Blanket Toss students, mentors, and UAS projects are shown in Figure 12.

Figure 12. Students with a simple scale model of a workable UAS quadcopter using K'nex parts, Student explaining design to mentor, final design using 3D printed components

Alaska Summer Research Academy (ASRA). Each summer, UAF's ASRA engages middle school and high school students in STEM opportunities. In 2015 and 2016, the two-week summer academy provided offerings in UAS, with a special focus on constructing vehicles and programming flight controls for unmanned blimps. This program involved UAF engineering faculty and students, as well as students in the scientific community as mentors and facilitators for the event. This topic 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. Samples of the ASRA Mini-Blimp UAS are shown in Figure 13.

Figure 13. Example individual project C2 module, individual project mini-blimp, team mini-blimp in final ASRA outbrief

Student Impact

On an individual course level, the *UAS Systems Design* course appears to have had significant positive impact on numerous students. In surveys taken before the course, students indicated a strong perception that the course would better prepare them for the workforce or for graduate studies, and post-course surveys indicated a strong perception that the course had succeeded in meeting those expectations. Of the 13 (graduate & undergraduate) students taking the course locally at UAF, 7 responding to the formal web-based evaluation rated the course as being highly effective in helping them achieve their expectations (5 strongly agreed, 1 agreed, 1 neutral). Unfortunately, the university system did not allow UAA to participate in the web-based survey.

From an overall program perspective, this course is one piece of a vibrant and growing program. Students are displaying high levels of enthusiasm for UAS-related courses and are asking for increased opportunities to become involved earlier in their education. UAF has witnessed exponential levels of participation in aerospace and robotics design teams and projects. The university has also seen much increased interest by potential students considering attending UAF. In addition, there is increasing call for UAS-related technical training – new courses and certificate programs are currently being formed at UAF's Community and Technical College. And across the University of Alaska, UAS opportunities have increased collaboration between faculty, departments, and campuses in coordinating programs supporting aerospace education.

Summary

This paper focused on how one academic course, *UAS System Design*, is helping to provide students at UAF with valuable UAS/aerospace experience. This course is not only of value in preparing students for the expectations of tomorrow's workforce, but also is helping to form the basis of UAF's growing aerospace program, including academic courses, arctic research efforts, and student clubs. These courses and capabilities can be used as a valuable recruitment tool for prospective UAF students, and to motivate our youth to maintain a STEM focus in school.

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