Low-cost Fixed-wing Construction Techniques for UAS Curriculum

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

Michael C. Hatfield is an assistant professor in the Department of Electrical and Computer Engineering at the University of Alaska Fairbanks, and Associate Director for Science & Education, Alaska Center for Unmanned Aircraft Systems Integration. He earned a B.S. in electrical engineering from Ohio Northern University; an M.S. in electrical engineering from California State University Fresno, and a Ph.D. in Electrical/Aeronautical Engineering from the University of Alaska Fairbanks.

Dr. Catherine F. Cahill, University of Alaska, Fairbanks

Dr. Catherine F. Cahill serves as the Director of the Alaska Center for Unmanned Aircraft Systems Integration – RDT&E (ACUASI) at the University of Alaska Fairbanks (UAF) and the CEO of the Pan-Pacific UAS Test Range Complex. For more than 30 years Cathy has conducted research on atmospheric aerosols and their impacts on visibility, global climate, and human health including the size and composition of particulate matter entering the Arctic from Asia and the sources and potential health impacts on U.S. forces of atmospheric aerosols in Iraq and Afghanistan. Since 2006, Cathy has collaborated with the UAF UAS program and worked on developing unmanned aircraft-based sensors for determining the concentration, composition, and spatial distribution of atmospheric aerosols. In August 2015, Cathy completed a nineteen-month Congressional Fellowship with the U.S. Senate Committee on Energy and Natural Resources and returned to UAF to join ACUASI's leadership team.

Dr. John Monahan, University of Alaska, Fairbanks

John Monahan is currently the Director of University of Alaska Fairbanks, Upward Bound and Principal Investigator of the National Science Foundations EPSCoR Track 3 "Modern Blanket Toss" project investigating the use of Unmanned Aerial Vehicles in K12 classrooms.

Low-Cost Fixed-Wing Construction Techniques for UAS Curriculum

Abstract.
Unmanned aircraft systems (UAS) offer an exciting platform to teach students about basic principles of aerospace engineering and the systems engineering design process, and to utilize these for investigation of important scientific phenomena. The widespread popularity of UAS, the emergence of affordable and capable systems, and recent advances in policy by the Federal Aviation Administration (FAA) have created a permissive climate where these may be effectively used by students as a means by which to conduct scientific research or may serve as the focus of a systems engineering design project in their own right. UAS-based projects and hands-on courses provide stimulating and relevant learning opportunities many students are seeking today.

While rapid prototyping is commonly used in making components for widely popular rotary-wing UAS (generally in the form of 3D printed components), similar technology may be brought to bear on the design and fabrication of somewhat more complex fixed-wing aircraft. In addition to 3D printing, the efficient design of fixed-wing UAS often requires the use of composite materials, larger sizes, complex geometries, and novel fabrication techniques. Additional challenges include the need for precise control of weight and balance, control surfaces, and desired flying qualities throughout the range of flight regimes for fixed-wing UAS.

This paper describes efforts being employed within University of Alaska Fairbanks (UAF) courses, student research activities and clubs to further the design and construction techniques used in fixed-wing UAS assets, and how these assets will support UAF's research portfolio. It also briefly outlines existing efforts and potential future activities to offer UAS-related STEM opportunities to local high school and middle school students.

Introduction.
Rapid prototyping provides students an invaluable opportunity to both 'think big', exploring new innovative design concepts and construction techniques, and then to hone their skills by optimizing 'tried and true' designs and processes. By providing forums for students to explore 'revolutionary' and 'disruptive' design practices with minimal constraints and negative consequences, we encourage creative thinking and innovative solutions. Complementing this with opportunities for students to replicate existing aircraft designs and with minimal modifications and construction techniques, we allow them to refine the science and the art of the possible and to perhaps make these processes even more effective and efficient.

This approach has been applied to the development of fixed-wing UAS at UAF's Alaska Center for Unmanned Aircraft Systems Integration (ACUASI). While UAF seeks to eventually develop an organic capability for constructing fixed-wing UAS of various shapes and sizes supporting a multitude of flight envelopes, as a first step, the same processes may be applied on a smaller scale to the repair or replacement of components for existing UAS assets.

Background.
UAF's ACUASI serves as lead range for one of 7 FAA national test sites chartered with exploring the application of UAS to academic and scientific research, as well as evaluating safety considerations and operating practices in order to integrate UAS into the National Airspace Space (NAS). To meet these needs rapidly and efficiently, ACUASI must integrate a wide variety of sensors onto UAS platforms in support of arctic research and public service projects. Often, unique mission requirements can also dictate the need for development of specific UAS components and platforms to satisfy necessary

payload and flight performance characteristics.

Central is the ability to rapidly create low-cost flight hardware utilizing 3D printing and composite layup techniques. To support the abbreviated fielding cycles often associated with arctic research and public safety missions, ACUASI requires a practical means of creating UAS components for rotary-wing and fixed-wing platforms. While rapid prototyping is commonly used in making components for widely popular rotary-wing UAS, much of this same technology may be harnessed and brought to bear on the design and fabrication of more complicated fixed-wing aircraft in order to satisfy a broader set of mission flight envelopes and payload requirements.

Motivation.
The desire for UAF to develop an organic fixed-wing UAS capability is motivated by several factors. From an academic perspective, students learn and develop best by doing. Students are most motivated when working on real-world projects and popular technology. Rapid prototyping serves as an enabler to these, as this provides students with a valuable tool to deliver rapid solutions with relatively little overhead and cost risk. This allows students the flexibility to explore and innovate without the burden of huge resource investments, impacts of failure, and fear of failure. It also allows them to opportunity to hone their skills and fine-tune proven designs, and to develop repeatable, sustainable processes.

From a research and operations standpoint, UAF's ACUASI holds broad-ranging scientific and public service responsibilities to local, state, and national agencies. Support of these assets and programs is paramount to the health of ACUASI and UAF, and requires support of numerous UAS/payload sets. Yet, as is to be expected with any university program, funding and personnel within ACUASI is necessarily lean. Finding fast, reliable, and inexpensive solutions to dynamic and varied mission requirements is essential. Rapid prototyping enables student and staff to work together to quickly solve problems with a minimum of resources and expense. In addition, this provides ACUASI with a viable route to develop flight-worthy components and UAS through a risk-managed process.

Finally, rapid prototyping provides university students and faculty an ability to create valuable 3D models and prototypes representing current research and activities for display, generating interest by prospective students and the local community. It also serves as a catalyst in providing low-cost and relevant STEM opportunities to local K-12 students.

UAS Selection and Operational Significance.
UAS selection was based on a number of factors: 1) Effort satisfies real-world requirements; 2) UAS systems in inventory/available; 3) Size and complexity of components requiring repair/replacement; 4) Likely operational requirement for UAS asset and support from ACUASI; 5) Facilities, equipment, and materials required for design and construction of UAS components; 6) Opportunities to provide student opportunities through academic courses, research projects, student club activities, and grant stipends; and 7) Student availability, motivation, and skill levels. Matching these has been a vital and ongoing aspect of the effort, especially in this initial phase of the program.

The Lockheed Martin Stalker was ultimately selected as an initial testbed as it represents a desirable capability gap in the current inventory in terms of flight envelope, speed, range, flight endurance, and payloads supported (2 lb payload for 2 hrs). ACUASI already possessed several assorted Stalker airframe components; however, these were gifted to UAF after having exceeded their intended design lifetime and most were no longer considered flight worthy. Only enough airframe components existed to reconstruct a single UAS, while a minimum of 2 sets are required for a system to be deemed flight operational and capable of supporting missions.

However, as the second system only lacked a simple unibody vertical stabilizer component, this was deemed a reasonable undertaking for the amount of investment required and was therefore selected as a suitable first item for investigation. It also represented a credible crawl/walk/run path to incrementally develop airframe design and construction skills and which would eventually yield an organic fixed-wing UAS production capability at UAF. Starting with a relatively simple component, students could learn with experience, gradually gaining confidence in their abilities and processes, eventually tackling more difficult/complex components and UAS.

In addition to the Stalker UAS, ACUASI also possesses various other legacy fixed-wing assets, including the AeroVironment Puma and Raven UAS. Likewise, these assets, while capable and proven, had also reached their effective end-of-life due to parts shortages. It was envisioned that the same processes to be developed in pursuit of ACUASI's Open Stalker research platform might also be applied to restoring the original or improved flight and payload capabilities for these assets. After individual components were repaired/replaced, these could undergo suitability testing. Then through the process of iterative design/build/test, these assets may be refined, proven, and perhaps eventually adopted to provide an enhanced operational capability for ACUASI. These assets are shown below in Figure 1.

Figure 1: (Left to Right) Lockheed Martin Stalker, AeroVironment Puma, AeroVironment Raven

By selecting an existing operational UAS for repair and study, ACUASI is able to chart a logical path for technology development and flight certification purposes. Using a 'crawl, walk, run' approach, ACUASI may incrementally develop technical expertise, first gaining basic skills in repairing existing components, then refining techniques necessary to build replacement components, and over time gaining the requisite knowledge and skills to build an entire UAS from scratch. In this way, students may methodically develop practical approaches for creating reliable, cost-efficient fixed-wing aircraft. The center is also able to systematically add levels of increased capability and flexibility in design, while cautiously balancing technical innovation with risk reduction for its operational fleet.

Successful outcomes in the university's UAS program subsequently result in additional UAS assets, material resources, and opportunities for students. Initial successes have resulted in further material support of senior/graduate design classes. In addition, students participating in design efforts often receive opportunities for follow-on graduate research support or employment.

Student Opportunities and Benefits.

Students can benefit both from participation in a range of UAS courses, research, and activities that all employ rapid prototyping tools to a varying degree. Some focus more on 'evolutionary' progress in more established design methodologies, while other activities emphasize 'revolutionary' or 'out of the box' designs to optimize a particular approach to satisfying a design challenge.

Courses and research. UAF provides several opportunities for students to participate in UAS-centric projects as part of senior/graduate design courses. In most of these, students are provided a significant opportunity to design, build, and fly UAS which required application of at least some rapid prototyping technology/process. In many of these courses, the main focus is on the development and production of a relatively major UAS system requiring significant prototyping (eg, 3D printing, composite work with fiberglass/Kevlar, CNC hot-wire shaping, or machine-shop work). Graduate research projects also generally require extensive amounts of rapid prototyping and modeling. Often, the focus of these efforts in on 'evolutionary' or incremental improvements of more traditional design methodologies.

Student clubs. Student clubs, such as the American Institute of Aeronautics and Astronautics (AIAA) student chapter, provide another venue for students to become familiar with UAS design and rapid prototyping. These efforts are generally of a 'high-stakes' or 'revolutionary' nature, exposing students to challenging design projects in which particular performance characteristics must be highly optimized (eg, AIAA Design/Build/Fly competition), or facilitate the use of radically different construction techniques (eg, balsa wood ribs reinforced with carbon fiber tape, or mylar wing surfaces). Exposure to these efforts can provide invaluable learning which the student can then apply to later design projects. By practicing these techniques over time, in a less optimized and competitive environment, these techniques can lead to breakthroughs in practical UAS design methodology.

Both sets of design experiences are valuable, contributing to the experience levels and skill sets of students. With sufficient practice and experience, these skills allow students to build practical, low-cost UAS supporting a wide range of payload and flight envelope requirements. These can be matured and standardized to form a fleet of reliable, inexpensive UAS capable of satisfying numerous operational missions. What's more, students are central to all aspects of the UAS lifecycle process, from mission inception through UAS development to mission accomplishment. Such experience is invaluable to providing students with key components of a quality UAS education and training program: mission requirements analysis, UAS design, flight operations, and data product generation. In addition, such a program is effective in generating student interest and support by industry and the local community.

Open Stalker Example.

The Open Stalker effort began with constructing a suitable replacement for the vertical stabilizer in order to achieve 2 complete UAS systems. Initially, the strategy was to attempt the construction of a component of identical size and shape. As a first step, the component was measured using a 2D lidar scanner, which would then be used to cut polystyrene foam via a computer numerical control (CNC) hotwire cutter. Unfortunately, this approach proved problematic as the wing possessed a deceptively complex shape that was difficult to model and fabricate. In addition, manpower for the project was quite limited. The airframe design team consisted primarily of two mechanical engineering students (one undergraduate and one graduate) who are authors on this paper, with occasional augmentation by other students for specific tasks. Instead, using successive approximations, a series of more simple 'functional equivalent' prototypes were constructed. Analysis of the production vertical stabilizer and subsequent prototypes are shown in Figure 2.

Figure 2: (Left to Right) Stalker vertical stabilizer analysis, early prototype strength testing, final prototype

This simplified process proved a success for the Open Stalker project and as a first step in developing an organic fixed-wing production capability. The relatively simple shape of the vertical stabilizer served as the initial building block to wring out the processes needed to shape the foam core segments and develop a workable process for the various wing shapes subsequently selected for Open Stalker. The knowledge gained through this process has also been fundamental to other UAF projects, including the AY2015-2016 and AY2016-2017 AIAA DBF projects.

Applying their initial experiences with component design, the team quickly abandoned the original concept of making replica parts as a first step and shifted to the longer-term strategy of designing a fixed-wing UAS from scratch based on desired performance requirements and utilizing the tools and materials on hand. Figure 3 shows the transformation of fuselage design based on experience gained as processes capabilities and limitations became better known.

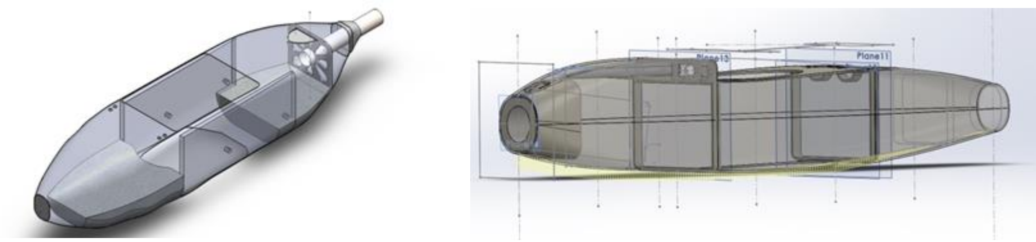

Figure 3: (Left to Right) Design of Open Stalker fuselage

Not only did the initial design experience reveal the need to modify processes based on design and manufacturing knowledge gained, but also strongly hinted at a need for team members to learn first-hand about flying qualities by building some low fidelity models and learning practical lessons from trial and error. Early models were constructed using crudely shaped components fashioned by hand from scrap materials. Figure 4 shows early glider design and construction performed by the team.

Figure 4: (Left to Right) Early glider construction from foam scraps, initial model

In parallel with this project, one of the authors had been experimenting extensively with processes for constructing wing planforms. Figure 5 below shows one example of the wing shapes he was able to craft by hand using insulation foam and a handheld CNC hotwire wand. Practice in honing this skill proved essential in constructing the example below. However, this method requires a high degree of craftsmanship and is labor intensive, generally proving impractical for purposes other than initial prototyping and one-off designs.

Figure 5: Early hand-shaped wing prototype

A CNC hotwire machine was used to construct wing segments. Initial segments were generated manually using a hotwire and sheet metal/aluminum end templates, however, the CNC process proved superior for minimizing human labor and manufacturing errors. Some of the earlier wing shaping efforts are show in Figures 6 & 7 below. From this experience, much experience was gained through trial and error in CNC hotwire settings (speed, temperature) for various cuts.

Figure 6: (Left to Right) Wing templates, wing section, wing section being cut, resultant wing shape

Figure 7: Wing side view with spar and electrical routing cutouts

In addition, much experience was gained by the team in the art and science of 3D printing. 3D printed components were necessary to join polystyrene foam wing segments due to the limited span length. Spans were limited to 3-4 ft maximum for practical purposes due to the size of the existing CNC jig and due to increased variability introduced if the wire were to be longer. In optimizing component strength-to-weight, several infill methodologies were investigated. Figures 8 & 9 below show examples of early infill methodologies and a more efficient 3D infill component using a hexagonal fill pattern. This methodology was adopted for several subsequent components, including the fuselage design.

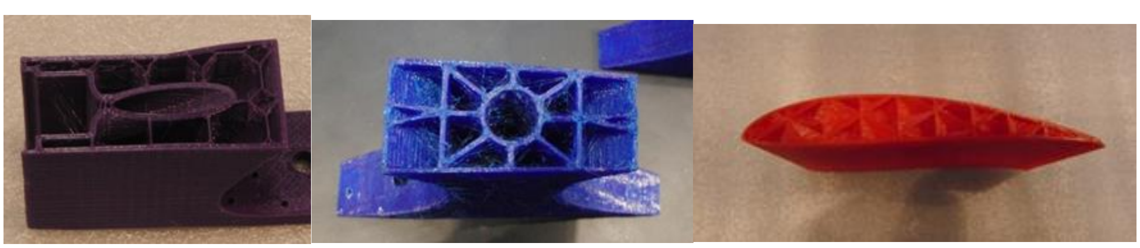

Figure 8: (Left to Right) 2D infill, 3D drawn infill, 3D hexagonal infill

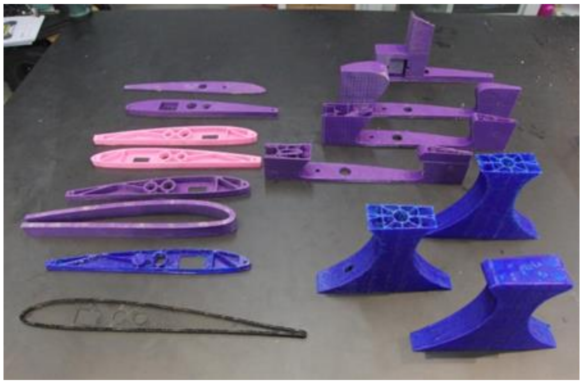

Figure 9: 3D printed components for Open Stalker

Methods were also developed to create several other components, such as wing spars and the empennage spine. Early wing spars were constructed using polystyrene cores with Kevlar wrapping. The process resembled wrapping sushi in seaweed wraps. Eventually, the performance of the product proved insufficient versus commercially available composite tubing. Figure 10 shows the construction of home-made wing spars.

Figure 10: (Left to Right) Cutting spar Kevlar sheet, wrapping foam core, final wrapping

Once all wing segment components were fabricated, these were integrated to form wing segments, which were then joined using a combination of wing spars and 3D printed components, depending upon the particular strength requirements and component sizes available for the application. Figure 11 below shows a 2-section foam wing segment with 3D printed connectors.

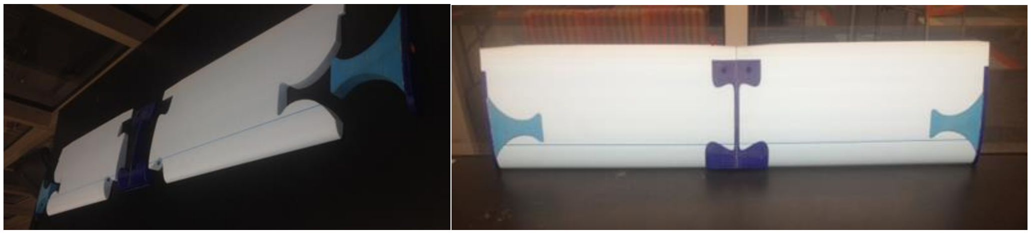

Figure 11: (Left to Right) Wing sections and fasteners, 2-section wing segment

After the segments are assembled, these were wrapped with fiberglass material and epoxied, with carbon graphite stiffeners added where necessary, and then sandwiched with Kevlar material to form the final wing sections. Assemblies were epoxied and vacuum bagged until cured (approximately 12-18 hours, depending upon the size and shape of the segment). Figures 12 & 13 below show stages of the wing assembly layup and vacuum bagging process.

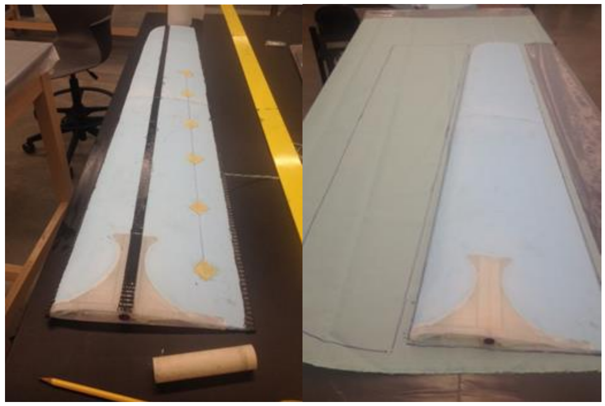

Figure 12: (Left to Right) Wing section with carbon stiffener and fiberglass covering, Kevlar templates

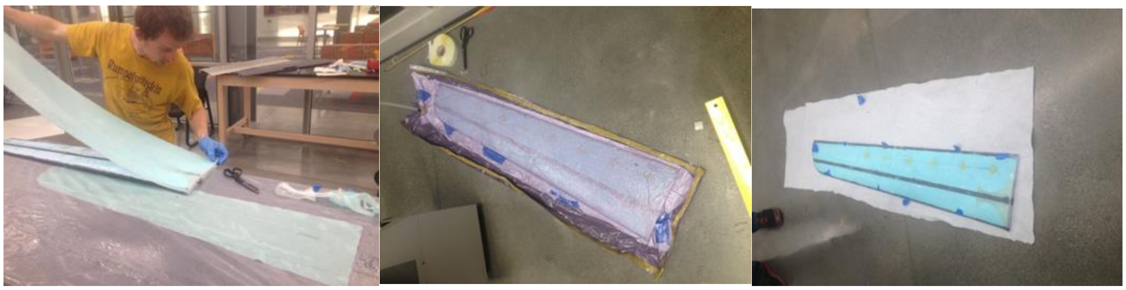

Figure 13: (Left to Right) Adhering wing core to Kevlar, vacuum bagged section curing, section ready to open

The empennage spine was formed in a multistage process using Kevlar and a PVC pipe as a form. One layer of Kevlar was epoxied and vacuum bagged. When cured, the segment was carefully sliced along the axis of the PVC pipe and the Kevlar removed. This was then wrapped with additional layers and again vacuumed. The result was very lightweight and rigid. Figure 14 below shows construction of a prototype empennage section.

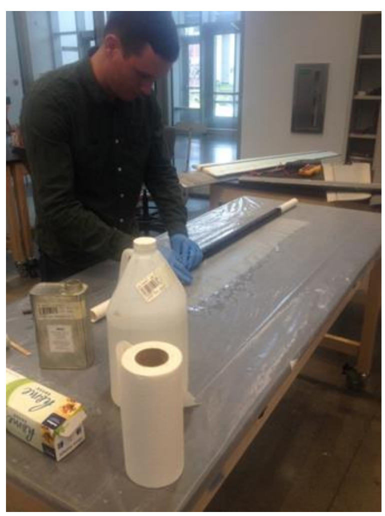

Figure 14: Building empennage spine

The final design of the resultant UAS has been captured in CAD files and sets of processes, including details for designing and constructing specific UAS modular components and connectors. These form the basis of an efficient, repeatable process for constructing multiple copies of the Open Stalker and various fixed-wing UAS. Sample CAD files for the Open Stalker effort are shown below in Figure 15.

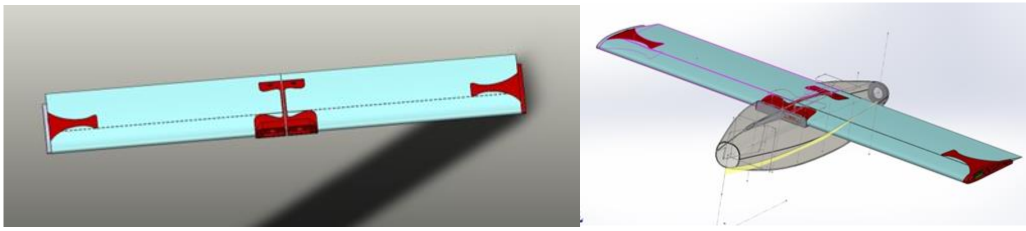

Figure 15: (Left to Right) CAD design of resultant wing design, wing section with fuselage

With initial articles available for all airframe components, the team proceeded with integration and bench test of the first Open Stalker. Integration consisted of mounting the motor, flight batteries, and communications hardware. Bench test consisted of static weight and balance checks versus predicted and systems checks for proper operations of motor and servos. Figure 16 shows sparse infill design used on the fuselage section and assembly of the Open Stalker for test.

Figure 16: (Left to Right) Cylindrical 3D infill sections, Open Stalker 3D infill fuselage and empennage

The first prototype Open Stalker UAS made its maiden flight earlier this year just prior to the first draft of this article (February 2017). Figure 17 below shows assembly and flight of the Open Stalker.

Figure 17: (Left to Right) Assembling Open Stalker, Open Stalker in flight

The UAS flew for approximately 45 seconds prior to crashing. The crash was attributed to changes in the wing from the original size and shape, as well as changes in the weight and balance of the fuselage and empennage sections. In addition, the UAS was not yet tuned to optimize servo actuation and account for disturbances such as wind gusts. At this time, the result is believed to be low static margin combined with a lack of control authority for flight conditions.

While not a pure success from a flight test perspective, the prototype did meet its goal of demonstrating the feasibility of the process and serves as a crucial step in developing the final system. Failures modes of the UAS were very favorable, requiring only replacement of the fuselage. No damage sustained to the wings, with the exception of the wing spars which are easily replaced. With the documented processes in place, the next prototype is expected to be ready in short order.

Lessons Learned/Future Efforts.

Lessons Learned. Overall, the message is resoundingly positive. We have made significant progress over the past year. Taken individually, many of the process achievements may seem small, but in concert these represent vital steps in developing an organic fixed-wing UAS design capability. The team has proven rapid prototyping to be an effective method for quickly designing, constructing, testing, and flying UAS. The relatively short production timeline and cost effective processes have enabled an environment conducive to student experimentation and learning. Students are able to 'learn by doing' vice previously constrictive production methodologies. Many successes were earned via hard-fought experience with missteps in early process attempts.

Some components have proved good targets for organic production, including the wing planform surfaces, numerous wing section connectors, and fuselage section. These are generally components with larger dimensions and limited quantities which would otherwise prove too expensive and timely to produce using conventional methods or via outsourcing. However, other components were found to be better served through purchase of relatively economic commercial stock. These components tend to be characterized as having generally standardized sizes which are more readily available, such as the smaller cylindrical wing spars. In these cases, while the process of fabricating suitable components may have been instructive, often times the time spent did not justify the cost of simply purchasing stock.

From an overarching UAS capability perspective, the program has been enormously successful. The goal of our first phase was to simply explore rapid prototyping processes and to demonstrate the feasibility of a set of these which could produce a usable UAS quickly and with low material cost. While initial process investigation and design iterations took much time, once the learning curve was tackled, the team was able to quickly converge on a set of processes and designs that achieve our objectives. Getting a first prototype into the air was an important step in the overall process and for the subsequent design evolution which can now take place.

Next steps. The next phase of the UAS design process includes several objectives. The first of these is to complete construction of the next version of the Open Stalker UAS (v2) and conduct flight test. Compared to the previous phase objectives of '*Can we do this*?', this next phase is intended to move toward more scientific quantitative approach of '*Now, how do we do it well*?'. As we begin to fine tune the design and construction techniques, focus will be on vehicle weight & balance and controllability. After the design is proven, we intend to create an initial small fleet consisting of 2-4 UAS for initial operations and suitability testing, with the end goal of producing a fleet of UAS supporting flight operations. We also will branch out from the initial design, extending the baseline UAS to other platform sizes and shapes based on the modular design approach (eg, various size fuselage and wings).

Future Outlook. The work accomplished to date by this small team of students has produced enormous results for our programs across the board. Academic design courses and individual student projects in aerospace, mechanical, and electrical engineering are benefitting by including these technologies and capabilities. In addition, this has enabled students to participate in design team activities such as the AIAA Design, Build, Fly competition. This has had the positive effect of energizing students at the university clamoring for aerospace experience and opportunities, and has been a primary attraction for new students considering UAF. This has also directly resulted in several STEM feeder program opportunities at UAF and in the local community.

Complementary UAF Activities
Beyond the efforts highlighted above with the Open Stalker project, the design experience and construction processes learned have had a positive impact on other UAF student projects and efforts. This includes traditional academic courses and classroom activities, as well as graduate thesis projects and senior design projects, and UAF design clubs.

AIAA Student Chapter. 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 18).

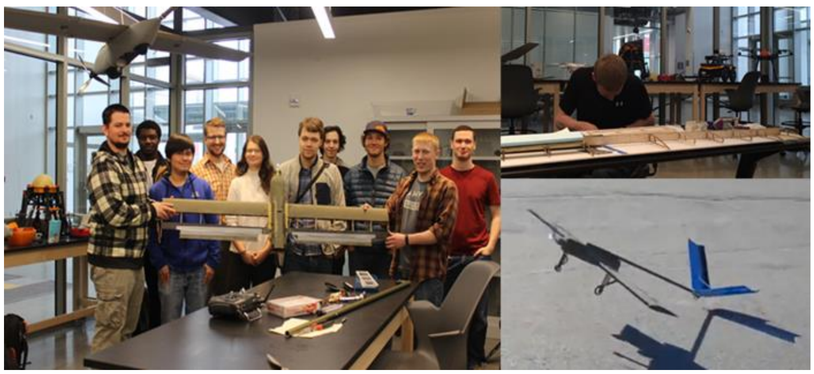

Figure 18. AY2015-2016 AIAA Club Design/Build/Fly effort

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 19.

Figure 19: AY2016-2017 AIAA Club Design/Build/Fly effort

STEM Activities.
UAF is very active in STEM development and recruiting efforts. A couple noteworthy examples include the university'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 high school and middle school students from across the state to participate in STEM-related activities. To date, these activities have been centered around rotary-wing UAS, predominantly

using less complex 3D printing fabrication techniques. However, we plan to eventually integrate simple techniques that may be adapted for K-12 students to design and construct fixed-wing UAS. 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 the popular drone racing.

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 UAS-centered learning activities structured into a "Challenge Series" that builds on a series of skills related to UAS operations and technologies. Figure 20 below shows students, mentors, and flight assets designed as part of the Blanket Toss program.

Figure 20. 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 serving 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. Figure 21 below shows examples of the individual designs and the team’s final group design vehicle (right).

Figure 21. Example individual project C2 module, individual project mini-blimp, team mini-blimp in final ASRA outbrief.

Summary.

This paper outlined rapid prototyping methodologies used by students to design the first organic fixed-wing UAS at UAF. These methodologies have been developed through a mix of academic courses, aerospace clubs, and individual undergraduate and graduate design projects. The UAS designs targeted have been developed with actual scientific research and public service missions in mind. Rapid prototyping processes have permitted students to efficiently experiment with potential designs and then to iterate on these designs in order to 'close' the system design. These opportunities are providing valuable UAS/aerospace experience preparing students for the expectations of tomorrow's workforce, and in helping to form the basis of UAF's growing aerospace program, including academic courses, arctic research efforts, and student clubs. These capabilities, clubs, and academic courses serve as a valuable recruitment tool for prospective university students, and a means to motivate our youth to maintain a STEM focus in school.

References

1. University of Alaska Fairbanks: http://www.uaf.edu/
2. Alaska Center for Unmanned Aircraft Systems Integration: http://acuasi.alaska.edu/
3. Pan-Pacific UAS Test Range Complex: http://acuasi.alaska.edu/pputrc
4. UAF College of Engineering and Mines: http://cem.uaf.edu/
5. UAF Geophysical Institute: http://gi.alaska.edu/
6. Lockheed Martin Stalker: http://www.lockheedmartin.com/us/products/stalker-uas.html
8. UAF Upward Bound Modern Blanket Toss: https://mbt.community.uaf.edu/
9. UAF Upward Bound Program: https://sites.google.com/a/alaska.edu/uaf-upward-bound/
10. UAF Alaska Summer Research Academy: http://www.uaf.edu/asra/