# Developing an Aerospace Degree Program Responsive to Student Needs—If You Build It They Will Come

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**Abstract**
Aerospace engineering has seen a resurgence in popularity in recent years, with major advancements being made across a broad spectrum of space exploration and technology. This interest spans various age groups and professions, from school students participating in science fairs to professionals in the aerospace industry. NASA's efforts in returning to the moon and in visiting Mars have redoubled the interest in our youth for learning about rocketry, satellites, and related aerospace technologies. Likewise, the success of private space companies like SpaceX and Blue Origin has also sparked a renewed interest in this field.

Due to strong and consistent student demand for aerospace education opportunities over the past decade and beyond, the University of Alaska Fairbanks (UAF) has initiated a new Aerospace Engineering bachelor's degree program, effective fall semester 2023. Even in its infancy, this program has already been well received by prospective students, current students, and faculty. There are only about 80 aerospace engineering programs across the country at this time.

Unfortunately, most colleges often do not possess an organic aerospace engineering program or other formal means of implementing interdisciplinary engineering at the program level. UAF, like many other small schools, initially lacked the resources to offer an aerospace engineering degree, and instead needed to thoughtfully and incrementally build such a program over a period of time utilizing the basic building blocks at its disposal.

This paper is intended to serve as motivation in providing aerospace experiences by faculty and institutions with limited resources. It will detail UAF's new aerospace program elements and opportunities; how it was purposefully grown in response to student desires and to provide increased academic and research opportunities within limited personnel/resources; how existing academic courses and design team opportunities were leveraged to satisfy student interests; and how this program satisfies University of Alaska (UA), State of Alaska, and federal needs in developing a vibrant and sustainable Alaska aerospace ecosystem supporting arctic research, industry, and national defense. The paper is authored by UAF's lead faculty for developing the aerospace engineering program and contains insights and motivations of students who have been a part of this program, past and present.

**Motivation**
General Motivation. Interest in aerospace-related programs and courses has arisen from a variety of perspectives. The relatively recent popularity of unmanned aircraft systems (UAS), and the renewed international interest in US aerospace programs focusing on lunar habitation and Mars exploration have all caused a strong resurgence in aerospace programs, in general. NASA's Artemis program ''will lead humanity forward to the Moon and prepare us for the next giant leap, the exploration of Mars.'' The Artemis program initially aimed to land humans on the moon again by 2024 as a first step in the process. [1] While this enormously ambitious milestone has suffered some delays, there is no doubt in how serious our nation and others are in achieving this goal soonest.

Satisfying these programs and other aerospace-related efforts will require a substantial workforce.

According to the US Department of Labor's Bureau of Labor Statistics, aerospace engineering is expected to grow at a pace of 6% from 2022 to 2032, above the average of all occupations. "About

3,800 openings for aerospace engineers are projected each year, on average, over the decade. Many of those openings are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire." [2] The *2022 Aerospace and Defense Workforce Study*, conducted by the Aerospace Industries Association (AIA) and the American Institute of Aeronautics and Astronautics (AIAA) cites the Aerospace & Defense (A&D) workforce attrition at 7.1% for 2021 and an area of concern for A&D companies. [3] NASA job vacancy statistics were not readily available, but a snapshot (as of 31 December 2023) of SpaceX listed over 180 full-time positions in Aerospace & Mechanical Engineering available for immediate hire. [4] According to Forbes Magazine, *The Aerospace Talent Shortage Is Complex. Solutions Can Be Simple.* (6 March 2023): "Bank of America Merrill Lynch has estimated that the global space economy may reach $2.7 trillion before 2050. Meanwhile, in Florida alone, a whopping 57 rocket launches took place last year—a new record, according to Space Florida." [5]

Many universities could be well positioned to take advantage of this movement, in many cases, with a relatively small investment needed to create relevant academic and research opportunities.

UAF Motivation for Engaging in Aerospace Activities. Aerospace engineering and related efforts (UAS, satellite, rocketry) are all deeply rooted in UAF research and academic efforts. In addition, these competencies all will help support the development of a strong, vibrant Alaska aerospace ecosystem which will continue to add to UA's student population and relevance in these and related areas.

Viewed from a systems perspective, college engineering programs may be modeled as a simple block diagram (Figure 1). The structure consists of an input (students/funding), the system/plant (academics, resources, applications), and output (better educated/trained students). Students are the raw material feeding the plant, or the 'currency' of the educational system. Without sufficient students, the process simply becomes inefficient (and perhaps eventually ineffective) and output necessarily slows. A quality program includes knowledgeable, motivated, and well-resourced teachers, as well as a reasonable amount of structured programs and supporting infrastructure. Outputs include not only better educated students and successful faculty, but also consist of greater opportunities for students in terms of follow-on education and career options. [6]

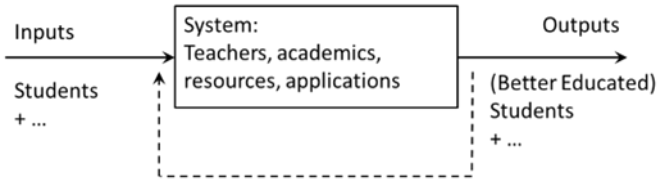

Figure 1: Educational programs as a system

From a macro perspective, the State of Alaska's aerospace industry health is essentially an ecosystem, subject to a synergistic relationship involving various technical sectors (Figure 2). Education programs within the UA system network must provide a constant stream of graduating students with requisite aerospace capabilities to support industry, agency, and scientific research needs. Likewise, STEM programs with the state's K-12 education system provide an influx of students to satisfy university educational programs, technical training, and commercial interests.

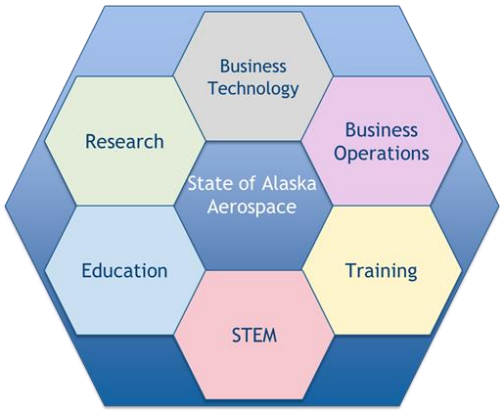

Figure 2: Alaska aerospace infrastructure ecosystem

Training programs provide essential skills supporting the design, fabrication, operation, and management of aerospace assets. Business technology sector creates the novel products and processes needed for aerospace applications, which are then employed by those businesses conducting or contracting for flight operations. As part of an ecosystem structure, the health of each individual sector relies on its ability to effectively interact with the other sectors to meet its own needs and that of the overall ecosystem, and Aerospace Education is a vital component.

**Overview**

The remaining sections of this paper include: (1) *Background* of why this program was developed for UAF, precedence for such a program and how it serves the student population; (2) *Aerospace Engineering Program* structure, flow, content, and related activities; (3) *Program Status* outlining significant efforts being undertaken to bolster the program; (4) *Resources* detailing current personnel and laboratory assets; (5) *Development Efforts* discussing how we are leveraging synergies with other UAF programs, activities, and collaborations to enhance all of these; and (6) *Future Efforts* charts anticipated additions UAF plans for their academic programs and outreach efforts in the near future.

**Background**

Aerospace Program Motivation. As mentioned earlier, the strong and consistent student demand for aerospace education opportunities, particularly over the last decade, eventually led UAF to initiate a new Aerospace Engineering bachelor's degree program (beginning fall semester 2023). Though in its infancy, this program has already been well received by prospective students, current students, and faculty. There are presently only about 80 aerospace engineering programs across the country, and students from Alaska now have an option to study in this growing field without leaving the state.

When the decision was finally made to enact the aerospace engineering degree program, UAF was by then relatively well positioned to take advantage of the opportunity, requiring only a modest additional investment to create the initial program. However, that juncture was reached only after years of thoughtful planning, steady progress, leadership support, and demonstrated student interest.

As an outline for the following discussion, this process involved demonstrating student interest in successive, incremental aerospace course and program offerings, each of which had to be made within existing faculty and program capacities: (1) 2014. Firstly, we offered graduate level courses in a popular topic related to university research programs (UAS, aka 'drones'). These courses were consistently taken by a mix of graduate and undergraduate students (usually about 50/50 mix). (2)

2015. Shortly after the initial courses were implemented, we began offering undergraduates the aerospace engineering minor as an initial means to distinguish themselves and show interest and commitment in aerospace studies. (3) 2021. In response to calls from graduate students, we offered a master's certificate in aerospace engineering.

As hoped, these courses and programs had the synergistic effect of attracting students and fanning interest in the courses and programs until students were actively calling for an aerospace engineering degree. (2022) Then as we pushed for adoption of the program, an unexpected but timely event occurred that breathed life into the program – the State of Alaska Governor & Legislation had determined to prioritize the state's UAS/aerospace education and training program.

With that brief roadmap, how and why did we decide to embark upon this journey?

Foundations – Places & People. First, UAF was fortunate to have a deep history examining and exploring the world around us…and a fairly unique location on the planet from which to do that – the arctic. Because of the extensive auroral studies undertaken by UAF over the years, the university had developed strong research infrastructure and activities to support these research efforts, including the Poker Flat Research Range (PFRR). The range has hosted sounding rocket programs to explore atmospheric phenomenon associated with the auroras for decades, and consequently supported academic efforts relating to this research, such as the UAF Student Rocket Program (SRP).

*[The remainder of this section is written from the perspective of the paper's lead author to clarify and simplify the discussion.]* Of course, the unique location of UAF and the capabilities of the PFRR made this a popular site for researchers, scientists, and engineers interested in space phenomenon and related aerospace engineering activities. It was this draw that brought me from the US Air Force Academy's program in the Department of Astronautics (USAFA/DFAS) to earn a PhD at UAF (1996-1999), and where the seeds for the Aerospace Engineering degree were sown by my faculty and research support personnel. When I retired from military life and was hired back at UAF (2013), I was immediately reminded of the need to pursue such a program on behalf of the institution.

Incremental Opportunities – Courses. With the goal of eventually providing an aerospace engineering degree, I first sought student input to develop a series of courses and capstone/research experiences at the graduate and undergraduate level that provided an aerospace flavor to their education and distinguished them as such in their transcripts. My first opportunity to affect the curriculum came at the graduate course level. As an aerospace engineer hired into a joint position supporting both engineering academics and UAS research, I was able to create a series of UAS/ aerospace courses which quickly proved to be very popular with students, both at the graduate and undergraduate level.

Aerospace Minor. Building upon that, with the help of our engineering faculty and leadership, we then introduced an *aerospace engineering minor*, consisting of courses that had already previously existed at that point. We were fortunate to take advantage of a pre-existing mechanical engineering (ME) option (emphasis) program in aerospace engineering. With support of the College of Engineering & Mines (CEM) leadership, the program was passed through the UAF Faculty Senate process and instituted in fall 2015. Now students, both within and outside of the ME department could earn a minor in aerospace engineering and have that distinction shown directly on their transcripts.

While it was theoretically possible for students in electrical engineering (EE) and other disciplines outside of ME to earn the minor, it was still a very difficult task to achieve. The primary reasons for this were: (1) ME-heavy prerequisites for many of the later courses (aeronautics, astrodynamics) by foundational aerospace topics such as fluids and thermodynamics. (2) Limited offering of these (eg, several courses were only offered every other year) made it impractical for many students to take them without significantly extending their graduation timelines. Some students attempted the aerospace minor along with EE, and some attempted dual majors in EE and ME, but the majority of these were not completed. Even so, students often conveyed that they were happy with completing the limited number of courses accomplished outside their primary discipline and felt this was good for their education and increased degree prospects (many of which entered aerospace fields).

Master's Certificate. In a similar vein, I was often approached by graduate students who were aware of the aerospace minor and were looking for a similar level of experience/distinction at their level. As this request became more pronounced over time, we eventually formulated a proposed program for an *master's certificate in aerospace engineering* and a *master's certificate in systems engineering & program management*, both of which UAF adopted in the fall 2021.

Senior Design Projects. Alongside the academic programs, interested students actively sought senior capstone courses with aerospace interdisciplinary projects available, as well as (in many cases, follow-on) graduate student research projects. In addition, students also enthusiastically joined aerospace related clubs and worked on efforts such as NASA's cubesat program and AIAA UAS competitions.

Aerospace Engineering Bachelor's Degree. As student interest in the courses and programs continued to increase, the demand for an aerospace engineering degree eventually became unmistakable. Once resources supporting additional manpower (to increase frequency of some courses and develop new courses) were provided by the State of Alaska, the program was finally approved (beginning fall 2023).

**UAF Aerospace Program Goals**

Program goals include the following:

1. *Overarching Goal - Grow UAF Aerospace Program.* Leverage UA System expertise, State of Alaska and federal agency support, and aerospace industry resources to grow a vibrant aerospace program at UAF which provides aerospace education opportunities for new and existing students covering a wide range of needs, ranging from career technical training to undergraduate and graduate education programs, and applied research activities.
2. *Create an Aerospace Undergraduate Degree Program at UAF.* Utilizing existing courses within the CEM, provide UAF aerospace students with a specified professional degree and significant level of knowledge in aerospace engineering and related subject matter. This augments existing UAF aerospace courses and programs, including the aerospace engineering minor, graduate certificates in aerospace engineering and systems engineering/program management, and the current development of online UAS courses.
3. *Establish a Recognized UAF Cadre of Aerospace Faculty & Staff.* Leverage professional competencies of personnel within the Mechanical Engineering (ME) Department, the Electrical & Computer Engineering (ECE) Department, other CEM departments, the Geophysical Institute (GI) centers/agencies (Remote Sensing, Space Physics, etc), and across UAF to address relevant technical/operational challenges and opportunities in the aerospace environment. Provide a recognized UAF center for academic and research efforts related to aerospace topics.

4. *Create Professional Development Opportunities for Students.* Through the synergy of UAF's Aerospace Program faculty, staff, and collaborators, create new professional development, educational pathways, career opportunities, internships, and professional mentoring for aerospace engineering students and others across UAF's programs.
5. *Attract & Retain Students.* Provide a popular, sought-after technical degree program, allowing both in-state and out-of-state students to receive relevant education and skills aligned with today's aerospace workforce needs in Alaska and throughout the country. Retain students in state that might otherwise leave for similar program opportunities. Attract outside students looking for opportunities and excitement in Alaska.
6. *Support Development of Alaska's Aerospace Ecosystem.* Provide a key link in Alaska's education program, allowing students to receive relevant education and skills aligned with Alaska's nascent aerospace industry (UAS, commercial/cargo aviation, space launch operations, engineering, research, technology, and operations).

Desired Components of the program include:

- Competency threads supporting core areas of UAS, manned aircraft (AC), rocketry, and satellites
- Community & Technical College (CTC) programs and courses supporting design, fabrication, operations, and maintenance
- Undergraduate and graduate academic programs
- Applied research projects integrated with academic and training programs
- Hands-on operations and maintenance (O&M) activities integrated with academic and training programs
- Program structure promoting inter/multi-disciplinary program growth and opportunities
- Traditional classroom and asynchronous online learning opportunities

**Aerospace Engineering Program Description**

UAF's aerospace engineering degree offers several tracks responsive to student desires. These include a track with traditional aeronautical engineering focus (aircraft design and performance), a track focusing on astronautical/space systems engineering (satellites, rockets, communication and guidance systems), and a track emphasizing UAS design and operations. The program also can be tailored toward other aerospace-related interests and goals.

Learning Objectives. Students successfully completing the Aerospace Engineering BS Degree will:

- Demonstrate the technical ability and knowledge to function as professionals in the aerospace engineering concentration area.
- Demonstrate the ability to perform design or research within the constraints of the component courses selected for the degree.
- Be poised to enter professional careers in areas associated with either their major area of study within engineering or the aerospace career field or may elect to attend graduate school to further their studies.

Program Tracks. UAF's Aerospace Engineering degree offers tracks in (1) Aeronautics, (2) Space Systems – Astronautics, (3) Unmanned Aircraft Systems, and (4) General. The flowchart for the General program is shown below (Figure 3). Expanded flowcharts for each track/concentration, as well as the aerospace engineering minor, are provided in Appendix B. Detailed descriptions of the

programs and courses are available at UAF's Aerospace Engineering website. [7]

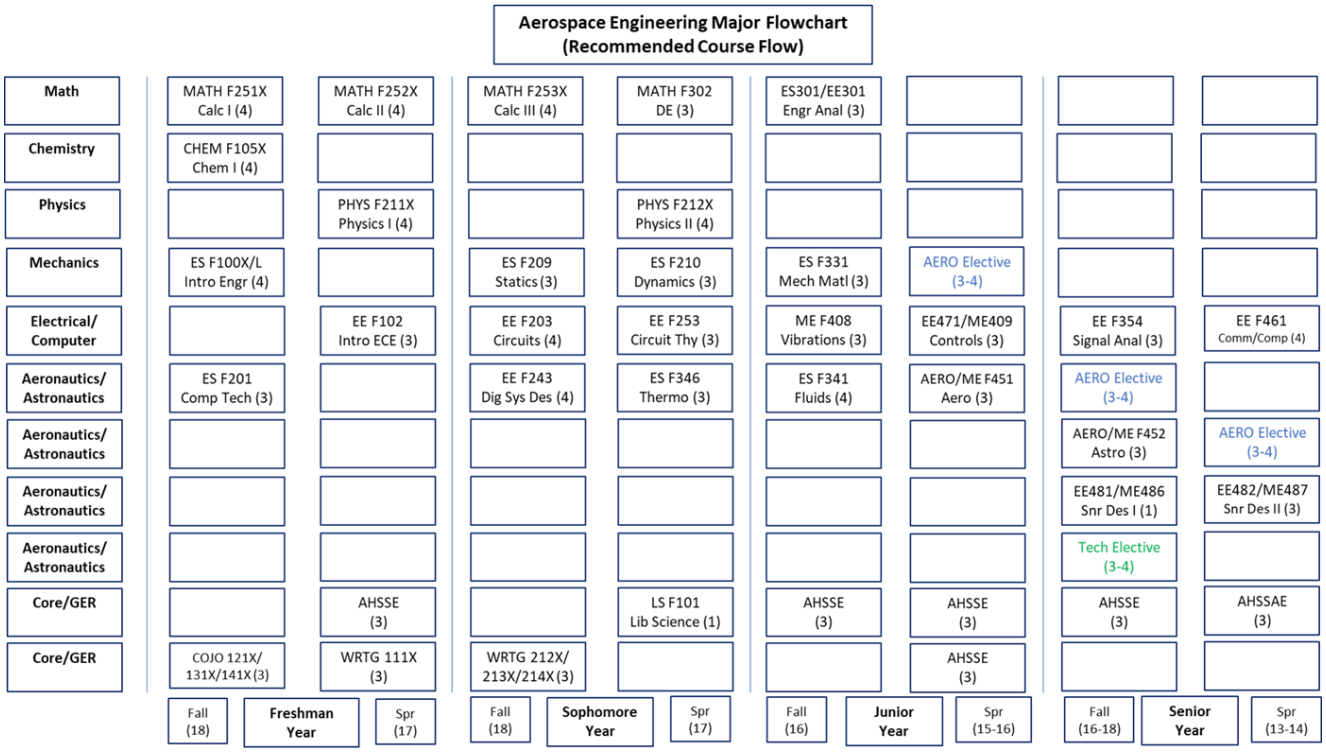

Figure 3: UAF aerospace engineering degree, general content flowchart

Foundational Courses. Core courses for UAF's Aerospace Engineering degree include various General Education Requirements (GER) courses (listed on UAF's website) and the following foundational courses in Chemistry (CHEM), Engineering Sciences (ES), and Mathematics (MATH).

- CHEM F105X Chemistry I (4 credit hours)
- ES F100X/L Introduction to Engineering (4)
- ES F201 Computer Techniques (3)
- ES F209 Statics (3)
- ES F210 Dynamics (3)
- ES F301 Engineering Analysis OR EE F301 Engineering Analysis (3)
- ES F331 Mechanics of Materials (3)
- ES F341 Fluid Mechanics (4)
- ES F346 Introduction to Thermodynamics (3)
- MATH F251X Calculus I (4)
- MATH F252X Calculus II (4)
- MATH F253X Calculus III (4)
- MATH F302 Differential Equations (3)

Required Courses. The following courses are considered central to UAF's Aerospace Engineering degree, regardless of the Concentrations selected. Courses represent a wide swath of both mechanical and electrical topics deemed essential in the highly technical and multidisciplinary environment found in today's aerospace projects and programs. This breakout allows students to recognize strengths and potential weaknesses which could help them facilitate career choices, select future graduate programs, or even lateral within the undergraduate program into other engineering

disciplines (eg, mechanical or electrical engineering). Likewise, this framework also provides a reasonable bridge for engineers in the aforementioned disciplines to broaden their academic portfolios with options supportive of aerospace engineering. This can range from dual-majoring, completing an aerospace engineering minor in addition to their home major, or may simply include an emphasis in aerospace-related courses.

- AERO/ME F451 Aerodynamics (3)
- AERO/ME F452 Introduction to Astrodynamics (3)
- EE F102 Introduction to Electrical and Computer Engineering (3)
- EE F203 Electric Circuits (4)
- EE F243 Digital Systems Design (4)
- EE F253 Circuit Theory (3)
- EE F354 Engineering Signal Analysis (3)
- EE F461 Communication Systems and Networks (4)
- EE F471 Automatic Control or ME F409 Controls (3)
- EE F481 Electrical & Computer Engineering Design I or ME F486 Senior Design I (1)
- EE F482 Electrical & Computer Engineering Design II or ME F487 Design Project (3)
- ES F201 Computer Techniques (3)
- ES F209 Statics (3)
- ES F210 Dynamics (3)
- ES F301 Engineering Analysis3 or EE F301 Analytical Methods for Electrical & Computer Engineers (3)
- ES F331 Mechanics of Materials (3)
- ES F341 Fluid Mechanics (4)
- ES F346 Introduction to Thermodynamics (3)
- MATH F253X Calculus III (4)
- MATH F302 Differential Equations (3)
- ME F408 Mechanical Vibrations (3)

Electives Supporting Concentrations. Courses are intended to provide students options a range of options for accumulating additional depth in particular areas of aerospace engineering. Students must take 3 courses from the following list, according to the concentration selected:

- Aeronautics Concentration
    - ME F313, Mechanical Engineering Thermodynamics (3)
    - AERO/ME F450, Theory of Flight (3)
    - AERO/ME F453, Propulsion Systems (3)
    - +1 additional technical elective
- Space Systems (Astronautics) Concentration
    - EE F303, Electric Power Systems & Machines (4)
    - EE F333, Electronic Devices (4)
    - EE F444, Embedded Systems (4)
- Unmanned Aircraft Systems (UAS) Concentration
    - AERO F654, UAS Design (3)
    - AERO F656, Aerospace Systems Engineering (3)
    - AERO F658, UAS Operations (3)
    - +1 additional technical elective
- No Concentration

- 12 credit hours – combination of any of the above courses or the following electives

Technical Electives. Technical electives allow students to tailor their academic experience, providing options to add breadth and depth to their program in a variety of areas. Students must take a total of 12 credit hours (combination of the following + previously identified course concentration courses):

- AERO F660 Rocket Systems Design (3) (in approval cycle)
- CS F453 Robotics & 3D Printing (3)
- CS F463 Cryptography & Data Security (3)
- CS F465 Computer & Network Security (3)
- EE F404 Electric Power Systems Analysis (4)
- EE F443 Engineering Analysis & Design (4)
- EE F444 Embedded Systems Design (4)
- EE F451 Digital Signal Processing (4)
- EE F607 Electric Motor Drives (3)
- ESM F422 Engineering Decisions (3)
- GEOS F416 Applied Geophysics (3)
- GEOS F422 Geoscience Applications of Remote Sensing (3)
- ME F405 Computer Aided Design (3)
- ME F406 Computer Aided Manufacturing (3)
- ME F441 Heat & Mass Transfer (3)
- STAT F300 Statistics (3)

Notes:
(1) Many of the above AERO-designated courses previously existed within the ME department and were co-listed as AERO/ME to signify course content and applicability to the new aerospace program. These include AERO/ME F450, F451, F452, and F453.
(2) AERO F654, F656 & F658 were created as electives for graduate and undergraduate students desiring opportunities to learn about UAS/aerospace topics.
(3) AERO F660, Rocket Systems Design, is a recent addition (in progress) intended to satisfy student desire for a hands-on rocketry program. Now that the aerospace degree is in place, students have articulated an expectation that UAF provides this as an option. This course will also aid in satisfying ABET requirements for some student concentrations.
(4) Other new courses being introduced include AERO F453, *Flight Dynamics*, and AERO F465, *Introduction to Space Mission Design*. These courses are being added both to satisfy student demand and ABET requirements for various student concentrations.

**Program Status**
While UAF is very excited to get the new aerospace engineering major off the ground, much work remains to stabilize and grow this nascent effort into a mature and robust program. Areas of immediate focus include program accreditation, faculty hires, research efforts, partnerships, and student awareness.

Accreditation Board for Engineering and Technology (ABET). Gaining ABET accreditation for the program is, of course, a key emphasis item for UAF. As is the case for any new program, we must graduate at least 1 student from the program prior to applying for accreditation. UAF is working diligently to ensure this process is as quick and efficient as possible. The new aerospace program has

been built from existing UAF programs (all accredited) with the specific ABET aerospace engineering accreditation standards in mind from the beginning, and UAF's Faculty Senate process has overseen the process through its initial implementation. In addition, the author has solicited several aerospace experts covering the gamut of specialties within the field (aeronautical, astronautical/space systems engineering, UAS engineering) to serve on UAF's External Advisory Board for the degree and has solicited informal feedback from ABET Program Evaluators to identify any potential areas of concern.

Initial Student Cadre. To aid the ABET process, UAF has been working closely with specific students who have continued to show interest in aerospace engineering through their time at the university. Many of these students were attracted to UAF due to its pre-existing aerospace engineering minor program (see Appendix A). A number of these students are interested in obtaining a dual degree so that they may graduate under a program covered by ABET while accreditation of the aerospace program is accomplished. Helping them to navigate the new program requirements and leveraging previous credit to make this a viable option is essential.

Faculty Hires. While the new aerospace engineering degree program consists of no new courses, it is still highly desirable to increase the numbers of our faculty. Increasing the number of faculty in the supporting departments (UAF has no Aerospace Engineering Department at this time) (1) allows for increased frequency in the offering of key courses, (2) broadens the selection of aerospace related upper division electives and graduate courses, and (3) expands the research breadth of the departments and associated opportunities for students. Fortunately, the State of Alaska Governor & Legislature have made UAS/aerospace education and training a priority in growing and robusting Alaska's aerospace ecosystem. This has resulted in on-ramping support for 3 new faculty hires – 1 each in mechanical, electrical, and UAS engineering. The effect of these new positions is expected to have a dramatic positive impact on the aerospace engineering degree and UAF programs, in general.

Partnerships. The new aerospace program and faculty represent a significant increase in UAF's competency set, and in our ability to offer integrated academics/research opportunities to students and faculty in this area. Figure 4 below shows the interrelationship between the elements of academics, research, and aerospace operations. The synergistic effects of these benefit all involved and, in turn, generate increased opportunities for UAF to partner and collaborate with various external agencies, companies, and other universities interested in shared problem sets and competencies. The result is growth in both the % overlap in academics and applied research, and in the total amount of opportunities and resources available, thereby increasing the size of each component program. This increased capacity and awareness provides growth to UAF programs, in general, and supports larger institutional goals (eg, such as the campaign to attain R1 research status).

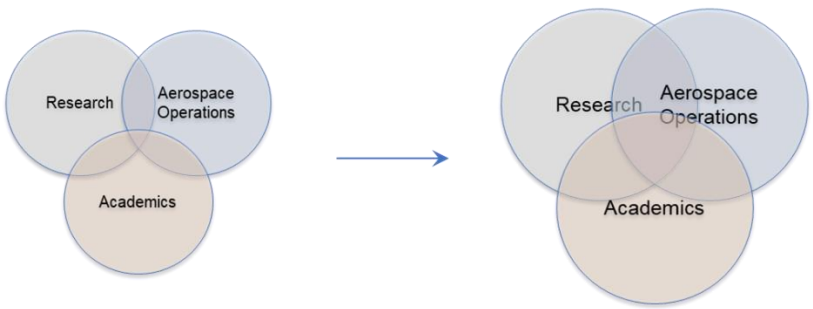


Figure 4: Synergy between UAF academics, research & operations

Student Awareness. Closing the loop on the aerospace education process is the involvement of students (see Figure 1). It was with this model that UAF's aerospace engineering degree program was undertaken 10 years ago. Obviously, making students broadly aware of the program and its resultant career/education opportunities is key to its success. This is being accomplished through a variety of means (eg, K-12 outreach events, recruiting events), however, the vast number of students find it through internet searches of aerospace programs and research activities. I am constantly contacted by both prospective students (undergraduate and graduate) looking to come to UAF for an aerospace engineering experience, and by current students seeking projects for design projects or considering switching to aerospace engineering or taking on a dual degree.

**Resources**

Personnel. As the aerospace program has grown from its earliest inception to now, several personnel have aligned their efforts to support and expand the team. The aerospace degree program does not have its own academic department but is administratively housed within the Mechanical Engineering (ME) Department. The team consists of faculty members who are assigned to the ME, Electrical & Computer Engineering (ECE), and Computer Science (CS) Departments. These members represent a broad swath of topics and interests associated with aerospace courses and research and have roles in developing/refining new course offerings and maturing the academic program and research activities.

The lead author provides administrative oversight for the program and is attached to the ECE Department, with technical specialties in the field of astronautics (astrodynamics, rocketry, and satellite design), systems engineering, and aeronautics (UAS design and operations). Another author is the ECE Department Chair and leads the UAF Space Systems Engineering Program (SSEP) (nano-satellites) and Alaska Space Grant Program (ASGP). Yet another team member of the ECE Department is a remote sensing expert and works with the UAF UAS program. ME aerospace team members include the ME Department Chair who leads the ME senior capstone design program and graduate research projects. Another ME member leads much of the team's efforts in aeronautics (propulsion, flight dynamics, wind tunnels and modeling). And another team member is attached to the CS Department and is an expert in robotics (cyber/physical systems, lunar rover/mining robots).

We expect the team to grow both in size and breadth of experience as we move to integrate various academic and research programs across the university.

Labs & Assets. Within the College of Engineering & Mines (CEM), our faculty and students have access to numerous laboratories supporting academics and research efforts aligned with the new aerospace degree program. These include:

- Aeronautical Systems Laboratory (wind tunnels)
- Aerospace Systems Laboratory (multirotor UAS and rocketry)
- Engineering on Display Room (multirotor fixed-wing UAS)
- Space Systems Engineering Laboratory (nano-satellites)
- Special Projects Laboratory (robotics)

In addition, students and faculty have access to the numerous university-owned research sites and Alaska resources mentioned throughout this paper. Again, as we continue to build and leverage the program, we expect these opportunities to expand significantly.

**Development Efforts**

Collaborations. This new aerospace engineering degree allows UAF to leverage existing assets and relationships to access and grow new partnerships and opportunities. This includes: (1) Academics - sharing academics information, access to courses and programs, and support in developing new programs. (2) Research – expanding shared facilities and assets, increased projects and opportunities for researchers, faculty, and students. (3) Personnel Development – visiting professor (VP) and student internship opportunities.

The potential for new collaborations is vast, both as a function of current UAF programs, facilities, and location, and due to the background and experience of personnel involved in aerospace-related programs. This network includes: (1) Military services and service academies (eg, USAF laboratories and product centers, USAFA academics, research, and personnel opportunities). (2) Universities academics programs and research projects (access to courses and leveraging programs withing the UA System and other universities). (3) Professional Organizations and conferences (eg, ASEE Aerospace Division and AIAA SciTech education forums). (4) Research opportunities leveraging UAF research sites and activities (ACUASI, PFRR, High-frequency Active Auroral Research Program – HAARP) and those within Alaska (Kodiak Launch Complex, Clear Space Station, Ft Greely, Eielson, Ft Wainwright, Joint Base Elmendorf-Richardson).

Club Activities. UAF is poised to capture the interest of both current and prospective students by expanding the role of the Aerospace Club from its previous sole focus on AIAA Design/Build/Fly (DBF) competition to now incorporate broader student interests and the range of topics supported by the aerospace degree. Students have asked the author (and UAF Aerospace Club faculty advisor) to provide new opportunities/design challenges related to multirotor UAS; prototype fixed-wing UAS with a focus on modular/rapid construction techniques and flight qualities; participation in Drone Racing League (DRL) activities; and model rocketry and space launch design competitions. It is also expected that UAF's Space Systems Laboratory team working on nanosatellite designs will likely expand to incorporate other satellite design and missions operations opportunities.

STEM Outreach. UAF has long been involved in numerous community STEM and community outreach events, including K12 classroom activities and science fairs, career days, UAF tours and Engineering Open House events. To date, UAS design, demonstrations, and simulators have been an extremely popular part of our outreach effort. Adding to this, we will now expand our demonstrations and activities to include small rocketry events suitable for a range of ages, increase participation and support of the Free Flight Society (FFS) competitions, and provide information on our new UAF academics, design clubs, research programs and opportunities.

**Future Efforts**

Aerospace & Other Academic Programs. UAF is already looking to develop next steps in growing and solidifying our Alaska aerospace ecosystem (see Figure 2) by leveraging existing programs in engineering, science, and management. These include: (1) Development of a full Master of Science (MS) degree program in Aerospace Engineering and emphasis opportunities for PhD students. (2) Creation of additional Interdisciplinary programs at both the undergraduate and graduate levels supporting engineering and sciences (eg, Applied Geosciences, such as remote sensing utilizing UAS, rockets, or satellites). (3) Development of a full Systems Engineering/Program Management

undergraduate and graduate degrees. (4) Extension of aerospace program to include Robotics Engineering programs and research supporting efforts such as paired operations between Unmanned Ground Vehicles (UGV), and Autonomous Surface/Submersible Vehicles (ASV).

Other Efforts. The initiation of UAF's Aerospace Engineering degree is expected to act as a catalyst for increasing support of various Science, Technology, Engineering & Math (STEM) and community outreach efforts. A couple examples include: (1) Develop Teacher's Workshops related to aerospace engineering and related topics. Teacher's Workshops typically last 1-week in duration and incorporate various lesson plans, hands-on activities, and learning resources the teachers may take back to their schools and communities. Such venues have proven extremely valuable in forging strong collaborative relationships between universities, K-12 schools, and communities. The lead author has personal experience in developing and conducting similar venues at the US Air Force Academy and at the US Air Force Research Laboratory. (2) Establish local Drone Racing League (DRL) clubs and competition events. The existence of UAF's Aerospace Engineering program has not only proven a catalyst in attracting students and faculty, but also those interested in the racing and flight test aspects of UAS.

**Conclusion**

This paper has provided an overview of UAF's new Aerospace Engineering BS degree, including courses and program emphasis options. Beyond describing the degree itself, the paper has outlined the motivation for UAF to develop this program; the history of how the program was incrementally developed using resources available at the time to maximize opportunities for students; how this program seeks to improve the outlook of UAF and Alaska's aerospace ecosystem; and next steps UAF intends to take in growing future programs opportunities.

If you have any questions, please feel free to contact:


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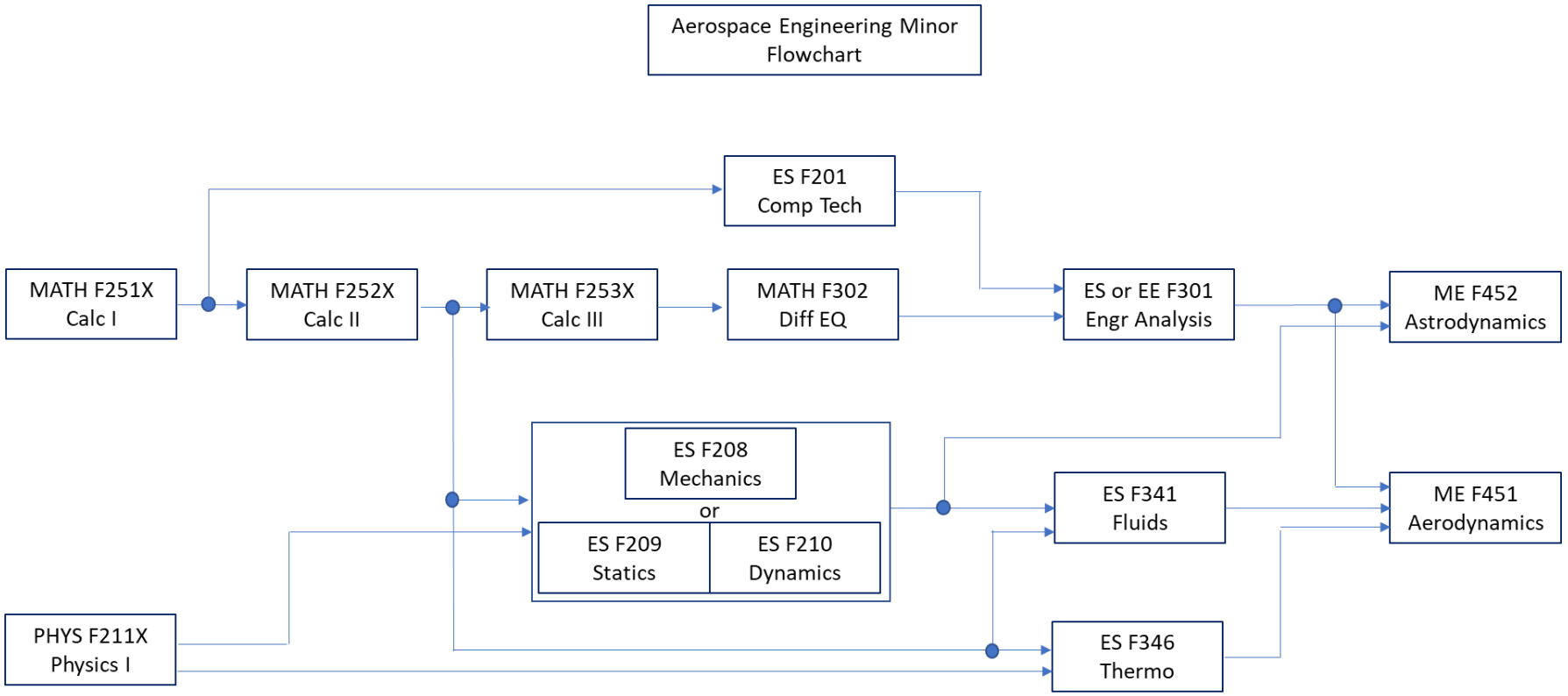
    - Chair, Department of Electrical & Computer Engineering
    - Associate Dean of Academics, UAF
    - Director, ASGP

## Appendix A: Aerospace Engineering Flows




[Note: Does not include information on electives]

# Aerospace Engineering Major Flowchart (Recommended Course Flow)

| | Fall (18) | Spr (17) | Fall (18) | Spr (17) | Fall (16) | Spr (15-16) | Fall (16-18) | Spr (13-14) |
|---|---|---|---|---|---|---|---|---|
| **Math** | MATH F251X Calc I (4) | MATH F252X Calc II (4) | MATH F253X Calc III (4) | MATH F302 DE (3) | ES301/EE301 Engr Anal (3) | | | |
| **Chemistry** | CHEM F105X Chem I (4) | | | | | | | |
| **Physics** | | PHYS F211X Physics I (4) | | PHYS F212X Physics II (4) | | | | |
| **Mechanics** | ES F100X/L Intro Engr (4) | | ES F209 Statics (3) | ES F210 Dynamics (3) | ES F331 Mech Matl (3) | AERO Elective (3-4) | | |
| **Electrical/ Computer** | | EE F102 Intro ECE (3) | EE F203 Circuits (4) | EE F253 Circuit Thy (3) | ME F408 Vibrations (3) | EE471/ME409 Controls (3) | EE F354 Signal Anal (3) | EE F461 Comm/Comp (4) |
| **Aeronautics/ Astronautics** | ES F201 Comp Tech (3) | | EE F243 Dig Sys Des (4) | ES F346 Thermo (3) | ES F341 Fluids (4) | AERO/ME F451 Aero (3) | AERO Elective (3-4) | |
| **Aeronautics/ Astronautics** | | | | | | | AERO/ME F452 Astro (3) | AERO Elective (3-4) |
| **Aeronautics/ Astronautics** | | | | | | | EE481/ME486 Snr Des I (1) | EE482/ME487 Snr Des II (3) |
| **Aeronautics/ Astronautics** | | | | | | | Tech Elective (3-4) | |
| **Core/GER** | | AHSSE (3) | | LS F101 Lib Science (1) | AHSSE (3) | AHSSE (3) | AHSSE (3) | AHSSAE (3) |
| **Core/GER** | COJO 121X/ 131X/141X (3) | WRTG 111X (3) | WRTG 212X/ 213X/214X (3) | | | AHSSE (3) | | |
| | **Freshman Year** | | **Sophomore Year** | | **Junior Year** | | **Senior Year** | |

# Aerospace Engineering Major Flowchart
## (Sample Flow – Aeronautical Engineering Concentration)

| | Fall (18) | Spr (17) | Fall (18) | Spr (17) | Fall (16) | Spr (15) | Fall (16-17) | Spr (13) |
|---|---|---|---|---|---|---|---|---|
| **Math** | MATH F251X Calc I (4) | MATH F252X Calc II (4) | MATH F253X Calc III (4) | MATH F302 DE (3) | ES301/EE301 Engr Anal (3) | | | |
| **Chemistry** | CHEM F105X Chem I (4) | | | | | | | |
| **Physics** | | PHYS F211X Physics I (4) | | PHYS F212X Physics II (4) | | | | |
| **Mechanics** | ES F100X/L Intro Engr (4) | | ES F209 Statics (3) | ES F210 Dynamics (3) | ES F331 Mech Matl (3) | ME F313 ME Thermo (3) | | |
| **Electrical/ Computer** | | EE F102 Intro ECE (3) | EE F203 Circuits (4) | EE F253 Circuit Thy (3) | ME F408 Vibrations (3) | EE471/ME409 Controls (3) | EE F354 Signal Anal (3) | EE F461 Comm/Comp (4) |
| **Aeronautics/ Astronautics** | ES F201 Comp Tech (3) | | EE F243 Dig Sys Des (4) | ES F346 Thermo (3) | ES F341 Fluids (4) | AERO/ME F451 Aero (3) | AERO/ME F450 Theory Flight (3) | |
| **Aeronautics/ Astronautics** | | | | | | | AERO/ME F452 Astro (3) | AERO/ME F453 Propulsion (3) |
| **Aeronautics/ Astronautics** | | | | | | | EE481/ME486 Snr Des I (1) | EE482/ME487 Snr Des II (3) |
| **Aeronautics/ Astronautics** | | | | | | | Tech Elective (3-4) | |
| **Core/GER** | | AHSSE (3) | | LS F101 Lib Science (1) | AHSSE (3) | AHSSE (3) | AHSSE (3) | AHSSAE (3) |
| **Core/GER** | COJO 121X/ 131X/141X (3) | WRTG 111X (3) | WRTG 212X/ 213X/214X (3) | | | AHSSE (3) | | |
| | **Freshman Year** | | **Sophomore Year** | | **Junior Year** | | **Senior Year** | |

# Aerospace Engineering Major Flowchart
## (Sample Flow – Astronautics/Space Systems Concentration)

| | Fall (18) | Spr (17) | Fall (18) | Spr (17) | Fall (17) | Spr (16) | Fall (14) | Spr (13) |
|---|---|---|---|---|---|---|---|---|
| **Math** | MATH F251X Calc I (4) | MATH F252X Calc II (4) | MATH F253X Calc III (4) | MATH F302 DE (3) | ES301/EE301 Engr Anal (3) | | | |
| **Chemistry** | CHEM F105X Chem I (4) | | | | | | | |
| **Physics** | | PHYS F211X Physics I (4) | | PHYS F212X Physics II (4) | | | | |
| **Mechanics** | ES F100X/L Intro Engr (4) | | ES F209 Statics (3) | ES F210 Dynamics (3) | ES F331 Mech Matl (3) | EE F444 Embedded Sys (4) | | |
| **Electrical/ Computer** | | EE F102 Intro ECE (3) | EE F203 Circuits (4) | EE F253 Circuit Thy (3) | ME F408 Vibrations (3) | EE471/ME409 Controls (3) | EE F354 Signal Anal (3) | EE F461 Comm/Comp (4) |
| **Aeronautics/ Astronautics** | ES F201 Comp Tech (3) | | EE F243 Dig Sys Des (4) | ES F346 Thermo (3) | ES F341 Fluids (4) | AERO/ME F451 Aero (3) | EE F303 EPS/Machines (4) | |
| **Aeronautics/ Astronautics** | | | | | EE F333 Elec Devices (4) | | AERO/ME F452 Astro (3) | |
| **Aeronautics/ Astronautics** | | | | | | | EE481/ME486 Snr Des I (1) | EE482/ME487 Snr Des II (3) |
| **Aeronautics/ Astronautics** | | | | | | | | |
| **Core/GER** | | AHSSE (3) | | LS F101 Lib Science (1) | | AHSSE (3) | AHSSE (3) | AHSSAE (3) |
| **Core/GER** | COJO 121X/ 131X/141X (3) | WRTG 111X (3) | WRTG 212X/ 213X/214X (3) | | | AHSSE (3) | | AHSSE (3) |
| | **Freshman Year** | | **Sophomore Year** | | **Junior Year** | | **Senior Year** | |

# Aerospace Engineering Major Flowchart (Sample Flow – UAS Concentration)

| | Fall (18) | Spr (17) | Fall (18) | Spr (17) | Fall (16) | Spr (15) | Fall (16-17) | Spr (13) |
|---|---|---|---|---|---|---|---|---|
| **Math** | MATH F251X Calc I (4) | MATH F252X Calc II (4) | MATH F253X Calc III (4) | MATH F302 DE (3) | ES301/EE301 Engr Anal (3) | | | |
| **Chemistry** | CHEM F105X Chem I (4) | | | | | | | |
| **Physics** | | PHYS F211X Physics I (4) | | PHYS F212X Physics II (4) | | | | |
| **Mechanics** | ES F100X/L Intro Engr (4) | | ES F209 Statics (3) | ES F210 Dynamics (3) | ES F331 Mech Matl (3) | | | |
| **Electrical/ Computer** | | EE F102 Intro ECE (3) | EE F203 Circuits (4) | EE F253 Circuit Thy (3) | ME F408 Vibrations (3) | EE471/ME409 Controls (3) | EE F354 Signal Anal (3) | EE F461 Comm/Comp (4) |
| **Aeronautics/ Astronautics** | ES F201 Comp Tech (3) | | EE F243 Dig Sys Des (4) | ES F346 Thermo (3) | ES F341 Fluids (4) | AERO/ME F451 Aero (3) | AERO F656 Aero Sys Des (3) | |
| **Aeronautics/ Astronautics** | | | | | AERO F654 UAS Design (3) | | AERO/ME F452 Astro (3) | AERO F658 UAS Ops (3) |
| **Aeronautics/ Astronautics** | | | | | | | EE481/ME486 Snr Des I (1) | EE482/ME487 Snr Des II (3) |
| **Aeronautics/ Astronautics** | | | | | | AHSSE (3) | Tech Elective (3-4) | |
| **Core/GER** | | AHSSE (3) | | LS F101 Lib Science (1) | | AHSSE (3) | AHSSE (3) | AHSSAE (3) |
| **Core/GER** | COJO 121X/ 131X/141X (3) | WRTG 111X (3) | WRTG 212X/ 213X/214X (3) | | | AHSSE (3) | | |
| | **Freshman Year** | | **Sophomore Year** | | **Junior Year** | | **Senior Year** | |

**Appendix B: Acronyms**

| | |
|---|---|
| A&D | Aerospace & Defense |
| ABET | Accreditation Board for Engineering and Technology |
| AC | Aircraft |
| ACUASI | Alaska Center for Unmanned Aircraft Systems Integration (UAF) |
| AIAA | American Institute of Aeronautics & Astronautics |
| ASEE | American Society of Engineering Educators |
| ASGP | Alaska Space Grant Program |
| ASV | Autonomous Surface/Submersible Vehicle |
| BS | Bachelor of Science |
| CEM | College of Engineering & Mines (UAF) |
| CTC | Career & Technical College (UAF) |
| DFAS | Dean of the Faculty/Department of Astronautics (USAFA) |
| DRL | Drone Racing League |
| FFS | Free Flight Society |
| GI | Geophysical Institute (UAF) |
| HAARP | High-frequency Active Auroral Research Program (UAF) |
| HPR | High Power Rocketry |
| IEEE | Institute of Electrical & Electronics Engineers |
| JBER | Joint Base Elmendorf–Richardson |
| KLC | Kodiak Launch Complex (now, PSCA) |
| MS | Master of Science |
| NAR | National Association of Rocketry |
| O&M | Operations & Maintenance |
| PFRR | Poker Flat Research Range (UAF) |
| PSCA | Pacific Spaceport Complex – Alaska (formerly, KLC) |
| SEDP | Systems Engineering Design Process |
| SRP | Student Rocket Program |
| SSEP | Space Systems Engineering Program |
| STEM | Science, Technology, Engineering & Mathematics |
| TA | Teaching Assistant |
| UA | University of Alaska (System) |
| UAF | University of Alaska Fairbanks |
| UGV | Unmanned Ground Vehicle |
| USAFA | United States Air Force Academy |

## Appendix C: References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