Hands-On Aerospace Engineering – Learning By Doing: Rocketry

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Abstract
Rocketry has seen a tremendous resurgence in popularity over recent years, especially with the advancements in space exploration and technology. The interest spans various age groups and professions, from K-12 students participating in science fairs to professionals in the aerospace industry. NASA's space 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 topics. The success of private space companies like SpaceX and Blue Origin has also sparked a renewed interest in rocketry.

University of Alaska Fairbanks (UAF) course AERO F660/*Rocket Systems Design* provides students with the opportunity to gain practical, hands-on aerospace experience in the field of rocketry and launch operations. This course provides students with the requisite academic knowledge and technical experience needed to successfully design and build small rockets, and to train them in safe and effective launch and recovery operations. The course provides students with the foundational knowledge and tools needed to chart a career in rocket design and launch operations, and to successfully compete for technical grants involving rocket research and operations.

This paper will detail: (1) the course organization and how it has been structured to satisfy student interests in gaining hands-on engineering design experience and familiarity with conducting safe and effective launch operations; (2) how student knowledge from this course may be extended to solving important national interests and arctic research; (3) how this body of experience is expected to help them in their own careers and endeavors; and (4) how that experience ultimately strengthens the university program for future students.

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 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 hopes to land humans on the moon again by 2027 as a first step in the process. [1] While this enormously ambitious milestone is almost certain to be delayed, there is no doubt in the seriousness of our nation (and other countries) in achieving this lofty 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 10 January 2025) of SpaceX listed over 280 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] Space Florida reports 90 launches for 2024. [6] 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.

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

Viewed from a systems perspective, college engineering programs may be modeled as a simple block diagram. 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. [7]

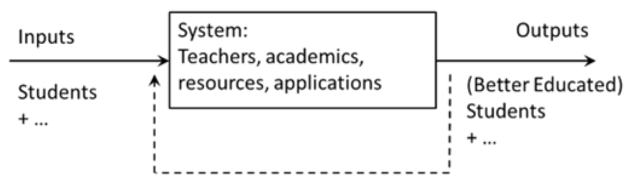


Figure 1: Educational programs as a system.

On a macro scale, the State of Alaska's aerospace industry health is subject to a similar synergistic relationship involving various technical sectors. *Education* and *research* programs within the University of Alaska (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.

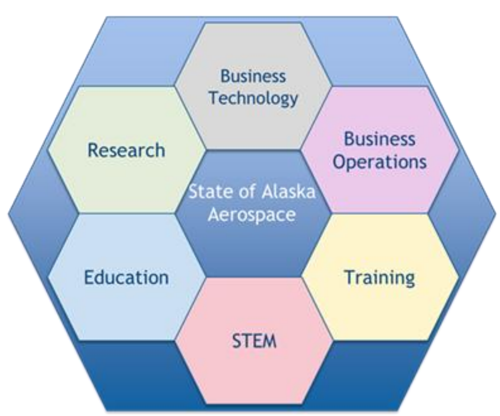


Figure 2: State of Alaska aerospace infrastructure ecosystem

Technical *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 *operations* 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.

While the discussion of emergent aerospace programs is a worthy topic, the specific focus of this paper is on the incorporation of one course in rocketry design and how this can broadly spur student interest and involvement in the aerospace field.

Rocketry Course Motivation. The field of rocketry design and flight operations is a highly sought experience for engineers of various disciplines, as well as computer science, robotics, physics, and geomatics/geosciences students. Many universities and educational institutions now offer courses in rocket science and engineering, and there are numerous clubs and organizations dedicated to rocketry. The National Association of Rocketry (NAR), for instance, is the oldest and largest sport rocketry organization in the world, with over 100,000 members. Online platforms also offer courses on rocket science, making it more accessible to a wider audience.

The lead author has often been queried by students regarding the possibility of offering such a course at the University of Alaska Fairbanks over the past several years. Now that UAF has been successful in spawning its new Aerospace Engineering degree program, student demand for rocketry experiences has sharply increased. It is expected that this course will be very popular and that it will attract numerous students to UAF (and to all schools within the UA network) in the long term. In addition, the new course has quickly drawn support by university leadership and has already resulted in offers of student internship programs by federal agencies.

This course follows the path of previous highly successful rocket design/launch programs (eg, the USAF Academy). Support for this course is high, both among student groups and university faculty and leadership. This course is already supported by various academic departments and student groups, including one mechanical engineering senior capstone team which designed a portable launch rail for their senior design project. The course is also being examined as one possible multidisciplinary senior design project which can satisfy various other department capstone requirements. Additionally, the course has sparked student interest in forming a design club participating in various high-power rocketry (HPR) competition events.

Overview

The remaining sections of this paper include: (1) *Background* of why this course was developed for UAF, precedence for such a course, how it fits within the curriculum, and how it serves the student population; (2) *Single-Semester Rocketry Course* structure, flow, content, and activities; (3) *Extensibility to Rocketry Program* for universities looking to build a higher-level academic and integrated research program; (4) *Application to UAF Aerospace Program* discusses how we are leveraging this course to make our programs more responsive to student needs and industry demand; and (5) *Results & Feedback from Initial Spring 2025 Offering*. (Note: About ½ of this paper is detailed information which is included in a set of appendices to make reading easier.)

Background
USAFA Origins. The development of this introductory rocketry course is based upon subject matter and techniques used successfully at other academic institutions as part of their aerospace-related curriculums. The course instructor has previous experience teaching similar courses at the USAF Academy (USAFA) Department of Astronautics, including both a single-semester course such as this one, and a multi-semester senior design sequence. The significance of this section is not only the development of the course materials, but in the high level of interest and personal motivation shown by the students (and faculty) involved.

To briefly summarize, USAFA provided a single-semester rocketry design course for many decades, beginning in 1964. [8] The content and structure of that course is largely reflected by the material described in the following section. The purpose of that course was to provide a hands-on, practical rocketry experience to USAF cadets desiring to pursue a career in astronautical engineering. The course was highly successful, as the author can personally attest, in that it drew students from around the country to USAFA to partake in this dynamic and exciting experience. As both an instructor for the course and an academic advisor over a span of some 8 years, I encountered numerous cadets who claimed the rocketry experience was a major factor influencing their decision to attend the USAFA.

While not the primary focus of this paper, it is important to note the impact of the USAFA rocketry program on the nascent UAF program. Space does not permit adequate treatment of this topic here, but the author's experience with the single-semester USAFA rocketry course and subsequent growth into a larger academic and research program heavily influenced the decision to push for such an endeavor at UAF.

The USAFA program grew to include a 2-semester capstone design course with an aligned research program focused on investigating various rocket/spacecraft propulsion technologies (gas, mono/bi-propellants, hybrid, and solid motors) and vehicle subsystems designs in creating a series of sounding rockets supporting national aerospace research studies. Among other things, the effort generated the design and construction of USAFA's own organic portable launch trailer (used across the US) and the initiation of the USAFA FalconLaunch sounding rocket program.

The FalconLaunch program saw the design of 8 total vehicles and spanned a period of 2003 – 2009 before being cut due to personnel and resource constraints in the face of competition with the highly successful USAFA FalconSat satellite program. Similarly, the single-semester USAFA rocketry course eventually died out after several decades of success (ending sometime after 2003 when the author departed). However, in the intervening years, the author has been in contact with the USAFA faculty who have inquired about use of the mobile launcher in support of ongoing research efforts. It is the author's belief that the USAFA program will continue to see ebbs and flows in the program interest and size.

The interested reader can find various news articles, pictures, and video segments of the USAFA FalconLaunch program online, which may be of some utility for those desiring to pattern a similar effort. Some representative pictures from the program are included in *Appendix B* of this paper and show possible futures for the UAF rocketry program.

UAF Program. The University of Alaska's *Rocket Systems Design* course is expected to accomplish much the same as was done with the USAFA rocketry program. This course is meant to be the first step in developing a similar multi-semester capstone design experience and closely tied research capabilities at UAF.

Local support for such a program is deep and has been longstanding. UAF has had its own Student Rocket Program (SRP) for several years, this being a convenient vehicle for both undergraduate and graduate students to receive real-world design experience as part of other academic courses (electrical, computer, mechanical engineering design) or supporting research projects, particularly important opportunities for graduate students working on their master's or advanced degrees.

A unique asset supporting the UAF SRP effort and Space Physics research is the Poker Flat Launch Range (PFRR), the only university-owned launch range in the world. In fact, it was this combination of the UAF SRP research opportunities and PFRR assets and programs (eg, NASA support) which drew the author to attend UAF after first teaching at the USAFA and participating in their rocketry program. Attending UAF and working on the SRP was expected to be a valuable experience in (then) building up the USAFA's program.

In addition to PFRR, the program is also expected to benefit by leveraging newer Alaska Pacific Spaceport Complex (PSC) capabilities. Support for UAF's new Aerospace Engineering degree and this rocketry course is high, not only in the College of Engineering & Mines (CEM), but also within the UAF research community. The UAF Geophysical Institute (GI) Director has been a stalwart proponent of the aerospace degree/rocketry program as these directly support GI research programs and opportunities, including an organic rocketry program which has been a niche favorite of various UAF faculty and students.

Finally, this course also directly supports UAF's nascent Aerospace Engineering program. This program currently consists of a minor in aerospace engineering (fall 2015), a graduate certificate in aerospace engineering (fall 2021), the newly established undergraduate degree in aerospace engineering (fall 2023), and a space operations minor (fall 2025). As mentioned previously, this course has been consistently requested by students over several years. With the establishment of the UAF Aerospace Engineering degree program and through the support of State of Alaska's Governor & Legislature, UAF has been able to expand its pool of faculty to support increased student enrollment and providing an opportunity for this course to finally be instituted.

Status of UAF Course. After a couple years of extensive review, the course finally kicked off in spring 2025 semester. The review process included: local CEM reviewing the course syllabus, contents, launch procedures, PFRR coordination, safety protocols, storage & transport procedures. The course will also become part of the elective course pool for UAF aerospace engineering degree programs.

As expected, the inaugural offering of the course has immediately proven to be popular with 13 (mixture of graduate and undergraduate engineering) students enrolled. For UAF, this is quite a large student population. Note that the enrollment would have been larger, but several students were unable to take the rocketry course due to time conflicts with other courses needed for their academic programs. In addition, this enrollment was achieved without any advertising but was solely due to word-of-mouth and students investigating the UAF courses availability for spring 2025.

On other fronts, support for the rocketry course and program continues to be robust at UAF. The author has been approached by several students who are looking for opportunities to participate, either within the new course or in other venues. One set of senior mechanical engineering students already began tackling the problem of building a reliable long-term launch rail to be used for both the smaller single-semester rockets and for some modestly larger-scale rockets to be built under a multiple-semester senior design course or by a UAF design team (eg, GI rocket program mentioned above, or UAF Aerospace Club who are expanding their venue of activities from UAS to now include rocketry competitions). The prototype launch rail (shown below) is 11 feet long and constructed out of steel (base), copper (truss), and aluminum (rail).

Figure 3: Picture of launch rail prototype built by ME senior design course.

In summary, support for the (currently proposed) single-semester *Rocket Systems Design* course looks quite bright, with no lack of interested students and broad support by the UAF leadership. With the information in this section as a backdrop, the next section discusses the specifics of the new course, based on the author's previous experience at the USAFA and placing the new course within the context of UAF's own academic curriculum, research interests, and student population.

Single-Semester Rocketry Course

This section covers the overall course structure; topics learned as part of the course academics, design/building phases, and launch operations; and provides a timeline and sample syllabus for administering the course (see appendix for course syllabus).

I. Course Structure

Overview. *Rocket Systems Design* covers the analysis, design, fabrication, test, and launch of small rockets. Students learn to estimate rocket performance; understand the function and design of various rocket subsystems, payloads, and infrastructure; and gain the foundational knowledge and experience needed to successfully launch a small rocket in support of a nominal suborbital mission.

Delivery Methodology. The course is designed to be delivered as a hybrid model. Lectures are delivered primarily via classroom face-to-face methodology to maximize group discussions, especially concerning hands-on activities, but with Zoom connectivity also supported for students who may be located off-site or who may be on travel status. Students participate actively within a small group setting (2-4 students, depending upon class size and project complexity) to tackle a small rocket/ payload design, fabrication, and launch, culminating with a final report and briefing on their data products and mission results. Design team activities may be accomplished either face-to-face or can be conducted remotely (requires coordination of remote personnel and resources).

Learning Objectives. Students demonstrate understanding of the systems engineering development process by completing the design, fabrication, testing, and operation of sounding rockets and payloads. Specific learning outcomes include: (1) Understand the systems engineering design process (SEDP); (2) Comprehend the complex interaction and interdependencies of rocket systems; (3) Understand mission operational planning considerations, such as flight planning, logistics footprint, and data requirements planning; (4) Design, build, and test a rocket supporting a payload with a selected remote sensing mission; (5) Clearly and concisely communicate a rocket design throughout the phases of the SEDP in both written and oral form; (6) Be familiar with missions performed by the PFRR and PSC supporting research and public service.

Point Summary. The following table summarizes the course expectations for deliverables and their associated point values. Letter grades are assigned for each team deliverable utilizing a 'plus/minus' grading scheme, as appropriate.

Graded Event	**Weight (%)**		**Graded Event**	**Weight (%)**
Individual Activities	**25%**		Final Report	10
Homework	10		Conference Paper	5
Quizzes	15		Team Video	5
Team Deliverables	**45%**		**Overall Performance**	**20%**
Conceptual Design	5		Technical	15
Preliminary Design	5		Management	5
Critical Design	5		**Class Participation**	**10%**
Testing	5		Peer Eval	5
Final Briefing	5		Instructor Points	5

Table 1: Point weighting summary for course

Grades. Grades are assigned on an individual basis, with input based upon the team's performance and instructor assessment of the individual's performance. The instructor factors in feedback from guest reviewers during presentations, as well as peer input. Detailed guidance on content and grading for each deliverable is provided by the instructor at the beginning of the semester and then reviewed prior to the period of time where the student teams are expected to begin work on these.

Class Participation. The grade for class participation depends on: (1) Attendance and asking and answering questions in class; (2) Participation in group activities; (3) Feedback by team members.

Class Project. The project consists of designing, building, and launching a team rocket and payload. In addition, course deliverables also include various project reviews (both briefing & written reports), culminating with a final project briefing and final report. The final briefing and report are cumulative and are expected to address instructor feedback provided during the semester. All submissions are shared by the entire team, and each member's work must be delineated.

Project Teams. Course projects are accomplished by small teams (2-4 students), depending on the class size and complexity of proposed payload mission. Project reports/briefings are expected to be a team effort with in-depth coverage of all major aspects of a rocket/payload suite supporting the mission. Detailed guidance for the flight missions/data products are provided by the instructor upon assignment of the project. Students are provided with several tools and templates to assist them with their analysis and preparation, including:

- Baseline Rocket Design Cover Sheet
- Payload Design Cover Sheet
- Flight Test Worksheet
- Sample Flight Test Report
- Rocket Motor Transport & Firing Checklist
- Written Report Guidelines
- Apogee Calculation Worksheet
- Apogee Calculation Handout

In addition, several other supplemental checklists cover actions required by the instructor and support technicians to ensure safe operations – from storage of motors/ignitors to range coordination and launch operations.

Review Process. Guest reviewers are subject matter experts (SMEs) from their fields. SMEs may be provided from the rocketry operations world, engineers, and scientific researchers conducting operations with similar rocketry systems. The student team is responsible for generating professional technical deliverables describing performance requirements for the system. Prior to delivering presentations or reports, SMEs are provided with expectations on anticipated product performance and recommended/current design details. SMEs then provide qualitative inputs to be considered by the instructor in evaluation of deliverables and determination of student grades.

Evaluation of Reports/Briefings. For the Design Proposals and Final Reports, students are required to highlight those aspects of the deliverables which they have personally worked on. This is to ensure there is a balanced effort given by all team members. Reports receive a team score as a baseline, and the individual grades for the students may be raised with respect to this baseline grade based on the quality of their individual input. Similarly, groups receive a baseline grade for their presentations. Individual students' grades may be adjusted up/down based on their individual performance and how this contributes to the overall flow of the briefing.

Conference Papers. The conference paper deliverable is meant to introduce students to the general process of submitting technical papers for consideration at a professional conference (eg, ASEE, AIAA, IEEE…). Papers are accomplished by incorporating the materials teams have generated for their final report and converting this into a format acceptable for the professional organization. The instructor provides samples of successful conference papers for students to pattern submissions after.

II. Course Topics

Rocket Systems Design is intended to be an interactive class, maximizing hands-on experience and introducing basic rocketry and aerodynamic principles, and integrating practical field operations principles, as needed. Using the instructor's previous experience at USAFA in teaching a similar rocketry course, the following sets of topics are provided and grouped according to the expected lesson delivery and team progression with their designs.

III. Syllabus & Detailed Lesson Plans

For more detailed information on the course flow, a sample student syllabus (Spring 2025) outlining course topics and task due dates is attached in *Appendix A*.

Extensibility to Rocketry Programs

This section discusses the role an introductory rocketry course, such as UAF's single-semester *Rocket Systems Design*, plays in laying the foundation necessary for developing a more in-depth course sequence and sustainable rocketry research program. The process employs a traditional *crawl, walk, run* approach to gaining competencies and mitigating risks as technical complexity and performance capabilities of rocket vehicles are increased.

Foundational Knowledge & Skills from Basic Course. Rocket Systems Design provides a sound basis for students desiring a more detailed experience in rocketry. The material contained in this course is appropriate for a single-semester entry level experience or for introductory rocketry club activities.

Motivation & Feedback. The timing of the academic materials and introduction of technical elements and activities is intended to capture the students' motivation and excitement early on and then build upon their successes with a series of increasingly more difficult challenges. The initial launch activities at the beginning of the course are intended as fairly simple, short-term and low-risk events requiring a relatively low level of involvement and providing quick feedback. As the semester progresses, the launch activities will incrementally become more complex and require increased time and commitment to complete. The sequence follows a trend of *fly* → *build/fly* → *rebuild/fly* → *design/build/fly* → *redesign/build/fly* as the course progresses.

Vehicle Performance. The course launch activities follow a progression incrementally exploring the capabilities of rocket performance. Initially, the focus of the course is to launch a simple design and just see *what it does* (observe a launch event and flow, see how high/fast/far the vehicle travels to gain an appreciation of the rocket's performance capabilities and hazards). Subsequent activities are intended to build more student interest in finding *what it can do* given rather simplistic vehicle design modifications and construction techniques. In the latter stages of the course, launch, students have accumulated sufficient design, construction, and launch experience allowing them to become more scientific in determining *what it might be possible to achieve*.

Academic, Design, Fabrication and Launch. Supporting the general learning sequence outlined above, the *Rocket Systems Design* course includes the following specific launch activities.

- Mini rocket build, launch, and debrief (LSNs 7-9). This activity is conducted using beginner, entry-level rocketry kits, such as might be used in early K-12 STEM launch demonstrations. In these kits, all pieces are prefabricated and the rocket is easy to build. This activity provides students a basic appreciation for the various components and their purposes. The kit contains low-power motors, delivering the vehicle to (generally) lower altitudes and is characterized by relatively little risk to participants with the incorporation of moderate safety considerations. The event is intended to provide students with an appreciation for safety required in motor handling and launch operations, as well as basic experience in the prediction and observation of vehicle performance.
- Small rocket build, launch, and debrief (LSNs 15-17). This activity is conducted using slightly more advanced (intermediate) kits. The intermediate kits possess more pieces that may require fabrication and a moderate level of skills needed for construction of the rocket. This activity is intended to provide a better comprehension of component designs and their functions. The kit includes higher power motors capable of propelling the rockets to a higher altitude, with somewhat more risk and care involved in the launch operations. This activity

stresses more active participation by the students in motor safety/handling procedures and launch operations and provides more emphasis on accurate prediction/observation of vehicle performance.

- Critical Design, System Fabrication & Flight Test phases (LSNs 18-39). This activity is the major portion of the students' design/build/launch experience for the semester. This phase is characterized by few prefabricated components – any of the nosecone, body, fins, motor mounts may require fabrication, depending on the student project design and parts which might be available. This requires a more detailed understanding of the effects of components and subsystems on vehicle performance and safety. Specific focus is provided on each of the subsystems (Structure/Controls/Aerodynamics, Motor/Nozzle, Recovery). This phase also requires the selection of a nominal payload with a purpose for flight and more detailed construction to integrate components/subsystems (eg, recovery system, communications, altitude sensor, payloads). This activity requires in-depth knowledge of component materials and construction techniques to optimize design performance and lifetime. The launch activity incorporates even higher power motors (but not HPR designated motors), higher altitudes, and moderate levels of risk to accomplish safely. In this phase, high emphasis is placed on motor safety/handling, detailed launch operations procedures, and the prediction, tracking, and analysis of vehicle performance.

More Complex Design Experiences. Having successfully gained the experience accumulated in the above single-semester course, more complex and capable rocket design experiences may be tackled. This level of complexity may be appropriate for follow-on single- or multi-semester design courses, research projects (involving students and/or faculty), or for more experienced club activities. These activities build upon foundational knowledge and experience accumulated over the previously described course/club activities. Through these earlier experiences the university entity will have developed important competencies in rocket design, launch, construction, and launch operations:

- Increased sense of vehicle performance capabilities & limitations
- Appreciation for the potential devastation which could be caused by the mishandling of higher-power rocket motors during storage/transportation/integration, or their failure at launch
- Detailed understanding of the effects of components/subsystems on vehicle performance & safety (structure/controls/aerodynamics, motor/nozzle, recovery)
- Appreciation for the potential impacts of vehicle performance anomalies
- Knowledge of viable design & fabrication techniques for all rocket subsystems/components
- Awareness of pros/cons of using some commercial products vs making these
- Experience with phased integration of subsystems/components within a complex rocket
- Design/integration of more advanced payloads
- Demonstrated experience and competency in
    - Motor/ignitor Safety/Storage/Transport & Range/Launch Operations
    - Often will incorporate HPR motors, requiring NAR certification

Having developed a program capable of dealing with these issues provides an excellent opportunity for students and faculty researchers alike to conduct advanced engineering, applied science research, and significant launch operations, thereby continuing to attract students, faculty, research scientists, and outside partners/opportunities for the university program.

Application to UAF Aerospace Program

Aside from the inherent 'coolness factor' associated with offering a new local course in rocketry design, there are several identifiable and important benefits to UAF. These range from the immediate positive impacts of the establishment of this course in satisfying student needs/desires; to supporting the growth and maturity of the aerospace engineering program and research capabilities for our students and faculty; and to the long-term reputation and opportunities for the UAF community.

CEM Aerospace Engineering Program. The *Rocket Systems Design* course supports the growth and stability of UAF's Aerospace Engineering Program in several ways: (1) Satisfying current student demand for a hands-on design experience within the field of aerospace engineering, specifically focused on rocketry design and launch operations. (2) Attracting prospective students, faculty, and researchers to an exciting program with a unique focus on artic applications and opportunities. (3) Supports ABET accreditation by strengthening UAF competencies in areas of aerospace design, rocketry, and propulsion. (4) Provides additional career/internship program opportunities for students (already occurring).

GI Research Programs. The new Aerospace Engineering degree program, and more specifically, this and future rocketry courses represent new opportunities for UAF's highly integrated research activities: (1) Near term rocketry launch operations will be performed at PFRR, exposing students and faculty to research assets and programs in place already. (2) The programs and courses are expected (and have begun) to attract additional research clients, partners, and collaborators. (3) Longer term launch operations with significant research potential will eventually target use of the PSC.

Next Steps/Program Goals. Beyond the goals and benefits delineated above, near term specific actions supporting both UAF's academic and research programs include: (1) Begin development of the follow-on 2-semester senior design rocketry course supporting aerospace, electrical, computer, mechanical, and civil (structural) engineers. (2) Reinvigorate the UAF SRP program with CEM & GI participation. (3) Approve the pending Master of Science in Aerospace Engineering program. (4) Ancillary efforts: (a) Continue plan for expanding UAF Aerospace Club to encompass rocketry competitions. (b) Use cadre from Aerospace Club to support appropriate K-12 outreach events.

Results & Feedback from Initial Spring 2025 Offering

This section discusses the difference between what was planned (based upon the instructor's last experience with the course over 2 decades ago) and *what actually happened* (given substantially newer materials, tools, and processes available today).

Classroom Lecture/Discussion Materials. Lectures were originally planned based upon the syllabus presented (*Appendix A*), but were adjusted based upon interaction with students, their collective experience level, advances in materials/processes available, and emergent software design tools. In this, a goal was to properly balance an underpinning of foundational knowledge with an emphasis on practical experience gained by hands-on activities.

LSN0	Course Admin	LSN8	Build 2: Apogee Apprentice
LSN1	Course Overview	LSN9	Launch Operations
LSN2	Rocket Subsystems	LSN10	Build 3: Apogee Research Express
LSN3	Model Rocketry	LSN11	Team Rocket Design Project

LSN4	Rocketry Flight	LSN12	Recovery Systems
LSN5	Rocket Subsystems	LSN13	3D Printing Designs
LSN6	Design Tools	LSN14	Clustering Motors
LSN7	Build 1: Air Rockets		

Most lesson plans took about 1 class period to discuss. The goal of these was to introduce a concept, highlight examples of the principle/technology, and provide several illustrative videos emphasizing the concept/techniques. Students were provided with copies of all lesson slides at the conclusion of their delivery in the classroom. Note that the above is not a comprehensive list of all topics discussed throughout the semester, including lab fabrication and operations meetings/discussions.

Paper Rocket Build (Individual Effort). While this event was initially unplanned, I decided to require the students to participate in a paper rocket build/launch activity. When I surveyed the students at the beginning of the course, I was surprised to find that only 2/13 claimed any previous rocketry experience. The paper rocket build was a 2-stage event, with the first introducing students to simple construction techniques and tools available in the Aerospace Systems Lab. After the first launch, students were instructed to construct 2 additional rockets with designs that accentuated the effects of changing the rocket's center of gravity (C_g) and center of pressure (C_p). This set of activities also had the secondary benefit of familiarizing students with the event, which we then employed to help with K-12 STEM events.

Mini Rocket Build (Individual Effort). This initial build was accomplished utilizing the Apogee Apprentice (Beginner/Level 1 Build). This kit was selected due to the simplistic nature of the build and the availability of excellent construction/launch instructions, including a detailed step-by-step educational video. The kit included a preformed plastic fin can and nosecone section, requiring construction and attachment of the parachute/shock cords, motor mounts, and rail guide. Motors selected included the Estes ½A6-2 for the 1st launch, as this limited the altitude to about 50-75 ft and served to proof-test their fabrication techniques with ease of rocket/component retrieval. The 2nd launch utilized an Estes A8-3 motor, with an altitude of about 175-225 feet. Prior to construction, students were required to watch the design and launch videos, as well as model the rocket in Apogee's RockSim software (or Open Rocket). Feedback from students was that, though they had initially been somewhat skeptical of the simplistic nature of the build, that they enjoyed the experience and learned valuable feedback from errors in their initial construction techniques and gained important experience in launch operations.

Small Rocket Build Part 1 (Teams of 2). This build utilized the Apogee Research Express (Level 1 Build), an only incrementally more difficult design including the construction of balsa wood fins and incorporation of a payload bay. For this build, the students were to plan for higher altitude launches using (a) Estes B4-4 motors (~250-300 ft) and (b) Estes C6-5 motors (~700-800 ft) Note: We didn't fly these altitudes for operational considerations, instead loading ballast to keep the flights below 400 ft. They would also be flying a small payload in the bay (JollyLogic 2 altimeter) which would allow for a correlation of predicted, measured (via observed angles), and actual altitude values. The build also gave students added experience with modeling in RockSim/Open Rocket and higher altitude launch operations. Students winning either the Design or Decorating categories for the Apprentice rockets were given the option to work alone on the Research Express – both winners elected to work alone.

Small Rocket Build Part 2 (Teams of 2-3 – Planned but became Extra Credit). The next build for the class was to be the Apogee Sky Metra 2-stage (Level 2 Build), a 2-stage design with more complex construction required, such as requiring fin alignment between the 2 stages. The launch would employ Estes A8-0 (1^{st} stage) and Estes C6-7 (2^{nd} stage) motors and reach an expected 1200-1300 ft altitude. This build was originally embraced by the students. However, as they became immersed in the final build project, all of the teams asked to make this build an optional event (which I agreed to). Some of the teams not completing this build later expressed some regret for their decision.

Design Project (Teams of 2-4). This final build was based upon achieving a design comparable with that of the Apogee Zephyr (Level 3 Build), utilizing an AeroTech G67/G64 series motor. These motors were selected as they adequately power the larger rocket (~4" DIA x 54" long), falling just below the High-Power Rocketry (HPR) Level 1 (L1) Certification requirements, but would drive a rocket design which could easily be used for students to gain their HPR L1 Certification in the future. For this build, teams were to create their own designs using some/all parts of the Zephyr, but were encouraged to design/create their own components. In the end, only 1 team of 5 used any of the kit components (cardboard body tube).

Several design concepts were tackled, ranging from a nearly canned build of the Zephyr, to using some components (eg, cardboard body tube and/or nosecone), to 3D printing the entire rocket. Three additional requirements I levied on the teams: (1) Use an electronic timer system capable of dual-deployment drogue/main chutes. (2) Design a secondary payload in addition to the JollyLogic 2 flight altimeter (eg, camera, atmospheric sampler…). Teams had to demonstrate a safe recovery of their rocket prior to integrating their payload system. (3) Teams had to modify their designs, as necessary, to hit altitude windows of (a) 200-400 ft, and (b) 200-800 ft as a stretch goal, while maintaining safe static margins. Teams were also recommended to consider modifying their propulsion system to accommodate various motor configurations to provide maximum flexibility with available motor choices (eg, 3x Estes D12, 2x Estes E11, or 1x Estes F15 motors).

Student Feedback. While the students overwhelmingly supported and enjoyed the class, they also spanned a wide range of technical competencies (mechanical/electrical/aerospace engineering, computer science) and program levels (undergraduate through PhD students). With this being the first offering of this course at UAF, and as we plan to use this as a springboard in developing follow-on courses and research activities, it was important for me to engage with them closely to get their feedback on the course. I did this through multiple in-class discussion periods and with an end-of-semester survey tool. Digging more deeply into the students' objective evaluations and criticisms of the course, the following high-level themes emerged:

- Course was well-received by students across the board. The general consensus of the students throughout the semester was "Rockets are cool 😎. I want to continue working with them in future educational or career opportunities."
- Course rocket builds provided good hands-on experience & opportunities.
- Final design project was scaled properly to be challenging and fun, but should be introduced sooner in the course. (I agree and will do so in future offerings.)
- Earlier/simpler model rocket builds were seen by some as being beneath their expectations for the course level, while others felt these were quite valuable to bring their skill levels up in

preparation for the final design project. This variation in difficulty seemed to be more along the lines of previous rocketry experience, rather than by academic levels of the students.
- Not enough details on propulsion and subsystems design. Students desired more background information in all areas of rocket design, but many also made mention that the current course content & workload would make it difficult to accommodate the addition of these materials.
- Several students noted that their course experience would benefit by being augmented by separate courses in rocket propulsion and subsystems. (I will look for opportunities to offer a separate rocket propulsion course at some point in the future.)

Instructor Lessons Learned/Feedback (The Good, The Bad, and The Ugly)
- Buy components well in advance. Motors above D-class are considered hazmat and require freight-forward for non-CONUS locations such as Alaska.
- Initial stocking of common tools, equipment, materials, work/storage space require some resources $$. The first time out will be hardest, then will get easier.
- Assigning appropriate lab fees to students is a difficult balance to strike.
- If you decide to tackle this for your school, you will be rewarded for your efforts.
- Rockets are cool 😎. Students know it. Faculty knows it. And school administrators know it.

Next Steps. I am pushing ahead to develop: (1) A follow-on sounding rocket course that will use larger HPR motors (solids for now) and focus on development of all rocket subsystems; (2) A multi-semester rocket design projects which may be used for senior capstone requirements; and (3) An integrated undergraduate/graduate student research program. UAF CEM academics and GI research are actively engaged in supporting the development of new opportunities in the area of rocketry and hypersonics.

Conclusion
This paper has attempted to outline the development of a single-semester rocketry course, previously proven at USAFA but introduced into a new academic environment and era at UAF. It also endeavored to show how this popular course may be used as a first step in sowing the seeds for growing a vibrant university aerospace program over time. UAF's academic and research leadership are excited about this new course addition and expect this to be a major attraction drawing new students and building research opportunities.

Finally, a huge ***Thank You!*** to the Alaska Space Grant Program (ASGP) for their generous contributions supporting this first offering of the course.

Figure 4: AERO660 Students & Faculty/Mentors at Final Project Launch, Inaugural Offering, 26 April 2025

Appendix A: Course Syllabus Materials

Meeting	Date	Chapter	Topic	Assignments/Notes
1	January 13 Monday		Course Overview & Admin	
2	January 15 Wednesday		*Foundations of Flight Phase (LSN 2-6)* Systems Engineering Design Process	
3	January 17 Friday		Rocket Subsystems Aerodynamics of Rocket Flight	
LSN	January 20 Monday	Alaska Civil Rights Day		
4	January 22 Wednesday		Rocket Motor Performance Altitude Prediction	
5	January 24 Friday		Launch Support Functions Launch Operations	
6	January 27 Monday		Fabrication Resources Laboratory Tours	
7	February 29 Wednesday		*Conceptual Design Phase (LSN 7-10)* Mini Rocket Build	Personnel Assignments Due
8	January 31 Friday		Team Design Mini Rocket Launch	
9	February 3 Monday		Team Design Discussion of Mini Rocket Launch	Draft Conceptual Design Report Due
10	February 5 Wednesday		**Conceptual Design Briefing** Feedback & Discussion	
11	February 7 Friday		*Preliminary Design Phase (LSN 11-14)* Team Design	**Conceptual Design Report Due**
12	February 10 Monday		Team Design	
13	February 12 Wednesday		Team Design	Draft PDR Report Due
14	February 14 Friday		**Preliminary Design Review Briefing** Feedback & Discussion	
15	February 17 Monday		Team Design Small Rocket Build	**PDR Design Report Due**
16	February 19 Wednesday		Team Design Small Rocket Build	
17	February 21 Friday		Team Design Small Rocket Launch	Draft CDR Report Due
18	February 24 Monday		*Critical Design Phase (LSN 18-23)* Discussion of Small Rocket Launch	
19	February 26 Wednesday		Team Design	
20	February 28 Friday		Team Design	
21	March 3 Monday		Team Design	Draft CDR Report Due

Meeting	Date	Chapter	Topic	Assignments/Notes
22	March 5 Wednesday		**Critical Design Review Briefing** Feedback & Discussion	
23	March 8 Friday		Team Design, Fab & Ops	**CDR Report Due**
	March 10-14	Spring Break		
24	March 17 Monday		*System Fabrication & Flight Test Phase (LSN 24-39)*	LPP Due
25	March 19 Wednesday		Team Design, Fabrication & Operations	
26	March 21 Friday		Team Design, Fabrication & Operations	
27	March 24 Monday		Team Design, Fabrication & Operations	
28	March 26 Wednesday		Team Design, Fabrication & Operations	
29	March 28 Friday		Team Design, Fabrication & Operations	First Launch NLT Date
30	March 31 Monday		Team Design, Fabrication & Operations	
31	April 2 Wednesday		Team Design, Fabrication & Operations	
32	April 4 Friday		Team Design, Fabrication & Operations	
33	April 7 Monday		Team Design, Fabrication & Operations	
34	April 9 Wednesday		Team Design, Fabrication & Operations	
35	April 11 Friday		Team Design, Fabrication & Operations	
36	April 13 Monday		Team Design, Fabrication & Operations	
37	April 16 Wednesday		Team Design, Fabrication & Operations	
38	April 18 Friday		Team Design, Fabrication & Operations	Last Launch NLT Date
39	April 21 Monday		Team Design, Fabrication & Operations	Draft Final Report Due
40	April 23 Wednesday		*Reporting Phase (LSN 40-42)* Clean Up, Equipment Turn-in	
41	April 25 Friday		**Final Briefing**	**Final Report Due**
42	April 28 Monday		Course Wrap Up	**Conference Paper, Team Video Due**

Bold items denote graded events.

Lesson 1 … Course Policies and Engineering Design

Lesson Outline:

1. Opening Comments
2. Discuss course materials
    a. Course overview, events/deliverables, policies
    b. Course Syllabus
3. Show films of rocket launches
4. Split section into launch teams
5. Discuss at a high level the systems engineering design process (SEDP) as it applies to this course.
    a. Talk about the importance of conducting a design effort properly.
    b. Discuss the elements of the systems engineering design process (SEDP) and relate them to a major aerospace system.
    c. Discuss problems and their impact on the design process.
6. Pass out case studies. Each team will use the following format to prepare a formal briefing to the instructor on their case studies.

Lessons 2-6 ... Foundations of Flight Phase

Lesson Outline:

1. Hand out to the students their skills review (due LSN3). This can be either:
    a. A pre-course evaluation to give students a sample for what skill sets they will need to master over the semester)
    b. A true review if students are in a curriculum (aerospace engineering…) containing these elements
2. Discuss case studies and lessons learned in previous semester of the course – what worked and what didn't, stretch goals, recommendations for future efforts.
3. Provide lectures/guided discussions on various foundational topics needed to successfully perform rocket design and fabrication and safely conduct launch operations:
    a. Systems Engineering Design Process (SEDP). Introduce students to the SEDP and various steps to serve as a roadmap for the rest of the semester.
    b. Rocket Subsystems. Discuss at a high level the various subsystems comprising a rocket system and their roles. Give examples of common components/technologies that will be used throughout the semester.
    c. Aerodynamics of Rocket Flight. Provide an overview of the aerodynamic/structural components of the rocket body. Discuss the effects of its center of gravity (CG), center of pressure (CP), static margin (SM), and spin rates on performance and stability.
    d. Rocket Motor Performance. Discuss the concepts of thrust, time of burn, and impulse and how these affect rocket performance. Discuss categories of small rocketry motors and HPR classifications (not to be used in this initial course).
    e. Altitude Prediction. Discuss means of predicting rocket altitude and apogee, as well as means of measuring/estimating these using various multilateration sighting techniques and using on-board electronics.
    f. Launch Support Functions. Discuss team support functions needed for the safe storage, transport, and launch of small rockets. Discuss storage/separation requirements for motors and ignitors.
    g. Launch Operations. Discuss the timeline/process of launch operations, including pre-

coordination tasks, team communications, communications without outside agencies (eg, FAA), countdown sequence, launch/hold/cancel, 'safe-ing' a rocket after anomalies or launch halt, and recovery after launch.

h. Fabrication Resources. Introduce students to materials, equipment, tooling, and facilities supporting their rocket design/build/test/flight/recovery activities. Explain how they can get permission for use of materials and equipment on hand and request funds to additional materials.
i. Laboratory Tours. Provide tours of all facilities supporting the various aspects of the project (eg, electrical testing/battery storage, machine shop, 3D printing, laser cutters, chute packing…).

Lessons 7-10 ... Conceptual Design Phase
Lesson Outline:

1. Summarize what we have done during the last few lessons:
    a. Analyzed the propulsive loads acting on the launch vehicle and payload systems during flight.
    b. Designed the baseline rocket and performed a preliminary analysis of its performance.
    c. Emphasize that students now have most of the tools needed to design the payloads and subsystems that will fly on their team's rocket.
2. Start work on team rocket and payload design. Reference statement of work (SoW) for requirements. For these, the students can use whatever references they can find, with the exception of previous semester's rocket/payload design projects, when working on their conceptual designs.
3. Teams are to deliver their conceptual design briefing on LSN10 and receive instructor feedback on designs. Discuss the purpose of the review within the SEDP framework and expectations for the briefing and report. Point out the baseline design project cover worksheet and highlight the relative worth of each portion of the project.
4. Show the team a sample notebook from previous rocket designs which they can use as a reference for the rest of their rocket design effort. Point out strong areas & pitfalls the previous team may have encountered.
5. Discuss the contractor competitions. The purpose for these events is to make the teams investigate design considerations and trade-offs which will maximize vehicle performance.
6. (LSN9) Collect draft (ungraded) rocket Conceptual Design Review report designs.
7. (LSN10) Receive team's Conceptual Design Review briefing & provide feedback.
8. (LSN11) Collect final (graded) rocket Conceptual Design Review report packages.
9. Hands-on Introductory Exercise. During this phase the teams will conduct their *first* build and launch of a *mini* rocket system. This will be a beginner rocket kit that is *often* used in K-12 programs and *beginning* rocketry club settings. The purpose of this exercise is to give students an *early brief exposure* to the process of rocket construction techniques/challenges and launch operations, under *minimal risk* conditions associated with a *limited complexity* kits and under a *lower-power motor* and controlled environment.

Lessons 11-14 ... Preliminary Design Phase
Lesson Outline:

1. Summarize the previous and upcoming course events/phases.
2. Emphasize the requirements for the rocket and payload designs by discussing applicable

sections of the SOW. Point out the design project cover worksheets and highlight the relative worth of each portion of the project.
3. Discuss the preliminary design as described in the SOW. The purpose is to get the students started early on the "meat" of their design.
4. Teams are to deliver their preliminary design review (PDR) on LSN14. Discuss the purpose of the PDR within the SEDP framework and expectations for the briefing and report.
5. Spend the remaining lessons being available to students and answer reasonable design questions. Encourage them to find simple solutions to their problems.
6. (LSN13) Collect draft (ungraded) rocket/payload PDR report designs.
7. (LSN14) Receive team's PDR briefing & provide feedback.
8. (LSN15) Collect final (graded) PDR report packages.
9. Hands-on Intermediate Exercise. During this phase the teams will conduct their *second* build and launch of a *small* rocket system. This will be a larger-scale rocket kit that is used in *some* K-12 programs and *commonly* within rocketry club settings. The purpose of this exercise is to give students *added practical exposure & experience* to the process of rocket construction techniques/challenges and launch operations, under *nominal* risk conditions associated with *more complex* kits and under a *larger-power* (below HPR) motor and controlled environment. This exercise will act as a bridge between the first mini rocket exercise and the more complex activities to be completed during the team's System Fabrication & Flight Test Phase.

Lessons 18-23 … Critical Design Phase

Lesson Outline:

1. Summarize the previous and upcoming course events/phases.
2. Emphasize the requirements for the rocket and payload designs by discussing applicable sections of the SOW. Point out the design project cover worksheets and highlight the relative worth of each portion of the project. [Remind students that payloads may not be integrated into the rocket (System Fabrication & Flight Test Phase) until they have successfully demonstrated their rocket's recovery system in a test flight.]
3. Discuss the critical design as described in the SOW. The purpose is to have the students nail down the final detailed design.
4. Teams are to deliver their critical design review (CDR) on LSN23. Discuss the purpose of the CDR within the SEDP framework and expectations for the briefing and report.
5. schedule adherence at the end of the semester.
6. Spend the remaining lessons being available to students and answer reasonable design questions. Encourage them to find simple solutions to their problems.
7. (LSN20) Collect the team's Management Data. It contains information used for grading.
8. (LSN22) Collect draft (ungraded) rocket/payload CDR report designs.
9. (LSN23) Receive team's CDR briefing & provide feedback.
10. (LSN24) Collect final (graded) CDR report packages.

Lessons 24-39 ... System Fabrication & Flight Test Phase

Lesson Outline:

1. Summarize the previous and upcoming course events/phases.
2. (LSN24) Give the class an in-depth talk on general lab procedures, safety hazards, and daily cleaning requirements. Also discuss materials fund usage and request procedures.
3. Remind students that payloads may not be integrated into the rocket until they have

successfully demonstrated their rocket's recovery system in a test flight.

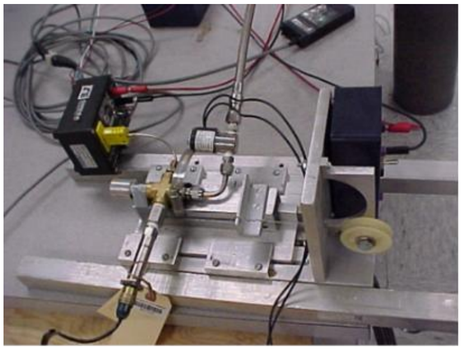
4. (LSN24) Collect the Launch Procedure Plan (LPP). Review it prior to the first Launch Readiness Review (LRR) so you can provide feedback at that time.
5. Maximize contact time in the lab with the students as they are working. Encourage everyone to contribute. Praise the movers and shakers in public and offer suggestions to improve the reliability and simplicity of their products.
6. Receive preflight and postflight briefings. Ensure that all instructors/TAs attend post launch briefings. Be sure that rockets are safe to launch; do not sign off on any system that, in your opinion, will not work. Ensure that students analyze the results of each flight and make the appropriate design changes before the next launch.
7. Go to LAUNCH SITE and review rocket launches. Award incentive points for technical achievements.
8. Be alert in the lab and at LAUNCH SITE for safety violations. Correct safety problems when you find them. Remember that you can penalize safety violations in the professional launch points.
9. (LSN29) First launch No Later Than (NLT) date.
10. (LSN38) Last launch NLT date.

Lessons 40-42 ... Wrap-up & Final Briefing

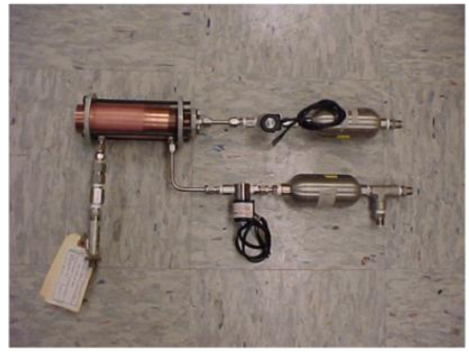
Lesson Outline:

1. (LSN39) Collect draft (ungraded) Final Reports.
2. (LSN40) Have the students turn in all equipment, empty the lockers, and clean the lab.
3. (LSN41) Receive team Final Briefing & provide feedback.
4. (LSN42) Receive final (graded) Final Reports. Comment on how well the team heeded the lessons learned last semester and the ones they presented in the case study briefings on LSN3.

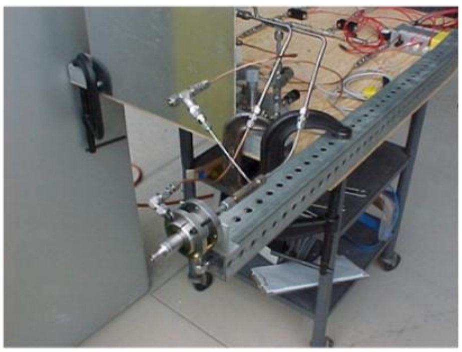
Appendix B: USAFA Rocketry Program Artifacts Influencing UAF's Future Aerospace Efforts



N_2 Cold Gas



NHMF / H_2O_2
Biprop



H_2 / O_2
S/C Thruster

PE / H_2O_2
Hybrid

Figure B1: Various rocket motor components and testing accomplished at USAFA (1999-2001)

(left) Figure B2a: USAFA-built mobile rocket launcher, construction complete and installing vehicle lighting (USAFA 2002)
(Right) Figure B2b: Small single-semester team rocket loaded onto USAFA mobile rocket launcher (USAFA 2002)

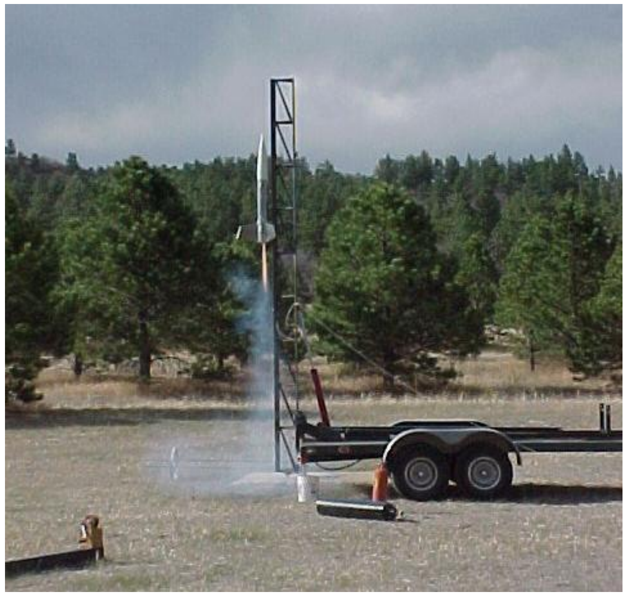


Figure B3: Small single-semester team rocket launching from USAFA mobile rocket launcher at Jack's Valley (USAFA 2002)

(Left) Figure B4a: Small single-semester team rocket in recovery under chute (USAFA 2002)
(Right) Figure B4b: Small single-semester team rocket remnants after recovery failure (USAFA 2002) (courtesy, USAFA/DFAS)

Figure B5: loading FalconLaunch-I (Humble Rumble) vehicle onto USAFA mobile launcher (Pinion Canyon Tank & Artillery Range 2003) (courtesy, USAFA/DFAS)

Figure B6: FalconLaunch-IV motor test fire (USAFA 2006) (courtesy, USAFA/DFAS)

Figures B7a & B7b: USAFA FalconLaunch-IV vehicle on mobile launcher (San Nicoles Island, CA 2006) (courtesy, USAFA/DFAS)

Appendix C: Acronyms

A&D	Aerospace & Defense
AGL	Above Ground Level
AIA	Aerospace Industries Association
AIAA	American Institute of Aeronautics & Astronautics
ASEE	American Society of Engineering Educators
ASGP	Alaska Space Grant Program
Cg	Center of Gravity
Cp	Center of Pressure
CDR	Critical Design Review
DFAS	Dean of the Faculty/Department of Astronautics (USAFA)
HPR	High Power Rocketry
IEEE	Institute of Electrical & Electronics Engineers
LPP	Launch Procedure Plan
LRR	Launch Readiness Review
LSN	Lesson
MSL	Mean Sea Level
NAR	National Association of Rocketry
NLT	Not Later Than
PDR	Preliminary Design Review
PFRR	Poker Flat Launch Range
PSC	Pacific Spaceport Complex
SEDP	Systems Engineering Design Process
SME	Subject Matter Expert
SoW	Statement of Work
SRP	Student Rocket Program
TA	Teaching Assistant
UAF	University of Alaska Fairbanks
USAFA	United States Air Force Academy

Appendix C: References

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