

Formation of the Citadel Aerospace and Rocketry Student Organization

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Abstract

The formation of the Citadel aerospace and rocketry student organization will provide extracurricular educational, applications, and professional development. The organization will also foster engagement within the Citadel community via multidisciplinary participation of faculty and students. The Citadel rocket club is a student-led club that was officially founded in the Fall of 2020 and is comprised of students from the Corps of Cadets, as well as veteran and evening undergraduates. It is an interdisciplinary club that includes students from both the Mechanical and Electrical Engineering programs at the Citadel. The club is heavily focused on research and development of new methodologies to improve rocket design through modeling, software simulations, and test launches. Students involved in the club also learn and participate in several sub-disciplines for rocketry design. This includes structures & integration, payload & recovery, propulsion, flight aerodynamics, and avionics. Each project built will strictly adhere to safety protocols and provide an educational outreach to understand the applied aerodynamics in rocket construction. The goals of each project are to further develop research and education for aeronautical engineering along with competing in collegiate competitions, along with participation in community outreach programs for primary and secondary education. The club initiatives and competitions will also be integrated into Mechanical and Electrical Engineering senior design projects. Overall, The Citadel rocket club aims to provide participating students the critical opportunity to gain an advanced understanding of rocket fabrication techniques and practices.

Key words

project-based learning, service learning, interdisciplinary education, rocketry, aerospace

Introduction

The formation of the rocketry club is an ongoing interdisciplinary effort between the Mechanical and Electrical Engineering departments at The Citadel, founded by day and evening students, veteran students and Cadets, with a primary adviser from Mechanical Engineering and co-adviser from Electrical Engineering. The veteran student lead formation of a rocketry club has been shown to have success in the past [4] and the development of rocketry projects engages students solve problems [1,5]. Competitions extend the project-based mindset of the club and allows for the student participation to meet professional development as students participate in a public forum as competitions similar to Spaceport America and the NASA rocket competitions [1,5]. The competition also has the potential to broaden participation and opportunities continuous explore the subject of rocketry as part of a larger community of competitors. [5] The responsibility of student organizations to give back to the community is common and can take the form of k-12 and other outreach activities [2,3]. The presence of an interdisciplinary student

organizations such as a rocketry club has the potential of generating opportunity for students and the educational institution in general

Club formation

Generating Interest

The first part of founding a club is generating interest. This was done early in the fall of 2020 by focusing on two aspects: first, showing students the amount of interest, investment and ambition that has been put with world's big corporations in this field to land on and occupy Moon and Mars. As these projects are very challenging and are on the leading edge of technology, excites and attracts passionate students. Also, we presented a list of growing number of companies that are getting involved in these projects to show them growing number of job opportunities that exists in this field for them upon graduation.

Second, we focused on nature of club activities, in which student take all responsibilities. We showed them this is unique opportunity for them to build upon their confidence to get leadership and responsibility for starting and running an organization on their own. This is very different from classroom experience where everything is provided by instructors to students. It was communicated to students that they are responsible for all stages, from doing the research on obtaining required knowledge, figuring out appropriate methods to build and test, participating in competitions and recruiting new members for sustainability of the club. For those students with leading and managing preferences, acted as an incentive. The club was started with 7 students including cadets, evening students and veterans.

Hands-on Activities

After attracting enough number of passionate students, the focus of club was to engage students in building activities and hand-on skills. This is one of main reasons students join the clubs in general, so in early stages we moved to this phase by purchasing starter kits to keep that passionate in the club alive. This also was fastest way to familiarize the student with different components of a rocket and how to assemble one. Students were split into groups of 3-4 and each group was responsible to choose its own starter kit and assemble it and launch it.

Financial Resources

As mentioned before, including building activities in early stage of club formation is crucial to continuity of the club. Deciding on having starter kit for each group required financial resources to support it. To have enough financial supports, few months after formation of club we started reaching out to different companies and applying for grants. We were able to receive a \$10,000 grant from NASA that supported all club activities for the first year and partially second year.

Recruiting

To make the club sustainable, we started recruiting new members from second semester of operation. We asked all engineering departments in School of Engineering send an email and distribute the flyer among the students. We also asked instructors to promote the rocket club in their courses. In some courses, rocket club members presented for the class and talked about

opportunities and plans for the club in upcoming semesters. We also participated in on campus events and poster sessions to make our presence known within that community.

Competitions

For any organization or club, it is suggested to set a goal to direct club activities in specific direction. Participating in competitions both set the annual goal for the club and also challenges the club to do its best to earn decent standing in the competitions, so it pushed club along with directing the club activities in a specific direction. In second year, we signed up for biggest collegiate rocket competition in the world with more than 151 teams from 16 countries participating in it [6]. This was very helpful decision because many specifications for a rocket is set with competition rules, so following those rules narrowed the requirements needed for the rocket and helped the club to set the goal easily. Many new clubs may have hard time setting annual goals and coming up to the detailed requirements for their rocket and launches. As requirements and rules are set with competition, it is suggested to participate in an appropriate competition to have annual plans for what is going to be accomplished.

Resource Allocations

One of key factors in success of student team works based on several experience in multiple student projects we had, is assigning students with specific skills/interest in corresponding rules. In the rocket club, students with hands on skills were assigned in fabricating process, students with research passion were responsible to research and find out about different competitions and opportunities, students good in communication skills promoted and expanded the club connections and those interested in visual arts helped in creating flyer and logos. At the end of each year, to make sure all are sharing their experiences in different field they got involved, we ran series of workshop in which each group presented their accomplishment for the rest of the club in a step by step process to pass those experience to others.

Chartering the Club

To formalize the club and be listed in college clubs list, we chartered the club in the second year of operation. This was important for us to be able to get college level financial supports from The Citadel and make the presence known to all student population on campus. It is suggested this stage be done in later years like 2nd or 3rd year as documenting may not interest many students and few get involved in this process.

Progress

Initial Launches

First, we applied for FAA waiver for Class 2 High Power Rockets [7]. The Class 2 High Power Rocket requirements are 14 CFR 101 section of the FAA manual. To apply for waiver form FAA 7711-2 [8] and annual launch schedules must be sent to FAA. After approval, for each launch rocket club must contact FAA agent three times: 48-72 hours before launch, 1 hour before launch and 15 minutes before launch. The club was able to have permission to launches its rockets up to 10,000 ft from North Charleston auxiliary Air Force base. One semester after club formation, The Citadel rocket club was able to make its first launch in February 2021, demonstrating

significant progress. In April 2021, the club had two more successful launches as well (see **Figure 1**). Also, three members of club became Class I certified rocketeer. These launches were all were single deployments. One dual deployment attempt was made but was not successful.

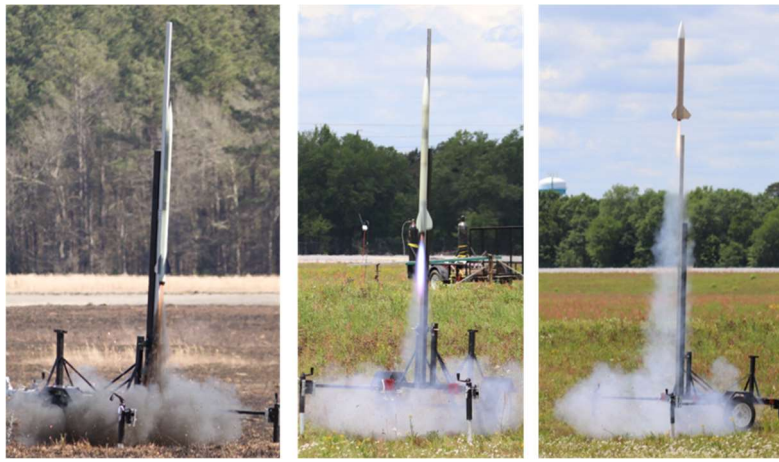


Figure 1. Three launches The Citadel rocket club had in April and May 2021. All three launches flew around 2000 ft.

Spaceport America Cup 2022

At the beginning of club formation, club set the goal to be able to participate in Spaceport America cup, biggest intercollegiate rocket competition in the World. More than 200 teams applied for the competition in 2021 and 151 teams were admitted, where The Citadel rocket club was one of 151 admitted teams. These teams are from 16 different countries (38 from US) and competing in six different categories:

-10K Commercial off the Shelf Components:

-10K Solid Rocket-Student Research and Developed Components:

-10K Hybrid/Liquid Rocket-Student Research and Developed Components:

-30K Commercial off the Shelf Components:

-30K Solid Rocket-Student Research and Developed Components:

-30K Hybrid/Liquid Rocket-Student Research and Developed Components

The Citadel rocket club is competing in 10k Commercial off the Shelf Components. Competition rules require all rockets have dual deployment and scientific payload not less than 8.8 lbs. and successfully fly up to 10,000 ft. Also, descend velocity should not be greater than 30 ft/s.

Multidisciplinary Involvement

Although the Citadel rocket club started in the Mechanical Engineering Department, it engaged different laboratories and departments in its activities such as Department of Electrical and Computer Engineering. After the initial launches, rocket club started using the material laboratory for making airframe, fins and strengthening the fins from composite materials (e.g. fiberglass and fibercarbon) as shown in **Figure 2**. Spaceport America cup required dual deployment with scientific payload, for the payload section students at the Electrical Engineering Department are working to make CO₂ measurements during the descend of the rocket. Also, students from Physics department has joined the club and rocket club is planning to engage Physics Department in near future as well.



Figure 2. Tip-to-tip carbon fiber reinforcing for the rocket fins done in the materials laboratory.

Recruitment Challenges

The student population at the Citadel is formed into three groups: 1-cadets, 2-evening students and 3-veterans. Due to military nature of The Citadel in which cadets are forming majority of student population and have small amount of free time outside classroom to allot for extracurricular activities, there has been some challenges in cadet recruitment for the club. Evening student population is limited and usually they are citizens who work in the day time and doing school at the evening which leaves minimum extra time for them during the day. Veterans are only group that they are doing the school but their number is limited in classrooms. This made big challenge for the rocket club to recruit new members. Currently, rocket club is formed from cadets, evening students and veterans although majority of leadership and management is done with veterans and evening students.



Figure 3. The Citadel rocket club is formed from cadets, veterans and evening students.

Critical Considerations

In rocket design, it is very important that center of mass be above (closer to nose cone) the center of pressure. This makes sure that rocket will have stable flight and not tumble about its center of mass. The stability number must be above 1 but for all of our rockets we considered a number between 2-3. Note that we do not want an over-stabilized rocket as stability number above 4 will cause weather cocking in a windy day which is unfavorable. To calculate stability number, we used Open Rocket software and did simulations to predict flight altitude, lateral drift and launch time to have estimate for rocket operations beyond lift off. Launch time is required to use proper amount of ejection charge to make sure deployment occurs exactly at the apogee.

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Manuel Millare is a bachelor's student in the Mechanical Engineering Department at the Citadel, with an expected graduation for 2022. He has been accepted into the Electrical Engineering graduate program, expected to graduate in 2024.

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