Julianne Owen’s Portfolio

Included:

- Project Proposal from Professional Communication for Engineers
    - Co-authors David Watt and Michael Milone
- Written Contributions to UF’s Rocket Design Team
    - Procedures
    - CDR Report Requirements

501st Legion of Engineers
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December 6, 2020

UF Contracts and Grants
300 SW 13th St.
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To the Office of Contracts and Grants:

On November 1, 2020, a Request for Proposals was received from the University of Florida's Office of Sponsored Research, the U.S. Department of Commerce, and the U.S. Department of Energy regarding the creation of new research opportunities for emerging technologies. The Request stated that proposals should improve the quality of life of American citizens, or the quality and competitiveness of American industry in the global marketplace. Attached is a proposal written by the 501st Legion of Engineers in response to the request.

With the advent of commercial and private space exploration initiatives, such as SpaceX, the progress being made in the aerospace industry is unparalleled. However, there are few places where these companies can effectively operate. So, to facilitate the advancement of these companies and technologies, more space centers must be built.

But, despite being home to a regional airport and a Space Grant University, Gainesville, Florida does not have a space center. The 501st Legion, comprised of three Aerospace Engineering students, proposes the modification of Gainesville Regional Airport to support Air-Launch to Orbit operations. This will be known as the Gainesville Air-launch To Orbit Research Center, or GATOR Center. These operations involve launching a rocket from an airplane at a high altitude, alleviating the need for a launch pad or a first stage. Improvements to the airport will come as more hangars, storage facilities, and reinforcing the runways.

This will be an investment for local education, business, aerospace research, and the country. Several companies currently possess the technology to operate from the proposed space center, and the infrastructure to support newer vehicles will be there when their time comes. The members of the 501st Legion can be contacted below regarding questions about this proposal.

Best,

Michael Milone   Julianne Owen   David Watt

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December 9 2020

GATOR Center

Gainesville Air-Launch to Orbit Research Center

Michael Milone
Julianne Owen
David Watt

Executive Summary

May 30th, 2020, was the first time in history that a private company, SpaceX, sent two American astronauts into space. If this event should prove anything, it proves that private space companies are and will continue playing a role both in the global economy and in future events in space.

The largest part of private space endeavors is the satellite market. More than ever, satellites are being launched to collect data of Earth and space, and a lot of money is being made. Companies are searching for the most innovative and cost-effective method of launching rockets, and there is no shortage of ideas. Ranging from traditional rockets to spaceplanes, almost anything goes. However, private space companies are limited to only a few cosmodromes, or space centers, to conduct operations from. Most of them are owned by the national government. Logically, with the potential market of private spaceflight, it is natural that these companies be given room to grow.

Being home to the University of Florida and its own regional airport, Gainesville, Florida, is a city that bears much consideration for a potential space center. In fact, many residents of the city would support building one. There are also the large economic and educational benefits that will come with it, serving as a catalyst for jobs. These could be in the engineering field or, more indirectly, in supporting the center's operations, like services to the center's employees. Conversely, there is concern about the environmental effects of such a center.

To address the needs and concerns about a space center in Gainesville, both sides must be included in the solution. Consequently, the proposed space center will cater to the needs of Air-Launch to Orbit rockets. That is, rockets carried into the air by an airplane and subsequently launched at 40,000 feet into Low-Earth-Orbit. The center will be called the Gainesville Air-launch To Orbit Research (GATOR) Center. This solution can be incorporated seamlessly into Gainesville Regional to provide a low-profile solution. Currently, the rockets launched this way are able to carry small satellites and fit under the body of a medium airliner. Launches can fit in between scheduled takeoffs for commercial and general aviation without disruption. All that is needed to facilitate the current technologies out there are just a few hangars and storage facilities, which can easily be added to the airport. Of course, improvements will need to be made in order to support larger-scale operations, which are in development now. The asphalt runway will have to be upgraded to concrete, increasing the weight capacity of the runway and allow larger planes with larger rockets to take off. Moreover, the potential space center will be able to support tourism. There are many opportunities for zero-gravity experiences, as well as trips to the edge of the atmosphere, like with Virgin Galactic's SpaceShipTwo.

By funding GATOR Center, the number of jobs in and around the center will create huge economic growth for the city of Gainesville, as well as research and internship opportunities for University of Florida students and staff. GATOR Center will make Gainesville a gateway to space and play a significant part in the future of space exploration.

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Problem Statement

On November 1st, 2020, the 501st Legion received a request for a proposal that would stimulate research at the University of Florida. One of the most innovative research sectors lies within the aerospace industry. As the aerospace industry has grown, so has the significance of space centers [1] [2] [3].Space centers serve as important hubs of research and advancement. They are especially effective when placed within the proximity of research institutions and universities [1] [4]. Even though Gainesville, Florida, has a regional airport and a Space Grant University, the city does not have a space center, and is currently unable to take advantage of the numerous opportunities associated with space complexes. This is an issue that needs to be addressed for the University of Florida to continue to uphold its reputation as a premier research institution with close ties to the space program. Furthermore, this project could also satisfy the residents of Gainesville. The opportunities presented by the implementation of this program provide immense incentive for its funding.

The construction of a space complex would have many educational, economic, and environmental impacts on a college town, like Gainesville. The educational opportunities provided by a space complex would benefit students at both the University of Florida and nearby scholarly institutions, as it would increase access and interest in the aerospace industry [4] [5]. The complex would also provide new training opportunities and promote the advancement of scientific research, leading to improvements in technology and advancements that would benefit manufacturers [1] [2] [4] [5]. Developments within the space industry have positive effects on the economies of other sectors, leading to more jobs [5] [6]. A new space complex has the potential to boost Florida's economy and increase general socio-economic productivity in the United States [6].

The 501st Legion proposes a modification of the Gainesville Regional Airport to support Air-Launch to Orbit operations. This will be done by improving the Gainesville Regional Airport, refurbishing its runways, and expanding its facilities to accommodate research equipment and vehicles. A diagram of the Gainesville Airport with the proposed expansions is depicted in *Figure 1*. To create an environment that facilitates research and innovation, this proposal highlights the importance of including an aviation training center, hangars for spaceplanes and their payloads, a fuel storage facility, and runway renovations. Also included are plans for operation which address company management, collaborations, and practices. As the proposal would directly improve the quality and competitiveness of the American aerospace industry, this project should be given top priority.

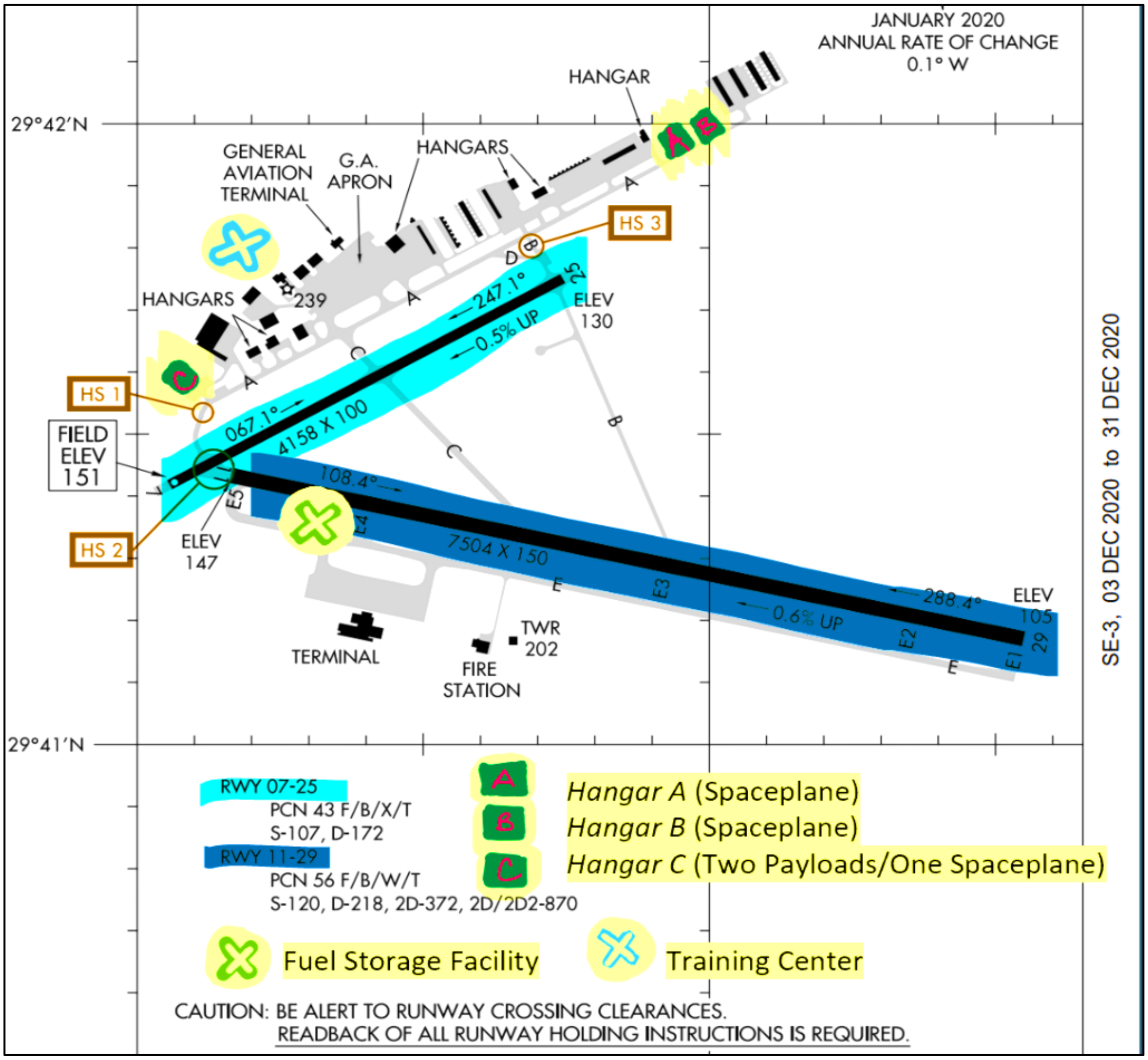


Figure 1: Diagram of Gainesville Regional Airport and proposed project additions [22]

Background Research

Introduction

With the growing significance of aerospace engineering, commercial aerospace companies have been able to provide much change, both good and bad, to surrounding communities [2] [5] [7]. Space centers provide boosts to the economy [2] [6] [7]. More jobs are created in manufacturing, with greater pay, and tax revenue increases with more company business that now must be regulated [6]. Space centers have had a hand in indirectly improving agriculture, meteorological forecasts, and satellite detection [2] [8]. The environment has also benefited from more efficient fuel in spacecraft [3]. Space centers also provide more educational opportunities through research collaborations and internships [1] [4].

However, space centers are not perfect. Economically, investments can be used poorly, canceling out any benefits to residents [2] [7]. Environmentally, rockets can still create strong carbon emissions and debris without proper usage [3] [8] [9]. To be a successful community, a town or city must provide opportunities for all residents. Universities can dominate public funding though, leaving residential areas, local job markets, and infrastructure in disrepair. Therefore, it is important to ask if there is a way to build human capital and improve the shortcomings of college towns. Can constructing a space center in a college town community benefit it with economic opportunities for residents, environmental improvement, and educational boosts?

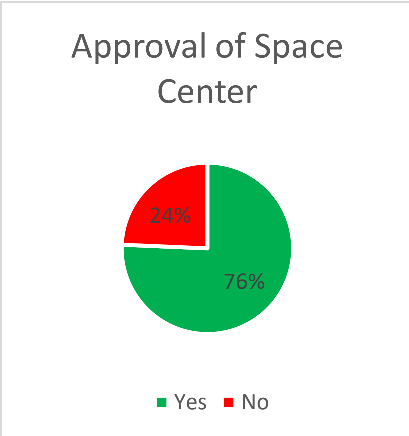
Methodology

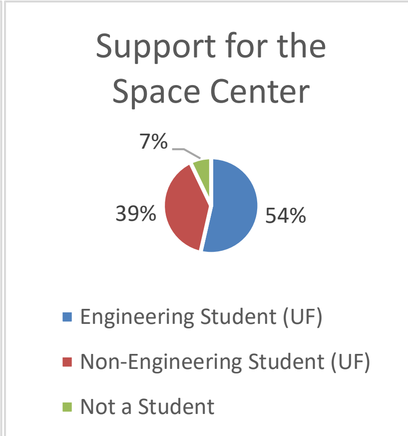
To determine if the construction of a space center is beneficial to a college town community, a survey was created to sample public opinion. Anyone could participate as occupation, age, ethnicity, and gender were not factors in choosing a sample. The survey was distributed through online formats such as social media and online group chats. It began with questions identifying participants by their residency and education. From there, participants were asked if they supported the creation of a space complex. They backed up their statements by commenting on educational, environmental, and economic impacts (see Appendix for complete survey). Once all data was recorded, binary responses were organized to compare demographics and stances. Each participant's free responses were interpreted to determine how they felt about a space center's impact on education, the environment, and the economy. If enough support is raised, research can be done on real life examples of recently built space centers to design a facility that addresses all concerns of Gainesville residents.

Information on environmental, economic, and educational effects of constructing a spaceport, was be found using the Elsevier Science Direct search engine and Google Scholar. Search terms included: "Spaceports", "environmental effects of spaceports", "educational effects of spaceports", "Camden Spaceport", "new spaceport", "case study in space centers", and "economic effects of spaceports". Articles were used if they provided real world examples of space centers that complement survey responses and aid in the construction of a new complex.

Results

Out of all participants, seventy-six percent approve of building a space center. Non-engineering students accounted for twenty-two percent of all who did not support a space center. However, four times as many non-engineering students would support a space center rather than not. Predicted effects of a space center varied more. The ratio of expected positive to neutral or negative impacts in education is 11:1. Forty-nine percent of participants believed the economic impact would be positive, with the rest being unsure or predicting negativity. However, eighty percent of all negative expectations across all factors related to the environment. Regarding the environment, eighteen percent more participants believed impacts would be negative as opposed to neutral. None expected a positive impact.





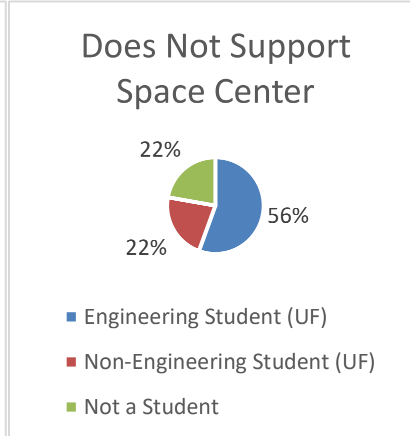


Figure 2 (left): Responses for if a Space Center should be built

Figure 3 (middle): Demographics of all participants that support space center construction

Figure 4 (right): Demographics of participants that do not support the space center

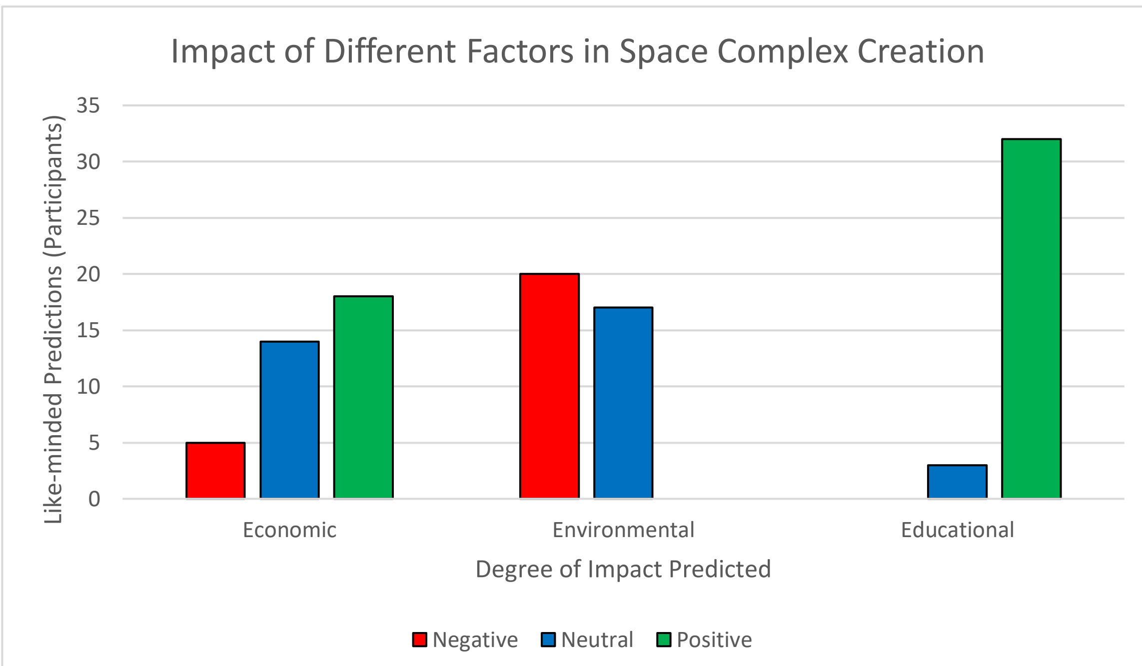


Figure 5: Predicted impacts of factors on Gainesville

Discussion

The following question was asked: Can building a space center within a college town improve the community and its prospects? Most surveyed participants believed that a space center would improve life for residents and students of the Gainesville community. They were positive about educational benefits but had worries about the environment post integration. Predicted economic impacts, however, were spread across positive, neutral, and negative, with a majority being positive. Participants are therefore cautiously optimistic. The newly hypothesized space center must play to the strengths it may offer but cannot allow for the detrimental faults predicted by the community.

One real world example to be inspired by is that of Virgin Space Flight. This private company launches rockets from the air. Payloads are released from the wing of a seven four seven airplane, carrying satellites into low orbit [10]. Space planes like Spaceship One offer a different solution. Space planes are aircraft capable of escaping the atmosphere and reentering it, needing only a light and reusable apparatus to do so [11]. Both solutions eliminate stationary launches, opting for democratized use. Since these launches can be carried out with mobility as opposed to stationary launch pads, it would be possible to modify an existing airport into a pseudo space center to compensate for them. A newly built facility would be unnecessary. This unique approach reduces costs, maintains a scale capable of communal interaction, and produces a platform for innovation in efficiency [7] [10] [11].

Technical Plan

Gainesville Regional Airport: Current Day Assessment

It is important to consider the many requirements of supporting space travel. For one, there must be proper storage for the rockets, their fuel, the carrier aircraft, experiments, and the payloads to be launched into orbit. None of this would matter though, if the runway was not able to support the carrier aircraft and her payload. Therefore, it must be sufficiently strong, long, and wide. Proper takeoff distance will ensure that the airplane is safely in the air before reaching the end of the runway. Additionally, should the plane need to abort takeoff or land, the runway has to allow the plane to come to a complete stop before taxiing back to the hangar. Moreover, the runway has to support the heavy load of the aircraft, the rocket, and their respective fuel.

Given these requirements, the most logical path to constructing a space center in Gainesville would be to assess the ability of the current facilities. According to an FAA Airport Master Record containing the details of a 2019 inspection, the Gainesville Regional Airport has two runways: 07/25 and 11/29. Their dimensions and qualities are as follows:

	General Specifications				Gross Weight Strength of Runway with Regard to Landing Gear Type (lbs.)			
Runway	Length (ft.)	Width (ft.)	Surface Type and Condition	Surface Treatment	Single Wheel Landing Gear	Dual Wheel Landing Gear	Dual Tandem Landing Gear	Double Dual Tandem Landing Gear
07/25	4,158	100	Asphalt Fair	Grooved	107,000	172,000	N/A	N/A
11/29	7,504	150	Asphalt Good	Grooved	120,000	218,000	372,000	870,000

Figure 6: Current Dimensions and Qualities of Gainesville Regional Airport [12]

By taking these qualities into account, the compatibility of current Air-Launch-to-Orbit systems can be assessed. There are several systems in use now or proposed for the near future. Northrop Grumman’s Pegasus rocket, Virgin Galactic’s WhiteKnightTwo/SpaceShipTwo, and Altair, a project by the European Commission, are some of these. The Pegasus rocket is used to launch small satellites of 450 kilograms from the underside of a Lockheed L-1011 named Stargazer [13] [14]. The L-1011 is a wide-body trijet with a dual tandem landing gear configuration [15]. Unfortunately, there is no recent information available about the plane, so it is necessary to use a modern-day comparison**.** Fortunately, the Boeing 767, albeit only having two jets, is a widebody airliner that is close to the dimensions of the Stargazer, and has a dual tandem landing gear configuration [16]. According to official Boeing technical specifications, the 767 has a length of 180 feet and a wingspan of 156 feet, having a maximum takeoff weight of around 412,000 pounds. Maximum takeoff weight is the total weight of the plane itself, fuel and reserve fuel, cargo, passengers, and pilots [17]. The 767's Maximum Takeoff Weight can be used for the L-1011 with the Pegasus rocket because the rocket itself can weigh up to 51,000 pounds.

With this in mind, the 412,000-pound takeoff weight of the launch system can be used as a baseline for most Air-Launch to Orbit systems. Runway 11/29 at Gainesville Regional is not capable of reliably supporting this load. Infrastructure improvement is required if Gainesville Regional Airport is to have a space center. In addition, there must be proper facilities for maintaining all vehicles involved. That means the rockets themselves, the carrier aircraft, any spaceplanes, and any space tourism planes [1] [18].

Arguably the most important facilities will be the ones storing the fuel for both the carrier aircraft and the launch vehicles. Rocket fuel is very volatile, and there would be severe consequences should an accident occur. To ensure that such a situation would never happen, there needs to be propellant storage tanks or facilities that can reliably stand up to harsh temperatures, weather conditions, and pressures from the fuel inside. This would also apply to the jet fuel that the carrier aircraft uses. Ensuring redundant safety measures is key to operating a safe and efficient space center [1] [18].

Likewise, hangars need to be built to house the carrier aircraft when not in use, and for the assembly and storage of rockets and their payloads. A Boeing 767 is 180 feet long and has a 156-foot wingspan [19]. So, the hangar must be more than large enough to accommodate the plane itself, the tools required to maintain it, and the parts needed to ensure a successful launch. The hangars housing rockets should have the same dimensions, so multiple operations can take place simultaneously [18]. But Gainesville Regional Airport does not have the size nor the number of hangars available, so they must be built [12].

A control center is necessary to keep track of the launch and ensure the success of the mission. Gainesville Regional Airport does have Air Traffic Control [12], but that is not equipped to guide systems meant to reach orbit. Though, ATC will serve a purpose in enabling the carrier aircraft to take off. Logically, ATC and the control center will coordinate.
Tourism and training centers are other ways to generate excitement, investment, and income for the space center [1] [2]. There could be dedicated flights merely taking passengers to the edge of space, flights allowing passengers to experience zero-gravity, and of course, training for pilots and engineers. These improvements would call for a training center to also be built [1].

Analysis of the current capabilities of the Gainesville Regional Airport shows there is a lot of work needed to reliably support space operations. This project will be an investment to the community of Gainesville itself, the state of Florida, and the United States. It will bolster the development of new and more efficient ways of reaching space, and it will act as a center for education and science. Moreover, the improvements to the runway will simultaneously allow for bigger flights into and out of Gainesville, further increasing its prominence on the global scale. These additions will lay out the necessary infrastructure to support spaceflight long into the future. As projects and systems become bigger and more ambitious, the Gainesville Space Center will be able to support them and their operations where other space centers and spaceports cannot.

Construction and Refurbishment of the Facility

1. Reinforce the main and secondary runways with concrete.
   The main runway of the Gainesville Regional Airport is currently asphalt [12] and needs to be concrete to support the mass of the spaceplanes [20]. Additionally, the secondary runway will also be refurbished. The refurbishment of the runways will be completed according to the proposed outline:
    a. Contact a contractor for design, materials, and labor
        i. The design of the new runways will be completed primarily by civil engineers, with aerospace engineers offering input on how to rebuild the runway to better support spaceplanes and rockets.
    b. Receive a cost estimate
    c. Receive funding
    d. Demolition/stripping of old runways
    e. Construction/pavement/refurbishment specifically tailored to the spaceplanes
        i. Construction and manufacturing will be completed through contracted companies, and will be funded by investors, private launch companies, and sponsors.
    f. Relight the runway
2. Construct a fuel storage facility
    a. Contact a contractor for design, materials, and labor
        i. The design and specifications of the new fuel storage facility will be completed primarily by civil, chemical, and mechanical engineers, with aerospace engineers offering input on how to modify aspects of the current airport to better support spaceplanes and rockets.
    b. Receive a cost estimate
    c. Receive funding
    d. Construct new facility just for spaceplane fuel
        i. This will be done by expanding the capacity of a current fuel storage tank
        ii. Construction and manufacturing will be completed through contracted companies, and will be funded by investors, private launch companies, and sponsors
        iii. Rockets should be fueled by private companies prior to arrival
3. Construct three hangars to house aircraft and spacecraft
    a. *Hangar A* to house one Spaceplane
        i. Contact a contractor for design, materials, and labor
            i. The design and specifications of the hangar will be completed primarily by civil engineers
        ii. Receive a cost estimate
        iii. Receive funding

iv. Construct a 215’x250’ hangar for a Spaceplane (dimensions are based off a combination of Boeing 747 and B-52 (both of which have been used as motherships)

b. *Hangar B* to house one Spaceplane
   i. Contact a contractor for design, materials, and labor
      i. The design and specifications of the hangar will be completed primarily by civil engineers
   ii. Receive a cost estimate
   iii. Receive funding
   iv. Construct a 215’x250’ hangar for a Spaceplane

c. *Hangar C* to house two payloads (rockets)
   i. Contact a contractor for design, materials, and labor
      i. The design and specifications of the hangar will be completed primarily by civil engineers
   ii. Receive a cost estimate
   iii. Receive funding
   iv. Construct a 215’x250’ hangar to hold the spacecraft
      i. This hangar has the same dimensions as the Spaceplane hangars as it can double as a Spaceplane hangar

4. Construct a training Center for instruction and tourism
   a. Contact a contractor for design, materials, and labor
      i. The design and specifications of the training center will be completed primarily by civil and mechanical engineers, with aerospace engineers offering input on how to modify aspects of the current airport to better support spaceplanes and rockets.
   b. Receive a cost estimate
   c. Receive funding
   d. Construction of center for training for operation of the launches, operation of flights, astronauts (Vomit Comet)
5. Complete Non-destructive testing on the structural soundness fuel storage facility, hangars, and training center
   a. Civil engineers will test the structures throughout and post construction.

Operations and Day to Day Use

The Gainesville Space Center is run on several different levels, with varying degrees of cooperation between the University of Florida, workers, and third-party businesses.

1. Staff
   a. Office Department
      i. The head team consists of a director of the facility, each project lead, and maintenance lead. Office workers serve under this team in addition to all tour guides. Office space provided by the training center.
      ii. In charge of all transactions between companies renting hangar space for use as well as guided tours. Rentals are quarterly but can be extended.
      iii. In charge of training.
      iv. Budget and earnings announced annually.

v. Corporate appeals for third party cooperation are sent to the board of investors of the 501st Legion. These appeals may include requests for equipment, collaboration, or expansion.
vi. A system of hiring workers, temps, and interns is made by staff.

b. Project Department
i. Every aircraft or spacecraft currently owned or rented is assigned to a research project.
ii. Each project has a lead manager, who runs their team and represents them in the office.
iii. Subsequent rankings and responsibilities for employees on the same team are designated by the lead manager.
iv. All work and workspace are found in one of three hangars for each project.

c. Maintenance Department
i. Head of maintenance staff is in charge of all aircraft, spacecraft, and facility repair. Designates hired staff where needed.
ii. All hires must have a technical background in engineering unless they work in facility or structural maintenance.

2. Project Launches

a. Pre-Launch
i. A project launch may utilize an owned aircraft or rented equipment from any company of any clout.
ii. All ordered parts and vehicles must be obtained before a project begins.
iii. Construction and research are conducted as necessary.
iv. The launch date is announced publicly.
v. Testing dates and use of runway space must be scheduled quarterly with the Gainesville Airport. In the event of negotiations, the 501st Legion executive board steps in due to ownership.
vi. A launch window consists of up to three weeks with no flights from the Gainesville Airport allowed for six hours of each day of those weeks.

b. Launch Day
i. Runway clearance is double checked. Launch window is ensured.
ii. Communication is made with residents and constituents of potential landing sites.
iii. Spectators pay a fee to watch at the launch at safe distance.
iv. The launch is conducted when airplanes have cleared the skies.

c. Post Launch
i. If a reschedule is needed, it is to be done.
ii. Aircraft/spacecraft are collected after landing.
iii. Repairs can be assigned and scheduled for vehicles to be reused.
iv. Failure analysis is conducted where needed, as is a press briefing by the office department.
v. Rented equipment is returned by the end of the quarter.

3. Maintenance

a. Runways
i. Daily sweeping and cleaning by staff.

        ii. Vehicles needed for transportation and cleaning are assigned if available, appealed for if not.
        iii. Bimonthly inspections of infrastructure and quality of runways.
        iv. Maintenance department is encouraged to work with that of the Gainesville Airport.
    b. Aircraft
        i. Staff are assigned repair jobs by project leads.
        ii. Daily inspection of aircraft and spacecraft.
    c. Hangars
        i. Janitorial staff work daily.
        ii. Equipment inspection carried out by approved staff members of project teams.
        iii. Hanger bay functionality inspected weekly.
    d. Training Center and Office Space
        i. Janitorial staff cleans daily.
4. University Collaboration
    a. Professors
        i. Invited to work with project teams and are given sole leadership in research development if approved by the 501st Legion board.
        ii. If so, they are considered part of the office team.
    b. Organizations
        i. All school organizations of the engineering field are on call. Quarterly communications are made by the office staff to create opportunities.
        ii. Additional organizations that contact the Gainesville Space Center will be added to the list.
    c. Interns
        i. The office staff work to make yearly posts for intern jobs as well as an appearance at the UF Career Fair.
    d. Volunteers
        i. Any student with a desire to volunteer can contact the office staff from the main website.
5. Economic Outreach
    a. Hires
        i. Janitorial staff, non-technical maintenance staff, and office staff are hired from a local pool of job applicants.
    b. Commitment to Local Business
        i. Materials, equipment, and vehicles are always sought for in the local vicinity first.
        ii. Events with local businesses are encouraged by the office staff.
6. Environmental Efficiency
    a. The 501st Legion board assigns carbon emission and material tolerances yearly.
    b. All ordered parts and vehicles are analyzed for maximum efficiency.
    c. Research projects involving more efficient aircraft are funded more often and incentivized for.

Budget and Schedule

Budget:

Cost of hiring engineering firm

Includes costs related to planning/design, software, personnel, and testing

- $1,750,000 for the design of new facilities
- $250,00 to conduct testing
- $25,000 for travel

Budget for engineering firm: **$2,000,000**

Construction personnel

Includes twenty-seven people hired over 28 weeks:

- 20 construction workers working 7 hours/day 4 days/week (28 hours/week)
- 5 leads working 7 hours/day 4 days/week (28 hours/week)
- 2 construction contractors involved for 3 hours/day 2 days/week (6 hours/week)

Cost of completing tasks:

- Construction workers hired at $20/hour
- Leads hired at $30/hour
- Contractors hired at $40/hour

Budget for construction personnel (including an additional $25,000 for construction travel costs): **$469,640**

Runways

The Gainesville Airport's main runway was refurbished in 2020 with asphalt [12], but should be overlaid with concrete to support heavy aircraft [20].

- Budget for refurbishing the main runway with concrete given the dimensions: [12] $7,000,000
- Budget for refurbishing the secondary runway with concrete given the dimensions [12]: $3,000,000
- Budget for demolition, stripping, and relighting the runways: $3,000,000

Budget for runways: **$13,000,000**

Facilities (including cost of materials and equipment)

- *Fuel Storage*

  Allot $5,000,000 to increase the capacity of the fuel storge facilities at the Gainesville Regional Airport
- *Hangars*

  Hangar cost is determined by square footage. The three hangars will be 215'x250'. Considering the dimensions of a Boeing 747 [19] and a B-52 [21] as model motherships, a hangar with ground surface area of 215'x250' would be appropriate.

  The proposed budget for a hangar this size is approximately $1,200,000. Budget for three hangars: $3,600,000.
- *Training Center*

  Allot $1,000,000 to for training facilities to provide opportunities for training for operation of airplanes, rockets, and Vomit Comet.

Budget for all facilities: **$9,600,000**

Total Budget:

Total Budget for Proposed Refurbishment of Gainesville Airport					
Costs	Components				
	Engineering firm	Construction team	Facilities	Runway	Travel
Individual Costs	$2,000,000	$469,640	$9,600,000	$13,000,000	$50,000
Combined Cost	**$25,119,640**				

Figure 7: Total budget of project

Schedule:

Event	Date of Initiation of Event									
	12/9/20	1/16/21	3/16/21	5/1/21	6/16/21	7/16/21	8/1/21	8/9/21	4/1/22	6/1/22
Application is accepted	■									
Companies and sponsors are contacted		■								
Funding is approved			■							
Contracts are created			■	■						
Design and Planning			■	■	■	■				
Design is approved							■	■		
Construction								■	■	
Testing									■	
Grand opening										■

Figure 8: Schedule of events necessary for completion of proposal

Evaluation Plan

This technical plan has the advantage of relying on an already existing structure, that being the Gainesville Airport. By acting as an added-on upgrade, more resources can be spent specifying the Space Center, and making it the ideal solution to improving the Gainesville community. A second advantage is that the Space Center provides an easily analyzable business plan that can be modified if needed and iterated upon should success occur.

To be successful, the Gainesville Space Center would have to launch at least three payloads each quarter, meaning at least twelve commercial and research projects would be taken on by the space center each year. These desired numbers would ensure a profit, as the cost of construction and operation would be offset by earning withing nine fiscal quarters. Announced quarterly earnings can be analyzed by the 501st Legion board, who can send for further funding if earned or needed through progress reports. Investors would respond, as necessary.

In addition, success would be shown through improvements in the surrounding community. This can be measured by surveys that are sent to all local organizations and companies once they collaborate with the space center. This survey would ask if the participant is satisfied with their experience. Participants would then get a chance to comment on economic, environmental, and educational factors. For example, professors can comment on the amount of flexibility and opportunity when working with students through research. Local unions can respond to questions about the satisfaction of workers. Environmental organizations can regularly report on the successes of certain collaborations with the Space Center.

Regardless of the background of an individual, they should be affected by the implementation of the Gainesville Space Center. With proper use, leadership, and vision, that individual would be one of many to come away with a vastly positive experience.

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Appendix

Gainesville Space Center Survey

This is a survey for a research report on the potential construction of a Space Center in Gainesville. The proposed Center will be modeled after this one in Georgia:

https://spaceportcamden.us/

We would greatly appreciate it if you took a few minutes to fill it out. Thank you very much!

Are you a resident of Florida? *

- ◯ Yes
- ◯ No

Are you a resident of Gainesville? *

- ◯ Yes
- ◯ No

Are you a student at the University of Florida? *

- ◯ Yes
- ◯ No

Are you an engineering student? *

- ◯ Yes
- ◯ No

Would you support the construction of a space complex in Gainesville? Why or why not? (1-2 sentences) *

Long answer text

Do you feel as if the environment will be affected negatively by the construction and operation of a space complex near Gainesville Regional Airport? *

- ◯ Yes
- ◯ No

Do you think this will have a positive impact on the educational opportunities of UF students? Why or why not? (1-2 sentences) *

Long answer text

How do you think this will affect the economy of Gainesville? (1-2 sentences) *

Long answer text

What other potential impacts do you think the construction of a space center will have on the community of Gainesville? (1-2 sentences) *

Long answer text

Is the construction of a space center in Gainesville important? *

- ◯ Yes
- ◯ No

Vehicle Test #20-- Center of Gravity Test
(Julianne Owen)

Scope:

- Subsystem in test: Full Vehicle

Purpose:
The purpose of this test is to determine the center of gravity of the launch vehicle. Knowing the center of gravity of the vehicle is crucial to the successful performance of the design, as it allows the team to properly set up the vehicle and create an accurate flight path. This will be done by finding the point around which the weight of the rocket is evenly balanced.

Design:

- For use on both subscale and full-scale launch vehicles and the payload parachute. Tests conducted independently from each other.
- Equipment: subscale or full scale launch vehicle, measuring tape, OpenRocket software
- Quantitative test
- Independent variable: position at which the rocket is balanced
- Dependent variable: the center of gravity of the vehicle

Procedure:

- Open the schematic diagram view in OpenRocket to see the center of mass of the rocket
- Using that position, test the vehicle to ensure that the program's center of mass and the vehicle's center of gravity are the same:
  - Use the measuring tape to find the point at which the rocket should balance
  - Place the rocket on a small elevated surface balancing at that point
  - Observe whether the vehicle balances or not
- Repeat with slight changes in position if acquired results are not satisfactory

Discussion:
In the event that the test continues to be unsuccessful, the relationship between the components of the vehicle will be reviewed and reassessed in OpenRocket.

Safety:

- Team members will not stand in the line of action of the test

Payload Test #2 - Payload parachute packing test
(Julianne Owen)

Scope:
- Subsystem in test: Recovery system for the payload
    - Payload parachutes
- Subsystem in test: Payload
    - Payload parachutes

Purpose:
The purpose of this test is to determine the best payload parachute packing configuration and verify that it does not tangle with other parachutes during separation. Effective packing is necessary to allow for the payload to land safely. Without proper packing of the payload parachute, the payload will fall at an unsafe speed, possibly causing injury or damage to the payload and its components. Proper packing will also allow for efficiency within the deployment of the parachute. Proper packing is critical to the successful performance of the design. Desired results include a packing technique that causes the parachute to smoothly emerge.

Design:
- For use on both subscale and full-scale launch vehicles and the payload parachute. Tests conducted independently from each other.
- Equipment: subscale or full scale launch vehicle, payload parachute, payload
- Qualitative test
- Independent variable: configuration of parachute
- Dependent variable: whether or not the parachute deploys effectively

Procedure:
- Set up the payload parachute in a specific configuration
- Launch rocket
- Observe separation and deployment of the parachute
- Repeat with other configurations if acquired results are not satisfactory

Discussion:
In the event that the test continues to be unsuccessful, the relationship between the payload and the parachute will have to be altered.

Safety:
- Team members will wear safety glasses at all times
- Team members will not stand in the line of action of the launch vehicle after the ejection charge has been prepared
- Team members will stand at a distance of at least 10 feet from the test
- Team members will not stand in the line of action of the test

Vehicle Test #10-- Main and Drogue Parachute Packing Test
(Julianne Owen)

Scope:

- Subsystem in test: Vehicle Recovery System
    - Main and drogue parachutes

Purpose:
The purpose of this test is to determine the most efficient packing orientation for the main and drogue parachutes. Effective packing is necessary to allow the vehicle to land safely. Without proper packing of the main and drogue parachutes, the body will fall at an unsafe speed, possibly causing injury or damage to the vehicle and its components. Proper packing is critical to the successful performance of the design as it allows for the parachutes to deploy and slow the descent of the airframe. Desired results include a packing technique that causes the parachutes to smoothly emerge.

Design:

- For use on both subscale and full-scale launch vehicles and the payload parachute. Tests conducted independently from each other.
- Equipment: subscale or full scale launch vehicle, main parachute, drogue parachute
- Qualitative test
- Independent variable: configuration of parachutes
- Dependent variable: whether or not the parachutes deploy effectively

Procedure:

- Set up the main and drogue parachutes in a specific configuration
- Launch rocket
- Observe separation and deployment of the parachute
- Repeat with other configurations if acquired results are not satisfactory

Discussion:
In the event that the test continues to be unsuccessful, the relationship between the airframe and the parachutes will have to be altered.

Safety:

- Team members will not stand in the line of action of the test

Vehicle Test #11--Shock Cord Strength Test
(Julianne Owen)

Scope:

- Subsystem in test: Vehicle recovery system
    - Vehicle parachutes
- Subsystem in test: Vehicle Structure

Purpose:

The purpose of this test is to measure the yield strength of the shock cord in tension. It is important to determine the yield strength of the shock cord to ensure that the cord is not stressed to the point that it breaks. Knowing the limits of the shock cord is necessary to allow for the vehicle to be recovered safely. Without efficient performance of the shock cord, the vehicle structure may fall at an unsafe speed, possibly causing injury or damage to the vehicle and payload

Design:

- For use on both subscale and full-scale launch vehicles
- Tests conducted independently from each other.
- Equipment: body tubes (including inner components), nose cone, shock cord
- Qualitative test
- Independent variable: force exerted on the shock cord when the nose cone is separated from the body
- Dependent variable: whether or not the shock cord breaks

Procedure:

- Using a constant force, separate the nose cone from the body of the rocket
- Observe and record whether or not the shock cord breaks
- Repeat

Discussion:

In the event that the test continues to be unsuccessful, the relationship between the shock cord and the body tubes will have to be altered.

Safety:

- Team members will not stand in the line of action of the test

	includes, but is not limited to, a computer system, video camera, speaker telephone, and a sufficient Internet connection. Cellular phones should be used for speakerphone capability only as a last resort	campus that has a computer system, video camera, speaker telephone, and internet connection	through inspection	
1.12	All teams will be required to use the launch pads provided by Student Launch's launch services provider. No custom pads will be permitted on the launch field. At launch, 8-foot 1010 rails and 12-foot 1515 rails will be provided. The launch rails will be canted 5 to 10 degrees away from the crowd on launch day. The exact cant will depend on launch day wind conditions	The team will design the launch vehicle around the launch pads provided by Student Launch	Requirement will be verified through inspection	Comply
1.13	Each team must identify a "mentor." A mentor is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year and may or may not be affiliated with the school, institution, or organization. The mentor must maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged recovery) a minimum of 2 flights in this or a higher impulse class, prior to PDR	The team identifies their mentor as Jimmy Yawn	Requirement will be verified through inspection	Comply

6.2.1.2 Vehicle Requirements

Table XXXVIII Vehicle Requirements

#	Requirement Description	Compliance Plan	Verification	Status
2.1	The launch vehicle will deliver the payload to an apogee altitude between 3,500 and 5,500 ft above ground level (AGL). Teams flying below 3,000 ft or above 6,000 ft on Launch Day will be disqualified and receive zero altitude points towards their overall project score	The launch vehicle will deliver the payload to an apogee altitude of 4500ft using a L-850W motor	Requirement will be verified through simulations, analysis, and testing including static motor and full-scale flight tests	Partial
2.2	Teams shall identify their target altitude goal at the PDR milestone. The declared target altitude will be used to determine the team's altitude score during Launch Week	The team will predict their target altitude goal at the PDR milestone by running simulations on the rocket using OpenRocket	Requirement will be verified through inspection	Comply
2.3	The launch vehicle will carry one commercially available, barometric altimeter for recording the official altitude used in determining the Altitude Award winner. The Altitude Award will be given to the team with the smallest difference between their measured apogee and their official target altitude on launch day. This altimeter may also be used for deployment purposes (see Requirement 3.4)	The launch vehicle will include a StratoLoggerCF altimeter to record the official altitude. A second StratoLogger CF will be used for backup parachute ejection purposes only	Requirement will be verified through inspection	Comply
2.4	The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications	The team will run simulations and use strong enough materials to ensure that the vehicle is recoverable and reusable	Requirement will be verified through analysis and testing during subscale and full-scale launches	Unverified
2.5	The launch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main vehicle using its own parachute	The launch vehicle will have three (3) independent sections	Requirement will be verified through inspection. Requirement will be verified through inspection	Comply

2.5.1	Coupler/airframe shoulders which are located at in-flight separation points will be at least one body diameter in length	The team will verify that coupler/airframe shoulders located at in-flight separation points will be one body diameter in length (5.5 inches) prior to construction	Requirement will be verified through inspection. Requirement will be verified through inspection	Comply
2.5.2	Nosecone shoulders which are located at in-flight separation points will be at least ½ body diameter in length	The team will verify that nosecone shoulders located at in-flight separation points will be ½ body diameter in length (2.75 inches) prior to purchase	Requirement will be verified through inspection. Requirement will be verified through inspection	Comply
2.6	The launch vehicle will be capable of being prepared for flight at the launch site within 2 hours of the time the Federal Aviation Administration flight waiver opens	The team will ensure the launch vehicle will be ready for flight within 2 hours by having a checklist prepared for launch day	Requirement will be verified through inspection and rehearsal. Requirement will be verified through inspection and rehearsal	Comply
2.7	The launch vehicle and payload will be capable of remaining in launch-ready configuration on the pad for a minimum of 2 hours without losing the functionality of any critical on-board components, although the capability to withstand longer delays is highly encouraged	The launch vehicle and payload will be capable of remaining in launch ready configuration for a minimum of 2 hours by ensuring our electronics have backup battery packs. The team will verify this by running multiple test beforehand	Requirement will be verified through thorough tests and analysis	Unverified
2.8	The launch vehicle will be capable of being launched by a standard 12-volt direct current firing system. The firing system will be provided by the NASA-designated launch services provider	The team will only use a motor configuration that can be ignited with a 12-volt direct current	Requirement will be verified through inspection	Comply
2.9	The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the launch services provider)	The team will not create a design that requires external circuitry or special ground support	Requirement will be verified through inspection	Comply
2.10	The launch vehicle will use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR)	The launch vehicle will use an Aerotech L-850W solid rocket motor	Requirement will be verified through inspection	Comply
2.10.1	Final motor choices will be declared by the Critical Design Review (CDR) milestone	The team will declare final motor choices by the Critical Design Review (CDR) milestone after completing many simulations on the vehicle using OpenRocket	Requirement will be verified through inspection, simulation, analysis and testing	Comply
2.10.2	Any motor change after CDR must be approved by the NASA Range Safety Officer (RSO) and will only be approved if the change is for the sole purpose of increasing the safety margin. A penalty against the team's overall score will be incurred when a motor change is made after the CDR milestone, regardless of the reason	The team will seek approval of the NASA Range Safety Office (RSO) if the motor is changed after CDR only if the change is for the sole	Requirement will be verified through inspection	Comply

		purpose of increasing the safety margin		
2.11	The launch vehicle will be limited to a single stage	The launch vehicle is one stage	Requirement will be verified through inspection	Comply
2.12	The total impulse provided by a College or University launch vehicle will not exceed 5,120 Newton-seconds (L-class)	The total impulse of the launch vehicle is 3694.98 N·s	Requirement will be verified through simulations, analysis, and testing during full scale flight test	Partial
2.13	Pressure vessels on the launch vehicle will be approved by the RSO	The team will not be using pressure vessels on the launch vehicle	Requirement will be verified through inspection	Comply
2.14	The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail	After running simulations on the current design of the launch vehicle, the vehicle has a static stability of 2.0 at the point of rail exit	Requirement will be verified though simulations and analysis. Requirement will be verified though simulations and analysis	Comply
2.15	Any structural protuberance on the launch vehicle will be located aft of the burnout center of gravity	The team will only place structural protuberances of the launch vehicle aft of the burnout center of gravity	Requirement will be verified though inspection	Comply
2.16	The launch vehicle will accelerate to a minimum velocity of 52 fps at rail exit	The team ran simulations to determine that the launch vehicle will accelerate to a velocity of 63.2 fps at rail exit	Requirement will be verified through simulations	Comply
2.17	All teams will successfully launch and recover a subscale model of their launch vehicle prior to CDR. Subscales are not required to be high pow er rockets	The team will launch and recover a subscale model of the launch vehicle prior to CDR. The team currently has a planned launch date of November 16th. This date allow s time for a back-up launch	Requirement will be verified by conducting a subscale launch test.	Unverifi ed
2.17.1	The subscale model should resemble and perform as similarly as possible to the full-scale model; however, the full-scale will not be used as the subscale model	The team will design and manufacture a sub-scale model to reflect the full-scale model that is separate from the full-scale model	Requirement will be verified through analysis and testing. Requirement will be verified through analysis and testing	Unverifi ed
2.17.2	The subscale model will carry an altimeter capable of recording the model's apogee altitude	The team will place a StratoLoggerCF in the subscale launch vehicle to record the model's apogee altitude	Requirement will be verified through inspection	Comply
2.17.3	The subscale launch vehicle must be a newly constructed rocket, designed and built specifically for this year's project	The team will construct the subscale launch vehicle for the current year's project	Requirement will be verified through inspection	Comply
2.17.4	Proof of a successful flight shall be supplied in the CDR report. Altimeter data output may be used to meet this requirement	The team will provide flight data and photo evidence to prove that a successful flight was achieved in the CDR report	Requirement will be verified through testing during the subscale flight test	Unverifi ed
2.18.1	All teams will successfully launch and recover their full-scale rocket	The team will successfully launch	Requirement will be verified through full scale flight test	Unverifi ed

	launch vehicle prior to FRR in its final flight configuration. The launch vehicle flown must be the same rocket launch vehicle to be flown on launch day. The purpose of the Vehicle Demonstration Flight is to validate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly (i.e. drogue chute at apogee, main chute at the intended lower altitude, functioning tracking devices, etc.)	and recover the full-scale launch vehicle prior to FRR in its final flight configuration. The current launch date is planned for February 15th; the same launch vehicle will be flown on launch day		
2.18.1.1	The vehicle and recovery system will have functioned as designed	The vehicle and recovery system will be tested to solve any malfunctions or errors before launch	Requirement will be verified through testing	Unverified
2.18.1.2	The full-scale launch vehicle must be a newly constructed launch vehicle, designed and built specifically for this year's project	The team will manufacture the currently designed launch vehicle	Requirement will be verified through inspection	Comply
2.18.1.3	The payload does not have to be flown during the full-scale Vehicle Demonstration Flight	The team plans to fly the payload during the full-scale Vehicle Demonstration Flight	Requirement will be verified through testing	Unverified
2.18.1.3.1	If the payload is not flown, mass simulators will be used to simulate the payload mass	The team will use mass simulators to simulate the payload mass if it is not flown	Requirement will be verified through testing	Unverified
2.18.1.3.2	The mass simulators will be located in the same approximate location on the launch vehicle as the missing payload mass	The team will place mass simulators in the same approximate location on the launch vehicle as the missing payload mass	Requirement will be verified through inspection	Unverified
2.18.1.4	If the payload changes the external surfaces of the launch vehicle (such as with camera housings or external probes) or manages the total energy of the launch vehicle, those systems will be active during the full-scale Vehicle Demonstration Flight	The team will activate any systems which change the external surface of the launch vehicle or manages the total energy of the vehicle during the full-scale Vehicle Demonstration Flight	Requirement will be checked through testing during the full-scale flight test	Unverified
2.18.1.5	Teams shall fly the launch day motor for the Vehicle Demonstration Flight. The team may request a waiver for the use of an alternative motor in advance if the home launch field cannot support the full impulse of the launch day motor or in other extenuating circumstances (such as weather)	The team will fly the launch day motor for the Vehicle Demonstration Flight	Requirement will be verified through inspection	Unverified
2.18.1.6	The launch vehicle must be flown in its fully ballasted configuration during the full-scale test flight. Fully ballasted refers to the same amount of ballast that will be flown during the launch day flight. Additional ballast may not be added without a re-flight of the full-scale launch vehicle	The team will fly the launch vehicle in its fully ballasted configuration during the full-scale test flight	Requirement will be verified through inspection	Unverified
2.18.1.7	After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components will not be modified without the concurrence of the NASA Range Safety Officer (RSO)	The team will preserve the design of the launch vehicle following full-scale	Requirement will be verified through inspection	Unverified

		demonstration flight unless the NASA Range Safety Office (RSO) is consulted		
2.18.1 .8	Proof of a successful flight shall be supplied in the FRR report. Altimeter data output is required to meet this requirement	The team will provide flight data and photo evidence to prove a successful flight in the FRR report	Requirement will be verified through testing and inspection	Unverified
2.18.1 .9	Vehicle Demonstration flights must be completed by the FRR submission deadline. No exceptions will be made. If the Student Launch office determines that a Vehicle Demonstration Re-flight is necessary, then an extension may be granted. This extension is only valid for re-flights, not first-time flights. Teams completing a required re-flight must submit an FRR Addendum by the FRR Addendum deadline	The team will complete Vehicle Demonstration flights February 15th, well before the FRR submission deadline	Requirement will be verified through testing and inspection	Unverified
2.18.2	All teams will successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload Demonstration Flight deadline. The launch vehicle flown must be the same launch vehicle to be flown on launch day	The team will successfully launch and recover the full-scale launch vehicle containing the completed payload February 15th. The team will ensure the launch vehicle flown will be the same launch vehicle to be flown on launch day	Requirement will be verified through testing and inspection	Unverified
2.18.2 .1	The payload must be fully retained until the intended point of deployment (if applicable), all retention mechanisms must function as designed, and the retention mechanism must not sustain damage requiring repair	The current payload design includes a retention system to ensure the payload will remain inside the launch vehicle until its intended deployment	Requirement will be verified through simulations, tests, and analysis	Unverified
2.18.2 .2	The payload flown must be the final, active version	The payload will not be flown until it is in its final version	Requirement will be verified through inspection	Unverified
2.18.2 .4	Payload Demonstration Flights must be completed by the FRR Addendum deadline. NO EXTENSIONS WILL BE GRANTED	The payload demonstration flight will be completed February 15th during the full-scale launch	Requirement will be verified through the payload demonstration test flight. Requirement will be verified through the payload demonstration test flight	Unverified
2.19	An FRR Addendum will be required for any team completing a Payload Demonstration Flight or NASA required Vehicle Demonstration Re-flight after the submission of the FRR Report	If the team requires a Payload or Vehicle Demonstration Re-flight, and addendum will be submitted to NASA. A launch date of March 21st has been scheduled to accommodate this	Requirement will be verified through a second payload demonstration test flight if necessary. Requirement will be verified through a second payload demonstration test flight if necessary	Unverified
2.19.1	Teams required to complete a Vehicle Demonstration Re-Flight and failing to submit the FRR Addendum by the deadline will not be permitted to fly the vehicle at launch week	The team will not fly the launch vehicle at launch week if unable to submit the FRR Addendum by the deadline	Requirement will not need to be verified	Comply
2.19.2	Teams who successfully complete a Vehicle Demonstration Flight but fail to qualify the payload by satisfactorily completing the Payload Demonstration Flight requirement will not be permitted to fly the payload at launch week	The team will not fly the payload at launch week despite successfully completing a Vehicle Demonstration Flight	Requirement will be verified through testing during the full scale flight test and the payloads flight test	Unverified

		if there is a failure to qualify the payload by satisfactorily completing the Payload Demonstration Flight requirement		
2.19.3	Teams who complete a Payload Demonstration Flight which is not fully successful may petition the NASA RSO for permission to fly the payload at launch week. Permission will not be granted if the RSO or the Review Panel have any safety concerns	The team may petition the NASA RSO for permission the fly the payload at launch week if the Payload Demonstration Flight is not successful	Requirement will be verified through inspection if needed be	Unverifi ed
2.20	The team's name and launch day contact information shall be in or on the launch vehicle airframe as well as in or on any section of the vehicle that separates during flight and is not tethered to the main airframe. This information shall be included in a manner that allows the information to be retrieved without the need to open or separate the vehicle	The team's name and launch day contact information will be clearly printed in and on the launch vehicle airframe as well as in and on any section of the launch vehicle that separates during flight and is not tethered to the main airframe in a manner that allows the information to be retrieved without the need to open or separate the vehicle	Requirement will be verified through inspection	Unverifi ed
2.21	All Lithium Polymer batteries will be sufficiently protected from impact with the ground and will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other payload hardware	The team will not be using Lithium Polymer batteries	Requirement will be verified through inspection. Requirement will be verified through inspection	Comply
2.22.1	The launch vehicle will not utilize forward canards. Camera housings will be exempted, provided the team can show that the housing(s) causes minimal aerodynamic effect on the rocket's stability. 2.22.2. The launch vehicle will not utilize forward firin g motors	The team will not design or manufacture forward canards on the launch vehicle unless used for camera housing which causes minimal aerodynamic effect on the launch vehicle's stability	Requirement will be verified through inspection	Comply
2.22.2	The launch vehicle will not utilize forward firing motors	The launch vehicle does not utilize forward firing motors	Requirement will be verified through inspection	Comply
2.22.3	The launch vehicle will not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.)	The motor uses White Lighting propellant, which does not contain any titanium sponges	Requirement will be verified through inspection	Comply
2.22.4	The launch vehicle will not utilize hybrid motors	The launch vehicle will use a solid rocket motor	Requirement will be verified through inspection	Comply
2.22.5	The launch vehicle will not utilize a cluster of motors	The launch vehicle utilizes only one motor	Requirement will be verified through inspection	Comply
2.22.6	The launch vehicle will not utilize friction fitting for motors	The team will utilize centering rings, a motor retainer and a thrust plate for motors	Requirement will be verified through inspection	Comply

2.22.7	The launch vehicle will not exceed Mach 1 at any point during flight	The launch vehicle will reach a Mach number of 0.48	Requirement will be verified through simulations and testing during full scale flight test	Partial
2.22.8	Launch vehicle ballast will not exceed 10% of the total unballasted weight of the launch vehicle as it would sit on the pad (i.e. a rocket with an unballasted weight of 40 lbs. on the pad may contain a maximum of 4 lbs. of ballast)	The unballasted launch vehicle weighs 37.0 lbs., while the ballasted launch vehicle weighs 39.8 lbs. The weight of the ballast is 9.4% of the unballasted launch vehicles weight	Requirement will be verified through simulation and inspection.Requi rement will be verified through simulation and inspection	Comply
2.22.9	Transmissions from onboard transmitters will not exceed 250 mW of power (per transmitter)	The transmitters the team will use do not exceed 250 mW of power	Requirement will be verified through inspection	Comply
2.22.10	Transmitters will not create excessive interference. Teams will utilize unique frequencies, handshake/passcode systems, or other means to mitigate interference caused to or received from other teams	The team will utilize unique frequencies for transmitters used. Testing will be done to ensure no excessive interference is created	Requirement will be verified through electrical testing	Unverified
2.22.11	Excessive and/or dense metal will not be utilized in the construction of the launch vehicle. Use of lightweight metal will be permitted but limited to the amount necessary to ensure structural integrity of the airframe under the expected operating stresses	The team will not use excessive and/or dense metal in the design and construction of the launch vehicle; the team will minimally use lightweight metal to ensure structural integrity of the airframe under the expected operating stresses	Requirement will be verified through inspection	Comply

6.2.1.3 Recovery System Requirements

Table XXXIX Recovery System Requirements

#	Requirement Description	Compliance Plan	Verification	Status
3.1	The launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee, and a main parachute is deployed at a lower altitude. Tumble or streamer recovery 10 from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue stage descent is reasonable, as deemed by the RSO	The team will use a StratoLoggerCF altimeters which utilizes black-powder ejection charges to deploy the drogue parachute at apogee and the main parachute at 550 ft	Requirement will be verified through inspection	Comply
3.1.1	The main parachute shall be deployed no lower than 500 ft	The main parachute will be deployed at 550 ft, with a backup ejection charge firing at 500 ft to ensure deployment	Requirement will be verified through inspection, simulation, and testing	Partial
3.1.2	The apogee event may contain a delay of no more than 2 seconds	The drogue parachute will be deployed at apogee, with the backup ejection charge occurring one second after apogee	Requirement will be verified through inspection	Comply
3.1.3	Motor ejection is not a permissible form of primary or secondary deployment	Parachute deployment will utilize black-powder ejection charges	Requirement will be verified through inspection	Comply