By:
Georgia Institute of Technology Team Autonomous Rocket Equipment System (A.R.E.S.)

Georgia Institute of Technology
North Ave NW
Atlanta GA, 30332
Project Name: Simple Complexity
MAXI-MAV Competition

Monday, October 6th, 2014

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1. Introduction

1.1. *School Information and NAR Section Contacts*

1.1.1. School Information

School Name: Georgia Institute of Technology
Team Name: Team A.R.E.S.

Project Title: Simple Complexity
Rocket Name: Pyroeis

Project Lead/Team Official: Victor Rodriguez
E-mail: rodriguez3@gatech.edu
Safety Officer: Raef Eagan
Team Advisor: Dr. Eric Feron
E-mail: feron@gatech.edu

1.1.2. NAR Section Contacts

NAR Section: Primary: Southern Area Rocketry (SoAR) #571
Secondary: GA Tech Ramblin' Rocket Club #701
NAR Contact: Primary: Jorge Blanco
Secondary: Joseph Mattingly

1.2. *Student Participation*

Team Autonomous Rocket Erector System (A.R.E.S.) is composed of seventeen students studying in different engineering fields. Our team is composed of less than 50% Foreign Nationals (FN) per NASA competition requirements.

To work more effectively, the team is broken down into groups that focus on special tasks. Each sub-team has a general manager supported by several technical leads and subordinate members. Team memberships were selected based on the individuals' areas of expertise as well as personal interest. Figure 1 shows the work breakdown structure of Team A.R.E.S.

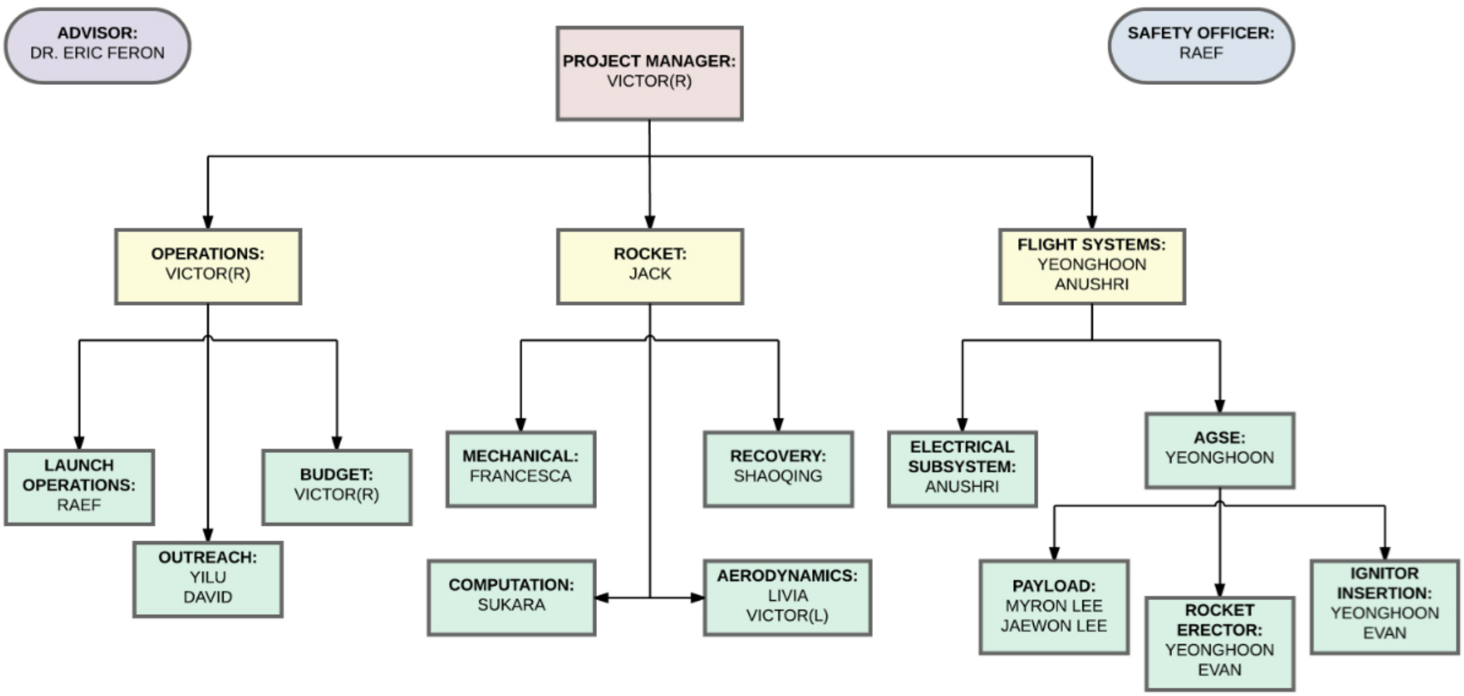


Figure 1: 2014-2015 Team A.R.E.S. work breakdown structure

1.3. *Facilities and Equipment*

This section will detail and list all applicable facilities, equipment, and software that Team A.R.E.S. will have access to in the design and testing of Simple Complexity.

1.3.1. Facilities

For manufacturing and fabrication of the rocket system and AGSE system, the Georgia Tech Invention Studio has tremendous capabilities for enabling a NASA SL team to construct innovative and creative projects. Team A.R.E.S. will have access to the Invention Studio from 10AM-5PM, Monday through Friday. These facilities will be useful for the team to build structural and electrical components. Under supervision of a Graduate Lab Instructor (GLI), or Undergraduate Lab Instructor (ULI), team members will be able to learn how to operate these:

- Laser Cutter
- CNC Mill & Lathe
- Water Jet Cutter
- Mills, Lathes, & Drill Presses
- Basic Power Tools
- Basic Hand Tools
- Oscilloscope
- Soldering Station
- Multimeter
- LCR Meter

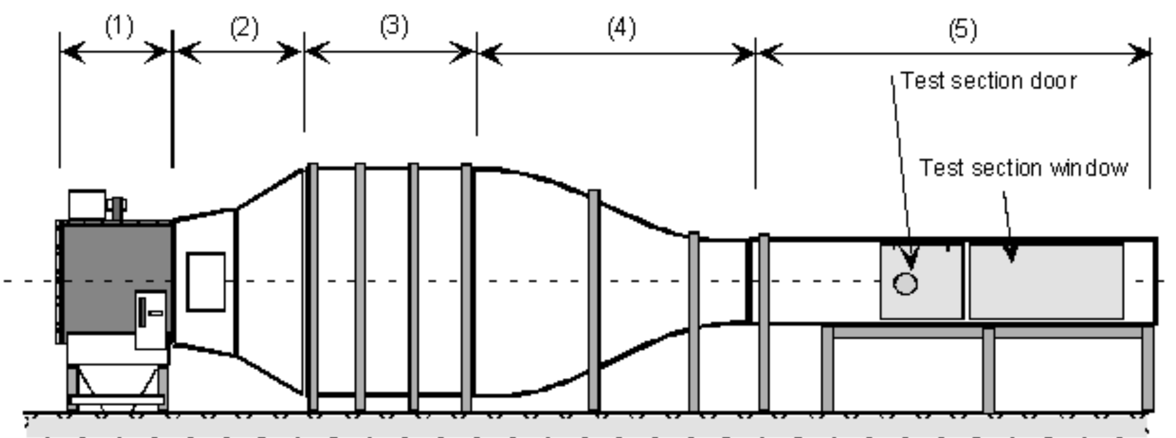


Figure 2: Open return, Low-Speed Aerocontrols Wind Tunnel schematic

The Georgia Tech campus is equipped with an open-return, Low Speed Aerocontrols Wind Tunnel, which will be available for use pending graduate student supervision from 9AM-6PM, Monday through Friday. This will enable Team A.R.E.S. to learn the aerodynamic characteristics of their rocket, and understand how to optimize parameters for the desired performance. The wind tunnel comes equipped with a 42" x 42" x 42" test section, Barocel pressure transducers, strain gage force-moment balance, high speed, multi-channel signal filtering, and computer data acquisition systems. Although the wind tunnel has only a maximum mean velocity of 78 ft/s, useful data can still be gathered through the use of flow similarity transformations.

Additionally, for participation in off-campus communications and video-teleconferences, Team A.R.E.S. has 24 hour/7 days per week access to Cisco Telepresence Systems (CTS 1000), as well as POLYCOM HDX video teleconferencing capabilities through the Georgia Tech Vertically Integrated Projects(VIP) program, with a T3 broadband connection. Team A.R.E.S. will maintain a dedicated website, and will include project documentation, current team information, team pictures, and other pertinent information. Compliance with all facets of the Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards(36 CFR Part 1194) Subpart B-Technical Standards will be implemented by Team A.R.E.S.

1.3.2. Software

Georgia Tech allows 24/7 access to all team members standard of industry-standard software suites. A number of engineering software packages are available on personal and campus computers, such as:

- SolidWorks, AutoCAD (FEA and CAD)
- OpenRocket
- Ansys Fluent(CFD)
- NX7, Abaqus(FEA)
- MATLAB, Simulink
- Autocoders(control algorithms)
- COSMOL(Multi-physics Modeling and Simulation)
- JMP(Data Analysis/Statistical Software)

These software capabilities are enhanced with standard software packages, such as various internet access capabilities, and Microsoft Office 2010.

2. Safety

2.1. *Mission Assurance*

The Safety Team will consist of members from Operations, Rocket, and Flight Systems Teams, that will work unilaterally to develop and implement a safety plan that will encompass all aspects of the teams' designs, construction and launch techniques. For quality assurance, the team will employ the technical knowledge and experience of our Graduate students, faculty, and NAR mentors. The safety plan will include sections on how to use Personal Protective Equipment when operating with possibly hazardous equipment. All NAR/TRA personnel involved with Team A.R.E.S. will enforce compliance with the NAR high power safety code regarding the rocket operation, rocket flight, rocket materials, and launch site activities.

2.2. *Material Handling*

Some of the materials requiring specific safety protocols and procedures include: ammonium perchlorate composite propellant, rocket motor igniters, and black powder. The Safety Team will brief all team members of the plan to properly handle and store hazardous materials. The Safety Brief will include knowledge and close proximity access to Material Safety Data Sheets (MSDS) for all potentially hazardous substances. The safety plan will ensure the use of proper Personal Protective Equipment when handling hazardous materials.

2.3. *Vehicle Safety*

Ground testing will be performed to ensure the reliability of the team's design and construction efforts. Various methods of loading, including impulsive – representative of parachute deployment – as well as static loading – representing constant thrust – will be performed multiple times to ensure repeatability and veracity of the data gathered for analysis. Wind tunnel testing will be able to evaluate the effects of aerodynamics on the design. The experimental data will be used to validate the theoretical models (FEA, CFD) to ensure safe operation of the rocket. The results of this experimental testing will be used to create a Pre-Flight Inspection Checklist of rocket system components.

2.4. *Purchase, Shipping, Storing, and Transporting of Rocket Motors*

Currently, there are no members of Team A.R.E.S. who currently hold a Low Explosives User Permit (LEUP). As a result, all rocket motors will be acquired from vendors at the launches we attend. Furthermore, for the HARA launch site in April 2015, Team A.R.E.S. will plan to order motors in advance from a specialized vendor.

2.5. *Launch Site Safety*

The Safety Officer (SO) will be in charge of ensuring all the requirements on the safety checklist are met. The SO will create a safety checklist and brief all team members of the safety requirements imposed therein. The safety checklist and briefing will include details of compliance with federal, state, and local laws regarding motor handling and unmanned rocket launches. Specifically, Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; Amateur Rockets, Code of Federal Regulation 27 Part 55: Commerce in Explosives; and fire prevention, NFPA1127"Code for High Power Rocket Motors." Additionally, the SO will provide a pre-launch safety briefing covering all the specific hazards for the launch, which will include the safety rules in place by the local NAR section. Launches will only occur at NAR sponsored launch events at high power fields, one such NAR club being Southern Area Rocketry and the Huntsville Area Rocketry will regulate the competition launch.

2.6. *High Power Rocket Certifications*

Currently, no members of Team A.R.E.S. have any NAR or TRA certifications. The certification process is designed to allow the candidate to demonstrate their understanding of the basic physics and safety guidelines that govern the use of high power rockets. Level 2 certification requires one to construct, fly, and recover a high power rocket in a condition that it can be immediately flown again, as well as pass a written exam that test the knowledge of rocket aerodynamics and safety. For the 2014-2015 competition cycle, Raef E. plans to receive his Level 1 and Level 2 certification through NAR prior to the end of October. However, in the mean time Joseph Mattingly will be the Team A.R.E.S. Level 2 sponsor and mentor for the competition cycle.

3. Technical Design

3.1. *Vehicle Technical Design*

3.1.1. Vehicle Requirements

The vehicle must carry a standard payload to an apogee of 3000 ft. Above Ground Level (AGL) measured using the competition altimeter in addition to our own redundant altimeter, and it must deploy the payload at 1000 ft. AGL. The vehicle must also be completely reusable except for motor and ejection charges.

3.1.2. General Vehicle Dimensions and Mass Breakdown

Table 1 contains the initial sizing dimensions for the vehicle. The mass breakdown of the rocket is shown in Figure 3; the rocket has a gross weight of 13.98 lb. with a mass margin of 30%.

Table 1: Mass Breakdown

Parameter	*Value (lb)*
Body Structure	7.55
Recovery System	1.39
Payload	1.26
Avionics System	0.979
Propulsion	2.80

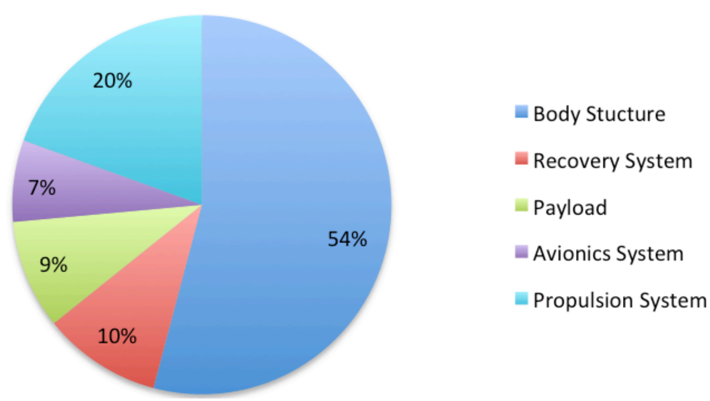


Figure 3: Rocket Mass Breakdown

3.1.3. Vehicle Characteristics

The Pyroeis rocket will have a layout shown in Figure 4. There will be four independent sections. From the aft end, it will consist of the booster section, avionics section, upper coupler section, and nose cone section. The length breakdown is shown in Table 2.

Figure 4: Internal layout of the Pyroeis rocket

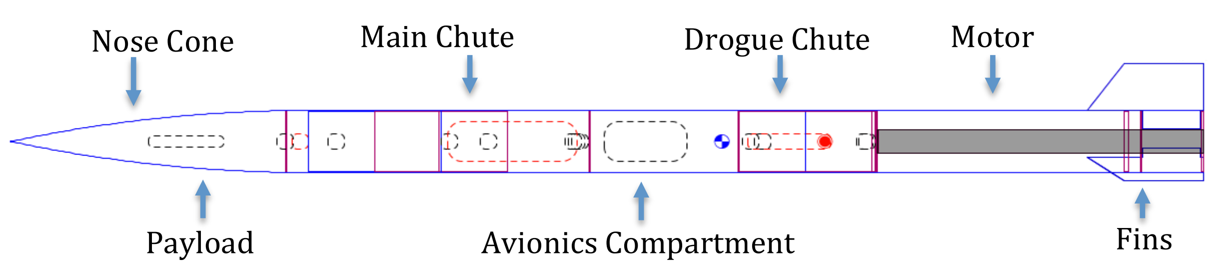


Table 2: Length Breakdown

Parameter	*Value*
Overall Length	72 in
Body Diameter	4 in
Nose Cone Length	18 in
Fin Height	3 in
Fin Root Chord	7 in
Fin tip Chord	4.75 in

3.1.4. Material Selection and Construction

The airframe of the rocket — including the nosecone, body tube, and fins — will be made with G10 fiberglass. Fiberglass is the chosen material because it provides one of the strongest strength-to-weight ratio of all options available. Fiberglass also has a weather-resistant finish, which will help with adjustability for competition day conditions. These fiberglass materials will be commercially bought and slots will be cut into the body frame for insertion of the fins, which will be kept in place by an epoxy.

3.1.5. Apogee Targeting System

The Pyroeis rocket will employ a variable drag control system to improve target apogee accuracy, the Apogee Targeting System (ATS). An array of pins around the fin section will be extended out of the rocket body to a distance determined by the flight computer that will produce additional drag. The extension distance will depended on expected apogee and velocity conditions after motor burnout. To reduce the computational load on the flight computer, a dictionary of pre-calculated scenarios will be loaded into an onboard memory bank to be accessed with velocity and altitude values. Aerodynamic responses to pin extension will be recorded and analyzed prior to launch. The wind tunnel data, combined with validated CFD results, will be used in building a guidance database and loaded onto memory accessible by the flight computer. Failure in the ATS will result in the rocket reaching its projected altitude of 3,373 ft.

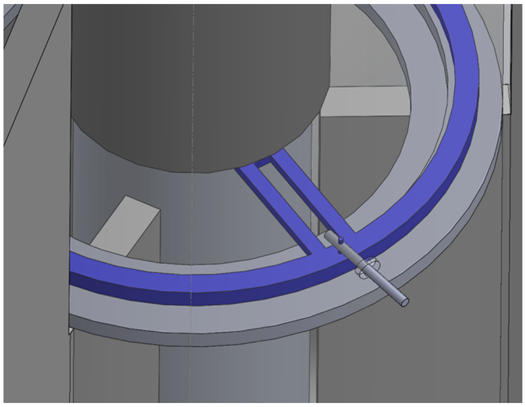


Figure 5: Drag pins extended

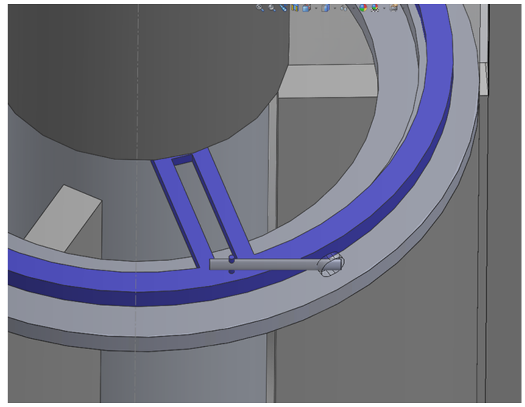


Figure 6: Drag pins retracted

Figures 5 and 6 show the drag pin configuration in its extended and retracted positions. The pin hub, shown in purple, will control the pin extension when rotated. The drive shaft, shown in dark gray, transfers rotation from a stepper motor above the motor to the pin hub.

The pins will be driven by a single stepper motor above the engine block to prevent any aerodynamic asymmetry resulting from the extended pins.

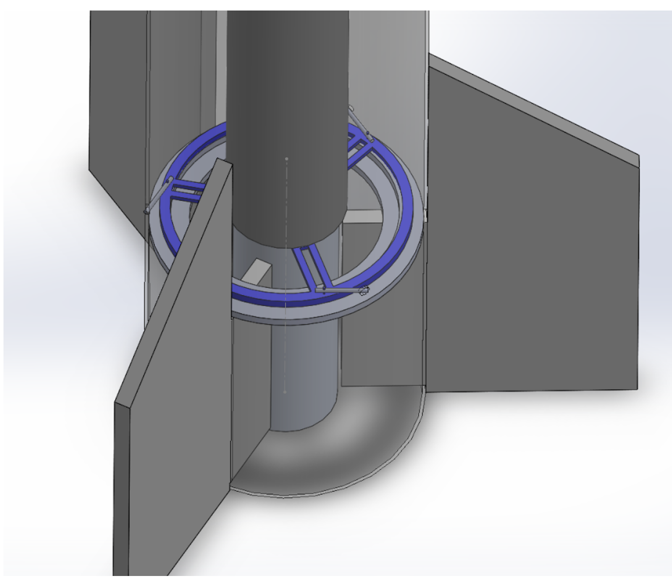


Figure 7: Expected position of the retracted drag pin assembly in relation to the fin tabs

3.1.6. Motor Selection

The booster section will house the Cesaroni J530-IM-8 motor and its retention system. This motor is the best option for our current design, predicting an apogee of 3373 ft. An apogee above 3000 ft. was chosen to allow the apogee targeting system to compensate with drag. The retention system will consist of a forward thrust plate integrated into the structure and an aft retention ring fastened to the base. We enabled the maximum capabilities of the Apogee Targeting System (ATS) to compensate for extraneous circumstances by varying drag.

3.1.7. Recovery

Table 3: Parachute Dimensions

Parachute	Diameter(in.)
Main	72
Drogue	18
Payload	25

The nose cone will be a hollow Ogive structure, which will house the payload and parachute during flight and aid in minimizing the overall weight of the launch vehicle. The main parachute will be housed in the avionics section. All chutes are made of rip-stop nylon to support the rocket weight. The parachute sizes, listed in Table 3, were determined through OpenRocket simulation and sized such that the impact kinetic energy of each independent section is below the 75 ft-lbf limit, listed in Table 4. The drogue parachute will be deployed at apogee to slow and stabilize descent and reduce downrange drift, allowing for payload and main parachute deployment. At 1000 ft. AGL, the nose cone section, which contains the payload, will eject from the rocket while deploying the payload parachute. The main parachute will then be deployed at 600 ft. AGL to minimize downrange drift. Furthermore, there will be a redundant use of commercially available altimeters and other systems such as black powder ejection charges.

Table 4: Impact Kinetic Energy

Section	Impact KE(lbf-ft)
Booster	42.54
Avionics	14.62
Upper Coupler	3.79
Nose Cone	14.61

3.1.8. Vehicle Performance

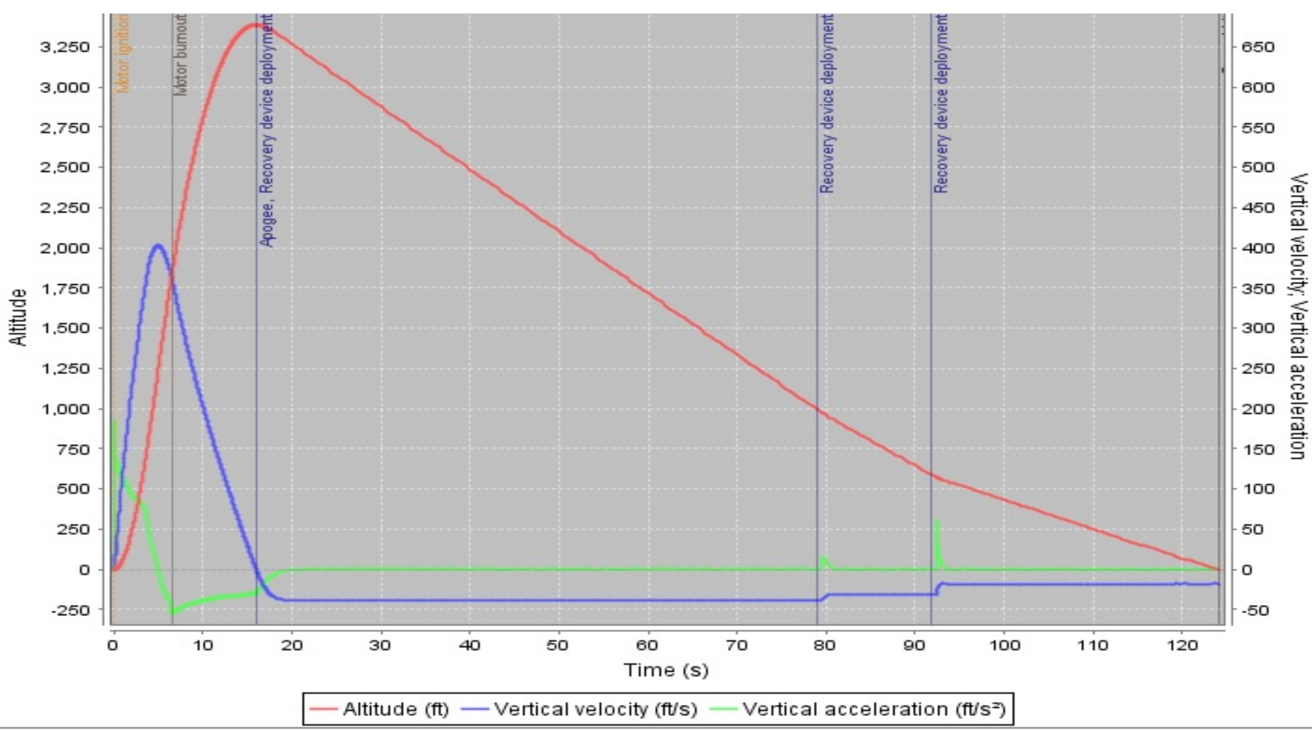
Flight simulations were conducted with OpenRocket software. Figureshows the predicted, mean ascent, and descent profile of the rocket (altitude, vertical velocity, and acceleration). Expected launch conditions in Huntsville, Alabama for April were included in Table 5.

Table 5: Simulated Flight Conditions

Conditions	Values
Wind speed	13.5ft/s
Temperature	60.8 °F
Latitude	34° N
Pressure	1013 mbar

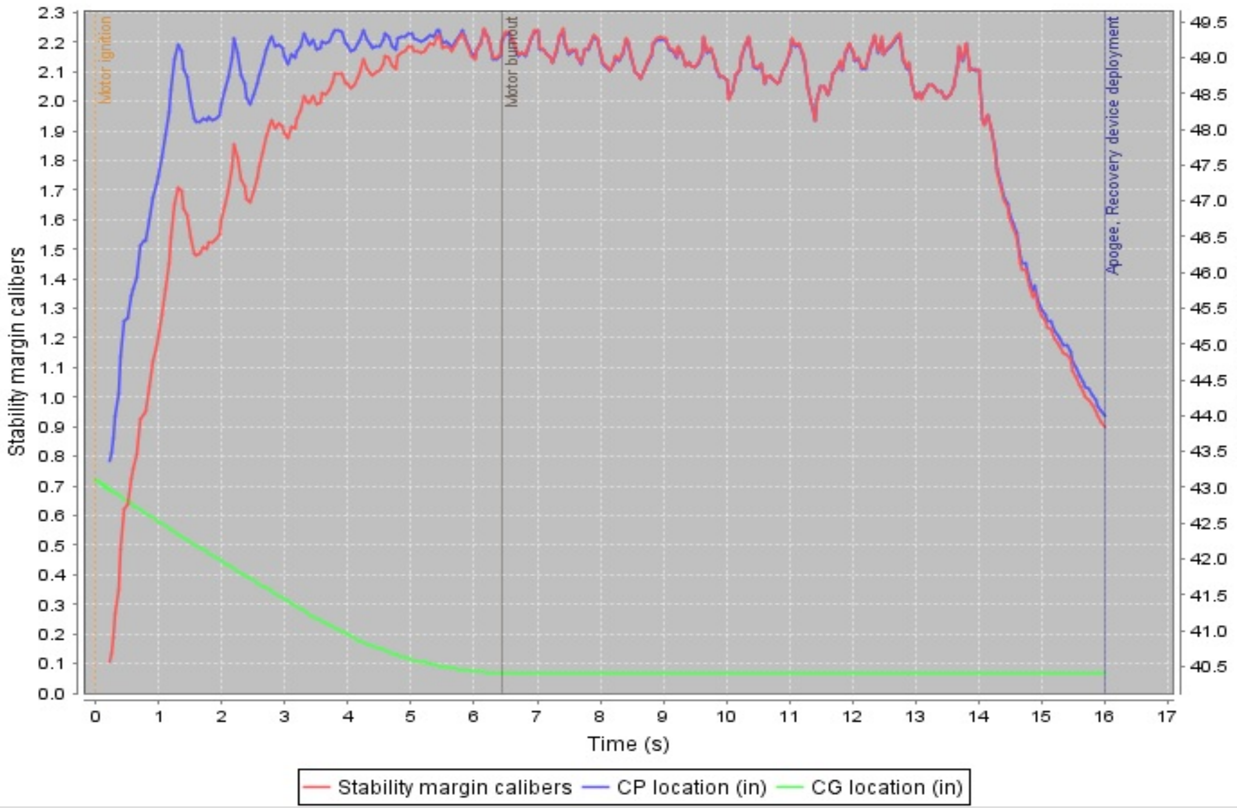
Figure 8 demonstrates that the rocket reaches apogee at approximately 16 seconds, where the apogee projected to be 3,373 ft. At apogee, the ejection charges for the drogue parachute will activate. Deployment of the main parachute will occur between 700 and 500 AGL to further decelerate the rocket so that the impact force is below75 ft-lbf.

Figure 8: Rocket flight profile from launch to landing



Motor burnout will occur approximately T+6s at an expected altitude of 1800ft.

Figure 9: Stability of the rocket from simulations



After burnout the apogee targeting system will adjust the drag on the rocket. Further experimentation and simulation will be carried out to quantify the effect of this system on apogee. Stability analysis was performed to ensure a safe flight profile as shown in Figure 9. The stability margin of our rocket during most of the flight is 2.1 calibers, where one caliber is the maximum body diameter of the rocket. This is close to than the general rule that the CP should be 1-2 calibers aft of the CG. The launch rod will be long enough to allow our rocket to reach a higher lift off velocity and hence be less affected by the wind, therefore we will be using an 8ft launch rod.

3.2. *AGSE Technical Design*

3.2.1. AGSE Requirements

As stated, Georgia Tech's Team A.R.E.S. will participate in the Maxi-MAV/Centennial Challenge as a college/university team.

Georgia Tech's projected Autonomous Ground Support Equipment (AGSE) will be a mechanically stable platform that incorporates its own electronics & sensors bay (with software to support autonomy) and wired/connected hardware modules or subsystems required to perform all outlined Centennial Challenge tasks: a robotic arm and manipulator system, a vehicle erector system, igniter-insertion-&-launch-ready system, safety and system indicator lights, and all necessary master & pause switch systems for autonomy, ignition procedures and final launch. Georgia Tech's projected AGSE system will operate in concordance to competition guidelines. Upon activation of the AGSE master switch to power and activate autonomous systems and procedures, activation of the pause switch (per competition rules) and subsequent deactivation of the pause switch:

1. Use its sensors bay to map the area surrounding the AGSE and locate a cylindrical payload with dimensions of ¾" diameter and a 4" length.
2. The AGSE will proceed to use its installed robotic arm and manipulator to grab and transport the payload to the loading area in proximity to the nose cone of the launch vehicle.
3. The payload will then be inserted into a secure payload compartment within the nose cone of the launch vehicle through a sealable opening in the nose cone.
4. The AGSE will then ensure that the nose cone entrance is securely sealed and ready for launch (the payload entrance will be sealed via an automatic closing mechanism or manipulation of the robotic arm to close the opening of the nose cone).
5. The AGSE will alert the vehicle erector system to begin raising the launch vehicle and launch platform until the launch vehicle is positioned 5 degrees off the vertical and halt in position.
6. The AGSE will then proceed to insert the igniter into the model motor of the launch vehicle via a loading module installed onto the vehicle erector system.
7. The AGSE will halt and be on stand-by for (launch vehicle) recovery electronics to be armed.
8. The AGSE will be on stand-by for launch vehicle inspection.
9. The AGSE will continue to be on stand-by until the area is evacuated and the Launch Control Officer activates the master-arming switch.

10. The AGSE will, upon activation of the master-arming switch, autonomously proceed with ignition procedures then halt, and be on stand-by.
11. After the LCO completes a 5 second countdown, and activates the final launch button the AGSE will initiate launch of the launch vehicle.

The requirements for the AGSE for the Maxi-MAV/Centennial Challenge as proposed by Georgia Tech's Team A.R.E.S. are in line with those outlined for the AGSE in the NASA SL Handbook:

- Compliance with general launch/Maxi-MAV competition procedures in 3.2 Maxi-MAV & requirements 3.2.2.2. & 3.2.2.3 of The Autonomous Ground Support Equipment (AGSE) section & 3.2.3. Prohibited Technologies for the AGSE & 3.2.5. Safety and AGSE Control

3.2.2. AGSE Subtask & Subcomponent Requirements

3.2.2.1. Payload Identification/Capture/Retrieval

The envisioned design of the AGSE will be able to autonomously:

- Identify the location of the payload outside of the mold line of the launch vehicle,
- Plan a path for the retrieval sub-part of the AGSE
- Execute the planned path to grip the payload and deposit it in the payload container on the vehicle.

3.2.2.2. Versatility

In an unpredictable environment, the AGSE will have to be adaptive and reactive accordingly to external conditions and events. In order to monitor changes in external conditions and detect targets of interests, a variety of percepts will be incorporated into the design of the AGSE.

3.2.2.3. Modularity

Complex tasks and platforms often require parts of the problem or system to be broken down into more simple subtasks and components that will eventually assembled into a functional solution. The AGSE design and operation will reflect this in its modularity of various components that are function specific and failure independent. Using and modifying established and mature technologies in order to fulfill the different tasks the AGSE must perform ensures a high likelihood of mission success and low risk of failure. The modular nature of having various components or system facilitates the ease of repair and upgrade over the operational lifetime of the AGSE.

3.2.2.4. Percepts

Percepts will provide visual and depth information (i.e. through MS Kinect Sensor), temperature, and pressure data (or any other required valuable data). These “environment sensors” will be mounted on an elevated “sensor bay” to provide a vantage point over the area of the AGSE and the surrounding environment. Additional visual and depth sensors will be mounted on the manipulator to assist in identification of payload and planning on the arm.

3.2.2.5. Manipulator

A six-degree-of-freedom robotic arm will be ideal in retrieving the payload. Since this manipulator will be able to achieve all possible combination of poses within the designed space, this will make path-planning easier. The main idea is for the manipulator to precisely retrieve the payload and deposit it in the payload chamber. The manipulator will be controlled by a microcontroller, which will translate received poses from the planning algorithms into actual arm movements. Servo motors can be utilized in combination with PID controllers for each joint for accurate movement. Combined with techniques such as Kalman filtering, noise can be reduced to achieve a high degree of precision.

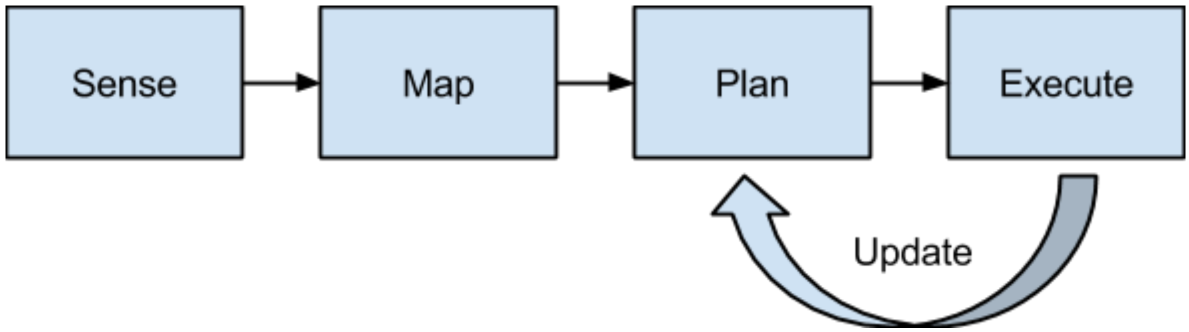


Figure 10: Concept of steps for retrieval mechanism

- Percepts will be responsible for gathering required information. This will include visual and depth information of the surrounding and also detecting the location of the target of interest (the payload).
- After processing the digital signal, a data map of the coordinate system to the 3D world will have to be constructed and stored in the system. Using a combination of OpenCV and the Point-Cloud-Library, a reflective representation of the world can be created.
- Using search algorithms such as A*, a path for the manipulator will be generated in the planning stage. The paths will have to be translated into arm movements through inverse kinematics algorithms.

The controller of the robot will take in the required movements for the manipulator and command each joint and the gripper to carry out the desired action (Figure 10).

3.2.3. General Dimensions and Function Breakdown

Figure 11 contains the general positioning information for the AGSE.

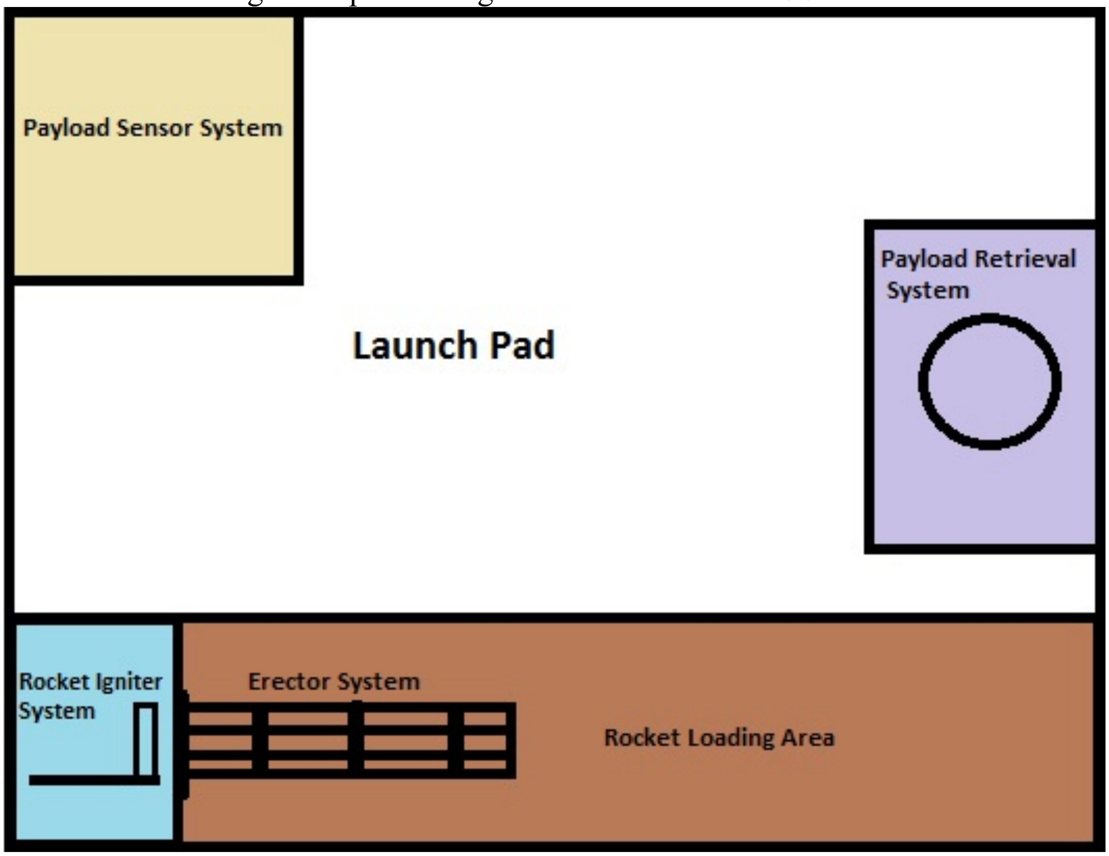


Figure 11: AGSE Layout

Rough dimensions of the various mechanical components are given below in Table 6.

Table 6: General Dimensions of AGSE Components

AGSE Part	*General Dimensions*
AGSE Platform	8' x 4' x 3''
Rocket Erector System	30''x 5''x 1''
Rocket Igniter System	10''x 3''x 1''
Rocket Loading Area	7'x 1'x 3''
Payload Retrieval System	1'x 1'x 1'
Payload Sensor System	11''x 3'' x 3''

In addition, a functional breakdown showing the estimated percentage of the allotted 10 minutes to be spent on each task by the AGSE is shown below in Figure 12.

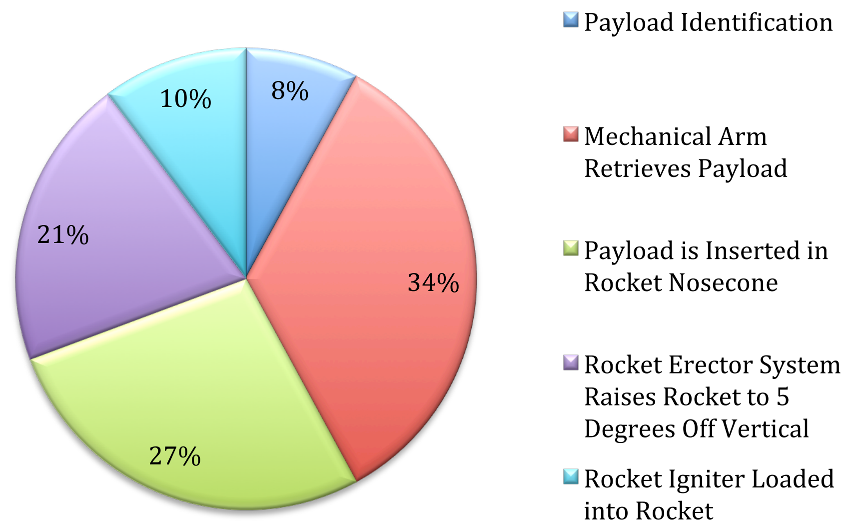


Figure 12: AGSE Function Breakdown

3.3. *Avionics*

3.3.1. Sensing

The sensors used in the rocket design will provide a variety of information and data that will help monitor and ensure the critical systems of the rocket are functioning. Table 6 shows the main breakdown of the sensors we will be using.

Table 6. Sensor Functions, Descriptions, and Possibilities

Sensor Function	*Descriptions*	*Sensors*
Critical System Monitor	Detect conditions (in flight) of the engine, avionics bay, and other structure locations	IMU, Thermistors, Humidity Sensor, Strain Gauges
Telemetry	Transmit Rocket and Payload Location	Transmitter, Antenna, GPS, Altimeters
Recovery	Engage Parachutes, provide flight data, and competition altimeter	Altimeters

3.3.2. Recovery

The recovery system will use two PerfectFlite miniAlt/WD (MAWD) altimeters. One altimeter will be used as the main altimeter and the other will be used for redundancy purposes. Table 7 will illustrate the requirements for the recovery system.

Table 7: the Recovery System requirements

Requirement Number	***Requirement Definition***
2.1	The launch vehicle shall stage the deployment of its recovery devices in the following order, drogue parachute, main parachute
2.2	Teams must perform a successful ground ejection test for both the drogue and main parachute
2.3	At landing, each independent section's kinetic energy shall not exceed 75 ft. lbf
2.4	The recovery system electrical circuits shall be completely independent of any payload electrical circuits
2.5	The recovery system shall contain redundant, commercially available altimeters
2.6	A arming swtich shall arm each alitmeter, which is accessible from the exterior of the rocket airframe
2.7	Each altimeter shall have a dedicated power supply
2.8	Each arming switch shall be capable of being locked in the ON position for launch
2.9	Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment
2.10	An electronic tracking device shall transmit the position of the rocket
2.11	The recovery system will by shielded from magnetic waves and all onboard devices, and placed in separate compartments within the vehicle

3.3.3. Shielding

Due to the nature of our other onboard electronics, the recovery system, as well as other sensitive electronics are going to be shielded either using a Faraday Shielding composed of aluminum, iron, or copper mesh, or a Passive Shielding by using a highly magnetically permeable metal alloy. Additionally, other shielding methods include Cabling Shielding, or a Dual Passive Shielding lining the electronics with aluminum. However, every shielding decision will have to consider the additional mass it is adding to the rocket.

3.4. *Major Technical Challenges and Solutions*

There were some important challenges the team had to address during the design process:

For the Rocket team, reaching the target apogee and delivering the payloads to a predetermined height were significant objectives of the project, and the team maximized the accuracy of the rocket by deliberately engineering the rocket system to exceed the target apogee and manipulating the drag with the pin drag system in order to correct the overshoot. The positioning of payload within the rocket was also a challenge, as ejecting a separate payload from the rocket would add more complexity to the recovery system. To address this issue, the payload would be placed in the nosecone and the tip was designed to open up like a hatch. This would also allow the payload to be loaded easily by the Autonomous Ground Support Equipment (AGSE) system.

Some of the challenges that arose in designing the Autonomous Ground Support Equipment include specification of the movement of the mechanical arm, reducing the noise from different sensors and the arm, and raising the launch platform to an angle of 5 degrees off vertical. Using an arm with multiple degrees of freedom and different sensors that take in measurements result in noise that causes inaccuracies in arm movements. To reduce noise and make arm movements more precise, the use of a Kalman filtering algorithm was considered. This algorithm estimates the possible variables in a specific state, and it updates the estimates when new measurements or movements are made using a weighted average, giving more weight to estimates with higher certainty.

The team decided to implement a pulley system in addition to a battery-powered motor in order to gain a mechanical advantage in raising the rocket that is approximately 1-kg in weight.

4. Educational Engagement

An important part of the 2014-2015 Georgia Tech Team A.R.E.S. mission is to build support in the Georgia Tech community. The USLI competition has been made into a highly integrated, class-based, team project through Georgia Tech's Vertically Integrated Program (VIP). The VIP Program unites undergraduate education and faculty research in a team-based context. VIP extends the academic design experience beyond a single semester, with students participating for up to three years. It provides the time and context to learn and practice professional skills, to make substantial contributions, and experience different roles on large multidisciplinary design/discovery teams. As part of this experience, the USLI team takes on the responsibility to contribute in turn to the community and promote scientific and engineering knowledge to high school students through educational outreach.

4.1. Community Support

Since the Georgia Tech Team A.R.E.S. is a relatively young team, its exposure to the community is very limited. In order to gain support from the community, Team A.R.E.S. will pursue advertising opportunities through on-campus events. This will allow the Team to gain exposure to local business and organizations that could help support the Team throughout the project.

Team A.R.E.S. has received financial support from the Georgia Space Grant Consortium and also received tutorials and hands-on training on building high-powered rockets from the Georgia Tech Ramblin' Rocket Club.

4.2. Educational Outreach

The goal of Georgia Tech's outreach program is to promote interest in the Science, Technology, Engineering, and Mathematics (STEM) fields. Team A.R.E.S. intends to conduct various outreach programs targeting middle school Students and Educators. Team A.R.E.S. will have an outreach request form on their webpage for Educators to request presentations or hands-on activities for their classroom. The team plans to particularly encourage requests from schools in disadvantaged areas of Atlanta, with the goal of encouraging students there to seek careers in STEM fields.

4.2.1. FIRST Lego League

FIRST Lego League is an engineering competition designed for middle school children in which they build and compete with an autonomous MINDSTORMS robot. Annual competitions are held centered on a theme exploring a real-world problem. Team A.R.E.S. plans to have a booth at the Georgia Tech FIRST Lego League Tournament, with the goal of illustrating how the skills and ideas utilized in the competition translate to real world applications; in particular, a rocket with autonomous capabilities. The team also plans to help judge the tournament.

4.2.2. Georgia Tech NSBE

The Georgia Tech chapter of the National Society of Black Engineers (NSBE) is one of the largest student-governed organizations at Georgia Tech. NSBE's mission is *to increase the number of culturally responsible black engineers who excel academically, succeed professionally and positively impact the community.* Team A.R.E.S. plans to engage the chapter throughout the year, coordinating with them on high-profile engineering outreach-related events to further both organizations' outreach goals.

5. Project Plan

5.1. Project Schedule

The Simple Complexity project is driven by the design deadlines set forth by the NASA SL Program office. These deadlines are listed in Table 8.

Table 7: Design milestones set by the NASA SL handbook

Deadline	*Date*
Proposal	6 OCT
Web Presence Established	31 OCT
PDR Documentation	5 NOV
PDR Teleconference	7-21 NOV
CDR Documentation	16 JAN
CDR Teleconference	21-31 JAN
FRR Documentation	16 MAR
FRR Teleconference	18-27 MAR
Competition	7-10 APR
PLAR Documentation	29 APR

5.2. Estimated Budget

In order to ensure we have a successful project, our team will be receiving donations in the form of financial donations or in material donations. Figure 13 and Table 9 illustrate the breakdown of the estimated budget across all of our sections.

Table 8: Estimated Budget for the 2014-2015 project

Section	*Cost*
Flight System	$2172.74
Rocket	$913.39
Testing	$1,096.07
Travel	$1,200.00
Outreach	$800.00
Total Budget	$6,410.55

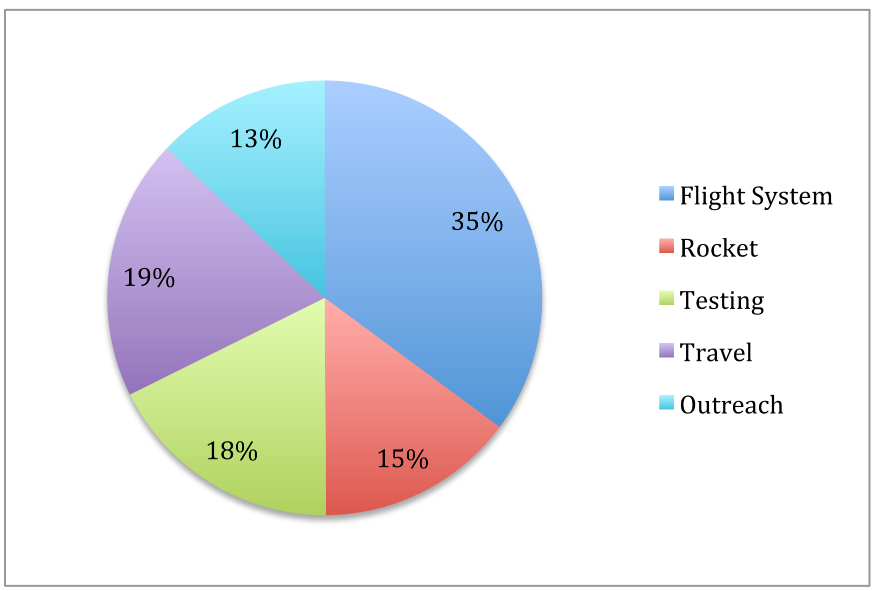


Figure 13: Budget Breakdown 1

Currently our only source of funding is from the Georgia Space Grant Consortium that is providing the team with $1,000. The team is actively looking for more sponsorships in the Georgia Tech Community and local Atlanta Companies as well as corporate sponsors, SpaceX, Boeing, etc.

5.3. Funding Plan

In order to achieve the maximum goal of raising $10,000 for the rocket and the AGSE and other supports for 2014-2015 Student Launch competition, Team A.R.E.S. have sought sponsorships through three major channels

- Georgia Tech Alumni
- Companies that team members have interned
- Local Companies in Atlanta area

The fund raising actions were started with the connections that can be reached on campus. Operation sub-team talked to several professors separately and obtained the contact information of Georgia Tech Alumni working in the Aerospace field. At the same time, all Team A.R.E.S. members were working together to provide contact information of past companies. After compiling this information, the Outreach and Budget managers reached out to potential sponsors via phone calls and email. In order to explain the project further, either in-person meetings or virtual meetings via Skype are scheduled to speak with these potential sponsors. Lastly, the Team has also received a dedicated room at Georgia Tech in which the Team can construct and store their launch vehicle, payload, and other non-explosive components.

5.4. Additional Community Support

Team A.R.E.S. will have the opportunity to recruit more fellow Yellow Jackets once the spring semester arrives in January 2015. Moreover, Team A.R.E.S. has developed a plan to outreach as many students in metro-Atlanta as possible. The plan will include teaming up with a local high school to develop their engineering, math, and science curriculum. The idea is to present the local schools with the lifestyle of being an engineer is like, for example, in the academic field by coming up with lesson plans to present engineering courses.

5.5. Plan for sustainability (VIP)

Recognizing the opportunities and experience gains offered by the NASA SL competition, the Georgia Tech Team A.R.E.S. has worked with Georgia Tech to offer the SL competition as a highly integrated team project through the Vertical Integrated Program (VIP). The VIP program provides the necessary infrastructure and environment that allows for a highly integrated design utilizing inputs from the aerospace, mechanical, and electrical engineering disciplines. Additionally, the VIP program provides technical elective credit for all students – both undergraduate and graduate.

Appendix I:

References:

2011-2012 Georgia Tech USLI Proposal

2012-2013 Georgia Tech USLI Proposal

NASA SL 2014-2015 Handbook

Appendix II:

2015 NASA SL Georgia Institute of Technology Safety Statement

I understand and will abide by the following safety regulations:

1.6.1 Range safety inspections of each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program.

1.6.2 The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny launch of any rocket for safety reasons.

1.6.3 Any team that does not comply with the safety requirements outlined in section 4, page 11, of the 2015 NASA SL Handbook will not be allowed to launch their rocket.

Anushri Dixit - 10/02/14	Victor Law - 10/02/14
[illegible] - 10/02/14	[illegible] - 10/2/14
[illegible] 10/02/14	[illegible] 10/2/14
[illegible] 10/02/14	[illegible] 10/2/14
[illegible] Bui Long 10/02/14	YILU ZHU 10/02/2014
Raphael [illegible] 10/02/14	[illegible] 10/2/2014
[illegible] 10/02/14	[illegible] 10/2/2014
[illegible] 10/02/14	[illegible] 10/2/2014
[illegible] 10/02/14	[illegible] 10/2/2014