University of Iowa AIAA USLI Flight Readiness Review

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Team Summary

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Launch Vehicle Summary

The launch vehicle has been designed to be lightweight and is centered around safely carrying a given payload. The vehicle airframe will be constructed from fiberglass, with various lightweight materials being used for other external and internal components as detailed later in this report. Table 1 gives an overview of the vehicle's main parameters.

Table 1: Launch Vehicle Overview

Overall Length (ft)	6.7
Diameter (in)	4
Mass (lb)	14.06lb
Motor	Cesaroni K490
Recovery System; parachute, drogue chute	52in, 24in drogue
Milestone Review Flysheet	See Appendix A
Payload Title	Mars Ascent Vehicle
Experiment Description	Autonomous acquisition, containment, and launch of payload through ground support system to launch vehicle and target altitude

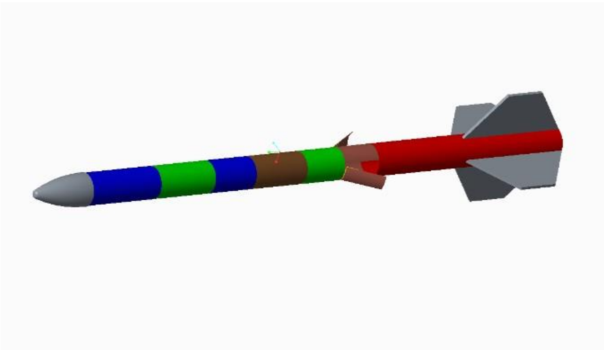


Figure 1: Full Launch Vehicle

Section 2: Changes Made Since CDR

Changes to Vehicle Criteria

Based on results from the first full-scale test launch (discussed in detail later in this report), the recovery system was updated. The streamers tangled with the shock cord along the length of the dual-deployment system, preventing them from properly deploying. The main parachute still deployed properly and safely returned the launch vehicle to the ground. Due to the streamers tangling, the design has been updated. The streamers will be removed, and a 24 inch drogue chute will be used instead. This will prevent tangling in later launches and ensure the safe recovery of the launch vehicle.

The drag system will not be operated. Results from torque tests on the drag flap system indicate that rotating motor system will not provide sufficient extension of the flaps on the sides of the rocket. With only 0.8kg*cm measured stall torque the force applied to the centroid of the flaps is 12.1N at maximum. This is not enough force to counteract the pressure acting on the area of the flaps, which based on test flight data was found to be 20.4N. Rearranging the calculation, the idealized maximum angle that the flaps could extend would be 15.02degrees. This only provides roughly 6N of added drag which is less than 7% of the average coast drag force on the rocket.

The number of fins has been reduced to 3 from the original 4. This was largely due to a manufacturing error, but the team elected to run with the change and use 3 fins. An updated simulation was run to ensure that the design would still be stable, and was proven to be stable.

Since CDR, the design of the AGSE system and its' overall functionality have been changed which has led to a change in the control subsystem in the vehicle. Originally, the design required wireless communication through IR communication in order to determine the proximity of the AGSE system to the launch vehicle. The new AGSE design doesn't require the use of IR communication to determine that the AGSE is over the cargo bay subsystem, therefore we have eliminated the IR communication electronics on the vehicle and the AGSE.

Since CDR, we have edited the recovery electronics. Originally, the recovery subsystem consisted of two PerfectFlite Stratologgers for our recovery electronics. One of the stratologgers has been replaced with a TeleMetrum which has dual deployment system and GPS tracking. The redundancy feature of the recovery subsystem is still present with the replacement of the stratologger with the TeleMetrum. The TeleMetrum adds a safety feature by reducing the chances of the same fault happening on the same device. The TeleMetrum has two capabilities in one thus saving money and space.

Changes to AGSE Criteria

The changes to the AGSE have been a large effort to move away from expenses that were to be occurred from the purchase of multiple linear stages and conveyor systems. The design was changed to utilize a robotic arm. This is the only design change, with all other aspects remaining the same. By making this change, the team will be able to better meet the deadline to complete the AGSE, and will have extra time to test the operation of the AGSE. The robotic arm is also significantly cheaper than linear actuators, and saved the team a significant amount of money.

Section 3: Launch Vehicle Criteria

Design and Verification of Launch Vehicle

Table 2 gives the overview of the launch vehicle, including the final selected motor.

Table 2: Launch Vehicle Overview

Overall Length (ft)	6.7
Diameter (in)	4
Mass (lb)	14.06lb
Motor	Cesaroni K630
Recovery System; parachute, drogue chute	52in, 24in drogue chute

The motor has been changed due to the decision to remove the drag system from the overall design. Based on this, the overall weight will be reduced. A new motor needed to be selected in order to hit the target altitude. The simulation data (given later in this report) confirms that the Cesaroni K630 motor will be a suitable replacement and will allow the launch vehicle to hit the desired altitude.

Recovery Subsystem

Overview

The recovery subsystem harnesses the drogue chute and the main parachute. The drogue chute and the main parachute will be deployed electronically. The recovery system is controlled by the dual deployment system. The recovery system will have redundancy in order to ensure deployment of the drogue chute and the main parachute for a safe recovery of the vehicle and the cargo.

Redundancy/Safety

The dual deployment system is controlled by two altimeters. One is a PerfectFlight Stratologger, and the other is an Altus Metrum TeleMetrum. The drogue chute will be deployed at apogee and the main parachute will be deployed at a predefined altitude of 500 feet. The redundancy altimeter will deploy the drogue chute at 2 seconds delayed from apogee and the main parachute will deploy at 450 feet. By using dual deployment and setting the ejection altitudes, the drift of the rocket can be controlled to ensure that the rocket does not drift too far from the launch area. By utilizing two altimeters, the system is ensured to work. If one altimeter fails, the other altimeter will be able to send the charge to ignite the black powder and deploy the recovery system.

Equipment

The Perfectflite Stratologger altimeter CF will be the device used for the dual deployment.
The first detonation is deployed at apogee and the second detonation occurs at a predefined height. There will be two Perflectflite Stratologger altimeters, one as the primary and the other as the redundancy dual deployment system. The two dual deployment systems will be housed in an avionics bay. The avionics will fit snug and create an air tight seal and isolate the dual deployment systems from the rest of the vehicle. The holes cut into the avionics bay will be allow the barometer to obtain the necessary readings to determine when apogee is achieved. The following table below from the manual of the Perfectflite Stratologger determines the necessary hole size for a single or 4 holes.

Table 3: Port Hole Sizes for Dual Deployment

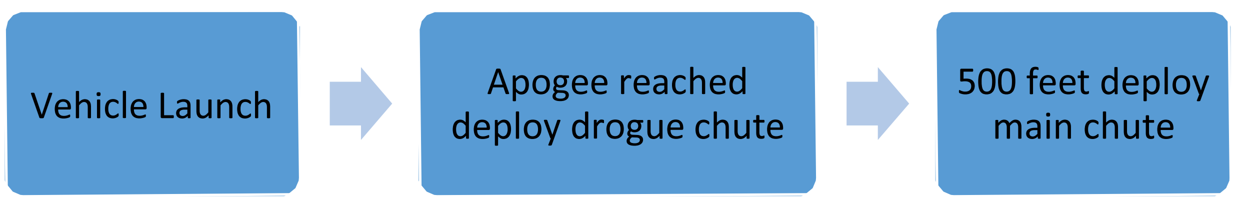
AvBay Diameter	*AvBay Length*	*Single Port Hole Size*	*Four Port Hole Size*
1.6"	6"	.032"	.020" (small pinholes)
2.1"	6"	.048"	.025"
3.0"	8"	.113"	.057"
3.0"	12"	.170"	.085"
3.9"	8"	.202"	.101"
3.9"	12"	.302"	.151"
5.5"	12"	—	.286"
7.5"	12"	—	.5"

Single Port, hole size = Diameter * Diameter * Length * 0.0016
Four Ports, each hole = Diameter * Diameter * Length * 0.0008

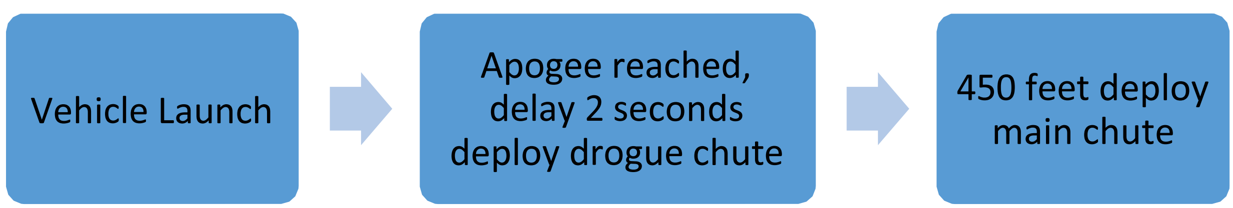
https://www.apogeerockets.com/downloads/PDFs/StratoLoggerCF_manual.pdf

Using the table above, the desired diameter is between .101" to .151". The use of 4 holes creates at 90 degrees apart helps to create an even pressure through the avionics bay for the barometer.

Block Diagram of the Dual Deployment System



Primary dual deployment block diagram



Secondary/Redundancy dual deployment block diagram

The rocket's drift at various wind speeds was also studied. This was done to ensure that the rocket would stay within the designated launch and recovery zone.

Table 4: Drift calculation

Wind Speed (mph)	5	10	15	20
Flight Time (s)	47.5	47.5	47.5	47.5
Distance (ft)	348.33	696.67	1045	1393.33

Mission Performance Predictions Criteria

This mission requires a few key instances to occur for this mission to be considered a success. First, the AGSE system must successfully locate, recover and load the payload into the launch vehicle. Once the vehicle receives the payload, it must then be positioned correctly for launch. The rocket must then be launched and fly exactly one mile (5280 feet) into the air and safely be recovered with the payload intact. Only when these requirements are met will this mission be a success.

First Test Flight

The first test flight was conducted on Sunday, March 6th, 2016. This test flight did not contain all of the subsystems, but allowed for verification of stability and the recovery and dual deployment systems. The launch was successful, and the dual-deployment system successfully deployed the recovery system. The streamers tangled around the body tube of the dual-deployment system, leading the team to decide to change from streamers to a 24 inch drogue chute instead. This will prevent the shock cords from tangling, and allow the drogue chute to work more effectively.

Compared to the actual flight, the Openrocket simulation software proved to be quite accurate with the numbers. The rocket was simulated to reach an apogee of 1849 m (6066 ft) compared to the actual apogee of 1845 m (6053 ft). This result yielded a percent error of about 0.22%. The simulated rocket was projected to reach a maximum velocity of 248 m/s (813.6 ft/s) compared to the actual maximum velocity of 186 m/s (610 ft/s). This yields a percent error of 33.3%. The simulated maximum acceleration of the rocket was 126 m/s^2 compared to the actual maximum acceleration of 105 m/s^2 (344.5 ft/s^2). This yields a percent error of 20%. On average, the simulation proved to have a percent error of about 25%. However, the apogee is the most important data collected from the test launch, and Openrocket was shown to be extremely accurate in predicting the altitude with an error of just 0.22%.

Simulations have been done to verify the stability of the design. The results from these simulations are given below.

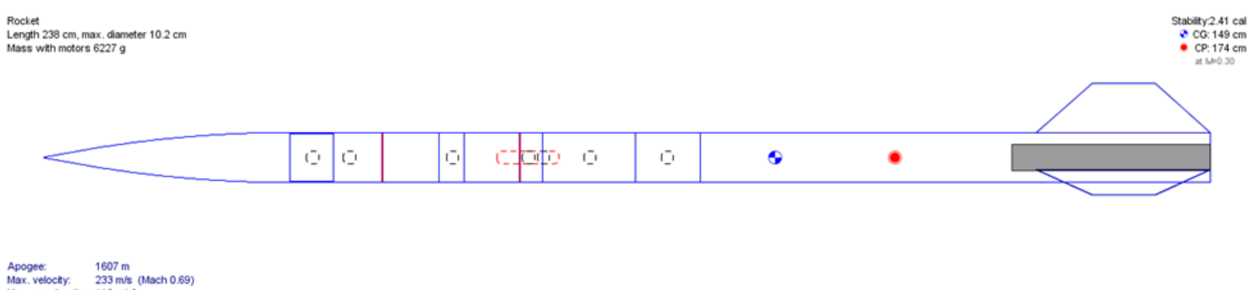


Figure 2: Rocket Design in OpenRocket

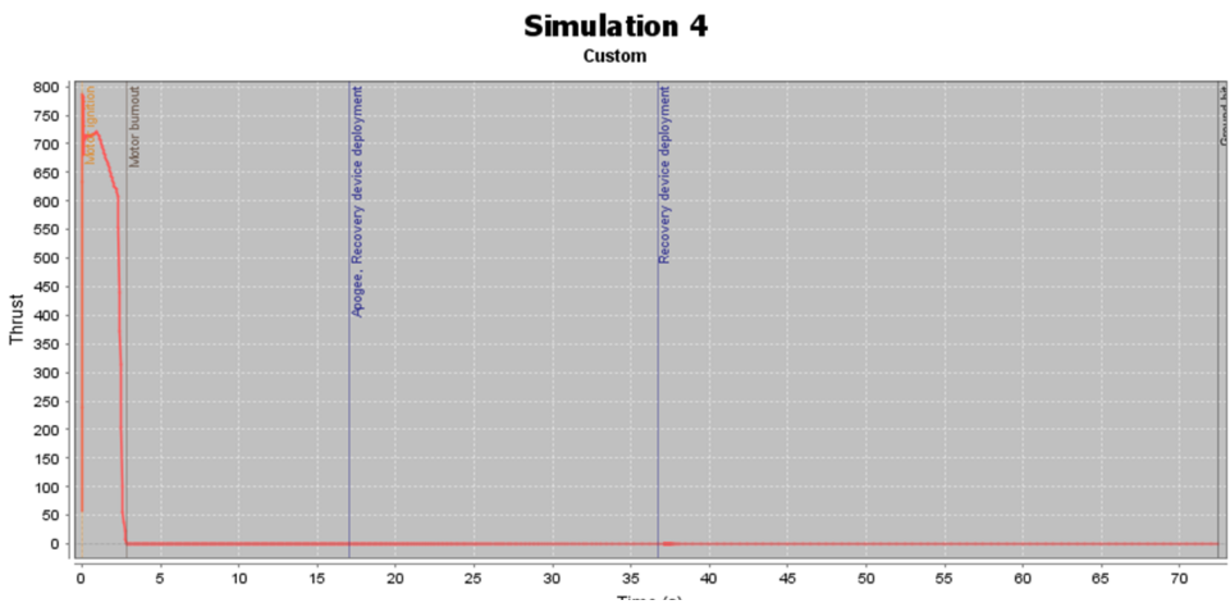
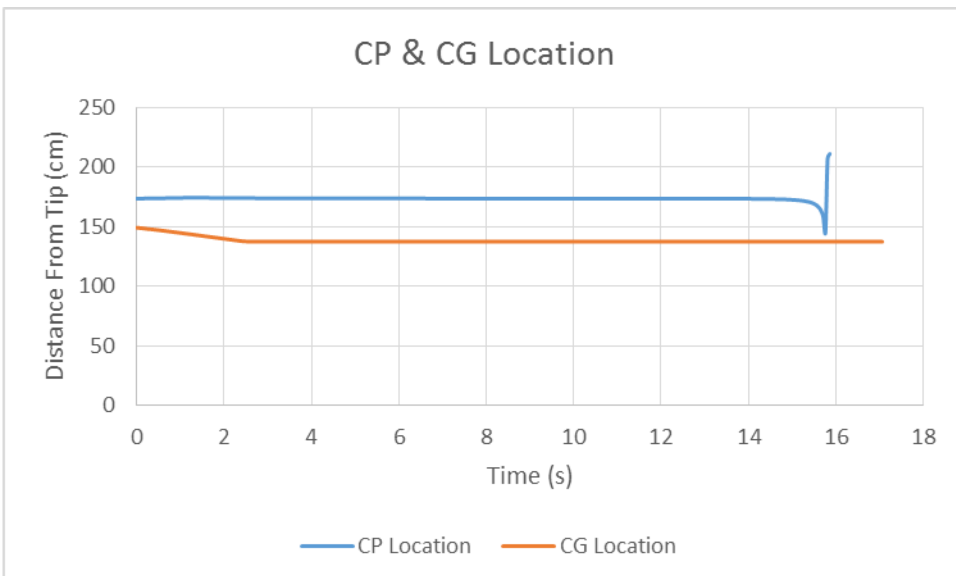


Figure 4: CP and CG Location Over Time

Figure 3: Thrust Curve



From this figure, it can be seen that the center of gravity is above the center of pressure for the entire duration of the flight.

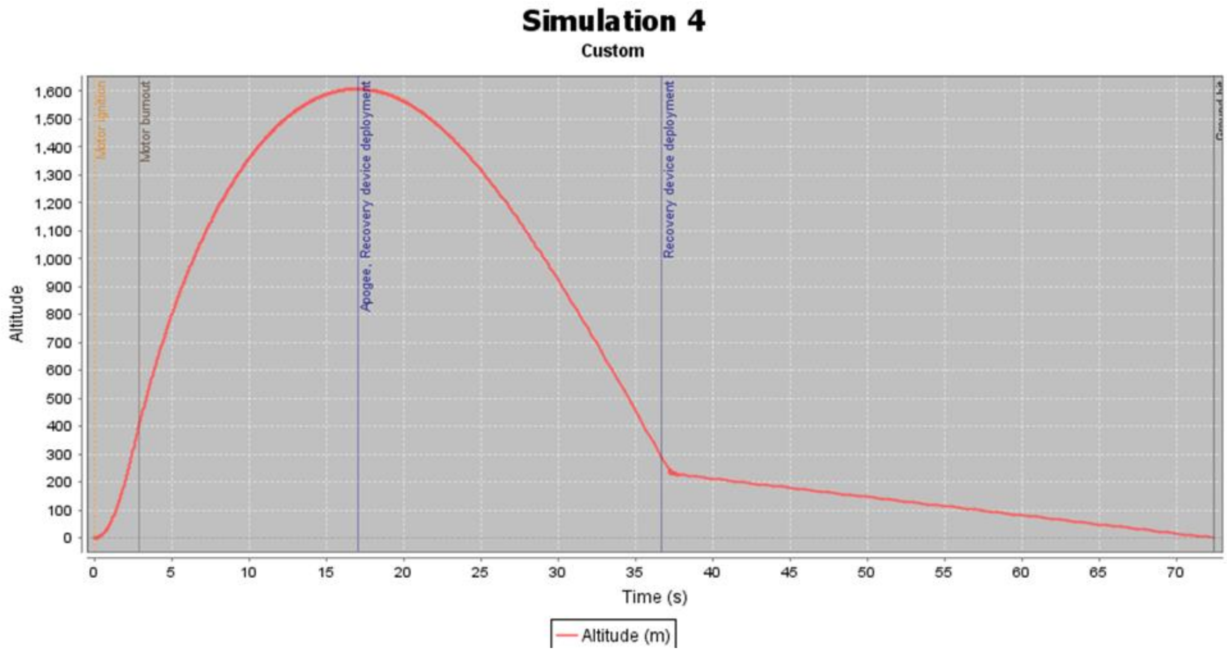


Figure 5: Altitude Curve

Based on the above figure, the predicted apogee is 1607 m, or 5272 ft. This is extremely close to the desired apogee of 5280 ft.

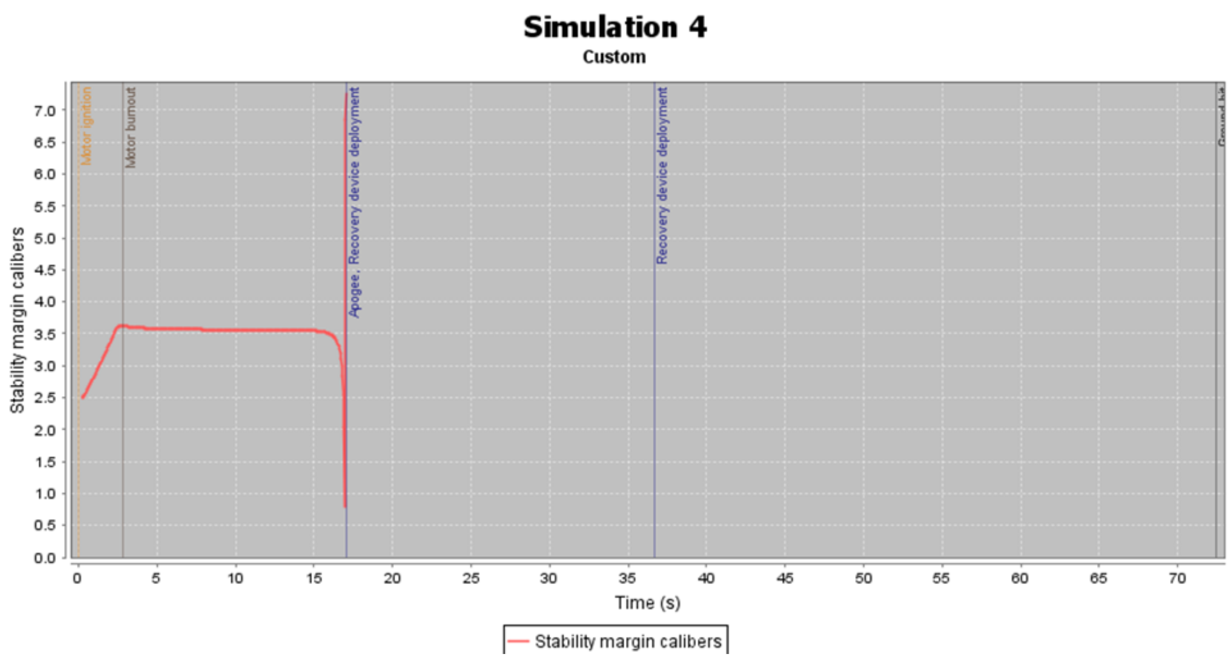


Figure 6: Stability Curve

As seen in the above figure, the rocket has a stability greater than 2.5 cal until it reaches apogee. The moment diagram was also drawn for the rocket, and is given below.

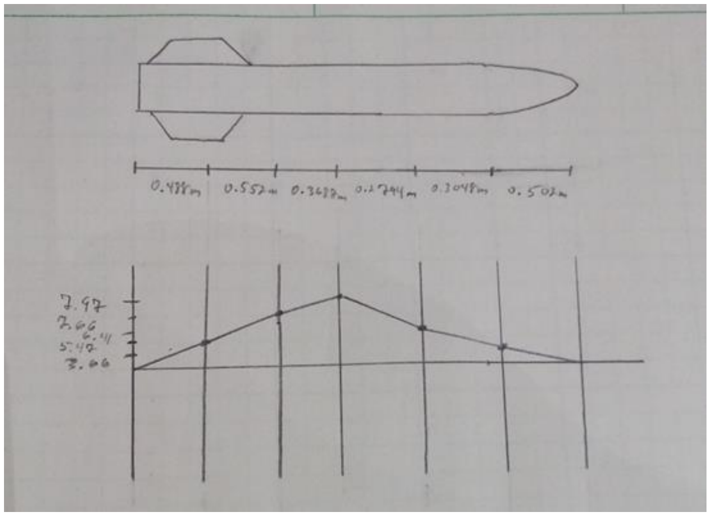


Figure 7: Moment Diagram

Interfaces and Integration

The cargo bay is made to protect the payload from any stresses due to flight. The controls have to be secured during the full duration of the operation and flight. The cargo and the controls are to not be affected by the ignition system. During the recovery, the cargo and the control have to withstand the g forces and changes in momentum due to loss of acceleration. The dimensions of the payload and the controls have to be relatively close to ensure that the payload fits and does not produce drag on the system.

The control system has to link the cargo system to insure successful installation. The recovery system deploys the ejection charges by careful calculations from the altimeter. The recovery system has its own power supply and microcontroller, which insures isolation from the rest of the system which produces a safer, more reliable system.

The payload will be inserted into the launch vehicle using the AGSE. The robotic arm will pick up the payload and insert the payload. Once the payload is in the launch vehicle, the payload bay will rotate to the shut position.

The interface between the launch vehicle and the ground launch system consists of the ignition system and the AGSE. A linear actuator will push the plug into the ignition. After a few seconds delay, the applied voltage force will launch the rocket. The launch system will then disengaged from the launch system from the ground.

Electronic Subsystem Overview

The control subsystem houses the electronics that monitor the vehicle from launch to recovery. The control subsystem is a separate bay that house its' own power supply and Arduino microcontroller. The control subsystem will be placed adjacent to the drag subsystem and the cargo bay subsystem. This subsystem will consist of 6 components: accelerometer, altitude/pressure sensor, temperature sensor, IR receiver, Arduino Nano microcontroller, and a 9 V battery. An air gap will be introduced on the side of the control system in order to obtain the correct pressure readings.

System Level Requirements

The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any critical on-board component.
The batteries used for the electronics on the vehicle and the payload will have at least 12 hours of battery life. The battery life will be tested to ensure that all electronic systems are ready and don't lose power while sitting for at least 1 hour. New batteries will be used for all electronics on the day of launch and they will be tested to ensure that they all have sufficient battery life to sit and operate for at least 1 hour.

Component Analysis

Temperature sensor

The temperature sensor that will be used is a tmp36 used to monitor the temperature of the vehicle and the control subsystem. The temperature sensor is uses an analog voltage which then can be translated into a readable temperature. The temperature sensor is not used with any other part of the vehicle, but is instead used as a safety measure to insure that the vehicles' temperature isn't increasing unexpectedly.

The test setup and test procedure can be seen in the electronics test procedures section.

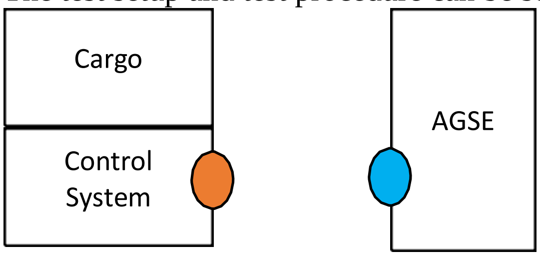


Figure 13: AGSE and Cargo interaction via prox sensors

Arduino Nano Microcontroller

The Arduino Nano microcontroller controls and monitors all the sensors in the control subsystem. The choice of the Nano microcontroller was determined due to the size and capacity of the device. The microcontroller can be operated on an external power supply and it efficient in size thus allowing more room for wires and other sensors.

9 V battery

The 9 V battery was chosen because the microcontroller can be operated at 9 V. The 9 V battery is easy to work with and has been proven to work with microcontroller operation. The 9 V battery will be connected the external power supply pin on the microcontroller.

Accelerometer

The accelerometer used for the control subsystem is a triple axis accelerometer, ADXL335 from adafruit. Only one axis of the device will be utilized for the drag subsystem deployment as vertical acceleration is the desired direction of acceleration. The accelerometer uses analog voltage values that are then translated into practical values of acceleration. The accelerometer was chosen due to its' g force ratings and the accuracy of the accelerometer. Accurate accelerometer readings are needed for proper deployment of the drag subsystem. The accelerometer will be used to determine the velocity of the vehicle. The accelerometer is used to retract the flaps of the subsystem once the desired velocity is reached, so that the vehicle can reach a more precise altitude. The block diagram/flowchart in figure 14 shows the interaction between the drag subsystem and the control subsystem.

Altitude/Pressure Sensor

The altitude/pressure sensor used in the control subsystem is a sparkfun product model number MPL3115A2. The sensor uses I2C communication to relay the pressure, altitude and temperature. The primary use of the sensor is the altitude measurement. The altitude measurement will be used to determine the deployment of the flaps of the drag subsystem. Once a desired altitude, below apogee has been reached, the microcontroller will deploy the drag system to slow the descent. The pressure sensor will act as a secondary safety check for the drag subsystem if the altitude sensor malfunctions during flight.

At this time, we haven't looked into the temperature sensor portion. If the temperature sensor is sufficient then the temperature sensor tmp36 will be disregarded and thus save space in the control subsystem. The block diagram/flowchart in figure 14 shows the interaction between the drag subsystem and the control subsystem.

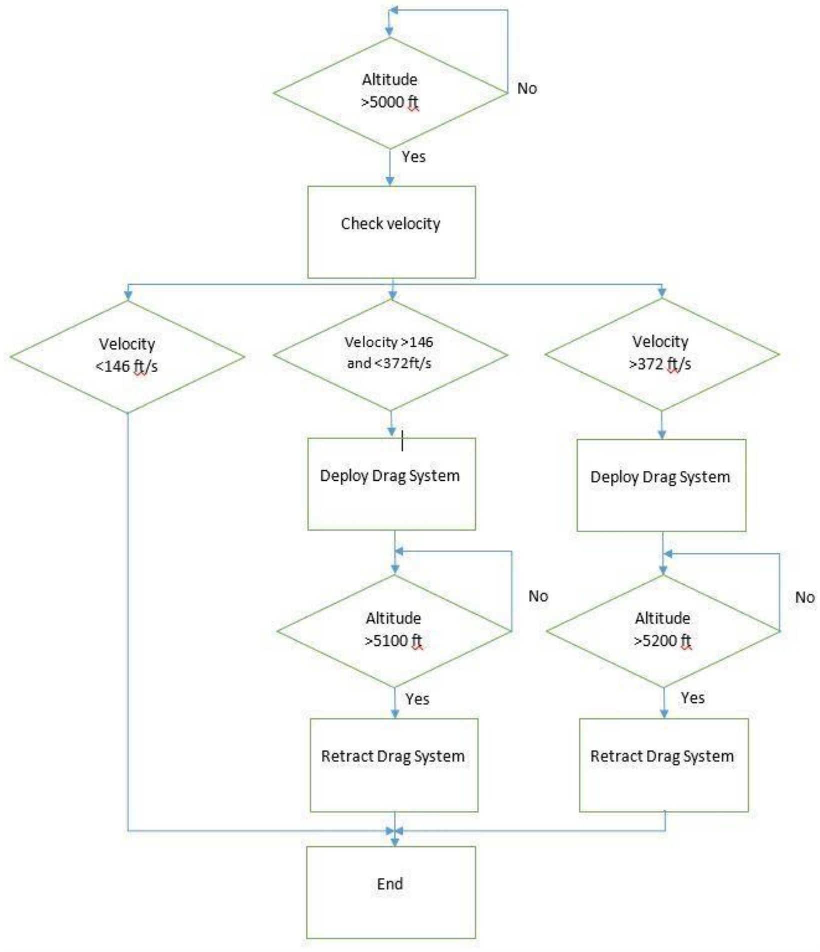


Figure 14: Drag Subsystem and Control Subsystem Interaction

Safety Plan

The team safety officer is Victoria. It is her responsibility to create safety plans and to ensure that these plans are followed throughout the project. These safety plans detail potential hazards to the health of the team members, as well as hazards to the success of the project. Along with hazard identification, mitigations for each risk have been determined and will be applied as the project progresses. By identifying these risks, the team has been able to pursue a proactive design process, rather than a reactive design process. As risks are further studied, the design or construction processes can be updated to reflect these new risks and the mitigations used. A full list of Victoria's duties as safety officer are given below.

- Write and distribute safety documents for the team, including hazard analyses, PPE requirements, MSDS and operator manuals, FAA/NAR/TRA regulations, safety plans, and procedures for construction, testing, and launch.
- Confirm that all team members have access to and have read all safety documents.
- Identify risks to the project and create mitigation strategies for each risk.
- Create safety plans for construction, testing, and launch, and brief team members on these plans.
- Oversee all testing to ensure that safety plans are being followed.
- Maintain an active role in the design, construction, testing, and flight phases of the project to ensure that all safety procedures are being followed.
- Enforce use of proper PPE during construction, testing, and flight.
- Ensure that all applicable MSDS and operator manuals are accessible to the team.
- Provide plans for purchasing, storing, transport, and use of all energetic devices.
- Ensure compliance with all laws and regulations, including local, state, and federal laws, and NAR/TRA regulations.
- Ensure safety during hands-on educational outreach activities and provide PPE as needed for these activities.

Hazard Analysis

A hazard analysis has been done for the project. This analysis was done by the entire team, and led by the safety officer. The team analyzed all subsystems of the launch vehicle, as well as specific components. Each component/subsystem was analyzed in three areas: human safety, mission success, and environment. The severity of each risk was analyzed using Table 5, shown below. The probability of each risk was analyzed using Table 6. Further discussion is also given below for the largest risks to human safety during the construction process, along with mitigation strategies. These mitigation strategies have already been put into place during the construction process, and will continue to be used throughout the building process. Team safety is the top priority, and new strategies to prevent injury are being determined as the process continues.

Table 5: Severity Definitions for Hazard Analysis

Description	**Human Safety**	**Mission Success**	**Environment**
1-Catastrophic	Death or permanent injury that causes disability.	Total loss of component(s); inability to complete given aspect of mission.	Severe damage that violates laws/regulations and is irreversible.
2-Critical	Severe injury.	Major damage to component that has significant effect on mission success.	Severe damage that violates laws/regulations that is reversible.
3-Marginal	Minor injury that requires medical attention.	Minor damage to component that has a small effect on mission success.	Some environmental damage that does not violate laws/regulations; can be cleaned up.
4-Negligible	Minor injury that only requires first aid.	Minimal damage to component that has almost no effect on mission success.	Minimal environmental damge.

Table 6: Probability Definitions for Hazard Analysis

Description	Definition
A-Frequent	High likelihood; expected to occur immediately.
B-Probable	Likely to occur at some point.
C-Occasional	Expected to occur occasionally.
D-Remote	Unlikely, but likely to occur at some point.
E-Improbable	Very unlikely and not expected.

The color-coded table below shows the risk levels based on a combination of the probability and severity of each risk. Below that are the risk assessment tables. The largest safety risks are centered around working with power tools, and working with fiberglass. To mitigate these risks, team members will wear proper PPE at all times. All power tools will be inspected prior to use to ensure that nothing is damaged. For working with fiberglass, the risk lies primarily around fiberglass dust. To prevent irritation, team members will be required to wear respirators, safety glasses, and gloves while cutting and sanding fiberglass. All other mitigation strategies are given in the hazard analysis tables below.

AGSE Risk Assessment

Hazard	Cause	Outcome	Severity Value	Probability Value	Risk Level	Mitigation
Use of power tools.	1. Improper use or lack of use of PPE. 2. Lack of or improper training. 3. Use of damaged power tools.	1. Minor to severe injury, including lacerations. 2. Damage to rocket structure due to use of damaged power tools.	2	B	High	1. Team members will wear proper PPE when working with power tools. 2. Team members will be trained on power tool use and will have operator manuals for consultation. 3. Power tools will be inspected prior to use, and damaged tools will not be used.
Use of welding equipment.	1. Improper use or lack of use of PPE. 2. Lack of or improper training. 3. Use of damaged welding equipment.	1. Minor to severe burns. 2. Vision damage. 3. Damage to AGSE structure due to use of damaged equipment.	2	B	High	1. Only members properly trained in use of welding equipment will be allowed to weld. 2. Proper PPE will be worn when welding or working near welding areas. 3. Welding equipment will be inspected prior to use and damaged equipment will not be used.
Linear actuators.	1. Improper setup of linear actuators.	1. Inability of AGSE to move payload into launch vehicle. 2. Inability of launch vehicle to move launch vehicle into upright position.	1	E	Low	1. Team members will read manuals prior to installation of linear actuators. 2. Linear actuators will be tested prior to launch. 3. At launch, the actuators will be inspected to ensure that they are in proper working order.
Use of power tools.	1. Improper use or lack of use of PPE. 2. Lack of or improper training. 3. Use of damaged power tools.	1. Minor to severe injury, including lacerations. 2. Damage to rocket structure due to use of damaged power tools.	2	B	High	1. Team members will wear proper PPE when working with power tools. 2. Team members will be trained on power tool use and will have operator manuals for consultation. 3. Power tools will be inspected prior to use, and damaged tools will not be used.
Use of composite fabrics such as fiberglass.	1. Improper use of PPE.	1. Splinters from composite fibers.	4	A	Low	1. Proper PPE (specifically gloves) will be worn when cutting/working with composite fibers.
Use of servo motor.	1. Improper setup of servo motor. 2. Human interaction with system.	1. Damage to system that could lead to failure. 2. Fingers/hair caught in system.	3	C	Moderate	1. Servo motor manual will be read by team prior to installation. 2. Team members will take care to ensure that hair/fingers are out of the way during setup/testing of system.
Rotation of payload bay.	1. Items getting caught in path of bay.	1. Damage to payload bay that may compromise mission. 2. Inability of payload bay to rotate to fully closed position.	2	D	Moderate	1. Bay will be tested to ensure that no other components interfere with operation of door. 2. Team members will take care to not leave extra items in payload bay area.
Disintegration of launch vehicle during flight.	1. Improper construction of launch vehicle.	1. Catastrophic failure of mission.	1	E	Low	1. Proper construction techniques will be used during construction process. 2. Quality materials will be used, and
	2. Poor material quality. 3. Improper manufacturing methods.	2. Damage to environment (ranging from minor to severe) due to falling debris.				damaged components will not be used in launch vehicle.

Section 4: AGSE/Payload Criteria AGSE Overview

The ground system is made of steel tubing, extruded aluminum, and robotic arm, all used in order to capture, contain and the launch vehicle. The ground system contains controls to safely pause the system, communicate with the launch vehicle, and monitor the stage of the loading process. The size is 8 ft long, 3 ft tall, 8 ft when vertical, and 3 ft wide. The weight of the materials will be 150 lbs. Electronics will be controlled by an Arduino connected to a computer and powered by batteries to release the winch, move the robotic arm and turn the servos.

Figure 15: AGSE Arm

Payload Capture and Containment

The fully autonomous robotic mechanism has an objective to capture, contain, and launch the payload of one inch in diameter and 4.75 inches long cylinder. In addition to securing the payload in the rocket, the automated system will also erect a rocket from the horizontal position to the vertical position and install igniters autonomously. Completion of the step Requirements 3.3.2.1.1 – 3.3.2.1.4 are outlined in the MAV hand book and will be followed within a 10 minute time frame this will verify a successful performance. The Autonomous Ground Support Equipment (AGSE) will follow a PLC on an Arduino board along with batteries to supply power to release the winch, move the robotic arm. The code will follow a series of tasks that will check, confirm, and carry out steps as the payload is delivered, there will also be proximity switches and prox sensors to ensure security between each step and provide safety of progress. To engage the AGSE there will be a master switch given to the operator and have two lights on it, one will be a flashing orange light of 1Hz to symbolize the AGSE is powered on then will be a solid orange when the power is on and AGSE is paused. The second light will be a green light to indicate that the AGSE has passed the verification and ready for start.

Milestones

Proposed schedule of milestones are part ordering, construction, testing, redesign, assembly, program control coding, control testing, safety controls coding and testing, and report writing. The subscale tests for the AGSE will include each part being tested and verified to work in the environment. Tests will include: torsion spring strength, release speed of the winch, movement of the robotic arm and servo power.

Materials

The materials required will start with the framework of the base foundation. The base will be made out of 1 inch square steel tubing welded together in the same general shape in figure 16.

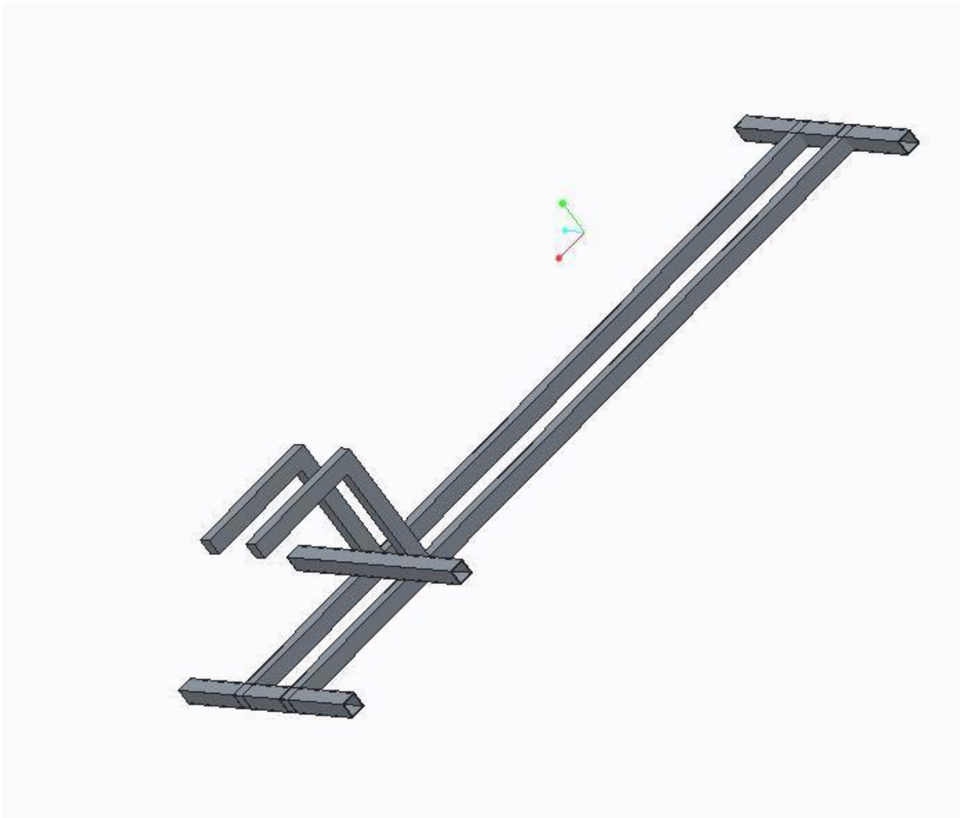


Figure 16: ground base frame.

The materials for this were decided based on low material costs and low material weight. Next design area was creating a way of erecting the rocket. The rocket will sit on a guide rail with a square launch pad attached on the base near the nozzle of the rocket. The launch pad will be attached to two torsion springs that will be able to create a moment rotating the launch pad to a full 90°. To provide resistance and to make the system able to stop on command there will be an electric winch slowly releasing line as the launch pad rotates to 90°. The guide rail will be made out of 1 inch square extruded aluminum because it will be lightweight and fit the rail guides on the rocket. The bottom plate will be made out of 2 square 8 inch and 1/8” thick steel sheet metal because of low material cost, and high structural strength plus welding ease. The torsion spring was an idea to save costs and still provide enough force to rotate the rocket vertical. This eliminated the initial idea of a motorized system that would have lifted the rocket upright. The AGSE main objective to pick up the payload will use the robotic arm.

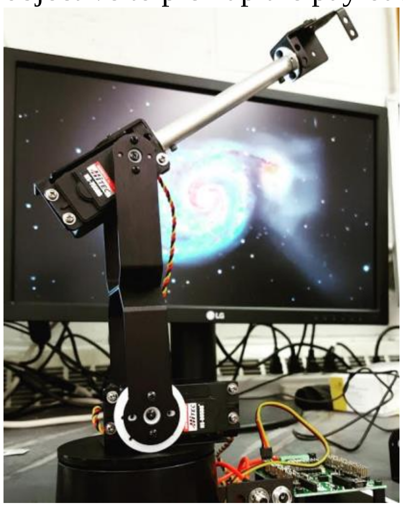


Figure 17: Robotic Arm

The system in figure 17 is the robotic arm partial completed, the payload will be placed 12 inches away from the AGSE outer mold line and will be placed in a specific area reachable by the arm. After dropping the cargo into the rocket, a prox sensor will be used to communicate to the AGSE signaling a full bay. Then the rocket will be lifted to a full 90 before the igniters are inserted.

Once the payload has reached it's vertical position the igniters will be placed in the rocket as the last step with servo driven linear actuator. Once the linear actuator reaches the home position with the igniters, a voltage is applied for a set duration and the rocket is launched. In the event that the rocket does not launch, there will be a disconnect of the battery after the voltage application time and the system is off.

Operating and Construction

The standard operating procedure starts with laying out the pieces of the AGSE framed assembly, then assembling the mechanical system and wiring the electronics, testing each electrical component, and getting the green light for the ok to start the AGSE on the remote.

The construction of the AGSE frame is nearly completed shown in figure below.

Figure 18: AGSE Frame

There is still construction left to be made for the the rail attached and robotic arm. Finally there is construction the linear stage for igniters and connecting a servo winch.

Safety

Safety will be focused on the electrical setup, robotic arm, winch, proximity switches, and linear stage. For the mechanical systems the torsion springs, material failure, and fatigue will be tested. Tests will need to be run to determine the force required to rotate the rocket vertically and the tension needed on the winch cable. The electrical wiring needs to be precise and the procedure needs to follows detailed logic. The power required to run the conveyor motors and winch are also a safety concern, tests need to be done to find the amperage needed. During the construction of the AGSE there will be safety for the machine shop. Every member will complete the necessary safety quizzes to work with power tools. There will be cutting, welding, and drilling to design the AGSE.

Section 5: Project Plan Funding Plan

The funding will be acquired from the following sources:

$3000 Iowa Space Grant Consortium
$1000 Club Funding-AIAA Fundraising
$500 Company Donations

$4500 Total Budget

Budget Plan
Rocket:

altimeter	$50
parachute	$10
fins	$80
nose cone	$40
fiberglass	$13

2 ignition	$
nozzle	$
accelerometer	$
arduino controls	$
cargo bay and	
-360 degree	
-light sensor for	
-rotation door	
photoresistor	$

Total = $890

AGES: 30ft extruded
Screws
small electric winch
10ft² 1/8in steel sheet
3X 1in square steel tubing 8
3X servo motors
3X pneumatic air cylinders
mini photo cells
Pressure sensors
Torsion Spring
Custom fabrication
arduino controls
electrical assembly

Total = $1970

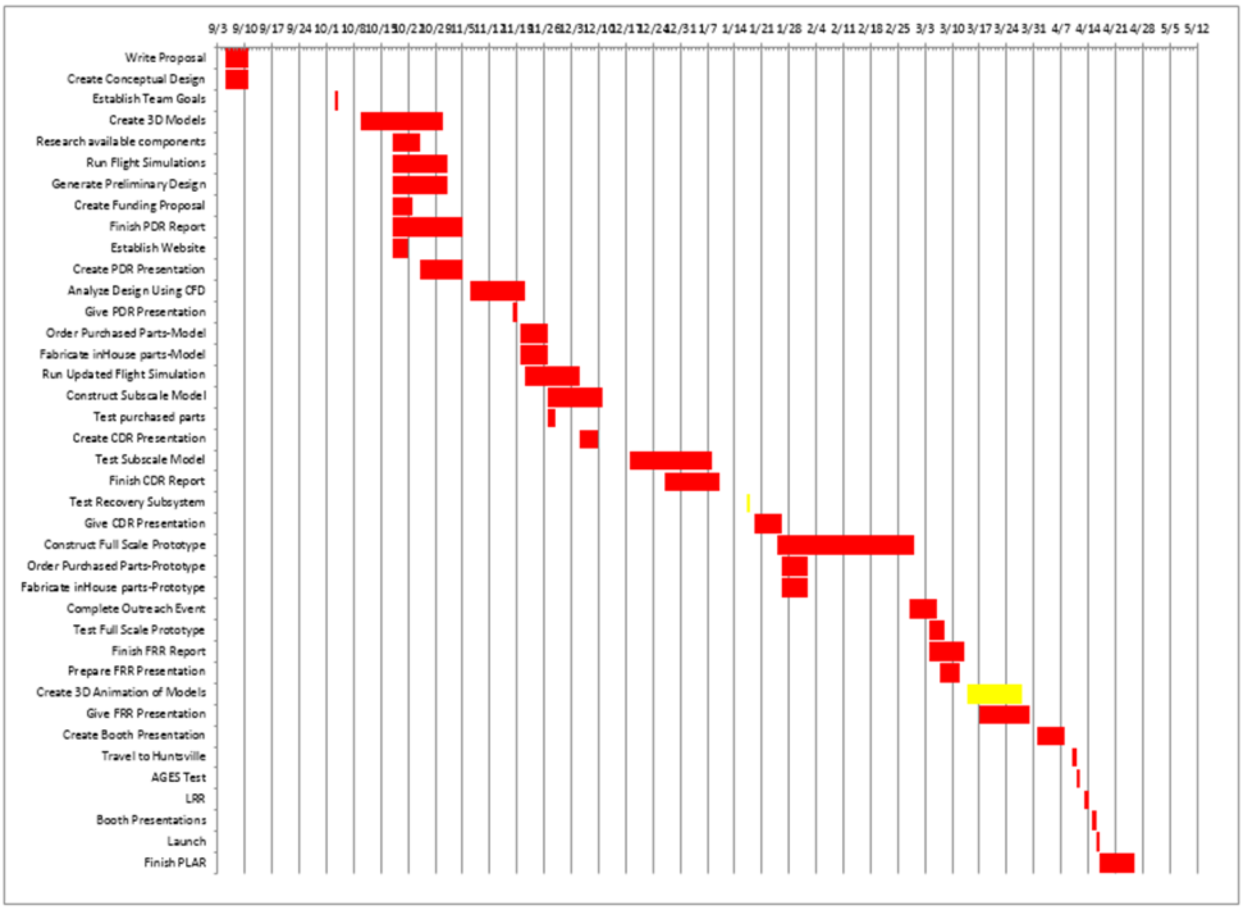
Travel: Gas (2 cars 759 miles
Hotels (4 people for 6 nights)

(4 people for 3 nights)

Total = $1300
Grand total: $4125

Timeline Schedule

The Gantt chart seen below outlines all the major events for this project. While a full test launch with all components has not been done, the stability of the rocket has been proven. The recovery system and dual-deployment system were also tested and verified. This ensures that the rocket can safely fly, and can still maintain stability and a safe recovery when the full weights are added. Another test launch is being scheduled to allow for testing with all mass objects. This second test flight will also allow for testing and verification of the new motor selection prior to the competition.



Educational Outreach

The University of Iowa AIAA will be doing educational outreach to the local high schools and junior high schools of Iowa City. The goal is to have four large group events that will involve 200+ high school students from around Iowa City. We have groups members mentoring students as they learn about the aerodynamics of rockets and the use today. We plan to make interactive stomp rockets integrate the experience. The plan is to contact the University of Iowa's outreach department where we will be assisted in finding the schools available and planning the time to be late February. Our group will use this outreach to also help our other teams in AIAA that need educational outreach for their own competition.