Preliminary Design Review

Vertical Projectile - AIAA OC Section 2018-2019
November 9th, 2018

Contents

Mission Statement

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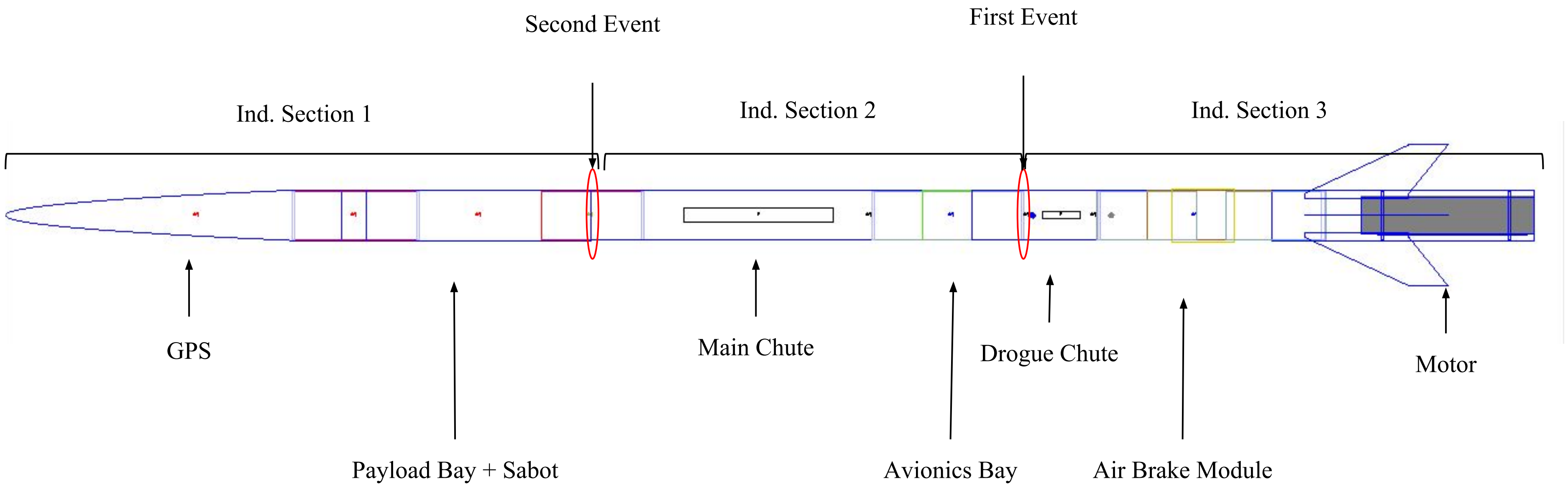
The rocket must reach a target altitude of 4600 ft, deploy its drogue chute at apogee, descend to 600 ft, deploy its main chute, and then deploy the payload, a rover, once the rocket has landed. The rover will then angle its camera towards the rocket and take pictures of the length of the rocket. The pictures will be returned so damage after the flight can be documented via the rover.

Vehicle

Material Justification

- Fiberglass body tubes
    - Affordable
    - Strong
- Fiberglass tape
    - Keep fins in fin slot
- Epoxy
    - Durable, compatible with fiberglass

Vehicle: System Diagram



Vehicle: Dimensions

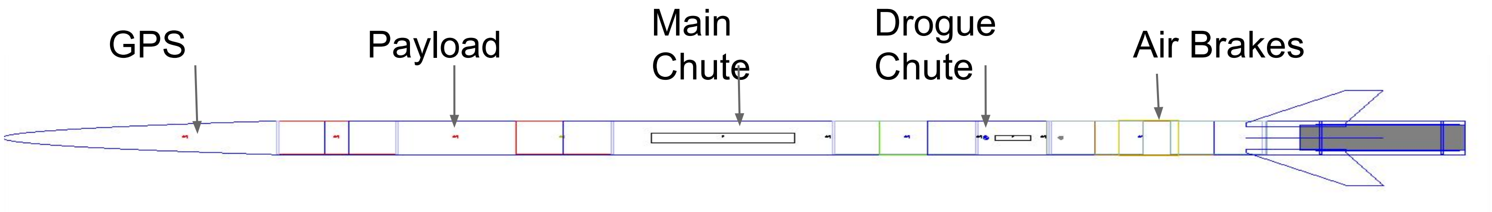
Length: 122.5 inches

Diameter: 4 inches

Semi-Span of Fins 3.25 in

Total Mass: 10987 g

Motor Choice: Cesaroni K1085WT

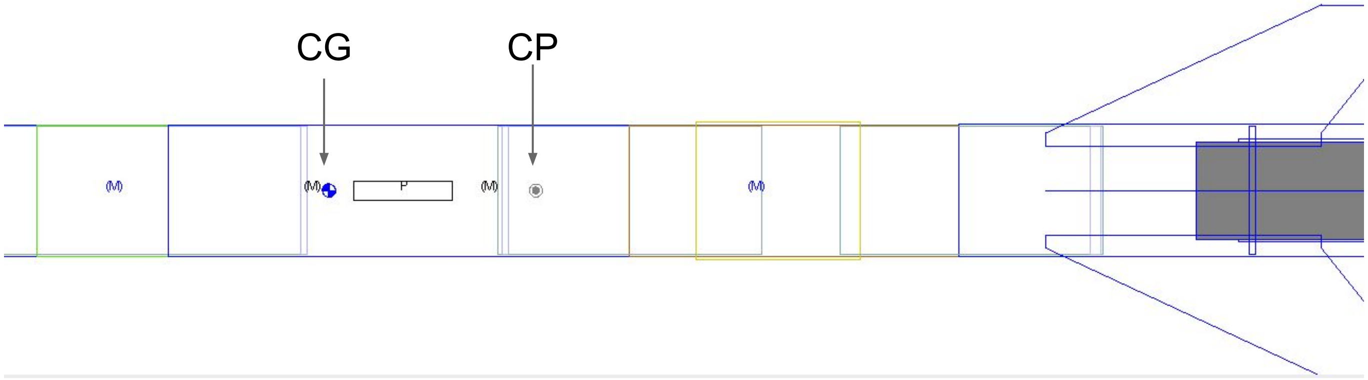


Vehicle: Dimensions

CG: 82.3643 in

CP: 88.6516 in

Stability Margin at Rail Exit: 3.2 Calibers



Vehicle: Dimensions

Thrust-to-weight ratio: 10:1

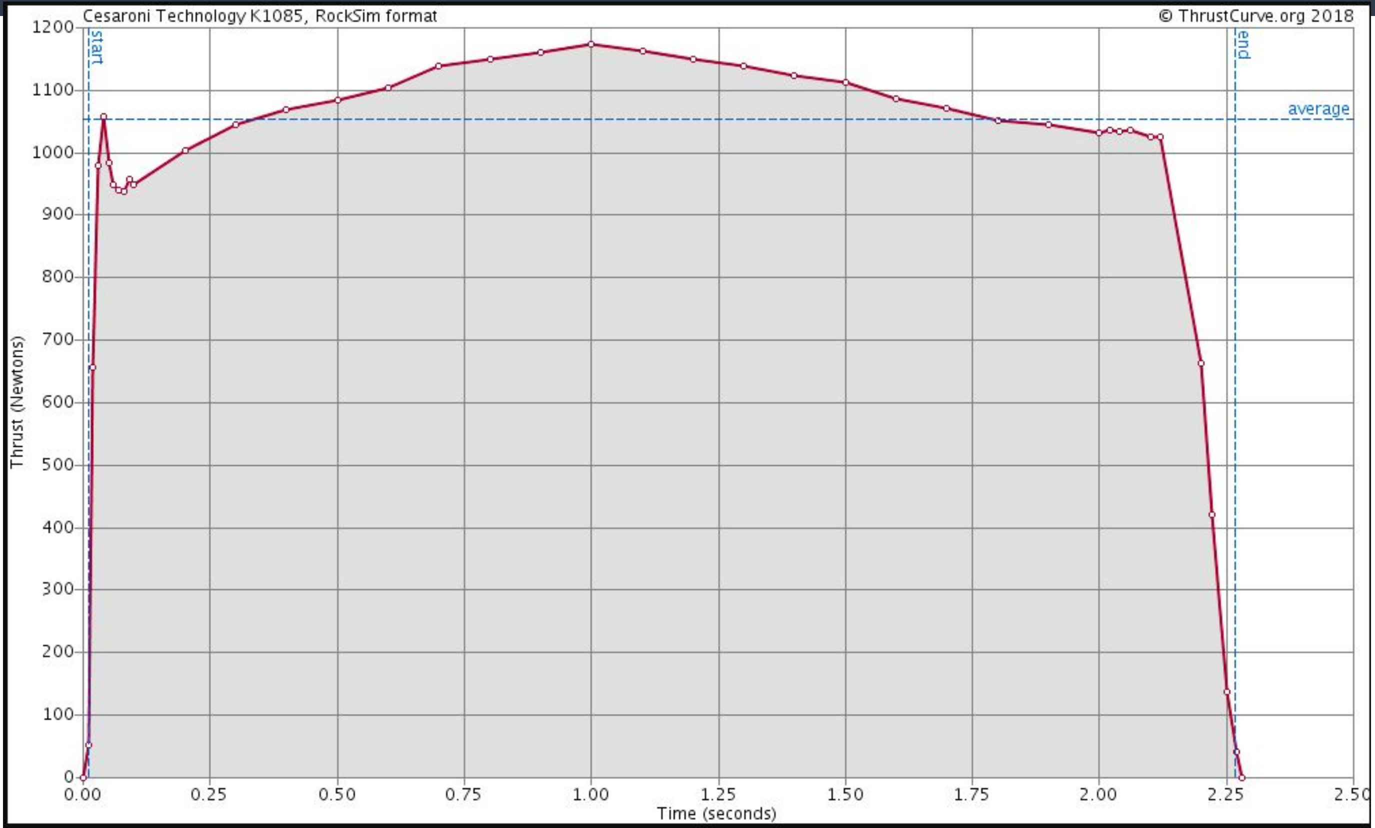
Rail Exit Velocity:

69.597 fps

Motor Selection Alternatives

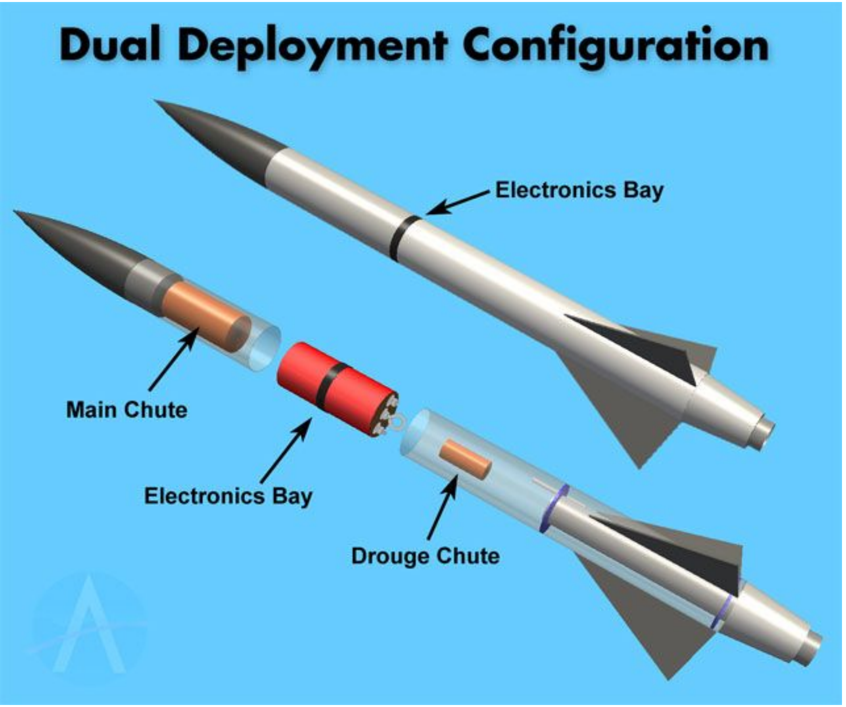
Motor	Total Impulse (Ns)	Total Mass (g)	Max Altitude (ft)	Max Velocity (ft/s)	Max Acceleration (ft/s^2)
CTI K661	2430.4	2528	5164.4	614.5	693.99
CTI K555	2406.2	2759	4886.42	547.75	693.93
CTI K2000	2329.9	2465	5072.87	691.57	749.44
CTI K735	1955.2	2509	5149.74	661.51	693.92
CTI K1085	2412.0	2430.0	5080.44	653.06	974.61

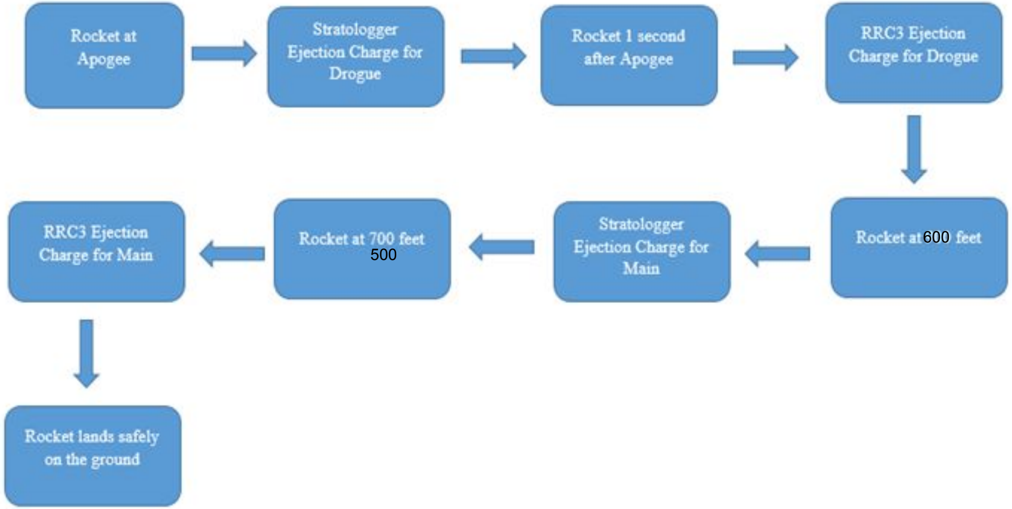
Thrust Curve



Subsystems

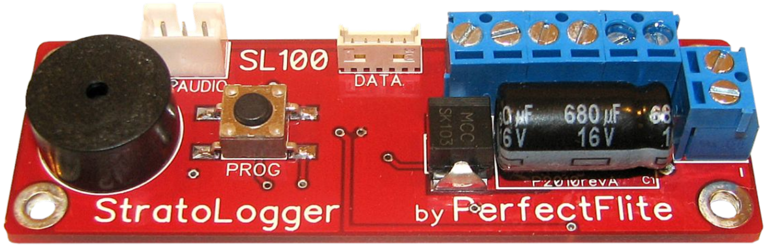
Recovery Subsystem

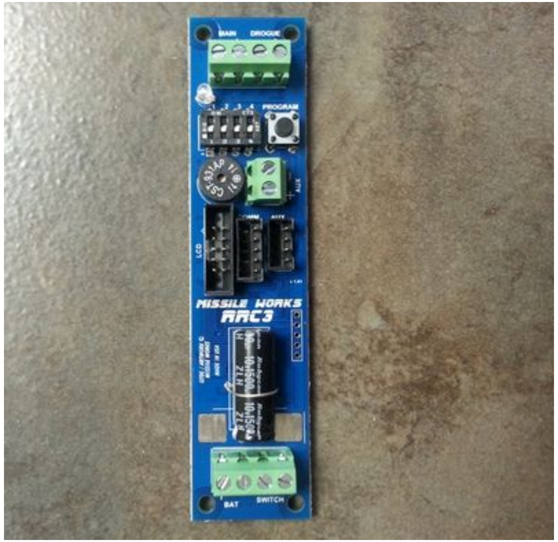




Recovery Subsystem

- Primary set of recovery electronics - Stratologger CF Flight Computer
- Backup set - RRC3 Flight Computer

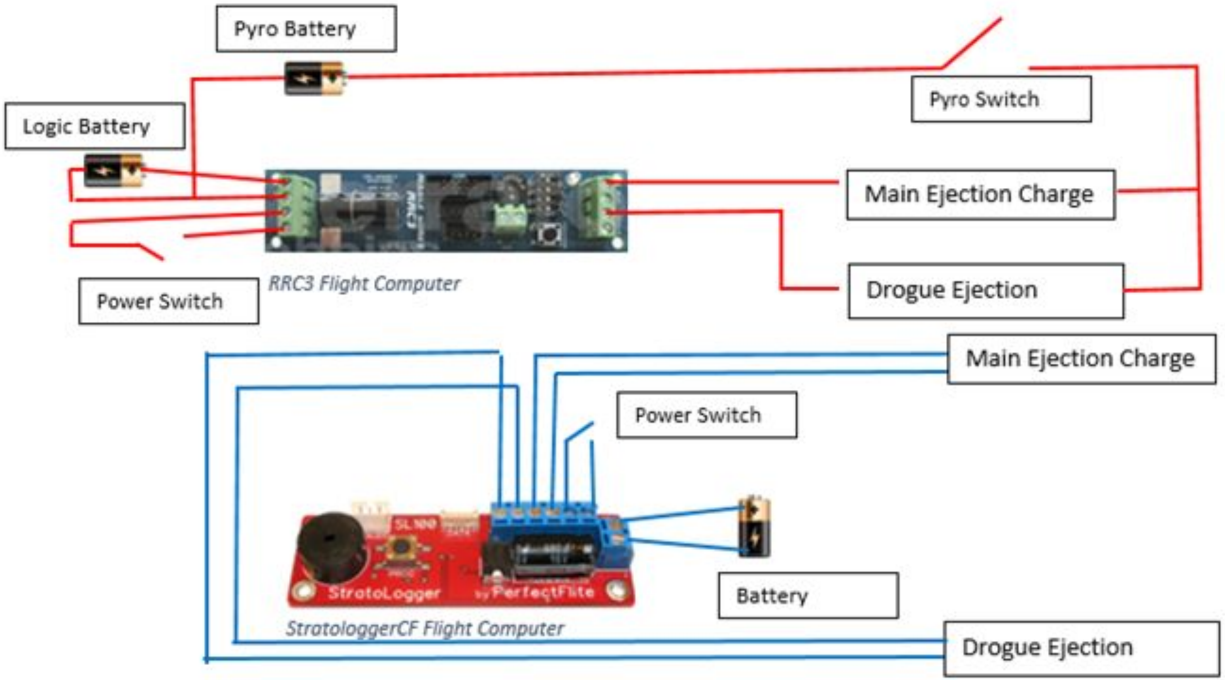




Recovery Electronic Alternatives Considered

Flight Computer	Pros	Cons
G-Wiz HCX	Easily programmable, dual deployment can be set in 100 foot increments. Comes with an SD card to record flights. Can also be used with 2 batteries to optimize safety.	Not available for sale anymore.
Stratologger CF	Easy to program, reliable manufacturer (PerfectFlite). It can record altitudes up to 100,000 feet, and stores 20 flights a second. Main deployment can be set in 1 foot increments for more precision.	Can only launch drogue at certain altitudes. Doesn't allow two batteries for increased safety.
RRC3 Sport	Easy to program and is pre set up at drogue deployment at apogee and main deployment at 500 feet. Reliable manufacturer (Mad Cow Rocketry) which we used in TARC. Allows two batteries.	Bigger than the stratologger and heavier (17g).
TeleMega Altimeter	Has an on board integrated GPS receiver (eliminating need for dog collar). Has accelerometer. Pyro events like dual deploy can be configured to specific heights and times to increase accuracy.	Really expensive (costs $500). Relatively heavy (25g).
Raven Flight Computer	Really small (saves space). High quality data (accelerometer, barometric pressure, etc). Main deployment at 700 feet (fits with our deployment plan).	Hard to program. No flexibility with main deployment (can't change the altitude). Really expensive ($155).

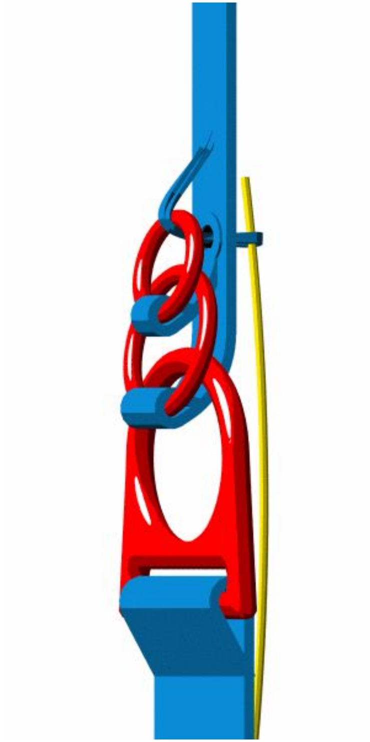
Recovery Subsystem



Recovery Subsystem

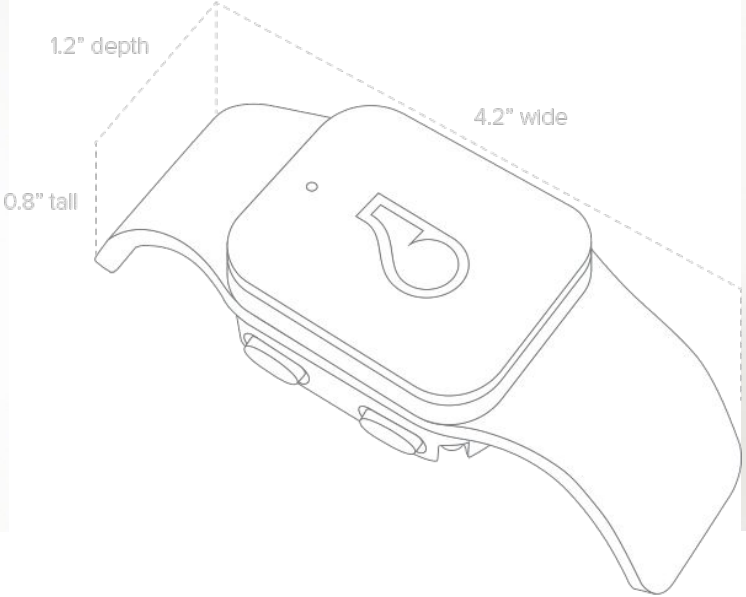
Deployment:

3-Ring System



https://www.youtube.com/watch?v=T6pXytpAnZ0&feature=youtu.be

GPS Subsystem



GPS Alternatives Considered

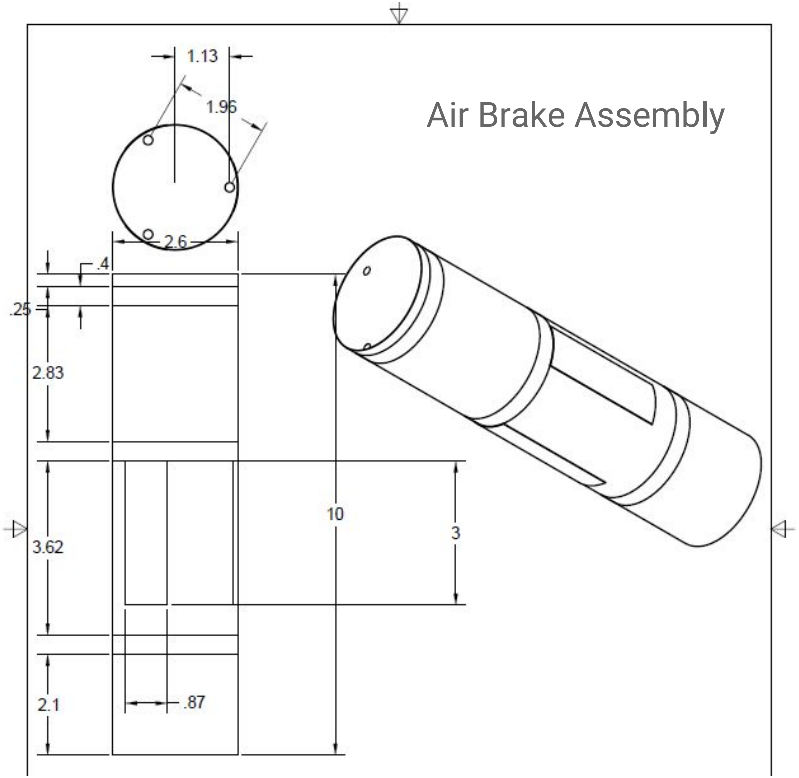
GPS system	Pros	Cons
Whistle GPS dog tracker	Easy to use because it requires knowledge of using a smartphone app. It can be recharged easily using the base station and is not dependent on any other external electronics. No additional telemetry required.	Only works where there is cellular coverage. Bigger than the other GPS options. More expensive because of money needed for cellular service.
EM-506 GPS Receiver	Really small, really accurate in rough geographical conditions like canyons, relatively cheap.	Relatively difficult to use compared to dog tracker. Also not as durable. Additional telemetry may be required.
Arduino GPS tracker	Small and easy to set up. It will be easy for us to use because of our experience with Arduino in TARC.	Additional space required for battery, really expensive, will require use to use a new and unfamiliar version of Arduino. Additional telemetry may be required, making it relatively harder to use.

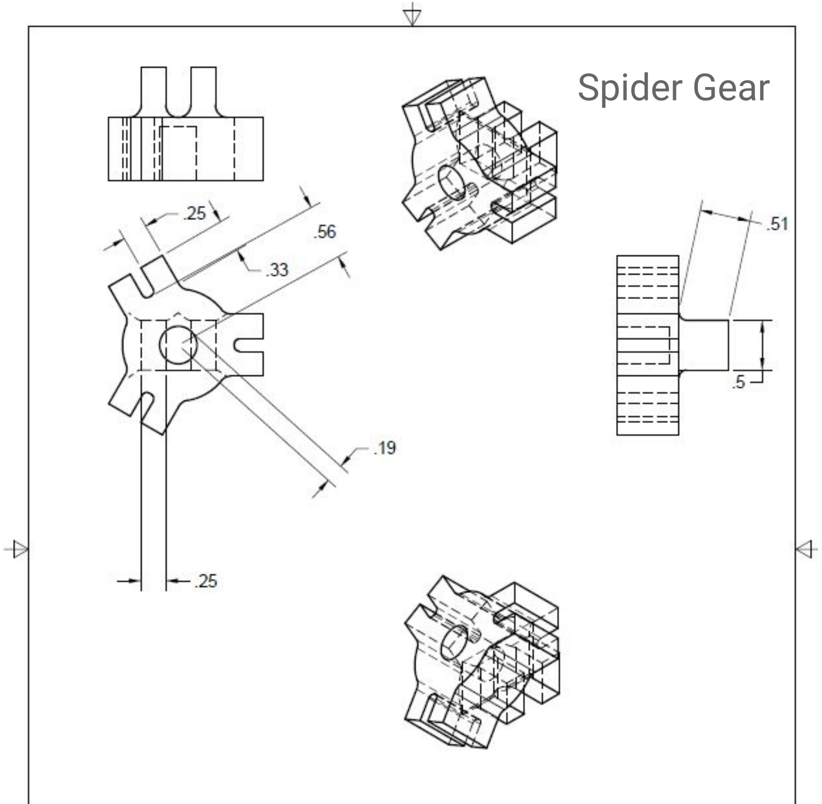
GPS Payload

Consideration: APRSdroid system

- Parallax GPS in the payload
- Mobilinkd and BaoFeng and APRSdroid system on the ground

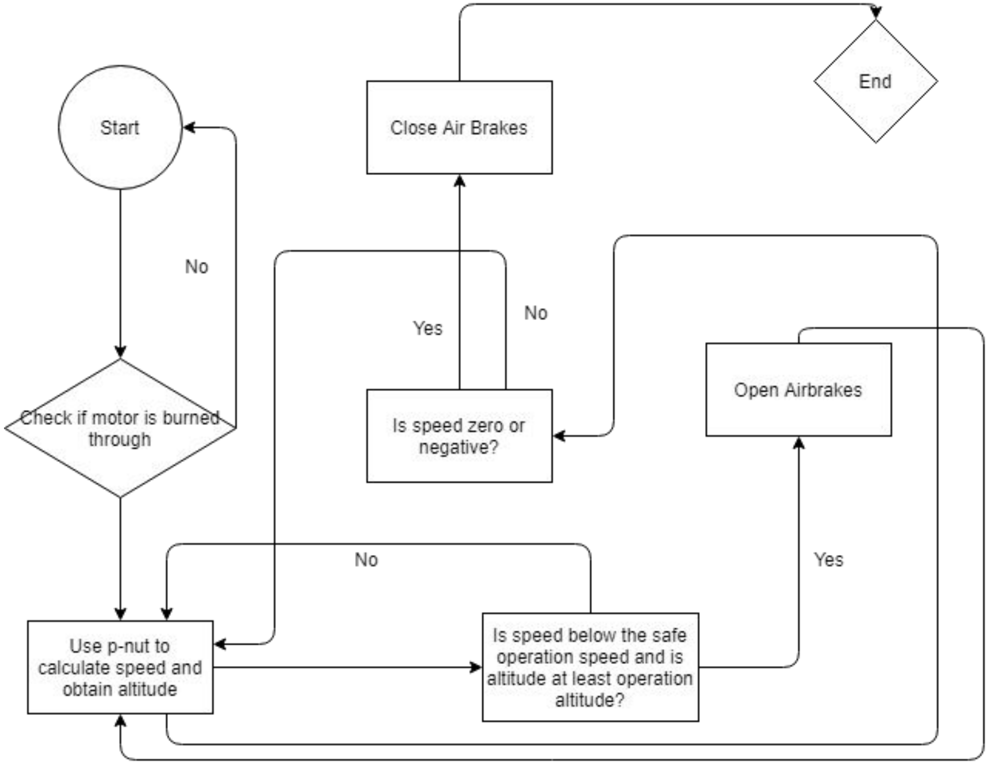
Air Brakes Subsystem





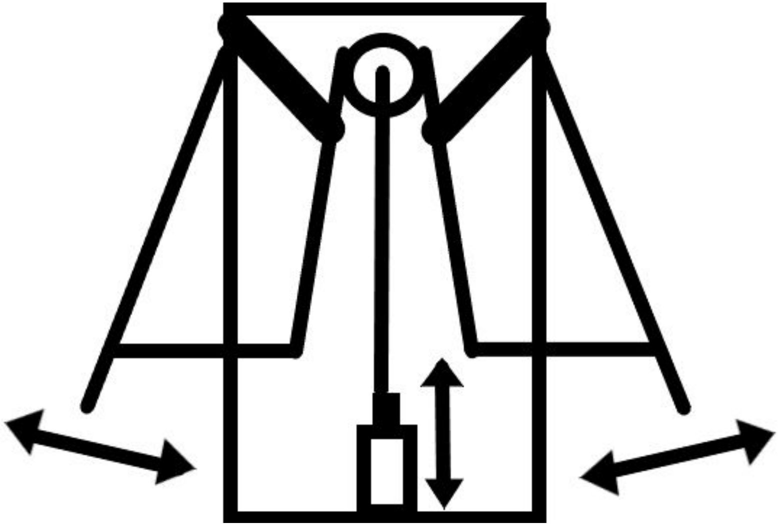
Air Brakes Subsystem

Air Brake Algorithm

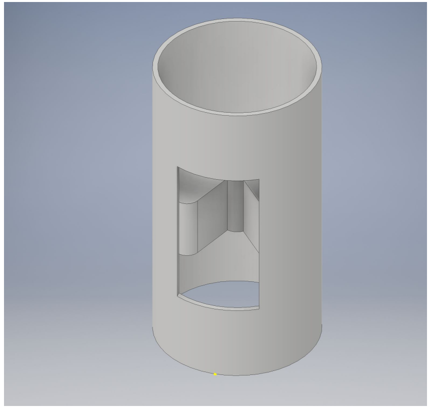


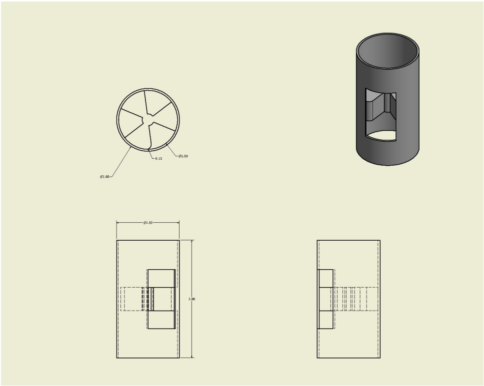
Air Brake Alternatives Considered

Solenoid



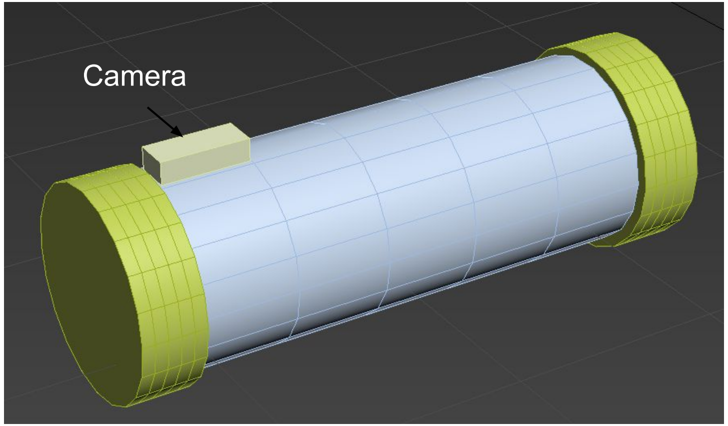
Electric Motor

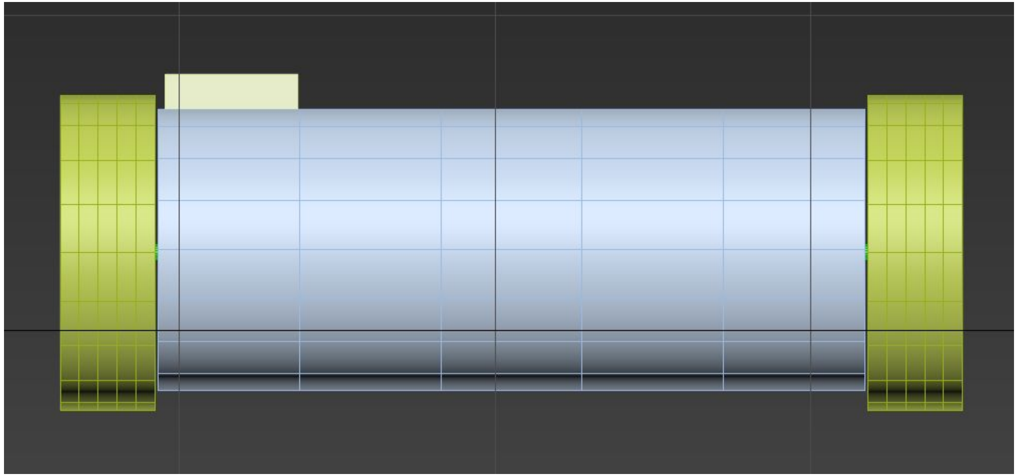




Engineering Payload

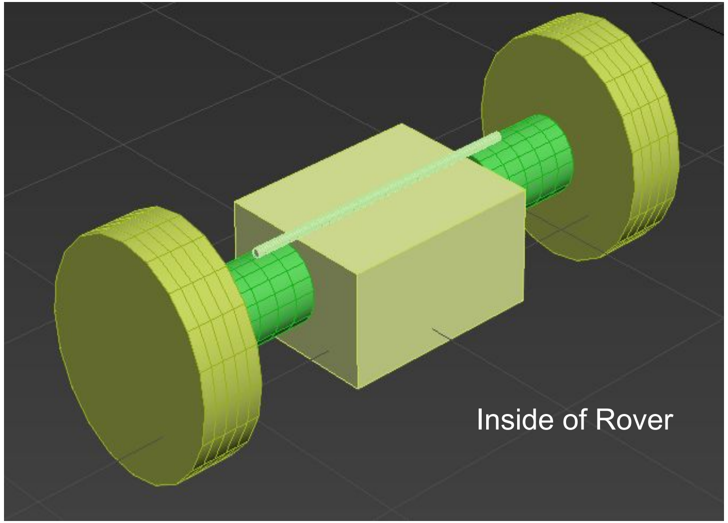
Rover

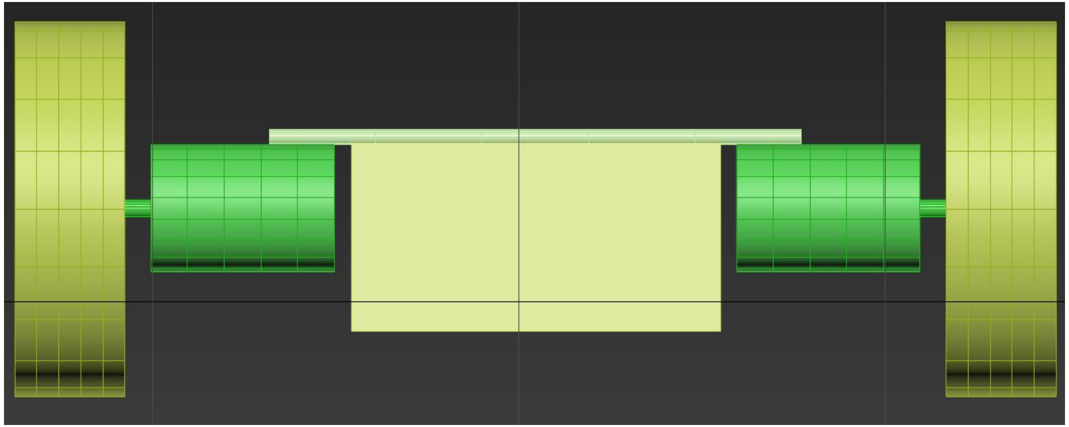




- This is the basic outlook of our rover.

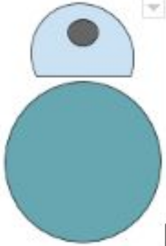
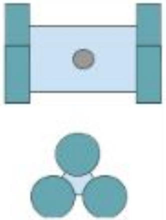
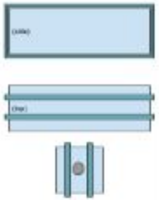
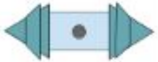
Rover



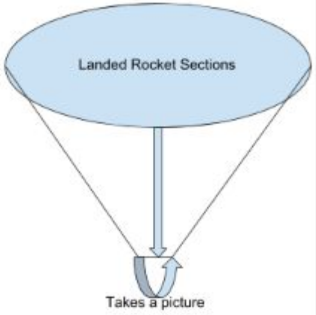
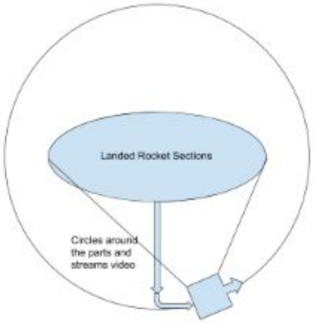


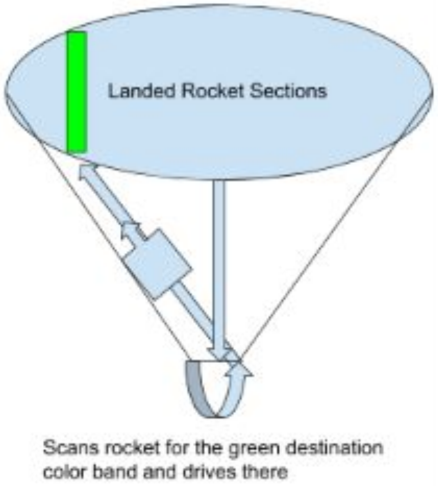
- Basic component distribution of the rover.

Payload Alternatives

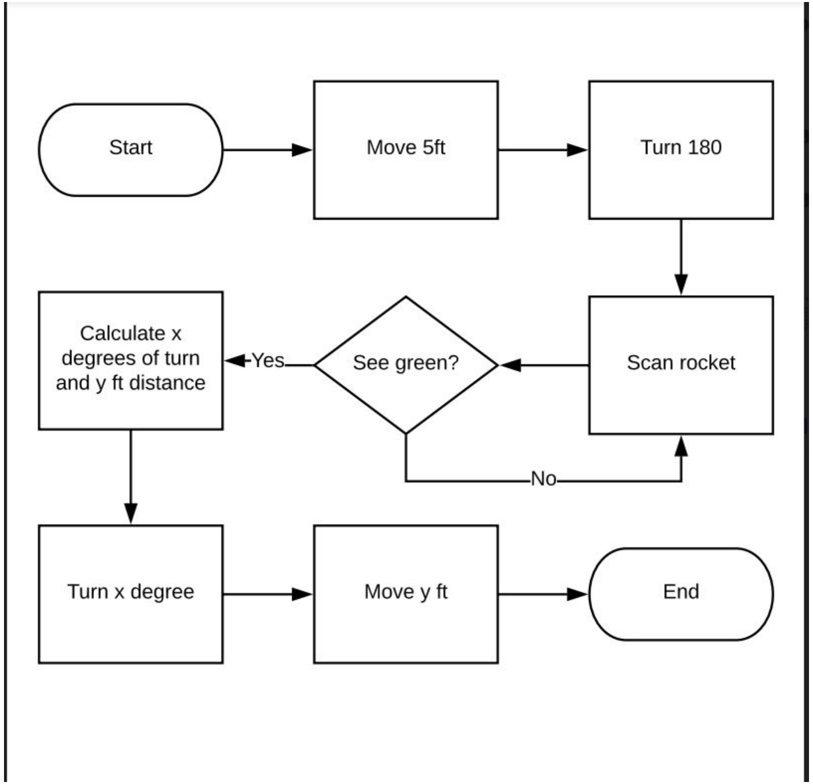
Rover Designs	Description	Positives	Negatives	Diagram
BB-8 Inspired	A spherical wheel with a magnet that allows a "head" to attach to the top, yet not physically touch and allow it to move freely as the sphere below it rolls	A design liked by the team, meaning increased enthusiasm toward building it A mechanical challenge for the team	The surface of the farmland that the final launch will be on is not suitable for this specific rover design.	
Long Beach Rover	California State University: Long Beach created a triangular rover for the 2018 SLI featuring a total of 6 wheels, three per corner.	Allows for freedom of movement disregarding its orientation. The rover design also makes it optimal for traversing the terrain of the farm It can easily roll out of the rocket/sabot regardless of the orientation of the rocket/sabot	If the rover were to flip onto another of the 3 sides, how would the camera be able to work?	
"The Tank"	A rectangular rover with 2 tracks running the longer length of the rover.	It can easily move over the tilled farmland we anticipate the rover will be traveling across.	If the rover wasn't deployed out a certain way, it would risk the rover landing on the side without tracks and cause the rover to fail. If the dirt on the farmland sticks to the tracks, it can obstruct the camera.	
"The IDC"	This is a cylindrical rover with cone wheels.	This can easily roll out of the rocket/sabot regardless of the orientation of the rocket/sabot		

Rover – Task

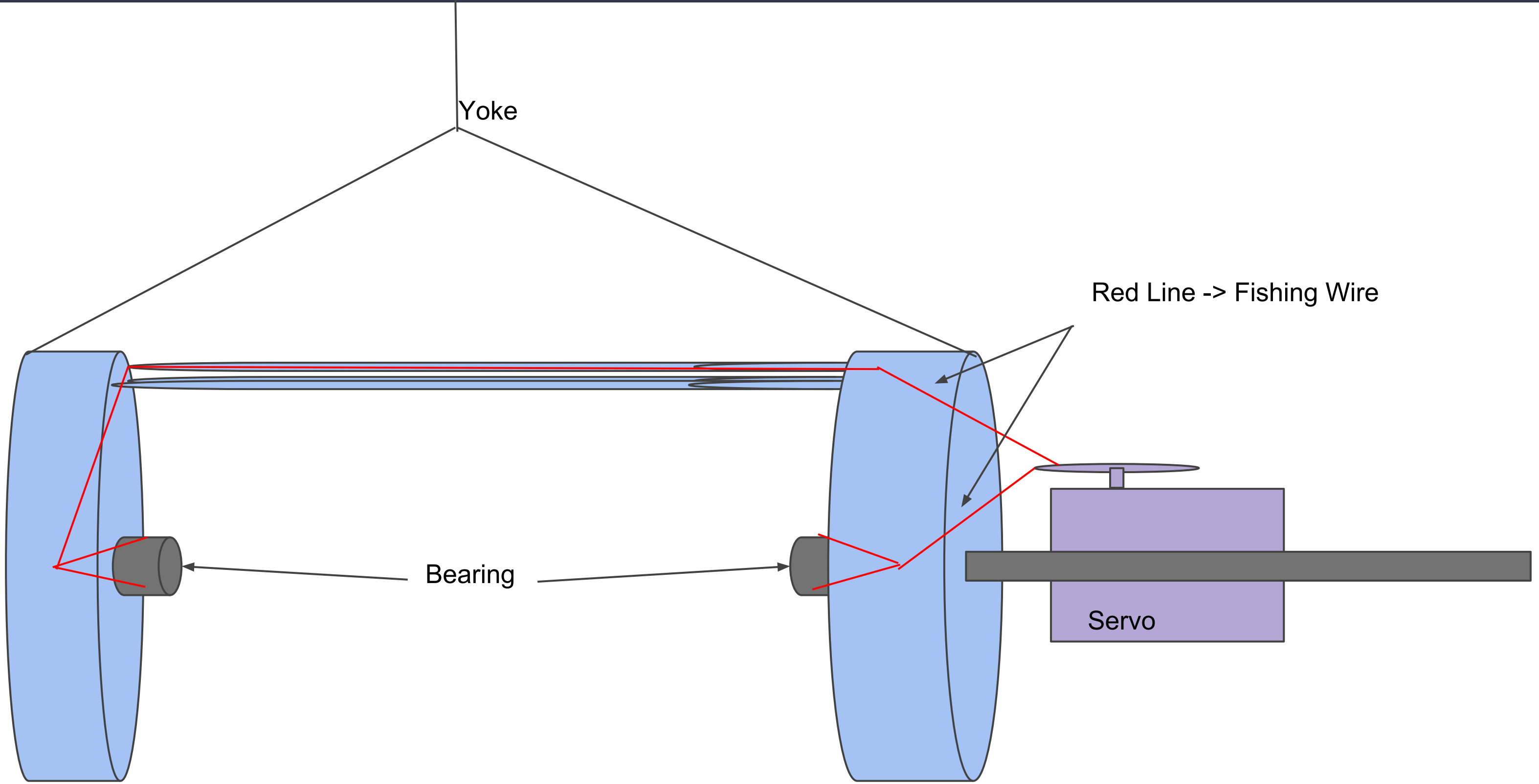
Alternate Task Description	Diagram
Rover snaps a picture of the remaining rocket parts.	
Rover circles around the rocket parts with the camera pointing at the parts. The live video will be relayed back to ground stations.	

Rover scans rocket for green color band and moves to it by calculating the angle it needs to turn and the distance it needs to travel.	

Rover – System Diagram



Payload Release Mechanism



Calculations

Kinetic Energy

Kinetic Energy of Each Section (Ft-lbs) Main Chute	Section 1	Section 2	Section 3	Section 4
	26.5272	14.4321	49.663	

Kinetic Energy of Each Section (Ft-lbs) Drogue Chute	Section 1	Section 2	Section 3	Section 4
	628.1598	341.536	1176.0125	

Drift

Wind Speed (mph)	0	5	10	15	20
Drift (ft)	0	617.4058	1234.8116	1852.2174	2469.6232

Safety

Safety

Risk	Mitigation
Impact to the body	Gloves, apron, goggles
Cut or puncture	Gloves and Apron
Chemicals – fumes and/or direct contact	Gloves, respirator, goggles
Heat/cold	Gloves
Harmful Dust and small particles	Mask and Goggles
Loud noises	Earplugs

- The following items will be present and available for team member use whenever they are working, constructing the vehicle or payload, or launching.
    - Safety goggles
    - Rubber gloves
    - Protective aprons
    - Ear Plugs
    - Leather gloves
    - Respirators / Dust Masks

Safety

Eye protection must be worn whenever there is a danger of:

- Dust, dirt, metal, or wood chips entering the eye. This can happen when sawing, grinding, hammering, or using power tools.
- Strong winds during a launch (common at Lucerne Dry Lake)
- Chemical splashes when using paints, solvents, or adhesives
- Objects thrown (intentionally or inadvertently) or swinging into a team member

These types of gloves must be worn to protect the team member's hands whenever there is danger of contact with a hazardous material:

- Latex or rubber gloves for possible contact with hazardous chemicals such as adhesive, paint, or thinners, or dangerous solid materials.
- Leather gloves to protect against impact, cuts, or abrasions (e.g. in the use of some power tools such as grinders)

Safety

Team members will always work in a clean, well-ventilated area. Protection for a team member’s lungs (dust mask or respirator) must be used when:

- Working with chemicals emitting fumes (e.g. paints and solvents). In this case, the team member must wear a respirator.
- Working in an environment where there is dust (e.g. sanding and working with power tools). The team member must wear a dust mask.

Body protection, such as an apron must be worn whenever there is danger of:

- Splashes or spills from chemicals
- Possible impact from tools

Ear protection (plugs or ear muffs) must be worn whenever there are loud noises present, which include:

- Using loud power tools or hammers
- Launching larger rocket motors at launches

Vehicle Risk Mitigation

The engine fails to ignite when launching the rocket.	Team members will make sure that the igniter is inserted into the engine completely, securing the connection between the engine and the igniter.
The engine is too loose or tight for the motor casing.	Team members will make sure the motor casing matches the corresponding engine size and that the motor casing fits into the motor mount without being too loose or too tight.
The air brakes don't function in flight.	Electronics will be activated at ground level for a test of the air brakes functions. Before the assembly of the whole rocket, the motor for the air brakes will be checked for its functions.
The rocket body bends inward on itself.	The materials used for the body tubes is fiberglass, which can stand against considerable amounts of outside forces. The flight boards, bulkheads, and centering rings on the inside of the body tubes will also support the circular structure of the body tube.
The quick links are not attached securely.	Team members will ensure that all connections between the body tubes and other parts of the rocket are assembled correctly before launching. A checklist will be written for the above tasks, members will be checking and signing off each of the tasks when completed.
The ejection charge does not have enough force to shear the shear pins.	The force required to shear the pins will be accurately noted when they are purchased. Black powder ground tests will be performed to make sure that the force provided from the ejections charges exceeds the force that the pin can withstand. To further make sure that the pin will shear, the backup charge will provide a greater force.
The electronic matches move outside of their specified area.	Team members will make sure that the matches are tightened in their specified area before attaching the shear pins. This task will be placed on the pre-launch checklist.
The motor explodes.	As a high school team, we are not allowed to build the motor and the construction of said motor will be done by a certified individual. The team will ensure that while the motor is in our hands, assuming that it has been assembled correctly, the motor will not be damaged nor will we alter the motor in a way that could cause a malfunction.
Parachute does not deploy because of packing issues.	Team members will check that the parachute is packed correctly into the body tube before launch and make sure the ejection charges will separate the body tubes when parachute is ready to deploy via black powder tests.

Payload Risk Mitigation

The camera malfunctions.	Team members will make sure the camera is turned on and functions correctly before the launch.
Batteries are not fully charged.	Team members will make sure to charge battery to max capacity before launch
Batteries fail.	Before launch, team members will use a voltmeter to check if the battery is functional and fully charged.
Payload doesn’t deploy	Before launch, the release mechanism of the sabot will be checked by team members to see if the payload can be released.
The wheels don’t move.	The payload will be tested by team members before the launch to see if the wheels can spin freely and move the rover on ground.
Payload unable to move on ground due to dirt.	The payload is equipped with a mechanism that scoops the dirt of the wheels after ever rotation, however, it will still be tested before the launch to see if the mechanism is capable of clearing the dirt of the wheels.
Payload deploys early due to loose sabot.	Team members will make sure that the sabot is not damaged or loose before the launch to ensure the rover doesn't drop from the rocket.

Recovery Risk Mitigation

The backup charges do not go off.	Team members will check if the RRC3 is beeping in the sequence that is shown on the manual.
The backup electronics batteries disconnect.	Battery holders and zip ties will be used to secure the battery in its position. The sturdiness of the battery holder and zip ties will be check before every launch by team members.
The backup RRC3 flight computers are shut down.	Team members will check if the flight computers are beeping and and signing their names on the checklist.
The drogue chute deployed at the incorrect altitude.	Team members will check that RRC3 and the Stratologger are both beeping in their respective sequences as shown on their manuals.
The air brakes not closing during descent and influencing the recovery.	Team members will upload the most recent code from the computer to the arduino and check if the arduino's respective LED light is blinking.
The drogue chute doesn't deploy.	Team members will make sure the electronics are turned on and check if they are beeping, and members who checked will sign on the checklist. The backup ejection charge can also resolve this issue.
The main chute doesn't deploy.	Solutions include both the backup Flight Computer and the backup ejection charges.
The Stratologger CF Flight Computer is shut down.	Team members will check the Stratologger is beeping in its respective sequence as shown on the manuals, they will sign their names on the checklist after.
The main battery disconnect.	Brand new batteries will be used, and a test will be contacted right before the launch to see if all of the electronics can be powered up correctly.

FMEA for Environmental Concerns

Potential Issues/ Failure Mode	Potential Failure Effects	Severity (1-10)	Potential Causes	Occurrence (1-10)	Mitigation
Wind speeds are unsuitable for launching the rocket.	If rocket is launched, rocket will fly in an unstable manner, making it difficult for performing proper tasks.	6	Environmental conditions are not suitable and worsen as the day proceeds at Lucerne Dry Lake.	6	Launch rail can be tilted at an angle that is with the wind in correlation with the speed of the wind. If wind speeds are too strong, the team will wait for conditions to improve.
Rain falls when the rocket is on the launch pad or in preparation.	Drag increases, resulting a possible lower altitude for the rocket. Stability also decreases.	5	Weather conditions are not suitable.	4	Rocket will be launched if rain is light; if rain is too strong, the team will wait for conditions to improve.
A fire can spread to the surrounding environment.	The launch site can catch on fire, resulting in damage to the nature.	9	Rocket can malfunction and once it lands, a fire can begin. Malfunction of the motor, sparks or ignition can set the rocket on fire.	0	If the rocket does catch on fire in any way, no parts of the environment will catch on fire. There is only dirt at Lucerne Dry Lake for miles. No grass is near the launch site.

FMEA for Design Concerns

Potential Issues/ Failure Mode	Potential Failure Effects	Severity (1-10)	Potential Causes	Occurrence (1-10)	Mitigation
Battery for the rover (payload) explodes or fail.	The rocket can be damaged, forcing a complete redesign and new construction process.	9	Incorrect wiring or the battery cannot withstand certain malfunctions in the coding.	1	The team decided to switch to a 9 volt battery to better suit the payload. A checklist will be followed when constructing the rocket so no incorrect actions will occur.
The Rover fails to deploy after landing	Experiment cannot be conducted. Sparking could occur within the rocket.	5	Wiring is incorrect. Battery was not activated, or no connection in the circuit.	1	A checklist will be followed during construction and when preparing the rocket to launch.
The rocket does not fly in a stable manner.	Altitude might not be met. Damage to the rocket can occur. The rocket will fly uncontrollably, possible hurting someone.	6	While constructing the rocket, mass change might have occurred. During the design process, stability margin might not have been considered. Weather conditions also influence instability.	3	Stability margin is always looked at when designing the rocket and when making any changes to that design. Weather conditions will be monitored, and the rocket will not be launched in unsafe conditions.

Project Risk Identification

Risk	Likelihood	Impact	Mitigation Technique
Time	M	H	If we do not have enough time, then there is nothing to do other than to work harder and reduce quality. To prevent this, we will create a coherent work schedule, divide the work evenly, and clearly delineate the formatting of the deliverables for uniformity in advance. Failing to meet deadlines in time may result in the termination of the SL team's participation.
Budget	M	M	If we run out of funds, we can either fundraise or gather money from within the team. The first method would guarantee a minimum $100 profit. The second would guarantee a minimum $700.
Functionality	L	H	If functionality within the project decreases, then we can mitigate this risk by providing clear work schedules and creating team activities to relax.
Resources	L	M	If we run out of resources, we can buy more and use our funds.

Key	
L	Low
M	Medium
H	High

Thank You!