North Carolina School of Science and Mathematics High-Powered Rocketry

Cluster Launch Airframe with Smokeless Powder (CLASP)

Project Proposal
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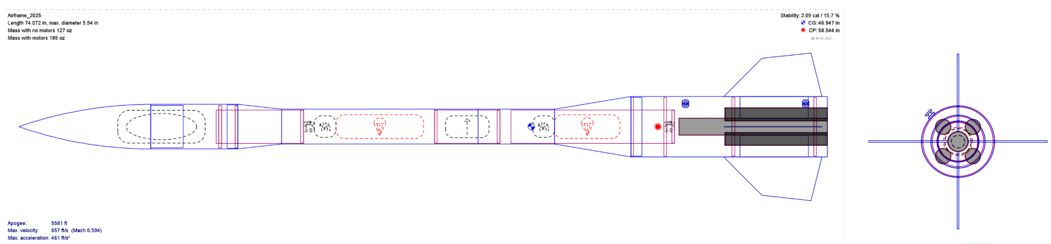
Summary

CLASP will be a class 2, level 2 rocket with five cluster motors to test aerial motor ignition, smokeless powder ejection charges to reduce residue, and member-led payloads to study the rocket's flight. Both the dual-deploy recovery system and air start motors will be controlled via redundant altimeters.

Technical Design

Rocket



Overall Design

Length	Outer Diameter	Apogee	Mass w/ Motor	Mass w/o Motor	Stability
74.072"	5.54"	5581 ft	185 oz	127 oz	2.09 cal

Airframe

The airframe will be composed of Bluetube (vulcanized fibers). There will be six sections: the payload bay, the two transitions, the main, the drogue, and the fin section. Couplers will be located between the payload and the main, and between the main and the drogue sections. These will be dislodged using smokeless powder detonations to deploy the recovery parachutes. All tube-size transitions will have non-load-bearing 3D-printed facades. There will be a 4:1 ogive, fiberglass nose cone.

Composite Fins

The fins will be our custom balsa wood/carbon fiber/fiberglass composite material which has many distinct advantages. A diagram of this material is shown below.

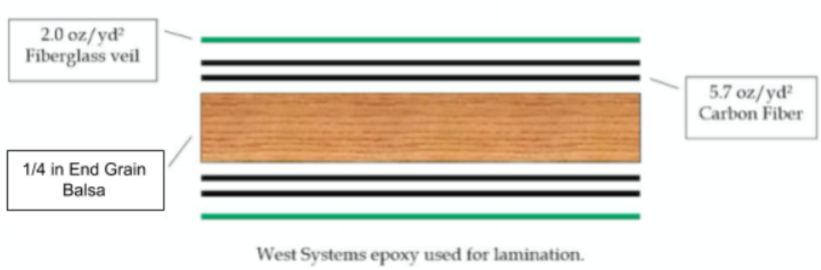


Figure 3.1.2.3: Fin Material Diagram

These fins will be a quarter-inch thick to stay light while remaining sufficiently stable and durable. These fins have a surface area of roughly 25 in^2 each. For maximum strength, the fins will be mounted using “through the wall” construction; the fins will penetrate the body tube, connect directly to the motor tube, and will be the structure that transfers the motor’s thrust from the motor mount to the airframe.

Recoverability

The rocket uses a dual-deployment recovery system, consisting of a drogue parachute deployed at apogee by primary and backup altimeters, and a main parachute deployed at a fixed altitude of around 500-600 feet by the same system, allowing a faster initial descent which minimizes drift.

Altimeter Systems

In the past, NCSSM Rocketry has used an altimeter bay with the design shown below. Two Featherweight Raven3 altimeters act redundantly to release the parachutes. The main altimeter sets off an ejection charge at apogee and around 500-600 feet, and the backup altimeter sets off ejection charges one second after each of the main ejection charges. The two altimeters are independent of one another allowing redundancy in case of an initial failure.

Experimental Smokeless Powder Testing

Black powder is commonly used as the propellant in the ejection charge of dual-deployment systems. While reliable, it creates a difficult-to-clean black residue. An alternative is smokeless powder, made of nitrocellulose and nitroglycerin, which produces less smoke and residue. This year, we plan to evaluate the feasibility of using smokeless powder for our ejection charge. However, it may be less reliable, as it requires higher pressure to burn completely; incomplete combustion can leave a sticky yellow residue. We will test various brands like Bullseye and Red Dot in a smaller ejection charge holder, firing them inside a 6-inch tube with a bulkhead to measure force output. Depending on the results, we may adopt smokeless powder as a substitute for black powder in this year's rocket.

Motor Information

Motor type	Total impulse	Max Thrust	Average Thrust	Burn Time	Weight	Thrust to Weight Ratio
1xJ500G-14A	723 N-sec	787.9 N-sec	500 N	1.4 s	1.44 lb	346.78 N/lb
4xH180W-14A	217.7 N-sec	228.5 N-sec	180 N	1.3 s	0.56 lb	324 N/lb

Motor Clustering

This year, NCSSM Rocketry will use cluster motors for our rocket. These will result in a longer burn at launch and a higher apogee. The purpose is to test aerial motor ignition without the separation and extra recovery system required for traditional staging. This cluster will consist of a central, 38 mm J500 motor, and four auxiliary 29 mm H180 motors. We will ignite the J500 motor on the ground. When this motor burns out, the altimeter will detect the change in acceleration and ignite two parallel auxiliary motors. When those motors burn out, the altimeter ignites the remaining two auxiliary motors. We will coat all air-start motor igniters with pyrogen to ensure fast and reliable ignition from the altimeter’s battery. Furthermore, the altimeter will not ignite any motor if the rocket is not vertical or moving too slowly for the fins to stabilize improper motor ignition.

Parts Layout and Costs

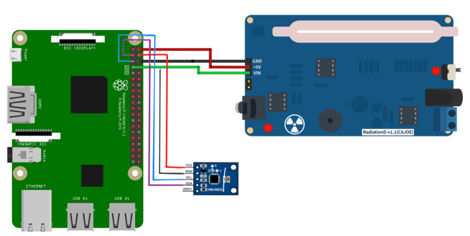
**All unlisted materials are owned by HPR in sufficient quantities for CLASP’s completion.*

#	Name	Vendor	Qty	Cost
1-1	J500G-14A	Aerotech	1	$95.99
1-2	H180W-14A	Aerotech	4	$167.96
1-3	3” Blue Tube	Always Ready Rocketry	1	$30.96
1-4	3” BT Coupler	Always Ready Rocketry	1	$31.95
1-5	38mm MMT	Always Ready Rocketry	1	$6.60
1-6	29mm MMT	Always Ready Rocketry	4	$16.20
1-7	5.5” Blue Tube	Always Ready Rocketry	1	$68.41
1-8	4” Fiberglass Nose Cone	Madcow	1	$97.00
1-9	38mm Motor Retainer	Aero Pack	1	$30.63
1-10	29mm Motor Retainer	Aero Pack	4	$112.72
1-11	1010 Rail Buttons	Apogee	10	$21.26
1-12	Kevlar Cord 1500#	Apogee	50	$68.50
1-13	24” Printed Nylon Parachute	Apogee	1	$10.28
1-14	36” Printed Nylon Parachute	Apogee	1	$18.69
Total Pre-Tax				$777.15

Payload

1. Radiation and Magnetic Field Monitoring

The payload's objective is to measure cosmic radiation and track Earth's magnetic field at different altitudes. By gathering data on radiation levels and magnetic field variations alongside visual imagery, the payload aims to determine how radiation and Earth’s magnetic field evolve with altitude.



Parts Layout and Costs

#	Name	Vendor	Qty	Cost
2-1	Raspberry Pi Zero 2 W	Amazon	1	$24.99
2-2	64 gb microSD	Amazon	1	$12.99
2-3	Geiger-Müller tube	Banggood	1	$34.99
2-4	HMC5883L magnetometer	Amazon	1	$6.69
2-5	2000 mAh LiPo	Amazon	1	$12.99
Total Pre-Tax				$92.65

2. **Gyroscope**

In prior years, rocket spin has caused shaky, poor quality video. A solution is active stabilization in response to rotation data. The first step to this is creating a gyroscope system responsive and accurate enough to inform this process.

Parts Layout and Costs

#	Name	Vendor	Qty	Cost
3-1	MPU-6050 Gyroscope	Adafruit	1	$12.95
3-2	Adafruit Feather RP2040 Adalogger	Adafruit	1	$14.95
3-3	2000 mAh LiPo	Amazon	1	$12.99
3-4	16GB MicroSD	Amazon	1	$7.43
Total Pre-Tax				$48.32

3. **Camera System**

The goal of this project is to record and live-transmit a video of our rocket's flight to an SD card.

Parts Layout and Costs

**Everything not mentioned here will be taken and reused from Cardinal's (last year's) video payload*

#	Name	Vendor	Qty	Cost
4-1	CSI cable	Adafruit	1	$4.00
4-2	Transistors	Mouser	2	$15.14
4-3	Resistors	Mouser	4	$11.12
4-4	Capacitors	Mouser	4	$12.60
4-5	Inductors	Mouser	4	$2.99
4-6	Breadboard	Mouser	1	$6.82
4-7	SMA Connector (Male and Female)	Mouser	1	$5.55
4-8	Other Testing Components & Spare Components	Mouser	–	$18.39
Total Pre-Tax				$76.59

Overall Project Budget

Overall Cost Breakdown		
Series	**Item**	**Cost**
1	**Rocket**	$777.15
2	**Radiation and Magnetometer**	$92.65
3	**Gyroscope**	$48.32
4	**Camera**	$76.59
5	**Spare Parts***	$200
Subtotal		$1194.74
Peripheral		$235.04
Total Request:		**$1,429.78**

**In the event parts must be replaced, or other unexpected costs arise, approximately 20% of the initial subtotal was added to the final budget.*