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Institution	North Carolina State University	Milestone	FRR

Vehicle Properties

Total Length (in)	93.75
Diameter (in)	6.17
Aspect Ratio	16:1
Gross Lift Off Weight (lb)	39.7
Ballast Amount (lb) / Material / Location	0.46 / Aluminum / Nose Cone
Launch Vehicle Burn Out Weight (lb)	35.5
Airframe Material(s)	G12 Fiberglass
Fin Material and Thickness (in)	G10 Fiberglass and 3/16 in.
Coupler Length(s)/Shoulder Length(s) (in)	Nose Cone: 6/3 (in.) Forward AVAB: 16/7 (in.) Aft AVAB: 16/6 (in.)

Motor Properties

Motor Brand/Designation	Aerotech L1520T
Max/Average Thrust (lb)	396.86/352.46
Total Impulse (lbf-s)	835.37
Mass Before/After Burn (oz)	128.79/63.39
Liftoff Thrust (N)	1545.4
Motor Retention Method	1/8 in. thick custom 6061-T6 aluminum retainer plate secured to thrust bulkhead with four #8-32 machine screws.

Stability Analysis

Center of Pressure (in. from nose)	67.8
Center of Gravity (in. from nose)	57.24
Static Stability Margin (on pad)	2.028 calibers
Static Stability Margin (at rail exit)	2.074 calibers
Thrust-to-Weight Ratio	8.75
Rail Size/Type and Length (in)	1515 / 144 in.
Rail Exit Velocity (ft/s)	78.5

Ascent Analysis

Maximum Velocity (ft/s)	609.6
Maximum Mach Number	0.55
Maximum Acceleration (ft/s^2)	285.4
Target Apogee (ft)	4600
Predicted Apogee (From Sim.) (ft)	4606

Recovery System Properties - Overall

Total Descent Time (s)	73.3
Total Drift in 20 mph winds (ft)	2150

Recovery System Properties - Energetics

Ejection System Energetics (ex. Black Powder)		#FFF Black Powder
Energetics Mass - Drogue Chute (grams)	Primary	2.8
	Backup	3.5
Energetics Mass - Main Chute (grams)	Primary	3.1
	Backup	3.8
Energetics Mass - Other (grams) - If Applicable	Primary	N/A
	Backup	N/A

Recovery System Properties - Recovery Electronics

Primary Altimeter Make/Model	PerfectFlite StratologgerCF
Secondary Altimeter Make/Model	Altus Metrum EasyMini
Other Altimeters (if applicable)	N/A
Rocket Locator (Make/Model)	Eggtimer Rocketry Eggfinder Mini
Additional Locators (if applicable)	N/A
Transmitting Frequencies (all - vehicle and payload)	919 MHz 144.39 MHz; 920.75 MHz
Describe Redundancy Plan (batteries, switches, etc.)	Altimeter circuits are fully independent of each other and all other electronics. Each altimeter has its own independent battery, micro switch, e-matches, and black powder charges.
Pad Stay Time (Launch Configuration)	5 hours

Recovery System Properties - Drogue Parachute

Manufacturer/Model			Fruity Chutes Classic Elliptical	
Size or Diameter (in or ft) / drag coefficient			15 in. / 0.8427	
Main Altimeter Deployment Setting			Apogee	
Backup Altimeter Deployment Setting			Apogee + 1 s	
Velocity at Deployment (ft/s)			0	
Terminal Velocity (ft/s)			100.8	
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)			5/8 in. flat Kevlar	
Recovery Harness Length (ft)			18	
Harness/Airframe Interfaces		3/8" Steel Eye Bolt, 3/8" Steel Quick Link, 1/4" Steel Quick Link, and Zinc-plated 5/16" Steel 2" ID U-Bolts		
Kinetic Energy of Each Section (Ft-lbs)	Section 1	Section 2	Section 3	Section 4
	3381	2228		

Recovery System Properties - Main Parachute

Manufacturer/Model			Fruity Chutes Iris Ultra Compact	
Size or Diameter (in or ft) / drag coefficient			96 in / 1.236	
Main Altimeter Deployment Setting			550 ft	
Backup Altimeter Deployment Setting			500 ft	
Velocity at Deployment (ft/s)			100.8	
Terminal Velocity (ft/s)			16.6	
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)			5/8 in. flat Kevlar	
Recovery Harness Length (ft)			16	
Harness/Airframe Interfaces		3/8" Steel Eye Bolt, 3/8" Steel Quick Links, and Zinc-plated 5/16" Steel 2" ID U-Bolts		
Kinetic Energy of Each Section (Ft-lbs)	Section 1	Section 2	Section 3	Section 4
	33.8	57.8	60.4	

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Payload	
Payload 1 (official payload)	Overview STEMCRaFT: The STEMCRaFT is a STEMnaut capsule housed within the rocket's Nose Cone, designed to accommodate four STEMnauts while capturing and transmitting crucial flight data. Equipped with a Raspberry Pi, ESP32S, IMU, barometric pressure sensor, and a GPS, it records key metrics such as landing time, maximum and landing velocities, sustained G-forces, calculated STEMnaut crew survivability, landing site temperature, apogee, battery status, STEMnaut orientation, and landing coordinates. Upon landing, the collected data is encoded and transmitted via APRS on the 2-meter band to a NASA receiver. The system is powered by two independent LiPo batteries: a 2200mAh 4s LiPo for data collection and a 2200mAh 2s LiPo for transmission. Activation is managed through pull-pin switches, rated for 5 amps or 42 watts, ensuring reliable operation from the power supply.
Payload 2 (non-scored payload)	Overview Air Brakes: After motor burnout, an onboard computer predicts the rocket's flight profile and actuates the fins to regulate ascent, ensuring the rocket reaches a precise target apogee. The system consists of 3D-printed components, including a housing and four fins linked through a gear mechanism. A central gear, driven by two servos, rotates the fins into the airstream, counteracting any friction caused by aerodynamic forces. Power is supplied by a single 2200mAh 4S LiPo battery for the flight computer and servo.

Test Plans, Status, and Results	
Ejection Charge Tests	Before each launch of the competition Launch Vehicle, a ground ejection test was conducted to satisfy Team Derived Requirement RF.24. The Subscale underwent a successful ejection test on November 15, 2024, while the first Full-scale ejection test took place on February 14, 2025. These tests required assembling the Launch Vehicle in its final launch configuration and verifying the drogue and main recovery events to ensure the accuracy of black powder calculations. If the Launch Vehicle did not separate as expected, 0.2 grams of black powder was added to the ejection charge, and the test was repeated.
Sub-scale Test Flights	On November 16, 2024, two successful test flights of the Subscale Launch Vehicle were completed, both powered by Aerotech J500G motors. Each phase of the flights proceeded nominally, and the Launch Vehicle was recovered intact. The measured apogees reached 1,500 ft and 1,513 ft, differing by 4.2% and 3.6%, respectively, from the predicted altitude of 1,567 ft. The primary payload, which contained data collection systems for the STEMCRaFT, encountered a software crash during the first flight but functioned as expected during the second. The secondary air brakes payload mechanism did not activate in either flight; however, its electronics and data logging components performed as intended.
Vehicle Demonstration Flights	On March 8, 2025, the Vehicle Demonstration Flight was completed on an Aerotech L1520T motor. During the flight the Launch Vehicle undershot the predicted apogee due to high winds and significant weather cocking. This caused the Air Brakes to not deploy, although they functioned as intended by accurately predicting apogee during flight, then determining that they did not need to deploy. The recovery system functioned nominally with the drogue parachute deploying at apogee and the main parachute deploying at 550 ft. There was slight entanglement of the shroud lines during descent, but the landing kinetic energy, descent time, and drift distance were well within NASA requirements. Additionally, the vehicle sustained no damage and was recovered in a relaunchable condition. Flight profile graphs were also complete, meeting all team derived success criteria.
Payload Demonstration Flights	The Payload Demonstration Flight on March 8, 2025 was a safety success, with no injuries or unintentional transmissions. All pre-launch procedures confirmed system functionality, and the payload retention system performed flawlessly, securing the STEMCRaFT throughout flight with no hardware damage. However, the mission was classified as a partial failure due to multiple technical issues. A faulty USB cable connecting the ESP32 to the Raspberry Pi caused intermittent serial disconnects, disrupting data collection and transmission. Additionally, the state change sequence started prematurely while on the launch rail, likely due to a pressure decrease in the Nose Cone and high winds affecting a sensitive altimeter. This led to rapid state transitions from MotorBurn to Coast to Freefall within four seconds. The script ultimately crashed upon landing due to an "Input/Output error" caused by a hardware-level interruption. The USB cable issue, likely due to wear and tear, was only discovered post-launch. Corrective actions have since been implemented, including replacing the cable and adding fault-handling code to improve reliability, with VV&T tests confirming restored system functionality.

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Transmitter #1			
Location of transmitter:	Avionics Bay		
Purpose of transmitter:	Launch Vehicle Tracking Device		
Brand	Eggtimer Rocketry	RF Output Power (mW)	100
Model	Eggfinder Mini	Specific Frequency used by team (MHz)	920.75
Handshake or frequency hopping? (explain)	Fixed Frequency, ID 7		
Distance to closest e-match or altimeter (in)	5		
Description of shielding plan:	A sheet of aluminum foil will be added between the tracker and other recovery electronics on the AV sled.		

Transmitter #2			
Location of transmitter:	Nose Cone/Payload Bay		
Purpose of transmitter:	Payload challenge. 2m Transmitter.		
Brand	NICE RF	RF Output Power (mW)	4000
Model	SA858	Specific Frequency used by team (MHz)	APRS (144.390)
Handshake or frequency hopping? (explain)	Fixed Frequency.		
Distance to closest e-match or altimeter (in)	24		
Description of shielding plan:	Altimeters will be shielded from RF with a sheet of aluminum foil in the Nose Cone/Payload Bay.		

Transmitter #3			
Location of transmitter:	Nose Cone/Payload Bay		
Purpose of transmitter:	Receive Remote Override Transmission		
Brand	Digi International	RF Output Power (mW)	100
Model	Digi XBee-PRO 900HP (S3B)	Specific Frequency used by team (MHz)	902-928
Handshake or frequency hopping? (explain)	Frequency Hopping		
Distance to closest e-match or altimeter (in)	24		
Description of shielding plan:	Altimeters will be shielded from RF with a sheet of aluminum foil in the Nose Cone/Payload Bay.		

Transmitter #4			
Location of transmitter:			
Purpose of transmitter:			
Brand		RF Output Power (mW)	
Model		Specific Frequency used by team (MHz)	
Handshake or frequency hopping? (explain)			
Distance to closest e-match or altimeter (in)			
Description of shielding plan:			

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Transmitter #5

Location of transmitter:			
Purpose of transmitter:			
Brand		RF Output Power (mW)	
Model		Specific Frequency used by team (MHz)	
Handshake or frequency hopping? (explain)			
Distance to closest e-match or altimeter (in)			
Description of shielding plan:			

Transmitter #6

Location of transmitter:			
Purpose of transmitter:			
Brand		RF Output Power (mW)	
Model		Specific Frequency used by team (MHz)	
Handshake or frequency hopping? (explain)			
Distance to closest e-match or altimeter (in)			
Description of shielding plan:			

Additional Comments