National Aeronautics and
Space Administration

NASA Student Launch ARW Flysheet Overview

PRESENTED BY NASA Student Launch

DATE July 24, 2023

NASA STEM

Milestone Review Flysheet 2022-2023

Institution		Milestone	

Vehicle Properties

Total Length (in)	
Diameter (in)	
Aspect Ratio	
Gross Lift Off Weight (lb)	
Ballast Amount (lb) / Material / Location	
Launch Vehicle Burn Out Weight (lb)	
Airframe Material(s)	
Fin Material and Thickness (in)	
Coupler Length(s)/Shoulder Length(s) (in	

Motor Properties

Motor Brand/Designation	
Max/Average Thrust (lb)	
Total Impulse (lbf-s)	
Mass Before/After Burn (oz	
Liftoff Thrust (N)	
Motor Retention Method	

Stability Analysis

Center of Pressure (in. from nose)	
Center of Gravity (in. from nose)	
Static Stability Margin (on pad)	
Static Stability Margin (at rail exit)	
Thrust-to-Weight Ratio	
Rail Size/Type and Length (in)	
Rail Exit Velocity (ft/s)	

Ascent Analysis

Maximum Velocity (ft/s)	
Maximum Mach Number	
Maximum Acceleration (ft/s^2)	
Target Apogee (ft)	
Predicted Apogee (From Sim.) (ft)	

Recovery System Properties - Overall

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

Recovery System Properties - Energetics

otion System Energetics (ex. Black Pow		
Energetics Mass - Drogue Chute (grams)	Primary	
	Backup	
Energetics Mass - Main Chute (grams)	Primary	
	Backup	
Energetics Mass - Other (grams) - If Applicable	Primary	
	Backup	

overy System Properties - Recovery Electro

Primary Altimeter Make/Model	
Secondary Altimeter Make/Model	
Other Altimeters (if applicable)	
Rocket Locator (Make/Model)	
Additional Locators (if applicable)	
Transmitting Frequencies (all - vehicle and payload)	
Describe Redundancy Plan (batteries, switches, etc.)	
Pad Stay Time (Launch Configuration)	

covery System Properties - Drogue Parachu

Manufacturer/Model				
Size or Diameter (in or ft)				
Main Altimeter Deployment Setting				
Backup Altimeter Deployment Setting				
Velocity at Deployment (ft/s)				
Terminal Velocity (ft/s)				
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)				
Recovery Harness Length (ft)				
Harness/Airframe Interfaces				
Kinetic Energy of Each Section (Ft-	Section 1	Section 2	Section 3	Section 4

ecovery System Properties - Main Parachut

Manufacturer/Model				
Size or Diameter (in or ft)				
Main Altimeter Deployment Setting				
Backup Altimeter Deployment Setting				
Velocity at Deployment (ft/s)				
Terminal Velocity (ft/s)				
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)				
Recovery Harness Length (ft)				
Harness/Airframe Interfaces				
Kinetic Energy of Each Section (Ft-	Section 1	Section 2	Section 3	Section 4

Vehicle Properties	
Total Length (in)	109
Diameter (in)	6
Aspect Ratio	18.166
Gross Lift Off Weight (lb)	45
Ballast Amount (lb) / Material / Location	4 / aluminum / nosecone
Launch Vehicle Burn Out Weight (lb)	41.13
Airframe Material(s)	Carbon Fiber
Fin Material and Thickness (in)	3/16" Carbon Fiber DragonPlate
Coupler Length(s)/Shoulder Length(s) (in)	12" / 4" nose cone

Motor Properties	
Motor Brand/Designation	Cesaroni L1720
Max/Average Thrust (lb)	437/398
Total Impulse (lbf-s)	822.8
Mass Before/After Burn (oz)	117.9/56.0
Liftoff Thrust (N)	1730
Motor Retention Method	Retaining Ring

Stability Analysis	
Center of Pressure (in. from nose)	70.9
Center of Gravity (in. from nose)	57
Static Stability Margin (on pad)	2.28
Static Stability Margin (at rail exit)	2.35
Thrust-to-Weight Ratio	9.1
Rail Size/Type and Length (in)	NAR/144 in (12 ft 1515 rail)
Rail Exit Velocity (ft/s)	59.2

Ascent Analysis	
Maximum Velocity (ft/s)	540
Maximum Mach Number	0.48
Maximum Acceleration (ft/s^2)	287
Target Apogee (ft)	4000
Predicted Apogee (From Sim.) (ft)	4031

Report: We calculated our thrust to weight ratio by doing the following:

- The mass of our launch vehicle is 45lbs and has a liftoff thrust of 1730N.
- To convert N to lbs. we multiply by 0.2248 so we have 1730N*0.2248 = 388.904lbs.
- When we divide 388.904 by 45, we get a thrust to weight of 8.64

Note the discrepancy on the flysheet

- Online calculators are fine for BP calculations
- Backup charge MUST be larger than primary

- 90 second limitation
- 2500 feet limitation

- 8 and 10 grams too large

Recovery System Properties - Energetics		
Ejection System Energetics (ex. Black Powder)		4F Black Powder
Energetics Mass - Drogue Chute (grams)	Primary	3
	Backup	4

Recovery System Properties - Overall	
Total Descent Time (s)	76.7
Total Drift in 20 mph winds (ft)	2250

Energetics Mass - Main Chute (grams)	Primary	3.5
	Backup	4.5
Energetics Mass - Other (grams) - Lander Jettison	Primary	8
	Backup	10

- Prefer teams to use two separate manufacturers altimeters (software bug)
- Transmitters – Important to “know your stuff” can’t have 60 teams operating same frequency
- Transmitter data Google sheet sent later in the year

Recovery System Properties - Recovery Electronics	
Primary Altimeter Make/Model	PerfectFlite StratoLogger CF
Secondary Altimeter Make/Model	PerfectFlite StratoLogger CF
Other Altimeters (if applicable)	2x PerfectFlite StratoLogger CF
Rocket Locator (Make/Model)	BigRedBee BeeLine TX
Additional Locators (if applicable)	2x BigRedBee BeeLine TX
Transmitting Frequencies (all - vehicle and payload)	433.91 MHz, 433.92 MHz, 433.93 MHz
Describe Redundancy Plan (batteries, switches, etc.)	Two altimeters in each avionics bay, all with dedicated independent power supplies and mechanical arming switches.
Pad Stay Time (Launch Configuration)	3 hours

- Most drogues are apogee (maximum 2 second delay).
- Deployment velocity should be 0 (unless a delay is used)
- Terminal Velocity – what is the velocity of the launch vehicle when the parachute is fully functioning.
- Kinetic Energy – 75 ft-lbs, but for landing. We understand under drogue you'll never be anywhere close to 75.

Recovery System Properties - Drogue Parachute				
Manufacturer/Model		Fruity Chute/Classic Elliptical		
Size or Diameter (in or ft)		18 in		
Main Altimeter Deployment Setting		apogee		
Backup Altimeter Deployment Setting		1 second after apogee		
Velocity at Deployment (ft/s)		0		
Terminal Velocity (ft/s)		86		
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)		1/2" flat Kevlar strap		
Recovery Harness Length (ft)		30/15		
Harness/Airframe Interfaces		Eye-bolts, quick links + swivel links		
Kinetic Energy of Each Section (Ft-lbs)	Payload Section	Tail + Vehicle Recovery Section	Section 3	Section 4
	2210	2144	N/A	N/A

- Deployment velocity of main parachute SHOULD match terminal velocity of drogue.
- Terminal velocity of main is what should be used for KE calculations.
- Terminal Velocity – what is the velocity of the launch vehicle when the parachute is fully functioning.
- Kinetic Energy – 75 ft-lbs for each independent section at landing.

Recovery System Properties - Main and Payload Parachutes	
Manufacturer/Model	Fruity Chute/Iris Ultra
Size or Diameter (in or ft)	72 in (96 in payload parachute)
Main Altimeter Deployment Setting (ft)	850 (600 ft payload jettison)
Backup Altimeter Deployment Setting (ft)	750 (500 ft payload jettison backup)
Velocity at Deployment (ft/s)	86 (24 fps prior to payload jettison)
Terminal Velocity (ft/s)	24 (vehicle terminal velocity is 20 fps after payload jettison; payload terminal velocity on parachute is 10 fps)
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)	1/2" flat Kevlar strap
Recovery Harness Length (ft)	15/10 (payload is harnessed with 45 ft of shock cord)

Harness/Airframe Interfaces		U-Bolt, Eye-Bolt, Quick Links + Swivel Links		
Kinetic Energy of Each Section (Ft-lbs)	Vehicle Recovery Section	Tail Section	Payload Bay	Payload
	59.2	56.7	40.2	19.8

Payload	
Payload 1 (official payload)	Overview
	The payload will locate the launch vehicle's landing grid box by using a single gimballed camera deployed at separation. The camera will take images of the ground under the launch vehicle and align them to create a map of the field. Once the map is created it will be compared with the gridded satellite image to determine the grid box. The grid box value will then be wirelessly transmitted to the ground station.
Payload 2 (non-scored payload)	Overview

Test Plans, Status, and Results	
Ejection Charge Tests	Separation Testing will be conducted to test the black powder deflagration on all separation points on both sub-scale and full-scale vehicles. This testing will confirm the black powder mass calculations are correct and confirm . The sub-scale separation test is in progress as it is scheduled for November 11th, 2021. The full-scale separation test will be in January 2022.
Sub-scale Test Flights	Sub-scale test flights will be conducted on the 13th of November with a backup launch date of November 20th. The November 13th flight will take place in Dalzell, South Carolina which is approximatly 2 hours south of [redacted] The backup flight on November 20th will take place in Bayboro, North Carolina which is approximatly 4.5 hours east of [redacted]. A total of three flights will be the goal for the sub-scale flights. If more testing is reqired and the team succesfully flies on the 13th of November, additional testing will be done in Bayboro, North Carolina.

Vehicle Demonstration Flights	The first full scale vehicle demonstration flight is tentativly scheduled for the 15th of January. Following succesful sub-scale launches, a full scale vehicle schedule will be better constructed to ensure the team is on track for the vehicle demonstration flight deadline of March 7th.
Payload Demonstration Flights	The team is aiming for the payload demonstration flight to take place on the next avaliable launch after the first full scale vehicle flight. This is to allow for the vehicle to be seen as safe to retain and launch the compeition payload with the least likelyhood of failure.

Transmitter #1			
Location of transmitter:	Nosecone		
Purpose of transmitter:	Verification of payload determined location via GPS		
Brand	EggTimer Rocketry	RF Output Power (mW)	100 mW
Model	EggFinder TX	Specific Frequency used by team (MHz)	902 MHz
Handshake or frequency hopping? (explain)	Handshake with ID code matched between receiver and transmitter		
Distance to closest e-match or altimeter (in)	9 inches to e-match/charge bay, 10.5 inches to nearest altimeter		
Description of shielding plan:	The GPS has a 0.5 inch carbon fiber bulkhead between the GPS and the nearest altimeter and e-match		

Transmitter #2			
Location of transmitter:	Tethered to booster section main parachute shock cord		
Purpose of transmitter:	To find the location of the booster section		
Brand	Featherweight Altimeters	RF Output Power (mW)	100 mW
Model	Featherweight GPS Tracker	Specific Frequency used by team (MHz)	915 MHz
Handshake or frequency hopping? (explain)	Handshake with ID code matched between receiver and transmitter		
Distance to closest e-match or altimeter (in)	14 inches to nearest e-match/charge bay, 15 inches to nearest altimeter		
Description of shielding plan:	1/4 inch bulkhead shields altimeter and e-match connections from RF signals		

Transmitter #1			
Location of transmitter:	Vehicle		
Purpose of transmitter:	Location tracking		
Brand	BigRedBee	RF Output Power (mW)	16
Model	BRB900	Specific Frequency used by team (MHz)	433.91
Handshake or frequency hopping? (explain)	Frequency User Defined		
Distance to closest e-match or altimeter (in)	9		
Description of shielding plan:	Separated from avionics by mylar-coated (for RF-opaqueness) bulkplate		

Vehicle Properties	
Total Length (in)	70
Diameter (in)	5
Gross Lift Off Weigh (lb)	10
Airframe Material(s)	Brown Kraft Paper
Fin Material and Thickness (in)	Bass word .25
Coupler Length(s)/Shoulder Length(s) (in)	5

Motor Properties	
Motor Brand/Designation	K1050W AeroTech
Max/Average Thrust (lb)	2172
Total Impulse (lbf-s)	2476
Mass Before/After Burn (oz)	2203
Liftoff Thrust (N)	
Motor Retention Method	RMS-54/2800

Stability Analysis	
Center of Pressure (in. from nose)	68.62
Center of Gravity (in. from nose)	49.91
Static Stability Margin (on pad)	1.18
Static Stability Margin (at rail exit)	
Thrust-to-Weight Ratio	
Rail Size/Type and Length (in)	
Rail Exit Velocity (ft/s)	

Ascent Analysis	
Maximum Velocity (ft/s)	
Maximum Mach Number	
Maximum Acceleration (ft/s^2)	
Target Apogee (ft)	5280
Predicted Apogee (From Sim.) (ft)	

Recovery System Properties - Overall	
Total Descent Time (s)	
Total Drift in 20 mph winds (ft)	

Recovery System Properties - Drogue Parachute				
Manufacturer/Model				
Size or Diameter (in or ft)			24	
Main Altimeter Deployment Setting			5280	
Backup Altimeter Deployment Setting			5000	
Velocity at Deployment (ft/s)			17.75	
Terminal Velocity (ft/s)				
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)			Naylon	
Recovery Harness Length (ft)				
Harness/Airframe Interfaces				
Kinetic Energy of Each Section (Ft-lbs)	Section 1	Section 2	Section 3	Section 4
	24.4	47.97		

Recovery System Properties - Main Parachute				
Manufacturer/Model				
Size or Diameter (in or ft)			84	
Main Altimeter Deployment Setting (ft)			1000	
Backup Altimeter Deployment Setting (ft)			Chute Release	
Velocity at Deployment (ft/s)			17.26	
Terminal Velocity (ft/s)				
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)				
Recovery Harness Length (ft)				
Harness/Airframe Interfaces				
Kinetic Energy of Each Section (Ft-lbs)	Section 1	Section 2	Section 3	Section 4
	24.4	47.97		

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Institution		Milestone	

Payload	
Payload 1 (official payload)	Overview
Payload 2 (non-scored payload)	Overview

Test Plans, Status, and Results	
Ejection Charge Tests	
Sub-scale Test Flights	
Vehicle Demonstration Flights	
Payload Demonstration Flights	

Milestone Review Flysheet 2022-2023

Institution		Milestone	

Transmitter #1

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

Transmitter #2

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

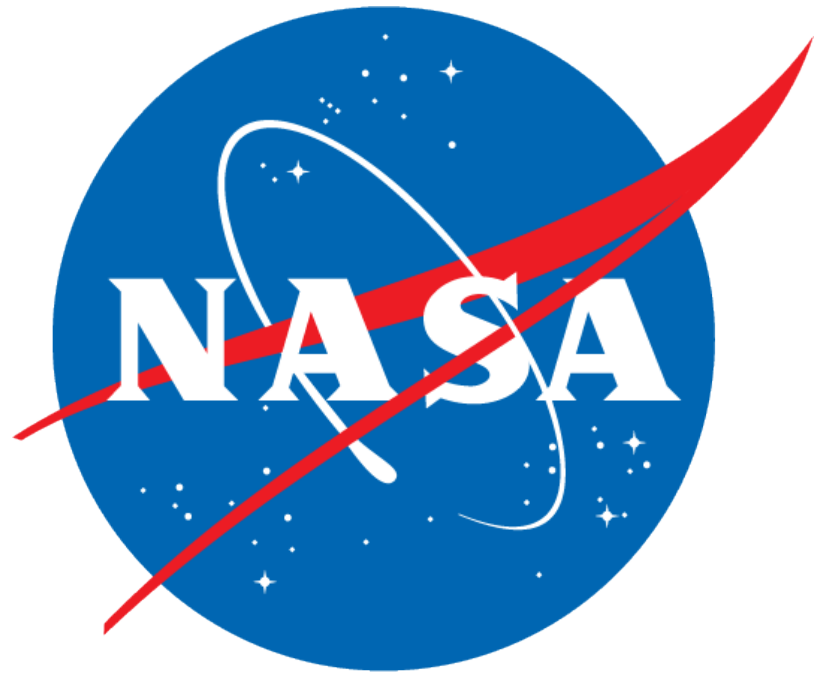
Transmitter #3

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

Transmitter #4

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

Questions?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