Initial Testing Results

NG Two-Stage Supersonic Rocket

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Design Requirement Summary

Customer Requirements

- CR1- Develop a two-stage launch vehicle.
- CR2- Use of a stage separation device.
- CR3- The vehicle will be constructed of composite materials.
- CR4- Vehicle will reach an altitude of at least 30,000 ft AGL (Above Ground Level).
- CR5- Final launch vehicle will be required to carry a maximum 10 Lb payload that will fit within a 6” diameter bay
- CR6- Vehicle required to reach a maintain over Mach 2 or roughly 1500 mph and maximize time spent at that speed or greater.
- CR7- Acceleration of the vehicle needs to meet a minimum of 12g’s
- CR8- Vehicle trajectory will be simulated in Rocksim.
- CR9- Vehicle required to use commercial rocket motors.
- CR10- Recovery of entire launch vehicle for reuse.

Engineering Requirements

- ER1- Max Velocity – Mach 2 or 1500 mph
- ER2- Separation Event – Successful or unsuccessful separation
- ER3- Altitude – 40,000 ft AGL (Above Ground Level)
- ER4- Payload Weight – 10lbs
- ER5- Cost of production - $7000 USD
- ER6- Reusable – more than 1 use
- ER7- Payload Volume – 282.7 in^3

Ground Level Testing Summary

Success Levels	Goals (Applied to CR1, 2, 10 and ER2 and 6)
Complete Ground Testing Success	• Flight computers and redundant systems initiate all energetics at the assigned time and altitude. • GPS tracking performs nominally through carbon composite. • GPS tracking performs nominally with natural obstructions around vehicle. (trees, bushes, hills, etc.) • All energetic deploy recovery systems with primary charges. Secondary charges will be based on primary charges with extra ordnance to ensure deployment if primary fails. • No anomalies (disconnection, hardware failure, and hard impacts) during simulated flight and payload mission until completed flight and recovery.
Partial Ground Testing Success	• Separation system performs nominally. • Recovery deployment fails to eject recovery systems. Test again with increased ordnance until deployment occurs nominally. Adjust for high altitude flight due to decreased expansion potential. • Flight computers, GPS, and redundant systems perform nominally. • All components are recovered and reusable with minor damage.
Partial Ground Testing Failure	• Failure of separation system ignition and structural parts • Deployment of recovery system are nominal, and no failures or damage occurs. • GPS system failure(disconnection, or hardware failure due to ejection system discharge) • Structures are intact and no anomalies occurs.
Complete Ground Testing Failure	• Failure of both GPS, flight computers, and redundant systems • Failure of recovery system deployment and beyond reasonable repair state (burn through, structural damage, electronics failure)\ • Failure of separation system(structural or binding) • Failure of chute protection system and shock cord failure.

Table 2: Ground Testing Success Criteria

Ground Level Testing Summary

Experiment/Test	Relevant DRs	Testing Equipment	Other Resources
EXP1- Avionics Functionality	CR1, CR2, CR10, ER2, ER6	Avionics Assemblies, Ground Station, Phone	Lab Space
EXP2- GPS Signal Test	CR1, CR2, CR10, ER2, ER6	Avionics Assemblies, Ground Station, Phone	Outside Space, Variety of Terrain
EXP3- Ejection Charge Mock Test	CR1, CR2, CR10, ER2, ER6	Avionics Assemblies, LEDs, Phone	Lab Space

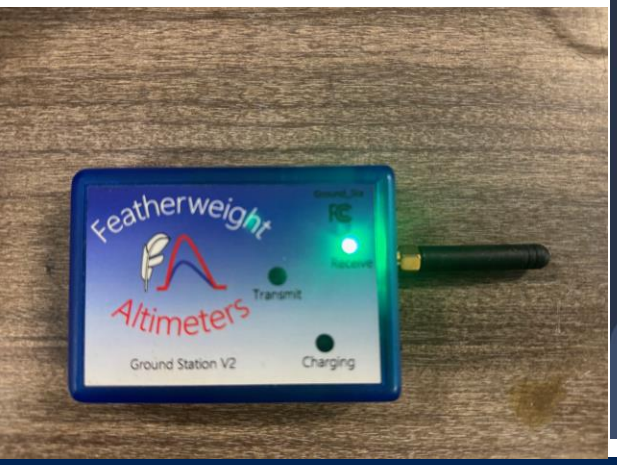
Table 1: Test Summary Table

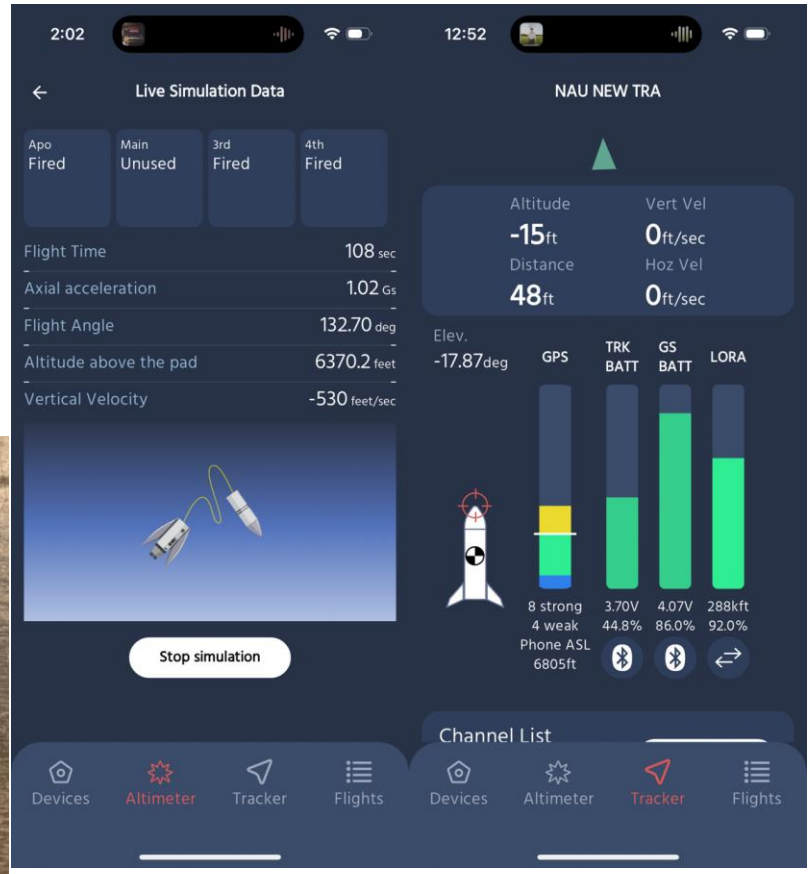
Detailed Testing Plans

Ground Testing Procedure

- Assemble Avionics Bays for both Booster stage and Main Vehicle
- Attach Flight computers, GPS, and Ejection Charge Terminal Block
- Connect flight computers to Ejection Charge Terminal Block
- Insert LED lights into Ejection Charge Terminal Block
- Connect Flight Computer and GPS to batteries, then connect to phone
- Ensure flight computer is reading all terminal blocks on phone app and multimeter.
- Set up flight simulation in phone app.
- Run full flight simulation.
- Ejection Charges set off, lighting up LED Lights.

Testing Results





- Verified Avionics Systems Functionality
- GPS tracking functions properly but is blocked when installed inside carbon tube.(Mitigated with outside whip antenna or fiberglass window)
- Ejection charge Mock test nominal
- Separation event confirmed at programmed timing

Engineering Specification Sheet

ER	Target	Tolerance	Measured/Calculated Value	ER Met?	Client Acceptable?
ER1- Max Velocity	Mach 2 or 1535mph	±100 mph or ± 0.13 Ma	Measured		
ER2 - Separation Event	Successful or unsuccessful separation	N/A	Measured		
ER3 - Altitude	30,000 ft AGL	±500 ft	Measured		
ER4 - Payload Weight	10 lbs	± 0.5 lbs	Measured	Yes	Yes
ER5 - Cost of production	$7,000 USD	N/A	Measured	Yes	Yes
ER6 - Reusable	>1	N/A	Measured	Yes	Yes
ER7 - Payload Volume	282.7 in^3	±50 in^2	Measured	Yes	Yes

Table 3: ER Summary Table

Customer Specification Sheet

Customer Requirement	CR Met?	Client Acceptable
CR1 – Develop Launch Vehicle	Yes	Yes
CR2 – Separation System	Yes	Yes
CR3 – Composite Materials	Yes	Yes
CR4 – Altitude (40,000 ft.)		
CR5 – Payload (10 lb.)	Yes	Yes
CR6 – Speed (Mach 2)		
CR7 – Acceleration (12+ g's)		
CR8 – Trajectory Simulation	Yes	Yes
CR9 – Commercial Motors	Yes	Yes
CR10 – Recovery	Yes	Yes

Table 4: CR Summary Table

QFD

System QFD

Project:	**Two Stage Supersonic Rocket**
Date:	3/18/2024

1	Altitude	(++)								
2	Body Diameter		(++)							
3	Vehicle Speed	(++)		(++)						
4	Vehicle Acceleration	(++)		(++)	(++)					
5	Payload Weight	(+)	(+)	(+)	(+)	(++)				
6	Seperation Event		(+)	(+)			(++)			
7	Reusable		(+)	(+)	(+)	(+)	(+)	(++)		
8	Payload Volume		(++)			(+)			(++)	
9	Body Material		(+)	(+)		(+)	(+)	(++)		(++)

			Technical Requirements								Customer Opinion Sur				
	Customer Needs	**Customer Weights**	Altitude	Body Diameter	Vehicle Speed	Vehicle Acceleration	Payload Weight	Seperation Event	Reusable	Payload Volume	Body Material	*1 Poor*	*2*	*3 Acceptable*	*4*	*5 Excellent*
1	Lightweight	4	9	3	9	9	9	1	3	1	9					
2	Altitude	7	9	1	9	9	9	9		1	3					
3	Max Velocity	8		1	9	9	9	9		1	3					
4	Payload Weight	5	3	9	9	9	9				1					
5	Cost of Production	3		3				1	9	1	9					
6	Separation Event	6	1	1	3	1		9	1		1					
7	Payload Volume	1		9	1		3			9						
8	Reusable	2		1	1	3		1	9	1	9					
	Technical Requirement Units		ft	in	mach	g's	Lbs	N/A	# of uses	in^3	lbs					
	Technical Requirement Targets		40000	6.25	2	12	10	Successful or not	5	282.7	45					
	Absolute Technical Importance		120	98	237	228	219	198	63	33	137					
	Relative Technical Importance		12.0	9.81	23.7	22.8	21.9	19.8	6.3	3.3	13.7					
			6	7	1	2	3	4	8	9	5					

Body Ranking System	
Strong	9
Moderate	3
Weak	1
None	0

Figure 1: QFD, House of Quality

Top Level Testing Summary

Success Levels	Goals
Complete Mission Success	• Separation system works as expected, successful separation and second stage motor ignition. (CR1, CR2, ER2) • Payload safely delivered and landed. Data captured. (CR4, CR7, CR6, CR10, ER1, ER3, ER6) • Launch vehicle performance meets altitude goal. (CR5, CR6, CR9, ER2, ER3, ER4, CR3) • Launch vehicle recovered in reusable condition, no damage to vehicle at all. (CR3, CR5, CR8, CR10, ER6, ER5) • Recovery system performs as expected and designed. (CR1, CR2, CR10, ER2, ER6) • No anomalies (drastic angle change, bird strike, etc.) during full flight and payload mission until completed flight and recovery (All CRs and ERs)
Partial Mission Success	• Flight success (All CRs and ERs) • Velocity and altitude requirements met (CR4, CR6, CR7, CR9, ER1, ER3) • Payload flown but no data recorded. (CR5, ER4) • All components are recovered and reusable with minor damage. (CR1, CR3, CR10, ER4, ER6)
Partial Mission Failure	• Failure of payload or launch vehicle performance (All CRs and ERs) • Successful flight with failure of payload data recording or delivery (CR5, ER4) • Velocity or altitude requirement missed. (CR5, CR6, CR9, ER2, ER3, ER4, CR3) • Vehicle or payload systems damaged during flight or landing (CR1, CR3, CR10, ER4, ER6)
Complete Mission Failure	• Failure of both launch vehicle and payload systems (CRs and ERs) • Failure of recovery system deployment and beyond reasonable repair state (CRs and ERs) • Failure of vehicle before, during, or after flight (All CRs and ERs)

Table 5: Mission Success Criteria

THANK YOU