NRG Rocket

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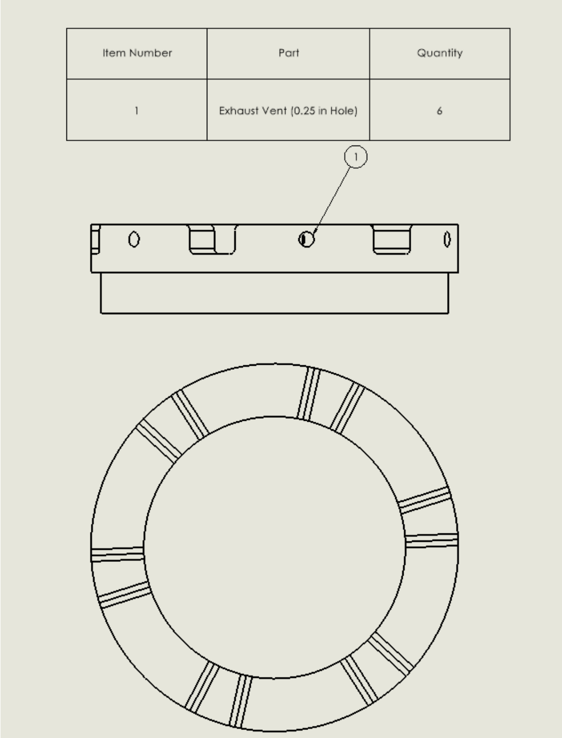
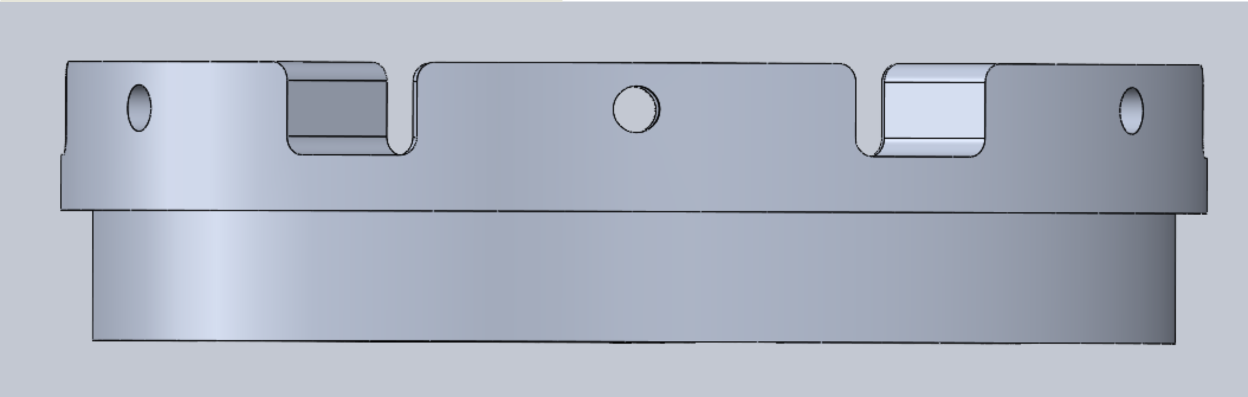
Project Description (Update)

- **Level 3 Rocket Launch (September 2025)**
  - Remanufacturing carbon fiber couplers
  - Ordering the motor and Recovery System
  - Implementing a **hot separation system** with air vent holes for stage separation
- **Magnetic Separation System Development**
  - **(Goal) Final design by the end of the semester** with a rough prototype
  - Potential implementation in the **November 2025** launch

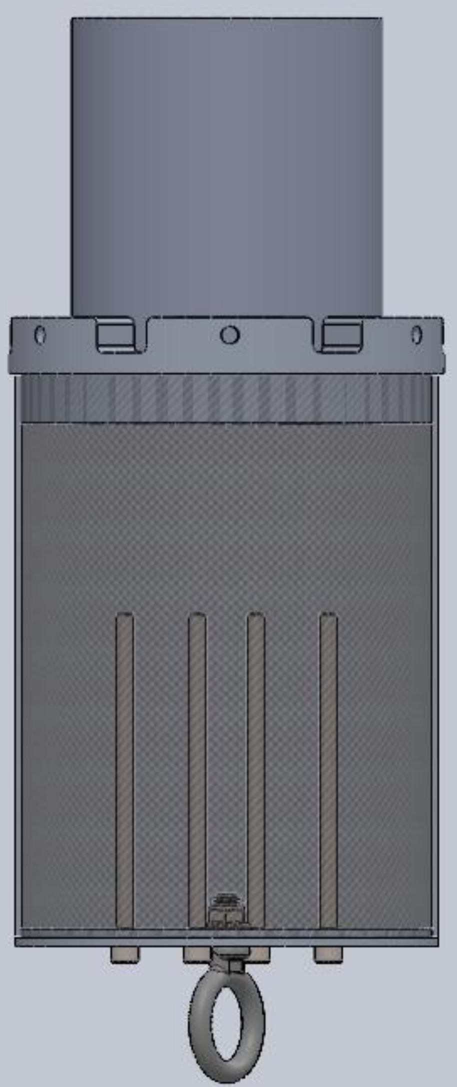
Topic 2: Hot Separation



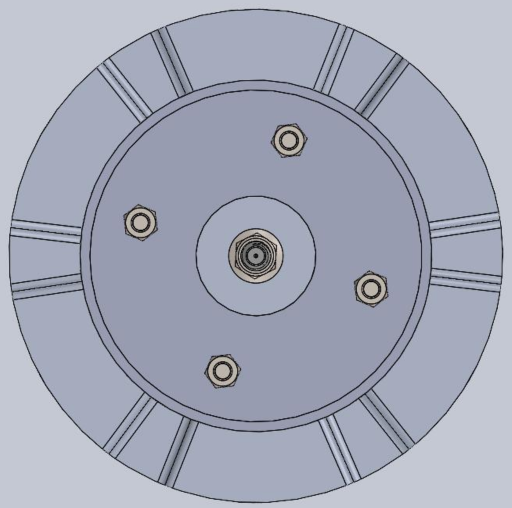
- Six exhaust vents need to be manufactured for heat transfer.
- The Images show the placement of some of the exhaust vents.
- The exhaust vents will be 0.25-inch diameter holes
- All six will be equal spacing between and concentric with the center.



Topic 2: Hot Separation

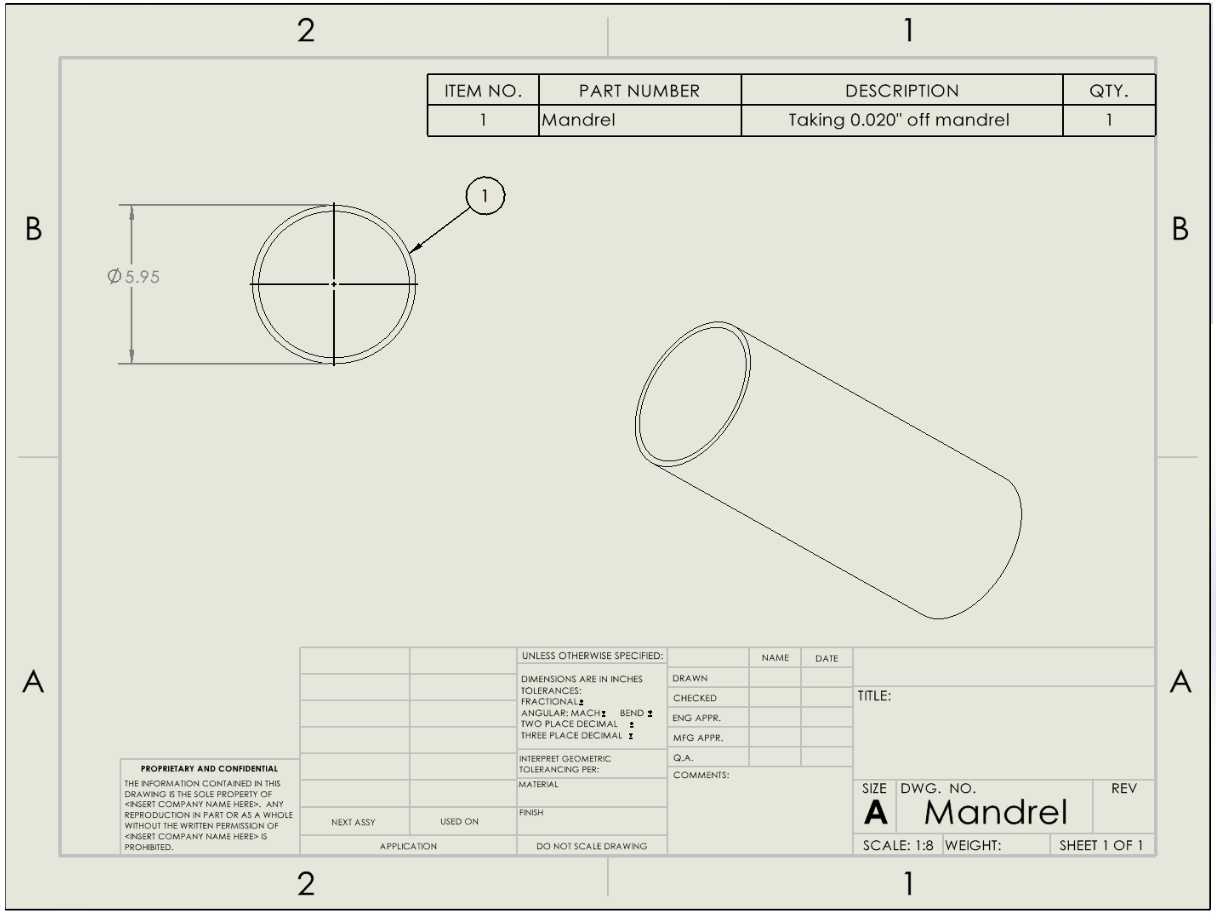


- Additionally, the material for the booster separation tube will require modifications
- Currently it is aluminum with a hole in the center.
- The team plans to fabricate a solid plate over it that will be constrained by the bolts shown here.

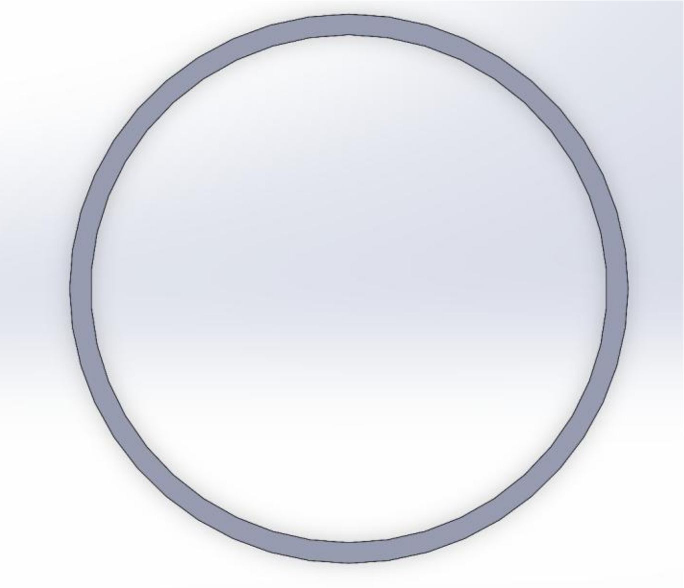


- The necessary material is currently unknown and will be discussed later in the presentation.

Topic 2: Mandrel Tubing



- Mandrel tubing is being reduce from 5.98" to 5.95"
- About 0.030" will be taken off from aluminum tubing. The new diameter will be used to refabricate the fiberglass couplers.



QFD

Customer Needs	Customer Weights	Low Weight	Total Drag Force	Thrust Force	Release Mechanism	Magnetic Fields Test	Testing	Altitude	Velocity	1 - Weak	3 - Moderate	9 - Strong
		Engineering Requirements								Benchmark Competitors		
Reusability	3	6	0	3	9	0	0	0	0	A	B	C
Functionality	5	0	0	6	9	9	0	3	3		B	AC
Magnets	5	6	6	6	9	9	9	0	0			
Two-Stage Separation	5	6	9	9	9	9	9	6	0			ABC
Stability	3	9	9	9	0	0	3	0	9		AB	C
Faster than Mach 1	4	9	6	9	0	0	3	6	9			ABC
30,000 ft altitude	5	6	6	9	0	0	3	9	9			ABC
Test Launch	4	0	0	0	0	9	9	9	9			
Actual Launch	5	9	0	0	0	9	9	9	9			
Technical Requirement Units		N	N	N	lbs	Yes	Yes	ft	Mach			
Technical Requirement Targets		445	<1000	4200	860	Yes	Yes	30000 - 50,000	2<			
Absolute Technical Importance		216	156	222	162	216	207	195	204			
Relative Technical Importance		2	8	1	7	2	4	6	5			
		ATI & RTI										

Separation Types		
A	Mechanical Separation	one-time use/ breaks
B	Pyrotechnic Separation	explosive/ propellant
C	Aerodynamic Separation	drag (space shuttle used)

9 = Strong
3 = Moderate
1 = Weak
Blank = No Relationship

QFD CR/ER Description

Customer Requirements (CRs)

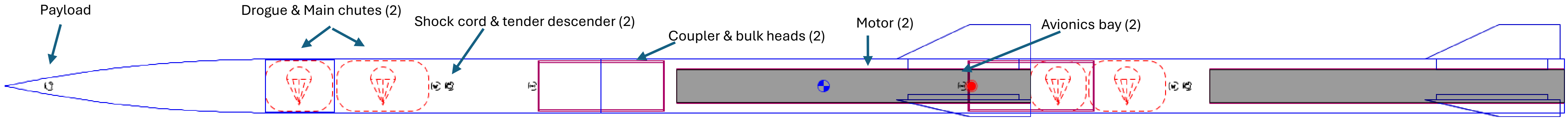
- Reusability: Designed for multiple launches
- Functionality: Ensures the separation system works effectively
- Magnets: Incorporates necessary magnetic components
- Two-Stage Separation: Supports proper separation of both rocket stages
- Stability: Ensures overall system integrity
- Mach 1+ Speed: Confirms the rocket exceeds Mach 1
- 30,000 ft Altitude: Ensures a minimum altitude of 30,000 ft
- Launches: September launch to test hot separation and November launch for Mag. Sep

Engineering Requirements (ERs) & Target Values

- Low Weight: Must be within the allowable range for launch feasibility
- Drag Force: Needs to be accurately calculated through aerodynamic analysis to assess its impact on separation
- Thrust Force: Must be sufficient to launch both rocket stages successfully
- Magnetic Force: Should provide enough strength to hold the two stages together until separation is triggered
- Spring Force: Needs to complement the magnetic separation system to ensure safe and effective stage disengagement
- Magnetic Fields: Must not interfere with the rocket's onboard computer system or other critical components.
- Testing: All test results from Rasaero simulations must align with real-world launch data
- Altitude: The rocket must reach a minimum of 30,000 feet.
- Velocity: The rocket should exceed Mach 1 speed

Bob’s OpenRocket Analysis

- All components of rocket are within simulation
- Both stages combined have a cal rating of 2.80 (according to NASA, the ideal margin is 1.5-2.0 & 3.0 is considered over-stable) [1]
- Sustainer has a cal rating of 1.66
- Payload is 19 pounds *subject to change*
- CG=95.132[in] from the nose (using CG found in OpenRocket simulation to input CG into RASAero simulation)



Bob's OpenRocket Analysis (cont.)

	Name	Configuration	Velocity off rod	Apogee	Velocity at deploy...	Optimum delay	Max. velocity	Max. acceleration	Time to apogee	Flight time	Ground hit velocity
!	Simulation 1	[N3300R-0; N3300R-0]	36.3 ft/s	12727 ft	1351 ft/s	28.1 s	1364 ft/s	326 ft/s²	24.8 s	809 s	14.8 ft/s

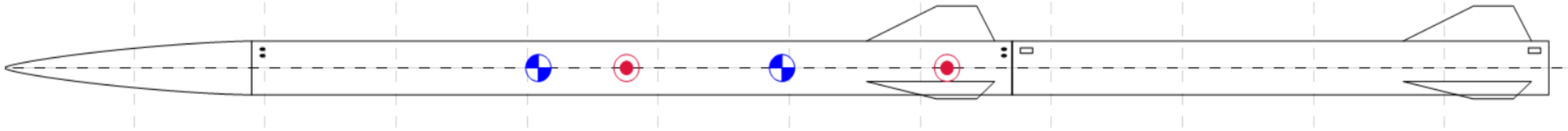
Rocket
- Sustainer
  - Nose Cone
    - Payload
    - Bulkhead
  - Body Tube
    - Pro X Drogue Parachute [Cd .97 (14.3 oz) 113.10 in^3]
    - Light Std Parabolic Parachute [Cd .97 (12.71 oz) 75.54 in^3]
    - Shock Cord
    - Tender Descender
    - Avionics Bay
  - Body Tube
    - Trapezoidal Fin Set
    - Inner Tube
    - Bulkhead
    - Tube Coupler
    - Bulkhead
- Booster
  - Body Tube
    - Trapezoidal Fin Set
    - Inner Tube
    - Bulkhead
    - Tube Coupler
    - Bulkhead
    - Pro X Drogue Parachute [Cd .97 (14.3 oz) 113.10 in^3]
    - Light Std Parabolic Parachute [Cd .97 (10.82 oz) 63.53 in^3]
    - Shock Cord
    - Tender Descender
    - Avionics Bay

- Concerns with velocity off rod, apogee, Mach number, & velocity at deployment
- Meeting with potential L3 advisor on 4/01 to begin troubleshooting
- Mass of components are accurate but not precise
- Precisely weighing ALL components this week

Emanuel's RASAero II Analysis

- Center of Gravity
  - Sustainer Motor: 65.34 (in)
  - Booster Motor: 95.1 (in)
- Flight Simulation
  - Max Alt. (w/ propellent): 23,936 (ft)
  - Max Alt. (zero propellent): 26,740 (ft)
  - Max Velocity: 1.53 Mach

- Undergoing current analysis of parachute and drogue for the rocket



Lee’s Black Powder Analysis

Black Powder Charge Estimation for Rocket Separation

Author: Lee Freytes

Date: 3/27/2025

```
% Given Parameters
P_min = 15;  % Minimum pressure required (psi)
P_max = 20;  % Maximum pressure required (psi)
V_coupler = 18.46;  % Coupler volume (in³)
C = 300;  % Black powder efficiency constant (psi per gram in a sealed space)

% Calculate black powder mass (grams)
W_min = (P_min * V_coupler) / C;
W_max = (P_max * V_coupler) / C;

% Display Results
disp(['Minimum Black Powder Charge: ', num2str(W_min), ' grams']);
disp(['Maximum Black Powder Charge: ', num2str(W_max), ' grams']);
```

```
Minimum Black Powder Charge: 0.923 grams
Maximum Black Powder Charge: 1.2307 grams
```

MATLAB Analysis & Tools:

- - Pressure estimation for black powder charge
- - Efficiency modeling using 300 psi/g constant
- - Sensitivity analysis on volume and pressure variations

Key Results:

- - Charge mass: 0.92 g to 1.23 g (safe range)
- - Predicted pressure: 15 to 20 psi for controlled separation
- - Ensures a safety margin for burn efficiency variations

Remaining ERs & CRs:

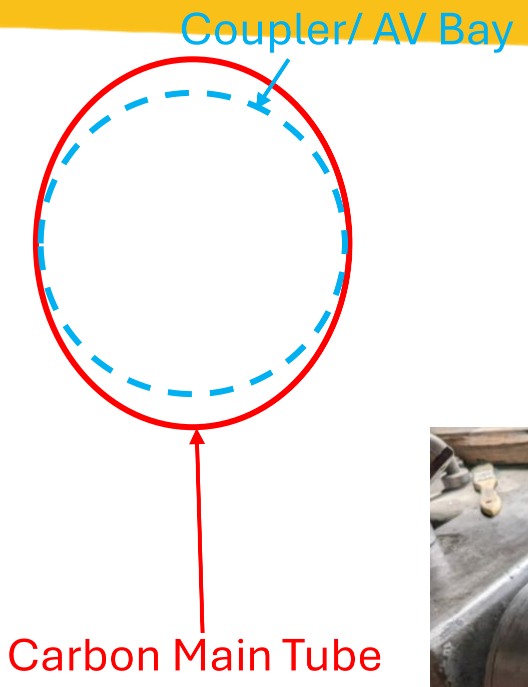
- - Environmental sensitivity testing in different conditions (If needed)

Thomas’ Hot Separation Update

- On Monday 03/31 I will be reaching out to the motor manufactures
- The goal is to gather information on the motor nozzle.
    - Material, Epoxy, Resin, or other coatings.
- The goal is to apply this to the booster stage.
- To protect the booster stage from the motor heat transfer.
- This will either require applying a finish or redesigning the booster stage.
- Redesign will include CAD Models, EGR Drawings, and Professional Review.

Stonn’s Manufacturing Update

- Reworking the sustainer tubing.
  - Reheating tubing to about 200F where resin cured to make the tubing circular.
  - Currently it’s an oval shape which makes the coupler harder to insert.
- Put aluminum tubing on the lathe to take off about 0.030”
  - 0.015” on both sides
  - Enough for about 2 plies of fiberglass which is about 0.010” thick. Adding 0.020” coupler thickness.



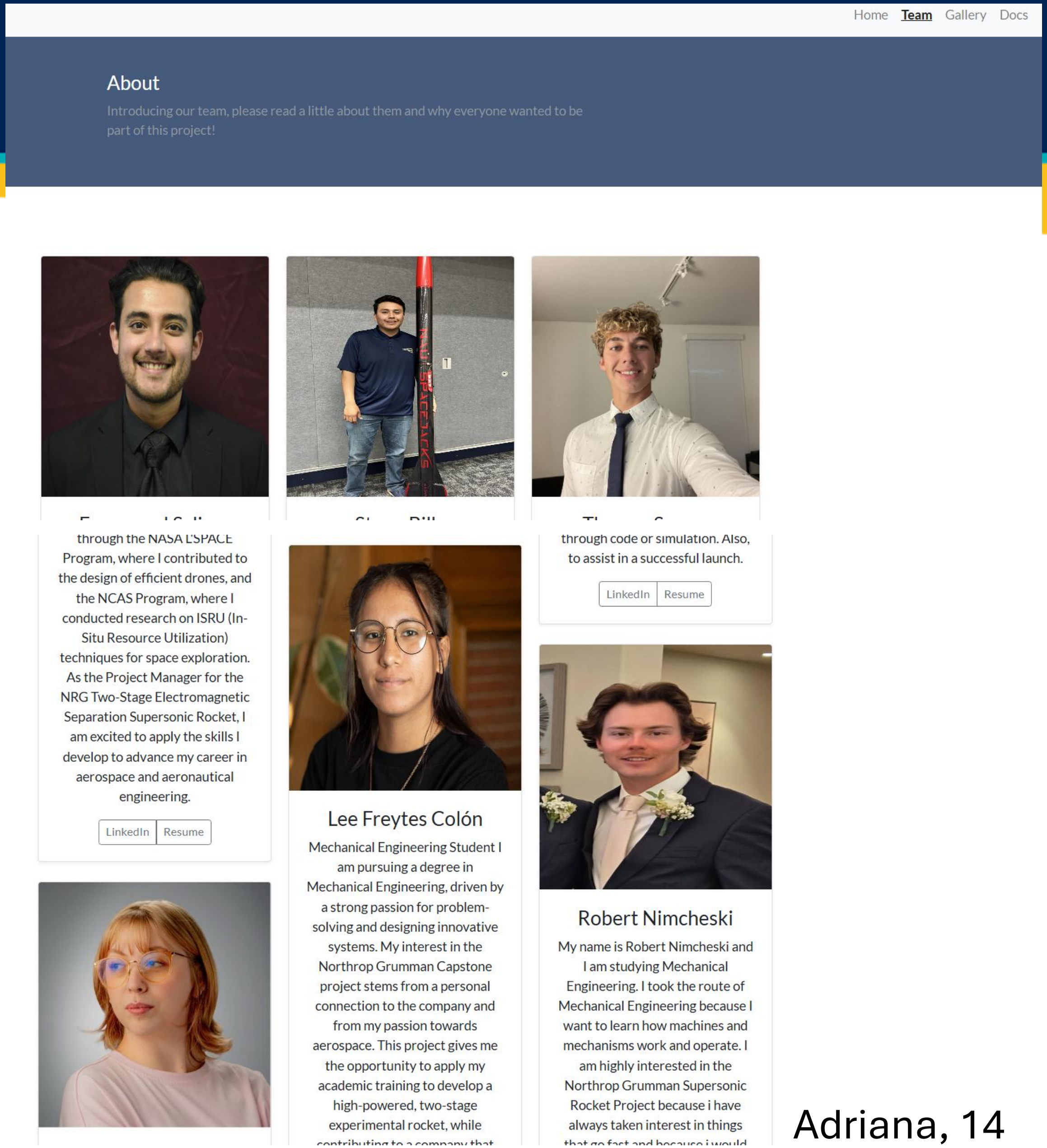
Adriana’s Analysis

Analysis Update

- While manufacture of new coupler, ensure skin drag is low consisting with previous calculations
- Cone drag is minimal along with fin drag

Current Work & Goals

- Updating website code with information as project progresses to show to Northrop
- Test and safety procedures documentation for separation testing
- Research recovery system



FMEA: Launch System

Launch System										
Part #	**Function**	**Potential Failure Mode**	**Potential Effect(s) of Failure**	**Severity** 1 = low 10 = High	**Potential Causes and Mechanisms of Failure**	**Occurence** 1 = No Effect 10 = Highly Likely	**Current Design Controls Test**	**Detection** 1 = Certain 10 = Uncertain	**RPN** 1: Good 1000: Bad	**Recommended Action**
1.1	**Booster Igniter**	Electrical or Charge	Booster motor fails to ignite.	1	Incorrect Wiring and/or insufficient amount of black powder.	4	Testing igniter wiring and consult experienced professional regarding black powder	3	12	Rewire electrical system and add additonal black powder
1.2	**Sustainer Igniter**	Electrical or Charge	Sustainer motor fails to ignite.	7	Incorrect Wiring and/or insufficient amount of black powder.	4	Testing igniter wiring and consult experienced professional regarding black powder	3	84	Rewire electrical system and add additonal black powder
1.3	**Motor Mount(s)**	Structural	Structural Integrity fails	9	Incorrect material and/or geometry.	2	Structural Analysis at stress concentration points.	1	18	Reanalyze current design and possibly redesign.
1.4	**Rocket (Body)**	Structural	Buckling	9	Incorrect material and/or geometry.	2	Structural Analysis at smallest diameter.	1	18	Reanalyze current design and possibly redesign.
1.5	**Launch Rail**	Launch	Rocket flight is unstable	9	Launch rail height is too short.	2	RASAero simulation to ensure a certain velocity is met on launch rail.	2	36	Redo RASAeor simulation and have professional review it.
1.6	**Fins**	Structural	Fins delaminate	2	High heat transfer to fin lamination.	8	Test launch.	8	128	Design a fin cover or apply a higher temperature resin.

FMEA: Hot Separation System

Hot Separation System										
Part #	**Function**	**Potential Failure Mode**	**Potential Effect(s) of Failure**	**Severity** 1 = low 10 = High	**Potential Causes and Mechanisms of Failure**	**Occurence** 1 = No Effect 10 = Highly Likely	**Current Design Controls Test**	**Detection** 1 = Certain 10 = Uncertain	**RPN** 1: Good 1000: Bad	**Recommended Action**
1.7	**Booster Stage**	Material	Possible structural damage to booster stage.	8	High heat transfer to booster stage.	5	Consulting a professional for material recommendations. Testing material through a launch.	5	200	Change booster material and have a professional review design.
1.8	**Sustainer Igniter**	Electrical or Charge	Sustainer motor fails to ignite.	7	Incorrect Wiring and/or insufficient amount of black powder.	4	Testing igniter wiring and consult experienced professional regarding black powder	3	84	Rewire electrical system and add additonal black powder
1.9	**Sustainer Motor**	Force	Separation does not occur.	7	Incorrect sizing of exhaust ports (Too Large) resulting in less vertical force.	2	Consulting a professional experience in Hot Separation. Testing with a launch.	5	70	Reduce exhaust port size, redo separation analysis, and have a profession review design.
2	**Exhaust Ports**	Geometry	Possible structural damage to booster stage.	8	Incorrect sizing of exhaust ports (Too Small) resulting in high heat transfer to booster stage.	4	Consulting a professional experience in Hot Separation. Testing with a launch.	5	160	Increase exhaust port size, possibly change booster material, and have a professional review design.

FMEA: Recovery System

Recovery System										
Part #	**Function**	**Potential Failure Mode**	**Potential Effect(s) of Failure**	**Severity** 1 = low 10 = High	**Potential Causes and Mechanisms of Failure**	**Occurence** 1 = No Effect 10 = Highly Likely	**Current Design Controls Test**	**Detection** 1 = Certain 10 = Uncertain	**RPN** 1: Good 1000: Bad	**Recommended Action**
2.1	**Altimeters**	Electrical, software, or power.	Recovery system failure.	10	Incorrect wiring, altimiters fail, or battery has insufficient power.	2	Testing avionics before launch and applying redundancy to avionics.	6	120	Rewire electrical system and/or replace altimeters.
2.2	**Parachute Depolyment**	Packing, protection, and deployment.	Recovery system failure.	10	Incorrect packing, parachute was not protected from black powder, or failed to deploy.	4	Practicing pack procedure and testing parachute deployment.	2	80	Review parachute packing procedure, analyze wether parachutes were damaged or obstructed during deployment.
2.3	**Parachute Force**	Lift Force	High Descent rate, possible structural damage.	7	Incorrect parachute sizing.	2	RASAero Simulation and professional consultation.	2	28	Redo RASAero simulation, apply a factor of safety to parachute size, and professional review.
2.4	**Tender Decender**	Electrical and/or charge.	Main chute deployment failure, high structural damage.	9	Incorrect wiring and/or insufficient amount of black powder.	4	Professional review on design and possible testing if applicable.	4	144	Review wiring and black powder amount, and redo testing.
2.5	**Shock Coord Snaps**	Material.	Recovery system failure.	10	Material strength is lower than initial impulse force.	2	Professional review and impulse analysis.	2	40	Get stronger shock coord
2.6	**GPS**	Electrical, software, or power.	Rocket trajectory (x,y) is unknown.	6	Incorrect wiring, GPS fails, or battery has insufficient power.	2	Testing GPS before launch.	5	60	Review electrical system, possibly buy new GPS.

Black Powder Testing

Test Procedures

- **Preparation:**
  - Fill cap with a specific amount of black powder
  - Insert E-Match into black powder
  - Seal black powder cap with multiple strips of tape
- **Assembly:**
  - Pack recovery and other components into the rocket
  - Secure first stage to prevent movement
  - Connect two stages with shear pins
  - Connect E-Match to mechanical switch
- **Ignition & Data Collection:**
  - Proceed to a safe test area
  - Ignite black powder remotely
  - Measure distance between separated stages

Equipment, Resources and Space

- **Testing Equipment:** Black Powder, Safety Equipment/PPE, Camera, Test Stand, Data Collection System
- **Rocket Components:** Nose Cone, Rocket Bodies, Black Powder Charge Container, E-Match, Mechanical Switch

Avionics Testing

Test Procedures

- **Preparation:**
  - Draw up wiring diagram
  - Upload simulation data to Blue Raven Application
- **Assembly:**
  - Connect the battery connector to the breadboard.
  - Connect the positive and negative ports of the altimeter to the breadboard
  - Connect the negatively charged wires to the LED Lights
  - Connect the Aft, Main, 3rd, and 4th ports to the specified LED Lights
  - Connect the battery to the battery connector
- **Data Collection:**
  - Run the simulation software.
  - See if the correct lights turn on at specific timing

Equipment, Resources and Space

- **Testing Equipment:** Bread Board, Wires, LED Lights, Battery, Battery Connector, Blue Raven Application
- **Rocket Components:** Altimeters, Power Perch, GPS, Ground Station

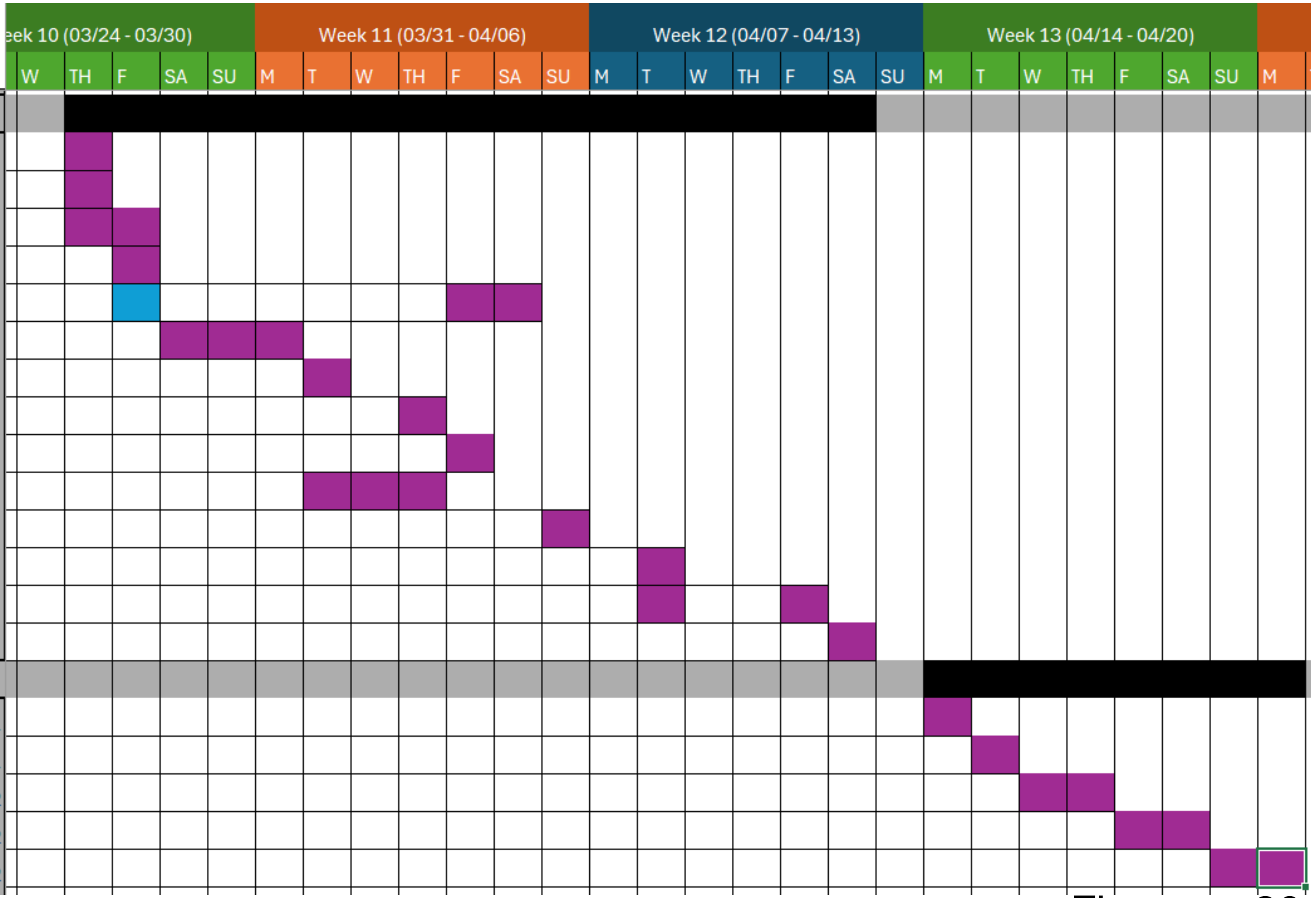
Gantt Chart

- Currently on Schedule

NRG Hypersonic Rocket

Start Date: 01/20/2025

Stage 4: Finish Building Rocket		Completion (%)	16d
Rework mandrel / apply chem-lease (Nova Kinetics)	Stonn, Thomas	100	1d
Hot Separation Meeting (Nova Kinetics)	Stonn, Thomas	100	1d
Black Powder Analysis	Lee, Adriana	100	2d
Order Altimeters and GPS	Bob, Emanuel	100	1d
Design and Order Recovery System	Team	0	2d
Presentation 3	Team	0	3d
Refabricate Coupler 1 (Nova Kinetics)	Stonn, Thomas	0	1d
Refabricate Coupler 2 (Nova Kinetics)	Stonn, Bob	0	1d
Sanding Couplers	Stonn, Emanuel	0	1d
Hot Separation Analysis	Thomas	0	3d
Wire Avionics	Thomas, Bob	0	1d
Fabricate Holes and Plate (Nova Kinetics)	Stonn, Thomas	0	1d
Measure Full Rocket and Sustainer Stage CG	Team	0	1d
Finalize RASAero and OpenRocket Simulations	Emanuel, Bob, Thomas	0	1d
Stage 5: Rocket Finalization		**Completion (%)**	
Black Powder Testing	Team	0	1
Altimeter Testing	Thomas	0	1
Safety Procedure Document	Team	0	2
Launch Procedure Document	Team	0	2
Final BOM	Bob	0	2



Next Semester Schedule

- Finish redesigning new **Magnetic Separation Device**
- Begin **Manufacturing** and **Testing** of **Mag Sep Device**
- **Launch Rocket** in September with **Hot Separation**
- Analyze data from launch and make any necessary changes to rocket.
- Implement **Mag Sep Device** in November Launch.

Budget

	Description:	Amount [$]:
Available funding:	NRG funding	$6,115.13
Donations:	GoFundMe	$700
Current Expenses:	Featherweight GPS System	-$529.27
	Featherweight Blue-Raven Altimeters	-$336.08
In-Progress Expenses:	N/A	
Upcoming Expenses:	2 7[ft] Drogue parachutes	-$337.00
	16[ft] Main parachute	-$180.00
	14[ft] Main parachute	-$165.00
	2 50[ft] 8,600lb Braided Kevlar Shock Cords	-$135.00
	2 30[in] Shock cord protectors	-$37.00
	L3 Tender descender	-$45.00
	4 Parachute bags	TBD
	4 Quick connects	TBD
	Hot separation materials	TBD
Net Balance:		$5,949.78

Not including upcoming expenses

- N2220 ----> N3300R
- L3 expert will confirm upcoming expenses
- Upcoming Panda Express fundraiser
- GPS system has arrived
- Still waiting on altimeters

Next Steps

- Manufacture Couplers
- Design Recovery System Schematic
- Level 3 expert rocket review
  - RASAero, OpenRocket, Recovery System, and Hot Separation
- Order/Build Recovery System
- Mag Sep design matrix
- Mag Sep design this semester (CAD)

References

[1] NASA Student Launch, “NASA Student Launch ARW Rocketry by the Numbers,” NASA, Jul. 2023. Accessed: Mar. 31, 2025. [Online]. Available: https://www.nasa.gov/wp-content/uploads/2023/09/nasa-sl-2024-arw-rocketry-by-the-numbers-508.pdf