River City Rocketry

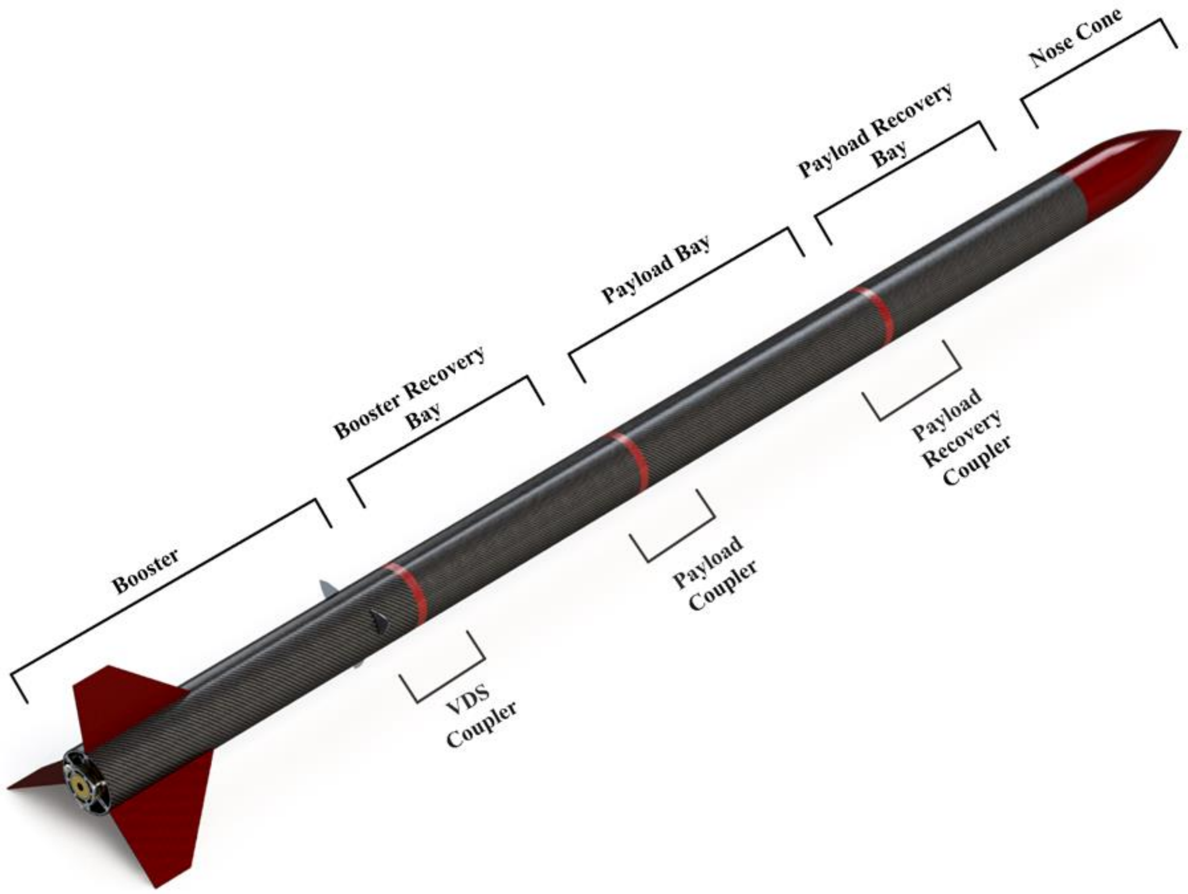
PRELIMINARY DESIGN REVIEW(PDR) PRESENTATION 2017-2018

PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Launch Vehicle Overview

- 6.25 in. Diameter, 145 in. Long
- 12 in. Parabolic Nose Cone
- Aerotech L2200-G Motor
- Variable Drag System
- Three Swept Cropped Delta Fins
- Removable Fin System



Airframe Material

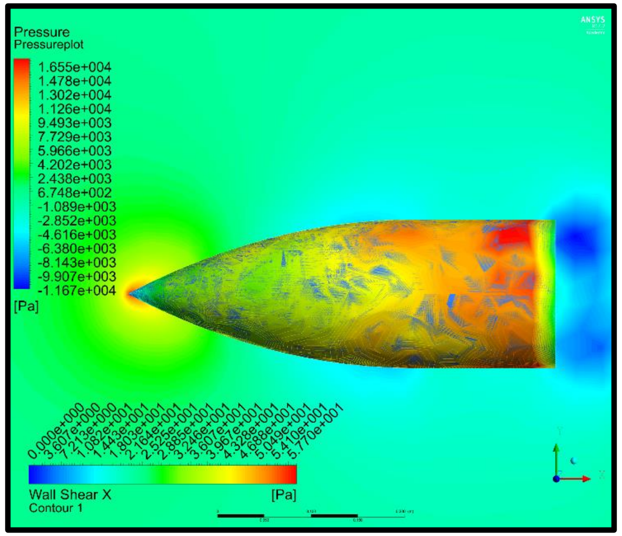
- A&P Technology QISO quasi-isotropic carbon fiber fabric
  - Lightweight
  - Strong
  - Cost effective
  - Controllable manufacturing process

Airframe Material Trade Study

Options		Fiberglass		Filament Wound Carbon fiber		A&P Technology QISO Carbon Fiber Fabric		BlueTube	
Mandatory Requirements									
Support loads during lift off		YES		YES		YES		YES	
Impact resistant		YES		YES		YES		YES	
Wants (0-10)	Weights	Value	Score	Value	Score	Value	Score	Value	Score
Weight	35.00%	4	1.4	7	2.45	8	2.8	8	2.8
Strength	35.00%	8	2.8	9	3.15	9	3.15	5	1.75
Availability	20.00%	8	1.6	7	1.4	9	1.8	7	1.4
Cost	10.00%	7	0.7	3	0.3	9	0.9	8	0.8
Total Score		6.5		7.3		8.65		6.75	

Nose Cone Design

- CFD simulations were performed on the Conical, ½ Power series, LD Haack, and Parabolic nose cone designs.
- 12’’ Parabolic nose cone design was chosen for use due to it’s low coefficient of drag, mass, and adequate internal volume .
- Will be constructed from carbon fiber fabric using a positive and negative mold.

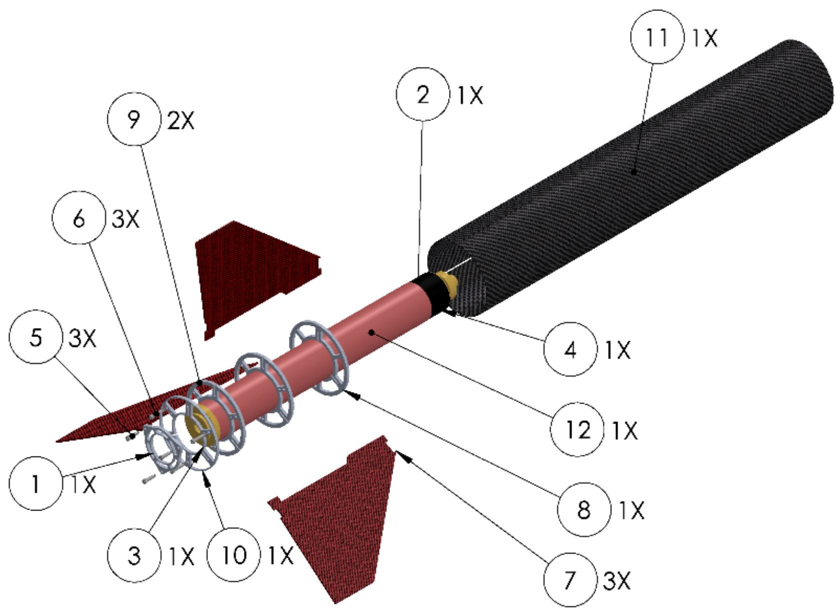


Nose Cone Design Trade Study

Options		12in. LD Haack		12in. 1/2 Power Series		12in. Conical		12in. Parabolic	
Mandatory Requirements									
Overall length does not exceed 12 inches.		YES		YES		YES		YES	
Coefficient of Drag less than 0.5.		YES		YES		YES		YES	
Wants	Weights	Value	Score	Value	Score	Value	Score	Value	Score
Coefficient of Drag (0-10)	35.00%	8	2.8	7	2.45	5	1.75	9	3.15
Mass (0-10)	30.00%	6	1.8	5	1.5	7	2.1	5	1.5
Manufacturability (0-10)	20.00%	6	1.2	5	1	7	1.4	6	1.2
Internal Volume	10.00%	8	0.8	8	0.8	6	0.6	9	0.9
Total Score		6.6		5.75		5.85		6.75	

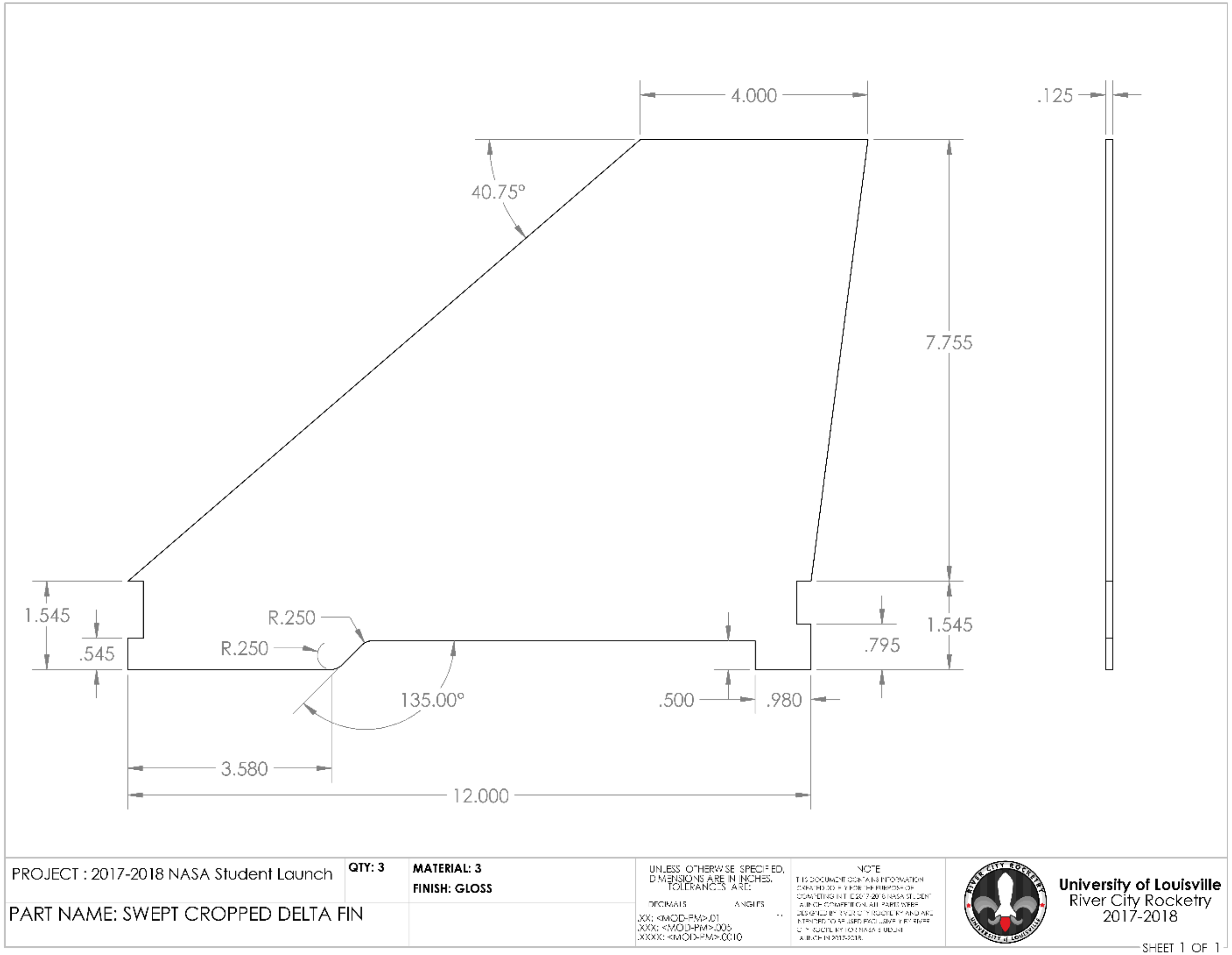
Removable Fin System

- Quick and easy installation/removal of fins
- Accurate fin mounting
- Adjustable fin dimensions
- Easy transportation
- Can replace a damaged fin



ITEM NO.	PART NUMBER	QTY.
1	Motor Retainer	1
2	Motor Casing	1
3	Aft Closure	1
4	Forward Closure	1
5	#10-32 Shoulder Bolt	3
6	1/4" - 20 Shoulder Bolt	3
7	Swept Cropped Delta Fin	3
8	Fore Centering Ring	1
9	Mid Centering Ring	2
10	Fin Retainer	1
11	Booster Tube	1
12	Motor Mount Tube	1

Fin Mounting System							
Options		Epoxied Through the Wall		Removable Fin System		Fin Can	
Mandatory Requirements							
Ability to replace broken fins		NO		YES		YES	
Wants (0-10)	Weights	Value	Score	Value	Score	Value	Score
Fin rigidity	40.00%	7	2.8	7	2.8	8	3.2
Weight	25.00%	9	2.25	7	1.75	5	1.25
Cost	5.00%	8	0.4	5	0.25	3	0.15
Durability	30.00%	6	1.8	8	2.4	7	2.1
Total Score		7.25		7.2		6.7	



Fin Design

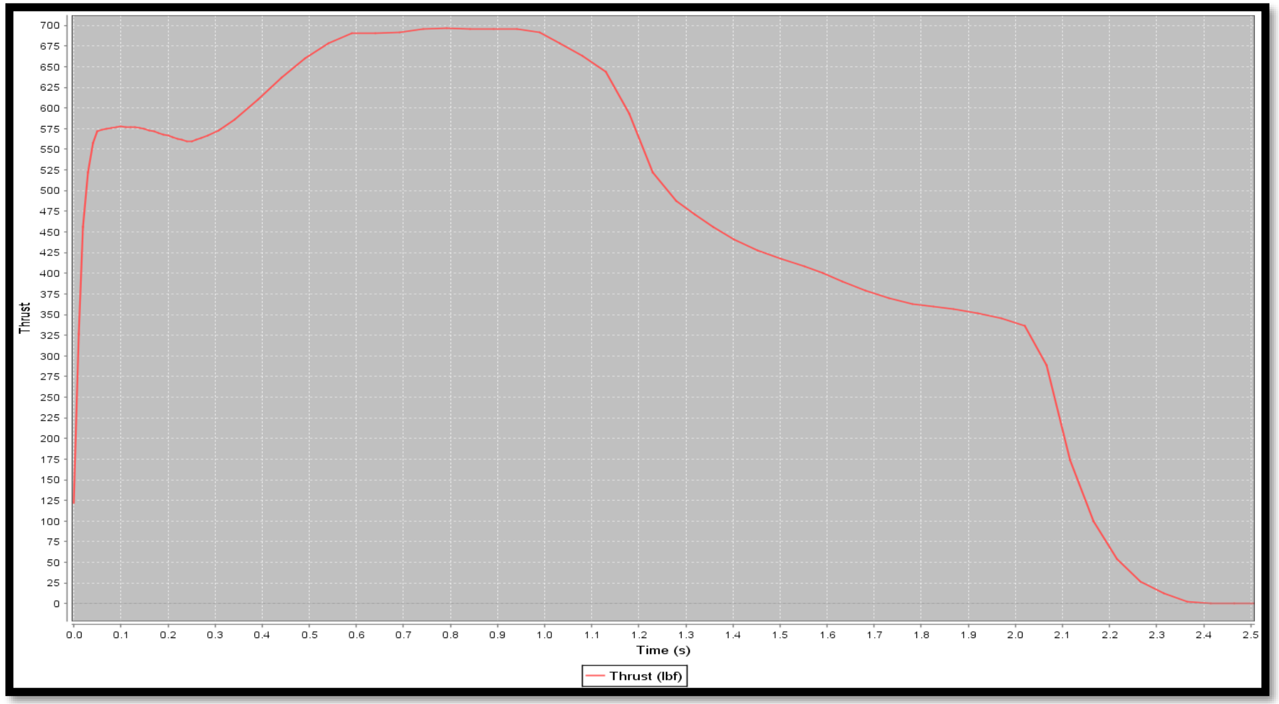
- Three swept cropped delta fins
- Cut from 0.125 in. thick carbon fiber
- Researching manufacturing carbon fiber sheet in house

Fin Material							
Options		Plywood		Fiberglass		Carbon Fiber	
Mandatory Requirements							
Impact resistant		YES		YES		YES	
Compatible with RFS		NO		YES		YES	
Wants (0-10)	Weights	Value	Score	Value	Score	Value	Score
Stiffness	40.00%	4	1.6	8	3.2	9	3.6
Durability	40.00%	4	1.6	8	3.2	9	3.6
Cost	5.00%	10	0.5	5	0.25	1	0.05
Weight	15.00%	6	0.9	5	0.75	8	1.2
Total Score		4.6		7.4		8.45	

Motor Selection

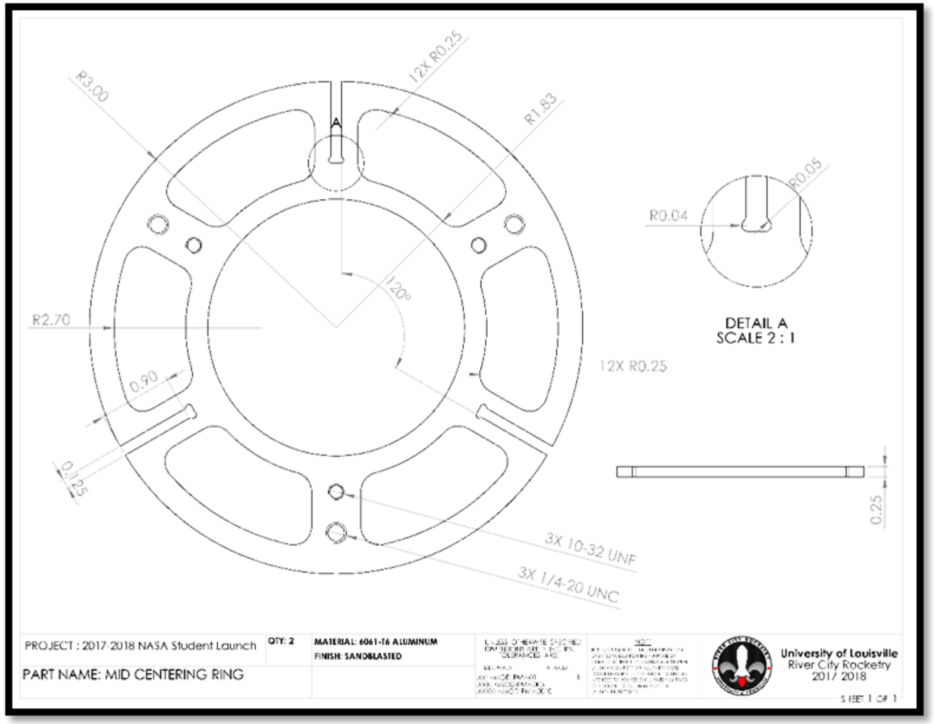
- Aerotech L2200-G selected after reviewing several OpenRocket simulation results. Will deliver vehicle to approximately 5,500 ft. with an inactive Variable Drag System.
- Cesaroni 2375 or Cesaroni 3150 may be used if launch vehicle mass decreases

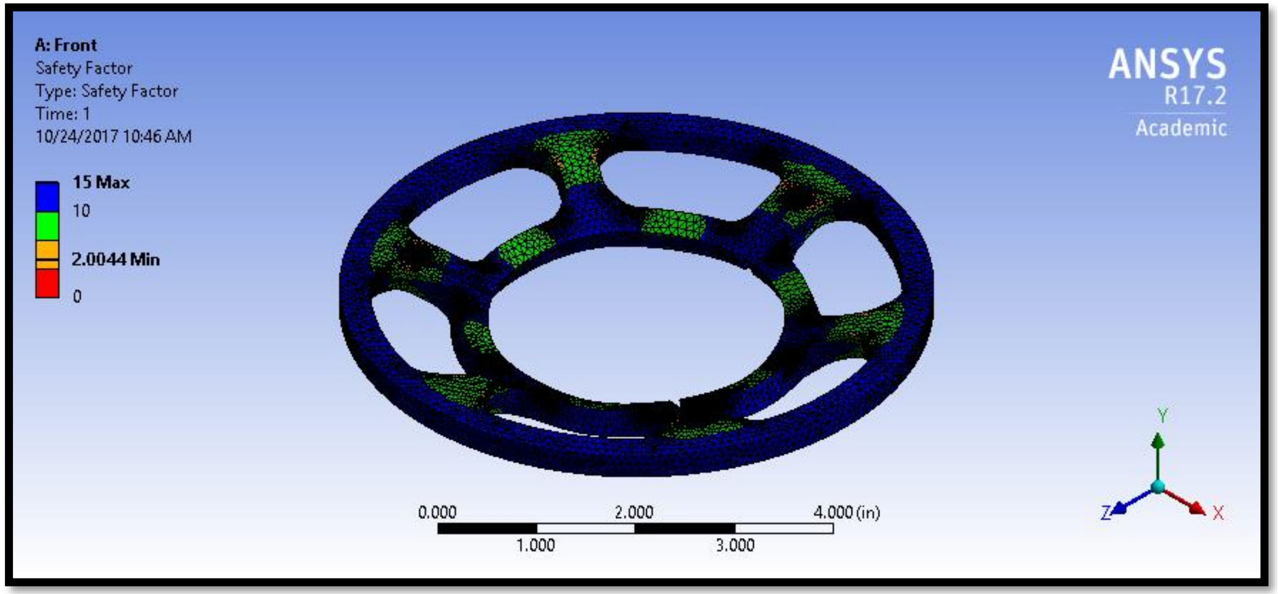
Diameter	75 mm
Length	68.1 cm
Total Weight	4,783 g
Propellant Weight	2,518 g
Average Thrust	2,200 N
Maximum Thrust	3,104 N
Total Impulse	5,104 Ns
Burn Time	2.3 sec



Centering Ring Design

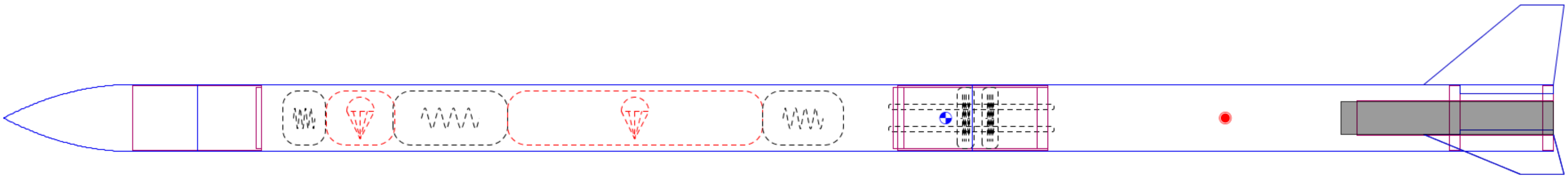
- 0.25 in. thick 6061-T6 aluminum
- Designed to minimize mass and maintain a factor of safety greater than 2.0 during motor burn





Subscale Launch Vehicle

- A half scale model will be launched to verify the launch vehicle design.
- Will verify:
  - Aerodynamic properties and stability of the launch vehicle
  - ARRD deployment device and toroidal parachute design



Flight Characteristics

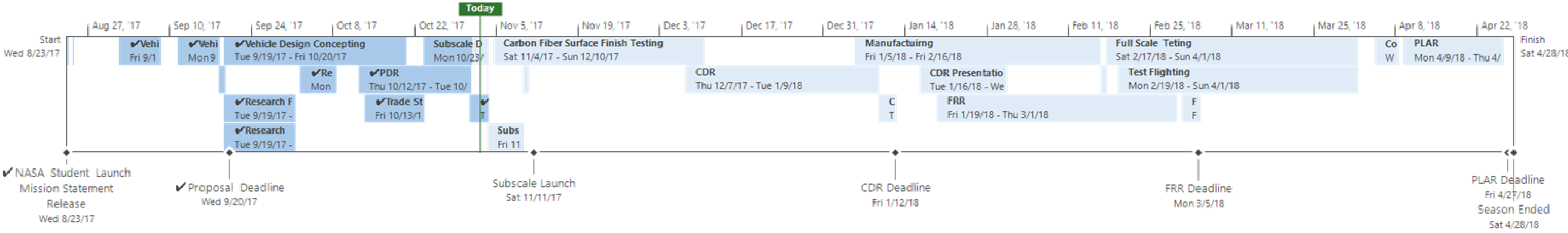
Characteristic	Sub-Scale	Full-Scale
Stability Margin at Rail Exit (in.)	2.23	2.25
Simulated Center of Pressure (CP) Location from Nose Cone Tip (in.)	50.40	96.51
Center of Gravity (CG) Location from Nose Cone Tip (in.)	43.42	82.33
Exit Rail Velocity (ft./s)	94.9	95.4
Maximum Velocity (ft./s)	515	732
Maximum Acceleration (ft./s^2)	595	479
Simulated Apogee (ft.)	2,214	5,562 (No VDS)
Thrust-to-Weight Ratio	20.01	15.26

Vehicle Requirements Compliance Plan

- All launch vehicle requirements will be verified using the standards laid out in the NASA Systems Engineering Handbook.
- Statement of Work Requirements 2.1 -2.21 will be complied with via Inspection, Analysis, Demonstration or Test.

Requirement Number	Requirement Description	Method of Verification
2.1	The vehicle will deliver the payload to an apogee altitude of 5,280 feet above ground level (AGL).	**Analysis:** The launch vehicle shall be designed to reach an apogee altitude of 5,280 feet AGL. Several OpenRocket simulations as well as hand calculations will be performed to ensure the ideal motor is selected. The VDS will be tested to ensure an accurate altitude is achieved.
2.2	The vehicle will carry one commercially available, barometric altimeter for recording the official altitude used in determining the altitude award winner.	**Inspection:** A PerfectFlite StratoLogger CF altimeter will be used to record the official apogee altitude for the competition flight.
2.3	Each altimeter will be armed by a dedicated arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.	**Inspection:** The altimeters shall utilize a 6-32 PCB Screw-Switch purchased from Missile-Works. The screw switch shall be mounted on the altimeter sled with a small hole drilled into the airframe to provide access to the switch. The screw switch holes shall be placed opposite from the rail buttons to ensure the launch rail will not block access.

Vehicle Project Plan



Project Plan through CDR

Task	Start	End	Task	Start	End
Subscale Manufacturing	10/23	11/8	CDR	12/7	1/9
Carbon Fiber Surface Finish Testing	11/4	12/10	Manufacturing	1/5	2/16
Subscale ground testing	11/9	11/10	CDR Review	1/9	1/12
Subscale Launch	11/11	11/11	CDR Deadline	1/12	1/12

PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Variable Drag System

The Variable Drag System (VDS) is an autonomous active apogee targeting system which will bring the vehicle to 5,280 ft. AGL +/- 23 ft.

VDS Agenda:

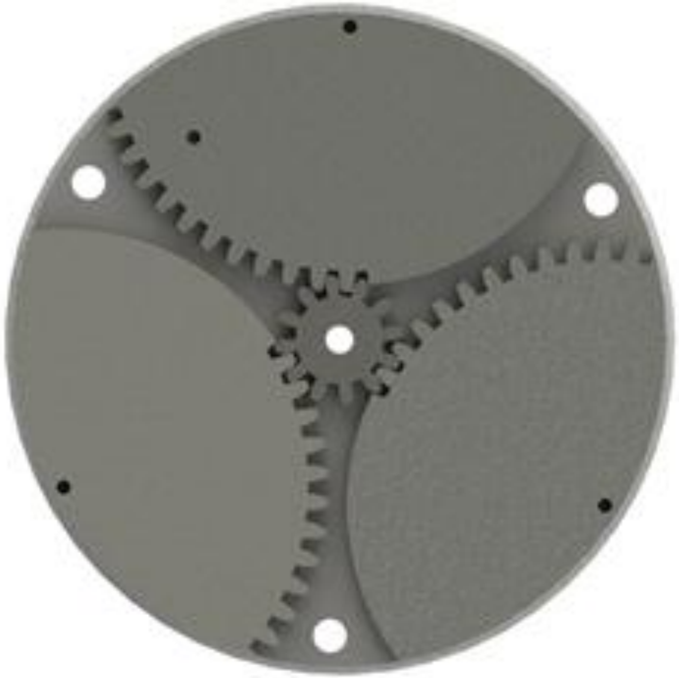
- Technical design of the VDS
- Altitude predictions and control theory
- Safety of the VDS

Technical Design - Mechanical

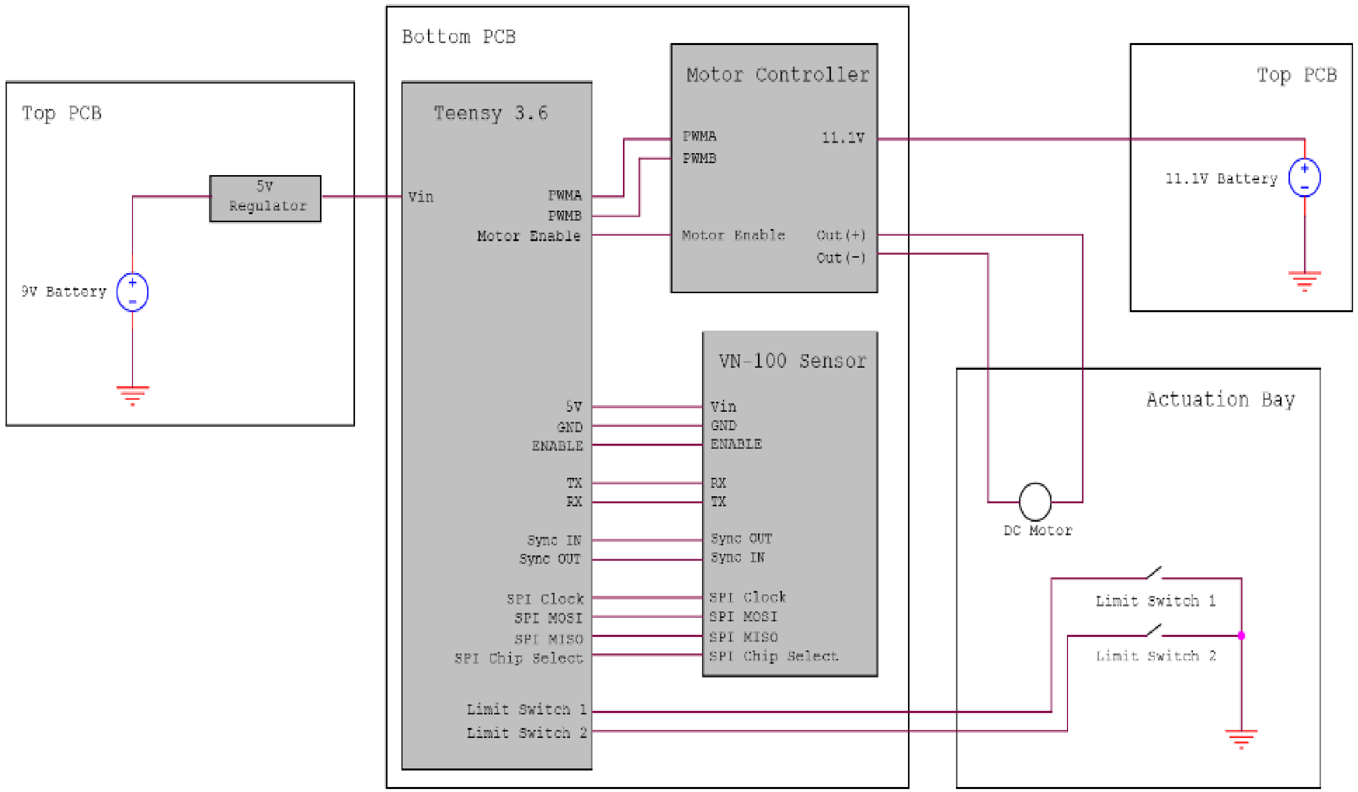
- Increases Drag Coefficient of Vehicle by factor of

1.38 to reduce apogee from 5,500 ft. to 5,280 ft.

- Three 6061-T6 aluminum drag blades
- Delrin plates provide a low friction bearing surface
- Simultaneously actuated by central DC motor



Technical Design - Electrical



- Data input from VN-100 IMU
- Custom built software running on Teensy 3.6 microcontroller
- Telemetry System through XBEE pro RF transmitter
- Setpoint path

Telemetry System

VDS RF telemetry system features:

- Designed to relay real-time VDS data to ground.
- Custom designed ground station GUI.
- Integrated with Teensy 3.6.
- Data transmission up to 120 kb/s.
- Maximum transmission range of 65 miles.

P900 OEM

XBEE SX

RN2903A

Telemetric Long Distance Radio (TLDR)

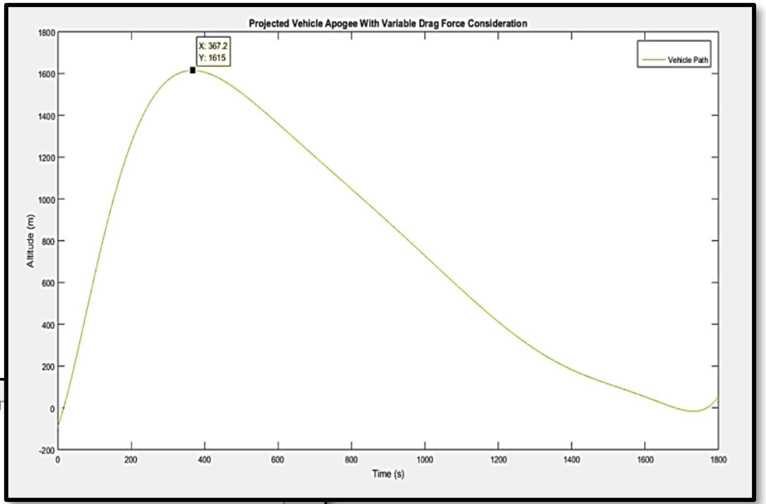
Options:		P900		XBEE SX PRO		XBEE SX		RN2903A-I	
Mandatory requirements									
Range > 1 mile		Yes		Yes		Yes		Yes	
ISM Band		Yes		Yes		Yes		Yes	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Transmit Power (0-10)	25.0%	10	2.5	10	2.5	6	1.5	7	1.75
Ease of integration (0-10)	25.0%	5	1.25	8	2	8	2	5	1.25
Data Rate (0 - 10)	20.0%	8	1.6	7	1.4	7	1.4	9	1.8
Sensitivity (0 - 10)	15.0%	6	0.9	5	0.75	5	0.75	9	1.35
Cost (0-10)	10.0%	4	0.4	2	0.2	7	0.7	10	1
Current Draw (0-10)	5.0%	2	0.1	4	0.2	8	0.4	6	0.3
Total Score			**6.75**		**7.05**		**3.25**		**4.45**

Altitude Predictions

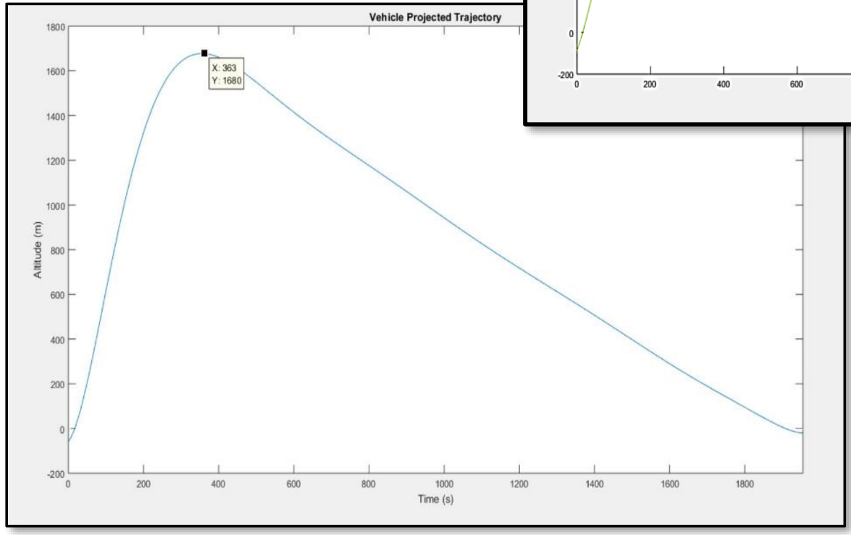
	Predicted vehicle apogee with VDS drag consideration	Predicted vehicle apogee without VDS drag consideration
Altitude (ft.)	5,298	5,562
Time (s)	367	363

Matlab simulations are used to:

- Model drag effects
- Tune the control scheme
- Perform failure analysis



Trajectory with VDS

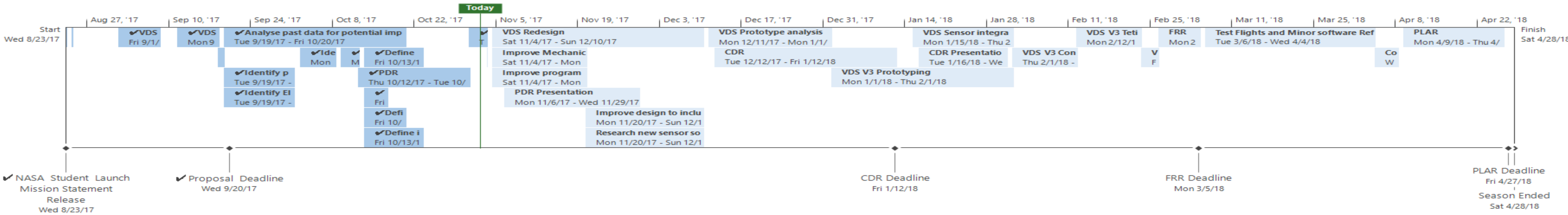


Trajectory without VDS

VDS Safety

Hazard	Cause	Outcome	Severity	Probability	Rating	Mitigation
Pressure phenomenon from open-ended propulsion bay causes altitude error	Vacuum formed under propulsion bay	VDS actuates too early, launch vehicle undershoots altitude resulting in mission failure	2	3	Moderate	Electronics bay will be airtight from the actuation bay to prevent possible interference
Broken gearbox	VDS blades remained actuated during recovery	Permanent damage to VDS assembly Hazard to crowd if recovery is unsuccessful	2	4	Moderate	VDS is programmed to retract blades after apogee The team is currently investigating recovery force reduction
Time variable overflow	Extended run time	VDS drag blazes could potentially actuate on rail, leading to increased rail friction, rail button shear and lower than expected exit velocity	1	4	Moderate	If time on rail is excessive, VDS can be restarted removing the issue of the variable overflow

VDS Project Plan



Project Plan through CDR

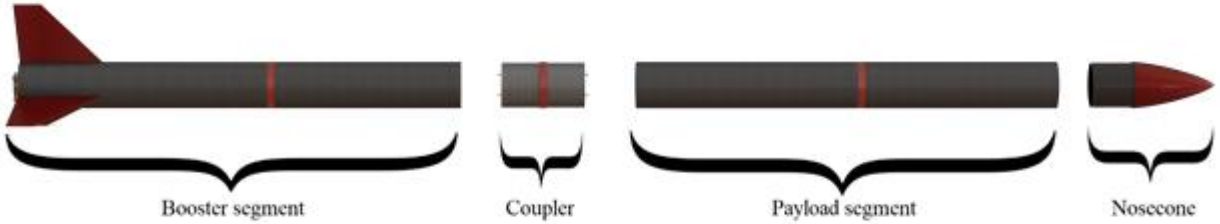
Task	Start	End	Task	Start	End
Improve mechanical systems to mitigate gear friction	11/4	11/20	Improve design to include external power and cable connectors to improve integration	11/20	12/10
Improve programming to remove errors	11/4	12/10	VDS Prototyping	12/11	1/1
Sensor Data Collection and Analysis	11/11	12/10	CDR	12/12	1/12
			CDR Deadline	1/12	1/12

PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Recovery Overview

- Cruciform design chosen for drogue.
- Toroidal design chosen for main.
- Dual deployment utilizing a release device.
- Charge well and reduction ring research.



Design choices

- All parachutes were considered for drogue and main parachutes, but not all met specifications.
- Qualitative characteristics were also considered.

Design	Cd	Angle of oscillation
Annular	0.90	$\le \pm 6$
Cruciform	0.60	$\le \pm 2$
Toroidal	1.40	$\le \pm 6$
Vortex ring	1.80	$\le \pm 2$
Flat hexagonal	0.75	$\le \pm 30$
Hemispherical	0.70	$\le \pm 10$

Cruciform Drogue

- Easily manufactured
- Customizable for drag or stability
- Functions as main for coupler and nosecone

Payload Drogue and Booster Drogue									
Options		Annular		Toroidal		Flat Hexagonal		Cruciform	
Mandatory requirements									
Oscilation < 10 degrees		Yes		Yes		No		Yes	
Wants (0-10)	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Efficiency (drag coefficient)	10%	5	0.5	8	0.8	0.4	0.04	3	0.3
Stability (angle of oscilation)	30%	3	0.9	3	0.9	1	0.3	7	2.1
Ease of Deisgn	20%	7	1.4	6	1.2	10	2	9	1.8
Ease of Manufacturing	20%	7	1.4	6	1.2	10	2	9	1.8
Deployment Simplicity	15%	7	1.05	7	1.05	10	1.5	10	1.5
Testablility	5%	7	0.35	7	0.35	10	0.5	10	0.5
Total score		**5.6**		**5.5**		**6.34**		**8**	

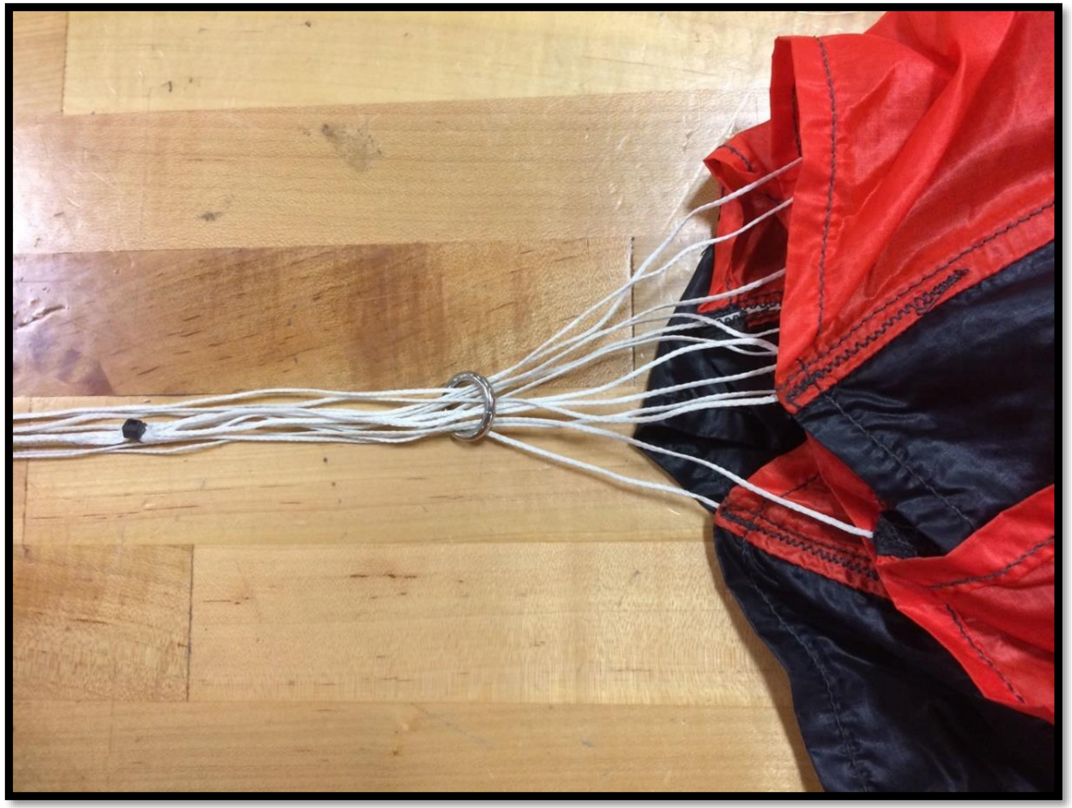
Toroidal Main

- Low volume, low mass, high drag
- Reliably deployed
- High opening force

Payload Main and Booster Main									
Options		Annular		Toroidal		Vortex Ring		Cruciform	
Mandatory requirements									
Drag Coefficient > 0.8		Yes		Yes		Yes		No	
Wants (0-10)	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Efficiency (drag coefficient)	40%	5	2	8	3.2	10	4	3	1.2
Stability (angle of oscilation)	10%	3	0.3	3	0.3	10	1	7	0.7
Ease of Design	15%	7	1.05	6	0.9	2	0.3	9	1.35
Ease of Manufacturing	10%	9	0.9	7	0.7	2	0.2	8	0.8
Deployment Simplicity	20%	7	1.4	7	1.4	3	0.6	10	2
Testablility	5%	7	0.35	7	0.35	2	0.1	9	0.45
Total score		**6**		**6.85**		**6.2**		**6.5**	

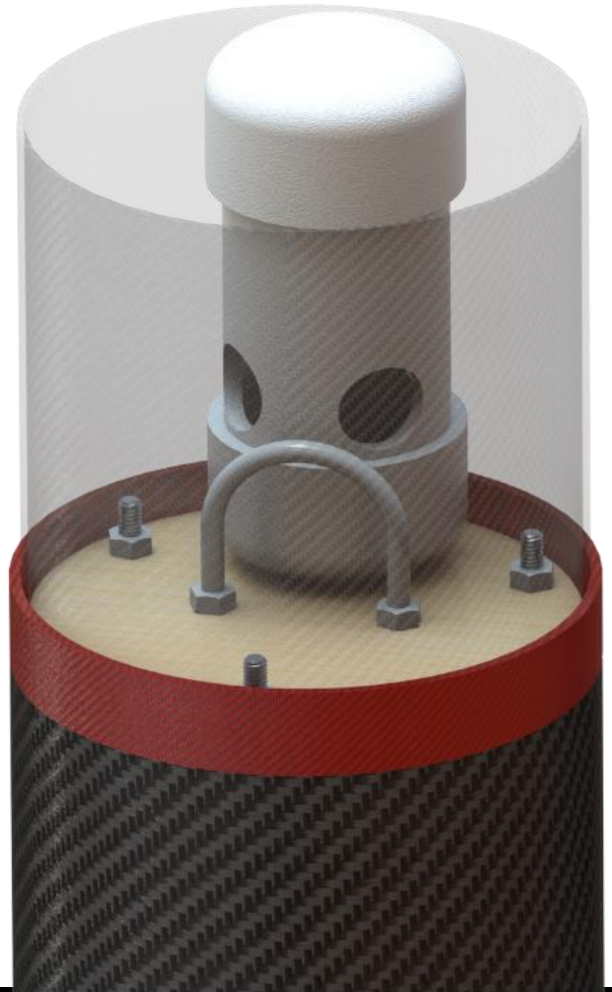
Opening Forces

- Due to the large opening forces seen by the toroidal design, the team has begun research towards the use of opening force reduction rings.
- The ring is placed over the lines to the mouth of the parachute.
- Shroud lines must fight the ring to expand.



Charge Wells

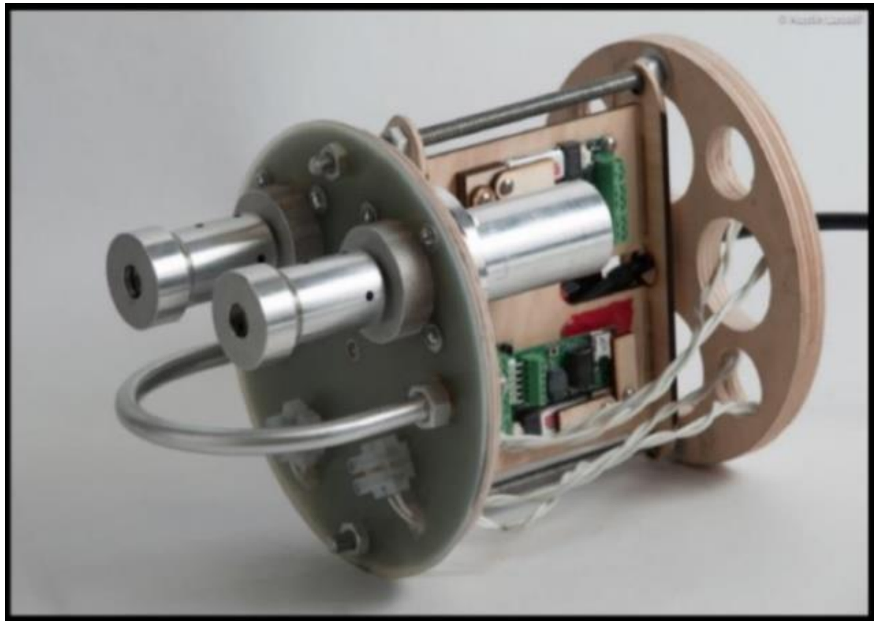
- The need to protect the payload from black powder separation charges has led us to pursue the use of charge wells.
- Contain the residue and smoke from a black powder ignition.



Charge Well vs. CO2 Separation

- CO_2 produces no residue or smoke
- More complex system
- Heavier system
- May be pursued in the future if weight limits permit

Separation methods					
Options		CO2		Charge Well	
Mandatory requirements					
Produces > 6 PSI		Yes		Yes	
Wants (0-10)	**Weights**	**Value**	**Score**	**Value**	**Score**
Cleanliness	40%	10	4	9	3.6
Reliable	30%	8	2.4	9	2.7
Simplicity	30%	5	1.5	9	2.7
Total score		**7.9**		**9**	



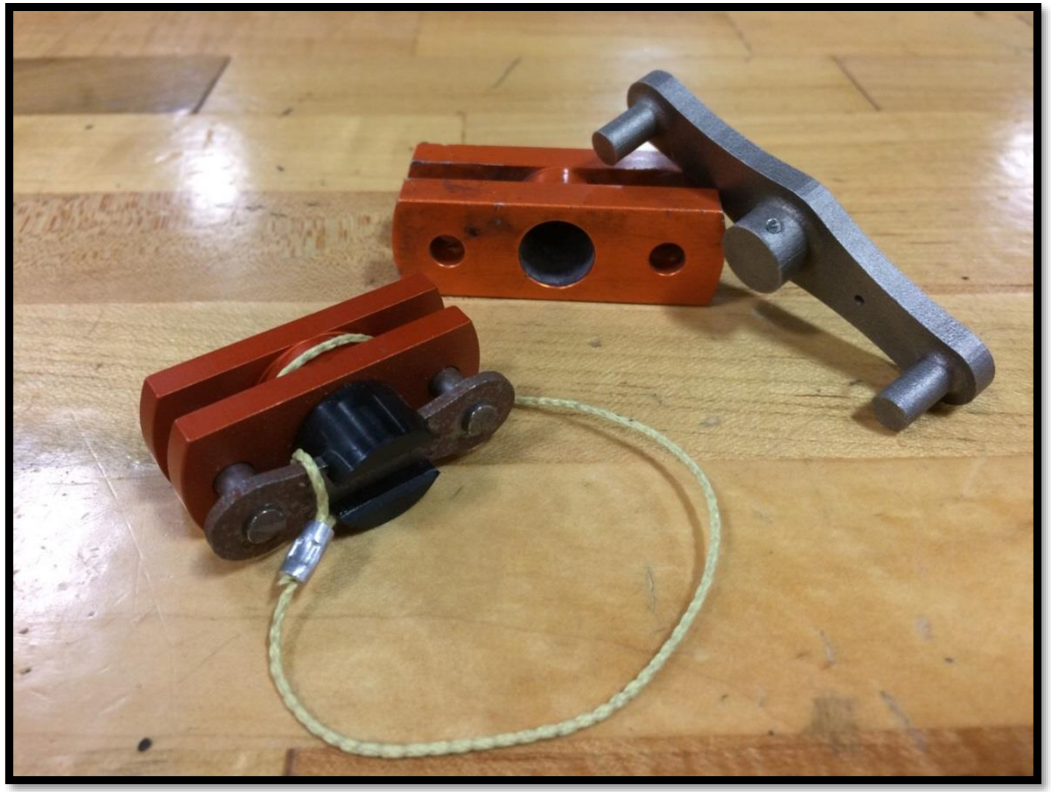
Advanced Retention and Release Device

- The need to separate the launch vehicle into two independent sections has led to the use a dual deployment bay
- The Advanced Retention and Release Device (ARRD) was chosen

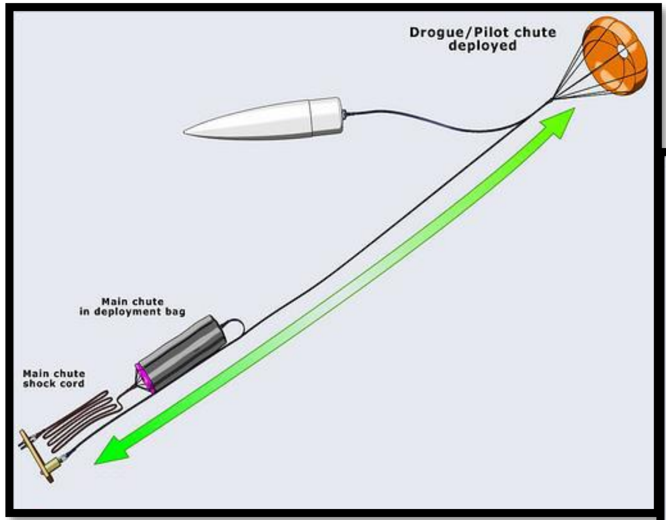
ARRD vs. Tender Descender

- ARRD has more contained parts
- TD parts can impact the airframe when activated or be lost if not tethered properly

Release device					
Options		ARRD		Tender Descender	
Mandatory requirements					
Provides retention until activated		Yes		Yes	
Wants (0-10)	**Weights**	**Value**	**Score**	**Value**	**Score**
Ease of Use	40%	7	2.8	6	2.4
Reliable	50%	8	4	8	4
Simplicity	10%	6	0.6	8	0.8
Total score		**7.4**		**7.2**	

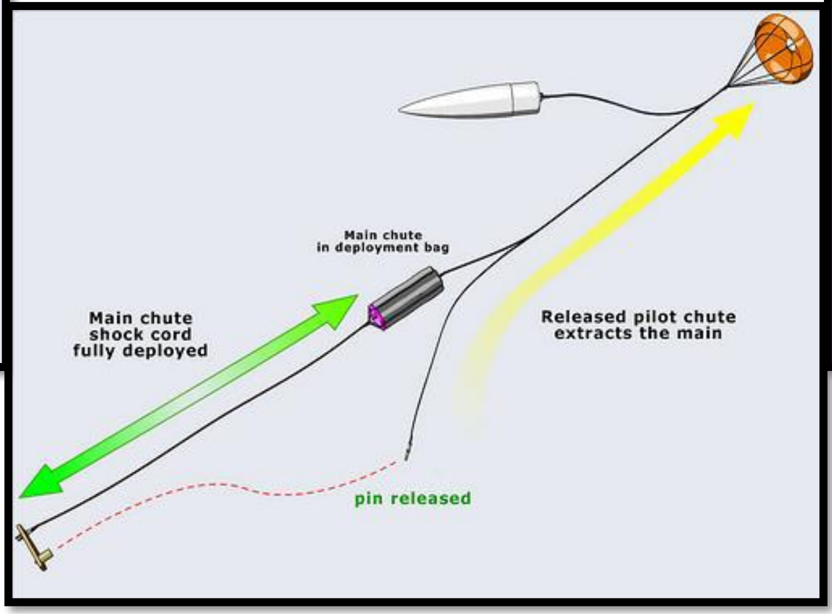


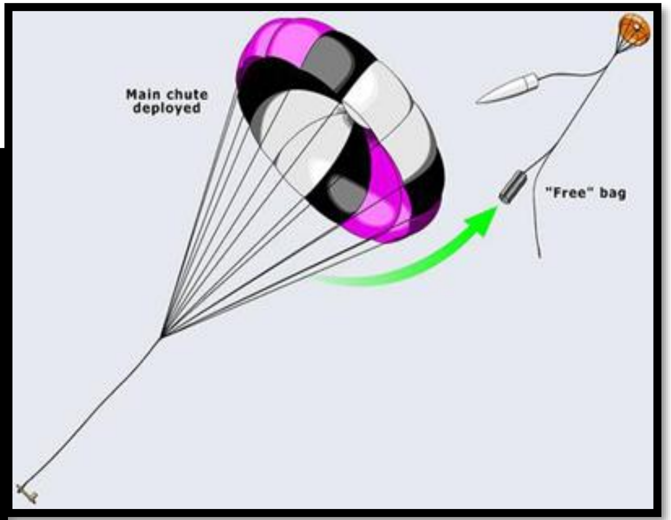
Release Device and Dual Deployment



Drogue steady state

Line stretch and bag deployment





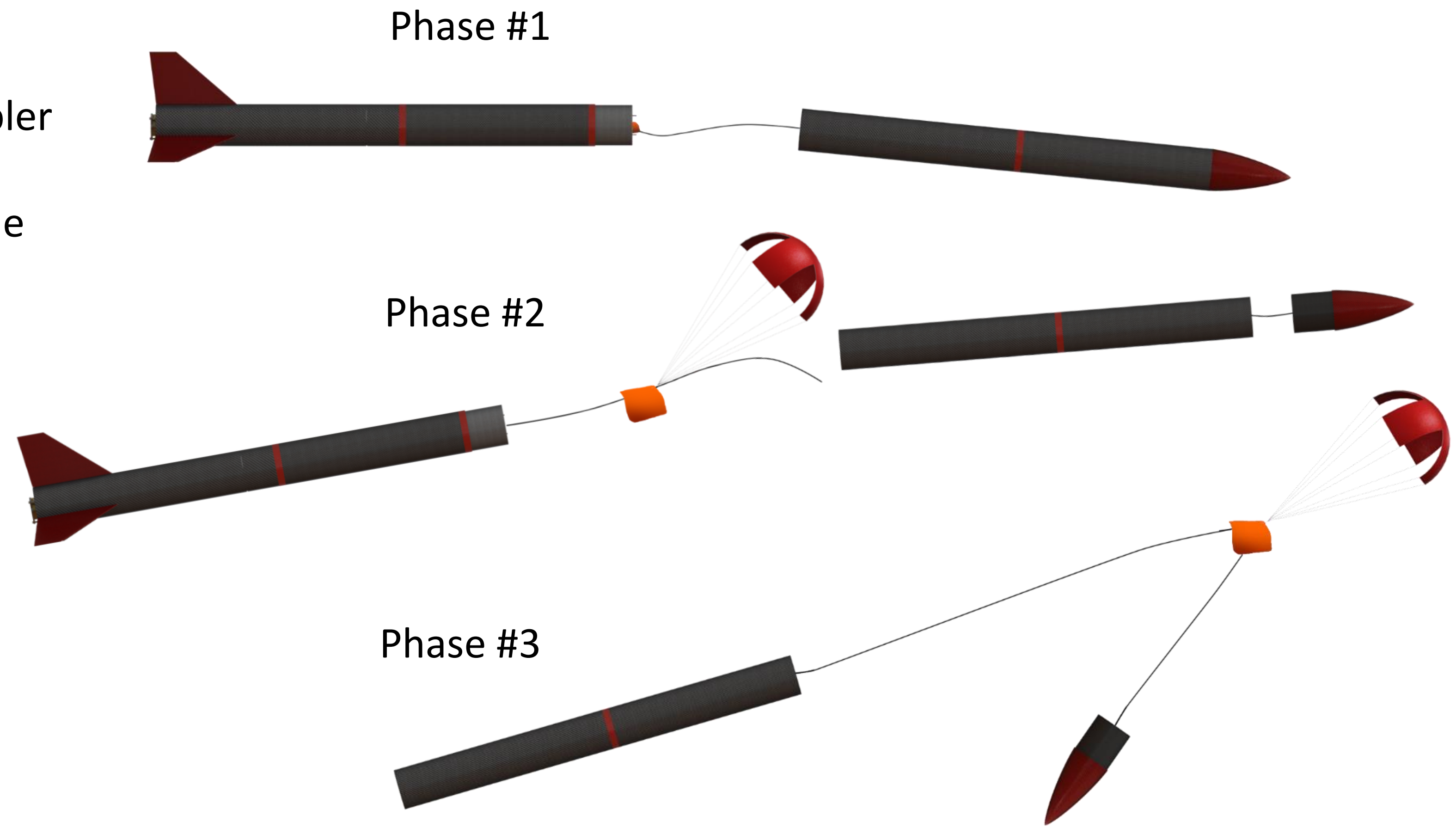
Main deployment

Apogee Events

1: separation between payload and coupler

2: booster drogue deploy and nosecone separation after +2 sec. Delay

3: payload drogue deploy

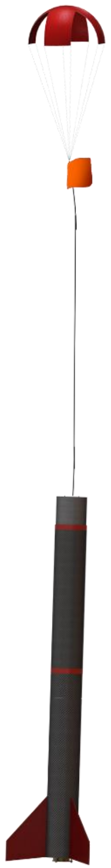


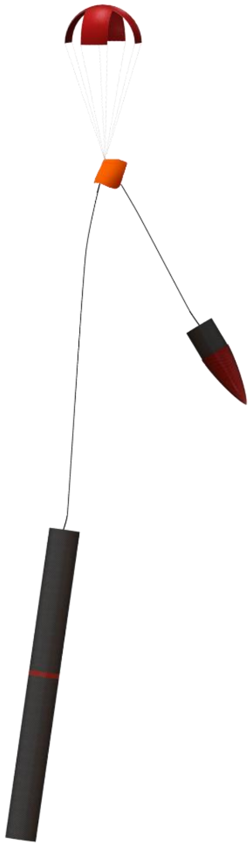
Drogue Phase

Booster Drogue

Deployment vel. :32.4 *ft/s*

Steady state vel. : *58.7 ft/s*





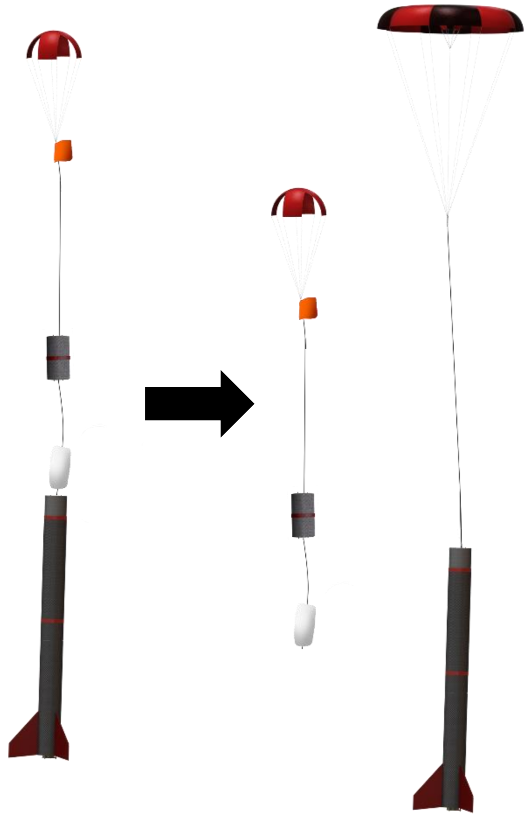
Payload Drogue

Deployment vel. :64*.5 ft/s*

Steady state vel. : *58.7 ft/s*

Booster Main Event

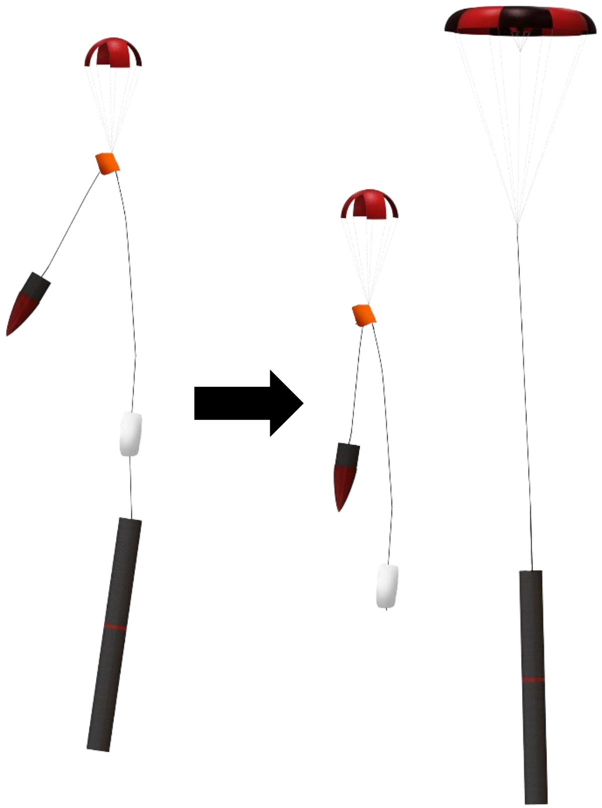
- Coupler separation at 500 ft.
- Deployment bag pulled from recovery bay.
- Coupler becomes own entity.



Booster segment	Coupler drogue	Booster main
Deployment velocity	--- ft/s	58.7 ft/s
Steady state velocity	26.5 ft/s	21.4 ft/s
Opening force	--- lbs-f	260.8 lbs-f
Kinetic energy of impact	6.7 ft-lbs	65 ft-lbs

Payload Main Event

- ARRD release at 500 ft.
- Deployment bag pulled from recovery bay.
- Nosecone becomes own entity.



Payload segment	Nosecone drogue	Payload main
Deployment velocity	--- ft/s	58.7 ft/s
Steady state velocity	26.5 ft/s	21.4 ft/s
Opening force	---- lbs-f	254.0 lbs-f
Kinetic energy of impact	15.0 ft-lbs	65 ft-lbs

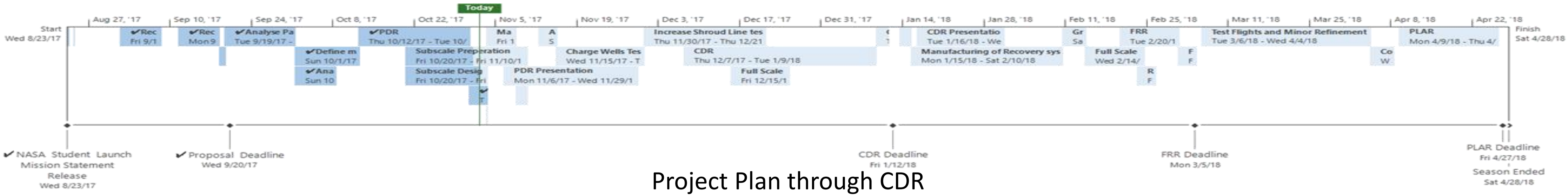
Recovery Procedure Summary

Drogue Descent phase				
section of Launch vehicle	weight (lbs)	Diameter (in.)	Deployment vel. (ft/s)	Terminal Vel. (ft/s)
Nose Cone + Payload Section	3.17	50	96.5	58.7
Coupler + Booster Section	16.83	50	64.3	58.7
Main Descent phase				
section of Launch vehicle	weight (lbs)	Diameter (in.)	Terminal Vel. (ft/s)	Kinetic Energy (ft-lbs)
Nose Cone	3.17	50	26.5	15
Payload Section	16.83	81	21.4	65
Coupler	2.04	50	26.5	6.7
Booster	16.61	80	21.4	65

Drift Calculations

Wind speed	Drift distance – weather-cocking distance (Ft.)			
	Booster	Payload	Coupler	Nosecone
0 MPH	0.0	0.0	0.0	0.0
5 MPH	634.9	629.4	532.4	532.4
10 MPH	1269.9	1258.7	1064.8	1064.8
15 MPH	1724.3	1709.3	1597.2	1597.2
20 MPH	2299.1	2279.1	2149.8	2149.8

Recovery Project Plan



Project Plan through CDR

Task	Start	End	Task	Start	End
Subscale Preparation and design	10/20	11/3	Increased shroud line testing	11/30	12/21
Subscale manufacturing	11/2	11/8	Full Scale Recovery design	12/5	12/30
Subscale ground testing	11/8	11/11	CDR	12/7	1/9
Subscale Launch	11/11	11/11	Recovery manufacturing and ground testing	12/30	2/10
Analyze Subscale launch	11/12	11/15	CDR Review	1/9	1/12
Charge wells testing	11/15	11/30	CDR due date	12/7	1/9

PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Safety

Risk Assessment Matrix				
Probability Level	**Severity Level**			
	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Almost Certain (1)	2-High	3-High	4-High	5-Moderate
Likely (2)	3-High	4-High	5-Moderate	6-Moderate
Moderate (3)	4-High	5-Moderate	6-Moderate	7-Low
Unlikely (4)	5-Moderate	6-Moderate	7-Low	8-Low
Improbable (5)	6-Moderate	7-Low	8-Low	9-Low

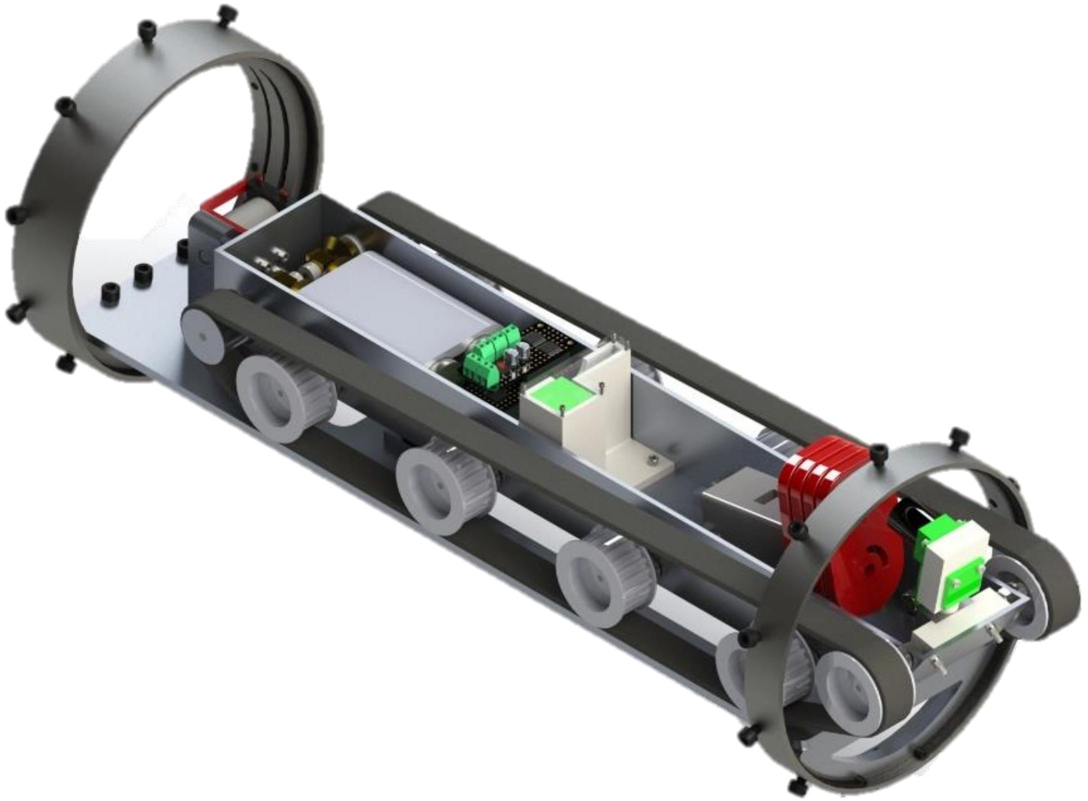
- Safety Manual
  - Garage and team rule revisions
  - Material Information (MSDS)
  - Emergency equipment
- Launch Procedures
  - Test launch procedural check list/item lists
  - Assembly Instructions and warnings of potential hazards
  - Mandatory safety briefing to address hazards

PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Payload Agenda

- System Level Trade Studies
- Payload Subsystems
- Payload Overview
- Project Plan
- Safety



System Level Trade Studies

System	Intent of the Study
Landing Correction	Determine a system accounting for unpredictable orientation of the payload bay after landing.
Rover	Determine the wheel design and style of the autonomous rover.
Deployment Trigger	Determine a method ensuring deployment signal reception.
Foldable Solar Panels	Determine a deployment method for the foldable solar panels.

System Level Trade Study – Landing Correction

Landing Correction Trade Study							
Options:		Center Bearings		Perimeter Bearings		Actuators	
Mandatory Requirements							
Achievable within 1 season		YES		YES		YES	
System will ensure correct orientation of rover		YES		YES		YES	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Integration	25.00%	6	1.5	9	2.25	3	0.75
Simplicity of Design	20.00%	7	1.4	9	1.8	2	0.4
Manufacturability	15.00%	8	1.2	10	1.5	1	0.15
Affordability	10.00%	10	1	5	0.5	2	0.2
Possible Effect on Ascent Attitude	10.00%	10	1	10	1	3	0.3
Payload Weight	10.00%	8	0.8	6	0.6	2	0.2
Impact on Size of Rover	10.00%	7	0.7	4	0.4	10	1
Total Score	**100%**		76.00%		80.50%		30.00%

System Level Trade Study – Rover

Rover Trade Study									
Options:		Augers		Standard Tires		Tank Treads		Treds/Tires Combo	
Mandatory Requirements									
Able to advance rover on multiple terrains		YES		YES		YES		YES	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Integration	25.00%	8	2	8	2	8	2	7	1.75
All Terrain Handling	20.00%	8	1.6	4	0.8	10	2	8	1.6
Drive Mechanism/Control Simplicity	20.00%	9	1.8	9	1.8	8	1.6	4	0.8
Maneuverability	10.00%	5	0.5	6	0.6	9	0.9	5	0.5
Payload Weight	10.00%	5	0.5	8	0.8	6	0.6	5	0.5
Manufacturability	10.00%	6	0.6	9	0.9	6	0.6	5	0.5
Affordability	5.00%	6	0.3	9	0.45	7	0.35	6	0.3
Total Score	**100%**		73.00%		73.50%		80.50%		59.50%

System Level Trade Study – Deployment Trigger

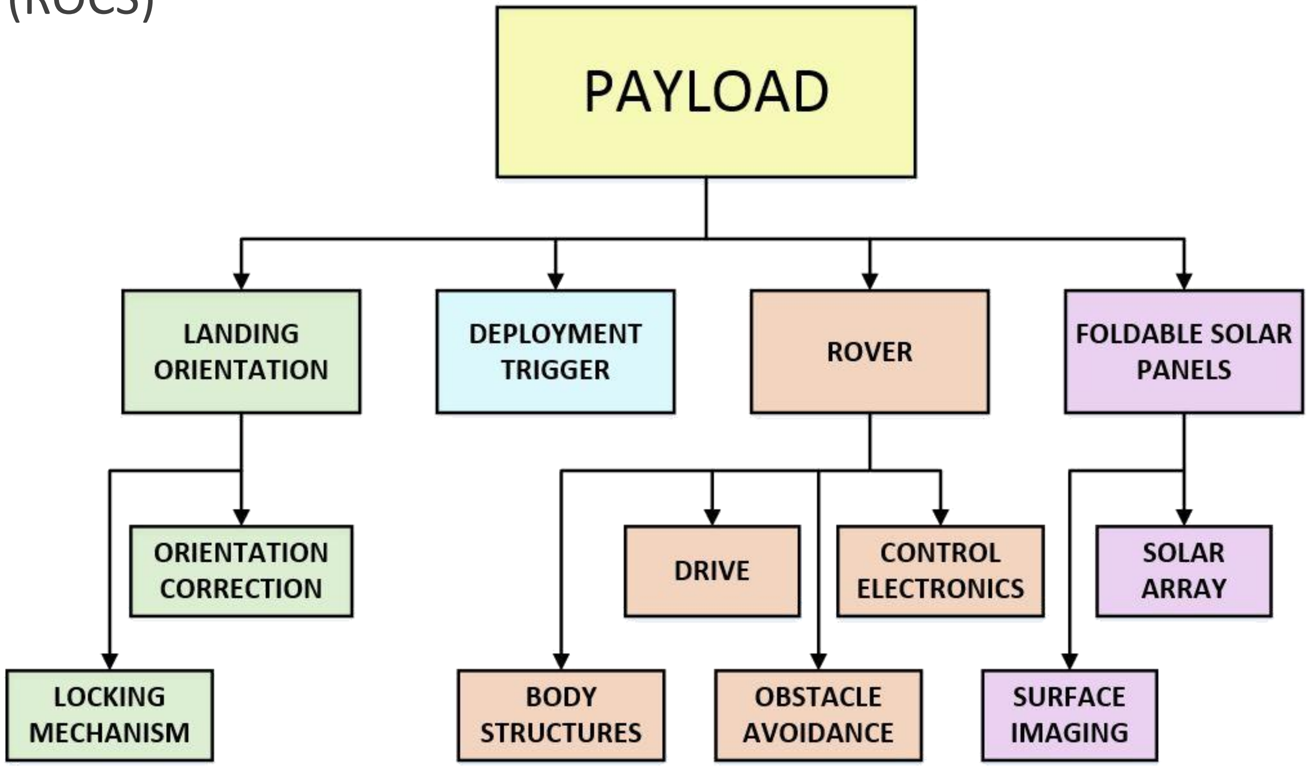
Deployment Trigger Trade Study									
Options:		Detach Receiver		Tether		Protruding Antenna		Fiberglass Airframe	
Mandatory Requirements									
Little to no effect on the design of the launch vehicle		YES		YES		YES		NO	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Integration	20.00%	7	1.4	7	1.4	6	1.2	10	2
Barriers to signal	20.00%	10	2	10	2	10	2	2	0.4
Potential for damage to antenna	20.00%	8	1.6	8	1.6	2	0.4	10	2
Simplicity of Design	10.00%	8	0.8	5	0.5	9	0.9	10	1
Affordability	10.00%	9	0.9	7	0.7	9	0.9	6	0.6
Complexity of signal radiation pattern	10.00%	5	0.5	5	0.5	9	0.9	7	0.7
Effect on motion of the rover	10.00%	7	0.7	5	0.5	10	1	10	1
Total Score	**100%**		79.00%		72.00%		73.00%		77.00%

System Level Trade Study – Solar Panels

Foldable Solar Panels Trade Study									
Options:		180 Degree Flip		Tower Rotate		Tent Style/Origami		Zig Zag	
Mandatory Requirements									
Achievable within 1 season		YES		YES		YES		YES	
Satisfies NASA requirement of foldable		YES		YES		YES		YES	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Integration	25.00%	9	2.25	8	2	5	1.25	6	1.5
Solar Array Area	25.00%	5	1.25	9	2.25	10	2.5	7	1.75
Simplicity of Design	15.00%	8	1.2	7	1.05	3	0.45	7	1.05
Affordability	15.00%	8	1.2	7	1.05	6	0.9	7	1.05
Payload Weight	15.00%	8	1.2	6	0.9	7	1.05	7	1.05
Availability of Useable Panels	5.00%	10	0.5	10	0.5	10	0.5	10	0.5
Total Score	**100%**		76.00%		77.50%		66.50%		69.00%

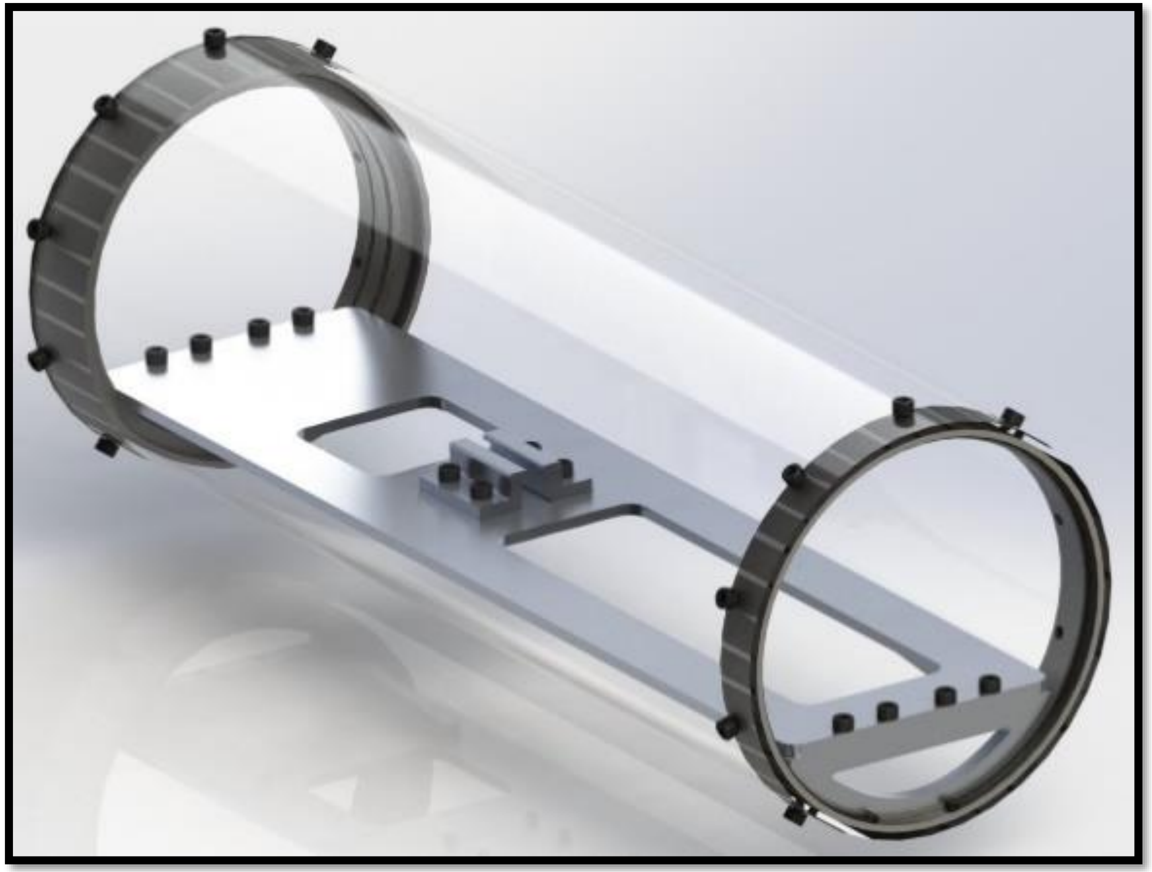
Payload Subsystems

- Rover Orientation Correction System (ROCS)
- Rover Locking Mechanism (RLM)
- Deployment Trigger System (DTS)
- Rover Body Structures (RBS)
- Rover Drive System (RDS)
- Obstacle Avoidance System (OAS)
- Solar Array System (SAS)
- Surface Imaging System (SIS)
- Control Electronics System (CES)



Rover Orientation Correction System (ROCS)

- Aft End Thrust Bearing
- Forward End Support Bearing
- Bridging Sled
- Material: D2 Tool Steel and AISI 1010 carbon steel ball bearings
- Supports rover throughout flight and ensures proper orientation of the rover prior to deployment

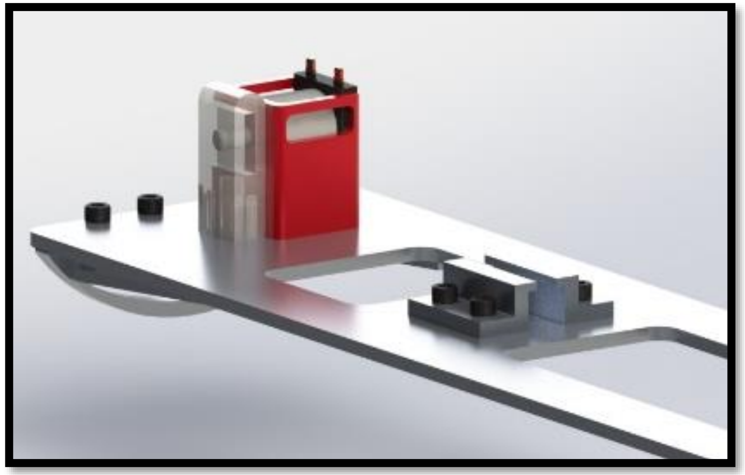


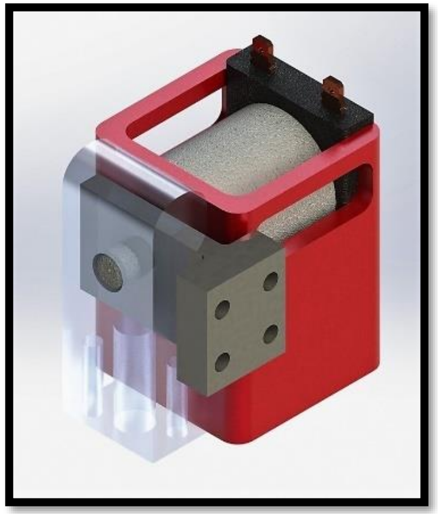
Rover Locking Mechanism (RLM)

- A solenoid armature passes through both a support bracket attached to the ROCS Bridging Sled and a bracket attached to the rear of the rover.

- Solenoid locks movement along central axis of the launch vehicle

- System is locked when no power is applied as a safety measure

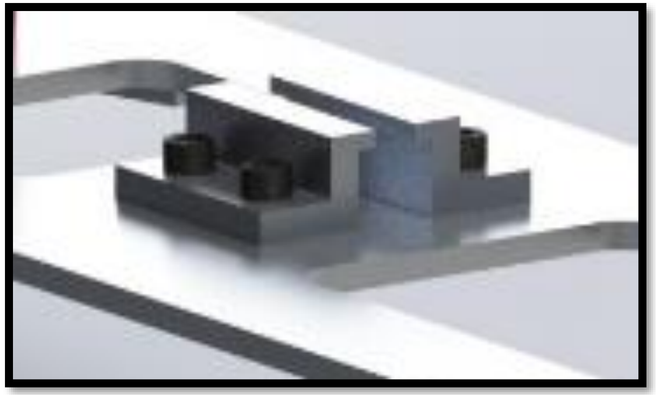


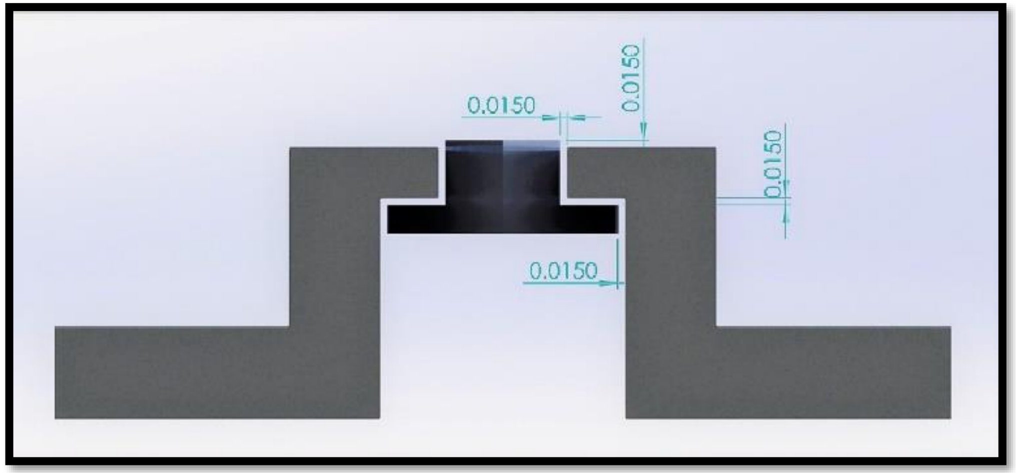


Rover Locking Mechanism (RLM) Cont….

- Female T-slot mounted to the Bridging Sled matches with male T-slot nut mounted to the under side of the rover

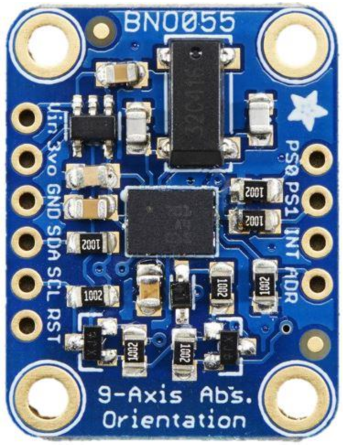
- Restricts motion relative to the ROCS in the axes perpendicular to the central axes of the launch vehicle

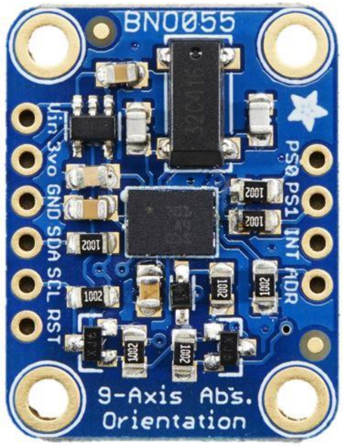




Rover Locking Mechanism (RLM) Cont….

- Two BNO055 9-DOF IMUs
- An orientation check will be performed prior to deployment
- Both sensors must read upright orientation of the rover to unlock
- Further mitigates possibility of premature deployment



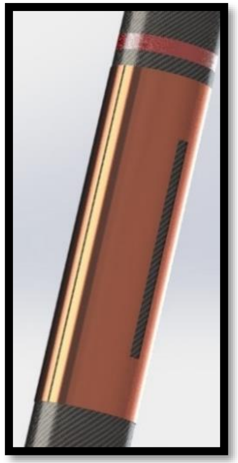
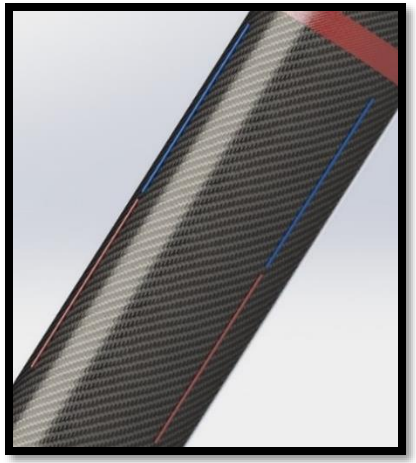
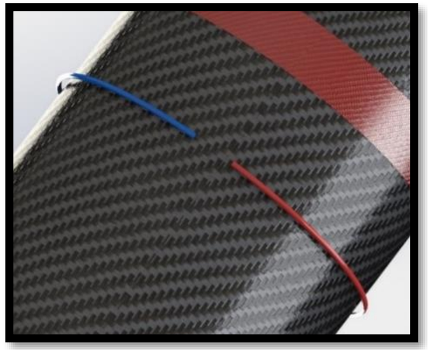
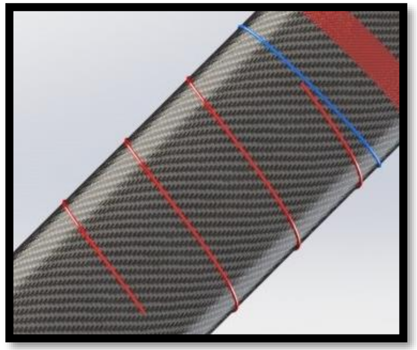


Deployment Trigger System (DTS)

- The deployment signal will be a unique package of data sent by a team member after gaining RSO permission

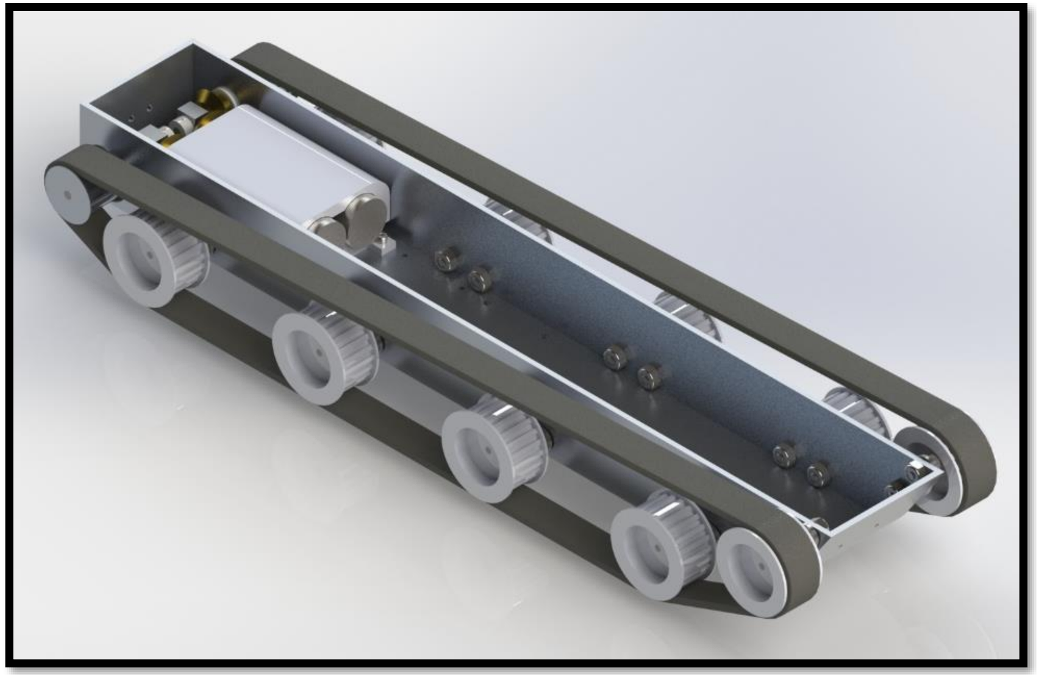
- Four options are being considered for mounting the antenna to the exterior of the airframe
  1.) Slot Antenna
  2.) Multiple Parallel Dipoles
  3.) Open Loop Antenna
  4.) Spiral Antenna

- ANSYS simulations and field testing are required to determine the design to be pursued

1

2

3

4


Rover Body Structures (RBS)

- Material: Aluminum Sheet
- Water-jet for precision
- Formed with CNC bending press
- Welded corners for strength
- Acts as main support for all systems and electronics bay

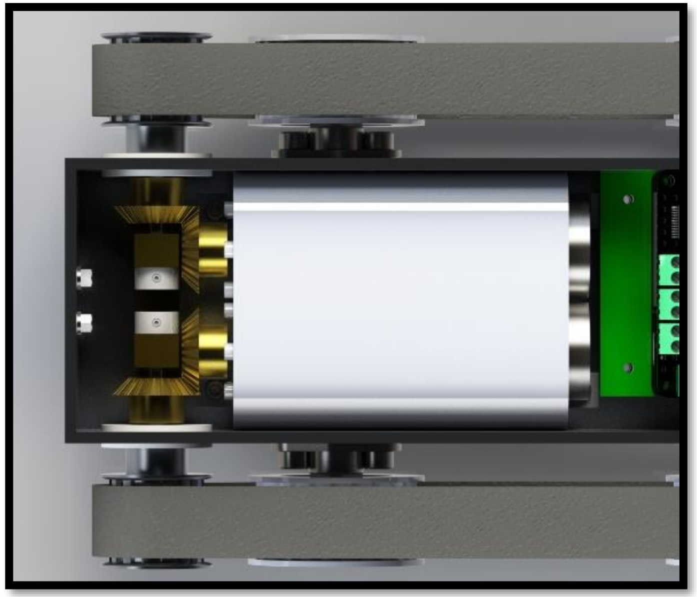


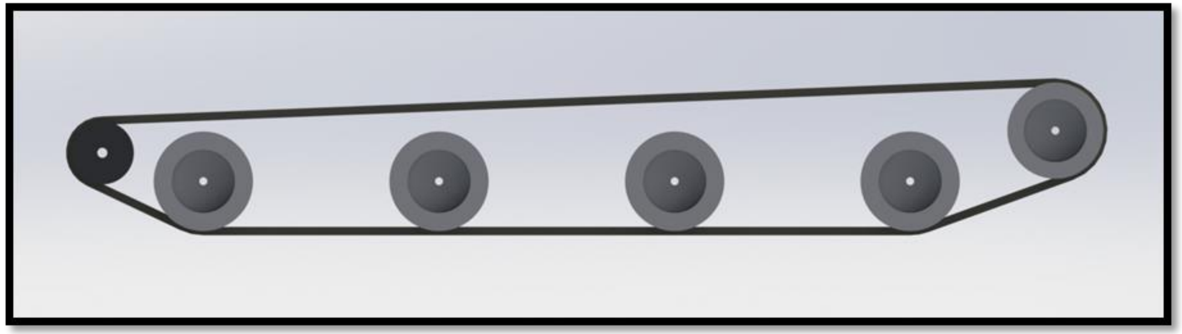
Rover Drive System (RDS)

- Two main drive motors transfer power to drive axels through a set of 90 degree bevel gears

- Drive motors are secured by a custom mount

- Track design intended to optimize terrain handling of the rover



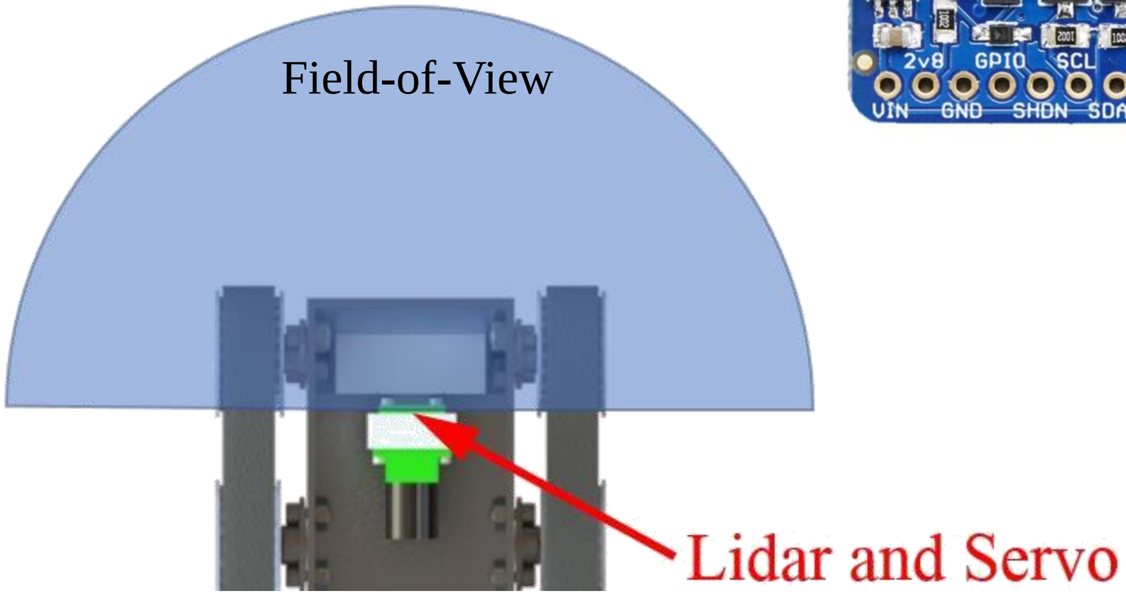


Obstacle Avoidance System (OAS)

- Lidar sensor for detection of insurmountable objects

- Lidar will be mounted on servo giving a 180° field-of-view

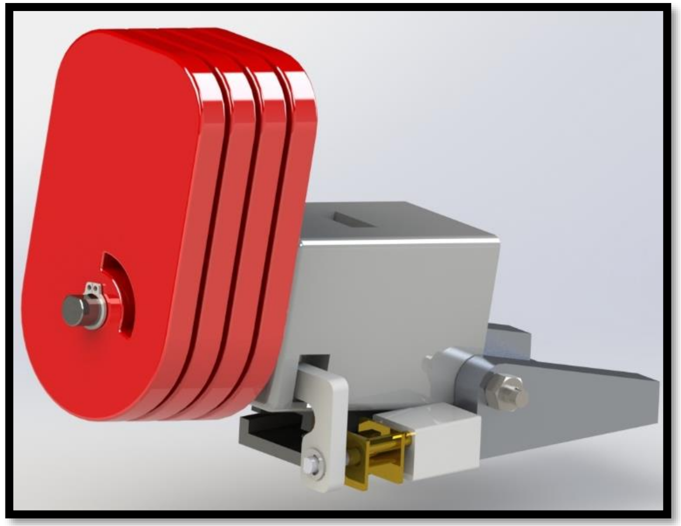
- Rover will turn in the direction of least obstruction

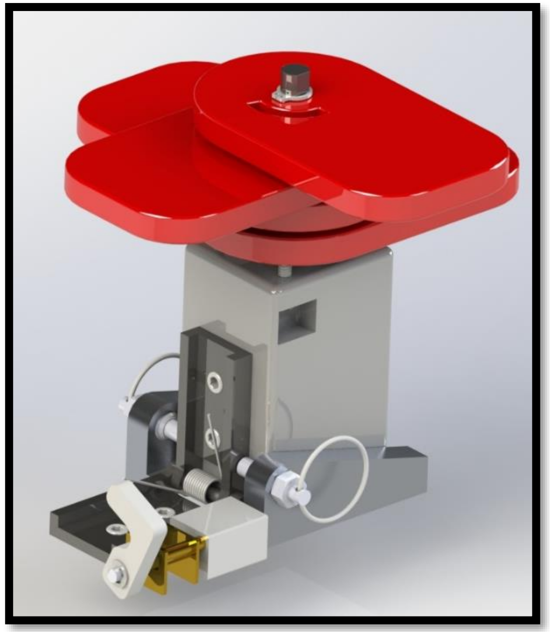


Solar Array System (SAS)

- Tower assembly will be unlocked after reaching final destination and actuate via a spring hinge

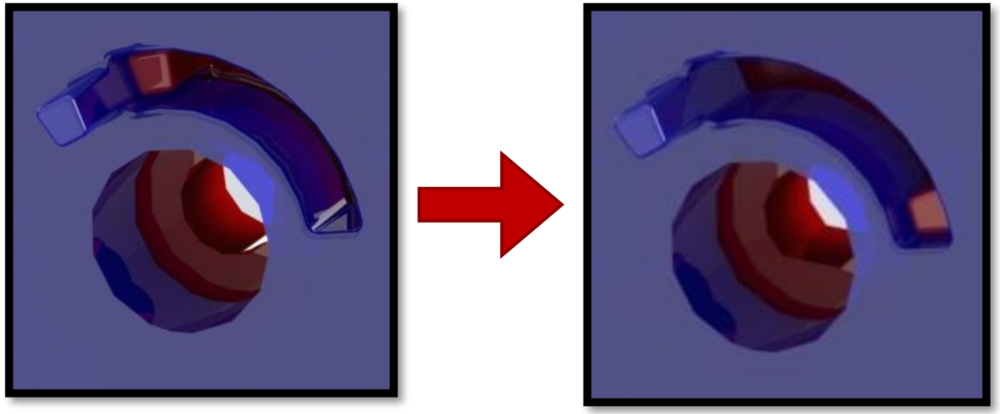
- Solar panel support arms will be mounted to deployment motor shaft





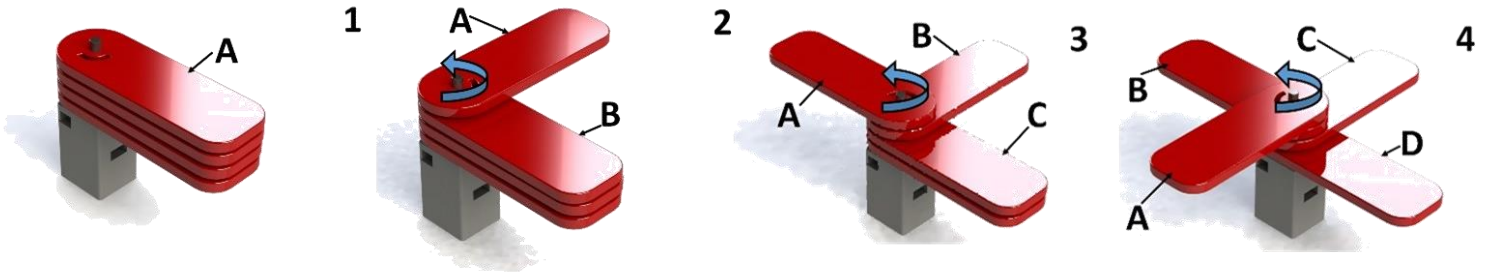
Solar Array System (SAS) Cont....

- Towing peg protruding from under side of each panel matches with slot cut in panel below it



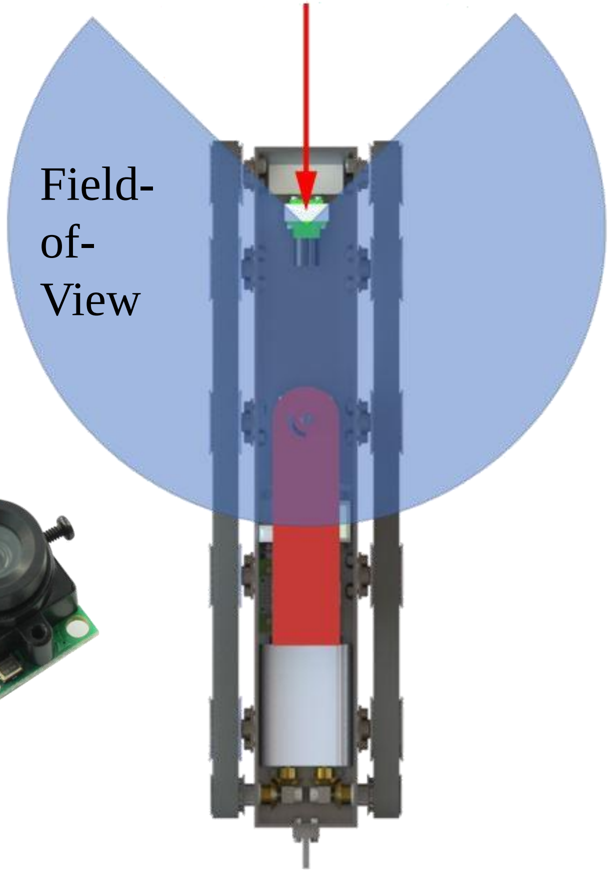
- Top support arm is driven

- Bottom support arm is fixed



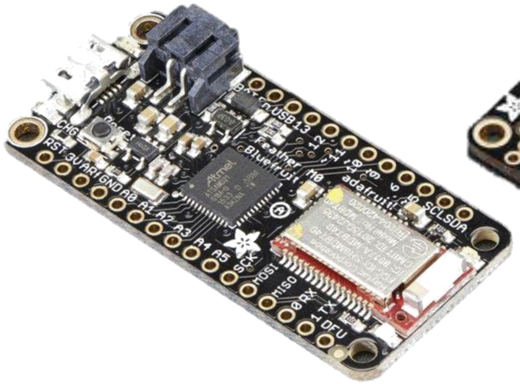
Surface Imaging System (SIS)

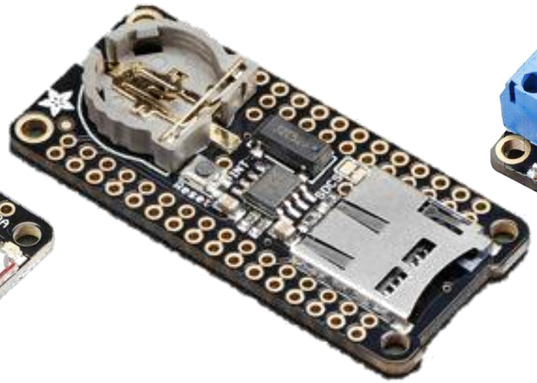
- Take images of payload and surrounding area
- Mounted on servo to increase field-of-view
- Store images on microSD card for analysis after retrieval of rover
- Operation is a secondary mission and will in no way effect the primary mission

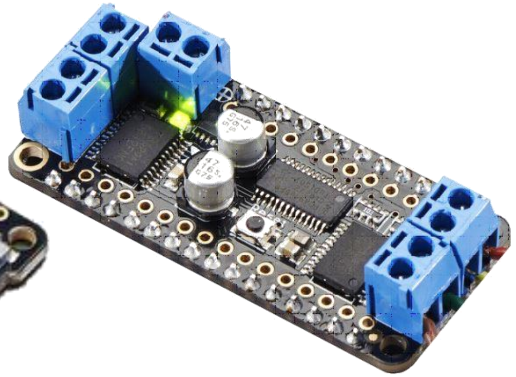


Control Electronics System (CES)

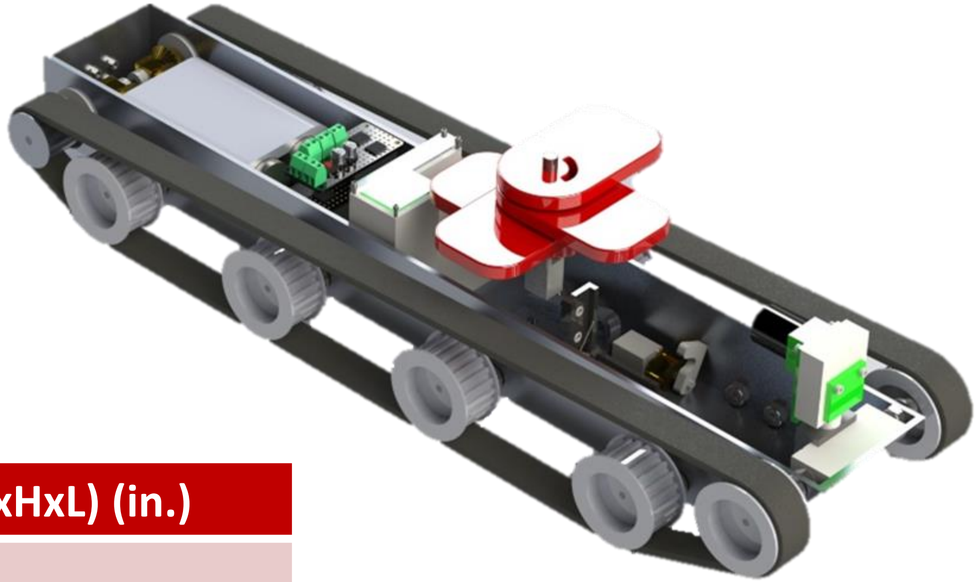
- Feather M0 Bluefruit LE microcontroller
  - Run the control scheme for the rover
- FeatherWing Adalogger data logging board
  - Record data collected throughout the flight
- FeatherWing Motor Shield
  - Drive two main drive motors, RLM solenoid, and SAS deployment motor







Payload Overview

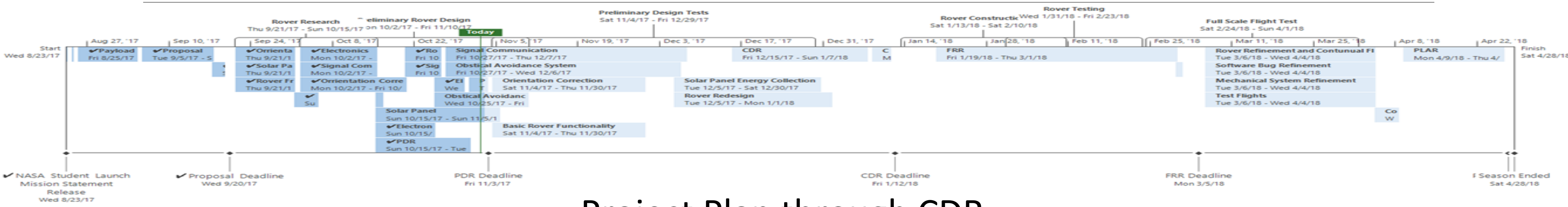


Assembly	Weight (lbs)	Dimensions (WxHxL) (in.)
ROCS	4.57	ID: Ø5.587 x 17.9
Rover (Stowed)	4.69	4.7 x 4.05 x 17.9
Rover (Deployed)	4.69	4.7 x 4.11 x 17.9
Total Payload	**9.26**	**Length: 19.6**

Requirement Compliance Plan

NASA Student Launch Handbook Requirement No.	Requirement	System Designed to Achieve Requirement
4.5.1	Teams will design a custom rover that will deploy from the internal structure of the launch vehicle.	The Rover Orientation Correction System, Rover Locking Mechanism, and Rover Body Structure
4.5.2	At landing, the team will remotely activate a trigger to deploy the rover from the rocket.	The Deployment Trigger System
4.5.3	After deployment, the rover will autonomously move at least 5 ft. (in any direction) from the launch vehicle.	The Rover Drive System, Obstacle Avoidance System, and Control Electronics System
4.5.4	Once the rover has reached its final destination, it will deploy a set of foldable solar cell panels.	The Solar Array System

Payload Project Plan



Project Plan through CDR

Task	Start	End	Task	Start	End
Signal Communication Testing	10/27	12/7	Rover redesign	12/5	1/1
Obstacle Avoidance System testing	10/27	12/7	CDR	12/15	1/7
Orientation correction testing	11/4	11/30	CDR Review	1/8	1/11
Basic rover functionality			Rover Construction	1/9	2/10
Solar panel energy collection	12/5	12/30	CDR Deadline	1/12	1/12

Payload Safety

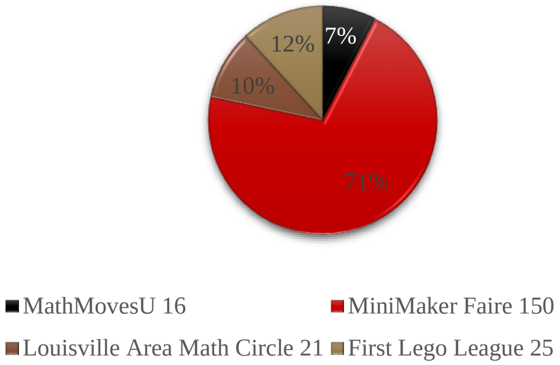
Hazard	Cause	Outcome	Severity	Probability	Rating	Mitigation
Premature deployment	Premature extraneous signal not transmitted by the team deploys the rover prior to the bay landing safely	The rover may fall out of the open end of the payload bay	1	4	Moderate	The payload will have a locking mechanism, two gyroscopes, and a unique deployment signal. The locking mechanism will remain locked while unpowered.
Failed mechanical locking system	1. Cannot withstand liftoff loads 2. Cannot withstand opening force loads 3. Cannot withstand landing loads 4. Solenoid retraction prevented due to loading from rover weight	The rover may fall out of the open end of the payload bay	2	4	Moderate	The mechanical locking system will be tested extensively
Unreceived deployment signal	1. Rover lands out of range 2. Receiver antenna is damaged 3. Obstructed receiver transmitter line-of-sight	The rover will not deploy. Failed payload mission	2	3	Moderate	Simulations and field testing will be conducted on multiple antenna configurations. Measures will be taken to ensure that the range can excess 2500 ft.

PDR Presentation Agenda

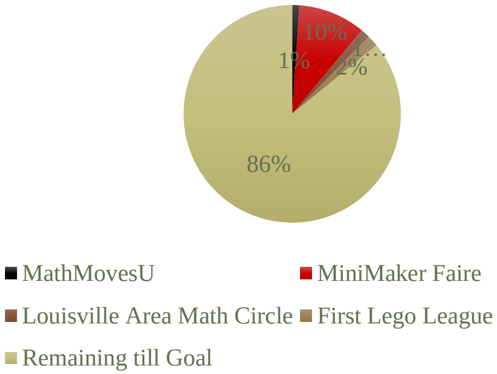
- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Outreach

Outreach



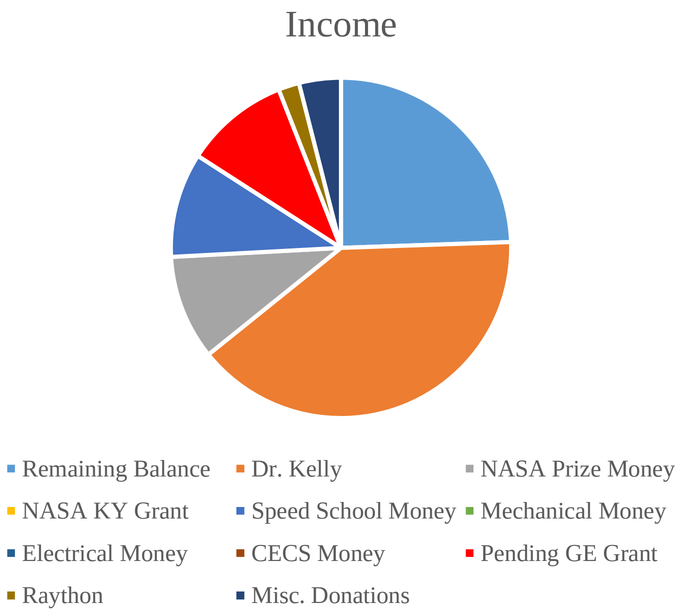
Outreach till Goal

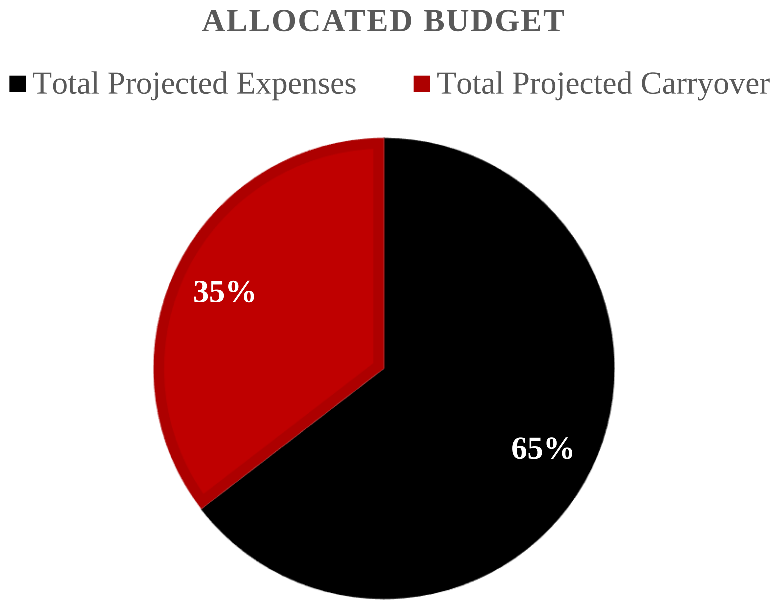


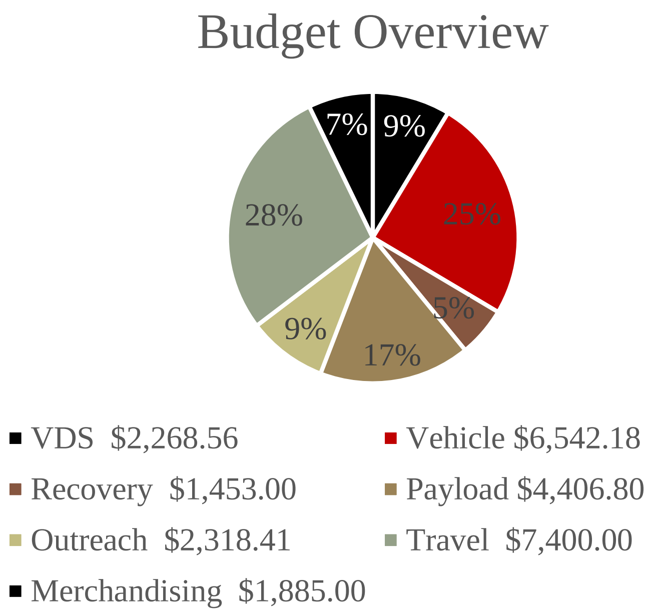
PDR Presentation Agenda

- Launch Vehicle
- Variable Drag System
- Recovery
- Safety
- Payload
- Educational Outreach
- Budget

Budget


Income
Remaining Balance
Dr. Kelly
NASA Prize Money
NASA KY Grant
Speed School Money
Mechanical Money
Electrical Money
CECS Money
Pending GE Grant
Raython
Misc. Donations


ALLOCATED BUDGET
Total Projected Expenses
Total Projected Carryover
35%
65%


Budget Overview
7%
9%
25%
28%
5%
9%
17%
VDS $2,268.56
Vehicle $6,542.18
Recovery $1,453.00
Payload $4,406.80
Outreach $2,318.41
Travel $7,400.00
Merchandising $1,885.00

Questions?