Preliminary Design Review

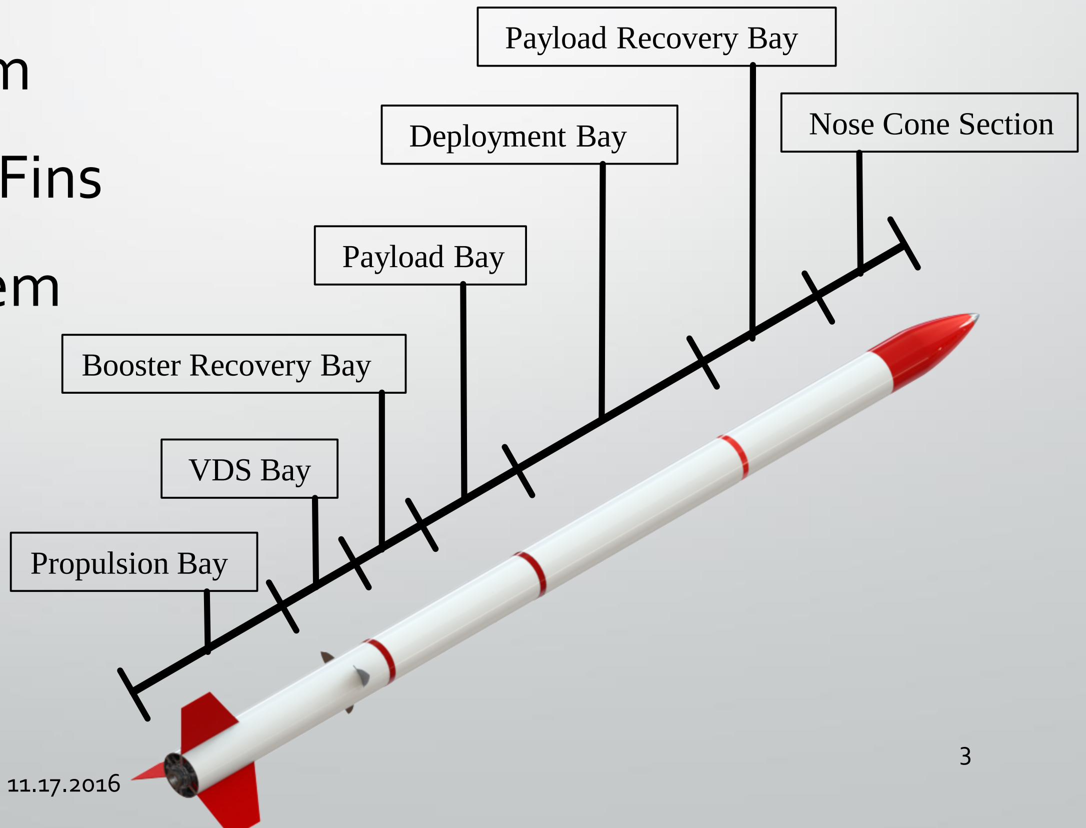
University of Louisville
River City Rocketry
2016-2017

PDR Presentation Agenda

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

Launch Vehicle Overview

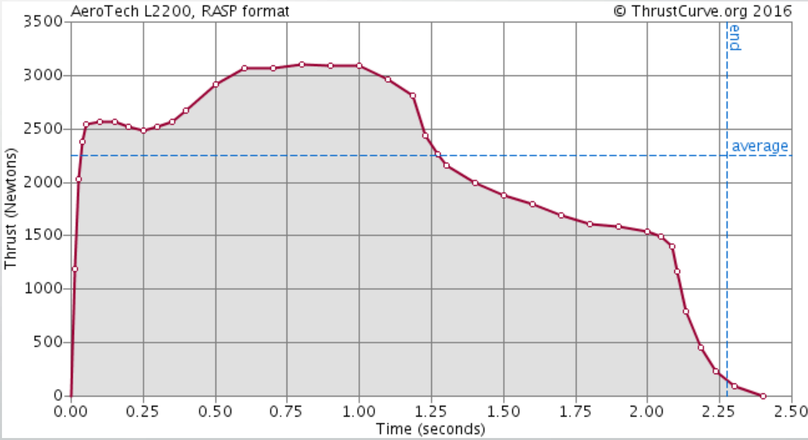
- 6"" Diameter Custom Filament Wound Carbon Fiber Airframe
- 12 inch LD Haack Nose Cone
- AeroTech L2200-G Motor
- Variable Drag System
- Three Clipped Delta Fins
- Removable Fin System



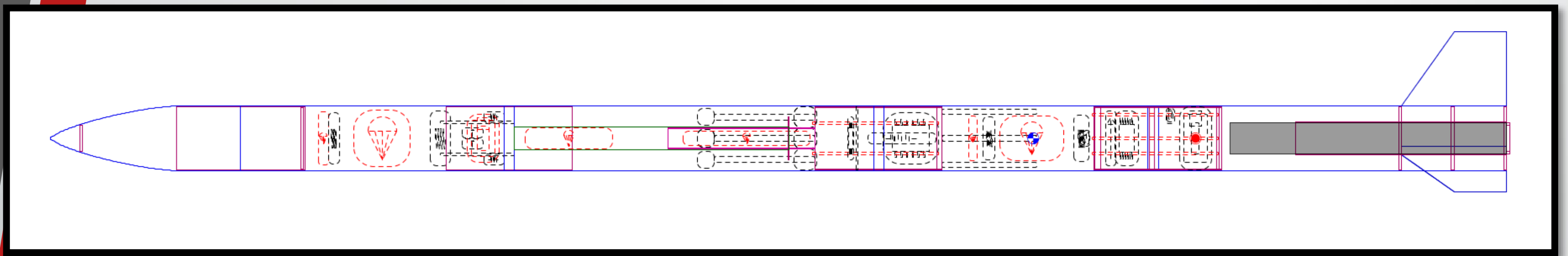
Motor Selection

- AeroTech L2200-G
- Motor selection based off predicted sub systems weights and OpenRocket simulations

Diameter	75.0 mm
Total Weight	167.59 oz
Propellant Weight	88.75 oz
Average Thrust	2200.0 N
Maximum Thrust	3101.8 N
Total Impulse	5104.1 N-sec
Burn Time	2.3 sec



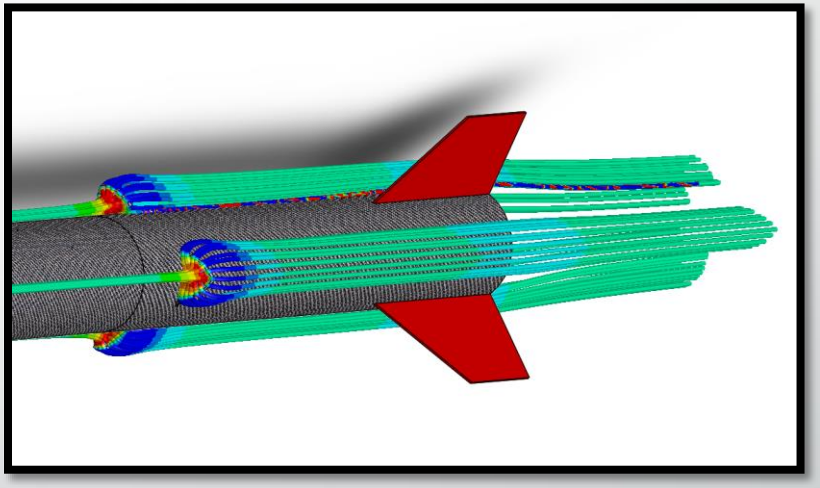
Stability Margin



- Overall Length: 138 in
- Overall Diameter: 6.1 in
- Overall Weight: 45.9 lbs
- Stability Margin (off the rail) : 2.2
- CG Location at rail exit (from tip): 88.585 in
- CP Location at rail exit (from tip): 102.11 in

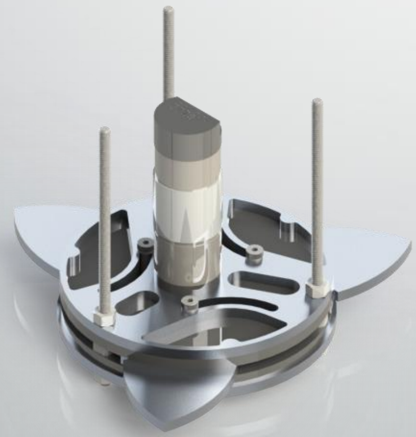
Stability Margin (cont'd)

- VDS drag blades located aft of CP and CG
- Turbulent air flow from drag blades did not interfere with air flow over fins

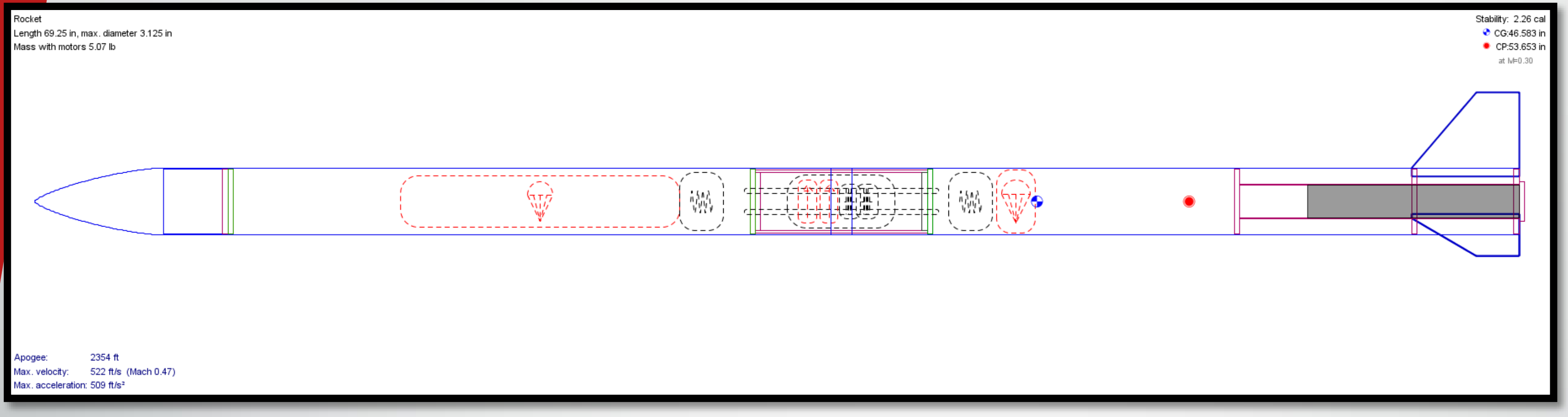


Test Vehicle

- Four test launches were conducted over the summer with a prototype of VDS
- VDS actuation did not effect vehicle stability



Subscale Verification



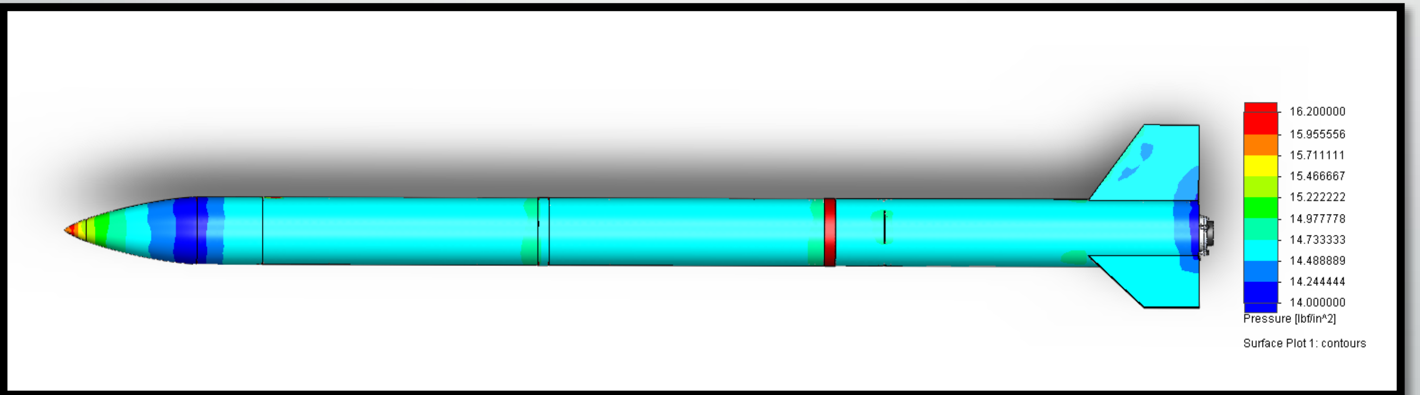
- A half scale model will be launched to verify aerodynamic properties of the launch vehicle design.
- Will verify:
  - Aerodynamic properties and stability of the launch vehicle
  - ARRD deployment device and toroidial parachute design

Subscale Verification (cont.)

Property	Full Scale	Subscale
Diameter (in)	6	3
Length (in)	138	69
Weight (lbs)	45.9	5.98
Motor Selection	AeroTech L2200-G	AeroTech I285-R
Stability Caliber (off the rail)	2.2	2.26
Burnout Velocity (ft/s)	721 (0.61 Mach)	522 (0.47 Mach)
Maximum Acceleration (ft/s^2)	469	509
Exit Rail Velocity (ft/s)	97.6	108
Thrust to Weight Ratio	14.65	14.06

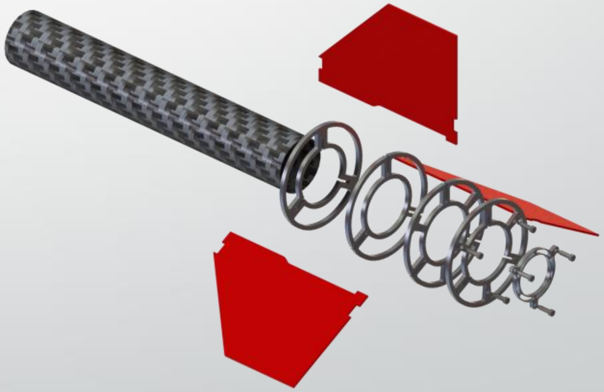
Nose Cone Design

- CFD simulations were performed on the LD Haack profile, elliptical profile, and conical profile to determine the ideal nose cone profile.
- 12 inch LD Haack was determined to have the lowest coefficient of drag.

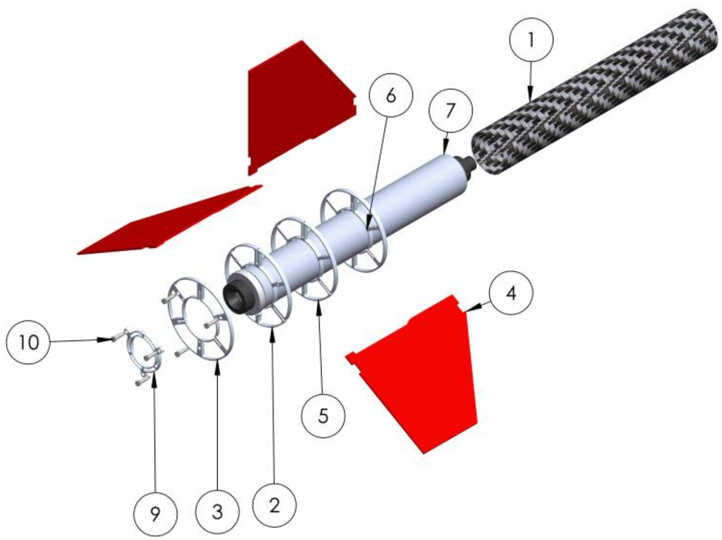


Removable Fin System

- Modular system that allows quick and easy installation of fins
- Accurate fin mounting
- Various fin shape testing ability
- Easier transportation



Removable Fin System (cont’d)



ITEM NO.	PART NUMBER	QTY.
1	Propulsion Bay Motor Mount	1
2	Aft Centering Ring	1
3	Fin Retainer	1
4	Clipped Delta Fin	3
5	Mid Centering Ring	1
6	Fore Centering Ring	1
7	Motor	1
8	Propulsion Bay Airframe	1
9	Motor Retainer	1
10	#10-32 UNF-3A shoulder screws	6

PROJECT SECTION :
PART DESCRIPTION:
PART NUMBER/NAME
Propulsion Bay BOM

QTY:
Model :
Detail :

MATERIAL: SEE PART FILES
FINISH:
DO NOT SCALE DRAWING
SHEET SCALE: 1:24

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
DECIMALS .XX: ±.01 .XXX: ±.005 .XXXX: ±.0010
ANGLES 30'

PROPRIETARY NOTE
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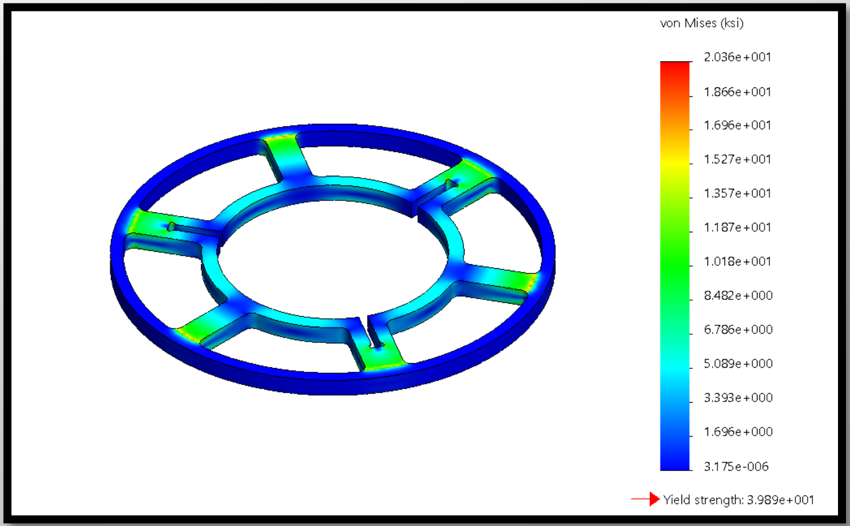
University of Louisville
River City Rocketry
2016-2017

SHEET 1 OF 1

FEA simulations

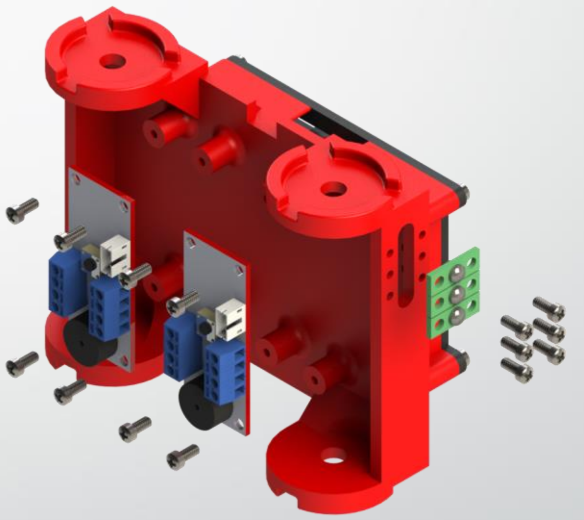
Component	Simulated Load (N)	% of Maximum Motor Thrust
Fore centering ring	1550.9	50
Mid Centering Ring	1550.9	50
Aft Centering Ring	1550.9	50

- Optimized to minimize mass of each centering ring with a factor of safety of 2.0.

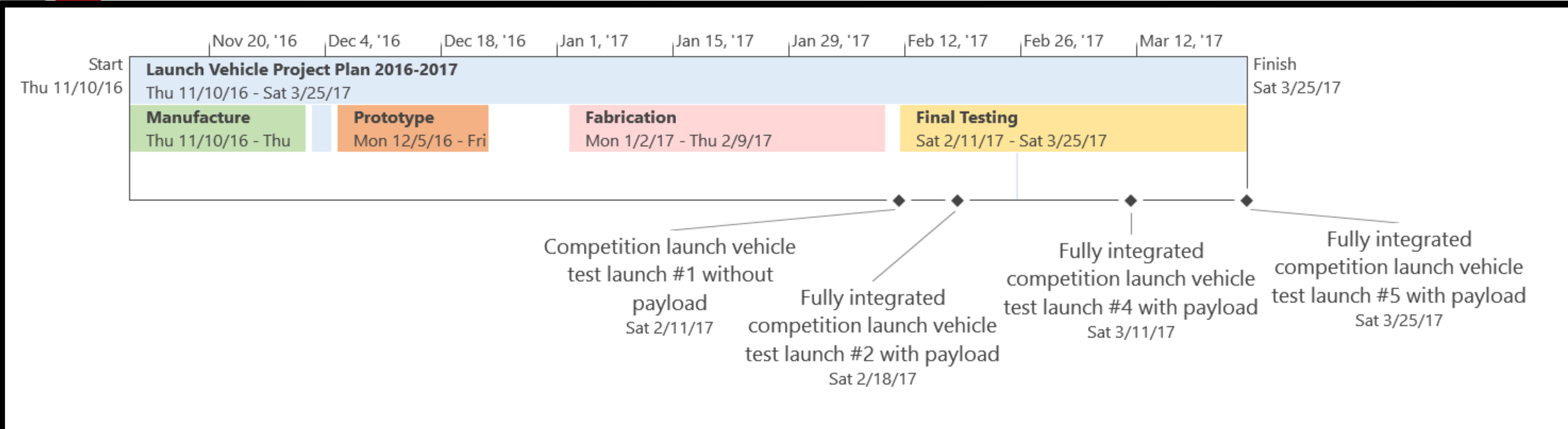


Avionics

- Four PerfectFlite StratoLogger CF altimeters will be located in launch vehicle
- Custom 3D printed altimeter sleds will be mounted via ¼”-20 all thread in bulkplates



Project Plan



Milestones	PDR	CDR	FRR
Requirements verified	Design, analysis, and integration launch vehicle systems.	Test flights of prototype and subscale. Fabrication of competition launch vehicle begins.	Competition launch vehicle fully fabricated. Test launch with all vehicle systems completed.

Safety

Hazard	Cause/ Mechanism	Potential Outcome	Risk	Mitigation
Rocket doesn't reach high enough velocity before leaving the launch pad.	1. Rocket is too heavy. 2. Average thrust of motor is too low. 3. High friction coefficient between rocket and launch tower. 4. Rail buttons shear during liftoff.	1,2. Unstable launch.	Moderate	Simulations are run to verify the motor selection provides the necessary exit velocity. Should the failure mode still occur, the issue should be further examined to determine if the cause was due to a faulty motor or in the booster needs to be redesigned.
Centering rings fail.	Epoxy is not properly applied to centering rings.	Motor is propelled through the inside the launch vehicle.	High	This probability will be mitigated through verification of the subscale construction techniques followed by a successful flight.
Airframe buckles during flight.	Airframe encounters stresses higher than the material can support.	Rocket will become unstable and unsafe during flight.	Moderate	Through prediction models, appropriate material selection, and a secure factor of safety, this failure mode can be nearly eliminated.
Joint did not have proper preload or thread engagements	Joint did not have proper preload or thread engagements	Motor casing and spend motor falls out of launch vehicle when the main parachute opens.	Moderate	Through prediction models, appropriate material selection, and a secure factor of safety, this failure mode can be nearly eliminated.

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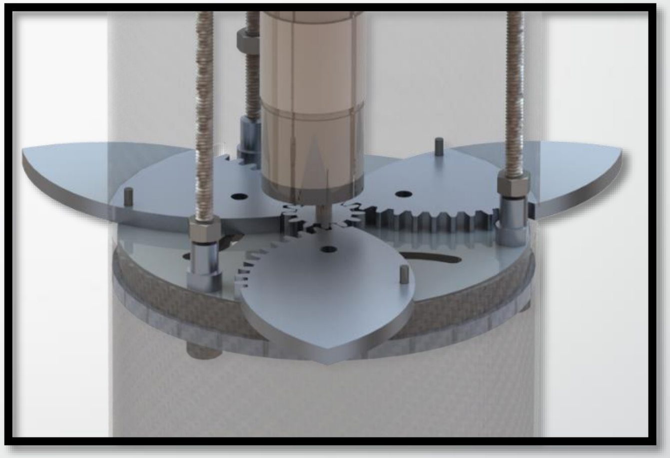
Variable Drag System (VDS)

The VDS is designed to serve as an improvement to a conventional ballast system. The VDS will safely and repeatedly deliver the vehicle to 1 mile AGL +/- 33 ft.

VDS Agenda:

- The basic design of the VDS
- Safety of the VDS system
- Highlight several team-derived requirements
- Requirements verification plan

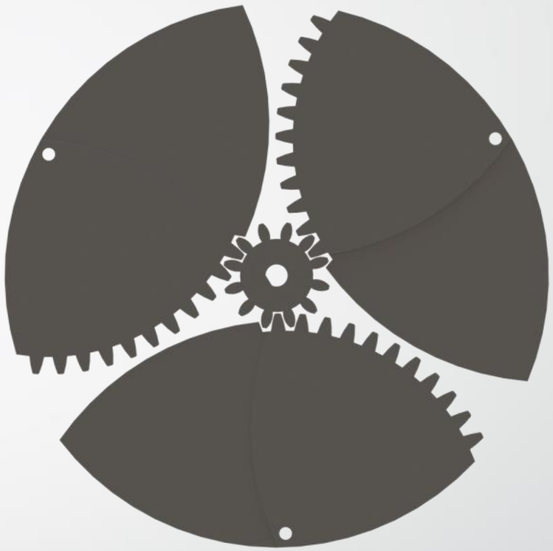


VDS rendering (airframe transparent).

VDS Design Overview

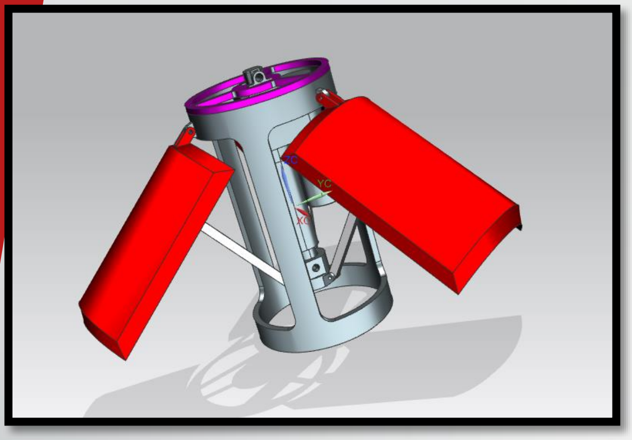
VDS Construction:

- Designed 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
- Runs custom software package on Teensy 3.6 microcontroller



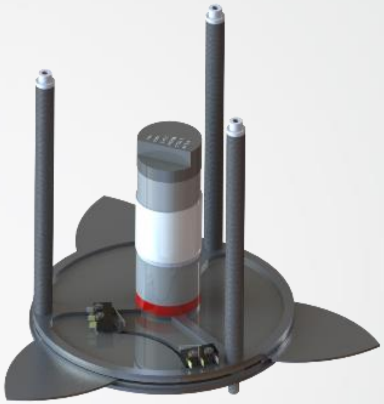
Gear meshing of drag blades.

VDS Trade Study



Three Drag Aileron System

Six Blade VDS



Three Blade VDS

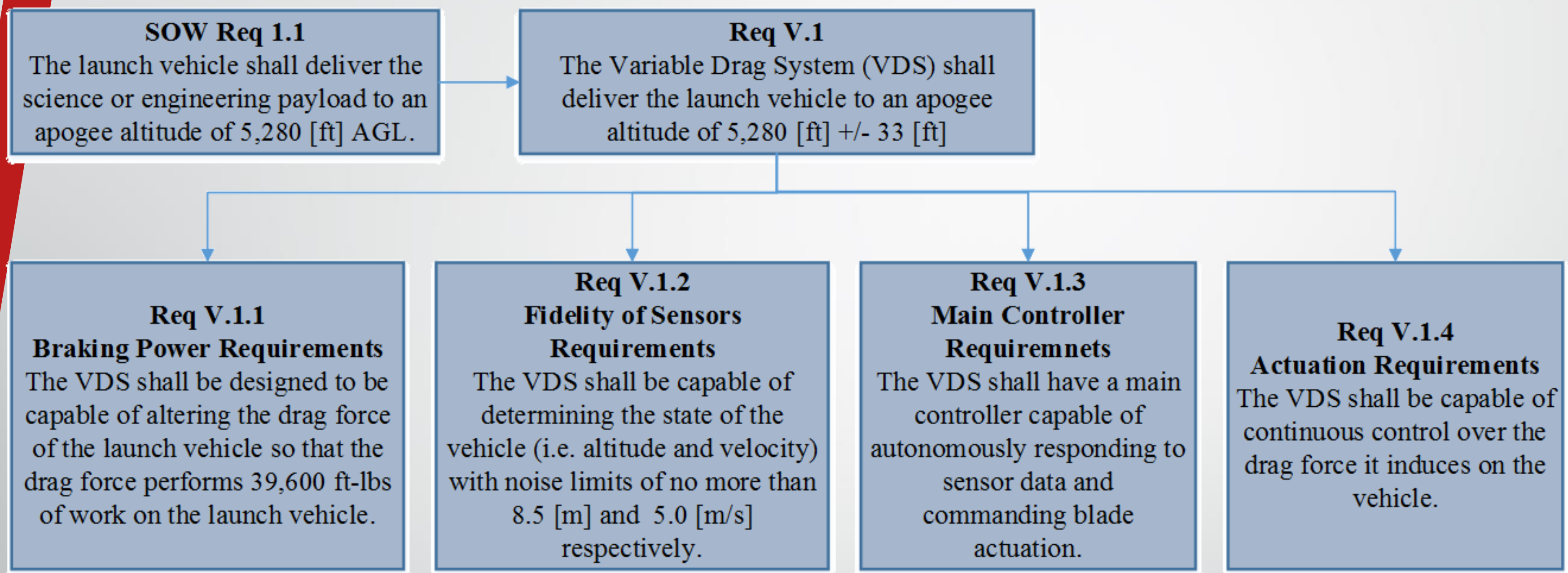
Drag Control System							
Options:		Three Blade Variable Drag System		Six Blade Variable Drag System		Three Drag Aileron System	
Mandatory Requirements							
Located aft of the center of gravity of the launch vehicle		Yes		Yes		Yes	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Actuation Speed (0-10)	20.00%	10	2	9	1.8	4	0.8
Projected Area (0-10)	20.00%	4	0.8	8	1.6	10	2
Continuous Actuation (0-10)	20.00%	10	2	10	2	0	0
System Simplicity (0-10)	5.00%	8	0.4	7	0.35	4	0.2
Laminar Fin Air Flow (0-10)	10.00%	8	0.8	6	0.6	5	0.5
Manufacturability (0-10)	5.00%	9	0.45	7	0.35	9	0.45
Price (0-10)	5.00%	9	0.45	8	0.4	6	0.3
Mass (0-10)	15.00%	9	1.35	7	1.05	7	1.05
Total Score		**8.25**		**8.15**		**5.3**	

VDS Safety

Hazard	Cause/ Mechanism	Potential Outcome	Risk	Mitigation
Airframe structural damage pre-flight	Improper installation	Equipment damage	Moderate	VDS installation will be inspected pre-flight
VDS actuates while on launch rail	Electrical failure	Lower off-the-rail velocity	Moderate	Margin will be added to off-the-rail velocity
VDS actuates during motor burn	Electrical failure	Mission failure	Low	Consistent testing will ensure reduced likelihood
DC motor induces noise on sensors	DC motor oscillates quickly	Mission failure	Low	A 1 micro-Farad capacitor will be soldered across the motor leads
VDS fails to actuate	Gear binding Electrical failure	Mission failure	Moderate	The motor and mass shall be chosen to not exceed the waiver in the event of VDS failure

VDS Requirements Derivations

The VDS requirements were derived from requirement 1.1 of the SOW.

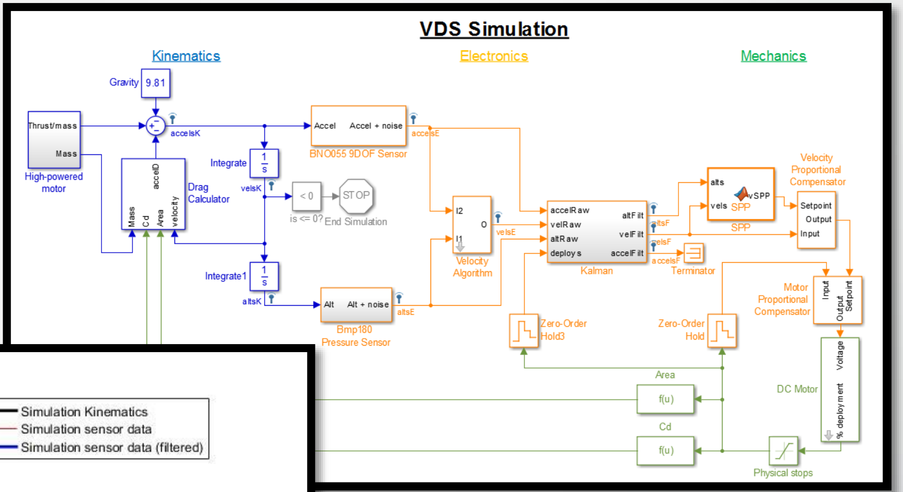


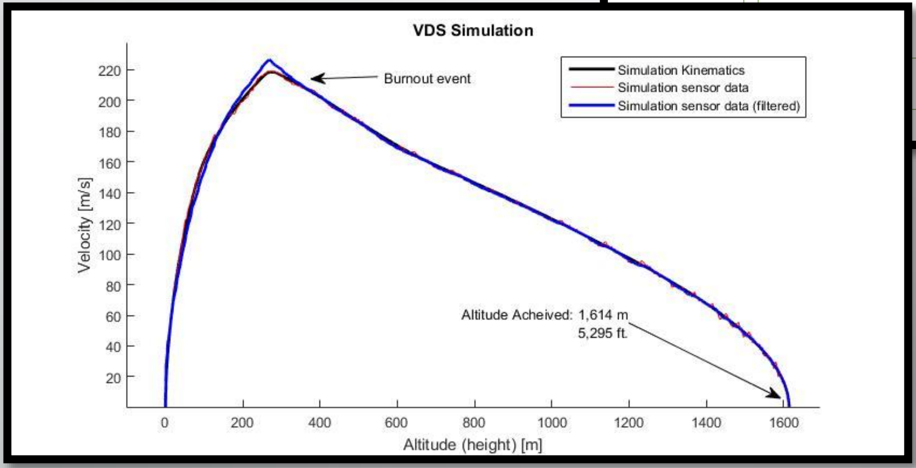
VDS: Mission Performance Predictions

Mission performance predictions were done in a Simulink simulation to accommodate the VDS.

The VDS simulation was also used to:

- Perform failure analysis
- Derive Requirements
- Tune the controls scheme

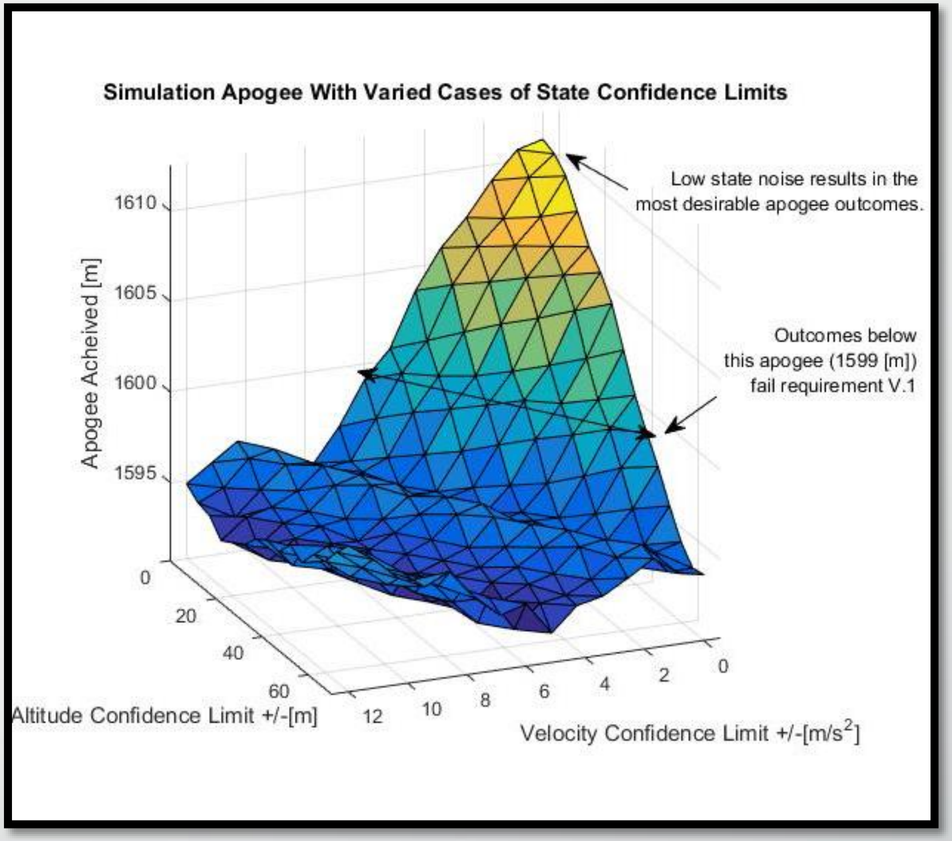




Simulation apogee = 5,295 ft.

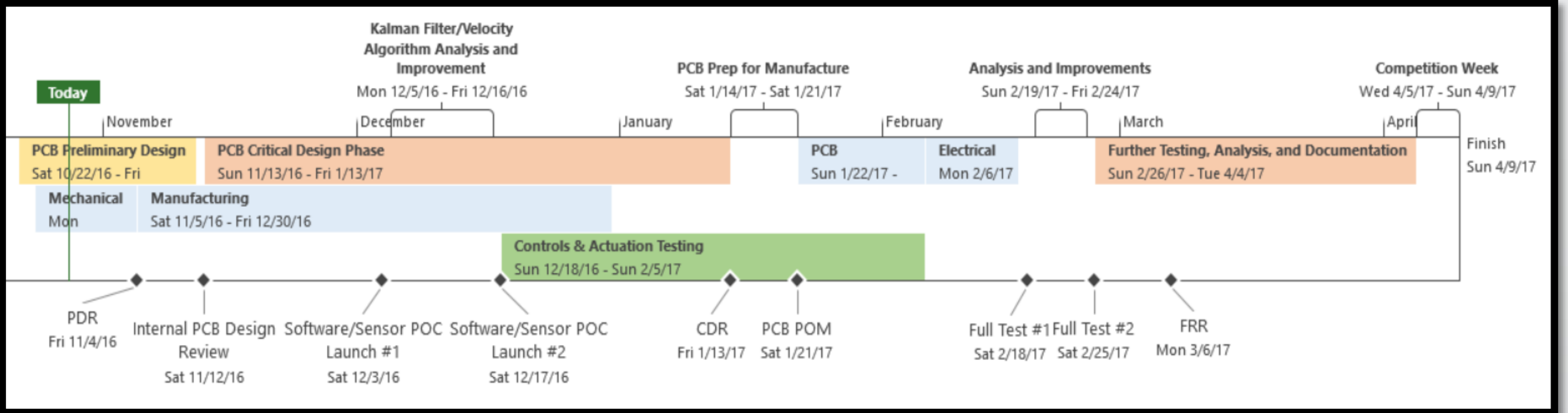
Performance Predictions Cont.

- Testing failure modes.
- Deriving requirements for complex design aspects.
- Run many simulations with different settings.



225 simulations with varied cases of input noise.

Project Plan



Milestones	PDR	December Test Launches	February Integration Phase	Pre-FRR Full-scale Launches
Requirements verified	Main controller requirements verified.	Sensor fidelity requirements verified.	Braking power requirements verified. Actuation requirements verified.	All requirements verified. SOW requirement 1.1 verified.

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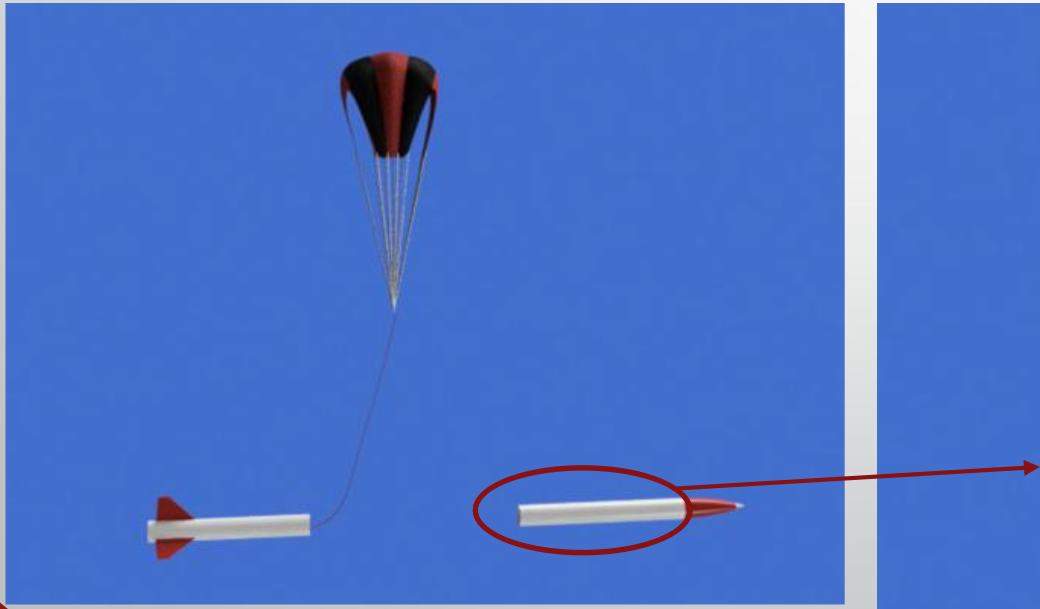
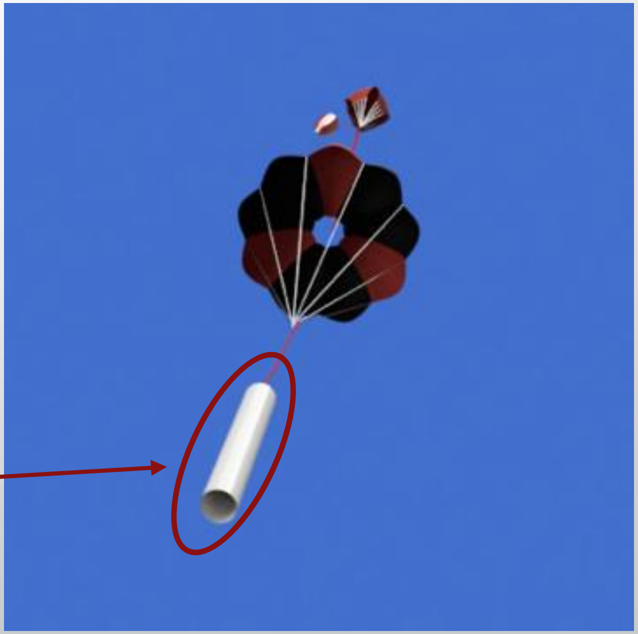
Recovery Overview

- Dual deploy from single bay using ARRD
- Crucifrom drogues for booster section and deployment bay.
- Toroidal main parachute for booster, deployment bay, and payload.





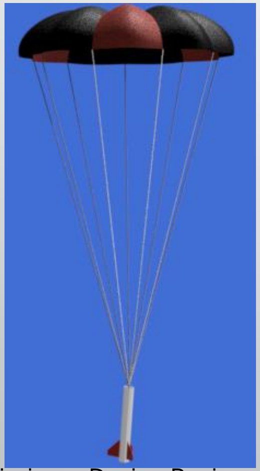
Parachute Selection

- Only high drag parachutes were considered in the interest of mass efficiency
- Vortex ring failure modes are major deterrent

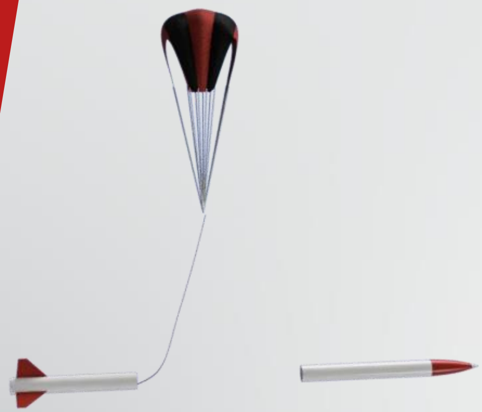
Parachute Type	Cd	Cx	Angle of Oscillation
Annular	0.85–0.95	1.4	<±6°
Cruciform	0.6–0.85	1.1–1.2	≤±3°
Vortex Ring	1.5–1.9	1.1–1.2	≤±2°
Toroidal	1.2-1.3	1.8	≤±6°

Main Parachute Trade Study

Main Parachutes									
Options:		Cruciform		Annular		Vortex Ring		Toroidal	
Wants	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Drag Coefficient/Efficiency (0-10)	30.00%	4	1.2	5.7	1.71	10	3	8.3	2.49
Stability (angle of oscillation) (0-10)	10.00%	7	0.7	4	0.4	10	1	4	0.4
Ease of Design (0-10)	10.00%	10	1	5	0.5	2	0.2	3	0.3
Ease of Manufacturing (0-10)	10.00%	9	0.9	5	0.5	4	0.4	5	0.5
Deployment Simplicity (0-10)	30.00%	8	2.4	9	2.7	2	0.6	9	2.7
Testability	10.00%	6	0.6	8	0.8	2	0.2	7	0.7
Total Score		**6.8**		**6.61**		**5.4**		**7.09**	



Drogue Phase Procedure



1: Apogee Separation

Booster Drogue Phase

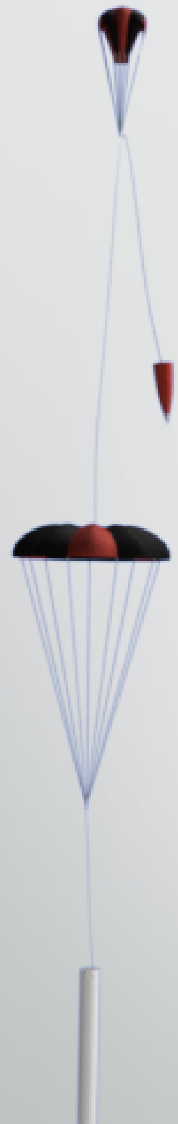
V_e = 93.6 ft/s

2: Deployment Bay Drogue Event

(2 sec. delay)

V_e = 129.0 ft/s

Main Phase Procedure



3: Deployment Bay Main Release
(~1700 ft)

V_e = 40.2 ft/s
F_x = 9.6 lb_f

4: Booster Main Release
(~800 ft)

V_e = 14.6 ft/s
F_x = 48.7 lb_f
$_E$ = 69.9 ft-lb

Multirotor Deployment Event

5a: Deployment Bay Unloading
(~1300 ft)

V_e = 22.3 ft/s
F_x = 0.9 lb_f
$_E$ = 39.4 ft-lb

5b: Deployment Parachute
Inflation

V_e = 23.4 ft/s
F_x = 2.0 lb_f
$_E$ = 69.9 ft-lb

5c: Nosecone Recovery

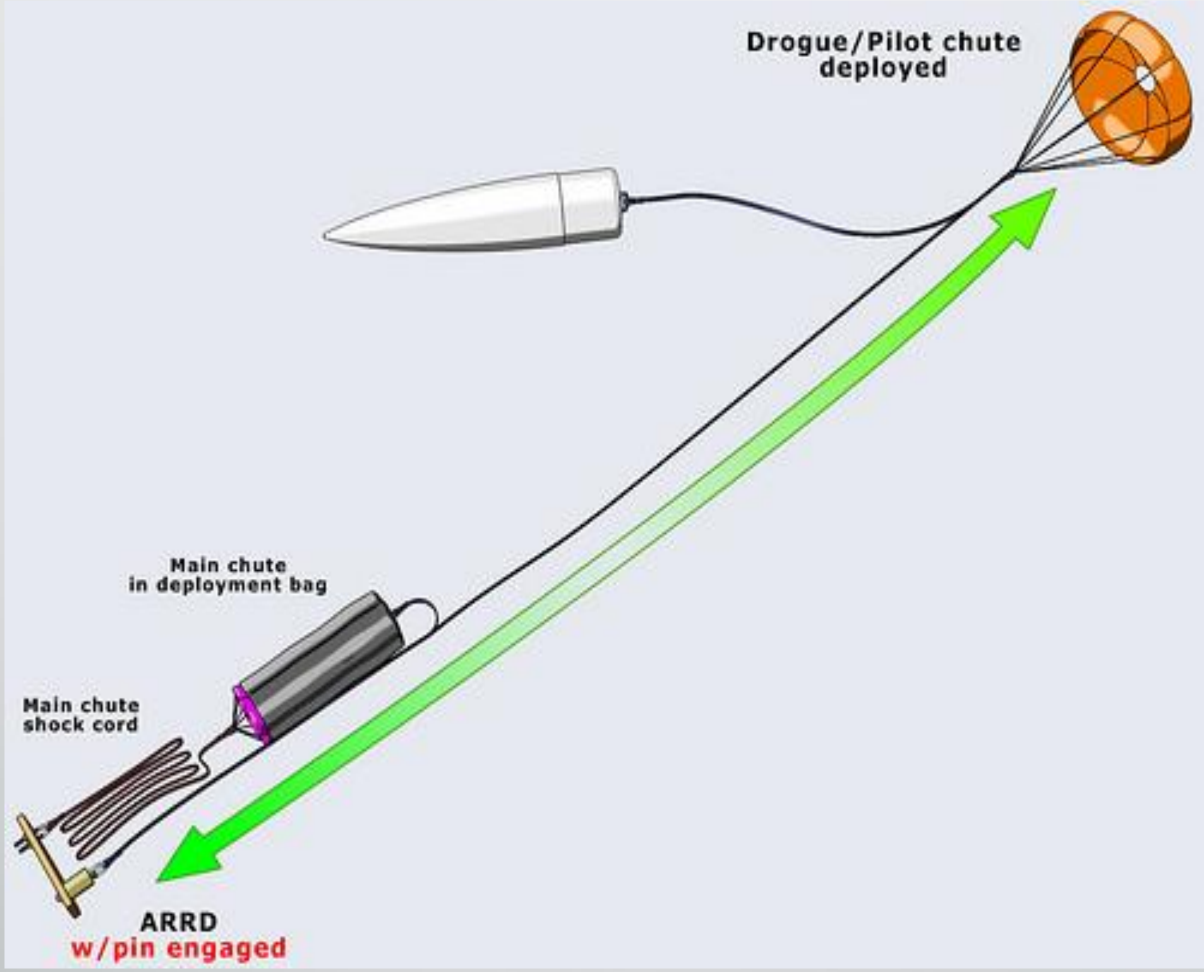
V_e = 42.5 ft/s
$_E$ = 69.9 ft-lb

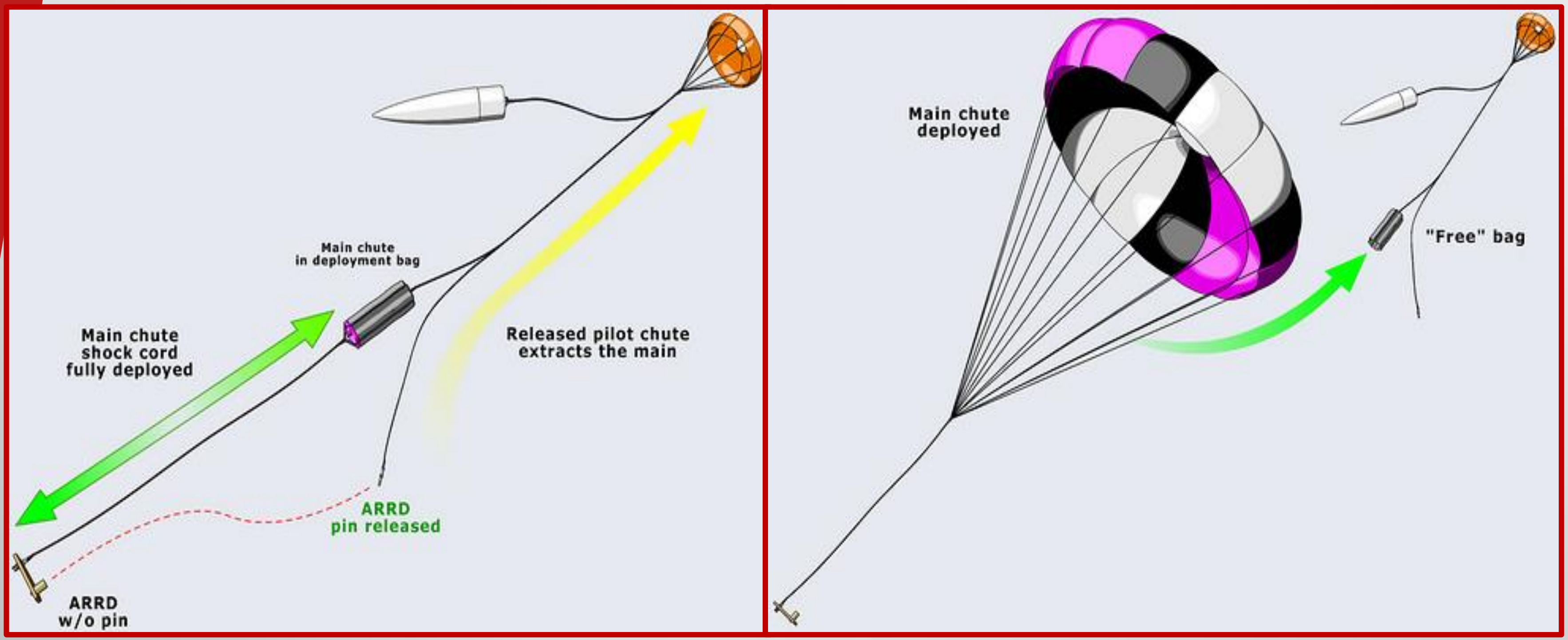
Deployment Parachute Cutaway

- Multirotor Deployment Parachute (MDP) enables safe recovery in off-nominal case.
- MDP cutaway is manually triggered upon go-ahead from RSO
- Multirotor will have reserve parachute identical to deployment parachute

Advanced Retention Release Device (ARRD)

- Reliable separable connection point for drogue
- Triggered by black powder and e-match
- Redundant e-matches will be used to ensure main deployment
- Can withstand ~2,000lbs of opening force
- Much more reliable than tender descender or other alternatives


Drogue/Pilot chute
deployed
Main chute
in deployment bag
Main chute
shock cord
ARRD
w/pin engaged


Main chute
in deployment bag
Main chute
shock cord
fully deployed
Released pilot chute
extracts the main
ARRD
pin released
ARRD
w/o pin
Main chute
deployed
"Free" bag

Drogue Phase

Drogue Descent Phase					
Section of Rocket	**Mass (lb_m)**	**S_o (ft^2)**	**D_o (ft)**	**V_e (ft/s)**	**Fx**
Booster	20.5	3.2	1.9	93.6	1.8
Deployment Bay (loaded)	16.1	1.5	1.3	129.0	7.0

- Rapid deployment bay drouge descent velocity allows for ~ 56.8 seconds for multirotor deployment
- Deployment bay drogue diameter: 1.9 ft
- Booster drogue diameter: 1.3 ft

Main Phase

Main Descent Phase					
Section of Rocket	Mass (lb_m)	S_o (ft^2)	D_o (ft)	V_e (ft/s)	E (ft·lb)
Nose Cone	2.0	1.5	1.4	42.5	69.9
Booster	20.5	65.9	9.0	14.6	69.9
Deployment Bay (loaded)	16.1	6.8	2.9	40.2	418.4
Deployment Bay (unloaded)	4.9			22.3	39.4
Multirotor	7.9	9.9	3.5	23.4	69.9

- Risk implicated by rapid deployment bay drouge descent velocity is mitigated by staging of deployment bay parachute and multirotor deployment

Opening Force Evaluations

Opening Forces						
Event	C_D	S_O (ft^2)	Velocity At Opening (ft/s)	C_x	X_1	F_x (lb_f)
Booster Drogue	0.6	3.2	25.8	1.2	1.0	1.9
Deployment Bay Drogue		1.5	72.9			7.0
Deployment Bay Main	1.2	6.8	129.0	1.8	0.032	9.6
Deployment Bay Unloading			40.2			0.9
Multirotor Main		10.0	2.0			2.0
Booster Main		66.0	93.6			48.7
Reserve Deployment		10.0	24.3			0.5

- Team has experienced Fx of ~ 500lbs in the past – 9.6lb opening force from high velocity deployment bay drogue state is a result of rapid staging of deployment bay main and multirotor deployment.
- 48.7 lb force is well within acceptable range for booster.
- Will verify via testing:
  - X1 variable
  - Predicted Cd

Drift

Predicted Drift Values

Crosswind Velocity (mph)	Section	Descent Duration (s)		Drift (ft)		Total Drift (ft)
		Drogue	Main	Drogue	Main	
0	Booster	49.4	40.6	0		0
	Nose Cone	30.1	31.3			
	Deployment Bay	30.1	59.6			
	Multirotor (off-nominal descent)	30.1	56.8			
5	Booster			362	298	659
	Nose Cone			221	229	450
	Deployment Bay				437	658
	Multirotor (off-nominal descent)				416	637
10	Booster			724	595	1319
	Nose Cone			441	459	900
	Deployment Bay				875	1316
	Multirotor (off-nominal descent)				833	1274
15	Booster			1086	893	1978
	Nose Cone			662	688	1350
	Deployment Bay				1312	1974
	Multirotor (off-nominal descent)				1249	1911
20	Booster			1448	1190	2638
	Nose Cone			883	918	1801
	Deployment Bay				1749	2632
	Multirotor (off-nominal descent)				1665	2548

- Deployment bay drift is limiting factor. Still witin ½ mile with 20mph winds.

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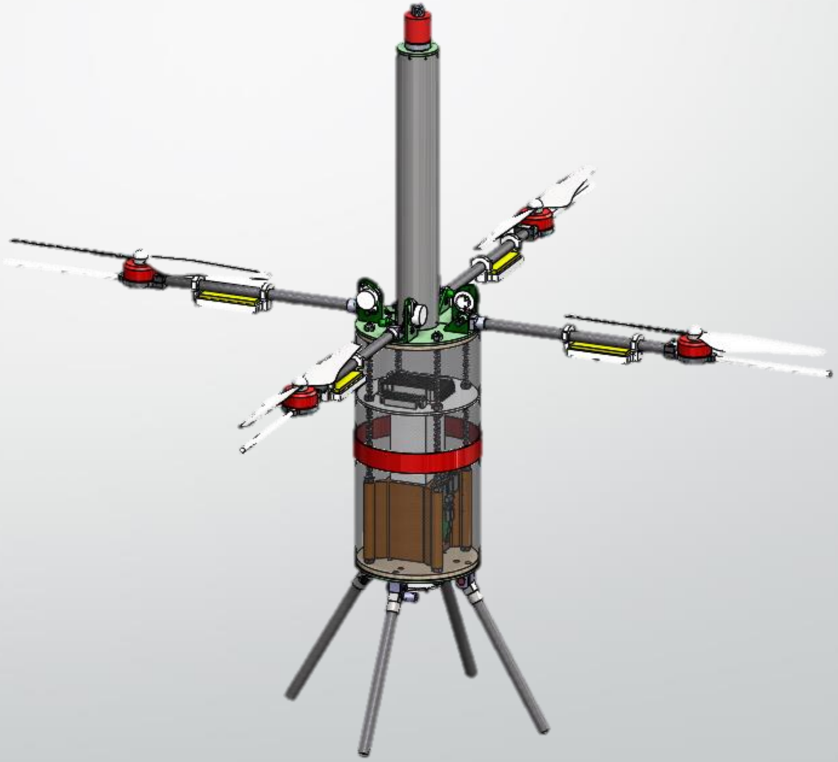
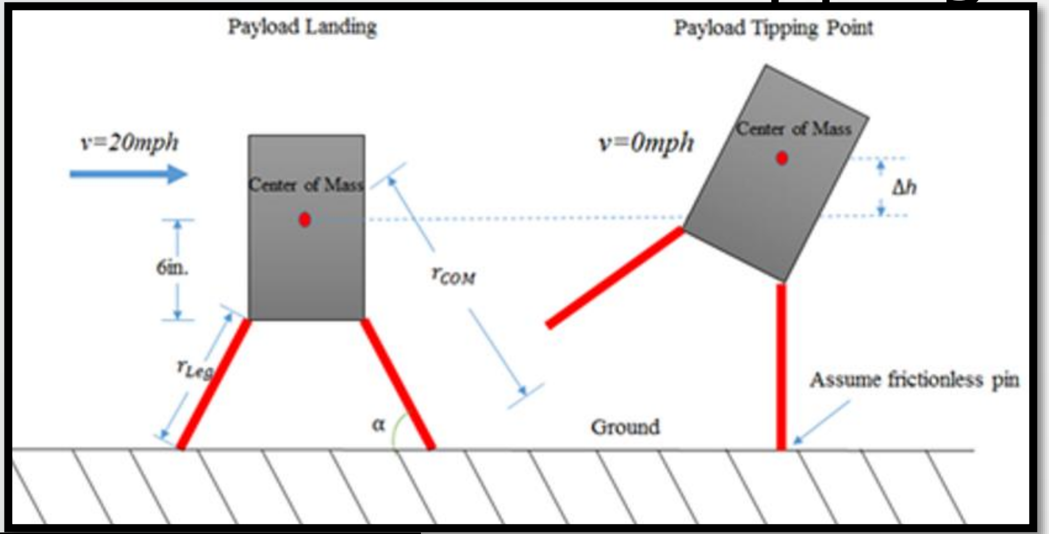
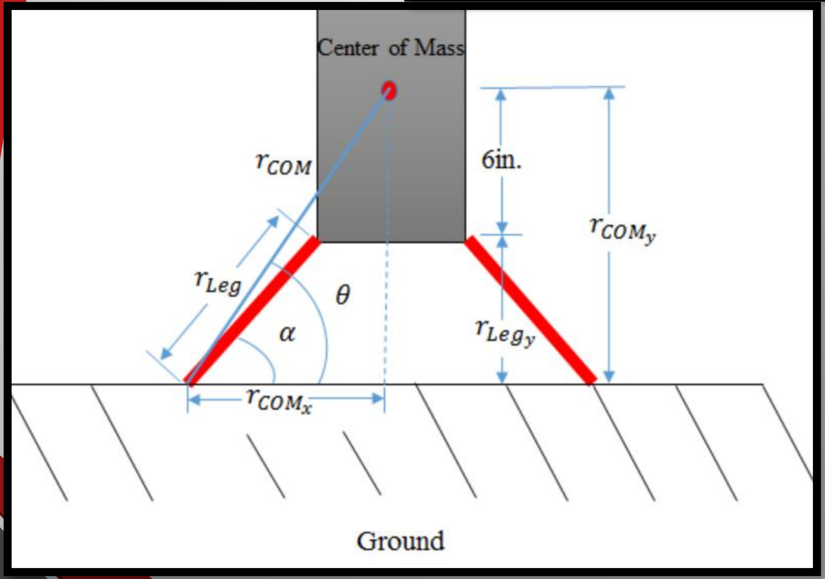
Payload Agenda

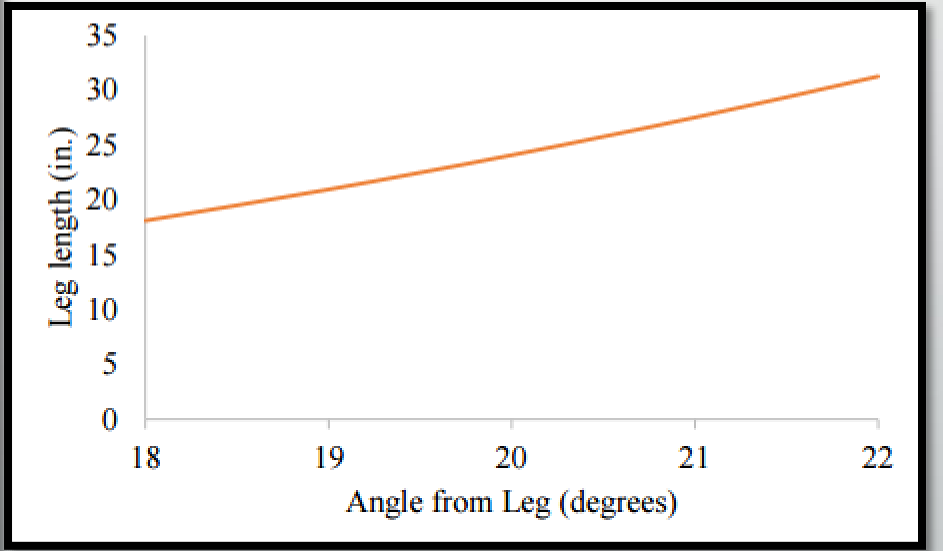
- Analysis and Derived Bounding conditions
- Payload Trade Study
- Payload design overview
- Payload Subsystems
- Project Plan and Testing
- Safety



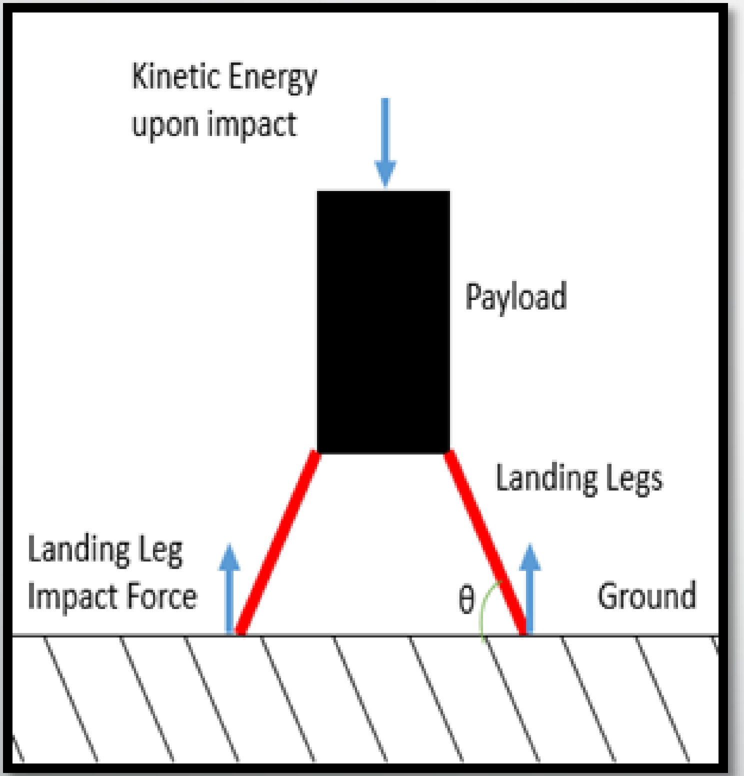
Worst Case Scenario Tipping Analysis

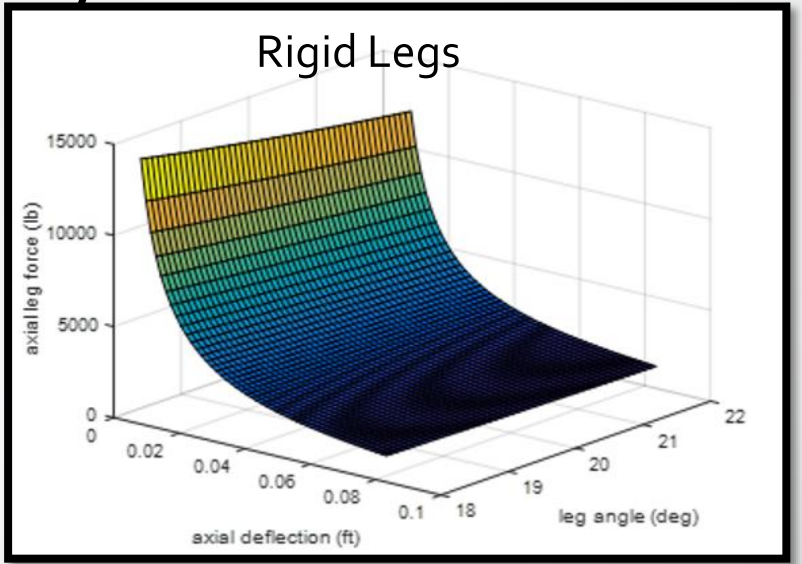


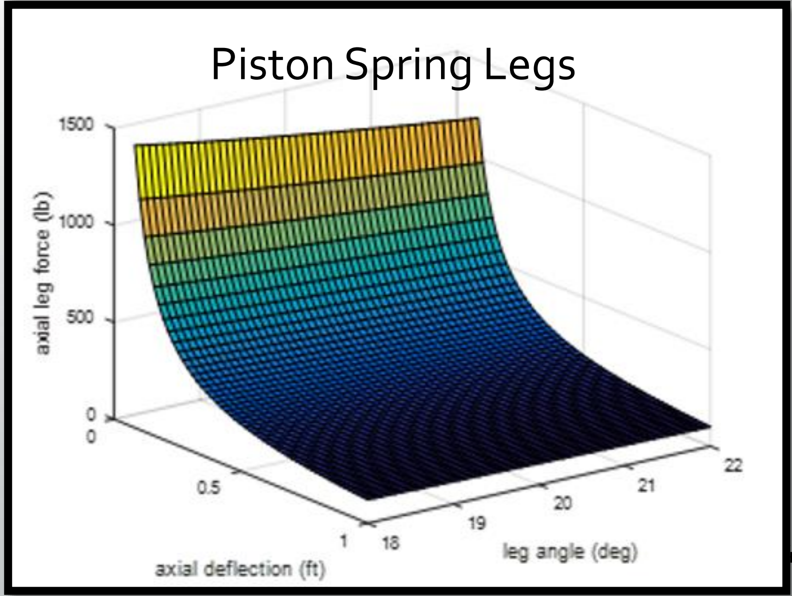




Worst Case Scenario Impact Landing Analysis







Derived Bounding conditions

Requirement Number	Requirement	Method of Verification
BC.1	Payload must have active control over its vertical velocity	Demonstration Demonstration of the payloads ability to control vertical velocity.
BC.2	Payload must have active control over its lateral velocity	Demonstration Demonstration of the payloads ability to control lateral velocity

Recovery Trade Study

- Six recovery systems were considered

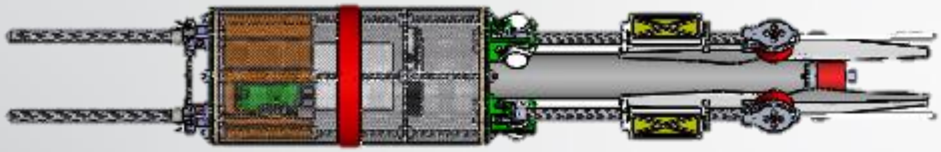
Payload Recovery System

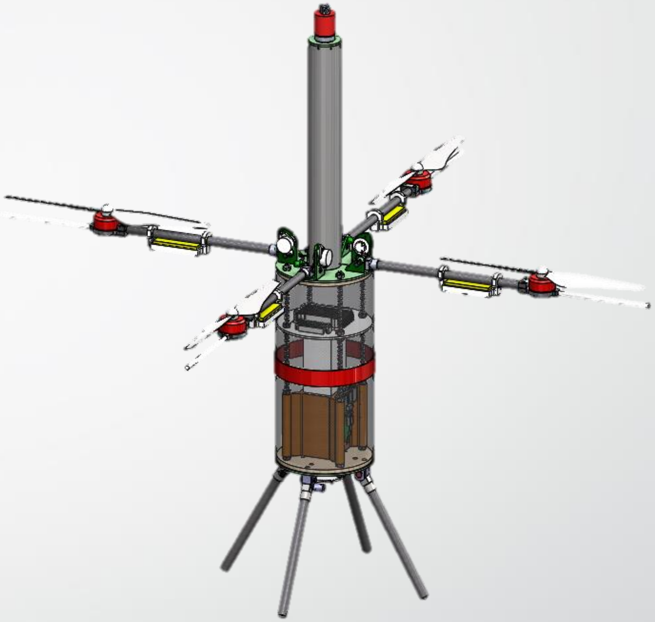
Options:		Single Parachute		Parachute with Pnuematic Thruster		Pnuematic Thruster with Redundant Recovery System		Parachute with Multi-rotor guidance		Multi-rotor with Redundant Recovery System		Manueverable Parachutes		Deployable Glider	
Mandatory Requirements															
Maintain Kinetic Energy requirement		Yes		Yes		Yes		No		Yes		Yes		Yes	
Lateral Velocity Control		No		Yes		Yes		Yes		Yes		Yes		Yes	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Mitigating Risk	20.00%	9	1.8	6	1.2	2	0.4	6	1.2	6	1.2	7	1.4	4	0.8
System simplicity	15.00%	8	1.2	2	0.3	2	0.3	0	0	6	0.9	4	0.6	1	0.15
Testability	15.00%	3	0.45	5	0.75	5	0.75	4	0.6	9	1.35	3	0.45	2	0.3
Landing control	15.00%	0	0	5	0.75	7	1.05	5	0.75	9	1.35	3	0.45	3	0.45
Available Documentation	10.00%	8	0.8	1	0.1	3	0.3	1	0.1	9	0.9	4	0.4	2	0.2
Manufacturability	10.00%	8	0.8	2	0.2	2	0.2	7	0.7	7	0.7	5	0.5	4	0.4
Flight Mobility	10.00%	0	0	4	0.4	4	0.4	4	0.4	10	1	5	0.5	7	0.7
Affordability	5.00%	9	0.45	2	0.1	1	0.05	5	0.25	5	0.25	9	0.45	7	0.35
Total Score		0		3.8		3.45		0		7.65		4.75		3.35	

Landing Leg Trade Study

Landing Leg System							
Options:		Deplyoable Rigid Legs		Deployable Gas Spring Legs		Inflatable Legs	
Mandatory Requirements							
Withstand Landing Impact Loads		Yes		Yes		Yes	
Landing Stability agianst Tipping		Yes		Yes		Yes	
Categories	**Weights**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Mitigating Risk	20%	9	1.8	6	1.2	2	0.4
System simplicity	15%	7	1.05	3	0.45	2	0.3
Weight	15%	8	1.2	3	0.45	5	0.75
Testability	15%	7	1.05	7	1.05	6	0.9
Impact Abosrbtion	10%	2	0.2	9	0.9	6	0.6
Manufacturability	10%	8	0.8	3	0.3	5	0.5
Size	10%	5	0.5	3	0.3	8	0.8
Affordability	5%	7	0.35	2	0.1	7	0.35
Total Score		**6.95**		**4.75**		**4.6**	

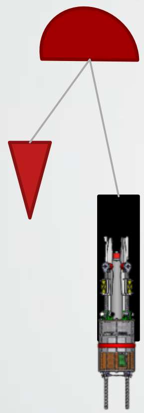
Payload Design Overview



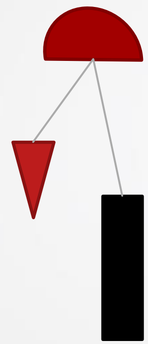


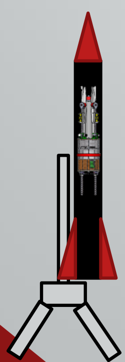
Mass (lb)	Motor to Motor (in)	Overall Deployed Width (in)	Height (in)	
			Stowed	Deployed
7.86	29.0	42.0	40.8	36.0

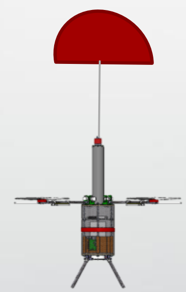
Payload Mission Overview



Payload separates from vehicle under deployment parachute.





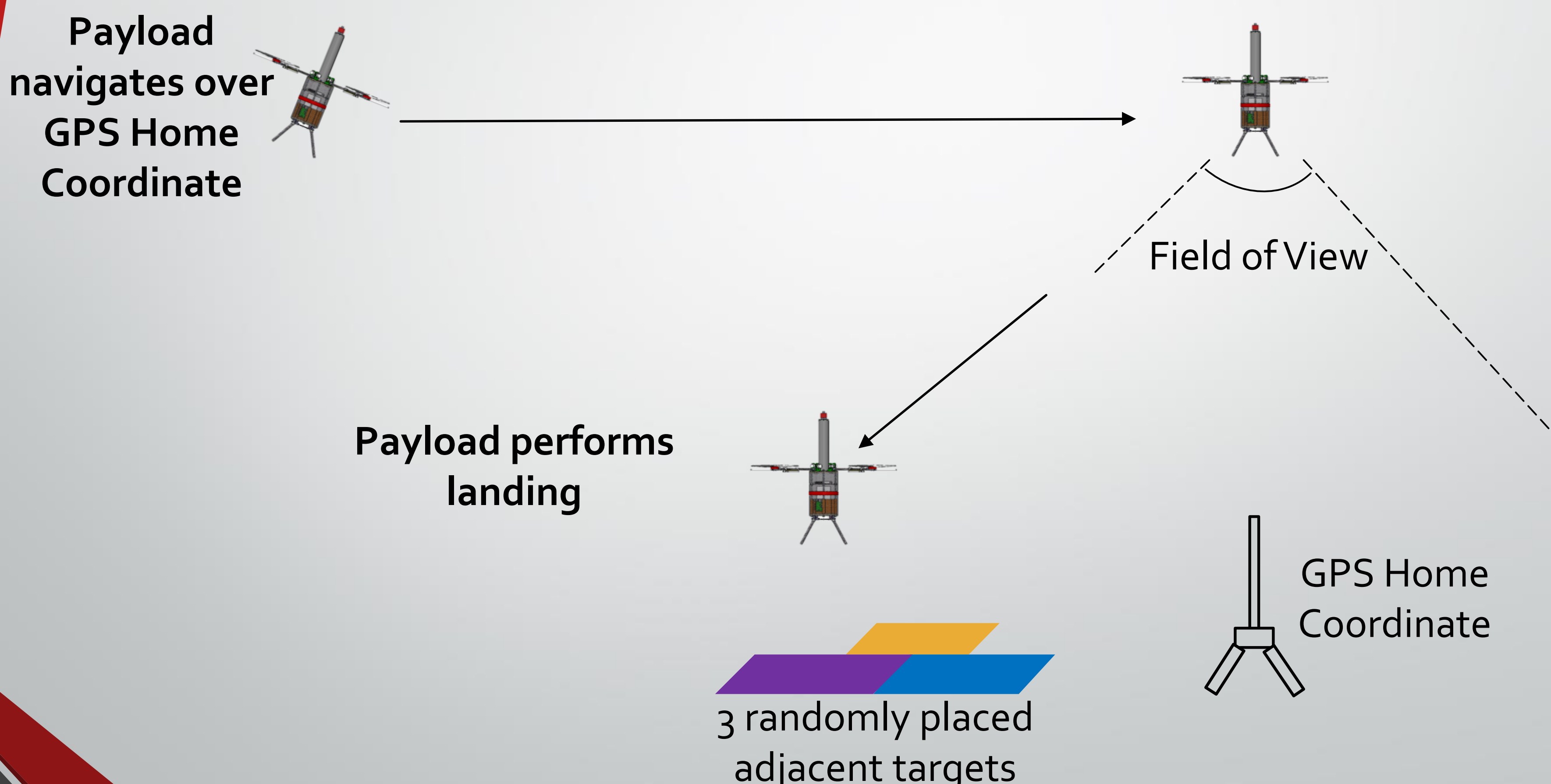


Home GPS coordinate initialized

Flight systems initialize.

Payload releases deployment parachute.

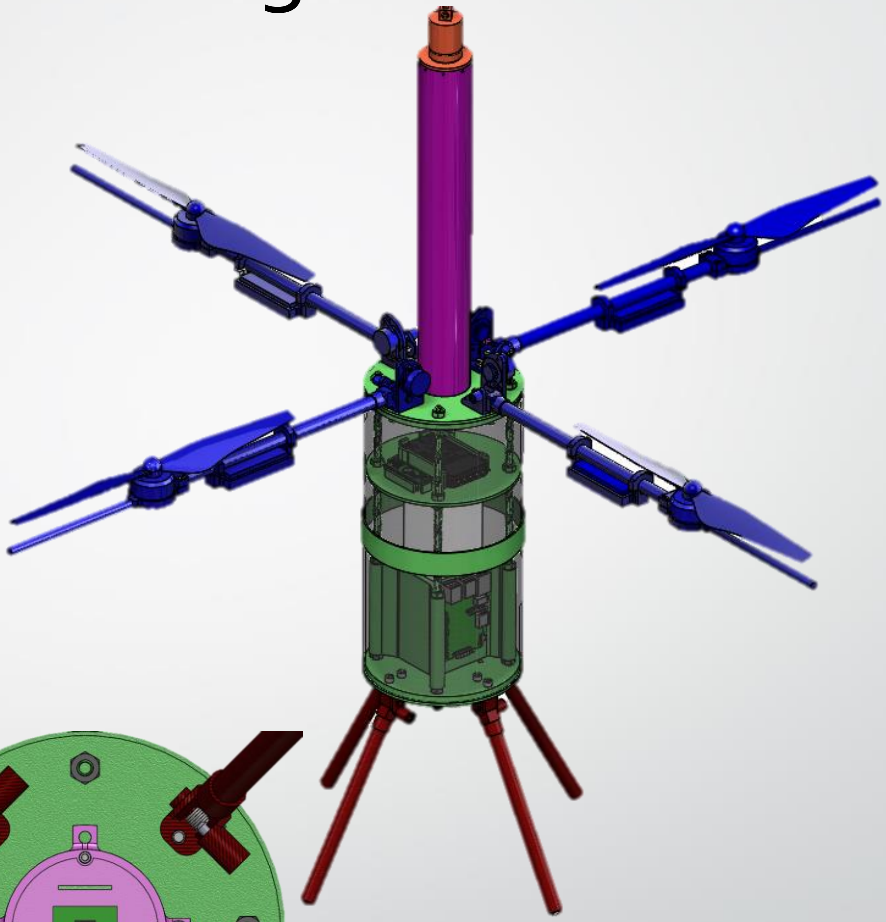
Payload Mission Overview

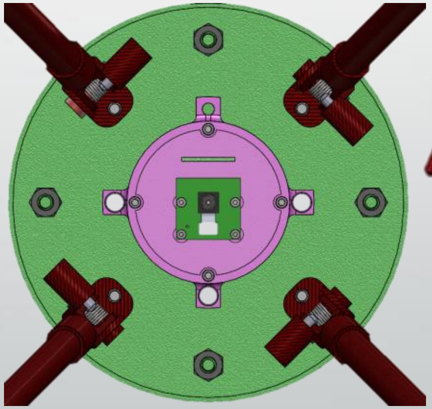


Payload Subsystem Design Breakdown:

Payload Subsystem Breakdown:

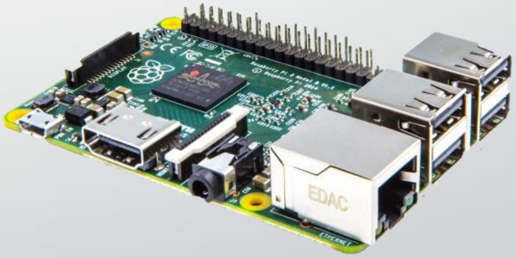
- Multirotor Recovery System (MRS)
- Redundant Recovery System (RRS)
- Deployment and Cutaway System (DCS)
- Target Detection System (TDS)
- Landing Leg System (LLS)
- Payload Structural System (PSS)

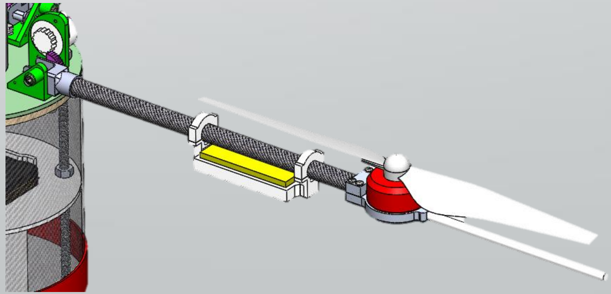




Multirotor Recovery System (MRS)

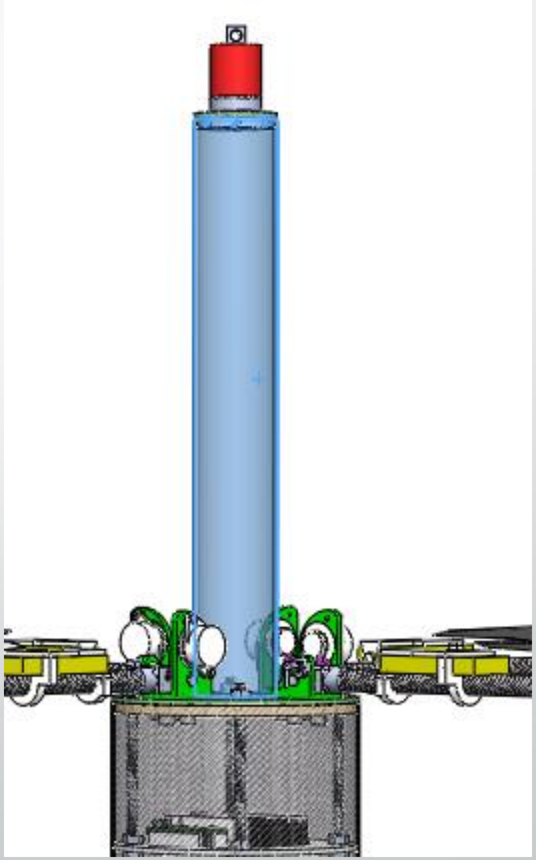
- Propulsion System
  - DJI E800
  - DJI 1345 Propellers
  - 620S ESC
- Flight Electronics
  - Raspberry Pi flight computer
  - Pixhawk flight controller
  - GPS and Telemetry
  - 22.2V lipo
- Deployable multirotor arms



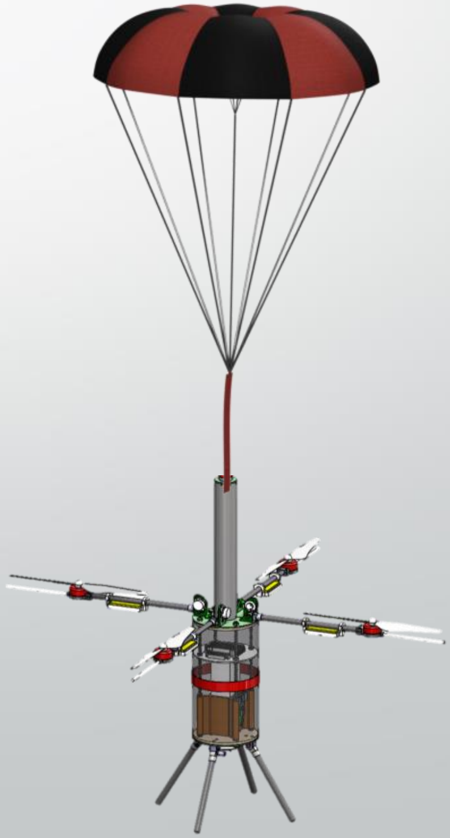
Redundant Recovery System (RRS)

- Central 2" tube w/ backup parachute
- Redundant deployment electronics.
  - Isolated system



Reserve Parachute

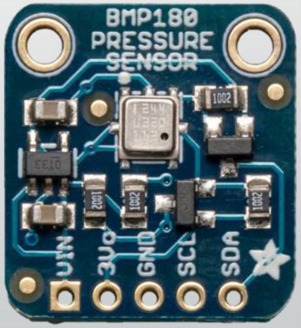
Multirotor Reserve Parachute		
So (ft2)	Do (ft)	Ve (ft/s)
9.9	3.5	23.4



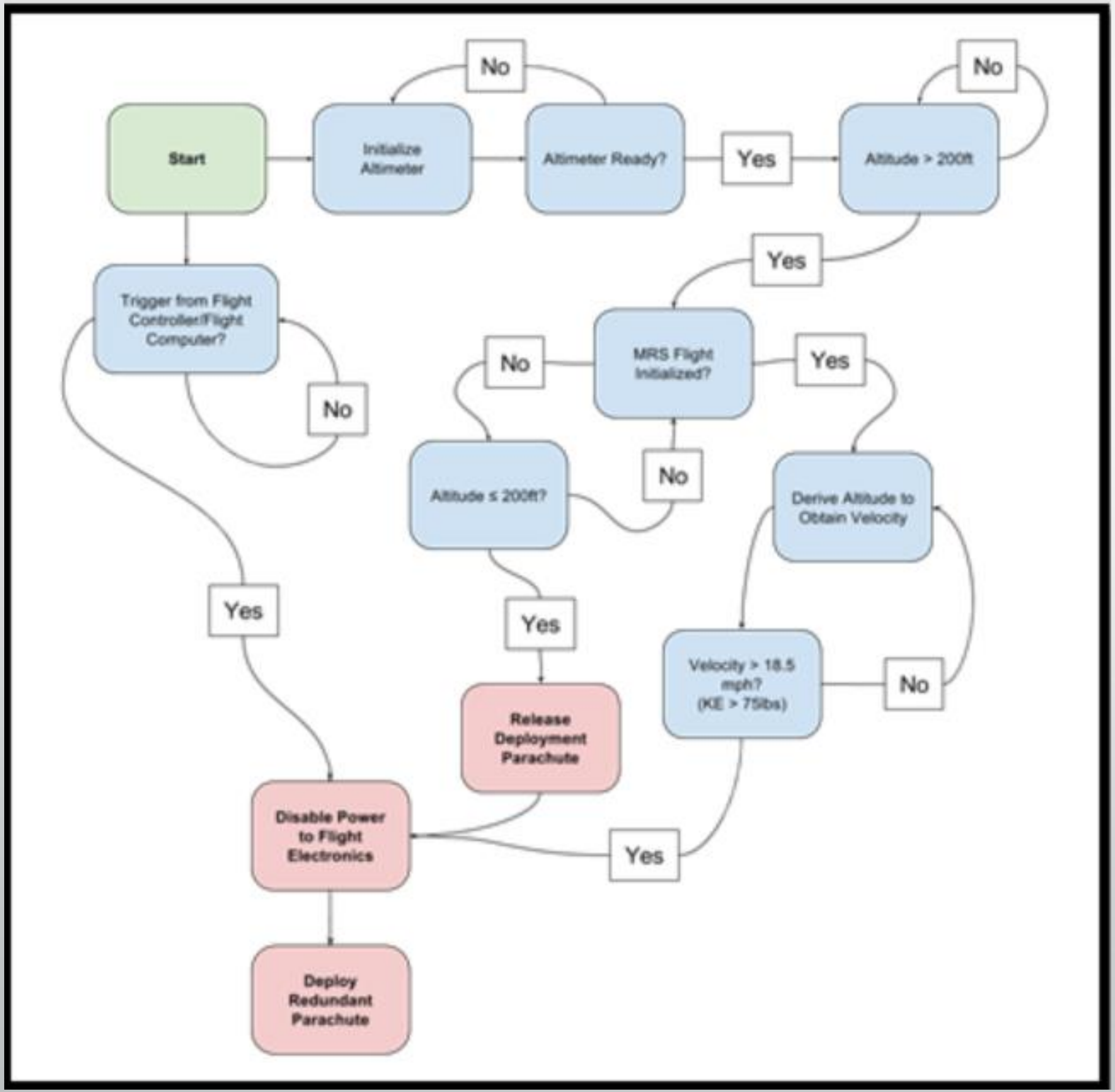
- Multirotor reserve parachute is identical to MDP

Redundant Recovery Electronics

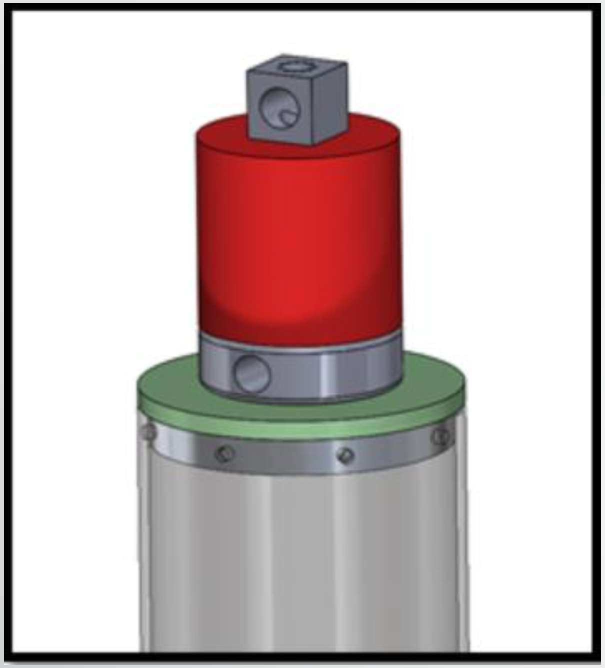
- Teensy 3.2 microcontroller
- BMP180 Pressure sensor

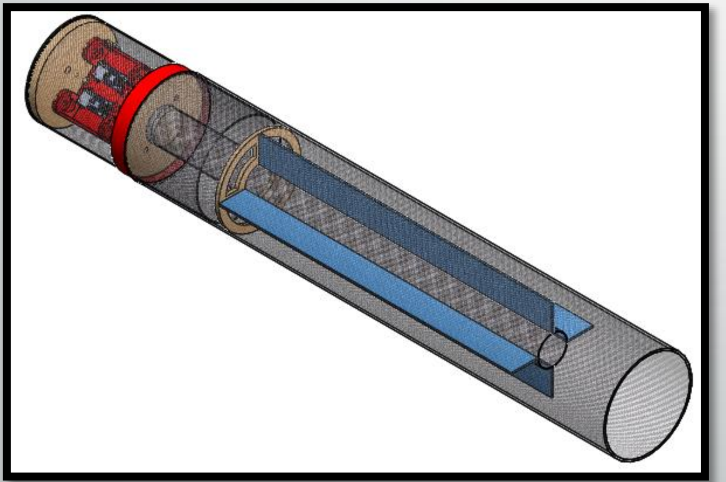


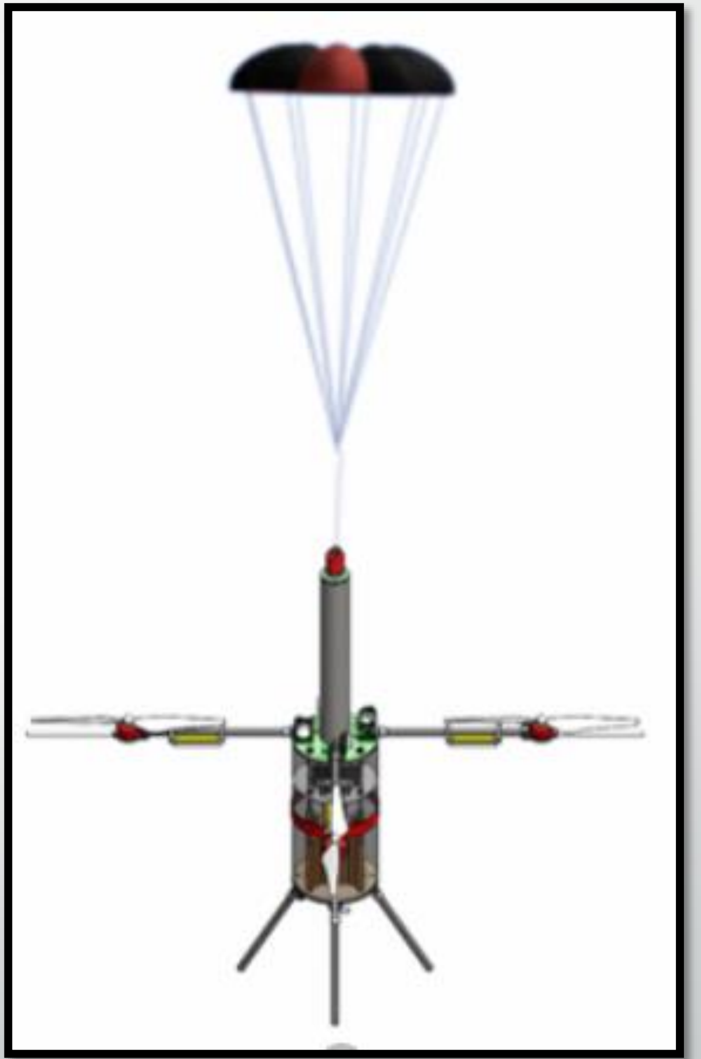
Redundant Recovery System Logic



Deployment and Cutaway System (DCS)

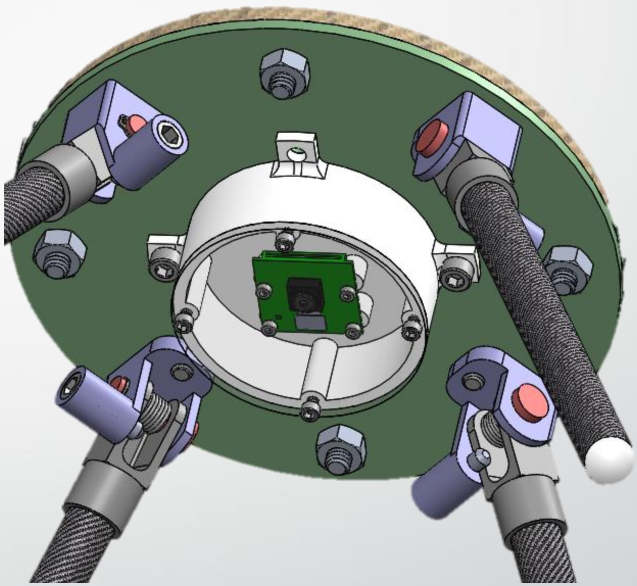




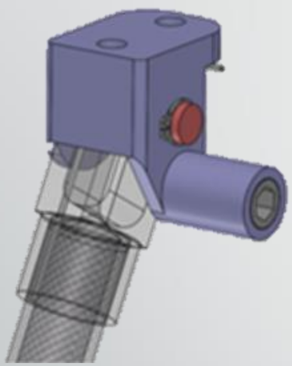
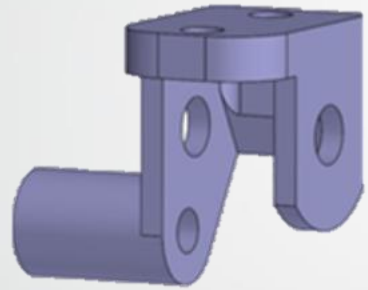


Target Detection System (TDS)

- Software package built into flight computer
  - OpenCV library
- Camera selected: Pi Cam

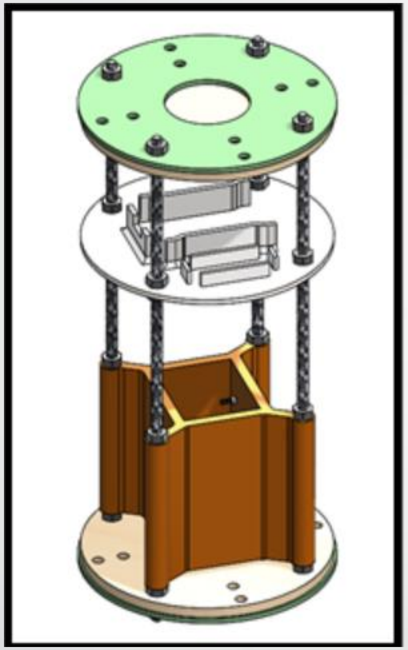


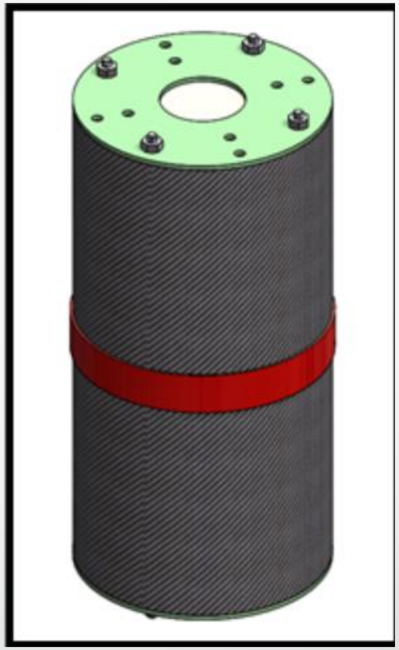
Landing Leg System (LLS)

Mass (lbs)	Length (in.)	Width (in)
0.081	8.83	1.00

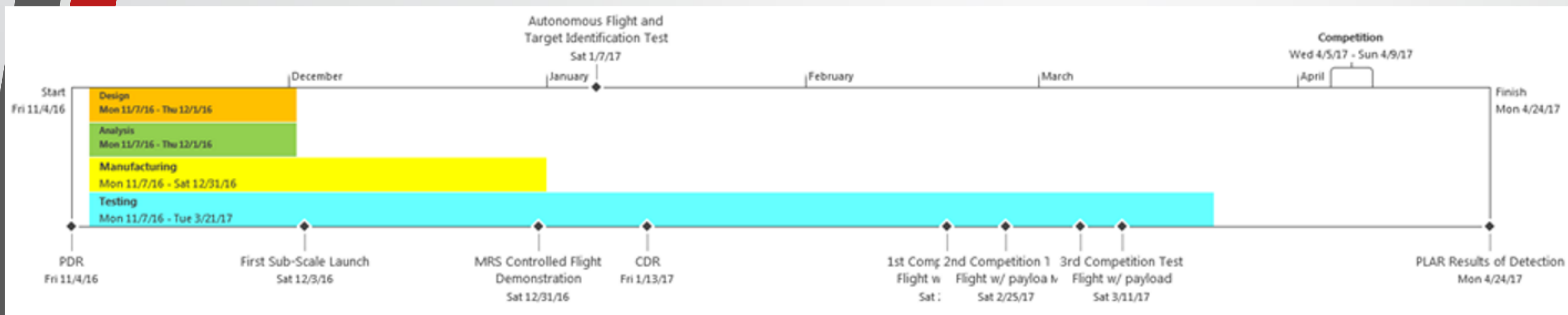
Payload Structural System (PSS)





Height (in)	Diameter (in)	Mass (lbs)
12.25	6.00	4.12

Project Plan



Milestones	PDR	Milestones Prior to CDR	Milestones prior to FRR	Milestones Prior to FRR
Requirements verified	Design and Analysis	Manually controlled flight and autonomous flight testing completed	First full scale payload mission flight completed	Second Full scale payload mission flight completed

Payload Safety

Hazard	Cause/ Mechanism	Potential Outcome	Risk	Mitigation
MRS fails to take flight	Failed propulsion arm deployment	Payload falls without propulsion	Moderate	Redundant Recovery System deploys to recover payload
Payload fails to deploy from Deployment Bay	Poor manufacturing tolerances	Kinetic Energy requirement is exceeded	High	Custom manufacturing jigs to correctly manufacture deployment bay
Black Powder harms MRS electronics	Poor DCS design	MRS electronics are unable to perform	Moderate	DCS designed to mitigate black powder effects
RRS fails to deploy in flight anomalies	RRS deploys before ARRD performs cutaway	Kinetic Energy requirement is exceeded	Low	DCS deployment logic prevents this from occurring

PDR Presentation Agenda

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

Safety Features

Risk Assessment Matrix				
Probability Value	Severity Value			
	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 COMPLIANCE FORM

River City Rocketry

UNIVERSITY OF LOUISVILLE

- Safety Manual
  - Shop Safety and checklists
  - Material information (MSDS Sheets)
  - Energetics Safety (Black Powder and Rocket Motors)
- Launch Procedures
  - Test Launch procedural check list/item list
  - Assembly Instructions and warnings of potential hazards

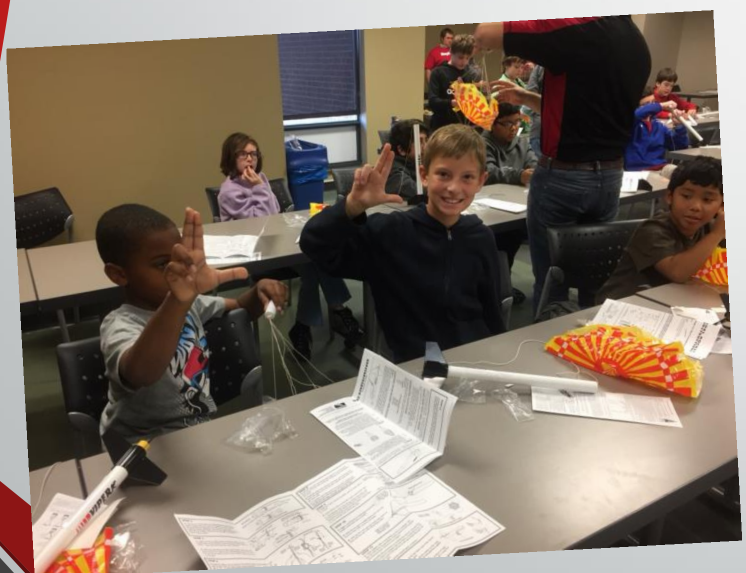
PDR Presentation Agenda

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

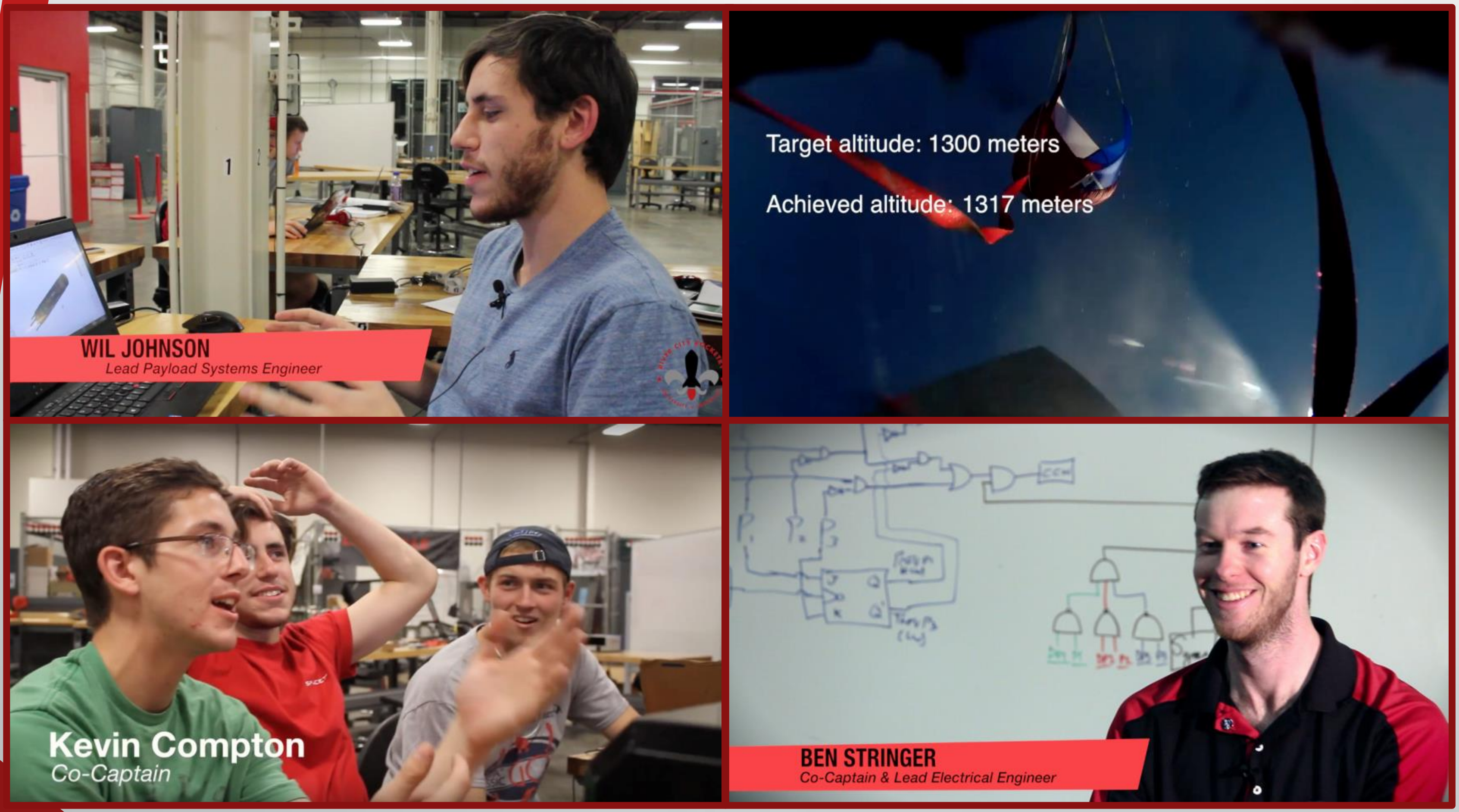
Educational Outreach

- MathMovesU
- Kentucky Science Center

	NASA Requirment	*Our Requirment*
Requirment to Reach	200	2,000
Students yet to be reached	104	1904
		Current Total **96**



Webseries & Video Content

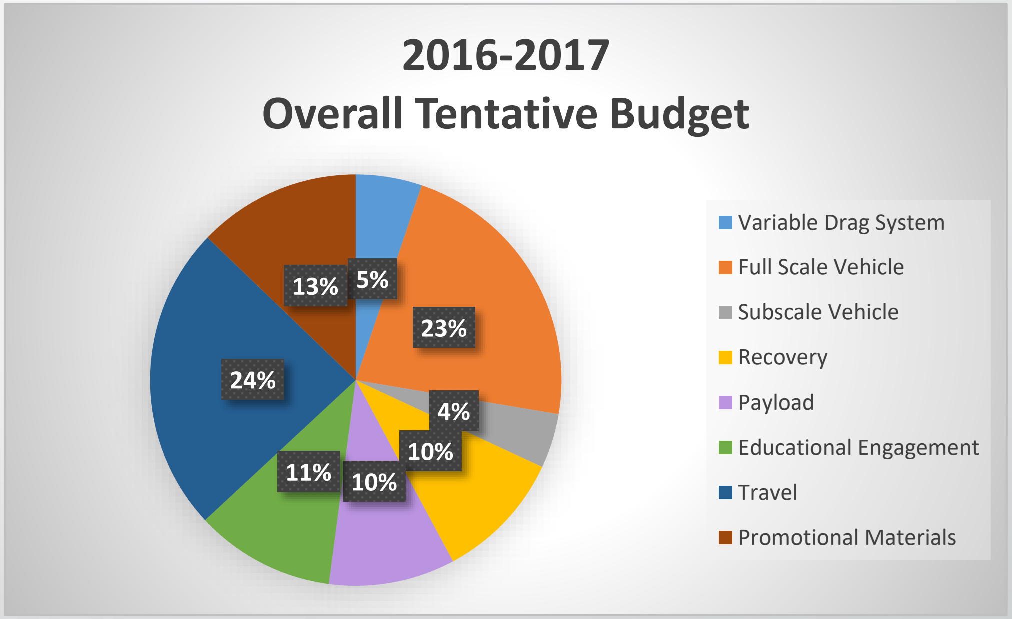


PDR Presentation Agenda

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

Budget Overview

Overall Tentative Budget	
Budget	**Total Cost**
Variable Drag System	$888.33
Full Scale Vehicle	$3,834.16
Subscale Vehicle	$733.24
Recovery	$1,744.99
Payload	$1,696.37
Educational Engagement	$1,877.03
Travel	$4,118.40
Promotional Materials	$2,187.50
Overall Cost	$16,191.69



Team Sustainability

Sustainable Budget					
Inflow					
Donor	**Description of Donation**	**Date Submitted**	**Date Received**	**Amount Requested**	**Accepted**
J.B. Speed School	The University of Louisville J.B. Speed School donates based off presentation of materials and amount requested/needed by the organization.	Thursday, September 22, 2016	Friday, October 28, 2016	$5,000.00	Y
Raytheon Missle Systems	Assistance in outreach event MathMovesU.	Thursday, October 13, 2016	Thursday, October 27, 2016	$1,000.00	Y
SpaceX	Grant for university teams not only NASA Student Launch but a multitude of competitions. They have no specific ceiling on the amount to request.	Tuesday, November 1, 2016	TBD	$10,000.00	TBD
2015-2016 RCR Remaining Balance	Remaining balance of the teams expenditures from the 2015-216 NASA Student Launch Competition	N/A	N/A	$23,799.00	Y
			Overall Income	**$29,799.00**	
Outflow					
			Expected Team Expenses	**$16,191.69**	
			End of the Season Expected Total	**$13,607.31**	

RIVER CITY ROCKETRY

UNIVERSITY of LOUISVILLE