CanSat 2024
Preliminary Design Review (PDR)
Version 2.0

Team #2078

Shockwave

Presentation Outline

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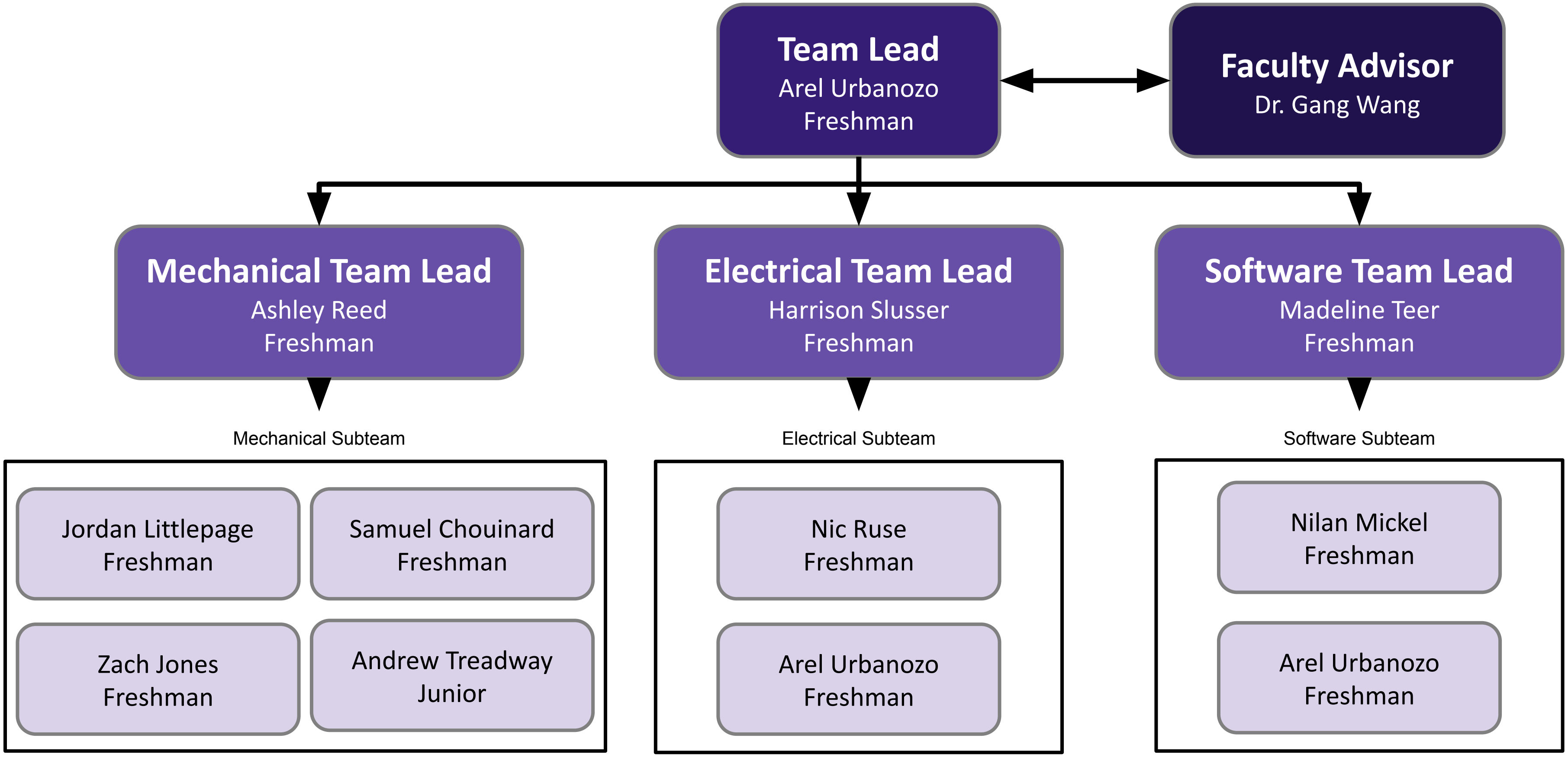
Team Organization



Team Lead
Arel Urbanozo
Freshman

Faculty Advisor
Dr. Gang Wang

Mechanical Team Lead
Ashley Reed
Freshman

Electrical Team Lead
Harrison Slusser
Freshman

Software Team Lead
Madeline Teer
Freshman

Mechanical Subteam

Jordan Littlepage
Freshman

Samuel Chouinard
Freshman

Zach Jones
Freshman

Andrew Treadway
Junior

Electrical Subteam

Nic Ruse
Freshman

Arel Urbanozo
Freshman

Software Subteam

Nilan Mickel
Freshman

Arel Urbanozo
Freshman

Acronyms (1 of 2)

Acronym	Definition	Acronym	Definition
ADC	Analog to Digital Converter	IMU	Inertial Measurement Unit
C	Celsius	Kb	Kilobit
Comm	Communication	LED	Light Emitting Diode
CSV	Comma Separated Value	MECH	Mechanical Subteam
COTS	Commercial-Off-The-Shelf	MCU	Microcontroller Unit
ELEC	Electrical Subteam	MHz	Megahertz
FSW	Flight Software	MISC	Miscellaneous
FOV	Field of View	MOM	Mission Operation Manual
GCS	Ground Control System	PETG	Polyethylene Terephthalate Glycol
Gs	Force of Gravity	PCB	Printed Circuit Board
Hz	Hertz	PFR	Post Flight Review
I2C	Inter-Integrated Circuit	PWM	Pulse Width Modulation

Acronyms (2 of 2)

Acronym	Definition
SD	Secure Digital
RSO	Range Safety Officer
RTC	Real Time Clock
UART	Universal Asynchronous Receiver/Transmitter
UAH	University of Alabama in Huntsville
ODR	Output Data Rate
GPS	Global Positioning System
SPI	Serial Peripheral Interface
SHC	Space Hardware Club
UTC	Universal Time Coordinated

Systems Overview

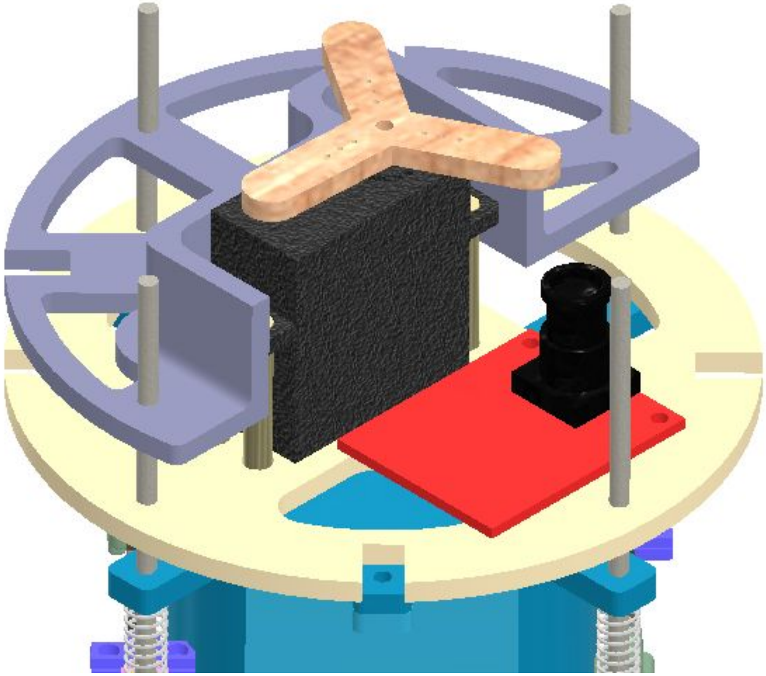
Arel Urbanozo, Ashley Reed

Mission Summary (1 of 2)

Mission Objectives	
1	Design a CanSat containing electronics, a hens egg, and a detachable heat shield that simulates a space probe entering a planetary atmosphere.
2	The CanSat shall function as the nose cone of the rocket during ascent.
3	The CanSat will be launched to a maximum of 725 meters before ejecting from the rocket and immediately deploying an aerobraking mechanism.
4	At 100 meters, the CanSat shall release the aerobrake and simultaneously deploy a parachute to descend at a rate less than 5 m/s.
5	The CanSat shall land with the egg intact.
6	A silver or gold mylar streamer shall be used to identify the CanSat.
7	The CanSat shall transmit telemetry to a ground station during flight and stop transmitting once landed.
8	The CanSat shall activate an audio beacon once landed.
9	A video camera will capture the horizontal view during ascent and landing and must be pointed in one direction during descent.

Mission Summary (2 of 2)

Bonus Objective
A video camera shall be integrated into the Cansat and point aft of the Cansat. The camera shall capture the Cansat being deployed from the rocket and the release of the parachute. Video shall be in color with a minimum resolution of 640x480 pixels and a minimum of 30 frames per second. The video shall be recorded and retrieved when the Cansat is retrieved.



System Requirement Summary (1 of 2)

System Requirement Summary
Requirement
The Cansat mass shall be 900 grams +/- 10 grams without the egg being installed.
The Cansat shall perform the function of the nose cone during rocket ascent and shall be symmetrical along the thrust axis.
Cansat structure must survive 15 Gs vibration and 30 Gs shock.
XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.
All mechanisms shall be capable of maintaining their configuration or states under all forces.
The Cansat shall deploy a heat shield after deploying from the rocket at 725m.
The Cansat shall transmit telemetry once per second.
Teams shall plot each telemetry data field in real time during flight.

System Requirement Summary (2 of 2)

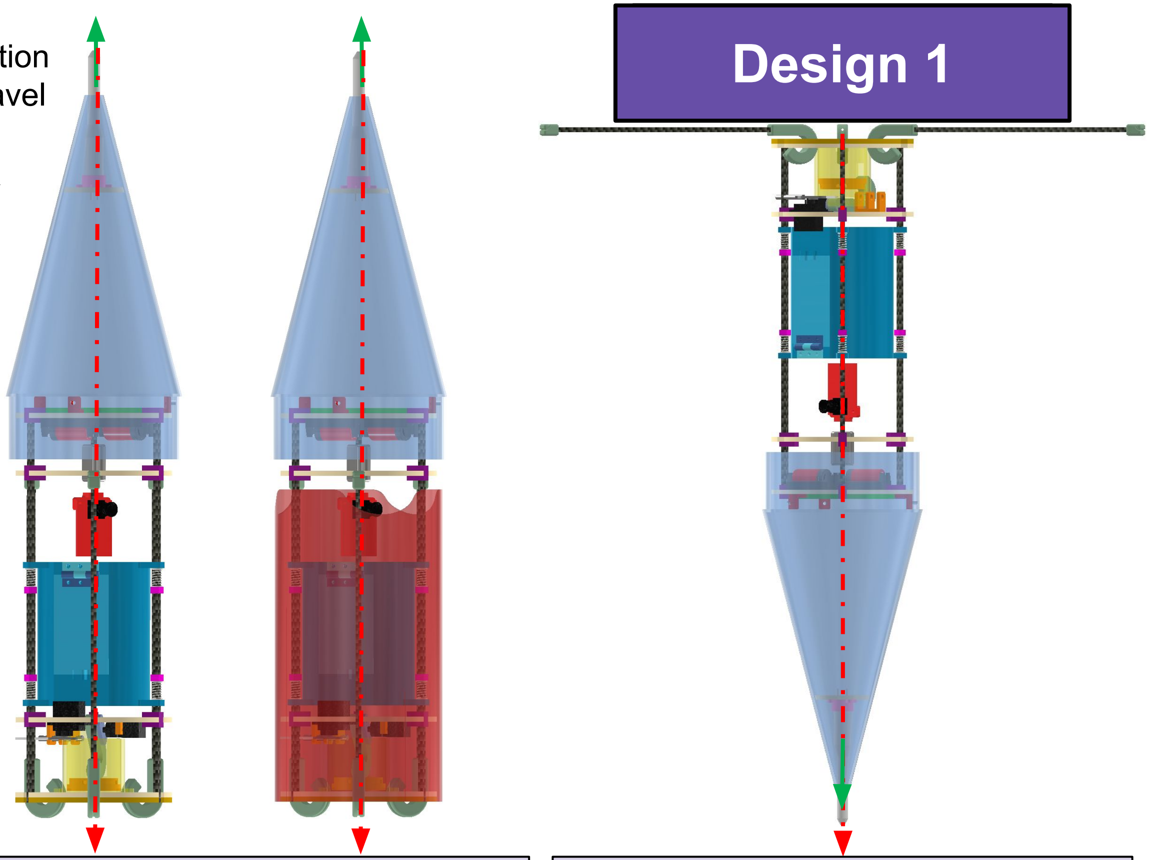
System Requirement Summary
Requirement
The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.
At 100 meters, the Cansat shall release a parachute to reduce the descent rate to less than 5 m/s.
The Cansat shall protect a hens egg from damage during all portions of the flight.
Cansat shall measure its air pressure, internal temperature, angle stability, rotation rate, and voltage.
The Cansat shall include a video camera pointing horizontally.
The video camera shall record the flight of the Cansat from launch to landing.
The video camera shall record video in color and with a minimum resolution of 640x480.
Each team shall develop their own ground station.
All telemetry shall be displayed in real time during descent on the ground station.

System Level CanSat Configuration Trade & Selection (1 of 12)

🟩 Direction of Travel

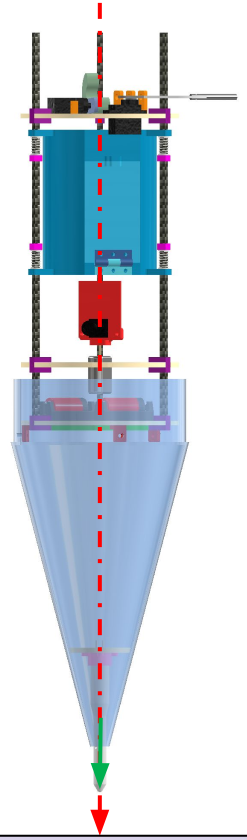
🟥 Nadir

Design 1



Stowed Configuration:
The CanSat will be stowed using friction and will be upside down for the duration of the ascent.

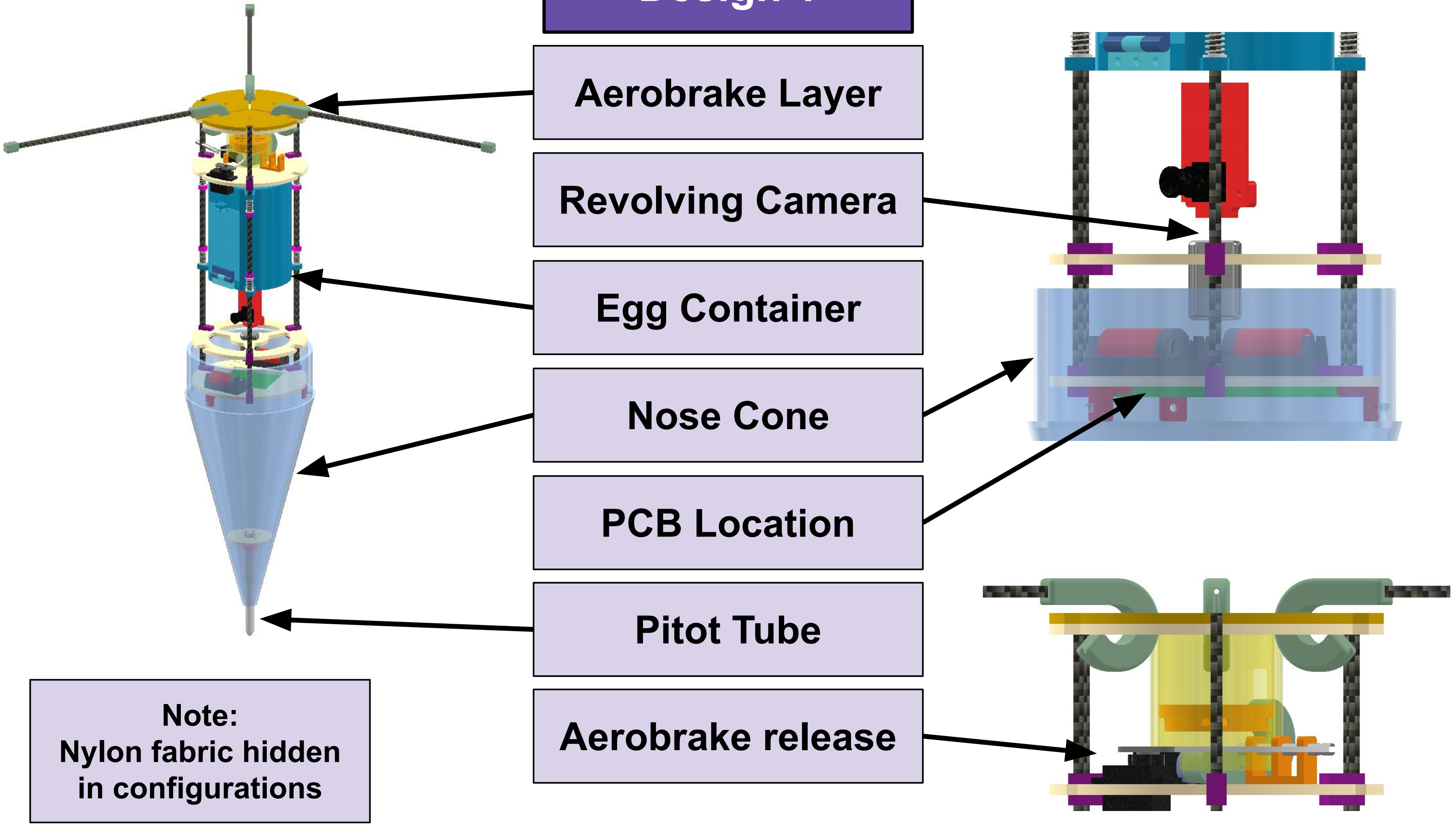
Aerobrake Descent Configuration:
The CanSat will flip to be nose cone down and immediately open an aerobrake.



Released Aerobrake Configuration:
The CanSat will release the aerobrake deploying the parachute.

System Level CanSat Configuration Trade & Selection (2 of 12)

Design 1



Aerobrake Layer

Revolving Camera

Egg Container

Nose Cone

PCB Location

Pitot Tube

Aerobrake release

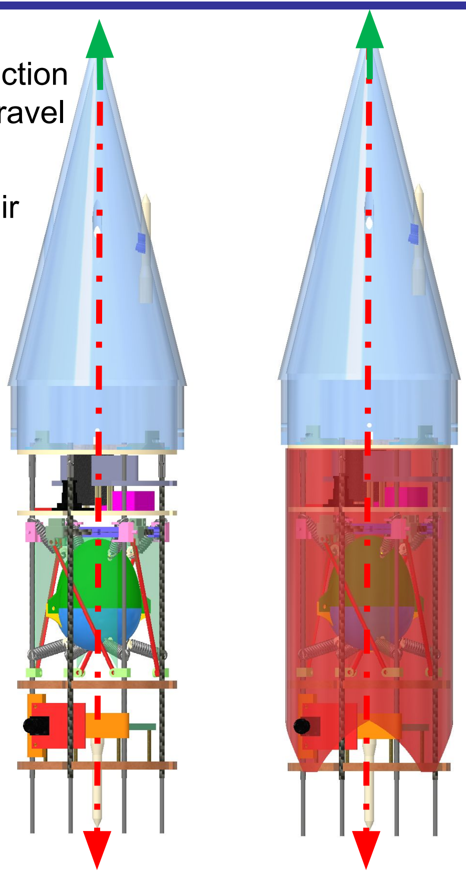
Note:
Nylon fabric hidden in configurations

System Level CanSat Configuration Trade & Selection (4 of 12)

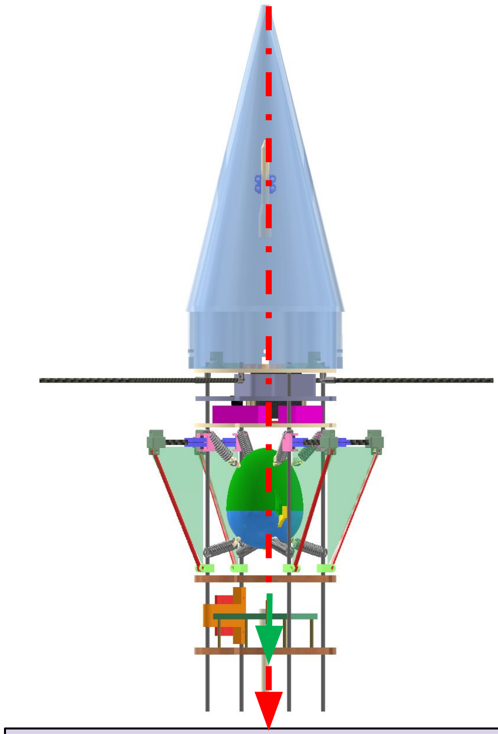
🟩 Direction of Travel

🟥 Nadir

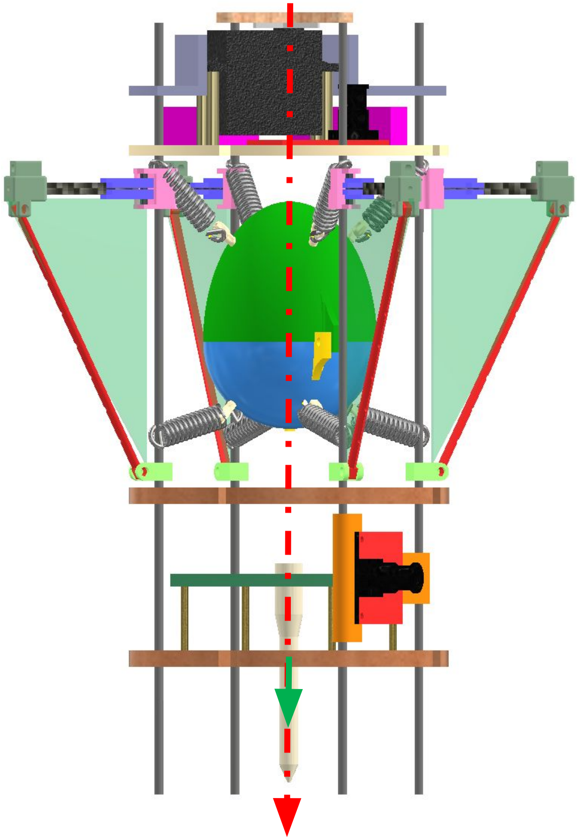
Design 2



Stowed Configuration: The CanSat will be stowed using friction and will be right side up for the duration of the ascent.

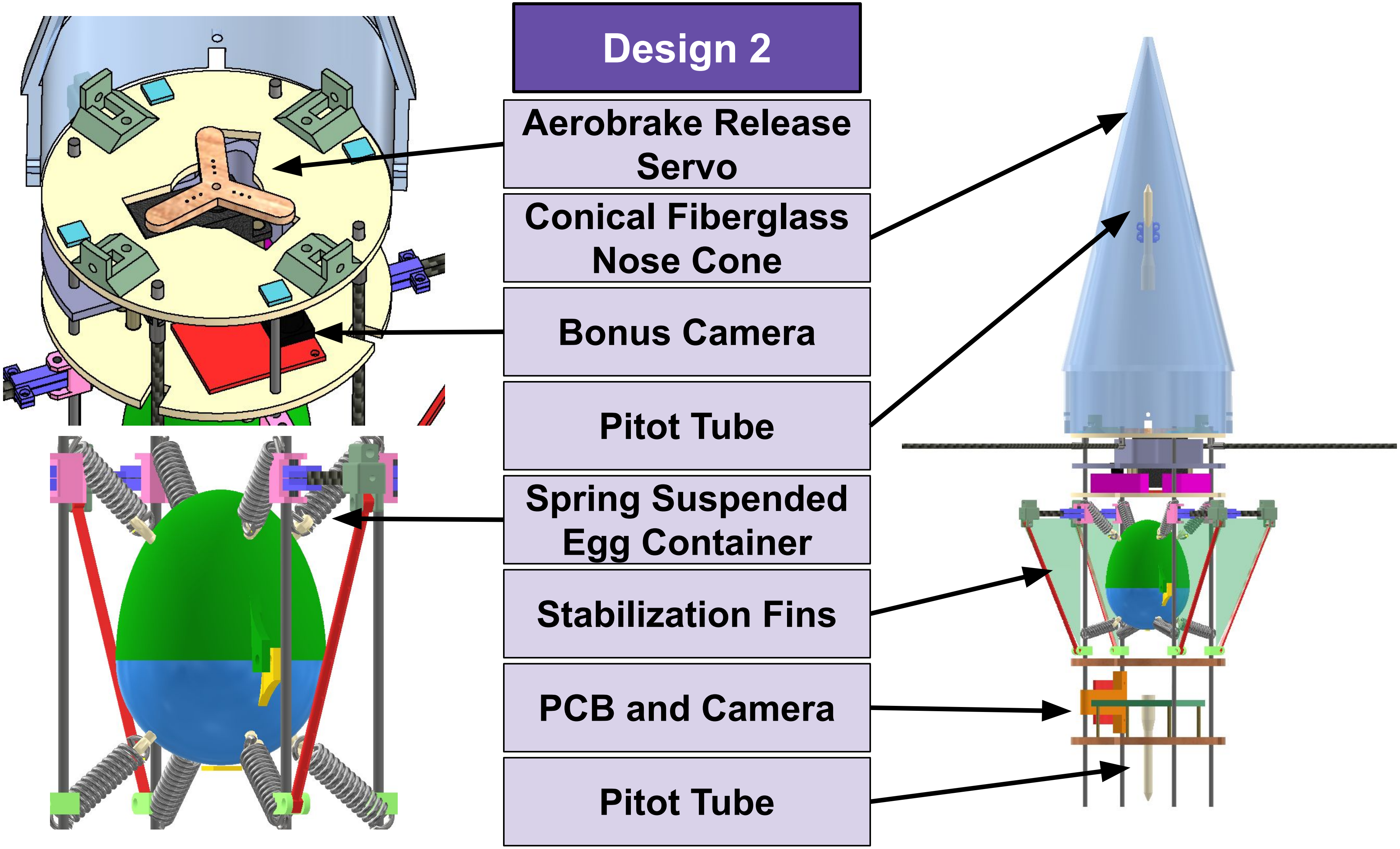


Aerobrake Descent Configuration: The CanSat will use a second pitot tube on descent.



Released Aerobrake Configuration: The CanSat will release the aerobrake and nose cone deploying the parachute.

System Level CanSat Configuration Trade & Selection (5 of 12)



Design 2

Aerobrake Release Servo

Conical Fiberglass Nose Cone

Bonus Camera

Pitot Tube

Spring Suspended Egg Container

Stabilization Fins

PCB and Camera

Pitot Tube

System Level CanSat Configuration Trade & Selection (7 of 12)

Aerobrake

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	4	32	8	64
Decent Rate	8	4	32	8	64
Cost	2	4	8	8	16
Complexity	4	2	8	4	16
Weighted Scores		80		160	

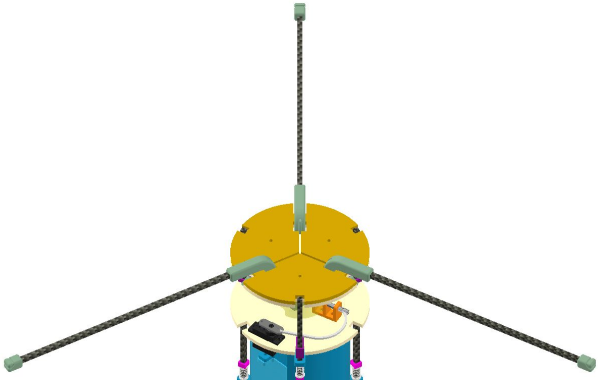
Selection and reasoning: Design 2
Design 2’s aerobrake system provides a smaller mass, slower descent rate, and lower cost than design 1. The selected design also completes all necessary functions with fewer parts through passive rather than active functions.

System Level CanSat Configuration Trade & Selection (8 of 12)

Aerobrake

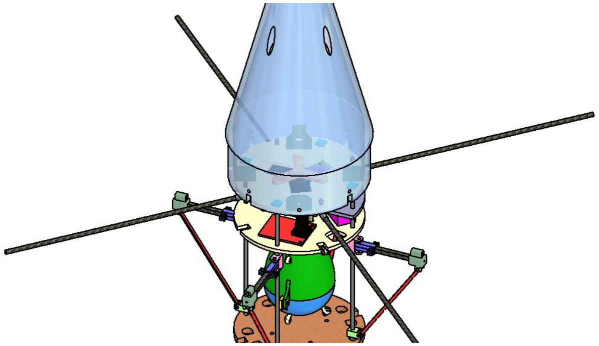
Aerobrake Deployment and Release	Fabric	Servos	Arms
Design 1	Nylon	2	3
Design 2	Nylon	1	4

Design 1



Final

Design 2



System Level CanSat Configuration Trade & Selection (9 of 12)

Camera

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Stabilization	8	8	64	2	16
FOV Control	8	8	64	4	32
Mass	4	4	16	8	32
Cost	2	4	8	8	16
Weighted Scores		152		96	

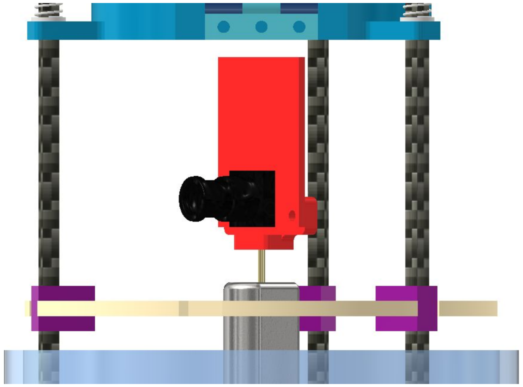
Selection and reasoning: Design 1
Design 1's camera system provides greater stability and has better field of view control. While the selected design completes all necessary functions with more parts and with active rather than passive functions, it will be more reliable than Design 2.

System Level CanSat Configuration Trade & Selection (10 of 12)

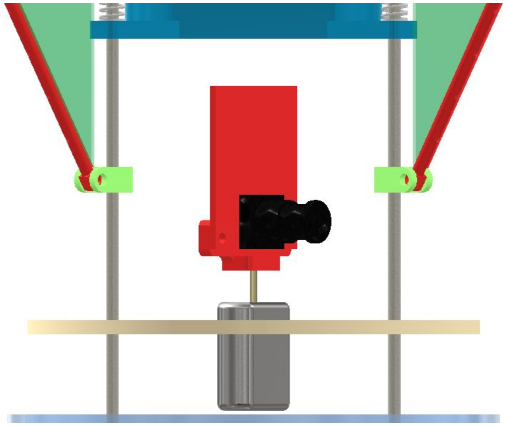
Camera

Camera	Mass (g)	Motors	Stabilization
Design 1	59	1	NF123G-305 Brushed Motor
Design 2	27	0	CanSat Frame

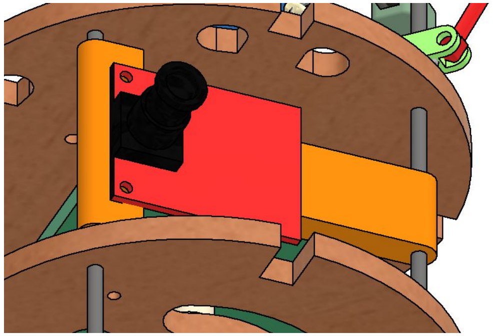
Design 1



Final



Design 2



System Level CanSat Configuration Trade & Selection (11 of 12)

Egg Container

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	8	64	2	16
Volume	8	4	32	8	64
Cushion Material	4	8	32	4	16
Accessibility	2	8	16	4	8
Weighted Scores		144		104	

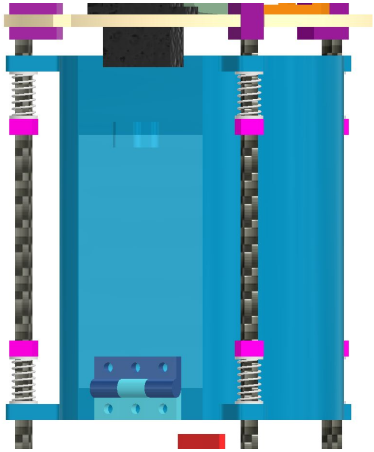
Selection and reasoning: Design 1
Design 1’s egg container has less mass, uses memory foam for better egg protection, and provides easier access to the egg during competition.

System Level CanSat Configuration Trade & Selection (12 of 12)

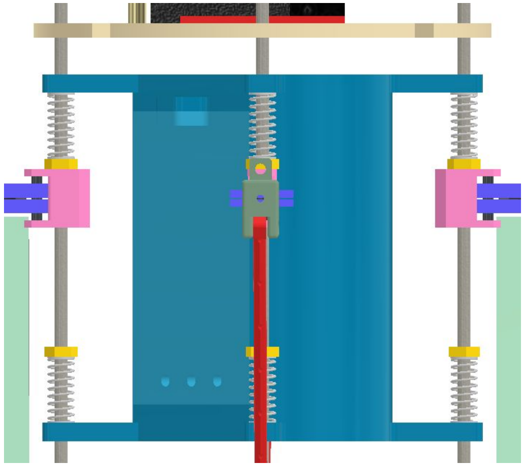
Egg Container

Egg Holder	Mass	Access Method	Egg Safety
Design 1	64g	Latch	Memory Foam
Design 2	125g	Screw Top	Bubblewrap

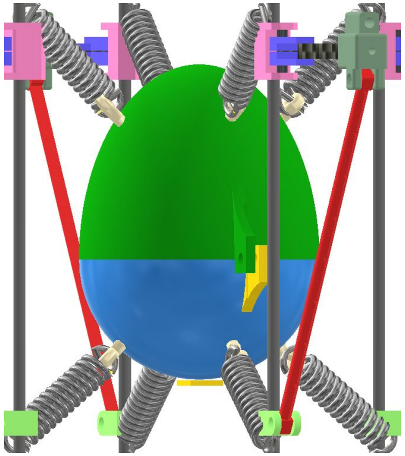
Design 1



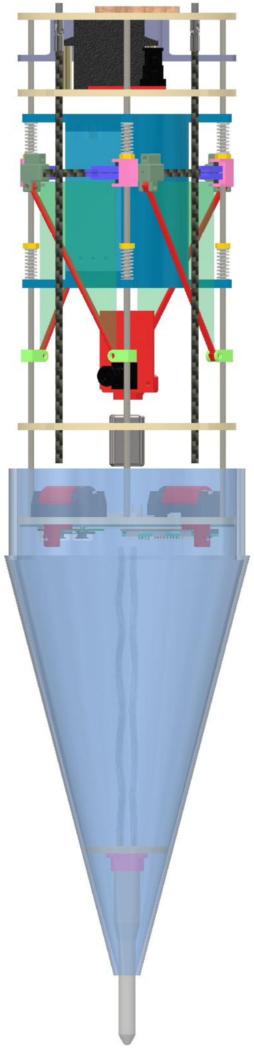
Final



Design 2

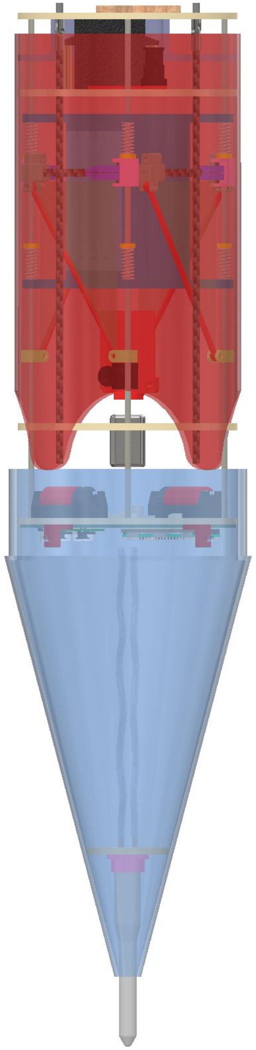


System Level Configuration Selection



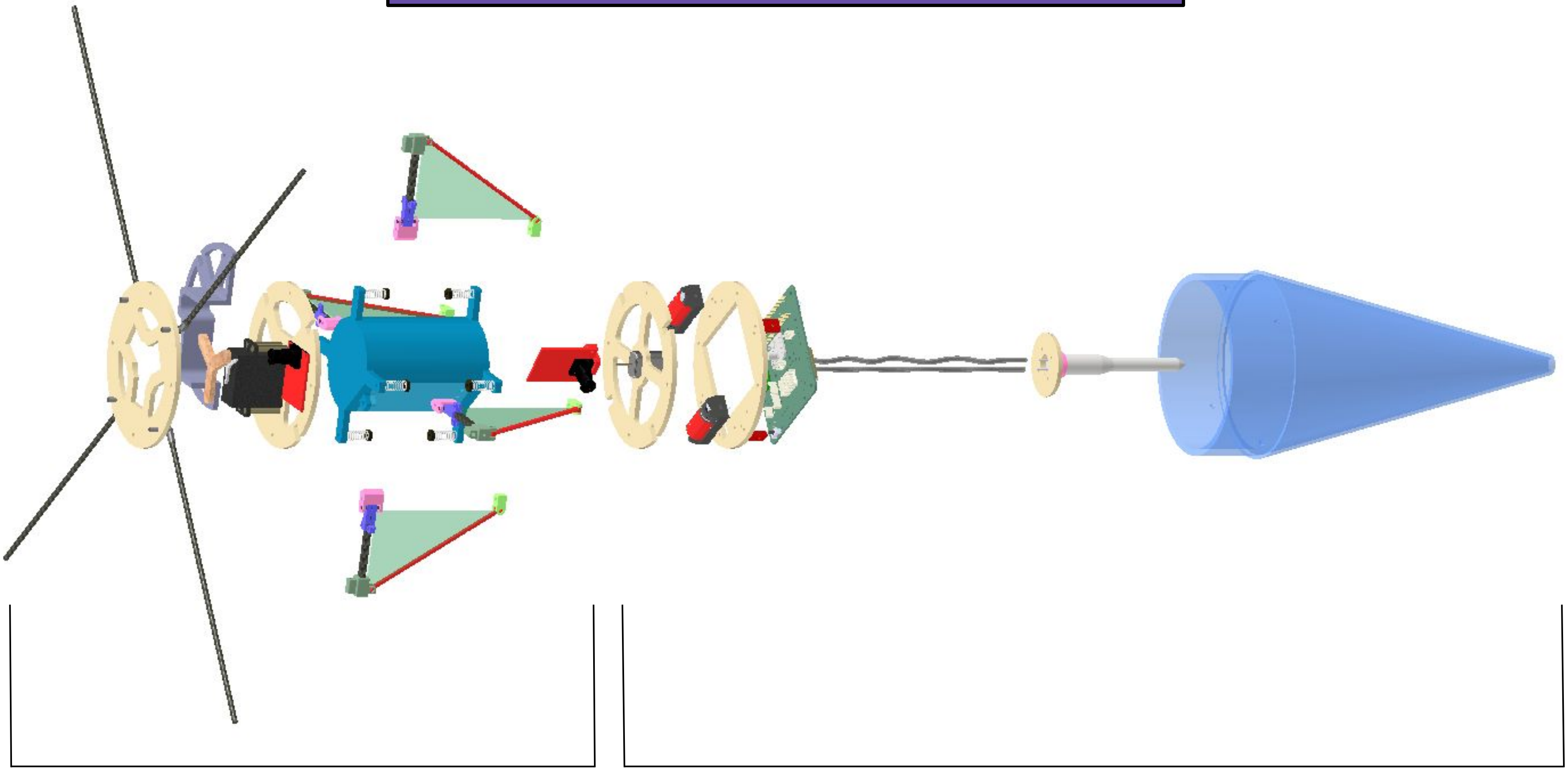
(THIS IS A COMBINATION OF BOTH DESIGNS)

Selection: Combination		
Component	**Design**	**Rationale**
Aerobrake Deployment and Release	Design 2	• Lighter • Used less servos • Used less space
Camera	Design 1	• Provides better camera stabilization • Active stabilization control
Egg Holder	Design 1	• More reliable • Easier access • Manufactuability



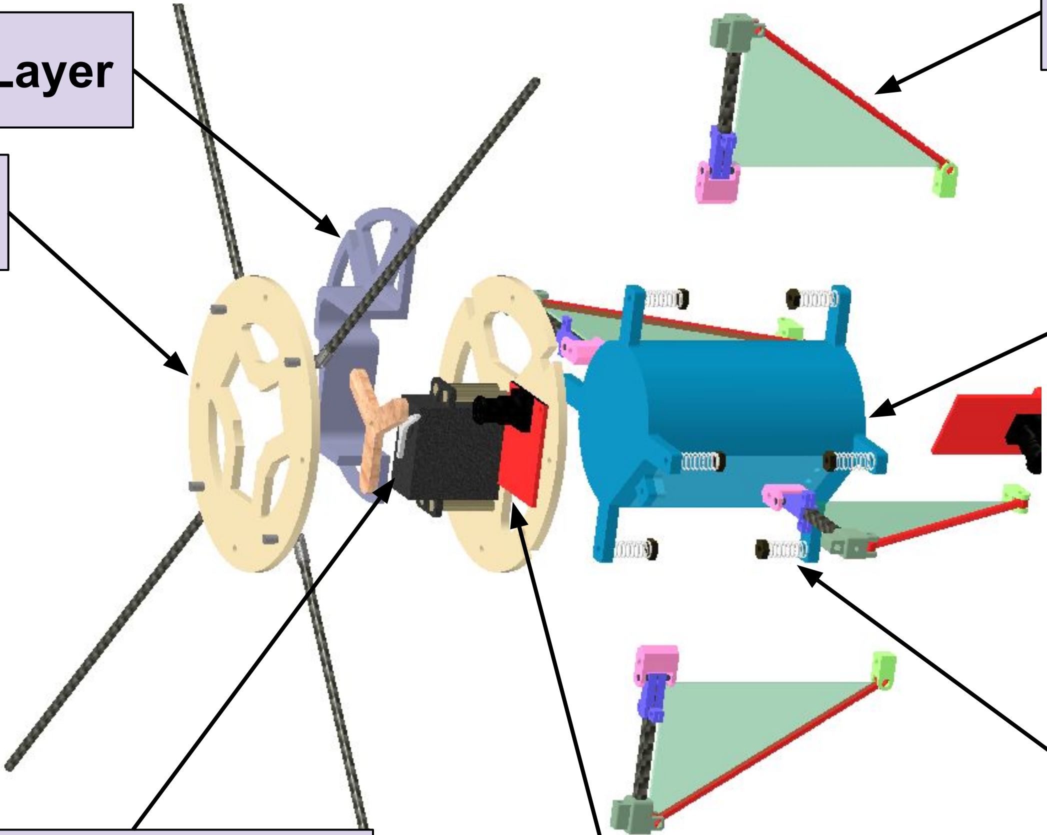
Physical Layout (1 of 6)

Final Design: Full Exploded View



Physical Layout (2 of 6)

Final Design: Top Exploded View



Stabilization Fins

Parachute Layer

Egg Container

Aerobrake Layer

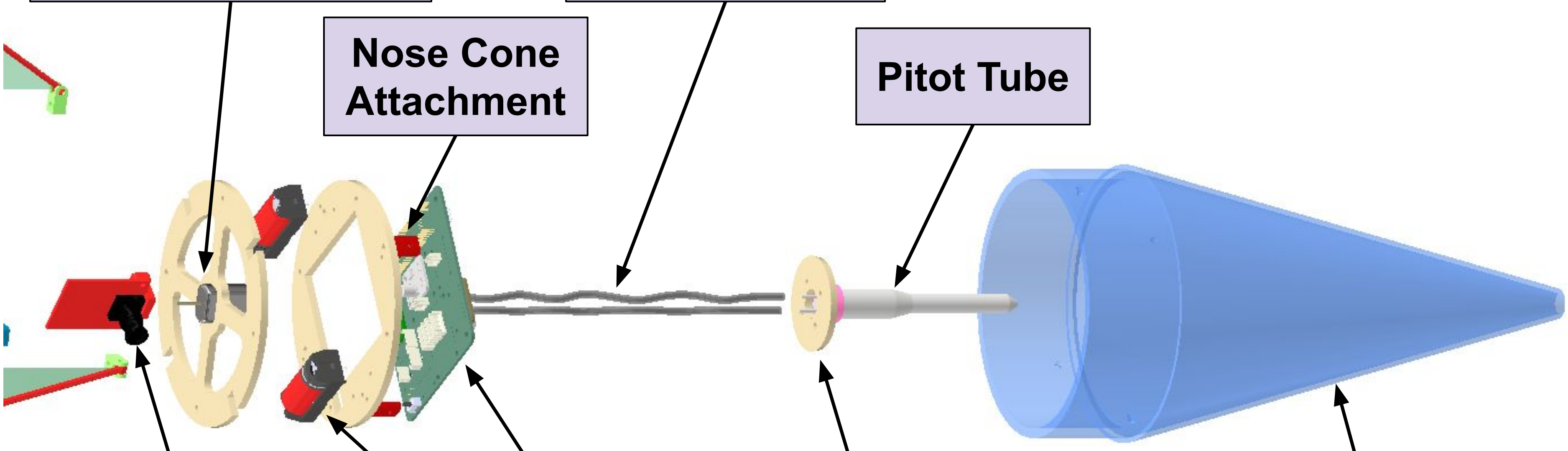
Springs

Parachute and Aerobrake Release

Bonus Camera

Physical Layout (3 of 6)

Final Design: Bottom Exploded View



DC Brushed Motor

Silicone Tubes

Nose Cone Attachment

Pitot Tube

2x CR123A Batteries

Pitot Tube Mount

Revolving Camera

PCB

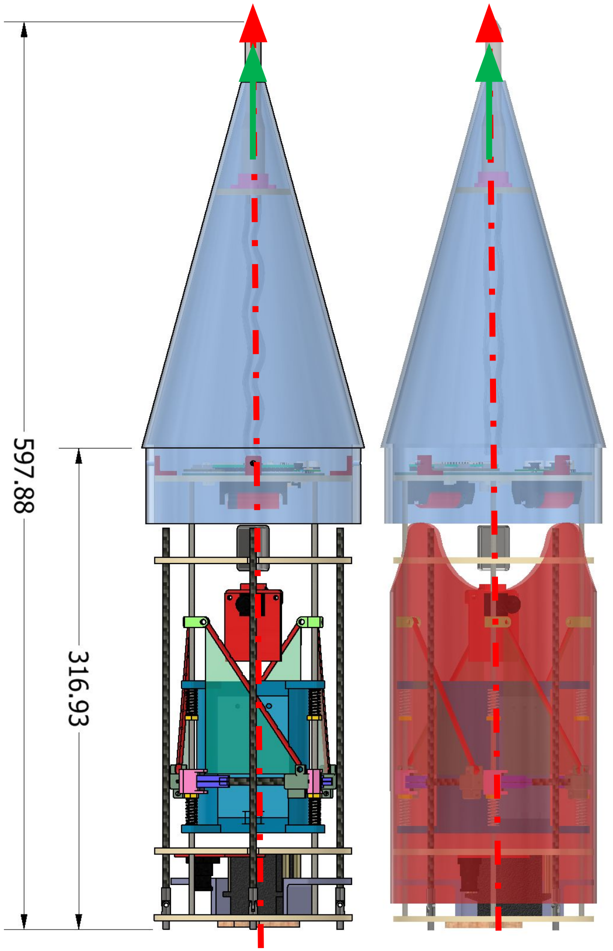
Fiberglass Nose Cone

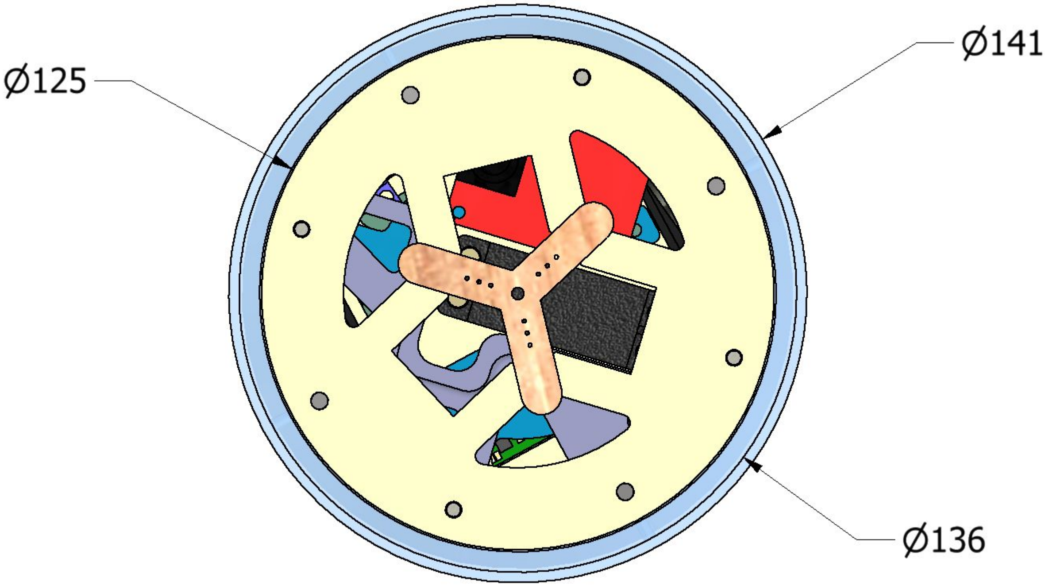
Physical Layout (4 of 6)

🟩 Direction of Travel

🟥 Nadir

Launch Configuration





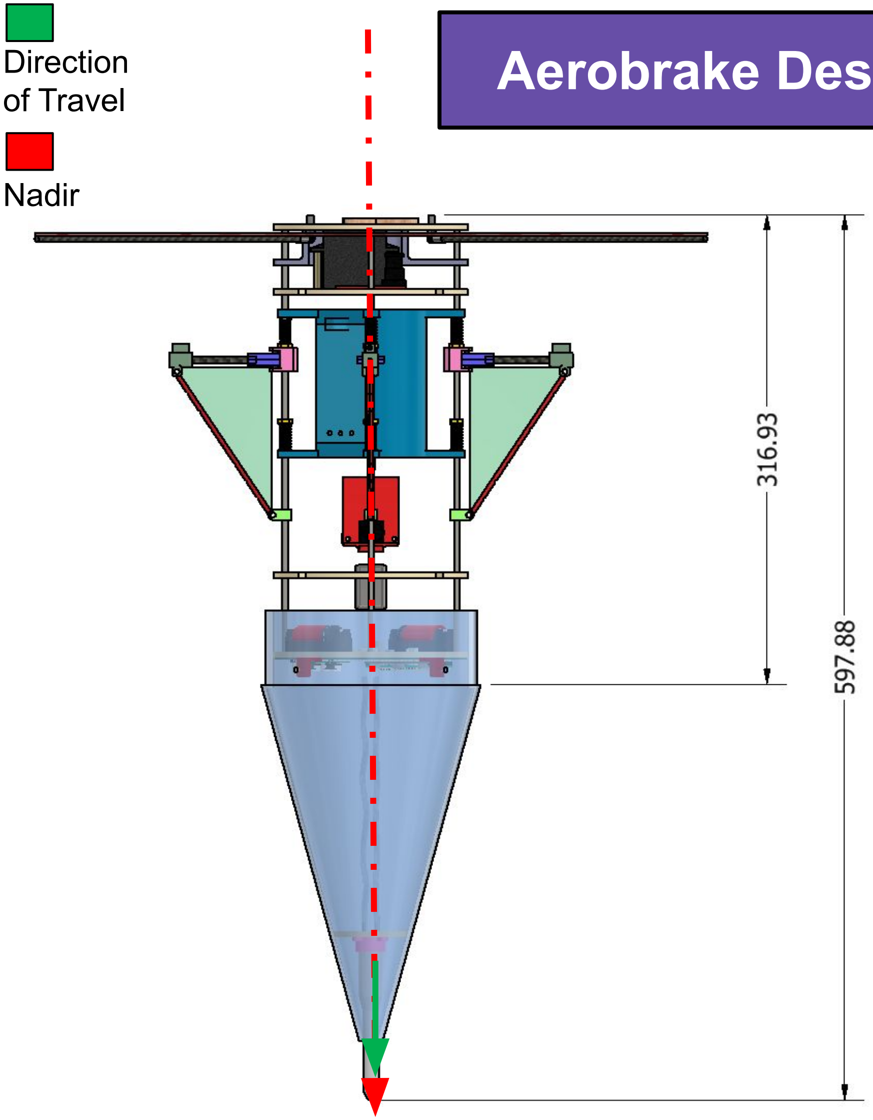
**Note:
All dimensions are in mm**

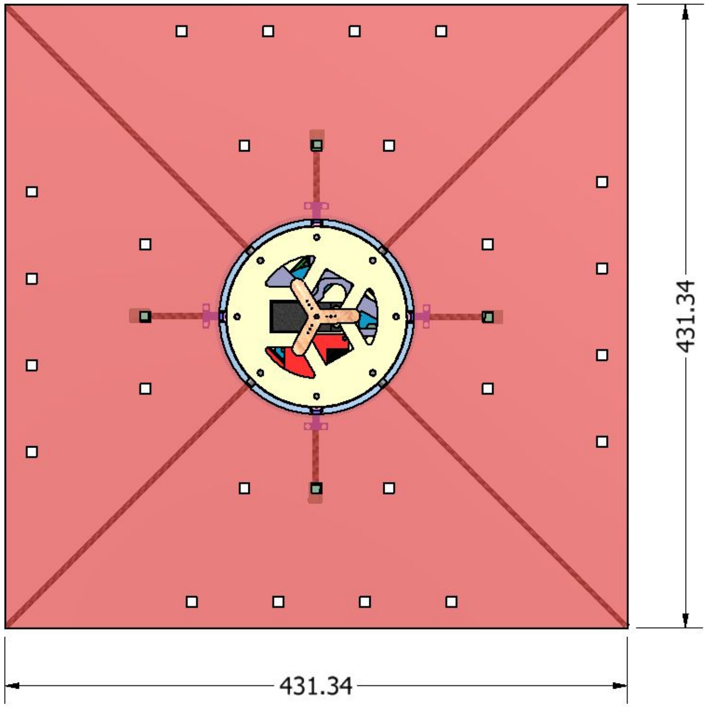
Physical Layout (5 of 6)

🟩 Direction of Travel

🟥 Nadir

Aerobrake Descent Configuration





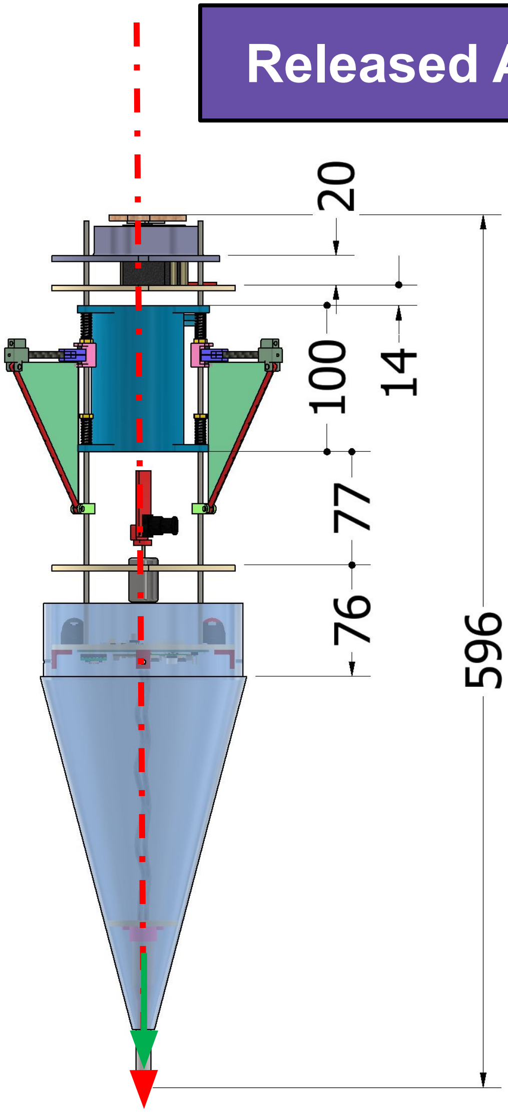
Note: All dimensions are in mm

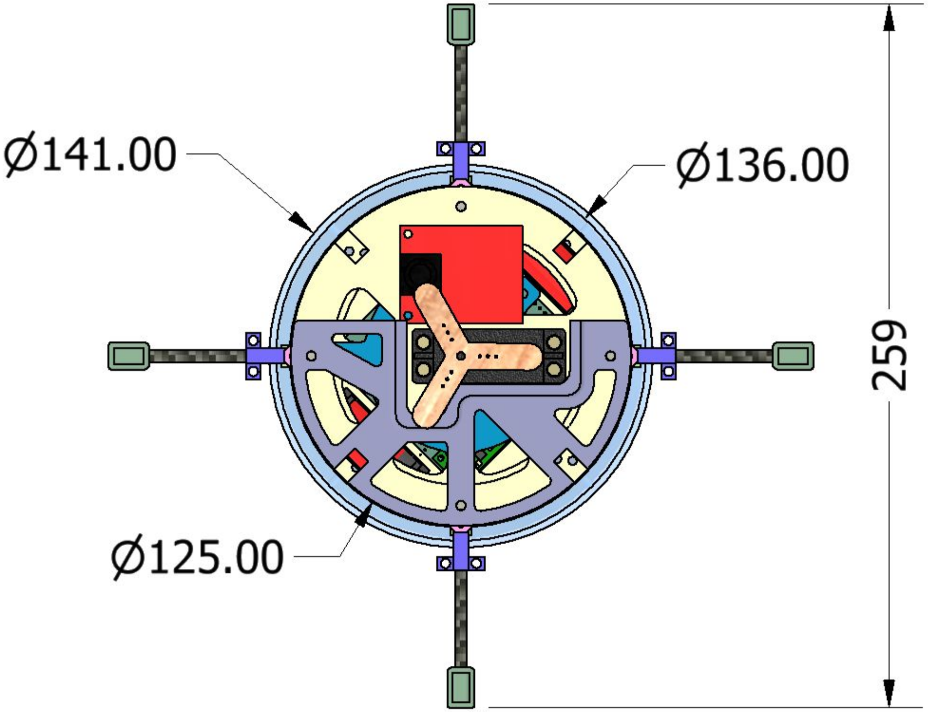
Physical Layout (6 of 6)

🟩 Direction of Travel

🟥 Nadir

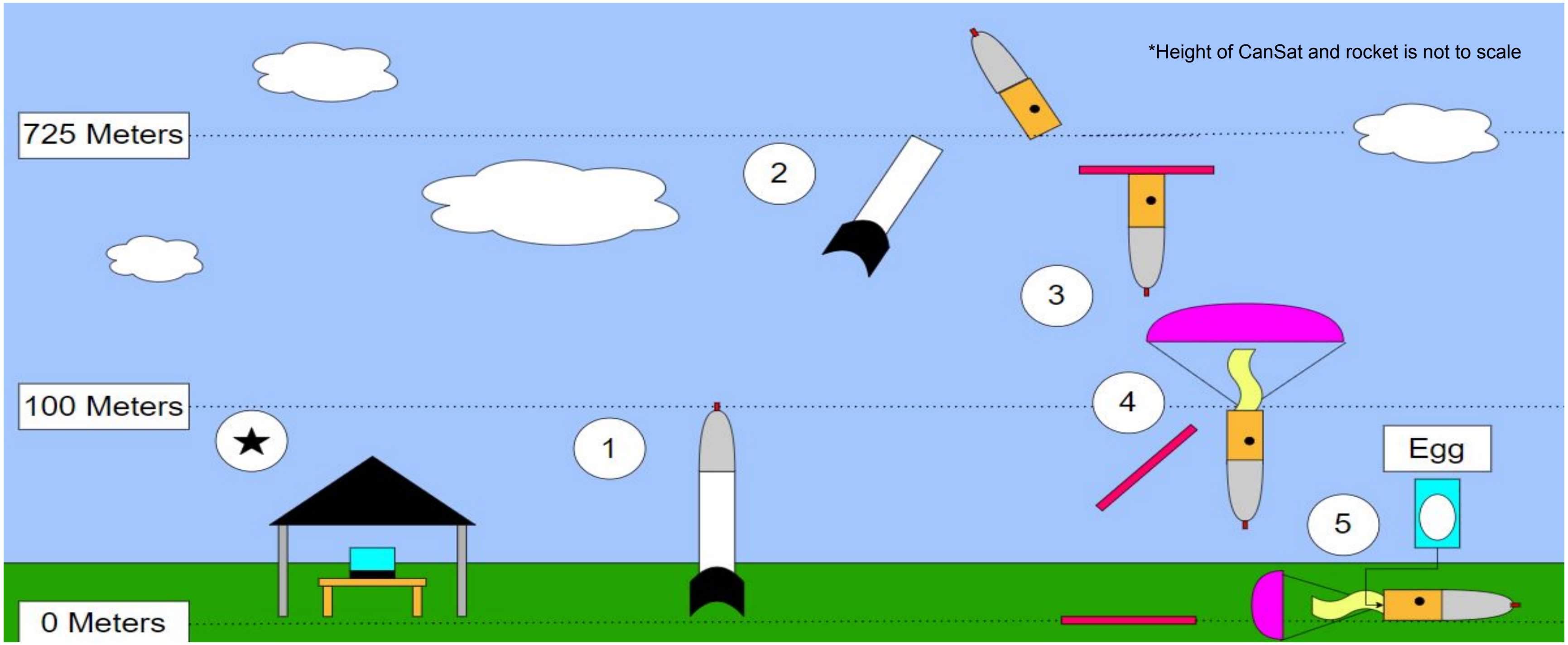
Released Aerobrake Configuration





Note:
All dimensions are in mm

System Concept of Operations



★	1	2	3	4	5
Ground Station receives telemetry during flight.	CanSat is loaded into rocket and zeroed before flight.	CanSat deploys at 725 meters above ground level.	After ejection, CanSat deploys aerobrake.	At 100 meters, the CanSat releases aerobrake and deploys parachute.	CanSat lands on the ground with egg intact and mylar visible.

Launch Vehicle Compatibility

🟩 Direction of Travel

🟥 Nadir

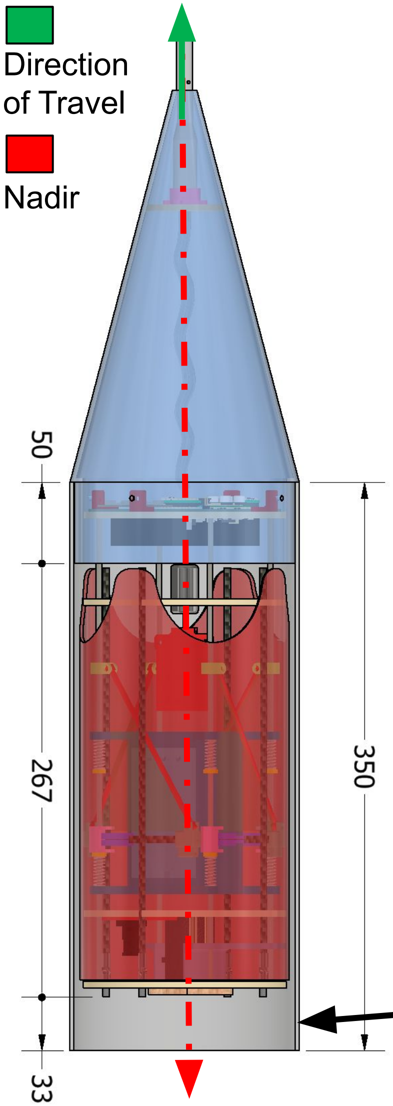
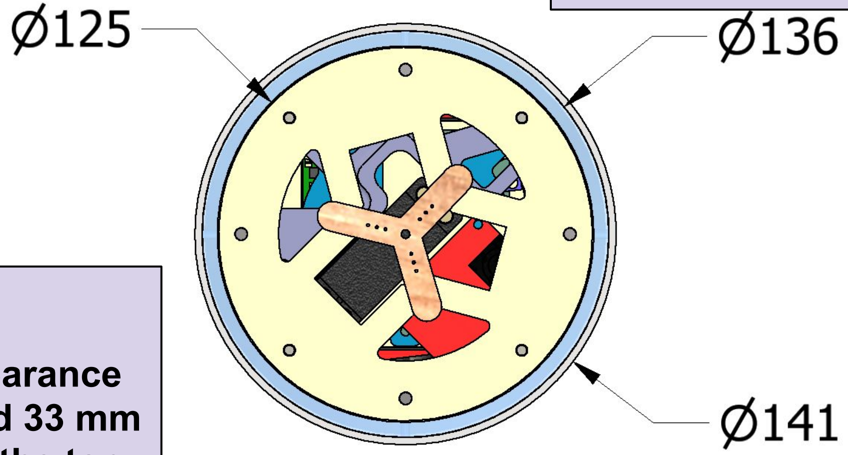


Plate Diameter

Payload Section Inner Diameter



Outer Diameter of Nose Cone

Note:
There is 5.5 mm of clearance around the payload and 33 mm of clearance between the top of the payload and the top of the payload section.

Shell of Payload Section of Rocket

Note:
All dimensions are in mm

Note:
The CanSat has no sharp edges or protrusions

Sensor Subsystem Design

Nic Ruse

Sensor Subsystem Overview

System	Sensor	Description
Air Pressure	Adafruit BMP390	Measures Air Pressure
Air Temperature	Adafruit BMP390	Monitors Air Temperature
Battery Voltage	Voltage Divider Circuit	Measures Battery Voltage
Air Speed Sensor	PixHawk PX4	Measures Air Speed
Orientation	Adafruit BNO055	Measures CanSat Orientation
GPS	SparkFun MAX-M10S	Tracks Longitude and Latitude of the CanSat
Camera	OpenMV Cam H7 R1	Records Single View From the CanSat
Bonus Camera	OpenMV Cam H7 R1	Records Parachute Release

Payload Air Pressure Sensor Trade & Selection (1 of 2)

Figures of Merit	Weight	SparkFun LPS35HW		Adafruit BMP390		Adafruit LPS25HB	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Rel. Baro. Accuracy	8	1	8	4	32	2	16
Power Consumption	4	4	16	8	32	1	4
Data Rate	4	2	8	4	16	1	4
Cost	2	4	8	4	8	8	16
Weighted Scores		40		88		40	

Payload Air Pressure Sensor Trade & Selection (2 of 2)

Sensor	Rel. Barometer Accuracy (Pa)	Data Rate (Hz)	Cost (USD)
SparkFun LPS35HW	±20	75	$12.50
Adafruit BMP390	±3	100	$10.95
SparkFun LPS25HB	±10	25	$9.95

Selection: **Adafruit BMP390**
- **Sufficient Accuracy**
- **Adequate Data Rate**
- **Lowest Cost**

Image Credit: adafruit.com

Payload Air Temperature Sensor Trade & Selection (1 of 2)

Figures of Merit	**Weight**	**SparkFun AS6212**		**Adafruit BMP390**		**Adafruit BME688**	
		Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Absolute Temperature Accuracy	8	4	32	2	16	1	8
Comm. Lines	8	2	16	4	32	4	32
Dual Purpose	4	8	32	4	16	1	4
Power Consumption	4	1	4	8	32	8	32
Cost	2	4	8	4	8	1	2
Weighted Scores		92		104		78	

Payload Air Temperature Sensor Trade & Selection (2 of 2)

Sensor	Absolute Temperature Accuracy (°C)	Dual Purpose (Yes, No)	Comm. Lines	Cost (USD)
SparkFun AS6212	±0.2	No	I2C	$9.95
Adafruit BMP390	±0.5	Yes	I2C, SPI	$10.95
Adafruit BME688	±1.0	Yes	I2C, SPI	$24.95

Selection: Adafruit BMP390
- **Dual Function**
- **Optimal Accuracy**

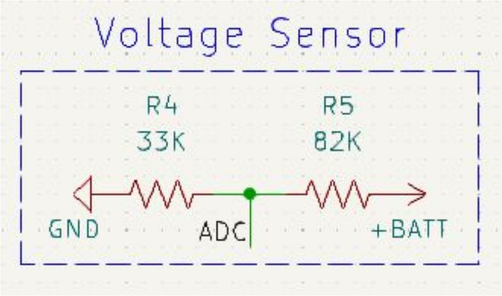
Image Credit: adafruit.com

Payload Battery Voltage Sensor Trade & Selection (1 of 2)

Figures of Merit	Weight	HiLetgo Voltage Sensor		Voltage Divider Circuit		WayinTop Hall Effect Current Sensor	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Mass	8	2	16	8	64	2	16
Voltage Range	4	4	16	4	16	4	16
Cost	2	4	8	8	16	2	4
Weighted Scores		40		96		36	

Payload Battery Voltage Sensor Trade & Selection (2 of 2)

Sensor	Comm. Lines	Voltage Range (V)	Accuracy (V)	Cost (USD)
HiLetgo Voltage Sensor	AD	0-25	±0.00489	$5.89
Voltage Divider Circuit	ADC	0.02-25	±0.00489	$0.15
WayinTop Hall Effect Current Sensor	AD	0-25	±0.00489	$9.99



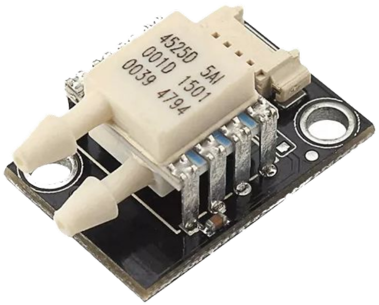
Selection: **Voltage Divider Circuit**
- **Low Cost**
- **Small Footprint**

Payload Speed Sensor Trade & Selection (1 of 2)

Figures of Merit	Weight	PixHawk PX4		Matek ASPD-DLVR	
		Unweighted	Weighted	Unweighted	Weighted
Maximum Pressure	8	8	64	2	16
Accuracy	8	8	64	4	32
Cost	2	4	8	1	2
Weighted Scores		136		50	

Payload Speed Sensor Trade & Selection (2 of 2)

Sensor	Maximum Pressure (kPA)	Accuracy (PSI)	Comm. Lines	Cost (USD)
Matek ASPD-DLVR	75	±0.36	I2C	$109.99
PixHawk PX4 Airspeed Sensor	137.9	±0.25	I2C	$49.99



<u>Selection:</u> PixHawk PX4
- **Higher Maximum Pressure**
- **Higher Accuracy**
- **Lower Cost**

Image Credit: robotics.org

Payload Tilt Sensor Trade & Selection (1 of 2)

Figures of Merit	Weight	SparkFun BNO086		Adafruit BNO055		Adafruit Tilt Ball Switch	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Gyroscopic Accuracy	8	4	32	8	64	4	32
Voltage	2	2	4	2	4	8	16
Cost	2	4	8	2	4	8	16
Weighted Scores		44		72		64	

Payload Tilt Sensor
Trade & Selection (2 of 2)

Sensor	Gyroscopic Accuracy (°)	Voltage (V)	Cost ($)
SparkFun BNO086	±3.1	3.3 to 5	$24.95
Adafruit BNO055	±2.5	3.3	$34.95
Adafruit Tilt Ball Switch	±15	0 to 24	$2.00

<u>Selection:</u> Adafruit BNO055
- **Highest Accuracy**
- **Voltage Integration**

Image Credit: sparkfun.com

Rotation Sensor
Trade & Selection (1 of 2)

Figures of Merit	Weight	Adafruit BNO085		Adafruit BNO055		SparkFun BNO086	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Gyroscopic Accuracy	8	4	32	8	64	4	32
Power Consumption	4	4	16	4	16	2	8
Cost	2	4	8	2	4	4	8
Weighted Scores		56		84		48	

Rotation Sensor Trade & Selection (2 of 2)

Sensor	Axis	Gyroscopic Accuracy (°)	Comm. Lines	Cost (USD)
Adafruit BNO085	9	±3.1	I2C, SPI	$24.95
Adafruit BNO055	9	±2.5	I2C, SPI	$34.95
SparkFun BNO086	9	±3.1	I2C, SPI	$29.95

<u>Selection:</u> Adafruit BNO055

- **Higher Accuracy**
- **Included 9 Axis**

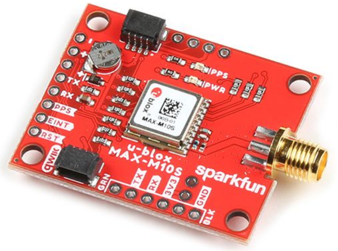
Image Credit: sparkfun.com

Payload GPS Sensor Trade & Selection (1 of 2)

Figures of Merit	Weight	SparkFun ZOE-M8Q		SparkFun MAX-M10S		SparkFun SAM-M8Q	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Horizontal Accuracy	8	2	16	8	64	2	16
Cold Boot Time	8	2	16	4	32	2	16
Antenna Support	4	2	8	8	32	1	4
Cost	2	1	2	4	8	4	8
Weighted Scores		42		136		44	

Payload GPS Sensor Trade & Selection (2 of 2)

Sensor	Accuracy (m)	Hot Boot Time (s)	Cold Boot Time (s)	Antenna Support	Integrated Battery	Cost (USD)
SparkFun SAM-M8Q	±2.5	1	26	N/A	Yes	$42.95
SparkFun MAX-M10S	±1.5	1	24	SMA	Yes	$44.95
SparkFun ZOE-M8Q	±2.5	1	26	U.FL	Yes	$49.95



<u>Selection:</u> SparkFun MAX-M10S

- **Most Accurate**
- **Fastest Cold Boot Time**
- **Durable Antenna Connector**

Image Credit: adafruit.com

Payload Camera Trade & Selection (1 of 2)

Figures of Merit	Weight	Spy Camera		OpenMV Cam H7 R1		TTL Serial Camera	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Video Preprocessor	2	1	2	8	16	1	2
Frame Rate	8	8	64	4	32	1	8
Onboard Video Storage	8	1	8	8	64	1	8
Cost	2	8	16	2	4	8	16
Weighted Scores		90		116		34	

Payload Camera Trade & Selection (2 of 2)

Module	Tracking Features	Battery	Onboard Video Storage	Frame Rate (fps)	Resolution	Cost (USD)
Spy Camera	No	No	No	60-90	640x480	$39.95
OpenMV Cam H7 R1	Yes	Yes	SD Card	75	640x480	$101.94
TTL Serial Camera	No	No	No	30	640x480	$39.95

Selection: OpenMV Cam H7 R1
- **Onboard Video Storage**
- **Onboard Battery Backup**
- **Chip for Object Recognition**

Image Credit: adafruit.com

Bonus Camera Trade and Selection (1 of 2)

Figures of Merit	Weight	Spy Camera		OpenMV Cam H7 R1		TTL Serial Camera	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Video Preprocessor	2	1	2	8	16	1	2
Frame Rate	8	8	64	4	32	1	8
Onboard Video Storage	8	1	8	8	64	1	8
Cost	2	8	16	2	4	8	16
Weighted Scores		90		116		34	

Bonus Camera Trade and Selection (2 of 2)

Module	Tracking Features	Battery	Onboard Video Storage	Frame Rate (fps)	Resolution	Cost
Spy Camera	No	No	No	60-90	640x480	$39.95
OpenMV Cam H7 R1	Yes	Yes	SD Card	75	640x480	$101.94
TTL Serial Camera	No	No	No	30	640x480	$39.95

Selection: **OpenMV Cam H7 R1**
- **Onboard Video Storage**
- **Onboard Battery Backup**
- **Chip for Object Recognition**

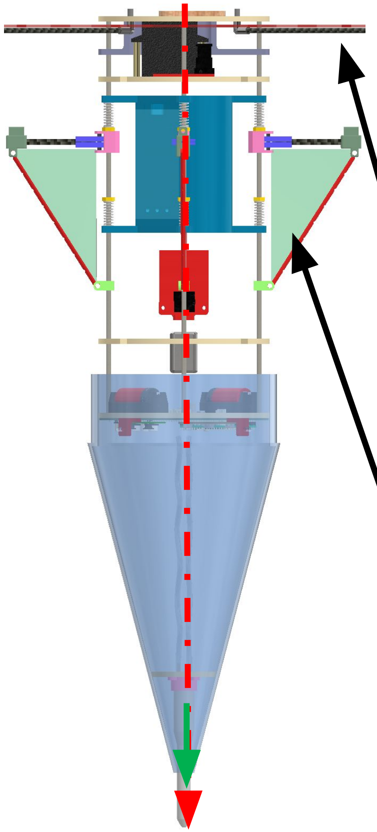
Image Credit: adafruit.com

Descent Control Design

Zach Jones, Jordan Littlepage

Descent Control Overview

Aerobrake Deployment Stage



(725 - 100 Meters)

Square Aerobrake With Spill Holes

- Components:
  - Servo
  - Rubber Bands
  - Nylon
  - Carbon Fiber

Stabilization Fins

- Components:
  - Fiberglass
  - 3D Print
  - Carbon Fiber
  - Rubber band

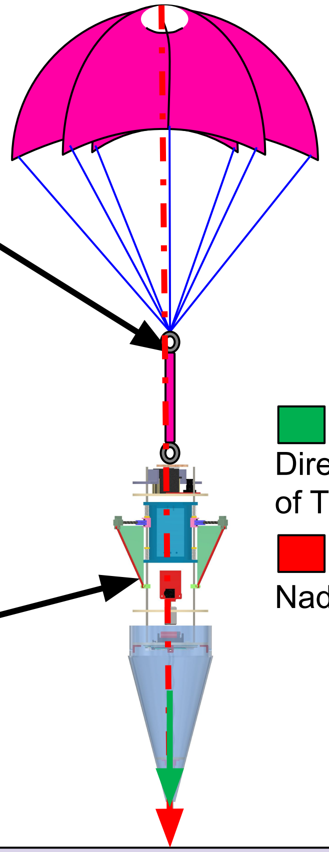
Parachute Mounts

- Components:
  - Metal O Ring
  - Paracord
  - Fishing Wire
  - Nylon

Active Rotating Camera about Z-Axis

- Components:
  - DC Motor
  - Camera
  - Composite Wood

Parachute Deployment Stage



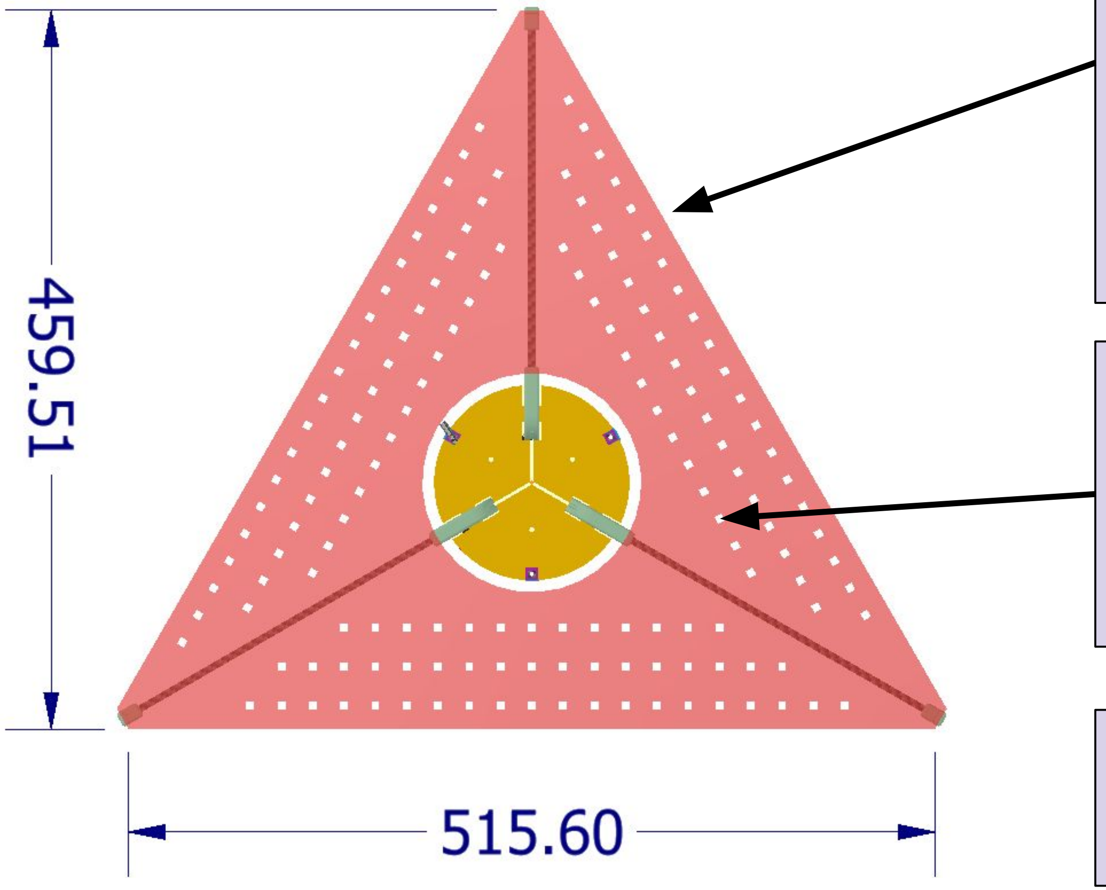
🟩 Direction of Travel

🟥 Nadir

(100 - 0 Meters)

Payload Aerobraking Descent Control Strategy Selection and Trade (1 of 4)

Design 1



Triangular Nylon Fabric

- Shape was chosen for the weight caused by the aerobrake carbon fiber arms.
- Size was calculated using descent rate formulas shown on slide 71.
- Descent rate = 14.4 m/s
- To be symmetrical, 120 degrees separates each aerobrake arm.

Spill Holes

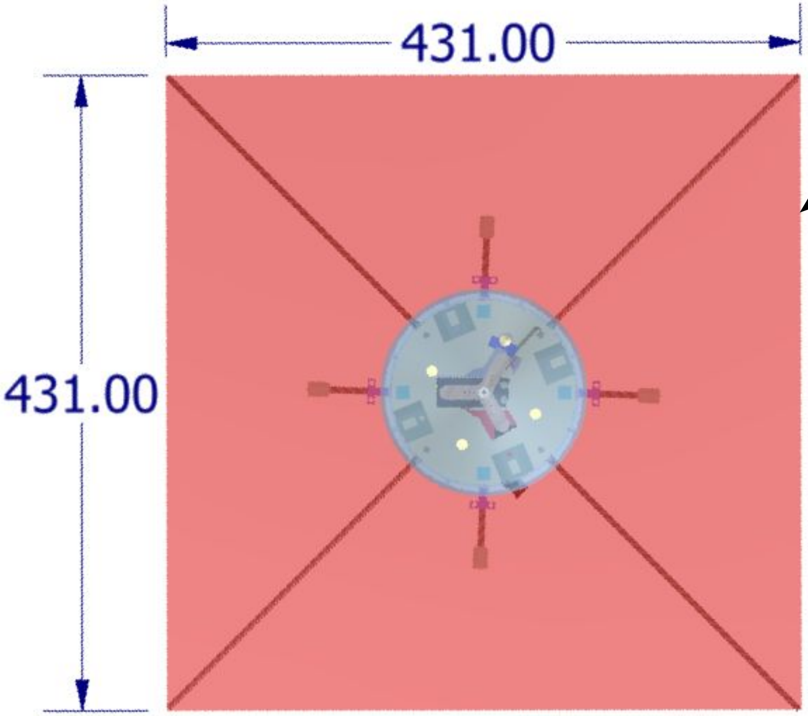
- The calculated function is to act as an air flow concentrator. Similar uses are on SBD Dauntless dive bombers to control descent.

Passive Control

Note:
All dimensions are in mm

Payload Aerobraking Descent Control Strategy Selection and Trade (2 of 4)

Design 2



Square Nylon Fabric

- Square shape was chosen because we wanted a shape close to a circle but weight constituted 4 arms.
- Size was chosen because of the descent calculations and limitations on CanSat height.
- Descent Rate = 11.2 m/s.
- We wanted a symmetrical shape to better calculate descent so the carbon fiber arms are 90 degrees apart.
- Nadir maintained by speed of CanSat and bottom heavy weight.

Rubber Band Operated

- Rubber bands were chosen due to them being lightweight .
- Rubber bands are also passive and do not require a servo.

Passive Control

Note:
All dimensions are in mm

Payload Aerobraking Descent Control Strategy Selection and Trade (3 of 4)

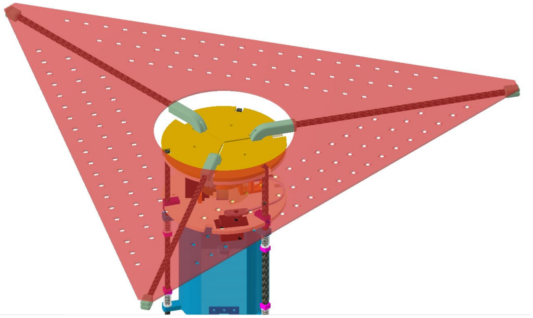
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	4	32	8	64
Descent Rate	8	8	64	4	32
Space Efficiency	4	2	8	8	32
Cost	2	8	16	8	16
Weighted Scores		120		144	

Selection and reasoning: Design 2
The square shape of Design 1 and spill holes added from Design 2 were combined into a final design. The final design has a width of 431 mm and a descent rate of 11.2 m/s. The spill holes will take up between 2.5% and 3% of the area and will slightly effect the descent speed, but they will provide additional stabilization and have a velocity between the 30m/s and 10m/s parameter.

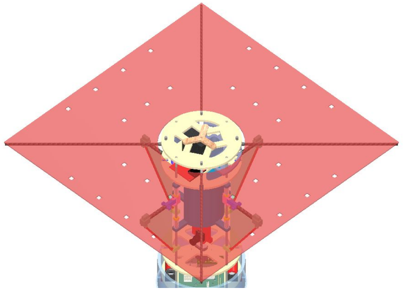
Payload Aerobraking Descent Control Strategy Selection and Trade (4 of 4)

Aerobrake Deployment and Release	Mass (g)	Servos	Arms	Shape	Size (mm^2)	Additional Descent Components	Descent Rate (m/s)
Design 1	~112	2	3 (120 degrees between arms)	Triangle	1.15x10^5	Spill Holes	14.433
Design 2	~88	1	4 (90 degrees between arms)	Square	1.86x10^5	N/A	11.218

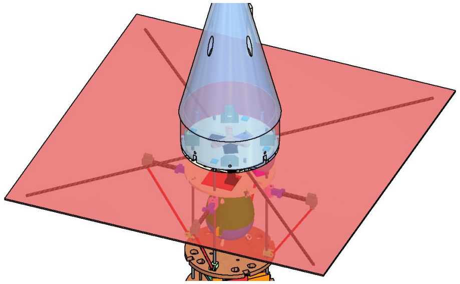
Design 1



Final



Design 2

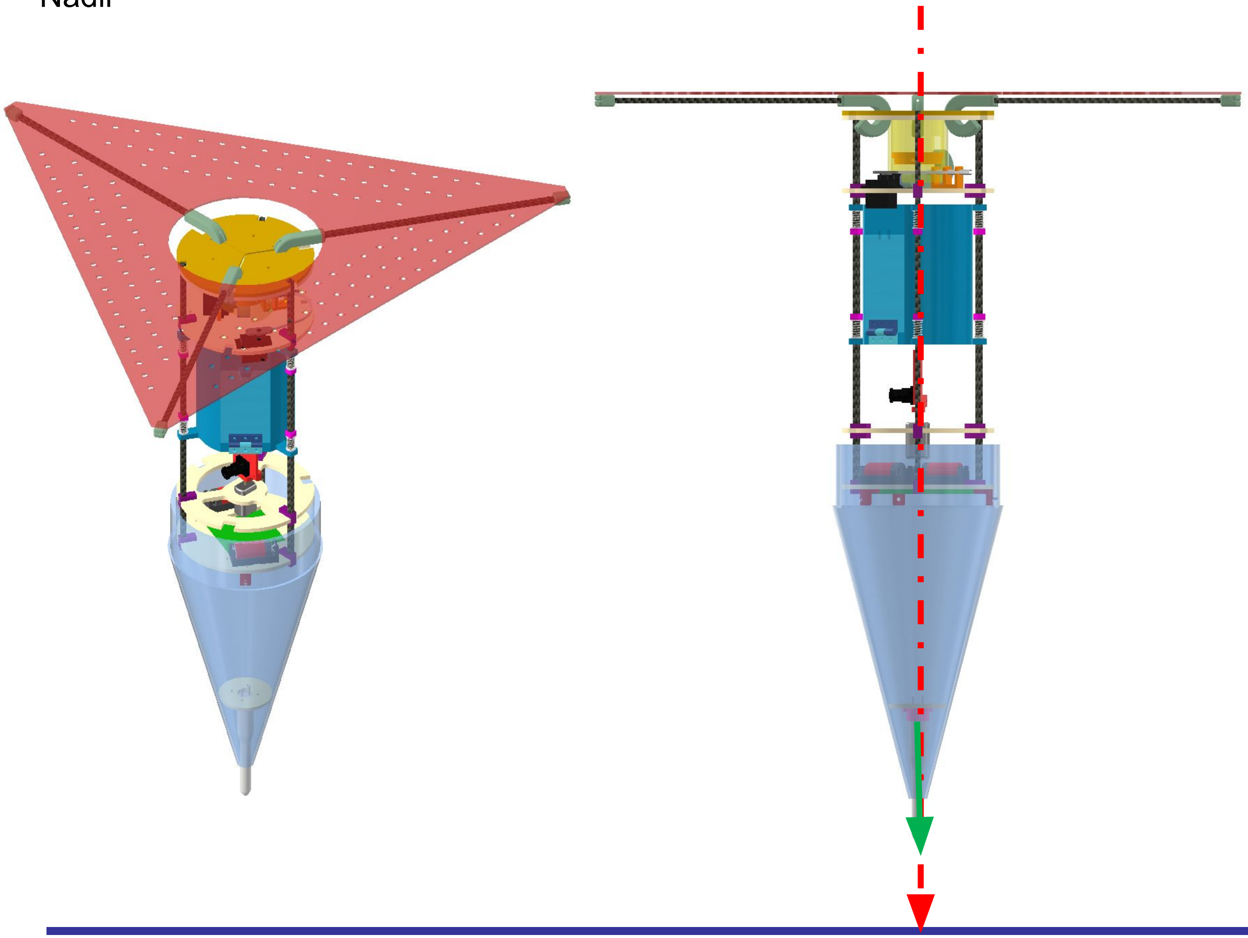


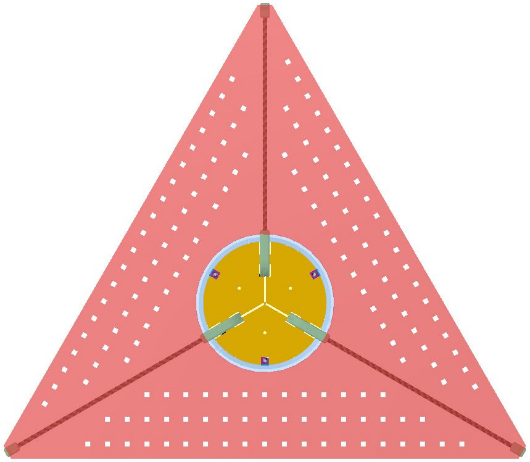
Payload Aerobraking Descent Stability Control Strategy Selection and Trade (1 of 4)

🟩 Direction of Travel

🟥 Nadir

Design 1





Triangular Shape

Passive Stability

- The spill holes are being used as a stabilization method.

Aerodynamic Shape

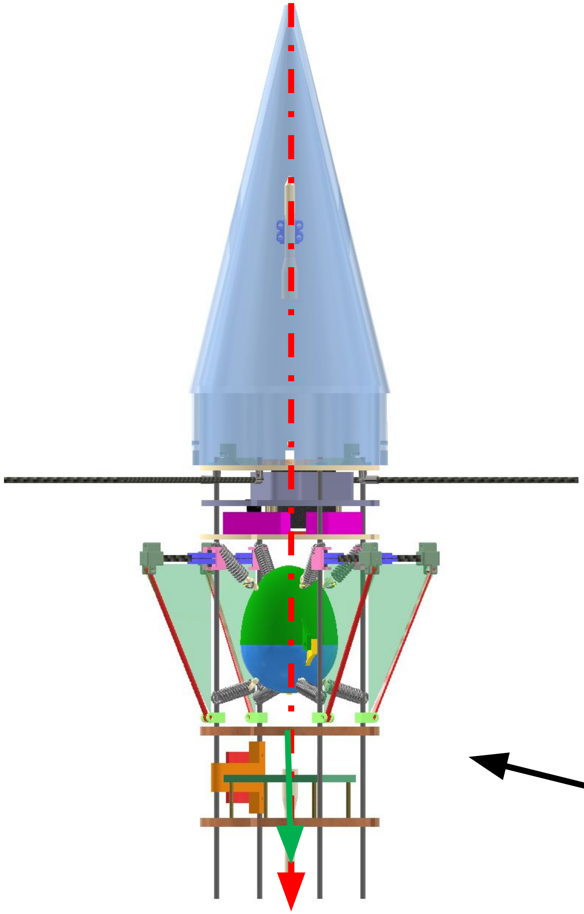
- Nose cone is used as a heat shield and is meant to prevent tumbling.

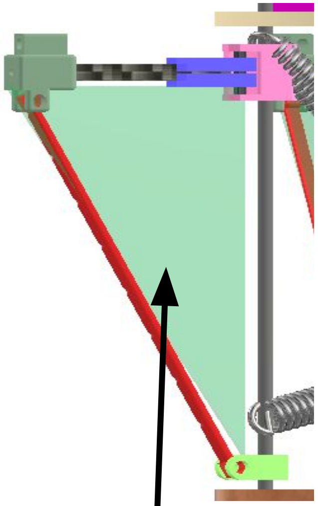
Payload Aerobraking Descent Stability Control Strategy Selection and Trade (2 of 4)

🟩 Direction of Travel

🟥 Nadir

Design 2





Fiberglass Sheet Inside Stabilization Fins

Passive Stability

- **Stability relies on stabilization fins to keep nadir.**

Square Shape

Payload Aerobraking Descent Stability Control Strategy Selection and Trade (3 of 4)

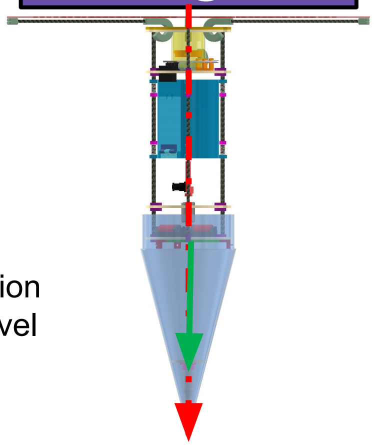
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	8	64	4	32
Stability	8	4	32	8	64
Reliability	4	2	8	8	32
Cost	2	4	8	8	16
Weighted Scores		112		144	

Selection and reasoning: Combination of Both Designs
A combination of both designs was chosen and integrated into our final design, including the nose cone in Design 1 and the stabilization fins in Design 2. The nose cone is made out of fiberglass, and the fins are made out of a carbon fiber, 3D printed frame, and a fiberglass sheet to save on mass while providing the same quality. This system results in passive stability control, and the stabilization fins with the nose cone maintain nadir.

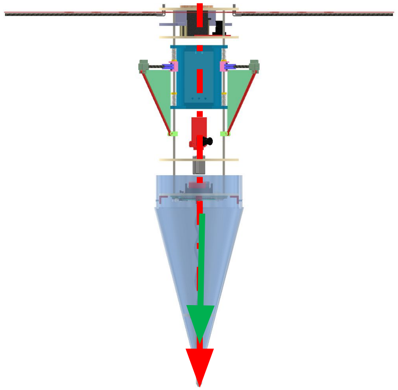
Payload Aerobraking Descent Stability Control Strategy Selection and Trade (4 of 4)

Design	Descent Method	Mass (g)	Materials	Shape	Assisting Systems
1	Passive	~47	Nylon Fabric, Carbon Fiber	Triangle	Spill Holes and Nose Cone
2	Passive	~65	Nylon Fabric, Carbon Fiber	Square	Stabilization Fins

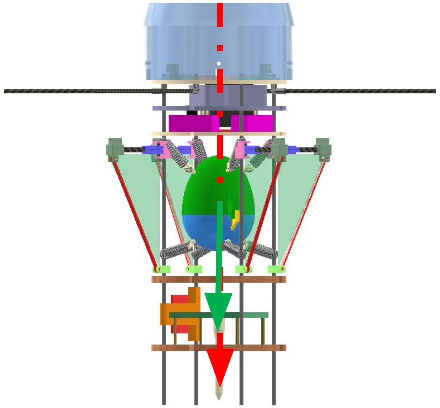
Design 1



Final



Design 2

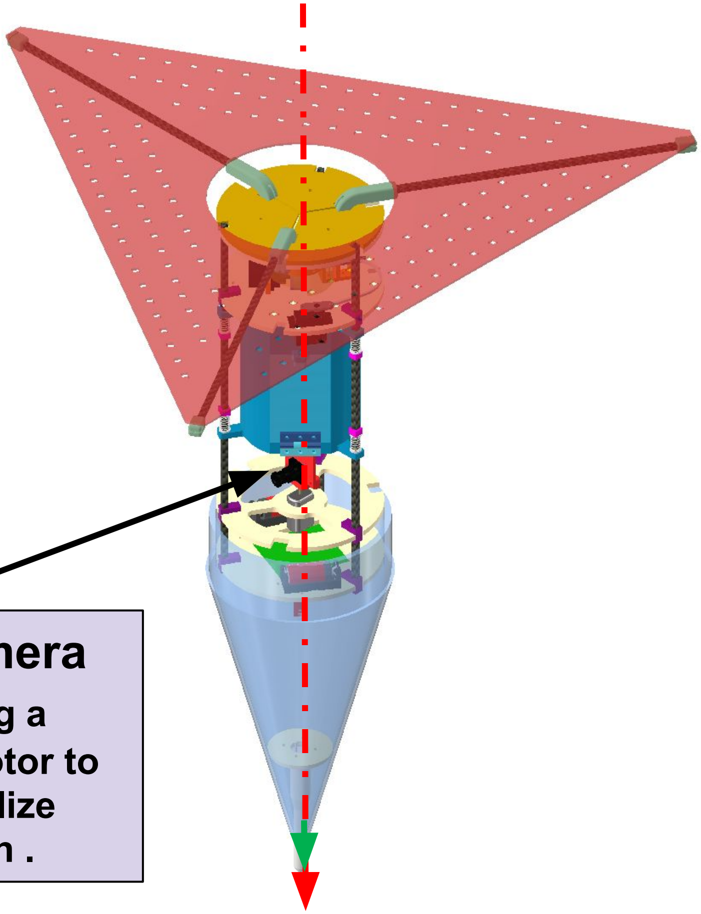


🟩 Direction of Travel

🟥 Nadir

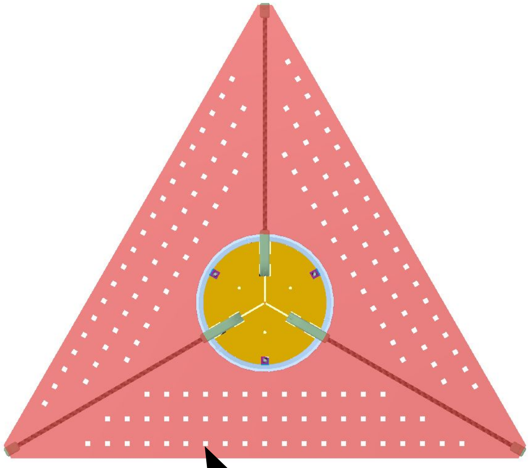
Payload Rotation Control Strategy Selection and Trade (1 of 4)

Design 1



Rotating Camera

- We are coding a brushless motor to actively stabilize z-axis rotation .

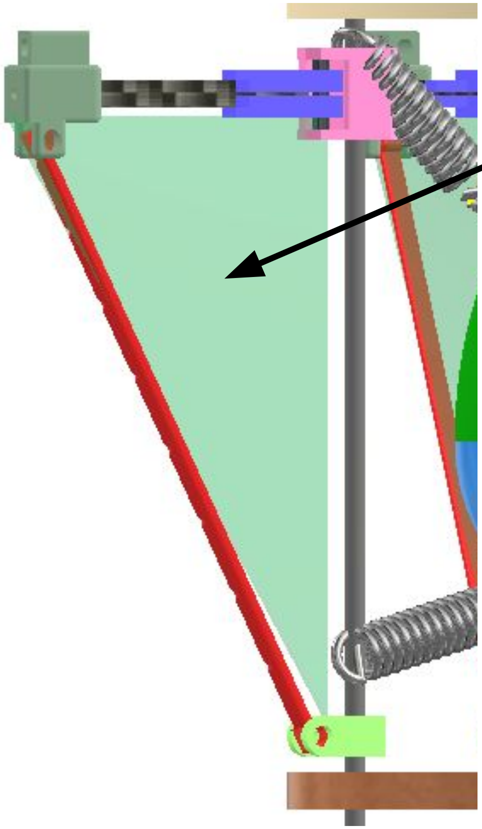


Spill Holes

- Working with the camera, the spill holes funnel air to stabilize descent.

Payload Rotation Control Strategy Selection and Trade (2 of 4)

Design 2

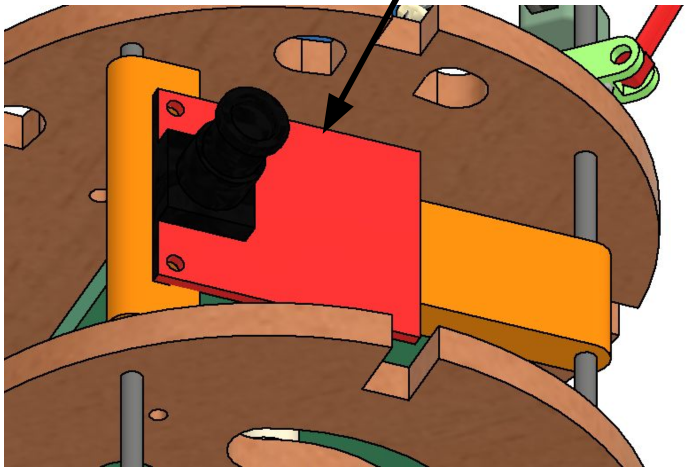


Relies on Stabilization Fins

- Fins are deployed via rubber bands.

Rigid Camera Mount To CanSat

- The camera will be stabilized by the stabilization fins. They will keep the payload from wobbling.



Payload Rotation Control Strategy Selection and Trade (3 of 4)

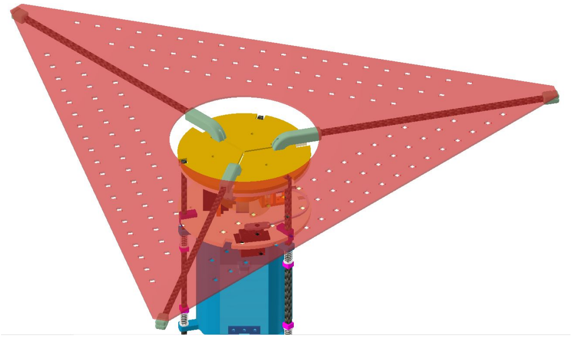
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	4	32	8	64
Volume	2	4	8	8	16
Camera Control	8	8	64	2	16
Weighted Scores		124		112	

Selection and reasoning: Combination of Both Designs
The active rotating camera from Design 1 and the stabilization fins from Design 2 were combined into a final design. Design 1 includes a brushless motor that will be mounted the camera to using a 3D print. In Design 2, the stabilization fins are made out of carbon fiber, 3D print and fiberglass. The fins are mounted to the four threaded rods acting as the frame of the CanSat. The system is an active rotation control system.

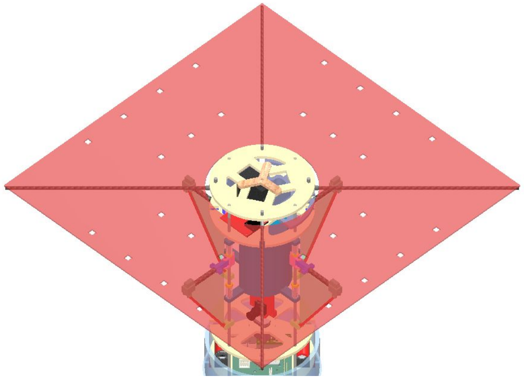
Payload Rotation Control Strategy Selection and Trade (4 of 4)

Design	Mass (g)	Servos/ Motors	Passive/Active	Material	Assisting Systems
Design 1	~80	1	Active	Servo and 3D Print	Spill Holes
Design 2	~30	0	Passive	3D Print	Stabilization Fins

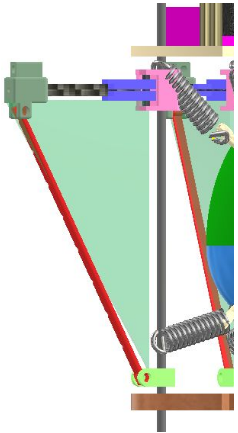
Design 1



Final



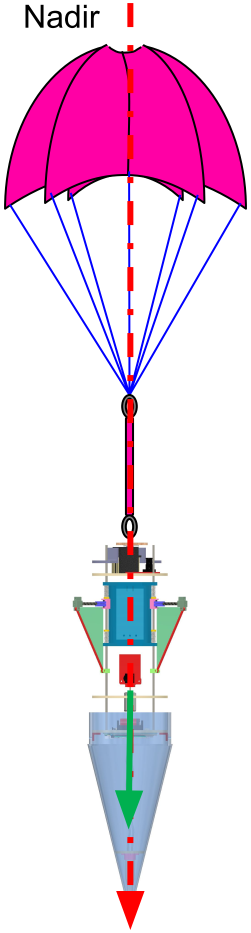
Design 2



Payload Parachute Descent Control Strategy Selection and Trade (1 of 4)

🟩 Direction of Travel

🟥 Nadir



Shape	Size (Diameter in mm)	Drag Coefficient	Opening Load Factor	Average Angle of Oscillation (degrees)
Flat (parasheet)	940	0.75	1.8	25
Hemispherical	920	1.5	1.6	12.5

Fabric	Tensile Strength (MPa)	Porosity (%)	Density (g/cm^3)	Price (per Sq Ft)
Nylon	89.49	1-2	1.14	$0.53
Terylene	27	1-3	1.38	$0.66

Cord Material	Maximum Load Capability (lbs)	Diameter (mm)	Price (per yard)
Braided Fishing Line	50	0.36	$0.4
Nylon Paracord	1000	4.5	$0.13

A combination of both cords were selected to ensure optimal functionality.

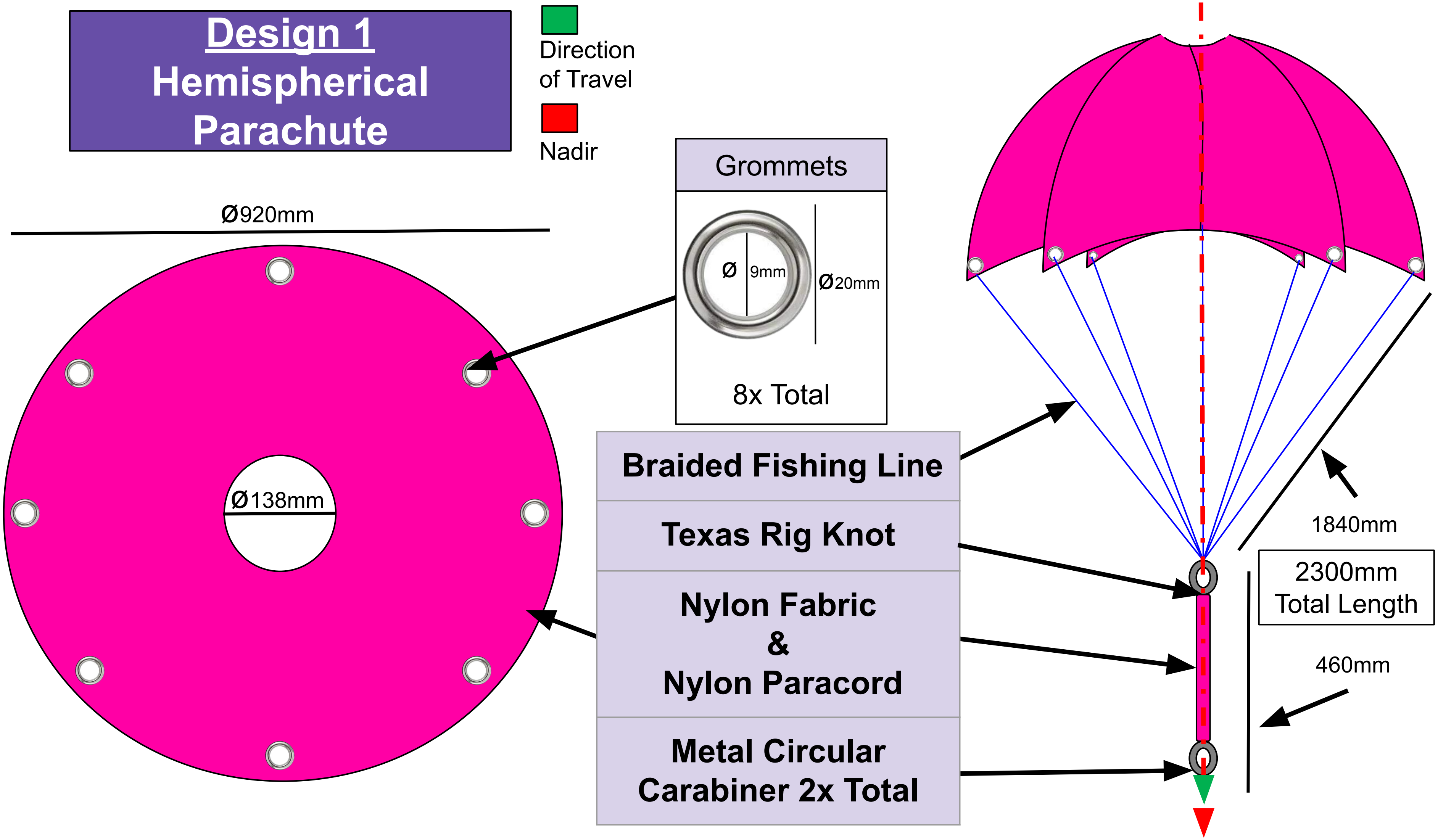
Payload Parachute Descent Control Strategy Selection and Trade (2 of 4)

Design 1

Hemispherical Parachute

🟩 Direction of Travel

🟥 Nadir



Grommets

8x Total

Braided Fishing Line

Texas Rig Knot

Nylon Fabric & Nylon Paracord

Metal Circular Carabiner 2x Total

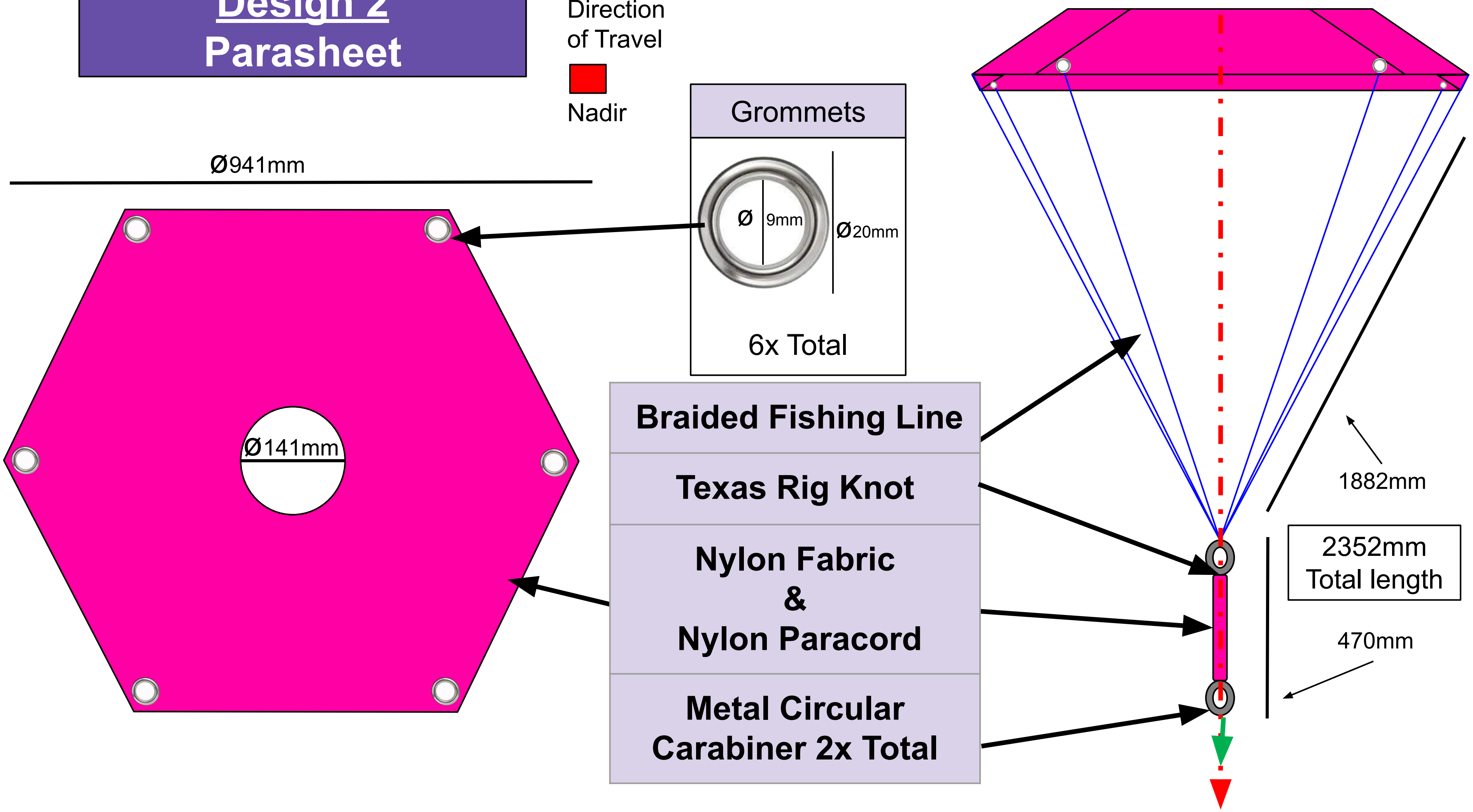
2300mm Total Length

Payload Parachute Descent Control Strategy Selection and Trade (3 of 4)

Design 2
Parasheet

🟩 Direction of Travel

🟥 Nadir



Grommets

6x Total

Braided Fishing Line

Texas Rig Knot

Nylon Fabric
&
Nylon Paracord

Metal Circular Carabiner 2x Total

2352mm Total length

Payload Parachute Descent Control Strategy Selection and Trade (4 of 4)

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	4	32	8	64
Stability (Oscillation)	8	8	64	2	16
Volume	2	4	8	8	16
Weighted Scores		104		96	

Selection and reasoning: Design 1
We selected Design 1 (the hemispherical parachute) for our final design. Both designs are similar in material usage and type; however, Design 1 has a more efficient physical layout. Considering the lower oscillation angle and higher drag coefficient, this design is both smaller and more stable than Design 2 (the parasheet). The parachute will be frictionally set in place between the composite plate of the aerobrake and the 3D printed plate. Nadir is maintained by having a clean parachute release ensured by the parachute platform and a triangular folding technique to prevent line tangling. The nose cone will keep the CanSat pointing downwards, and after the aerobrake is released the CanSat’s center of mass will move downwards towards the nose cone, which will prevent tumbling.

Descent Rate Estimates (1 of 6)

Design 1 & 2

Equation Variables

- mg = Force from Gravity
- m = Mass
- g = Gravitational Acceleration
- v = Velocity
- cd = Drag coefficient
- a = Area

Equations for Area

$$a = l^2$$

$$a = \frac{(l)^2\sqrt{3}}{4}$$

$$a = \frac{2mg}{v^2 cd}$$

Equations for Velocity and Force from Gravity

$$v = \sqrt{\frac{8mg}{\pi d^2 cd}}$$

$$mg = kg(9.8)$$

Aerobrake Diameter

$$d = \sqrt{a}$$

Parachute Diameter

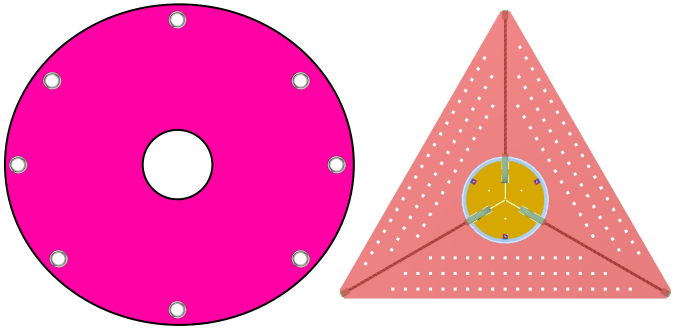
$$d = \sqrt{\frac{4a}{\pi}}$$

Parasheet Diameter

$$d = \sqrt{\frac{2a}{\sqrt{3}}}$$

Descent Rate Estimates (2 of 6)

Design 1



Aerobrake $mg = .9(9.8) = 8.82$

Parachute $mg = .816(9.8) = 7.99$

Assumptions & Variables

- Desired parachute descent rate =4m/s.
- Previously selected aerobrake is in use for the parachute.
- Parachute cd= 1.5
- Aerobrake cd= 0.75

Equation Variables

- mg = Force of Gravity
- m = Meters
- mm = Millimeters
- v = Velocity
- cd = Drag coefficient
- a = Area

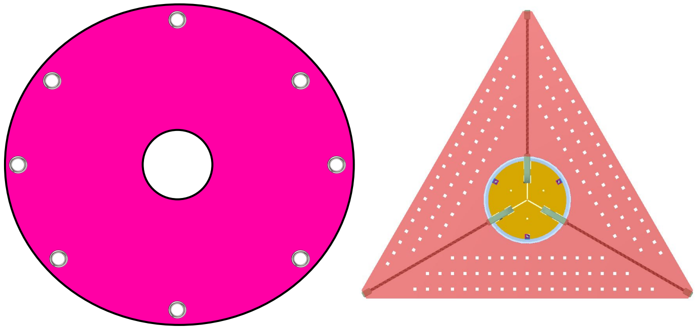
Diameter from Estimated Constant Velocity

Aerobrake $$a = \frac{(.52)^2\sqrt{3}}{4} = 0.117 \quad d = \sqrt{0.117} = 0.342m = 342mm$$

Parachute $$a = \frac{2(7.99)}{4^2(1.5)} = 0.665 \quad d = \sqrt{\frac{4(0.665)}{\pi}} = 0.920m = 920mm$$

Descent Rate Estimates (3 of 6)

Design 1



<u>Aerobrake</u> $mg = .9(9.8) = 8.82$

<u>Parachute</u> $mg = .816(9.8) = 7.99$

Assumptions & Variables

- Parachute ø= 967mm-15%=0.782m
- Aerobrake ø =0.472m
- Parachute cd= 1.5
- Aerobrake cd= 0.75

Equation Variables

- mg = Force of Gravity
- m = Meters
- mm = Millimeters
- v = Velocity
- cd = Drag coefficient

Estimated Constant Velocity from Diameter

<u>Aerobrake</u>

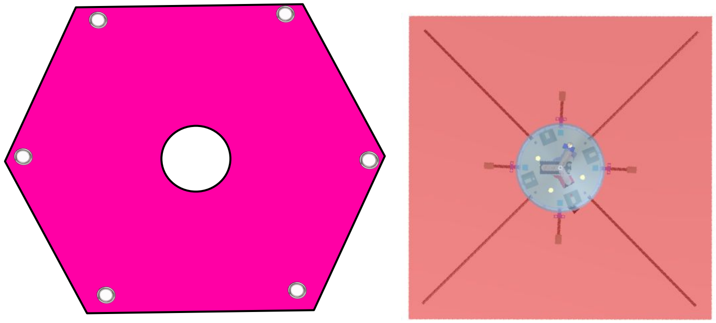
$$v = \sqrt{\frac{8(8.82)}{\pi(0.75)(1.229)(0.342)^2}} = 14.433\frac{m}{s}$$

<u>Parachute</u>

$$v = \sqrt{\frac{8(7.99)}{\pi(1.5)(1.229)(0.782)^2}} = 4.248\frac{m}{s}$$

Descent Rate Estimates (3 of 6)

Design 2



Aerobrake $mg = .9(9.8) = 8.82$

Parachute $mg = .816(9.8) = 7.99$

Assumptions & Variables

- Desired parachute descent rate =4m/s.
- Previously selected aerobrake is in use for the parachute descent rate .
- Parachute cd= 0.75
- Aerobrake cd= 0.75

Equation Variables

- mg = Force of Gravity
- m = Meters
- mm = Millimeters
- v = Velocity
- cd = Drag coefficient
- a = Area

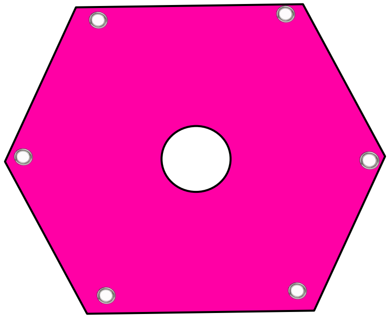
Diameter from Estimated Constant Velocity

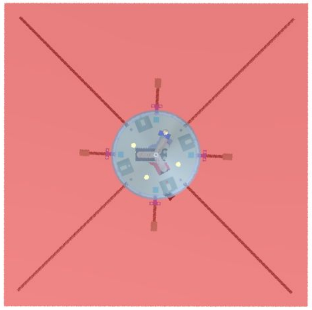
Aerobrake $a = 0.431^2 = 0.185 \quad d = \sqrt{0.18576} = 0.431m = 431mm$

Parachute $a = \frac{2(7.99)}{4^2(0.75)} = 1.33 \quad d = \sqrt{\frac{2(1.33)}{3}} = 0.941m = 941mm$

Descent Rate Estimates (5 of 6)

Design 2





Aerobrake $mg = .9(9.8) = 8.82$

Parachute $mg = .816(9.8) = 7.99$

Assumptions & Variables

- Parachute ø 941mm-15%=.8m
- Aerobrake ø =0.44m
- Parachute cd= 0.75
- Aerobrake cd= 0.75

Equation Variables

- mg = Force of Gravity
- m = Meters
- mm = Millimeters
- v = Velocity
- C_d = Drag coefficient

Estimated Constant Velocity from Diameter

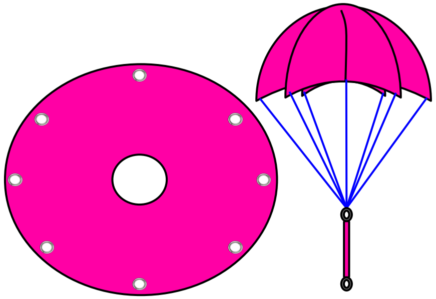
Aerobrake $$v = \sqrt{\frac{8(8.82)}{\pi(0.75)(1.229)(0.431)^2}} = 11.453\frac{m}{s}$$

Parachute $$v = \sqrt{\frac{8(7.99)}{\pi(0.75)(1.229)(0.8)^2}} = 5.872\frac{m}{s}$$

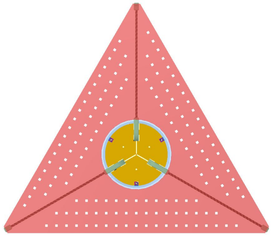
Descent Rate Estimate (6 of 6)

Velocity Summary

Design 1

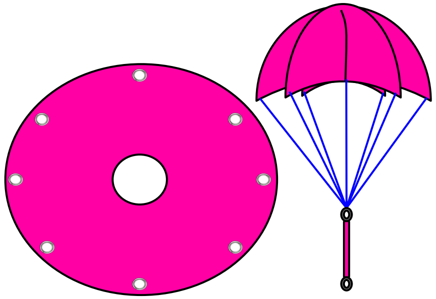


$$v = \sqrt{\frac{8(7.99)}{\pi(1.5)(1.229)(0.782)^2}} = 4.248\,\frac{m}{s}$$

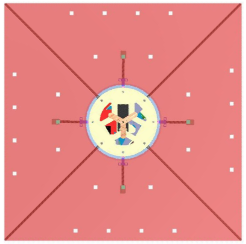


$$v = \sqrt{\frac{8(8.82)}{\pi(0.75)(1.229)(0.342)^2}} = 14.433\,\frac{m}{s}$$

Final

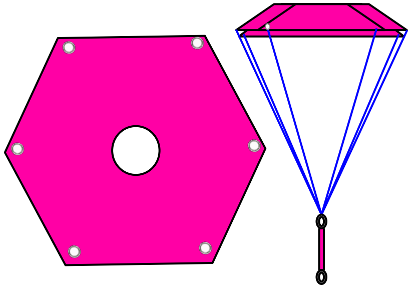


$$v = \sqrt{\frac{8(7.99)}{\pi(1.5)(1.229)(0.782)^2}} = 4.248\,\frac{m}{s}$$

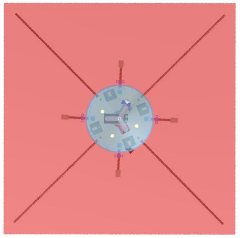


$$v = \sqrt{\frac{8(8.82)}{\pi(0.75)(1.229)(0.431)^2}} = 11.453\,\frac{m}{s}$$

Design 2



$$v = \sqrt{\frac{8(7.99)}{\pi(0.75)(1.229)(0.8)^2}} = 5.872\,\frac{m}{s}$$

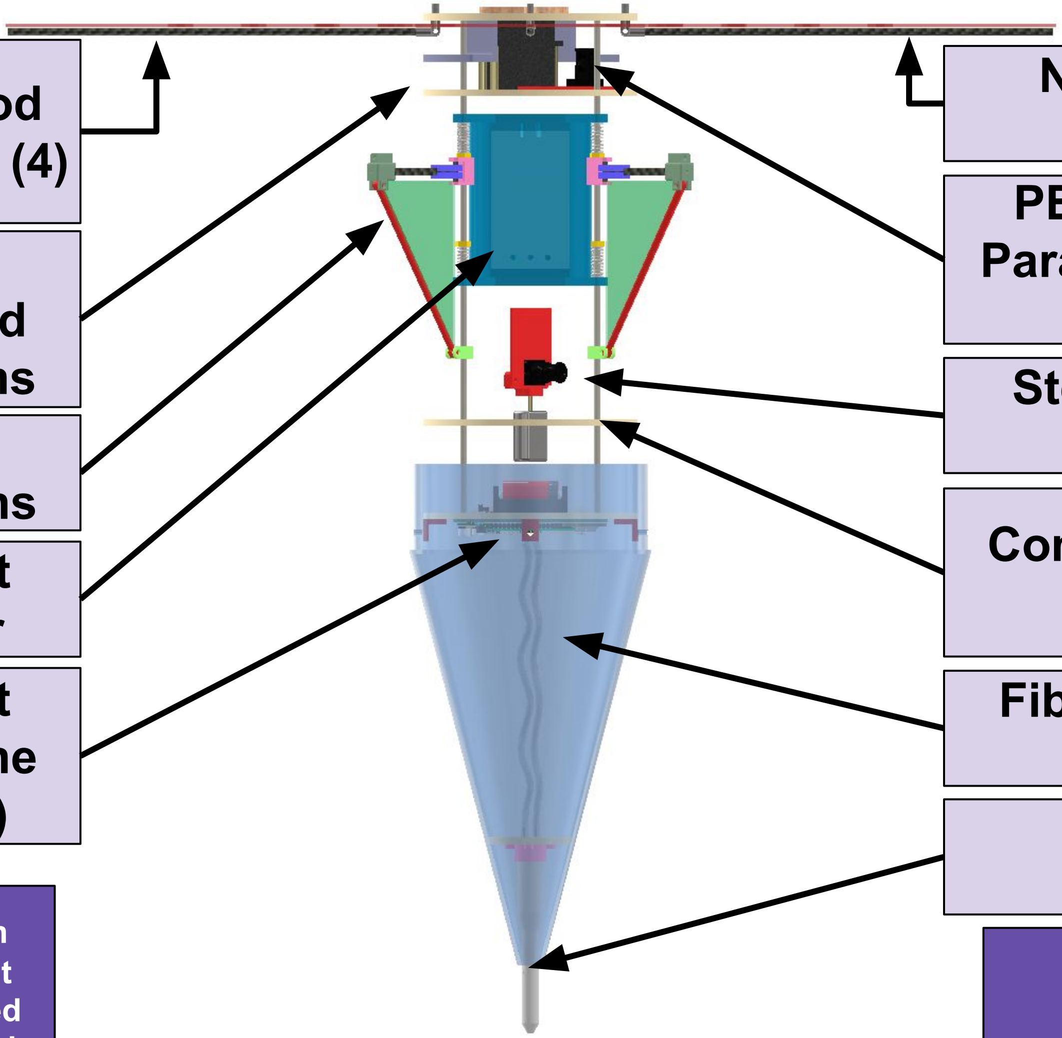


$$v = \sqrt{\frac{8(8.82)}{\pi(0.75)(1.229)(0.431)^2}} = 11.453\,\frac{m}{s}$$

Mechanical Subsystem Design

Andrew Treadway, Samuel Chouinard, Zach Jones

Mechanical Subsystem Overview



Carbon Fiber Rod Aerobrake Arms (4)

Aerobrake Deployment and Release Systems

Fiberglass Stabilization Fins

PETG Filament Egg Container

PETG Filament Static Nose Cone Attachment (4)

Nylon Fabric Aerobrake

PETG Filament Parachute Divider Plate

Steel Threaded Rods (4)

Composite Wood Plates (5)

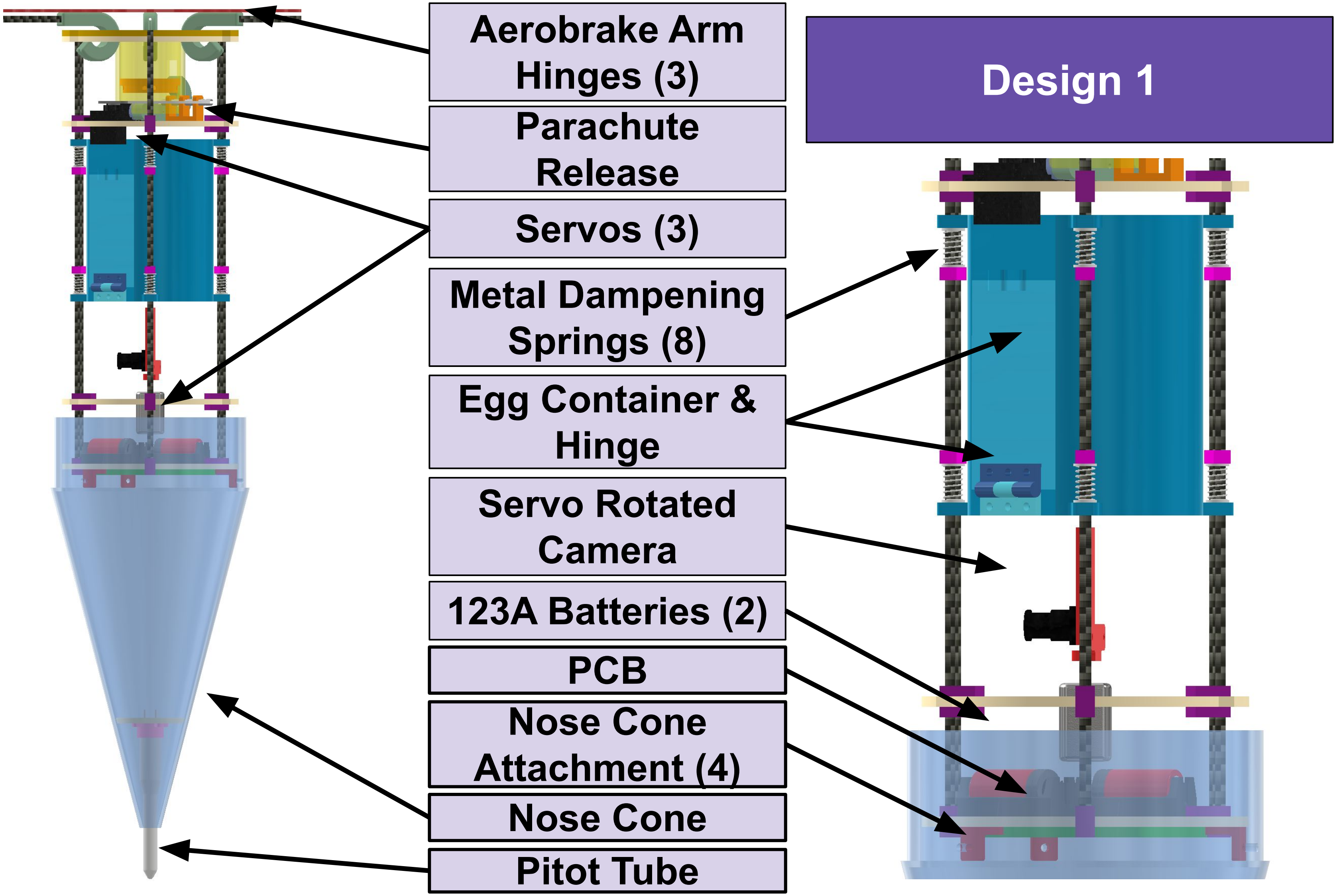
Fiberglass Nose Cone

Pitot Tube

Note: All numbers in parentheses represent the number of indicated structural element used.

Finalized Design

Payload Mechanical Layout of Components Trade & Selection (1 of 4)



Design 1

Aerobrake Arm Hinges (3)

Parachute Release

Servos (3)

Metal Dampening Springs (8)

Egg Container & Hinge

Servo Rotated Camera

123A Batteries (2)

PCB

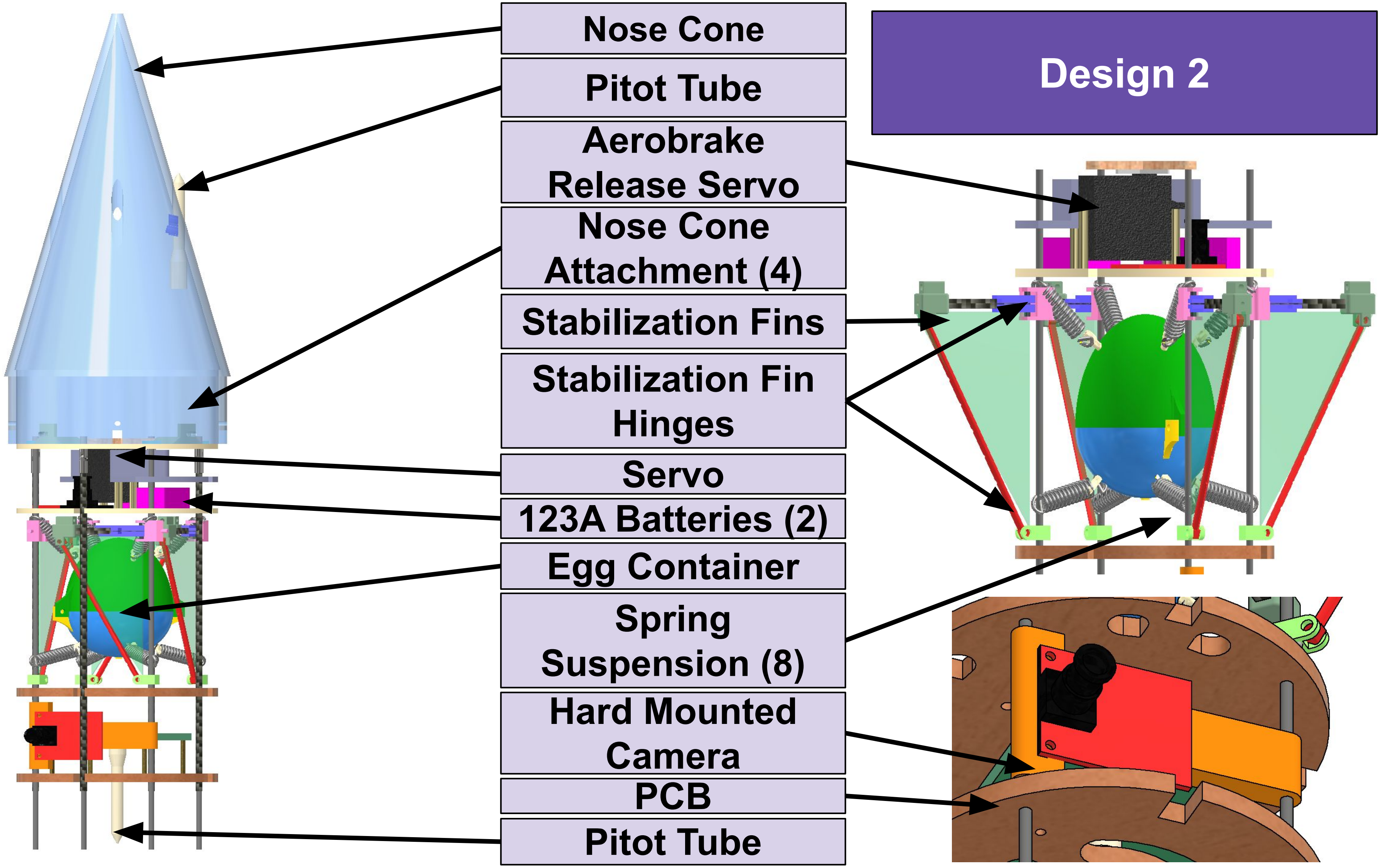
Nose Cone Attachment (4)

Nose Cone

Pitot Tube

Payload Mechanical Layout of Components Trade & Selection (2 of 4)

Design 2



- Nose Cone
- Pitot Tube
- Aerobrake Release Servo
- Nose Cone Attachment (4)
- Stabilization Fins
- Stabilization Fin Hinges
- Servo
- 123A Batteries (2)
- Egg Container
- Spring Suspension (8)
- Hard Mounted Camera
- PCB
- Pitot Tube

Payload Mechanical Layout of Components Trade & Selection (3 of 4)

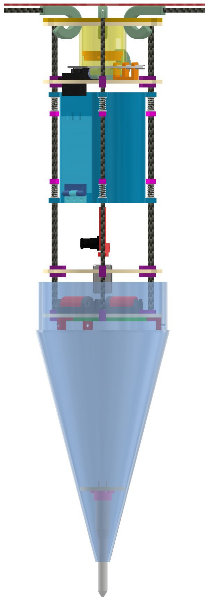
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	8	64	4	32
Cost	2	4	8	8	16
Weighted Scores		72		48	

Selection and reasoning: Combination of Both Designs
We decided to choose a combination of both designs choosing what we calculated to be the best components of each design. From Design 1, the location and direction of the nose cone, the location of the pitot tube (extruding from the center of the nose cone), the location of the PCB, and the location of the 3D printed egg container was chosen. From Design 2, threaded rods to be the frame of the CanSat, the aerobrake deployment system and the stabilization fins to be made out of carbon fiber and 3D print was chosen. Both designs fashion composite wood plates, carbon fiber aerobrake arms and a nose cone of length 270mm made from fiberglass with a conical shape of the nose cone. We used OpenRocket as a team to design a stable, lightweight and smaller nose cone. In research, conical was found to be the most stable and created optimal drag on descent. A 25kg torque servo will be (during descent) at the top of the CanSat, the brushless motor will be under the egg container, the PCB will be inside the nose cone with all sensors, along with the LED and the switch attached. The batteries are mounted on the opposite side of the composite plate the PCB is mounted to.

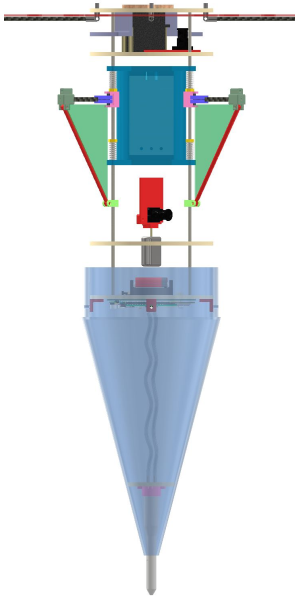
Payload Mechanical Layout of Components Trade & Selection (4 of 4)

Design	Mass (g)	Nose Cone	Egg Container	Servos and Motors
1	~902	Bottom of CanSat	Center Top of CanSat	3
2	~890	Top of CanSat	Center Top of CanSat	1
Final	~902.5	Bottom of CanSat	Center Top of CanSat	2

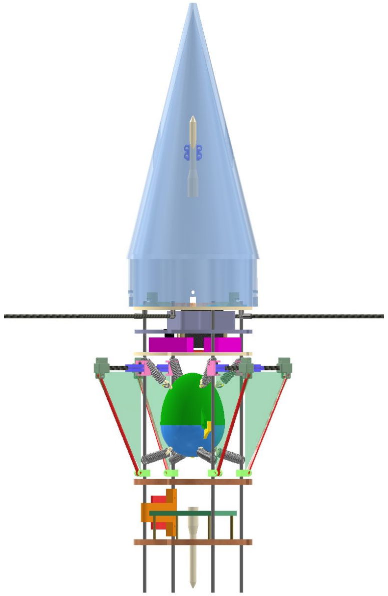
Design 1



Final



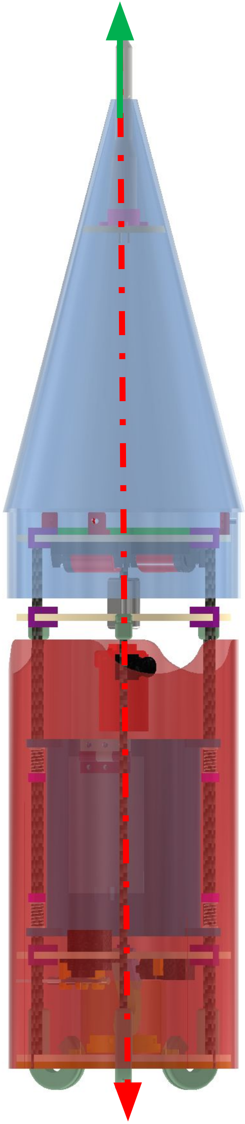
Design 2



Payload Aerobraking Pre Deployment Configuration Trade & Selection (1 of 6)

🟩 Direction of Travel

🟥 Nadir

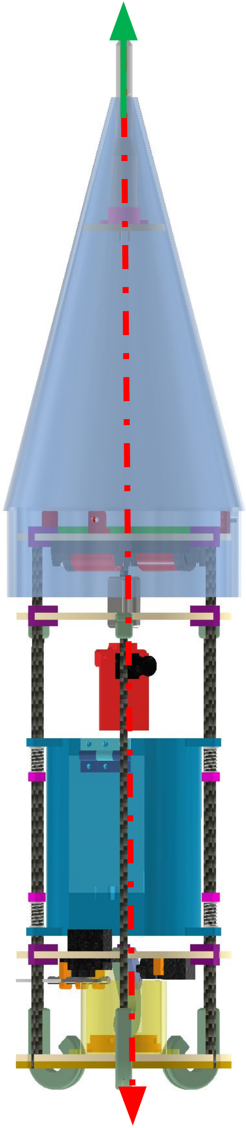


Design 1

Loaded Upside Down

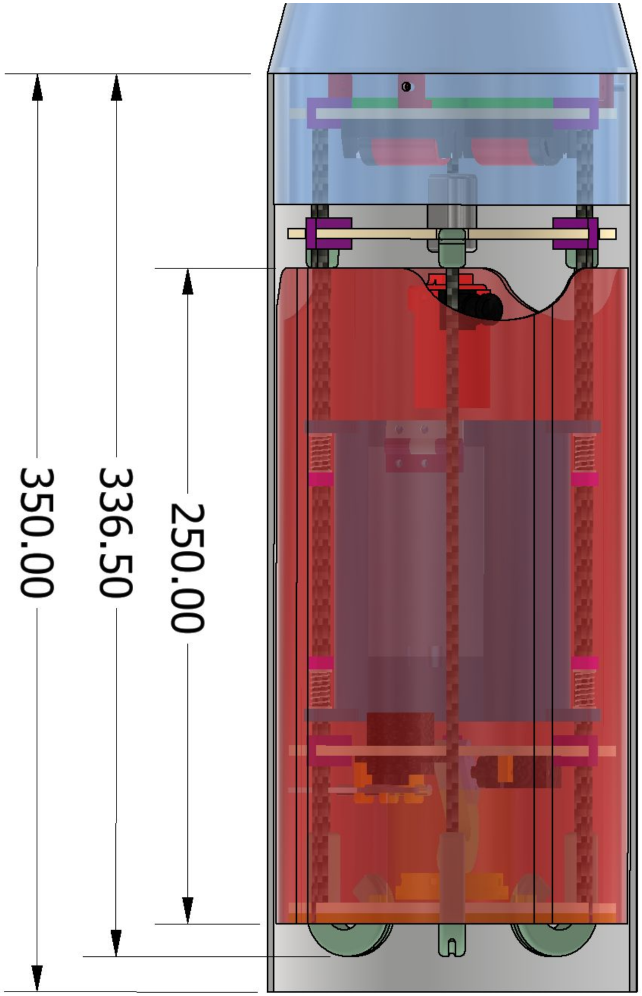
- CanSat is frictionally fitted inside the rocket wall. We will use duct tape in case our CanSat is too small.
- The nose cone will act as the heat shield and is stored on the “bottom” of the CanSat.

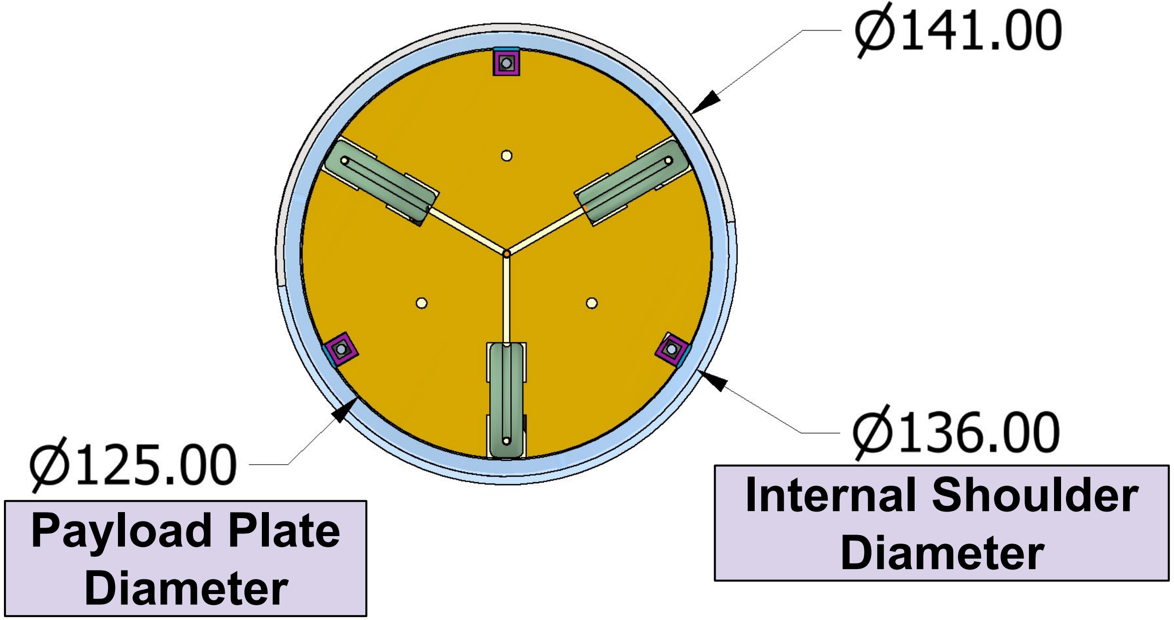
Aerobrake Arms and Fabric



Payload Aerobraking Pre Deployment Configuration Trade & Selection (2 of 6)

Design 1





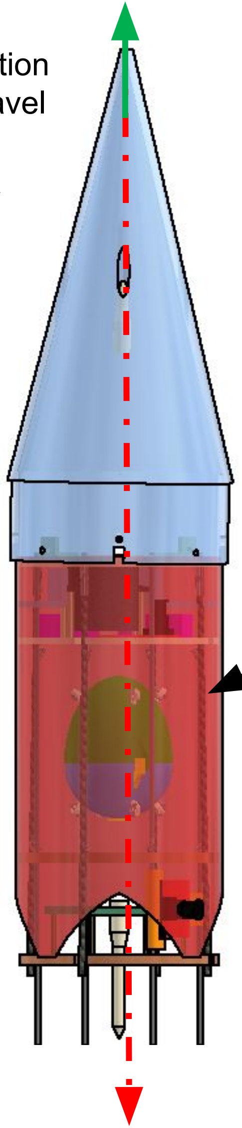
- There is 13.5 mm clearance between the height of the CanSat and the payload section. There is 5.5 mm of space around the payload for easy release.
- The CanSat will stay inside the payload section using friction.

Payload Aerobraking Pre Deployment Configuration Trade & Selection (3 of 6)

🟩 Direction of Travel

🟥 Nadir

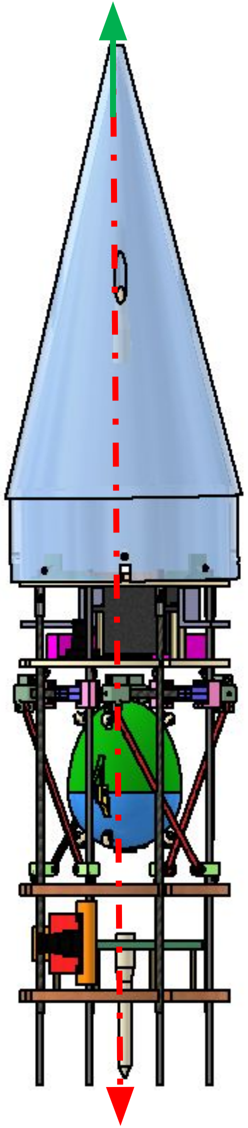
Design 2



Aerobrake Arms and Fabric

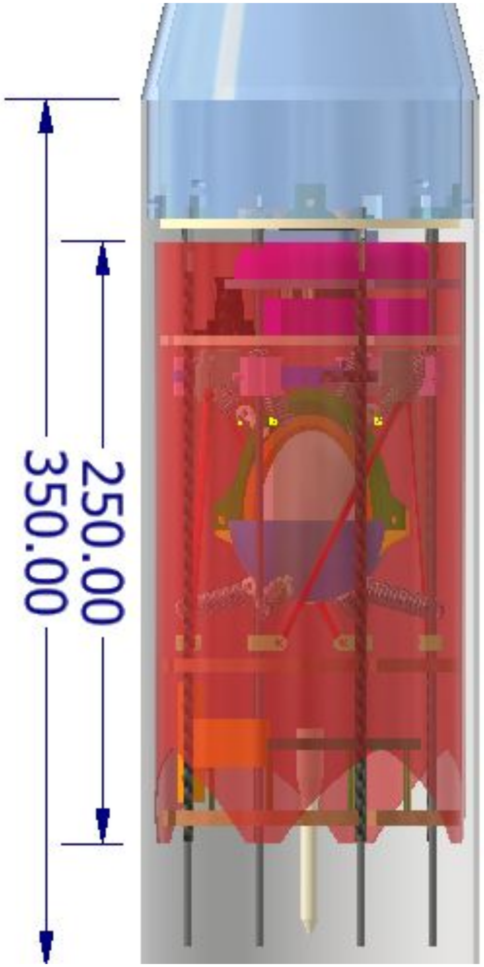
Loaded Right Side Up

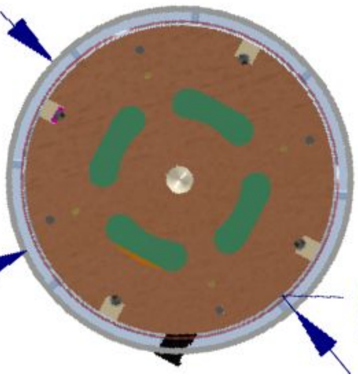
- **The CanSat will use friction to keep it stowed inside the payload section.**



Payload Aerobraking Pre Deployment Configuration Trade & Selection (4 of 6)

Design 2





Ø141.00

External Shoulder Diameter

Ø136.00

Internal Shoulder Diameter

Ø125.00

Payload Plate Diameter

- There is 5.3 mm clearance between the height of the CanSat and the payload section.
- The CanSat will stay inside the payload section using friction.

Payload Aerobraking Pre Deployment Configuration Trade & Selection (5 of 6)

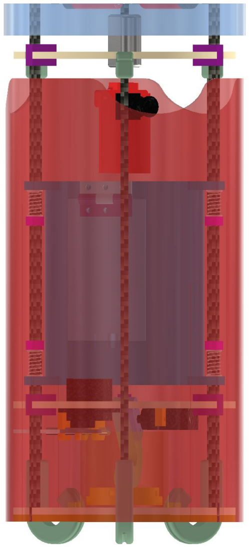
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Compatibility	8	8	64	4	32
Space Utilization	8	4	32	2	16
Ease of Storage	4	4	16	2	8
Weighted Scores		112		56	

Selection and Reasoning: Design 1
We decided to choose Design 1 because the location of the nose cone allows for one pitot tube and is more efficient with its space utilization. By loading the CanSat upside down, we are able to maximize our space and use the nose cone as the heat shield on descent. Both designs use friction to keep the CanSat inside the payload section and duct tape will be used in case it is too small to fit inside the payload section.

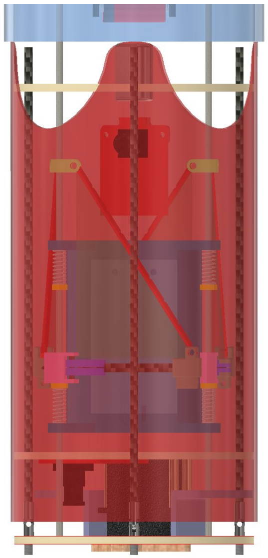
Payload Aerobraking Pre Deployment Configuration Trade & Selection (6 of 6)

Design	Mass (g)	Space Utilization	Compatibility	Passive Functions
1	~902	250mm of 350mm	Fits Within Constraints	0
2	~890	244.7mm of 350mm	Fits Within Constraints	2

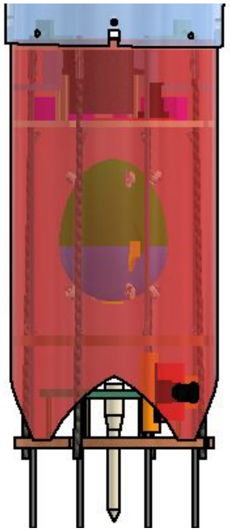
Design 1



Final



Design 2



🟩 Direction of Travel

🟥 Nadir

Payload Aerobraking Deployment Configuration Trade & Selection (1 of 6)

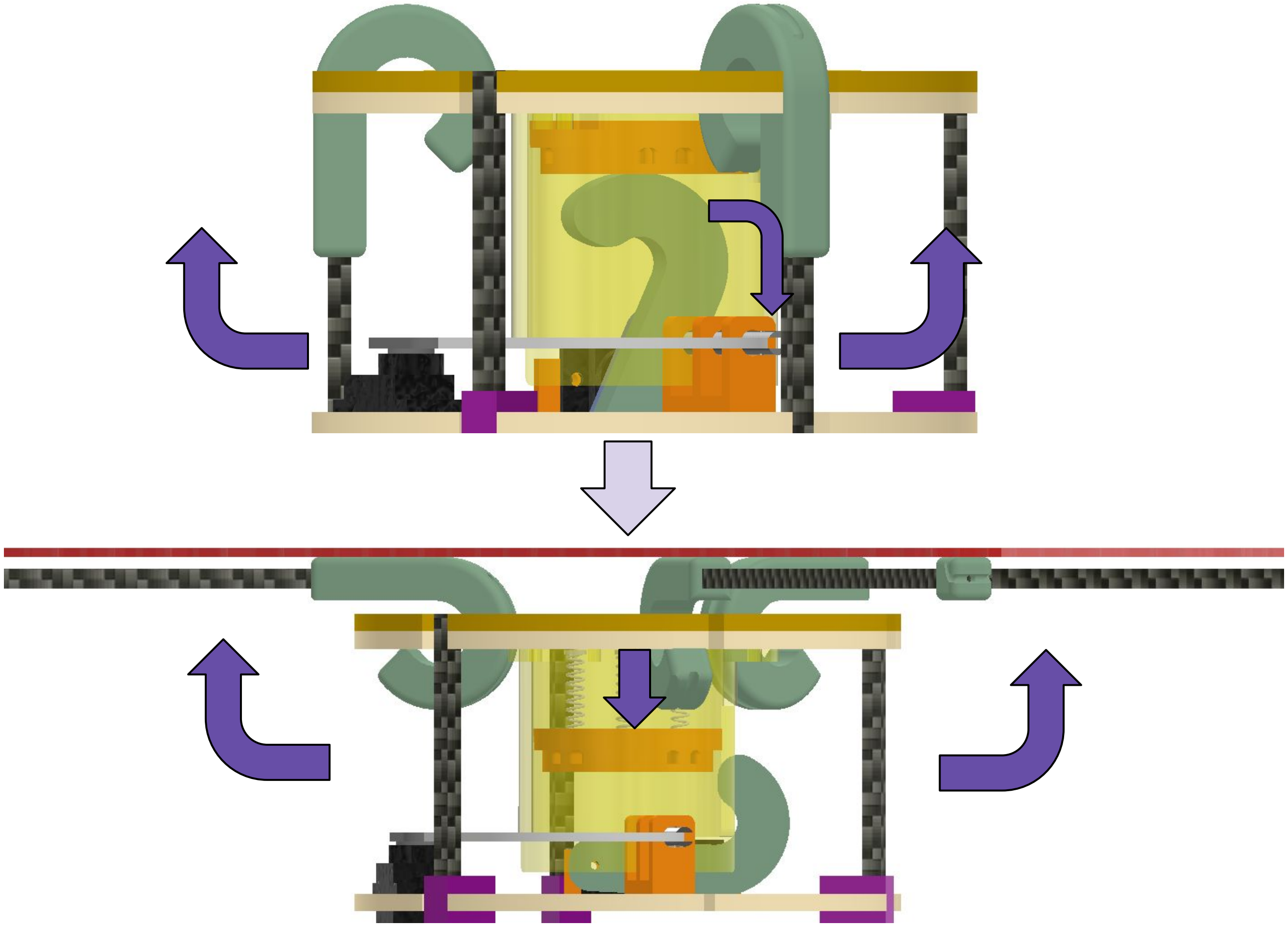
Order of Operations:

Stowed:
A servo-operated hook releases the orange cylinder pushed down by springs. The cylinder pulls attached strings as it falls, lifting the aerobrake arms.

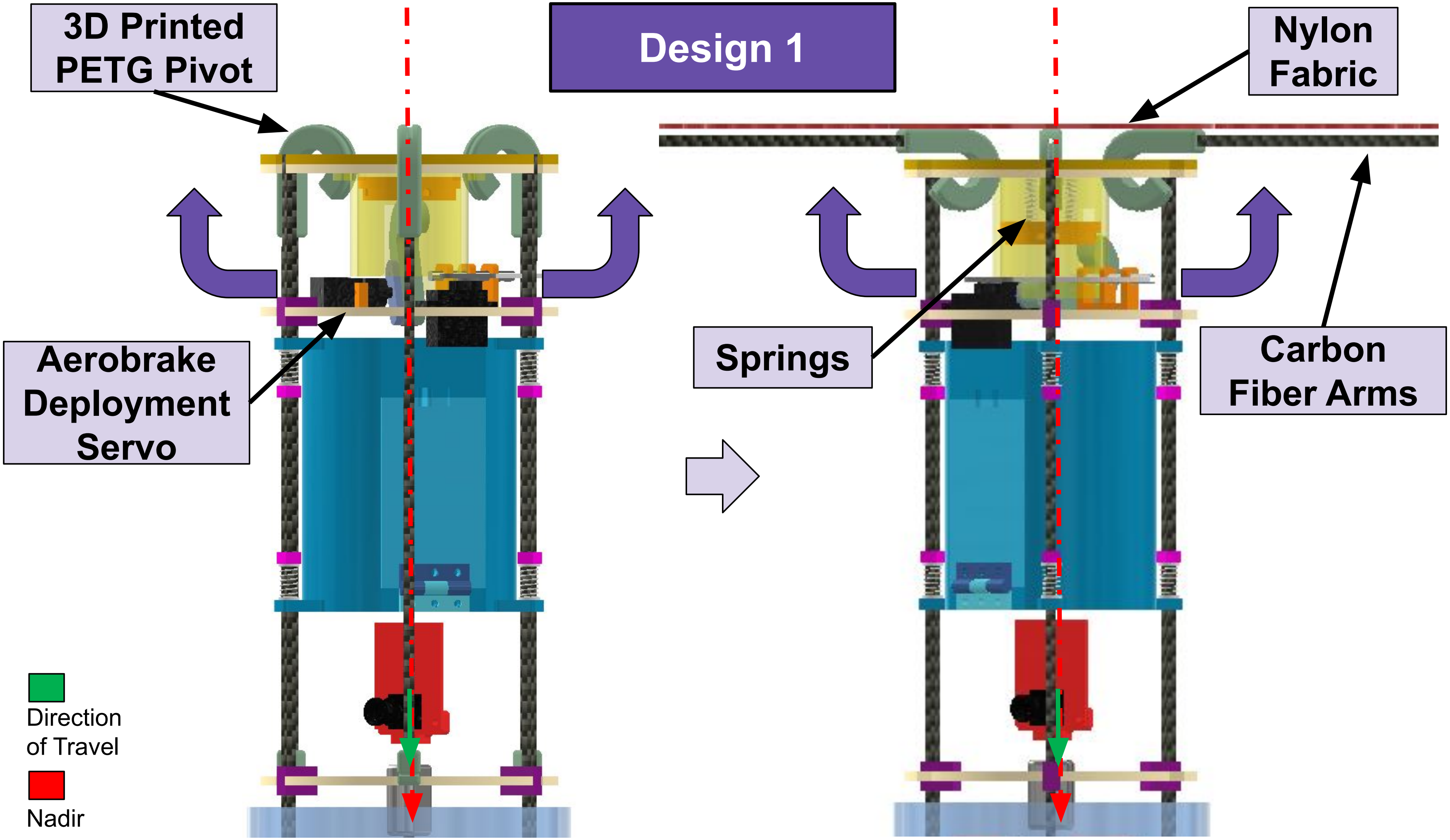
Transition:
The servo turns and the curved piece moves down to put tension on the string

Deployed:
The springs hold tension on the string keeping the aerobrake deployed

Design 1



Payload Aerobraking Deployment Configuration Trade & Selection (2 of 6)



Design 1

3D Printed PETG Pivot

Aerobrake Deployment Servo

Springs

Nylon Fabric

Carbon Fiber Arms

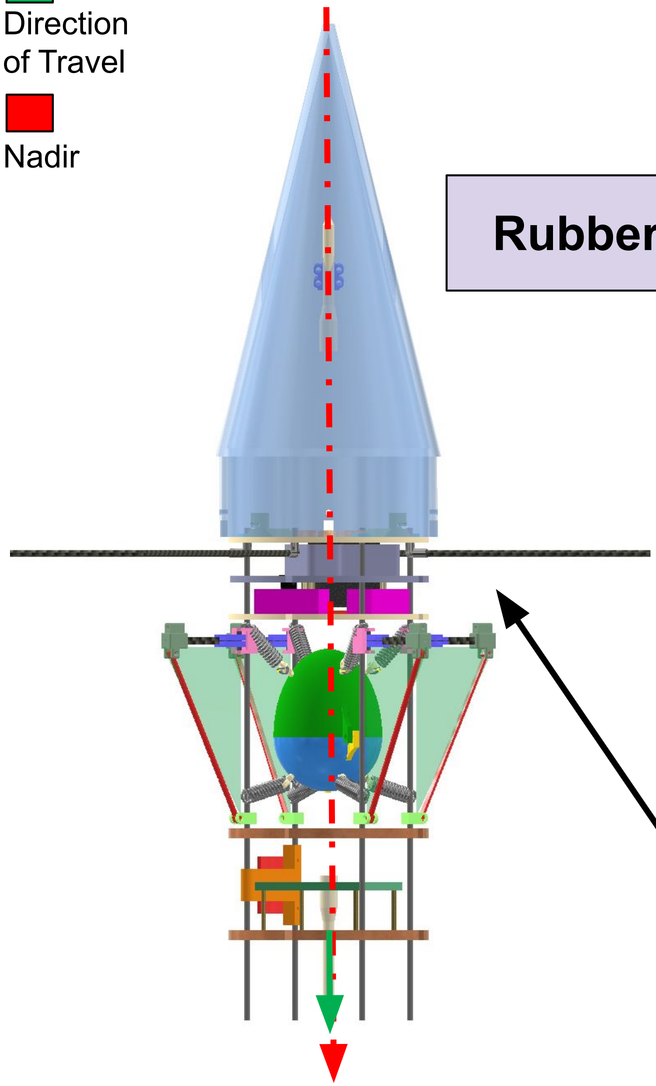
🟩 Direction of Travel

🟥 Nadir

Payload Aerobraking Deployment Configuration Trade & Selection (3 of 6)

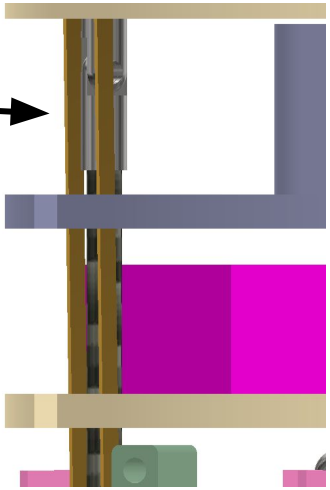
🟩 Direction of Travel

🟥 Nadir

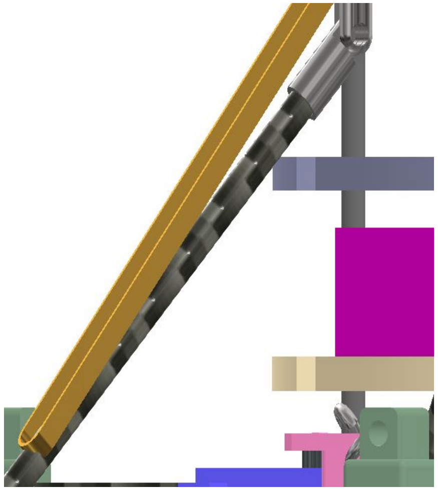


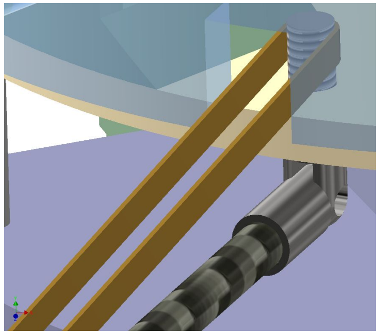
Design 2

Rubber Band



Order of Operations:



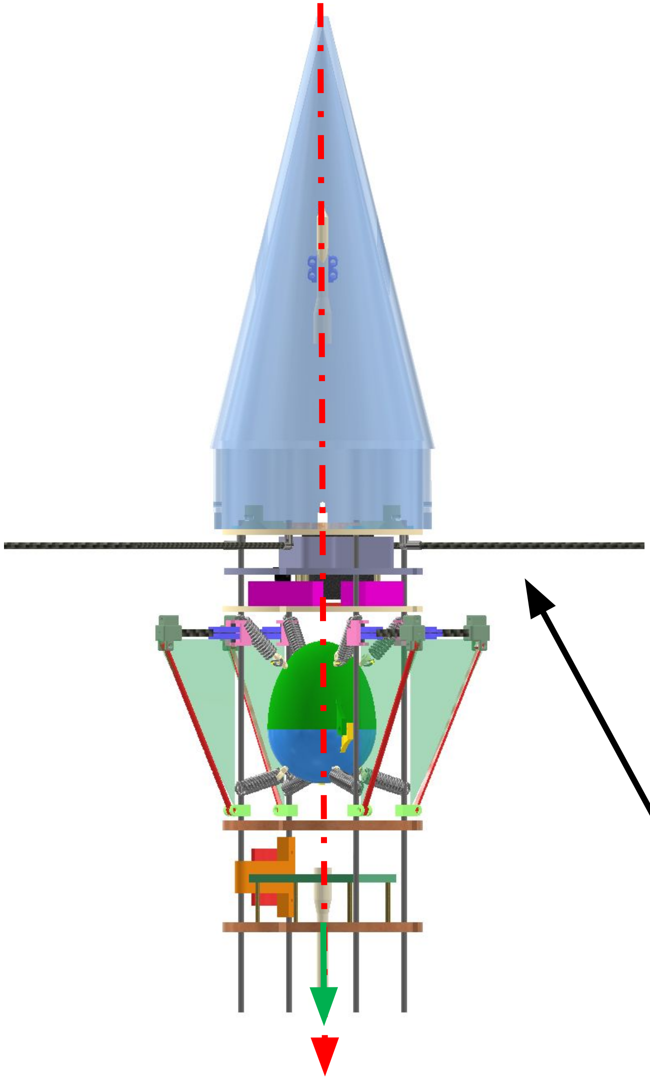


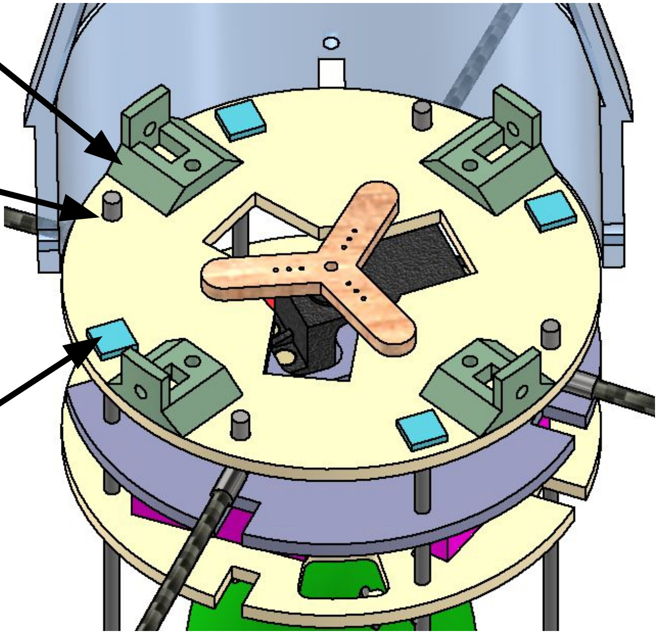
Rubber Band Operated

- The rubber band uses tension to pull the aerobrake arms up and the wind keeps them deployed

Payload Aerobraking Deployment Configuration Trade & Selection (4 of 6)

Design 2





PETG Filament Nose Cone Mounts

Male-Female Threaded Hinge

Bumpers

- **These prevent an uneven aerobrake release (e.g. if three frame rods let go of the composite but one doesn't).**

Carbon Fiber Arms

Payload Aerobraking Deployment Configuration Trade & Selection (5 of 6)

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Volume	8	2	16	8	32
Mass	4	2	16	8	32
Cost	2	4	8	2	4
Weighted Scores		40		100	

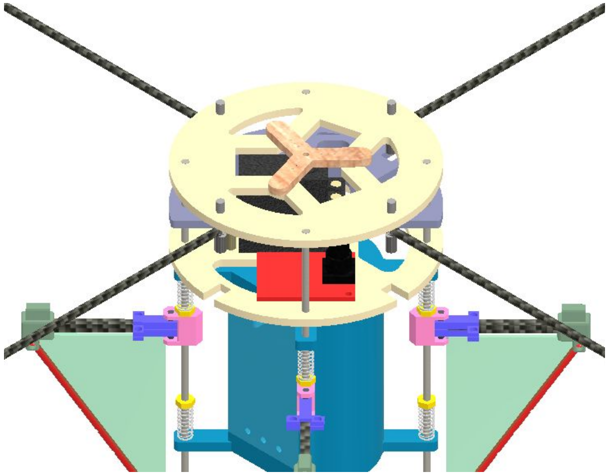
Selection and reasoning: Design 2
We selected Design 2 due to its overall mechanical simplicity compared to Design 1 while performing the same general function. Unlike Design 1, it does not require a servo and takes up under half of the limited space provided on the CanSat. It also consists of stronger material for the arm joints.

Payload Aerobraking Deployment Configuration Trade & Selection (6 of 6)

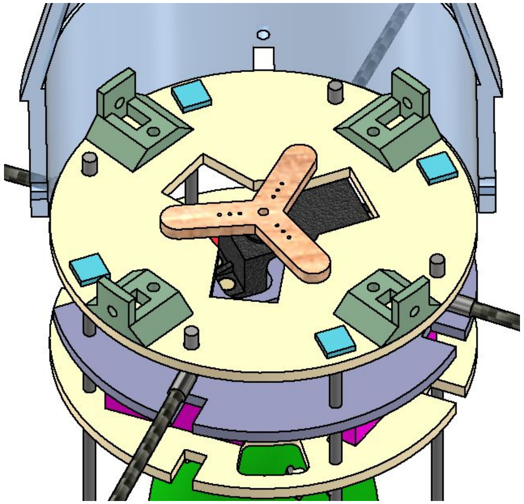
Design	Mass (g)	Materials	Passive Functions
1	~112	PETG, Carbon Fiber 4x, Servo, Springs, String, Nylon Fabric	0
2	~67	PETG, Carbon Fiber rods 4x, Rubber Bands 4x, Metal U-joints 4x, Nylon Fabric	1

Design 1

Final



Design 2



Payload Aerobraking Release Trade & Selection (1 of 4)

Design 1

Pin in Place

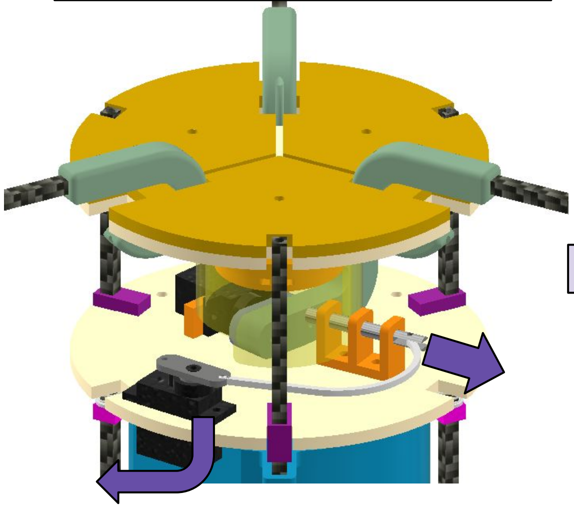
- Before release, a pin holds the aerobrake to the payload.

Head Rotates 90 Degrees

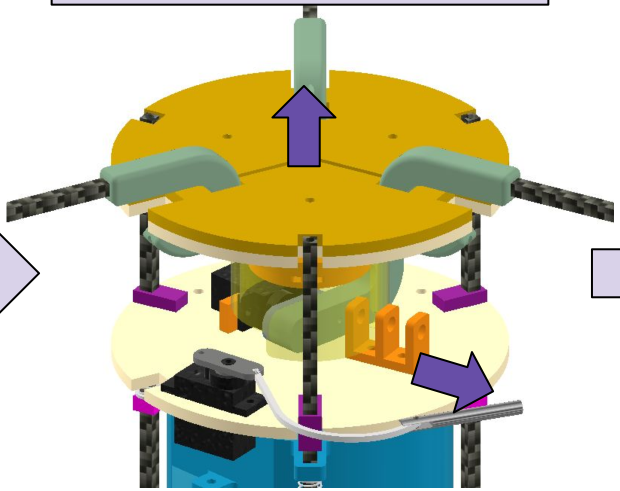
- A servo rotates 90 degrees to pull out the pin and release the aerobrake.

System Released

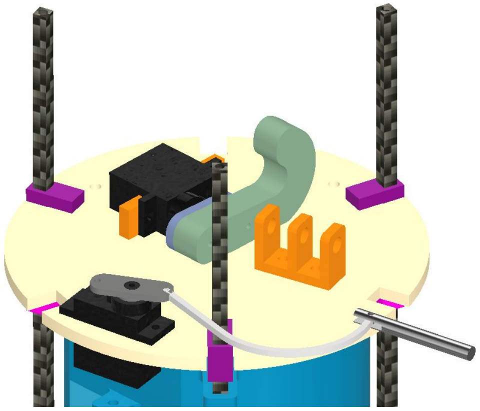
- The aerobrake falls on its own and the parachute is opened.



Before Release



During Release



After Release

Payload Aerobraking Release Trade & Selection (2 of 4)

Design 2

Servo Head

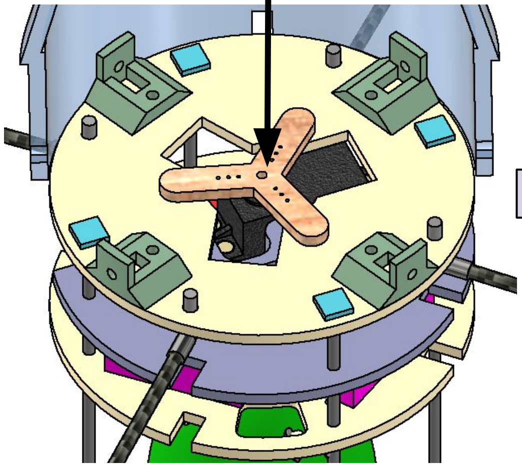
- This is composite wood screwed onto a steel servo head.

Head Rotates 180 Degrees

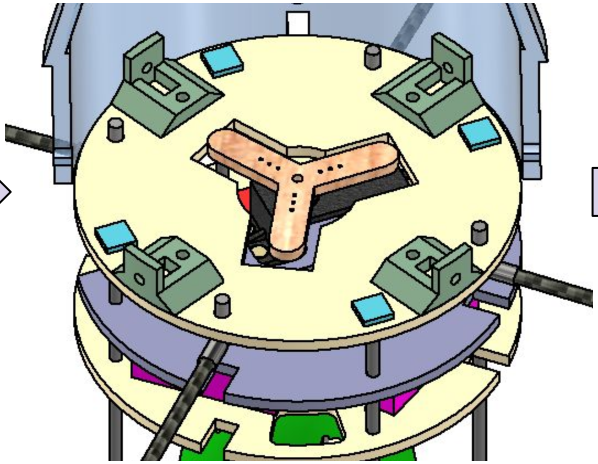
- 60 degrees are needed to release but 180 provides more chances for release.

System Released

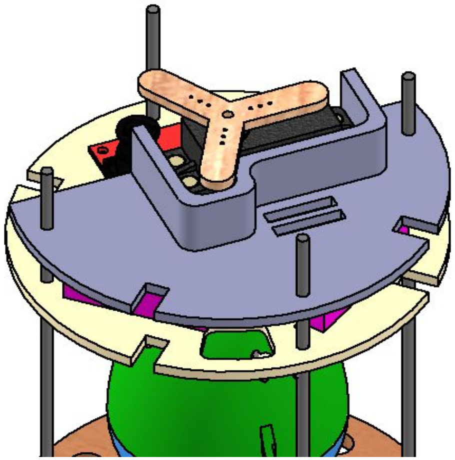
- Because the nose cone is considered a part of the aerobrake, it does not need to descend at less than 10m/s.



Before Release



During Release



After Release

Payload Aerobraking Release Trade & Selection (3 of 4)

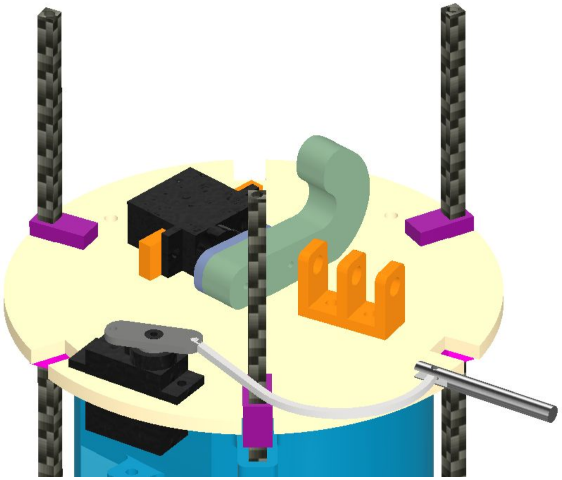
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	4	32	8	64
Volume	8	2	16	8	64
Material	4	4	16	8	32
Cost	2	2	4	4	8
Weighted Scores		68		168	

Selection and reasoning: Design 2
While both designs utilize servos in their release mechanisms, Design 2 is calculated to have a better efficiency. Design 1 utilizes a pin to keep the plate on the CanSat; however, this is likely to break under high stress and could snag on the plate. Design 2 has a wider attachment on top of a servo which stronger and less likely to snag on the plate.

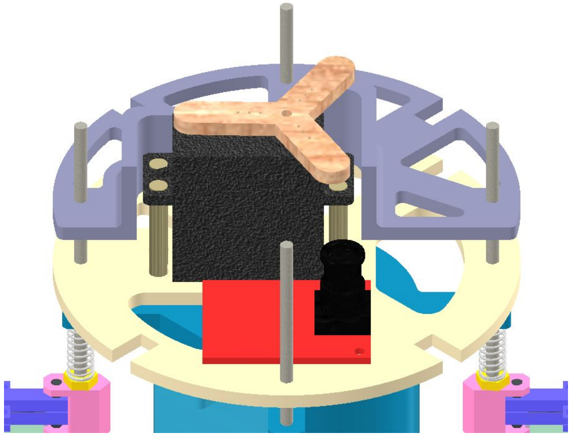
Payload Aerobraking Release Trade & Selection (4 of 4)

Design	Mass (g)	Material
1	~127	Composite Wood, 3D Print, Carbon Fiber Rod, 25kg Torque Servo
2	~67	Composite Wood, 3D Print, Carbon Fiber Rod, 25kg Torque Servo

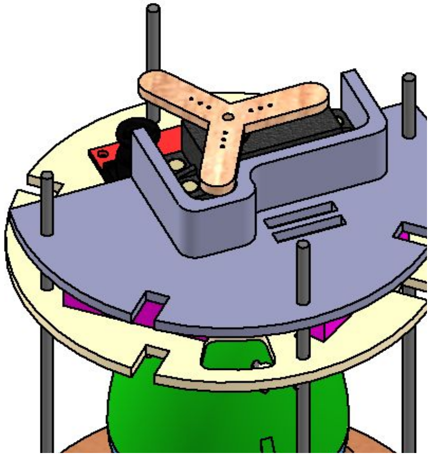
Design 1



Final



Design 2

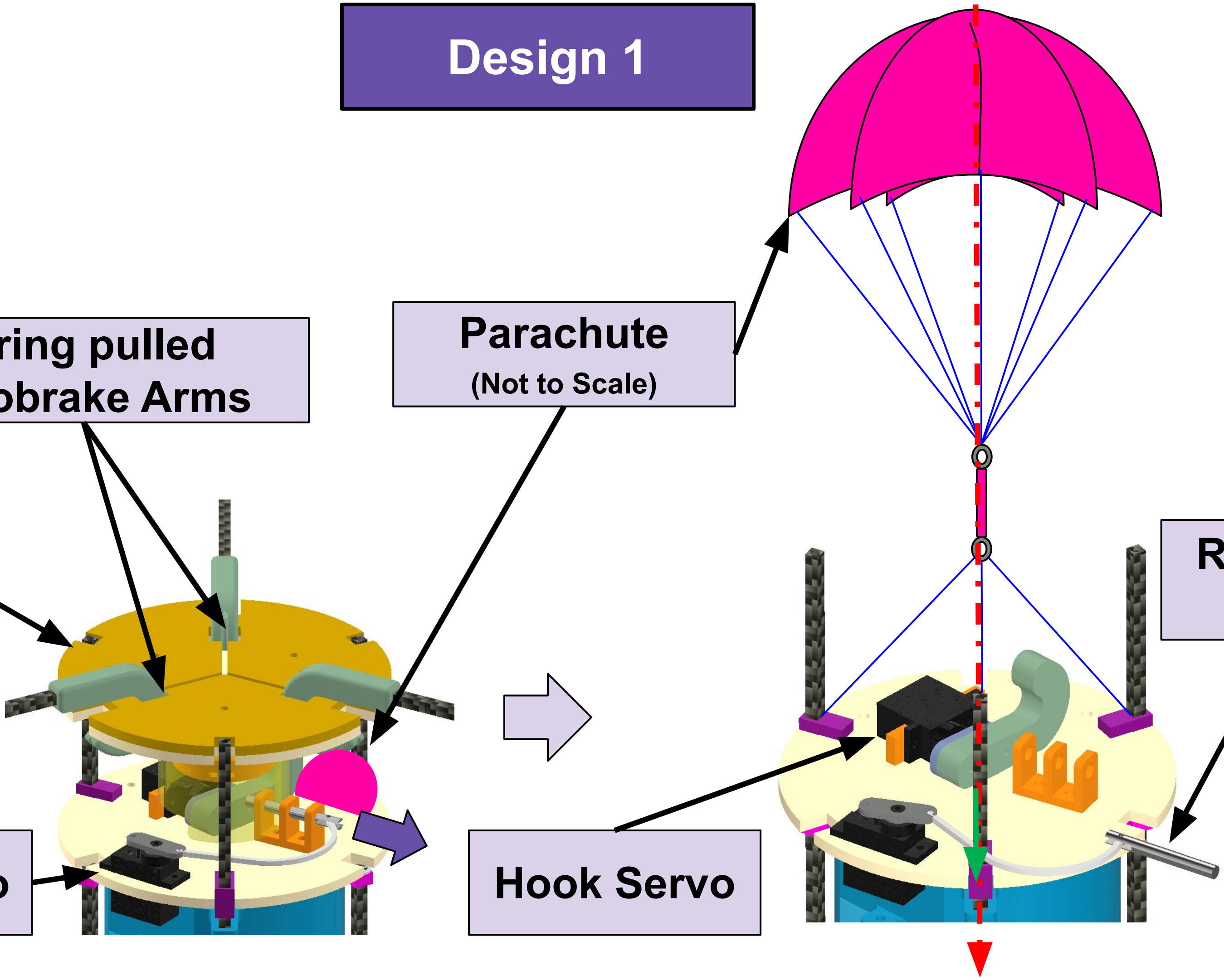


Payload Parachute Deployment Configuration Trade & Selection (1 of 6)

🟩
Direction
of Travel

🟥
Nadir

Design 1



String pulled Aerobrake Arms

Parachute
(Not to Scale)

Aerobrake Layer

Release Pin

Release Servo

Hook Servo

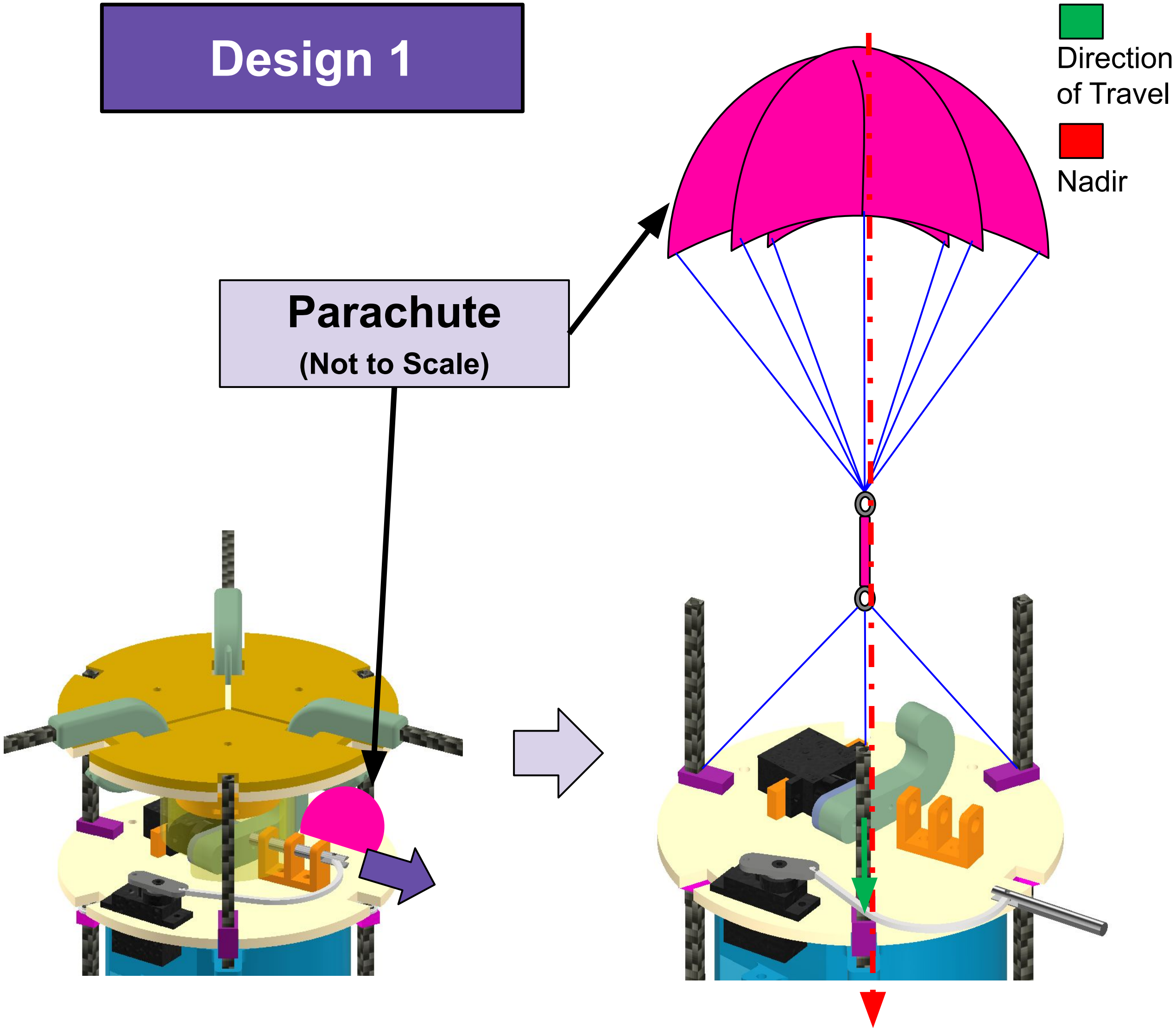
Payload Parachute Deployment Configuration Trade & Selection (2 of 6)

Design 1

Stowed:
Parachute is held in by the plate above it.

Transition:
The servo turns to release the pin and the layer lifts up.

Deployed:
The parachute catches the wind and passively deploys.



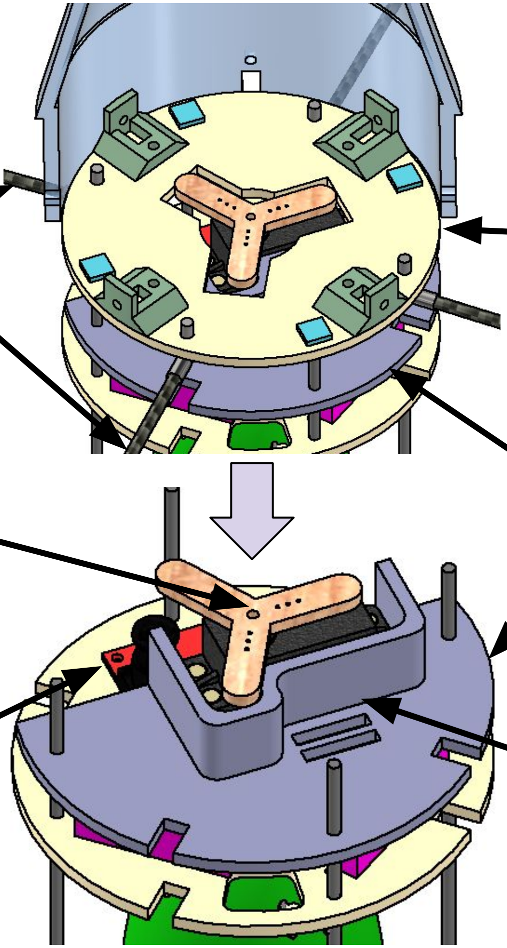
Parachute
(Not to Scale)

🟩 Direction of Travel

🟥 Nadir

Payload Parachute Deployment Configuration Trade & Selection (3 of 6)

Design 2



Aerobrake Arms

Aerobrake Layer

Motor Head Release Mechanism

Parachute Layer

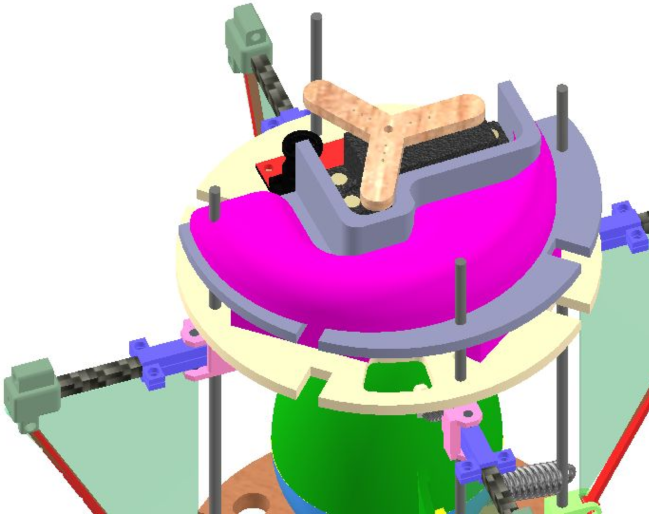
Bonus Camera

Mylar Attachment
- This will be stored under the folded parachute.

Payload Parachute Deployment Configuration Trade & Selection (4 of 6)

🟩 Direction of Travel

🟥 Nadir

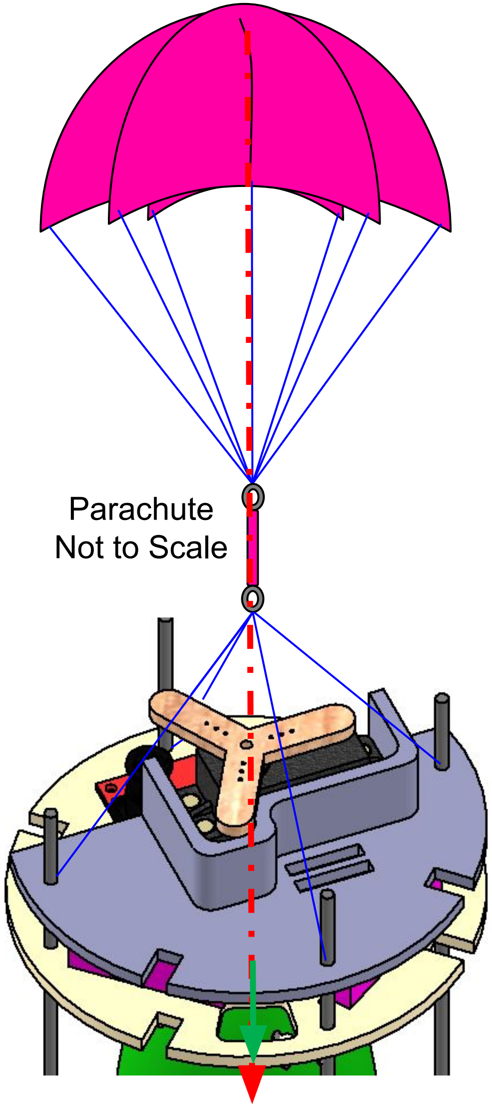


Design 2

Stowed:
The parachute is folded into a triangle before launch to keep the lines from tangling. It is placed on a 3D printed layer and is friction fitted between the 3D plate and the composite wood of the aerobrake.

Transition:
The servo head turns to fit inside the grooves laser cut into the composite wood.

Deployed:
The parachute catches the wind and keeps the CanSat nadir.



Payload Parachute Deployment Configuration Trade & Selection (5 of 6)

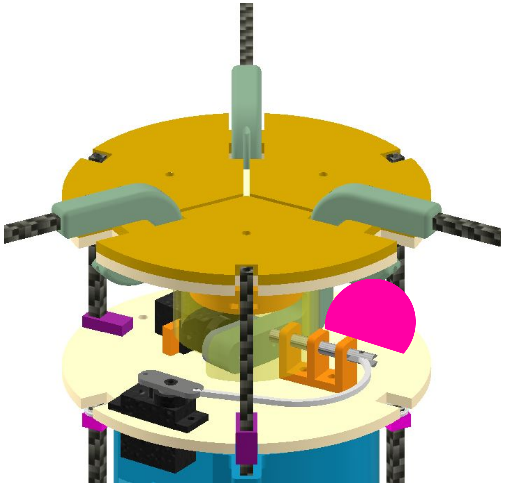
Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	2	16	8	64
Volume	8	2	16	8	64
Material	4	8	32	4	16
Cost	2	8	16	4	8
Weighted Scores		80		152	

Selection and reasoning: Design 2
While Design 1 weighs less, Design 2 has a designated location for the parachute to be stored. This helps prevent the possibility of the parachute cords snagging or getting tangled onto the rest of the CanSat.

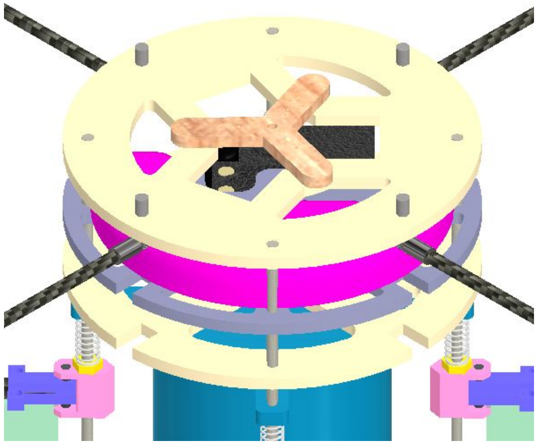
Payload Parachute Deployment Configuration Trade & Selection (6 of 6)

Design	Mass (g)	Servos	Parachute placement	Attachment Points
1	85	2	Loose in layer overtop release mechanism.	3
2	100	1	Separated from rest of layer.	4

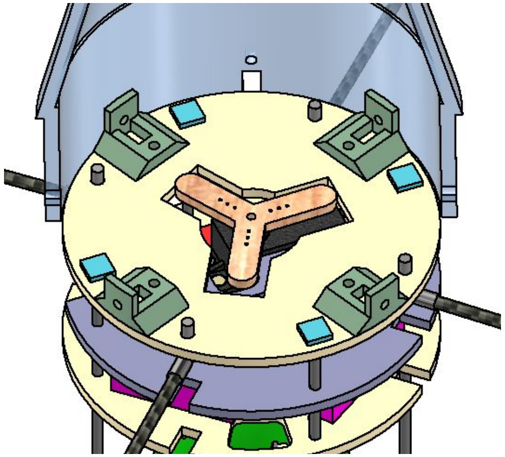
Design 1



Final

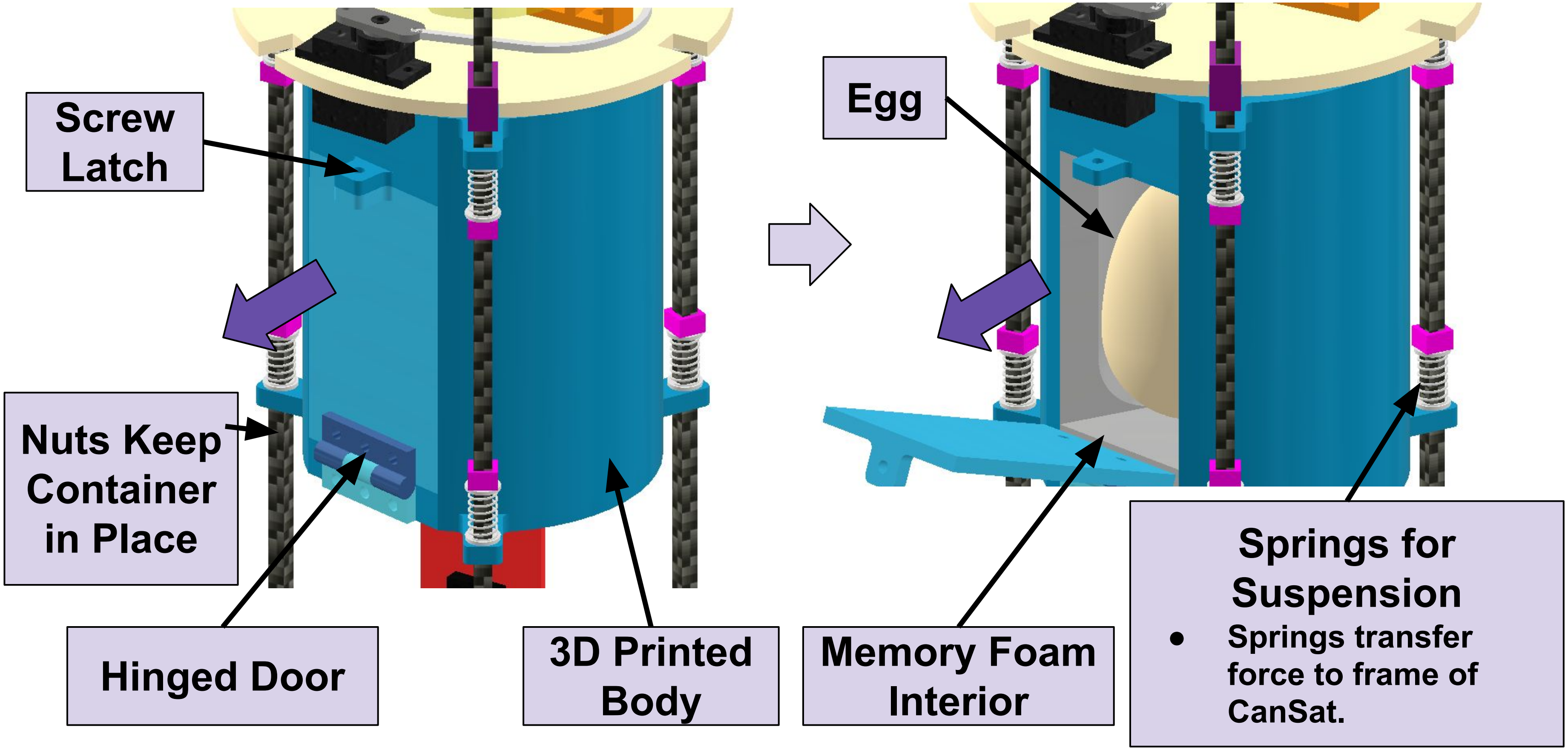


Design 2



Payload Egg Containment Configuration Trade & Selection (1 of 4)

Design 1


Screw Latch

Nuts Keep Container in Place

Hinged Door

3D Printed Body

Egg

Memory Foam Interior

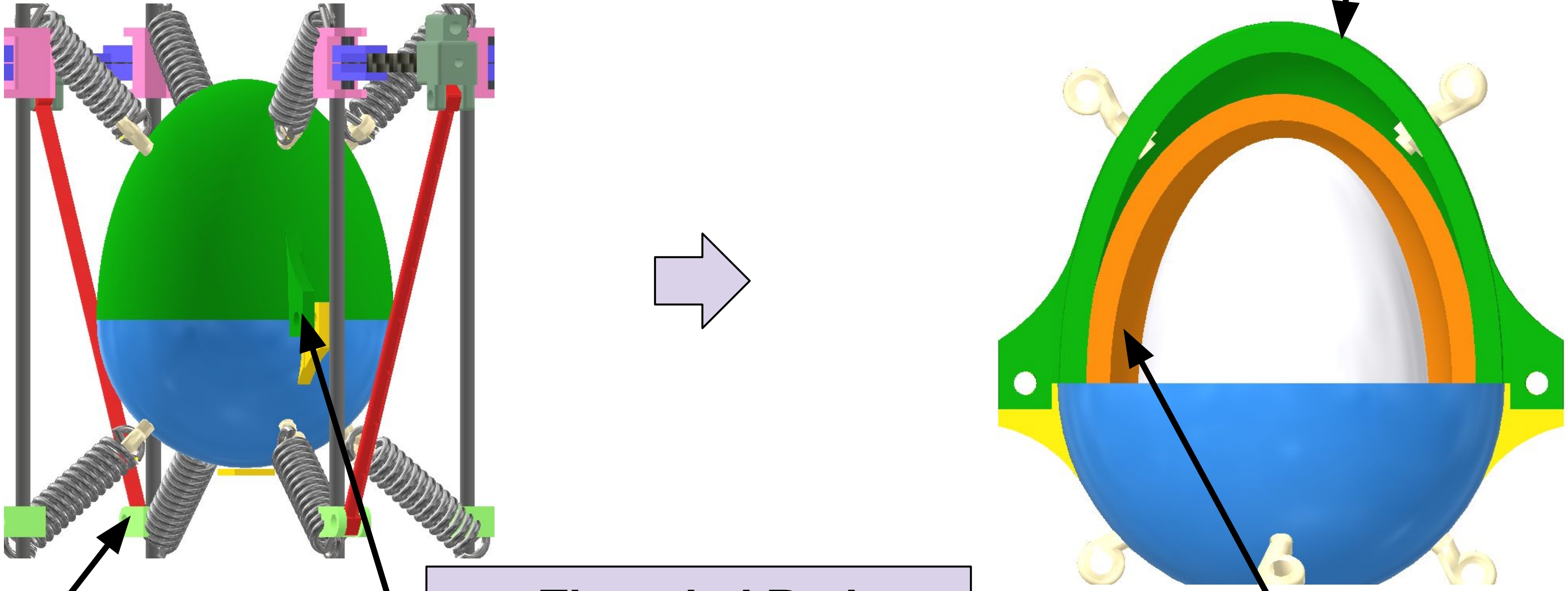
Springs for Suspension

- Springs transfer force to frame of CanSat.

Payload Egg Containment Configuration Trade & Selection (2 of 4)

Design 2

3D Printed Egg Shaped Canister



Spring Suspension

- Takes force off of the egg and transfers it to the frame.

Threaded Rod Attachment

- This is unscrewed and the green top piece seperates from the blue bottom piece.

Bubble Wrap Interior

Payload Egg Containment Configuration Trade & Selection (3 of 4)

Figures of Merit	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	8	64	2	16
Volume	8	4	32	8	64
Cushion Material	4	8	32	4	16
Accessibility	2	8	16	4	8
Weighted Scores		144		104	

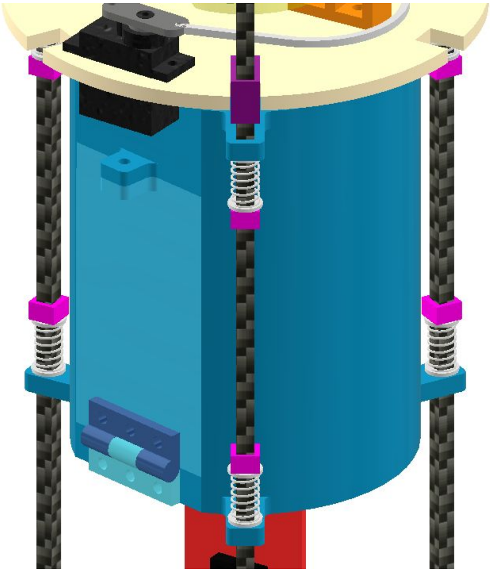
Selection and reasoning: Design 1
Design 1 is lighter and provides more protection for the egg due to the memory foam. The container also provide for easy access to the egg.

Payload Egg Containment Configuration Trade & Selection (4 of 4)

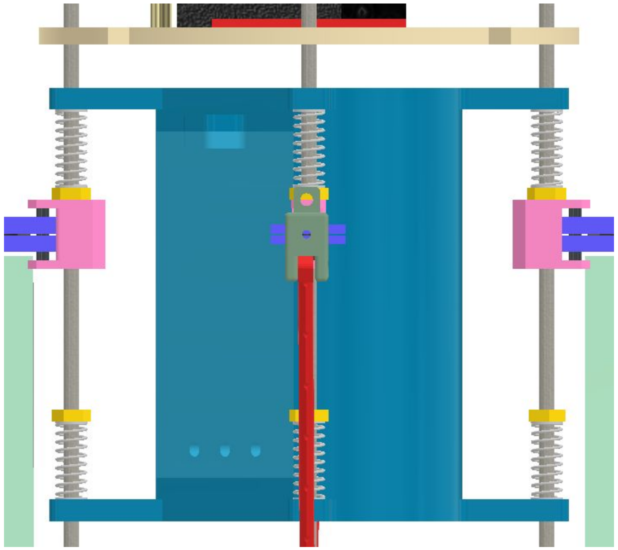
Selection

Design	Mass	Access Method	Egg Safety
1	64g	Screw Latch	Memory Foam
2	125g	Two Threaded Rods	Bubblewrap

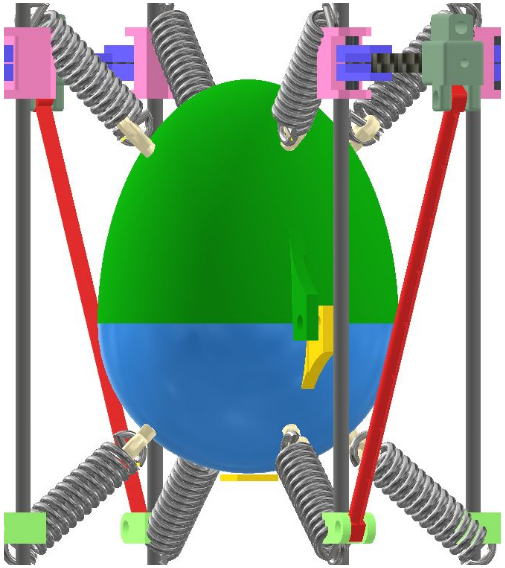
Design 1



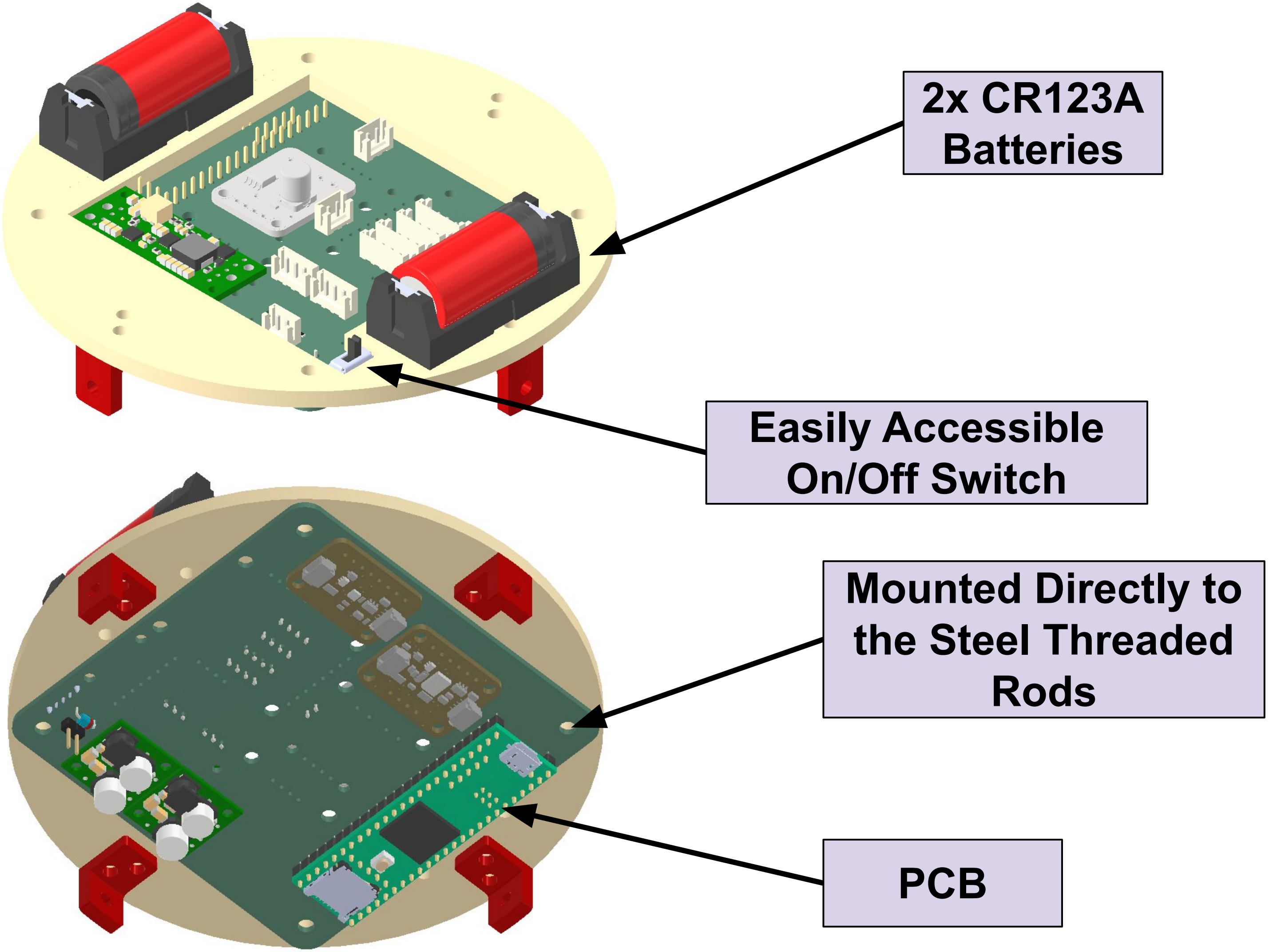
Final



Design 2



Electronics Structural Integrity


2x CR123A Batteries

Easily Accessible On/Off Switch

Mounted Directly to the Steel Threaded Rods

PCB

Mass Budget (1 of 2)

Part	Quantity	Mass (g)	Total Mass (g)	Source
Teensy 4.1	1	32.1	32.1	Datasheet
BNO055	1	3	3	Datasheet
MAX-M10S and Antenna	1	30	30	Estimate
BMP 390	1	3	3	Datasheet
PixHawk Airspeed Sensor	1	3.5	3.5	Datasheet
Open MV Camera	2	19	38	Datasheet
PCB	1	30	30	Datasheet
Battery	2	27	54	Datasheet
XBee Explorer Board	1	5	5	Datasheet
3.3V Regulator	1	2.3	2.3	Datasheet
5V Regulator	1	2.3	2.3	Datasheet
Switch	1	1.8	1.8	Datasheet
USB C Umbilical	1	1.3	1.3	Datasheet
LED	1	7.4	7.4	Datasheet

Total Mass: 902.5g
Margin: -2.5g

- Additional mass can be saved through composite manufacturing.
- Additional mass can be added with 3D printed weight brackets.

Mass Budget (2 of 2)

Part	Quantity	Mass (g)	Total Mass (g)	Source
Buzzer	1	8	8	Datasheet
12V Regulator	1	3.6	3.6	Datasheet
Motor Driver	1	2.2	2.2	Datasheet
Nosecone	1	200	200	Estimate
Parachute	1	10	10	Estimate
Composite Platform	5	20	100	Estimate
Steel Rod	4	16	64	Estimate
Carbon Fiber Rods	4	13	52	Estimate
Fastening nuts	40	1	40	Datasheet
Egg canister	1	64	64	Datasheet
Assorted 3D printed parts	-	40	40	Estimate
Pitot Tube	1	25	25	Datasheet
360 Servo	1	60	60	Datasheet
Brushed Motor	1	20	20	Datasheet

Total Mass: 902.5g
Margin: -2.5g

- Additional mass can be saved through composite manufacturing.
- Additional mass can be added with 3D printed weight brackets.

Communication and Data Handling (CDH) Subsystem Design

Arel Urbanozo, Madeline Teer

Payload Command Data Handler (CDH) Overview


Image Credit: adafruit.com

BMP390
Pressure/Altitude
I2C

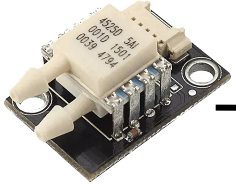


Image Credit: robotics.org

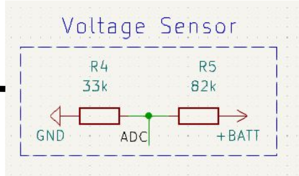
Pixhawk
Air Speed
I2C


Image Credit: adafruit.com

BNO055
Tilt/IMU
I2C


Image Credit: pjrc.com

Voltage Sensor
ADC



MAX-M10S
GPS
I2C

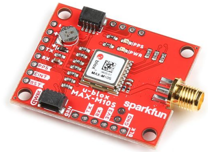


Image Credit: adafruit.com

Xbee-Pro 900
Radio
UART


Image Credit: Digikey.com

Open MV Camera
x2
Video Recording
I2C


Image Credit: adafruit.com

Payload Processor & Memory Trade & Selection (1 of 3)

Figures of Merit	Weight	Teensy 4.1		ESP 32		Raspberry Pi Pico	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Mass	2	4	8	2	4	4	8
Processor Speed	4	4	16	2	8	2	8
Cost	4	4	16	4	16	8	32
Comm	8	8	64	8	64	4	32
Power Consumption	4	1	4	1	4	4	16
Software Compatibility	1	8	8	8	8	4	4
Flash Memory	2	4	8	4	8	2	4
Weighted Score		124		112		104	

Selection: Teensy 4.1

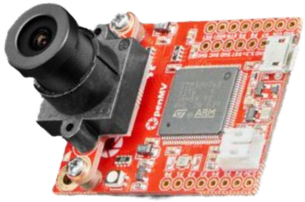
Image Credit: pjrc.com

Payload Processor & Memory Trade & Selection (2 of 3)

Processor	Boot Time (ms)	Power Consumption (mW)	Processor Speed (MHz)	Comm. Types	RAM (kB)	Decision Matrix Weight	Cost ($)
ESP32-S3-DevKit-C	200	400	240	3 UART 4 SPI 2 I2C	512	112	$15.00
Teensy 4.1	20	330	600	8 UART 3 SPI 3 I2C	1024	124	$31.50
Raspberry Pi Pico	1500	500	133	7 UART 3 SPI 3 I2C	264	104	$4.00

Payload Processor & Memory Trade & Selection (3 of 3)

Memory Unit	Interface	µSD Card	Flash (MB)	RAM (MB)	Cost (USD)
OpenMV Cam H7 R1	On Board SD Slot	64GB	2	1	$84.95
Teensy 4.1	On Board SD Slot	1TB	8	1	$31.50
DEV-13712	I2C/UART	32GB	-	-	$16.95

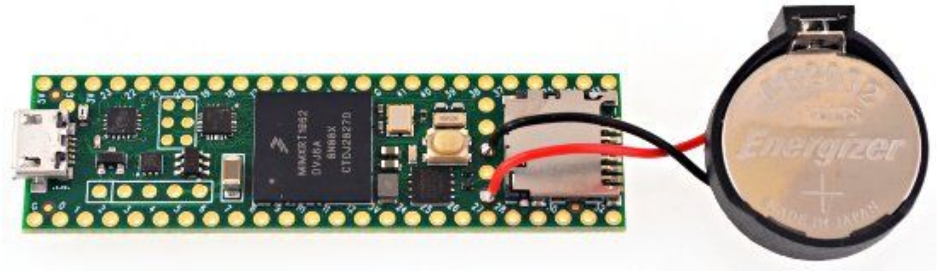


OpenMV and Teensy:
- **Integration**
- **µSD Size**

Image Credit: adafruit.com & pjrc.com

Payload Real-Time Clock

Unit	Accuracy (ns)	Battery	Mass (g)	Cost (USD)
MAX-M10S	±30	On Board	4	$44.95
Teensy 4.1	±1.2	Soldered On	2.8	$23.80

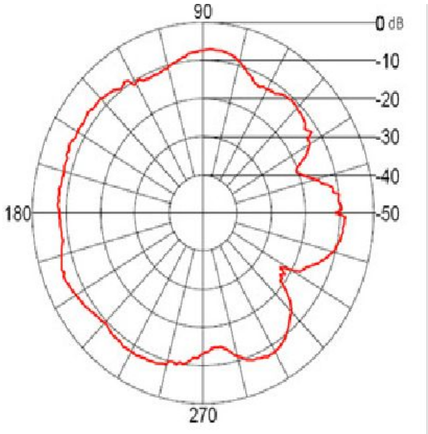


Teensy:
- **Accuracy**
- **Battery Capacity**

Image Credit: pjrc.com

Payload Antenna Trade & Selection

Antenna	Range (GHz)	Gain (dBi)	Mount	Mass (g)	Cost (USD)
A24-HABUF-P5I	2.4	2.1	Connector Mount	Not Listed	$6.33
Integrated Wire	0.87	1.9	Integrated	Negligible	Integrated
W1902	2.17	2.5	Connector Mount	11.07	$6.16



Integrated Wire:
- **Weight**
- **Cost**

Image Credit: Digikey.com & researchgate

Payload Radio Configuration

- **XBee Radio Selection**: XBee-Pro 900HP
- **NETID**: 2078
- **Transmission Control**:
    - Transmission begins once the payload has received the command cx_on and will transmit telemetry at a rate of 1Hz
    - Transmission will end one the payload has received the command cx_off or the payload has landed
    - The XBee will not be in broadcast mode
- **Baud Rate**: 9600

XBee	Mode	Destination High	Destination Low
Shockwave	API	Cybertron High	Cybertron Low
Cybertron	API	Shockwave High	Shockwave Low

Image Credit: Digikey.com

Payload Telemetry Format (1 of 4)

Telemetry Format
<TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>,< MODE>, <STATE>, <ALTITUDE>, <AIR_SPEED>, <HS_DEPLOYED>, <PC_DEPLOYED>, <TEMPERATURE>, <VOLTAGE>, <PRESSURE>, <GPS_TIME>, <GPS_ALTITUDE>, <GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_SATS>, <TILT_X>, <TILT_Y>, <ROT_Z>, <CMD_ECHO>

Packet Example
“2078,08:13:24.54,814,F,ASCENSION,4,N,N,34,6.7,1013.25,08:13:23,401.56,14.0056,3.6457,1,14.74,96.25,45.01,ACT,LED”

Payload Telemetry Format (2 of 4)

Data Field	Description	Units
<Team_ID>	Identification number	N/A
<MISSION_TIME>	Time since the mission began in UTC	hh:mm:ss.ms ±1s
<PACKET_COUNT>	Packet count since mission began (Data)	N/A
<MODE>	Payload and Ground Station Mode (Flight and Simulation)	N/A
<STATE>	State of the software (Ascension, descension, landing, etc.)	N/A
<ALTITUDE>	Height above launch site	Meters
<AIR_SPEED>	The air speed measured from the pilot tube in m/s	m/s
<HS_DEPLOYED>	“P” Indicates probe has deployed heat shield, “N” indicates otherwise	N/A
<PC_DEPLOYED>	“P” Indicates the probe has deployed the parachute, “N” indicates otherwise	N/A

Payload Telemetry Format (3 of 4)

Data Field	Description	Units
<TEMPERATURE>	The temperature of the CanSat in Celsius	°C
<VOLTAGE>	Voltage of the cansat with resolution of Volts	V
<PRESSURE>	Our air pressure, has a resolution of 0.1 kPa	kPa
<GPS_TIME>	Time from the GPS receiver in UTC	hh:mm:ss.ms
<GPS_ALTITUDE>	Altitude from our GPS receiver in meters above mean sea level. Has a resolution of 0.1 Meters	m
<GPS_LATITUDE>	Latitude from the GPS receiver in decimal degrees. Has a resolution of 0.0001 degrees North	°North/°South
<GPS_LONGITUDE>	Longitude from the GPS receiver in decimal degrees. Has a resolution of 0.0001 degrees West	°East/°West
<GPS_SATS>	Total number of GPS satellites being tracked by our GPS receiver.	N/A
<TILT_X>	Angle of cansat on the X axis. Has a resolution of 0.01 degrees	° (Degrees)

Payload Telemetry Format (4 of 4)

Data Field	Description	Units
<TILT_Y>	Angle of cansat on the Y axis. Has a resolution of 0.01 degrees	° (Degrees)
<ROT_Z>	Rotation rate of Cansat in degrees per second. Has resolution of 0.1 degrees per second	°/s
<CMD_ECHO>	Text of last command sent and received by the CanSat	N/A

Payload Command Formats (1 of 2)

Team ID	Command	Argument	Example Format	Command Description
2078	CX	ON	CMD,2078,CX,ON	Turning on telemetry
2078	CX	OFF	CMD,2078,CX,OFF	Turning off telemetry
2078	SIM	ENABLE	CMD,2078,SIM,ENABLE	Enabling the simulation mode
2078	SIM	ACTIVATE	CMD,2078,SIM,ACTIVATE	Activating the simulation mode
2078	SIM	DISABLE	CMD,2078,SIM,DISABLE	Disabling the simulation mode
2078	SIMP	[Float Input]	2078,SIMP,[Input]	Sending a random pressure input
2078	ST	UTC	2078,ST,UTC	Setting the time on probe to UTC
2078	ST	GPS	2078,ST,GPS	Setting the time on probe to UTC from the GPS

Payload Command Formats (2 of 2)

Team ID	Command	Argument	Example Format	Command Description
2078	BCN	ON	CMD,2078,BCN,ON	Turn on audio beacon
2078	BCN	OFF	CMD,2078,BCN,OFF	Turn off audio beacon
2078	CAL	-	CMD,2078,Cal	Calibrate Altitude to Zero
The Following Commands Are Team Designed				
2078	MECH	PAR	CMD,2078,MECH,PAR	Activate parachute release in case of emergency
2078	MECH	AERO	CMD,2078,MECH,AERO	Activate aerobrake release in case of emergency

Electrical Power Subsystem (EPS) Design

Harrison Slusser

EPS Overview

Batteries:
Two Surefire 123A's in series to take the voltage from 3V to 6V.

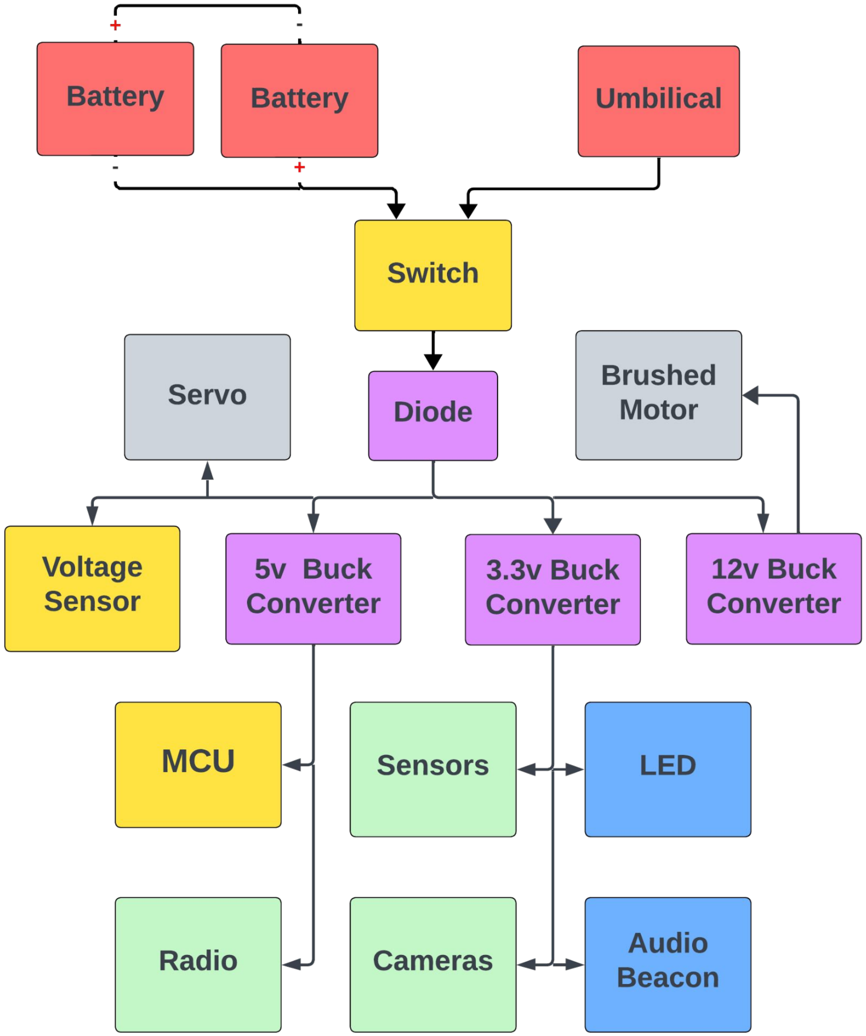
Umbilical:
USB C Power Delivery to provide 5V at 3 amps of wall power.

Switch:
Switches between battery power and umbilical power.

Diode:
Prevents the flow of power backwards up the stack.

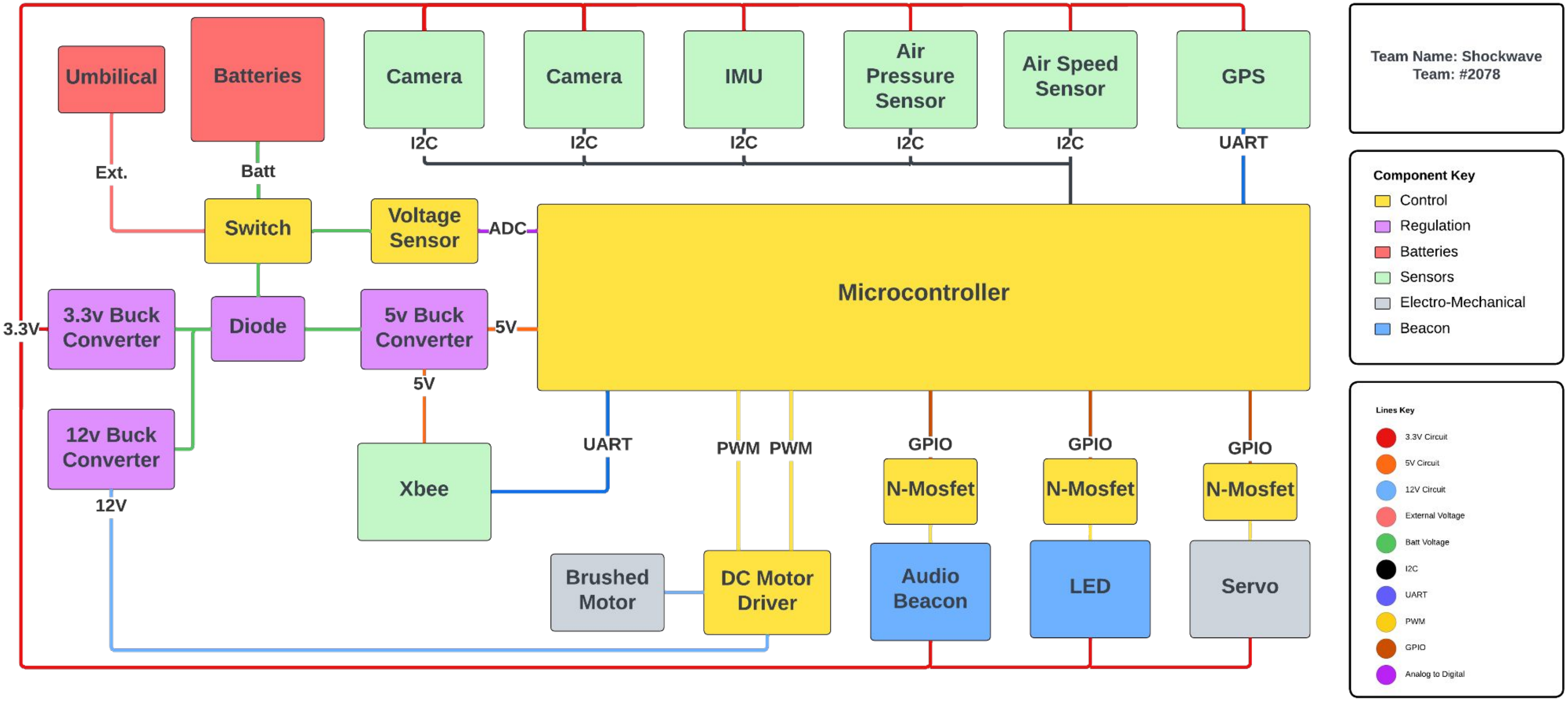
Voltage Sensor:
Monitors the voltage of batteries to determine the energy remaining.

Voltage Regulators:
Steps up/down the input voltage to 3.3V, 5V, 12V.



Payload Electrical Block Diagram

*** Switch is Mounted Externally; *Power Verified by LED Flash**



Payload Power Trade & Selection (1 of 2)

Figures of Merit	Weight	Procell PC1500		Surefire 123A		Procell Intense PX2400	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Capacity	8	8	64	4	32	2	16
Gravimetric Energy Density (Wh/kg)	8	2	16	8	64	2	16
Voltage	4	2	8	4	16	2	8
Mass	4	4	16	8	32	2	8
Cost	2	8	16	4	8	2	4
Weighted Scores		120		152		52	

Payload Power Trade & Selection (2 of 2)

Model	Capacity (mA)	Voltage (V)	Composition	Gravimetric Energy Density (Wh/kg)	Series or Parallel	Quantity Required	Mass (g)	Total Cost ($)
Procell PC1500	3,125	1.5	Alkaline Manganese Dioxide	189.78	Series	4	98.8	$3.20
Surefire 123A	1,550	3	Lithium	273.53	Series	2	32	$4.64
Procell Intense PX2400	1,465	1.5	Alkaline Manganese Dioxide	189.44	Series	8	92.8	$7.04

Selection: Surefire 123A

- **Highest Energy Density**
- **Only Requires Two Batteries**
- **Lowest Weight**
- **Not a Lithium Polymer Battery**

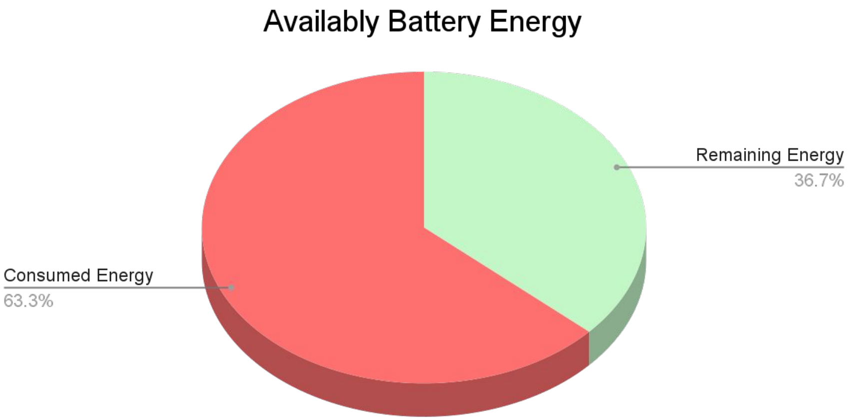
Image Credit:
surefire.com

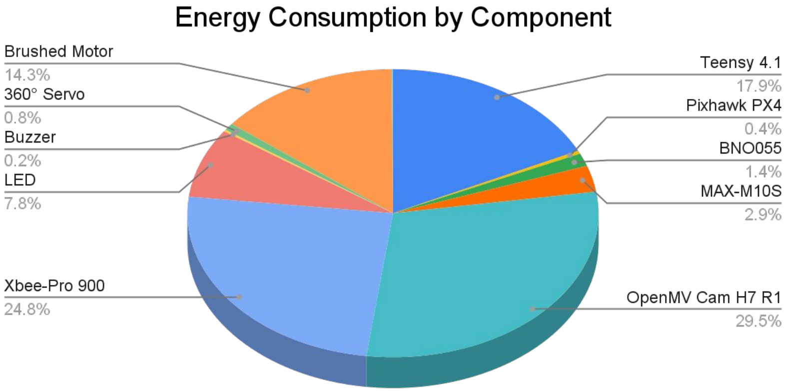
Payload Power Budget (1 of 2)

Components:	Quantity:	Voltage (V):	Active Current (mA):	Active Duration (h):	Idle Current (mA):	Idle Duration (h):	Energy (Wh):	Source:
Teensy 4.1	1	5	100	2	0	0	1	Datasheet
BMP390	1	3.3	0.0032	2	0.0005	0	~0	Datasheet
Pixhawk PX4	1	3.3	3	2	0.006	0	0.02	Datasheet
BNO055	1	3.3	12.3	2	0.04	0	0.081	Datasheet
MAX-M10S	1	3.3	25	2	2.2	0	0.165	Datasheet
OpenMV Cam H7 R1	2	3.3	250	2	0.00295	0	1.65	Datasheet
Xbee-Pro 900 Radio	1	3.3	210	2	2.8	0	1.39	Datasheet
LED	1	5	350	0.25	0	1.75	0.44	Datasheet
Buzzer	1	5	9	0.25	0	1.75	0.01	Datasheet
360° Servo	1	6	150	0.05	0	1.95	0.045	Datasheet
Brushed Motor	1	12	1330	0.05	0	0	0.80	Datasheet
Voltage Sensor	1	6	0.5	2	0	0	~0	Calculated
***Assumed 2 Hour Flight Time**				Energy Subtotal (Wh):			~5.60	Calculated

Payload Power Budget (2 of 2)

Energy Consumption Subtotal:	5.60 Wh
Power Supply Efficiency:	95.0%
Total Energy Consumption:	5.89 Wh
Available Battery Energy:	9.30 Wh
Energy Margin:	3.41 Wh
Remaining Battery Percentage:	36.62%





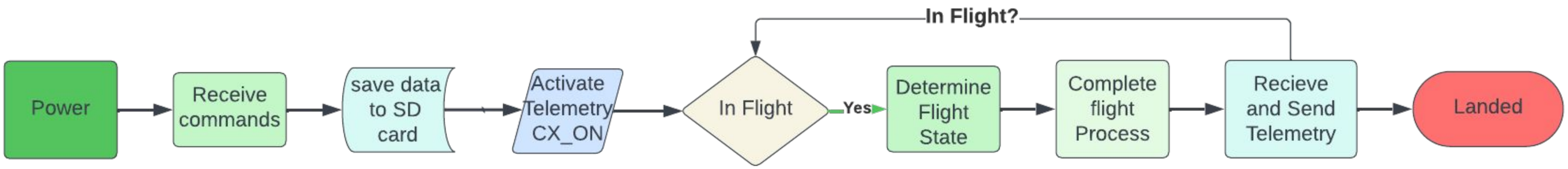
Flight Software (FSW) Design

Madeline Teer

FSW Overview

- **Language:** C++
- **Libraries:** Adafruit_BNO055, Adafruit_BMP3xx, Adafruit_Sensor, PID
- **Development Environment and Compiler:** Arduino IDE

Start Up	Flight	Landing
• Power all systems • Boot and calibrate all sensors • Read last saved packet	• Determine Flight state • Record all flight • Release the mechanisms at desired point • Save data	• Turn on buzzer and LED • End all recordings • Save all data

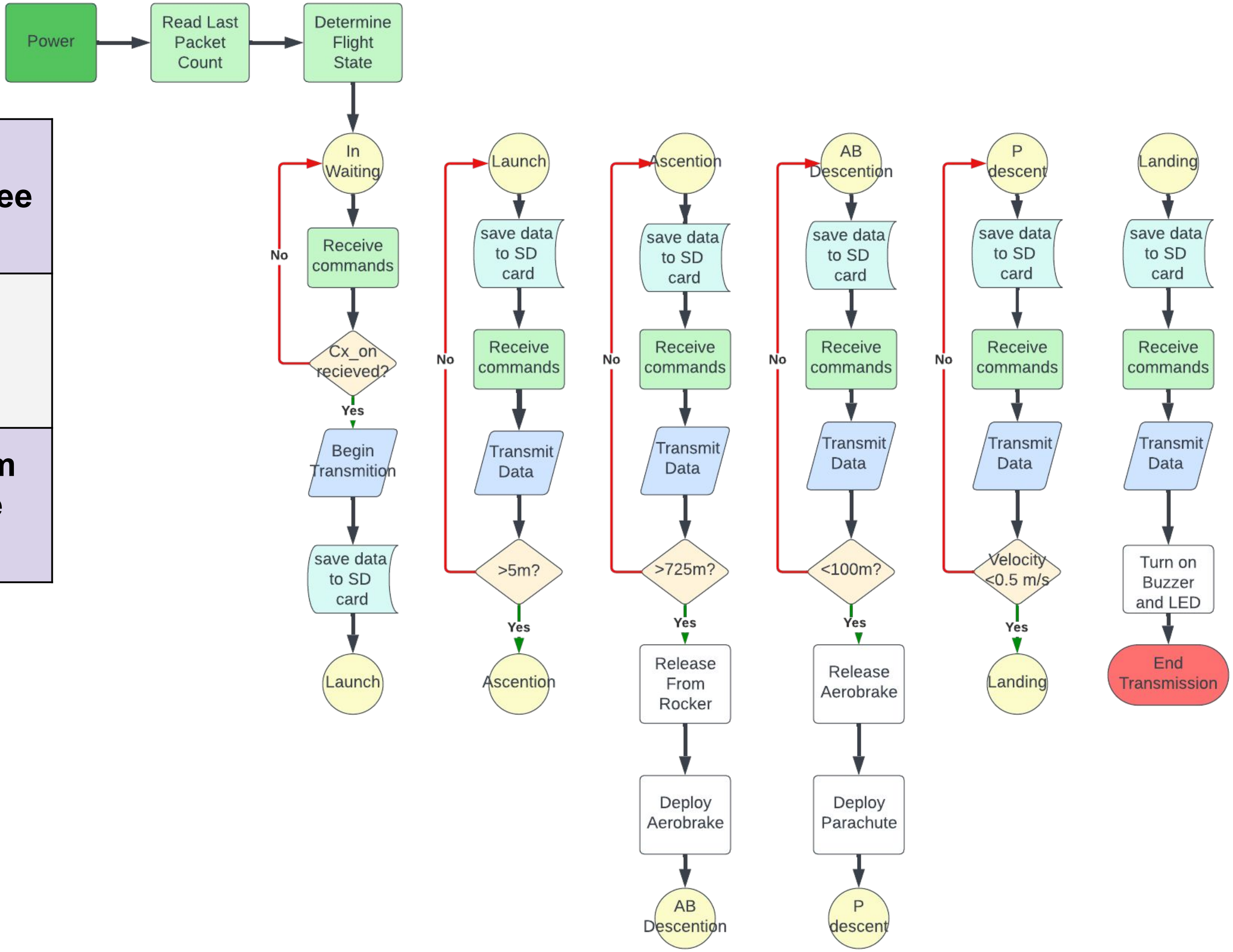


Payload FSW State Diagram (1 of 2)

Telemetry is transmitted over XBee at a rate of 1Hz.

Data is saved to the SD Card at a rate of 1Hz.

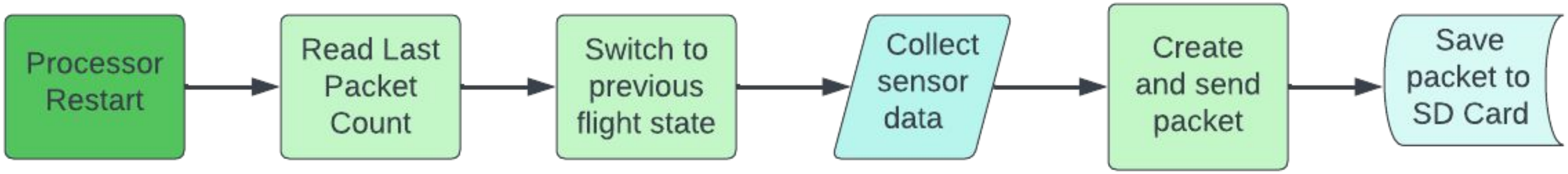
Data is sampled from the sensors at a rate of 3Hz.



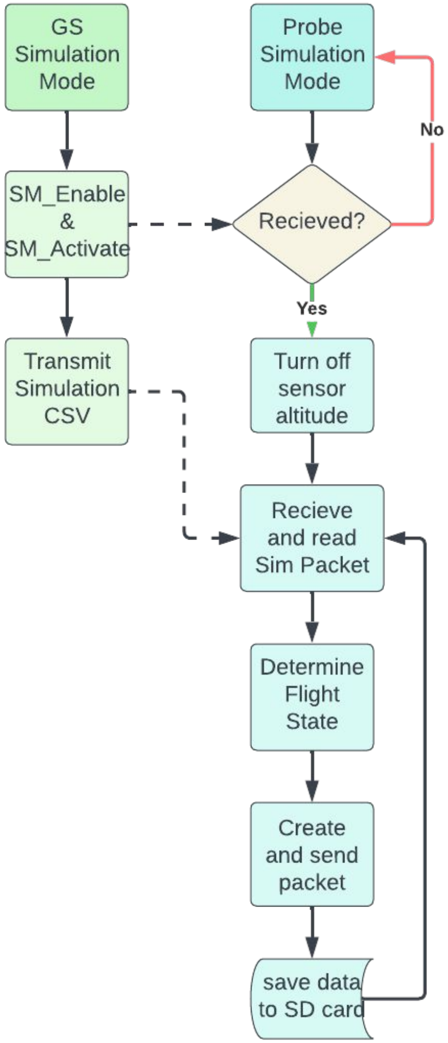
Payload FSW State Diagram (2 of 2)

Processor Restart:

- The last packet will be read from the SD card.
- Assign the previous flight state and restore sensor data.
- Create packet and send to Ground Station.
- Continue Flight.



Simulation Mode Software



Simulation Mode:

- Probe must receive both SIM_ENABLE and SIM_ACTIVATE to activate Sim Mode.
- Sim Mode will transmit altitude data at a rate of 1Hz to the probe.
- The probe will read all other sensor data except altitude data.
- The probe will determine the flight state and send telemetry packets throughout Sim Mode.

Commands:

SIM_ENABLE: turns on the ability to activate the Sim Mode

SIM_ACTIVATE: turns on Sim Mode

SIM_DISABLE: turns off Sim Mode

Software Development Plan

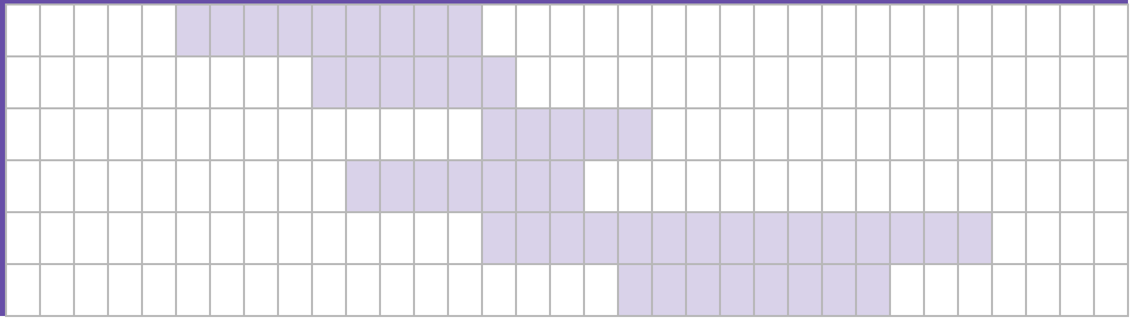
Prototyping:
- Environments: Arduino IDE

Team:
- Nilan Mickel - GCS development
- Madeline Teer- FSW development
- Arel Urbanozo- Electro-Software Integration

Test Methodology:
- Continuous integration and testing within development stages to debug and fix through the development process.

Organization:
- Github
- Header Files

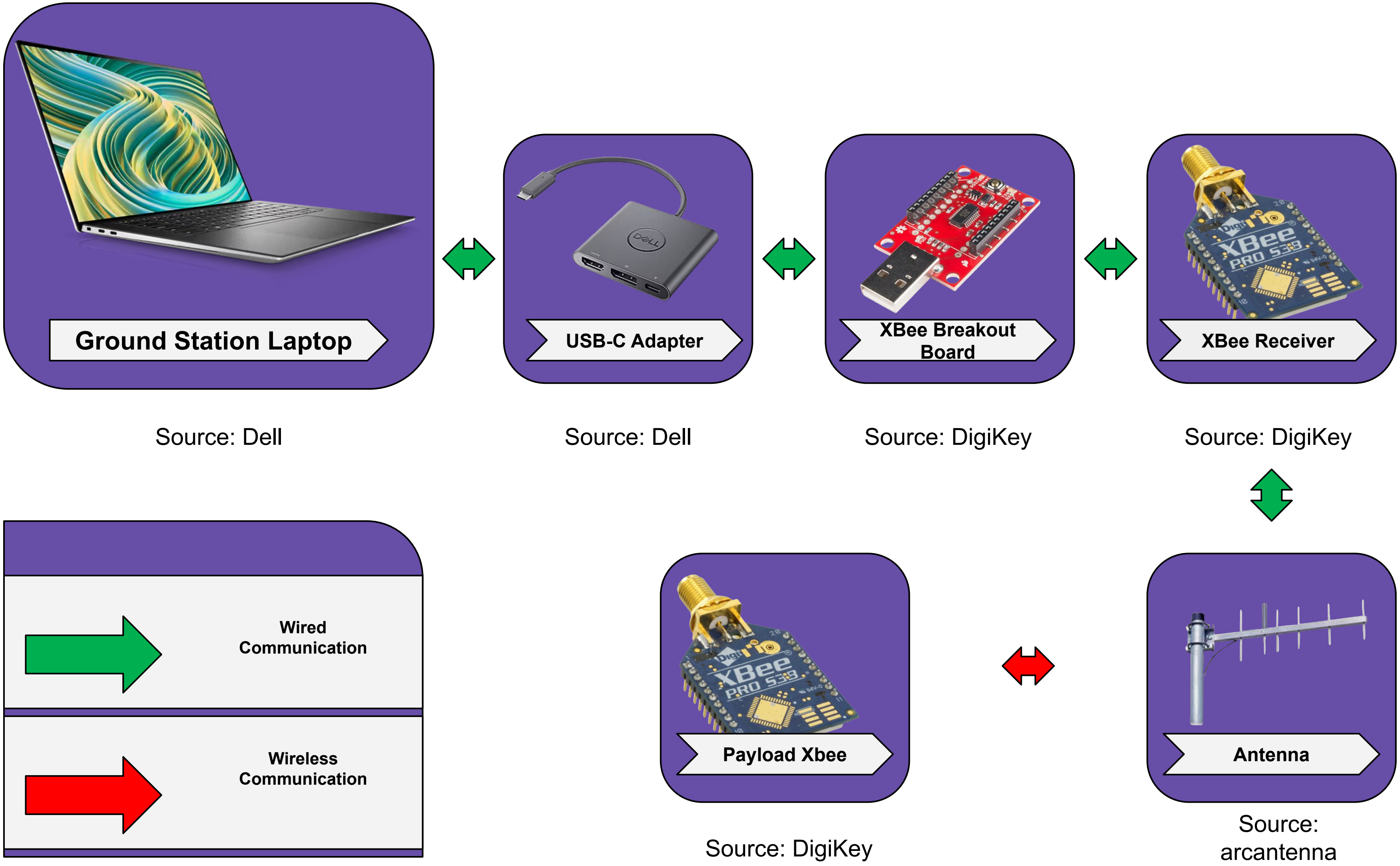
Software Development		
GUI Prototyping	12/11/2023	02/01/2024
FS Code Prototyping	01/02/2024	02/03/2024
FS Testing	02/03/2024	03/06/2024
GUI Testing	1/10/2024	02/24/2023
Finished GUI	02/06/2024	05/16/2024
FS Finished	03/06/2024	04/27/2023



Ground Control System (GCS) Design

Nilan Mickel

GCS Overview



Ground Station Laptop

Source: Dell

USB-C Adapter

Source: Dell

XBee Breakout Board

Source: DigiKey

XBee Receiver

Source: DigiKey

Antenna

Source: arcantenna

Payload Xbee

Source: DigiKey

🟩 Wired Communication

🟥 Wireless Communication

GCS Design (1 of 2)

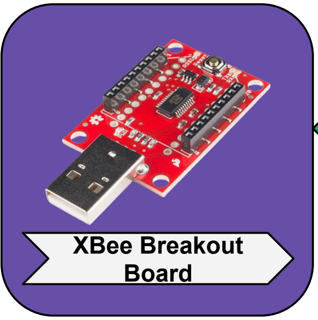
Ground Station Laptop

Source: Dell

Source: Dell

USB-C Adapter

Source: DigiKey



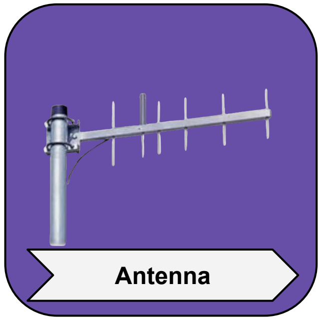
XBee Breakout Board

Source: DigiKey

XBee Receiver

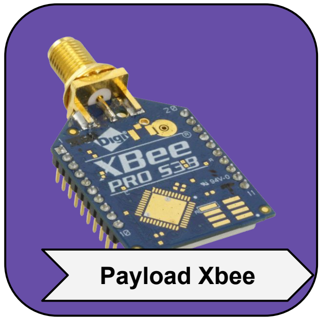
Coax Cable

Source: L-Com



Antenna

Source: arcantenna



Payload Xbee

Source: DigiKey

Connections

Laptop: The chosen laptop is the Dell XPS 15**.**

USB Connections: We use the following USB connections:

- USB-C to USB-A, to connect our XBee breakout board to the laptop
- USB-A, the connection our XBee uses

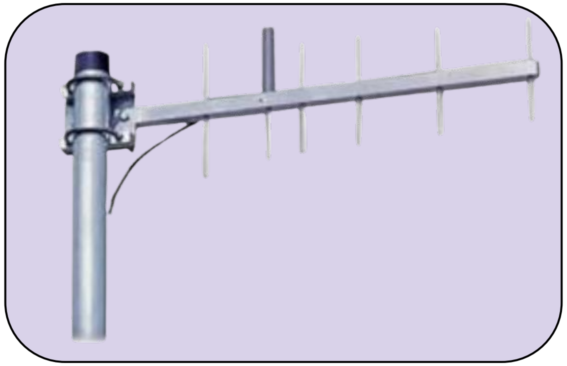
Coaxial: Our Yagi antenna uses an sma male to n female coax cable to connect to our XBee Receiver. This XBee communicates wirelessly to the payload XBee.

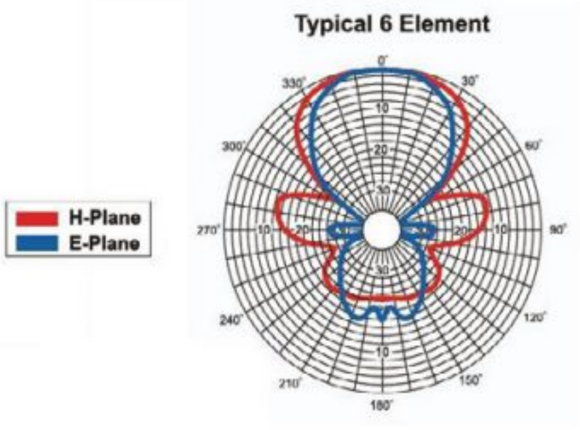
GCS Design (2 of 2)

Specifications
Battery Life: The XPS 15 Laptop has over 11 hours of battery life over a single charge.
Overheating Mitigation: We plan on using an umbrella to keep the laptop out of direct heat and laptop stands to increase airflow. If an overheat does occur, we will have a backup laptop on standby.
Auto-Update Mitigation: Auto Update for our laptop will be turned off the week of flight day.

GCS Antenna Trade & Selection

Antenna	Gain (dBi)	Frequency Range (MHz)	Polarity	Horizontal/ Azimuth Bandwidth	Vertical/Elevation Bandwidth	Cost
RFMAX 4-handheld	8.5 dBi	896-980 MHz	Linear	100 deg	70 deg	$98.26
PC906N-handheld	8.5 dBi	896-940 MHz	Linear	65 deg	55 deg	$65.68





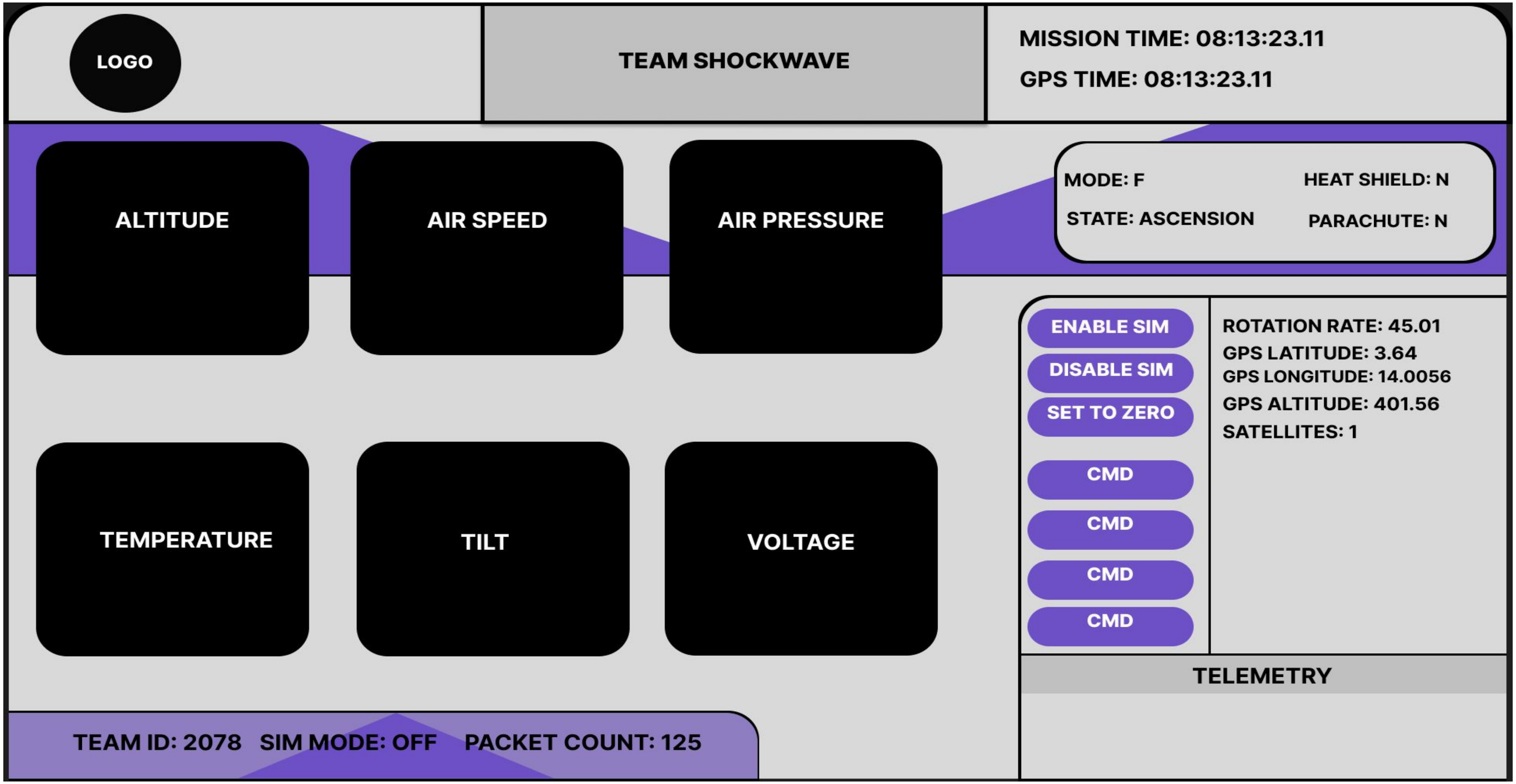
<u>Selection:</u> PC906N-Handheld

- **Gain**
- **Cost effective**

Image Credit: arcantenna.com

TE Connectivity

GCS Software (1 of 2)



MISSION TIME: 08:13:23.11
GPS TIME: 08:13:23.11

MODE: F
HEAT SHIELD: N
STATE: ASCENSION
PARACHUTE: N

ROTATION RATE: 45.01
GPS LATITUDE: 3.64
GPS LONGITUDE: 14.0056
GPS ALTITUDE: 401.56
SATELLITES: 1

TEAM ID: 2078
SIM MODE: OFF
PACKET COUNT: 125

Graphs will have bold plot traces and axes.

GCS Software (2 of 2)

GCS Software Decisions
Software ● Javascript and HTML as the frontend. ● GOLang as the backend. ● GCS will utilize Websocket communication as opposed to http so that our backend and front end can communicate and our information can consistently and continuously update in real time.
COTS software **Graphs and Plotting** ● Highcharts **CSS Framework** ● Bootstrap
Telemetry Data and CSV ● Receive packet, sort it by the packet number, each field is separated by delimiter. ● Seperated in GOLang and then plotted in the frontend**.** ● The ground station will also count the number of packets received. **Calibration and GCS Commands** ● Activated with a button press on the front end. When pressed, it sends a command over the XBee radio. ● When the button is pressed on our GCS a string is sent to the FSW code. When recieved, the FSW calibrates the current altitude to 0.

CanSat Integration and Test

Arel Urbanozo

CanSat Integration and Test Overview

Individual Subsystem	Each individual subsystem will be tested to make sure are requirements are met.
Integration	Each system will be integrated and tested to determine fit and function of all parts together.
Environmental	After complete integration the Cansat will be run through environmental testing as described in mission guide.
Simulation	Cansat will be put into simulation testing mode with two step commands to receive simulated CSV data.
Test Launches	Test launch the Cansat in launch day replica rocket and environments twice to determine any launch day complications and fix them.

Subsystem Level Testing Plan (1 of 2)

Subsystem	Components	Test Description	Requirements to pass
Sensors	BMP390 BNO055 PA1616S	Test all sensors using areas of known values to check the accuracy of the sensors.	All sensor data matches the accuracy of the data sheets.
CDH	Command Input	Send commands from GCS to the container.	The Cansat and GCS will communicate effectively and parse sent data/packets.
EPS	PCB Sensors MCU Batteries	2 hour battery life of the batteries and electrical continuity of proper voltage among all components.	The system has the proper operating voltage for the duration of 2 hours.
Radio Communication	GCS XBees	Testing long distance two way communication between GCS and XBees.	Packets must be sent between GCS and Cansat and the Cansat must receive commands from GCS.

Subsystem Level Testing Plan (2 of 2)

Subsystem	Components	Test Description	Requirements to pass
FSW	MCU	Test all command implementation, real time clock, and transition of flight states.	All flight states switch at the proper moment, all command implementation is successful and RTC is working correctly.
Mechanical	Aerobrake Parachute Release	Test deployment mechanisms for the aerobrake and parachute. Verify aerobrake release mechanism.	Aerobrake fully deploys. Parachute deploys on command. Aerobrake releases from rest of payload on command.
Descent Control	Aerobrake Servo	Test payload stability during descent, verifying the position of COM and effect of turbulent flow due to aerobrake.	Payload does not flip. Maintains stable orientation during descent.

Integrated Level Functional Test Plan

Subsystem	Testing Plan	Pass Requirements
Descent	● Throwing CanSat simulated weight with aerobrake and parachute off a high place. ● Rocket tests 1 and 2	The CanSat shall fall at a rate of 10-30m/s for aerobrake descent and less than 5m/s for the parachute descent.
Communications	● Long distance communication ● Two-way communication ● Optimal Antenna Position ● All tested during test launches	Communication is stable at 1000m and still sends and receives packets throughout the flight and 2 hour battery test.
Mechanisms	● Simulated tests using ground station commands ● Altitude tests with vacuum chamber	All release mechanisms work at the correct altitude.
Deployment	● Ejection from the rocket ● Test Flights 1 and 2	Clean ejection from the rocket without losing power, control, or mechanical function.

Environmental Test Plan (1 of 2)

Test	Method	Test Description	Requirements to Pass
Drop Test	Fixed Point Drop	Using a 61cm non stretch cord, The CanSat will be attached on one end and a fixed object will be attached to the other end. The Cansat will be raised to the attachment points are at the same height and will be released.	The structure must not flex during the drop test. Telemetry is still received. Power is still on.
Thermal Test	Thermal Chamber	Assembled using an insulated cooler, a hairdryer, and a thermometer. The hairdryer will circulate heated air inside the cooler at 60°C for 2 hours.	Structures and mechanisms have no damage and all epoxy joints and composites maintain strength.
Vibration Test	Random Orbital Sander	The CanSat will be attached to a random orbital sander that exposes it to vibrations of 0Hz-233Hz and generates 20-30Gs for one minute.	No damage and maintains functionality, and accelerometer data is still collected.

Environmental Test Plan (2 of 2)

Test	Method	Test Description	Requirements to Pass
Fit Check	Mock Rocket Test	The CanSat will be slid into a tube that has the same dimensions as the rocket used during the competition.	The CanSat slides in and out of the rocket easily with no impediments.
Vacuum Test	Vacuum Chamber	The fully configured and powered CanSat will be placed into a vacuum chamber, and will be pulled to a vacuum. Throughout the process telemetry will be monitored and when max altitude is reached the vacuum will be stopped.	The CanSat must transmit and save telemetry and be provided to judges.

Simulation Test Plan

Component	Description	Requirement
Ground Station	Testing two way communication sending CSV data to the CanSat using the SM and SMP commands.	The GCS should provide data to the CanSat with the simulated CSV file pressure at a rate of 1Hz.
Cansat	When activate and enable commands are received, the CanSat should record all data as normal except altitude which shall be received by CSV over XBee.	The Cansat enters simulation mode from the GCS. The CanSat should receive the CSV telemetry and respond according the the altitude with the proper flight protocols.

Mission Operations & Analysis

Madeline Teer

Overview of Mission Sequence of Events

Event	Task	Team
Arrival	**Arrive at launch site**	**All**
Prelaunch	Cansat Check In	CanSat
	GCS Setup and Antenna Construction	Ground Station
Launch	Cansat Integration	CanSat
	Monitor GCS	Ground Station
	Execute Launch Procedures	CanSat
Flight	Monitor GCS	Ground Station
Recovery	Recover Cansat	Recovery
Data Analysis	Analyze Data and Turn in Thumb Drive	All
	Post Flight Review	All

Role	Team Members
Missions Control Officer	Arel Urbanozo
Cansat Team	Ashley Reed, Samuel Chouinard, Jordan Littlepaige
Recovery Team	Andrew Treadway, Zach Jones, Harrison Slusser
Ground Station Team	Nilan Mickel, Madeline Teer, Nic Ruse

Mission Operations Manual Development Plan

Section	Content	Deadline
Team Roles	Team Roles of individuals.	11/28/23
Ground Station Overview	Overview of the breakout of GCS.	12/28/23
Ground Station Procedure	Procedures of how to operate all GCS components.	3/12/24
Pre-Launch Checklist	Checklist of all procedures to be complete before launch.	3/12/24
Preparation Procedures for Launch	Checklist of all procedures to be completed for launch.	3/12/24
Launch Procedures	Checklist for launch and flight procedures.	3/12/24
Recovery Process	Checklist for recovery procedures.	5/4/24

CanSat Location and Recovery

Component	Visibility
Container	Brightly Colored filaments and fabric to identify Cansat and nose cone.
Visible Beacon	Bright Flashing LED.
Audio Beacon	100dB Beeping Buzzer.
GPS	Real Time Position within 3m.
Team Contact	Phone Number of both team lead and recovery lead, return label address, and email address of team lead. Both on the Cansat and Nose Cone.

Team Contact Info:
Arel Urbanozo (314) 800-5382; Ashley Reed (423) 509-2726; Dr. Gang Wang (248) 434-5608
601 John Wright Dr Huntsville AL 35805

Requirements Compliance

Arel Urbanozo

Requirements Compliance Overview

Full Compliance
71/73 (97% Compliance)
Partial Compliance
S6, S7
No Compliance
Some compliance with all requirements.

Awaiting testing for full compliance.

Requirement Compliance (OR I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
C1	The Cansat shall function as a nose cone during the rocket ascent portion of the flight.	🟩	11, 28, 29	
C2	The Cansat shall be deployed from the rocket when the rocket motor ejection charge fires.	🟩	28	
C3	After deployment from the rocket, the Cansat shall deploy its heat shield/aerobraking mechanism.	🟩	26	
C4	A silver or gold mylar streamer of 50 mm width and 1.5 meters length shall be connected to the Cansat and released at deployment. This will be used to locate and identify the Cansat.	🟩	28	
C5	At 100 meters, the Cansat shall deploy a parachute and release the heat shield.	🟩	27	
C6	Upon landing, the Cansat shall stop transmitting data.	🟩	28	

Requirement Compliance (OR II)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
C7	Upon landing, the Cansat shall activate an audio beacon.	🟩	28	
C8	The Cansat shall carry a provided large hens egg with a mass range of 51 to 65 grams.	🟩	20, 102, 103	
C9	0 altitude reference shall be at the launch pad.	🟩	28, 142	
C10	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	🟩	73	
C11	At 100 meters, the Cansat shall have a descent rate of less than 5 m/s.	🟩	73	
C12	Cost of the Cansat shall be under $1000. Ground support and analysis tools are not included in the cost of the Cansat. Equipment from previous years shall be included in this cost, based on current market value.	🟩	171, 172, 173	

Requirement Compliance (SR I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
S1	The Cansat mass shall be 900 grams +/- 10 grams without the egg being installed.	🟩	107, 108	
S2	Nose cone shall be symmetrical along the thrust axis.	🟩	25, 29	
S3	Nose cone radius shall be exactly 71 mm.	🟩	29	
S4	Nose cone shoulder radius shall be exactly 68 mm.	🟩	29	
S5	Nose cone shoulder length shall be a minimum of 50 mm.	🟩	29	
S6	Cansat structure must survive 15 Gs vibration.	🟨	28	Awaiting Testing
S7	Cansat shall survive 30 G shock.	🟨	28	Awaiting Testing
S8	The Cansat shall perform the function of the nose cone during rocket ascent.	🟩	28, 29	

Requirement Compliance (SR II)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
S9	The rocket airframe can be used to restrain any deployable parts of the Cansat but shall allow the Cansat to slide out of the payload section freely.	🟩	29	
S10	The rocket airframe can be used as part of the Cansat operations.	🟩	28, 29	
S11	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	🟩	106	

Requirement Compliance (MR I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
M1	No pyrotechnical or chemical actuators are allowed.	🟩	11-29	
M2	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	🟩	11-29	
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	🟩	11-21	
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	🟩	106, 127	
M5	The Cansat shall deploy a heat shield after deploying from the rocket.	🟩	26, 28	
M6	The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.	🟩	51, 55, 73	

Requirement Compliance (MR II)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
M7	At 100 meters, the Cansat shall release a parachute to reduce the descent rate to less than 5 m/s.	🟩	28, 64, 73	
M8	The Cansat shall protect a hens egg from damage during all portions of the flight.	🟩	28, 102, 103	
M9	If the nose cone is to be considered as part of the heat shield, the documentation shall identify the configuration.	🟩	11, 13	
M10	After the Cansat has separated from the rocket and if the nose cone portion of the Cansat is to be separated from the rest of the Cansat, the nose cone portion shall descend at less than 10 meters/second using any type of descent control device.	🟩	52, 53, 55	

Requirement Compliance (E I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
E1	Lithium polymer batteries are not allowed.	🟩	127	
E2	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	🟩	127	
E3	Easily accessible power switch is required.	🟩	106, 125	
E4	Power indicator is required.	🟩	125	
E5	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	🟩	128	

Requirement Compliance (X I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	🟩	116	
X2	XBEE radios shall have their NETID/PANID set to their team number.	🟩	116	
X3	XBEE radios shall not use broadcast mode.	🟩	116	
X4	The Cansat shall transmit telemetry once per second.	🟩	116	
X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, Cansat tilt angles, air speed, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	🟩	118-119	

Requirement Compliance (SN I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
SN1	Cansat shall measure its speed with a pitot tube during ascent and descent.	🟩	38-39	
SN2	Cansat shall measure its altitude using air pressure.	🟩	32-33	
SN3	Cansat shall measure its internal temperature.	🟩	34-35	
SN4	Cansat shall measure its angle stability with the aerobraking mechanism deployed.	🟩	40-41	
SN5	Cansat shall measure its rotation rate during descent.	🟩	42-43	
SN6	Cansat shall measure its battery voltage.	🟩	36-37	
SN7	The Cansat shall include a video camera pointing horizontally.	🟩	18,47-49	
SN8	The video camera shall record the flight of the Cansat from launch to landing.	🟩	128,132	
SN9	The video camera shall record video in color and with a minimum resolution of 640x480.	🟩	47	

Requirement Compliance (G I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
G1	The ground station shall command the Cansat to calibrate the altitude to zero when the Cansat is on the launch pad prior to launch.	🟩	142	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	🟩	142	
G3	Telemetry shall include mission time with 1 second or better resolution.	🟩	118	
G4	Cansat shall measure its angle stability with the aerobraking mechanism deployed.	🟩	40,118-119	
G5	Each team shall develop their own ground station.	🟩	136-142	
G6	All telemetry shall be displayed in real time during descent on the ground station.	🟩	114,118-119	
G7	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) and the units shall be indicated on the displays.	🟩	118-119	

Requirement Compliance (G II)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
G8	Teams shall plot each telemetry data field in real time during flight.	🟩	118,141	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	🟩	137-138	
G10	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	🟩	137-140	
G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	🟩	121-122,134	
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the Cansat.	🟩	134	
G13	The ground station shall use a table top or handheld antenna.	🟩	140	

Requirement Compliance (G III)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
G14	Because the ground station must be viewed in bright sunlight, the displays shall be designed with that in mind, including using larger fonts (14 point minimum), bold plot traces and axes, and a dark text on light background theme.	🟩	141	
G15	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	🟩	142	

Requirement Compliance (F I)

Rqmt. Num.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	🟩	116, 121	
F2	The Cansat shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	🟩	114,117	
F3	The Cansat shall have its time set to within one second UTC time prior to launch.	🟩	118	
F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	🟩	134	
F5	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	🟩	134	
F6	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	🟩	121,134	

Management

Arel Urbanozo

CanSat Budget – Hardware (1 of 2)

Name	Designation	Quantity	Unit Price	Total Price	Source	Reuse
Air Pressure and Temperature Sensor - **BMP390**	ELEC	1	$10.95	$10.95	Digikey	
Microcontroller - **Teensy 4.1**	ELEC	1	$33.08	$33.08	Digikey	
Orientation and Tilt Sensor - **BNO055**	ELEC	1	$34.95	$34.95	Digikey	
GPS - **MAX-M10S**	ELEC	1	$44.95	$44.95	Digikey	
Camera - **OpenMV Cam H7 R1**	ELEC	2	$101.94	$203.88	Digikey	
Battery Voltage Sensor - **Resistor Module**	ELEC	1	$0.20	$0.20	Digikey	
Radio Module - **XBee Pro 900 HP**	ELEC	1	$55.66	$55.66	Digikey	X
Radio Board - **XBee Explorer Breakout Board**	ELEC	1	$3.50	$3.50	Digikey	X
360 Degree Servo - **Feedback 360 Degree**	ELEC	1	$34.99	$34.99	Digikey	X
Visual Beacon - **New Energy LED**	ELEC	1	$7.26	$7.26	Digieky	X
Audio Beacon - **PUI Audio Buzzer**	ELEC	1	$1.00	$1.00	Digikey	X
Power - **Surefire CR 123A**	ELEC	2	$2.33	$4.66	Digikey	X
Umbilical - **USB C Breakout**	ELEC	1	$2.95	$2.95	Digikey	
Power Regulation - **Diode**	ELEC	1	$0.08	$0.08	Digikey	X
Resistors	ELEC	6	$0.10	$0.60	Digikey	
Power Regulation - **N-Channel MOSFET**	ELEC	4	$0.44	$1.76	Digikey	X
Power Switch - **OS102011MS2QN1C**	ELEC	1	$0.68	$0.68	Digikey	X
Antenna- **W1902**	ELEC	1	$6.16	$6.16	Digikey	
Motor Driver **DRV8871**	ELEC	1	$7.50	$7.50	Digikey	
3.3v Regulator	ELEC	1	11.95	$11.95	Pololu	
5v Regulator	ELEC	1	11.95	$11.95	Pololu	
12v Regulator	ELEC	1	29.95	$29.95	Pololu	

Electrical Subtotal: $508.66

CanSat Budget – Hardware (2 of 2)

Name	Designation	Quantity	Unit Price	Total Price	Source	Reuse
Fabric - Nylon Sheet	MECH	1	$8.75	$8.75	Amazon	X
Cylinder Carbon Fiber Rods- 5 pack	MECH	1	$11.99	$11.99	Amazon	
Steel Rods	MECH	4	$0.92	$3.67	amazon	X
3MM 1/8" x 12" x 20" Baltic Birch Plywood	MECH	3	$10.65	$31.95	amazon	
Fastening nuts kit	MECH	1	$17.99	$17.99	amazon	X
PETG Roll	MECH	1	$23.99	$23.99	Amazon	X
Epoxy- 25Fl oz	MECH	1	$16.35	$16.35	Amazon	X
Fiberglass	MECH	1	$8.95	$8.95	Amazon	
Pitot Tube	MECH	1	$14.99	$14.99	Amazon	
Aerobrake 25kg Servo	MECH	1	$16.99	$16.99	Amazon	
Hinged Threaded Round Standoffs - 98010A460	MECH	6	$3.14	$18.84	McMaster Carr	
NF123G-305	MECH	1	$5.64	$5.64	Adafruit	
Gromets	MECH	1	$6.59	$6.59	Amazon	
Fishing Line	MECH	1	$4.99	$4.99	Amazon	
Mylar	MECH	1	$5.99	$5.99	Amazon	
Loctite	MECH	1	$8.99	$8.99	Amazon	
Screws	MECH	1	$15.99	$15.99	Amazon	
Standoffs	MECH	1	$22.96	$22.96	Amazon	

Electrical Subtotal: $508.66

Mechanical Subtotal: $245.61

Hardware Total: $754.27

CanSat Budget – Other Costs

Name	Designation	Quantity	Unit Price	Total Price	Source	Reuse
Ground Station Laptop - **Dell XPS 15**	GCS	1	$2,350	$2,350	Dell	X
GCS Antennae - **Laird Technologies PC906N**	GCS	1	$47.39	$47	Digikey	X
GCS Cable - **Coaxial Cable**	GCS	1	$11.99	$12	Digikey	X
Radio Board - **Sparkfun XBee USB Board**	GCS	1	$27.95	$28	Digikey	X
Radio Module - **XBee Pro 900 HP**	GCS	1	$56.00	$56	Digikey	X
USB Mini to USB A Cable	FSW	1	$6.99	$7	Digikey	X
Travel (Per Person)	MISC	10	$132.23	$1,322	Estimate	
Lodging (Per Person)	MISC	10	$283.33	$2,833	Estimate	
Food (Per Person)	MISC	10	$100.00	$1,000	Estimate	

Other Subtotal: $7,656

Graciously funded by the Alabama Space Grant Consortium.

Program Schedule Overview

Basic Program Schedule

TASK	Start	End	November					December				January					February				March				April				May					June	
			1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12
Shockwave																																			
Team Application	11/1/23	11/3/23	▨																																
PDR Phase	11/4/23	2/5/24	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																			
CDR Phase	2/6/24	4/8/24															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨									
Prototyping and Test Launch Phase	3/18/24	6/2/24																					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Competition Phase	6/3/24	6/9/24																																		▨	▨ a

Detailed Program Schedule (1 of 4)

TASK	Start	End	November					December				January					February				March				April				May					June	
			1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12
Detailed Schedule																																			
Team Application	11/1/23	11/3/23	▨																																
MCR	11/2/23	11/29/23	▨	▨	▨	▨	▨																												
Parts Ordering	12/1/23	1/1/24					▨	▨	▨	▨	▨																								
PDR Preparation	12/2/23	1/23/24						▨	▨	▨	▨	▨	▨	▨	▨																				
Fall Term Finals	12/4/23	12/8/23						■	■																										
Winter Break	12/9/23	1/8/23							▨	▨	▨	▨	▨																						
PDR Presentation	2/2/24	2/23/24														▨	▨	▨	▨																
E-Week	2/19/24	2/25/24																	▨	▨															
CDR Preparation	2/26/24	4/1/24																		▨	▨	▨	▨	▨	▨										
Initial Prototyping	1/10/24	3/14/24											▨	▨	▨	▨	▨	▨	▨	▨	▨	▨													
Test Launch 1	3/14/24	3/15/24																				▨													
CDR Presentation	4/8/24	4/26/24																							▨	▨	▨	▨							
Environmental Test Review	4/16/24	5/24/24																									▨	▨	▨	▨	▨	▨			
Spring Term Finals	4/29/24	5/3/24																										■	■						
Test Launch 2	5/6/24	5/10/24																												▨					
Competition Weekend	6/6/24	6/9/24																																▨	▨

Detailed Program Schedule (2 of 4)

TASK	Start	End	November					December				January					February				March				April				May					June	
			1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12
Shockwave																																			
Team Application	11/1/23	11/3/23	▨																																
PDR Phase	11/4/23	2/5/24	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																			
CDR Phase	2/6/24	4/8/24															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨									
Prototyping and Test Launch Phase	3/18/24	6/2/24																					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Competition Phase	6/3/24	6/9/24																																▨	▨
Mechanical Development																																			
Finish Initial CAD design (both sub teams)	11/9/2023	11/16/2023			▨																														
Integrated Designs	11/9/2023	11/26/2023			▨	▨	▨																												
Updated CAD Designs for PDR	11/26/2023	1/29/2024					▨	▨	▨	▨	▨																								
Full CanSat Assembly for Test Launch	1/8/2024	3/7/2024										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨													
Updated Design for CDR	3/7/2024	3/21/2024																				▨	▨	▨											
Fully Updated CanSat for Test Launch 2	3/7/2024	4/28/2024																				▨	▨	▨	▨	▨	▨	▨							
Final Designs	4/28/2024	5/24/2024																									▨	▨	▨	▨	▨	▨	▨	▨

Mechanical Schedule

Detailed Program Schedule (3 of 4)

TASK	Start	End	November					December				January					February				March				April				May					June	
			1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12
Shockwave																																			
Team Application	11/1/23	11/3/23	▨																																
PDR Phase	11/4/23	2/5/24	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																			
CDR Phase	2/6/24	4/8/24															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨									
Prototyping and Test Launch Phase	3/18/24	6/2/24																					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Competition Phase	6/3/24	6/9/24																																		▨	▨
Electrical Development																																			
Trade Studies	11/6/2023	11/10/2023		▨	▨																														
Block Diagram	11/10/2023	11/17/2023		▨	▨	▨																													
Power Budget	11/20/2023	11/24/2023			▨	▨																													
Schematic	11/20/2023	11/24/2023			▨	▨																													
PCB Design	12/8/2023	12/15/2023					▨	▨	▨	▨																									
PCB Order	12/17/2023	12/17/2023								▨																									
Breadboarding	1/8/2023	1/13/2023									▨	▨	▨	▨																					
PCB Assembly	1/13/2023	1/20/2023												▨	▨																				
Embedded Systems Research	2/20/2023	2/23/2023													▨	▨	▨	▨	▨	▨															

Electrical Schedule

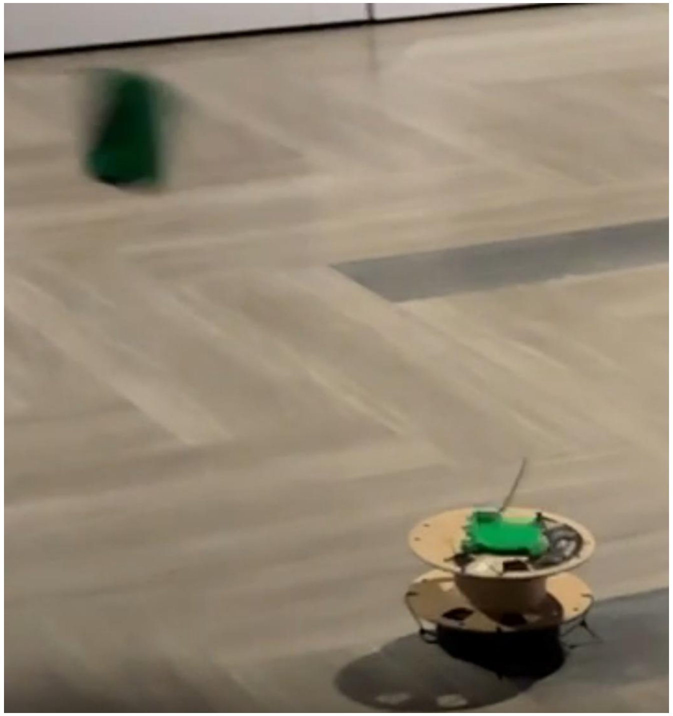
Detailed Program Schedule (4 of 4)

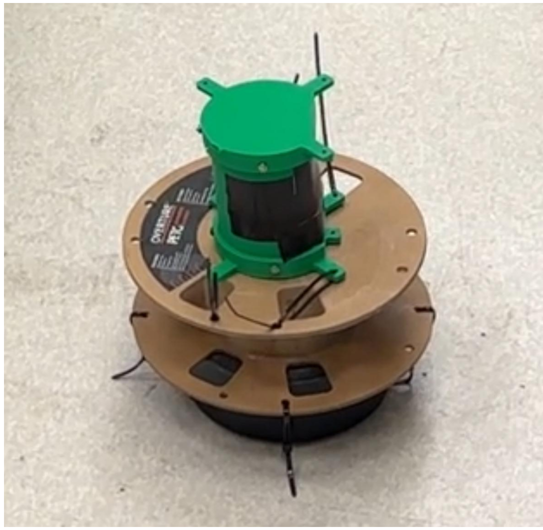
TASK	Start	End	November					December				January					February				March				April				May					June	
			1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12
Shockwave																																			
Team Application	11/1/23	11/3/23	▨																																
PDR Phase	11/4/23	2/5/24	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																			
CDR Phase	2/6/24	4/8/24															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨									
Prototyping and Test Launch Phase	3/18/24	6/2/24																					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
Competition Phase	6/3/24	6/9/24																																▨	▨
Software Development																																			
GUI Prototyping	12/11/2023	02/01/2024						▨	▨	▨	▨	▨	▨	▨	▨	▨																			
FS Code Prototyping	01/02/2024	02/03/2024										▨	▨	▨	▨	▨	▨																		
FS Testing	02/03/2024	03/06/2024															▨	▨	▨	▨	▨														
GUI Testing	1/10/2024	02/24/2023											▨	▨	▨	▨	▨	▨	▨																
Finished GUI	02/06/2024	05/16/2024															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨				
FS Finished	03/06/2024	04/27/2023																			▨	▨	▨	▨	▨	▨	▨	▨							

Software Schedule

Conclusions (1 of 5)

Mechanical Conclusions	
Accomplishments	Finished two designs and combined them to create a final design, created a CAD model and integrated design with electrical, tested egg holder design
Major To-Do's	Prototyping, testing components, update CAD, build a complete, fully functional model to test launch

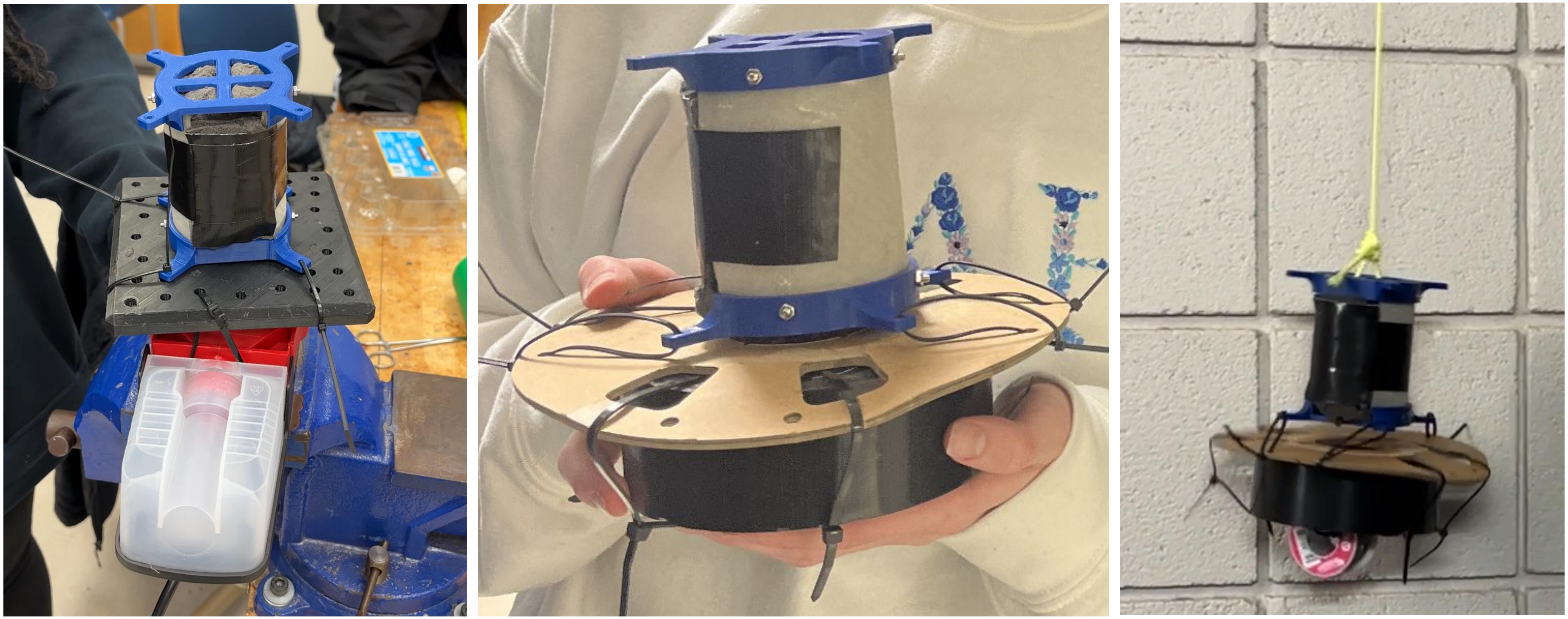




Tested the original design and found it broke easy and was heavy but did protect the egg. We increased the radius of the fillets and changed the main wall to be two layers of fiberglass. This design was 64g and still protected the egg.

Conclusions (2 of 5)

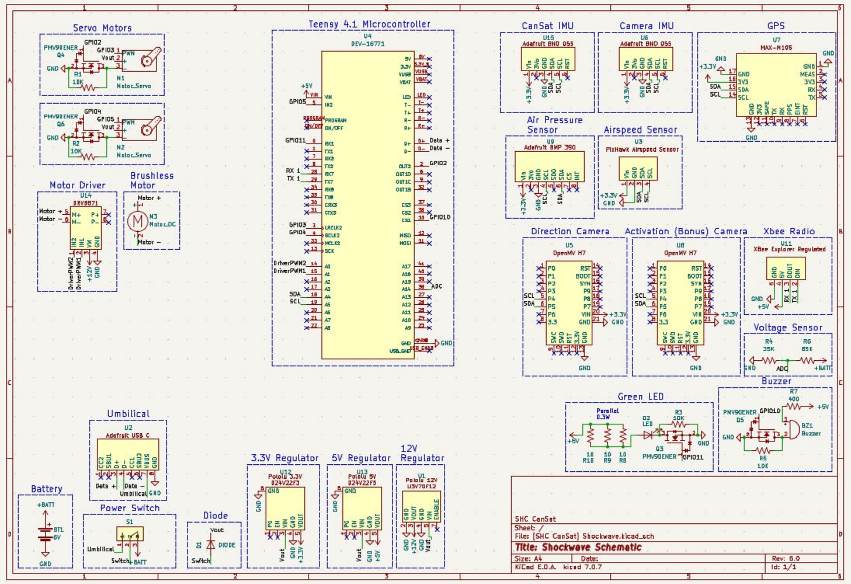
Mechanical Conclusions

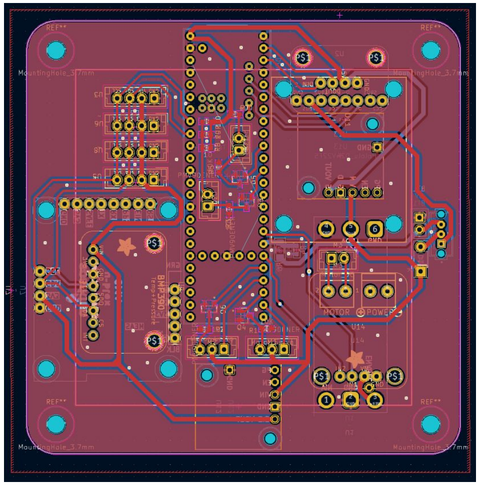


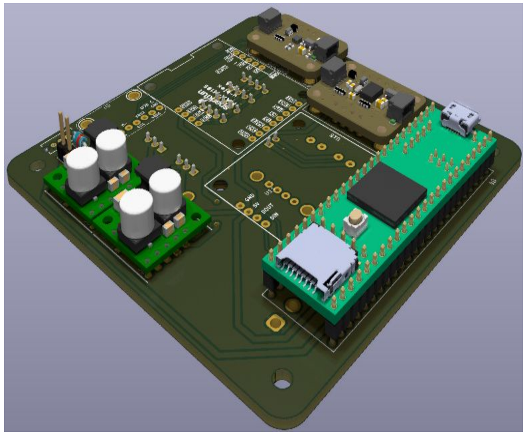
This design is 64g and survived shock, drop, and vibe tests while protecting the egg.

Conclusions (3 of 5)

Electrical Conclusions	
Accomplishments	Traded components, completed power budget, designed and ordered PCB, began breadboarding
Major To-Do's	Breadboard components, solder components onto PCB, Integrate with software, update PCB

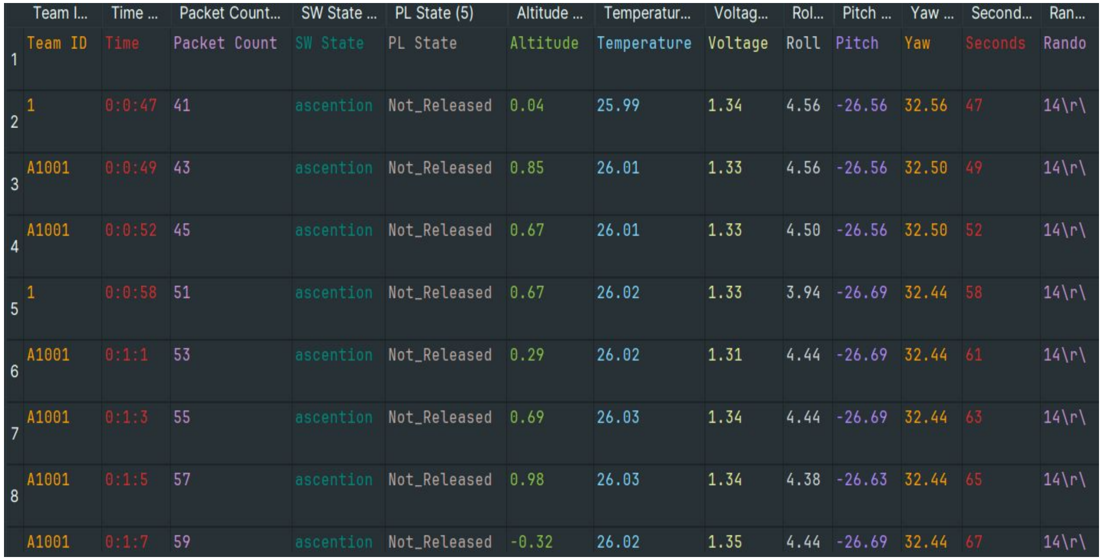




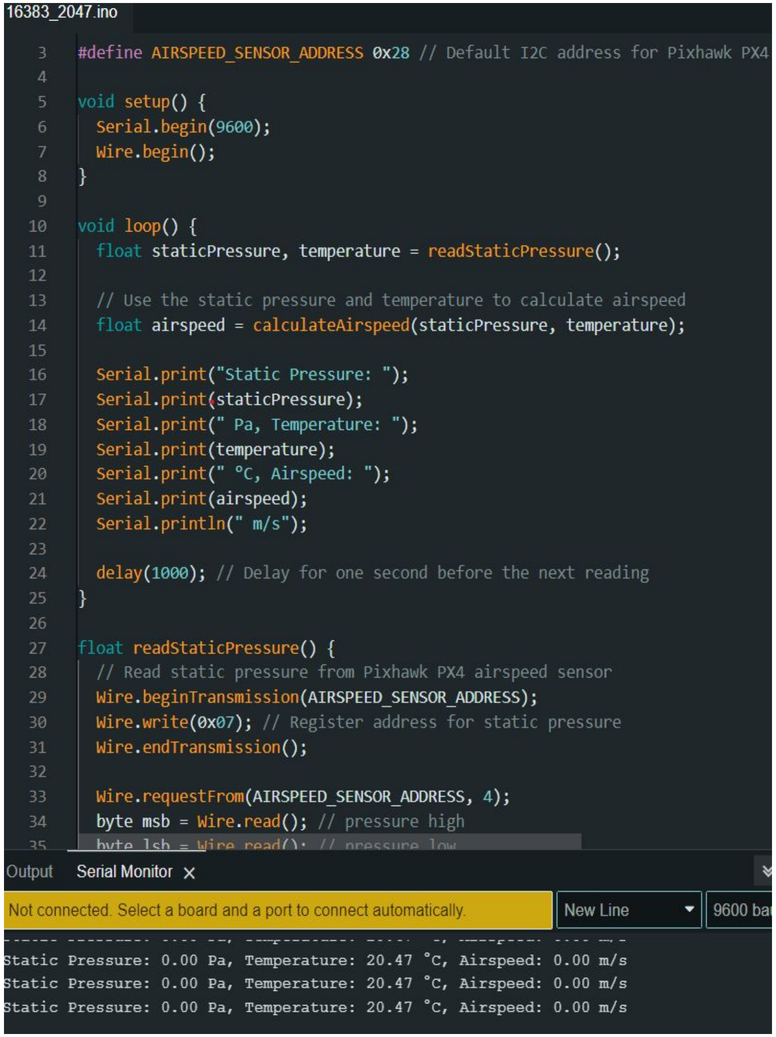


Conclusions (4 of 5)

Software Conclusions	
Accomplishments	FSW flowchart, GSC layout, basic FSW code, prototyping sensor readings
Major To-Do's	Functional GSC Prototype, Prototype websocket communication, FSW prototyping



	Team I...	Time ...	Packet Count...	SW State ...	PL State (5)	Altitude ...	Temperatur...	Voltag...	Rol...	Pitch ...	Yaw ...	Second...	Ran...
1	Team ID	Time	Packet Count	SW State	PL State	Altitude	Temperature	Voltage	Roll	Pitch	Yaw	Seconds	Rando
2	1	0:0:47	41	ascention	Not_Released	0.04	25.99	1.34	4.56	-26.56	32.56	47	14\r\
3	A1001	0:0:49	43	ascention	Not_Released	0.85	26.01	1.33	4.56	-26.56	32.50	49	14\r\
4	A1001	0:0:52	45	ascention	Not_Released	0.67	26.01	1.33	4.50	-26.56	32.50	52	14\r\
5	1	0:0:58	51	ascention	Not_Released	0.67	26.02	1.33	3.94	-26.69	32.44	58	14\r\
6	A1001	0:1:1	53	ascention	Not_Released	0.29	26.02	1.31	4.44	-26.69	32.44	61	14\r\
7	A1001	0:1:3	55	ascention	Not_Released	0.69	26.03	1.34	4.44	-26.69	32.44	63	14\r\
8	A1001	0:1:5	57	ascention	Not_Released	0.98	26.03	1.34	4.38	-26.63	32.44	65	14\r\
	A1001	0:1:7	59	ascention	Not_Released	-0.32	26.02	1.35	4.44	-26.69	32.44	67	14\r\



16383_2047.ino

```
#define AIRSPEED_SENSOR_ADDRESS 0x28 // Default I2C address for Pixhawk PX4

void setup() {
  Serial.begin(9600);
  Wire.begin();
}

void loop() {
  float staticPressure, temperature = readStaticPressure();

  // Use the static pressure and temperature to calculate airspeed
  float airspeed = calculateAirspeed(staticPressure, temperature);

  Serial.print("Static Pressure: ");
  Serial.print(staticPressure);
  Serial.print(" Pa, Temperature: ");
  Serial.print(temperature);
  Serial.print(" °C, Airspeed: ");
  Serial.print(airspeed);
  Serial.println(" m/s");

  delay(1000); // Delay for one second before the next reading
}

float readStaticPressure() {
  // Read static pressure from Pixhawk PX4 airspeed sensor
  Wire.beginTransmission(AIRSPEED_SENSOR_ADDRESS);
  Wire.write(0x07); // Register address for static pressure
  Wire.endTransmission();

  Wire.requestFrom(AIRSPEED_SENSOR_ADDRESS, 4);
  byte msb = Wire.read(); // pressure high
  byte lsb = Wire.read(); // pressure low
```

Not connected. Select a board and a port to connect automatically.

```
Static Pressure: 0.00 Pa, Temperature: 20.47 °C, Airspeed: 0.00 m/s
Static Pressure: 0.00 Pa, Temperature: 20.47 °C, Airspeed: 0.00 m/s
Static Pressure: 0.00 Pa, Temperature: 20.47 °C, Airspeed: 0.00 m/s
```

Conclusions (5 of 5)

Rationale for Further Development
Our team is ready to move on to the phase of prototyping and testing because of our subteams' current progress. Our mechanical team has researched and begun prototyping two separate mechanical systems that can fulfill the mission requirement. The electrical team has designed, ordered, and tested 2 PCB designs which work with the selected components. Bare bones flight software and ground station prototypes will be able to support flight as soon as the CanSat mechanical and electrical subsystems integrate. Because of this, the mechanical, electrical, and software subteams are ready to begin testing hardware and software in order to perform tests and confirm mission readiness.