



---

# CanSat 2026 Preliminary Design Review (PDR) *Version 2.0*

**Team #1093  
Vortex**



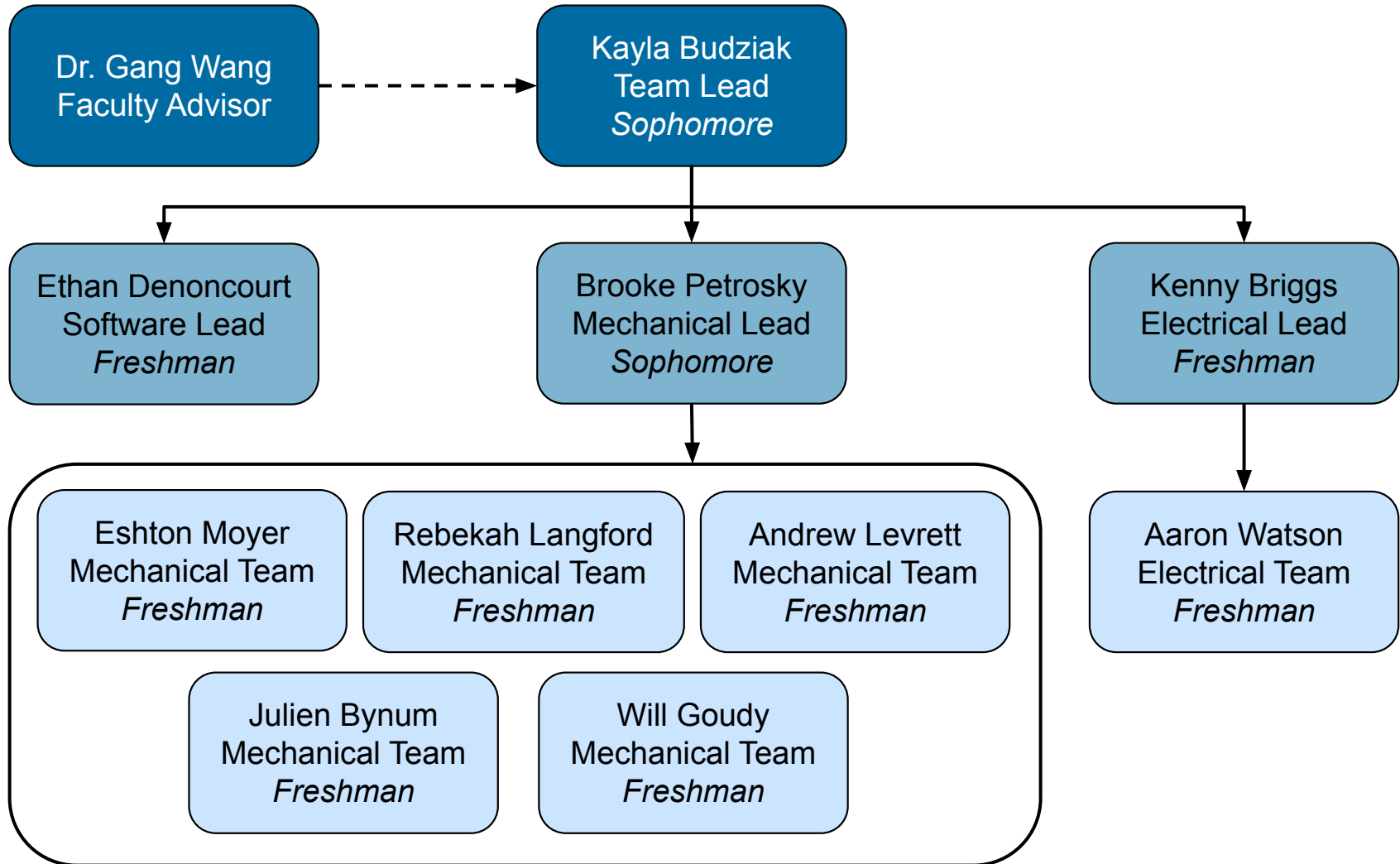
# Presentation Outline



Section	Presenter(s)	Slides
Introduction	Kayla Budziak	1 - 9
Systems Overview	Brooke Petrosky	10 - 47
Sensor Subsystem Design	Kenny Briggs	48 - 79
Descent Control Design	Andrew Levrett, William Goudy	80 - 109
Mechanical Subsystem Design	Eshton Moyer, Rebekah Langford, Julien Bynum	110 - 198
CDH Subsystem Design	Ethan Denoncourt, Kenny Briggs	199 - 218
EPS Design	Aaron Watson	219 - 228
FSW Design	Ethan Denoncourt	229 - 236
GCS Design	Kayla Budziak	237 - 245
CanSat Integration and Test	Kayla Budziak	246 - 251
Mission Operations and Analysis	Kayla Budziak	252 - 258
Requirements Compliance	Kayla Budziak	259 - 274
Management	Kayla Budziak	275 - 292



# Team Organization





# Acronyms (1 of 6)



Acronym	Meaning	Acronym	Meaning
3D	Three-Dimensional	CAD	Computer-Aided Design
A	Amperes	CAL	Calibrate
AC	Alternating Current	CDH	Communication and Data Handling
ACCEL_P	Accelerometer Pitch	CEP	Circular Error Probable
ACCEL_R	Accelerometer Roll	cm	Centimeters
ACCEL_Y	Accelerometer Yaw	CMD	Command
ACS	Autonomous Control System	CONOPS	Concept of Operations
ADC	Analog to Digital Converter	COTS	Commercial Off-the-Shelf
Alt	Altitude	CSV	Comma Separated Values
AOA	Angle of Attack	D	Denier
C	Celcius	DAC	Digital Analog Converter



# Acronyms (2 of 6)



Acronym	Meaning	Acronym	Meaning
dB	Decibel	GNSS	Global Navigation Satellite System
dBi	Decibel Relative to Isotropic	GPa	Gigapascals
deg	Degrees	GPIO	General-Purpose Input/Output
EPS	Electrical Power Subsystem	GPS	Global Positioning System
etc	Et Cetera	GS	Ground Station
FSW	Flight Software	GUI	Graphical User Interface
g	Grams	GYRO	Gyroscope
g	Acceleration Due to Gravity	GYRO_P	Gyroscope Pitch
G	Gravitational Constant	GYRO_R	Gyroscope Roll
GCS	Ground Control System	GYRO_Y	Gyroscope Yaw
GHz	Gigahertz	h	Hours



# Acronyms (3 of 6)



Acronym	Meaning	Acronym	Meaning
HDMI	High-Definition Multimedia Interface	kPa	Kilopascals
hh:mm:ss	Hours, Minutes, Seconds	LED	Light Emitting Diode
HP	High-Performance	LiPo	Lithium Polymer
hr	Hour	LNA	Low-Noise Amplifier
Hz	Hertz	LSB	Least Significant Bit
I2C	Inter-Integrated Circuit	m	Meter
ID	Identification	mA	Milliampere
IDE	Integrated Development Environment	mAh	Milliampere-Hour
JST	Japanese Solderless Terminal	Max	Maximum
KB	Kilobyte	MB	Megabytes
kg	Kilogram	MCU	Microcontroller



# Acronyms (4 of 6)



Acronym	Meaning	Acronym	Meaning
MEC	Mechanism	NETID	Network Identification
MHz	Megahertz	Ni-Cad	Nickel-Cadmium
mm	Millimeter	Ni-MH	Nickel-Metal Hydride
MOSFET	Metal Oxide Semiconductor Field Effect Transistor	ns	Nanoseconds
MPa	Megapascals	oz	Ounce
ms	Milliseconds	Pa	Pascal
MtF	Male to Female	PANID	Personal Area Network Identifier
N	No	PCB	Printed Circuit Board
N	Newtons	PDR	Preliminary Design Review
N/A	Not Applicable	PETG	Polyethylene Terephthalate Glycol
NACA	National Advisory Committee for Aeronautics	PFR	Post Flight Review



# Acronyms (5 of 6)



Acronym	Meaning	Acronym	Meaning
PID	Proportional-Integral-Derivative	SATS	Satellites
PLA	Polylactic Acid	SAW	Surface Acoustic Wave
PMOS	P-Channel Metal-Oxide-Semiconductor	SD	Secure Digital
PPM	Parts Per Million	SI	International System of Units
PRO	Proper Ram-Air Orientation	SIM	Simulation
PWM	Pulse Width Modulator	SIMP	Simulation Pressure
R	Resistor	SMA	SubMiniature Version A
RF	Radio Frequency	SMD	Service Mount Device
RP	Reverse Polarity	SPI	Serial Peripheral Interface
RQ#	Requirement Number	ST	Set Time
s	Second	THT	Through Hole Technology



# Acronyms (6 of 6)



Acronym	Meaning
TPU	Thermoplastic Polyurethane
UART	Universal Asynchronous Receiver/Transmitter
UI	User Interface
USB	Universal Serial Bus
UTC	Coordinated Universal Time
V	Voltage
VSC	Visual Studio
Wh	Watt-Hour
XCTU	XBEE Configuration and Test Utility
Y	Yes
$\mu$ A	Microampere



# Systems Overview

**Brooke Petrosky**



# Mission Summary



Mission Objectives	
1	Design a CanSat that will function as the nose cone to a rocket during launch.
2	At peak altitude the CanSat will be ejected from the rocket, deploy a parachute, and descend at a rate no greater than 15 m/s.
3	At 80% of peak altitude the payload will release from the container and deploy a paraglider, which will descend at a rate around 5 m/s.
4	The payload shall steer towards a target set of coordinates to drop a protected egg.
5	At 2m from the ground, a protected egg will be released from the payload and descend at a rate no greater than 5 m/s.
6	A video camera will record the separation of the payload from the container, and the subsequent steering functions of the paraglider.
7	A second camera will record the ground during descent and capture the egg release.
8	The CanSat shall collect and transmit telemetry to the ground station at a rate of 1Hz, and continue transmitting telemetry once the payload has landed until CXOFF is received.



# System Requirement Summary (1 of 4)



RQ#	Requirement
C1	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.
C4	After deployment, the CanSat payload and container shall descend at 15 m/s using a parachute that automatically deploys. Error is $\pm 3$ m/s.
C5-C6	At 80% flight peak altitude, the payload shall be released from the container and deploy a paraglider descent control system.
C7	The payload shall descend at 5 m/s averaged over the entire descent within $\pm 3$ m/s with the paraglider descent control system.
C8	The payload shall steer toward a target location.
C10-C11	The payload shall record video of the release of the payload from the container and the deployment of the paraglider descent control system. A second video camera shall point at the ground.
C12	The payload shall release a protected hen's egg when the payload is $2\text{m} \pm 0.5\text{m}$ above the ground without breaking the egg.



# System Requirement Summary (2 of 4)



RQ#	Requirement
C13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat battery and electronics.
S1	The CanSat and container mass shall be 1000 grams $\pm$ 10 grams.
S15	The CanSat shall perform the function of the nose cone during rocket ascent.
S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 m/s.
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.
E3	An easily accessible power switch through the container is required.
E6	The CanSat shall operate for a minimum of two hours when integrated into the rocket.
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.
X4-X5	The CanSat shall transmit telemetry once per second and shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.



# System Requirement Summary (3 of 4)



RQ#	Requirement
SN6	CanSat payload shall video record the deployment of the paraglider at 80% peak altitude.
SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.
G4	Each team shall develop their own ground station.
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.
G7-G8	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates and display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.
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.
G17	The ground station shall be able to activate all mechanisms on command.



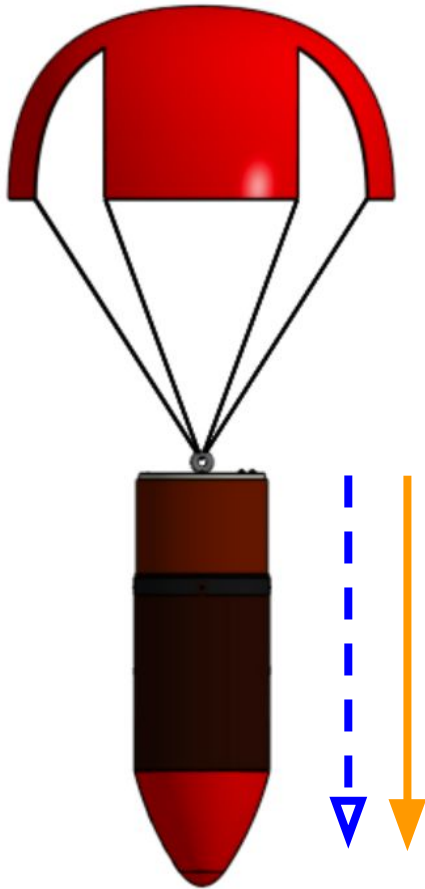
# System Requirement Summary (4 of 4)



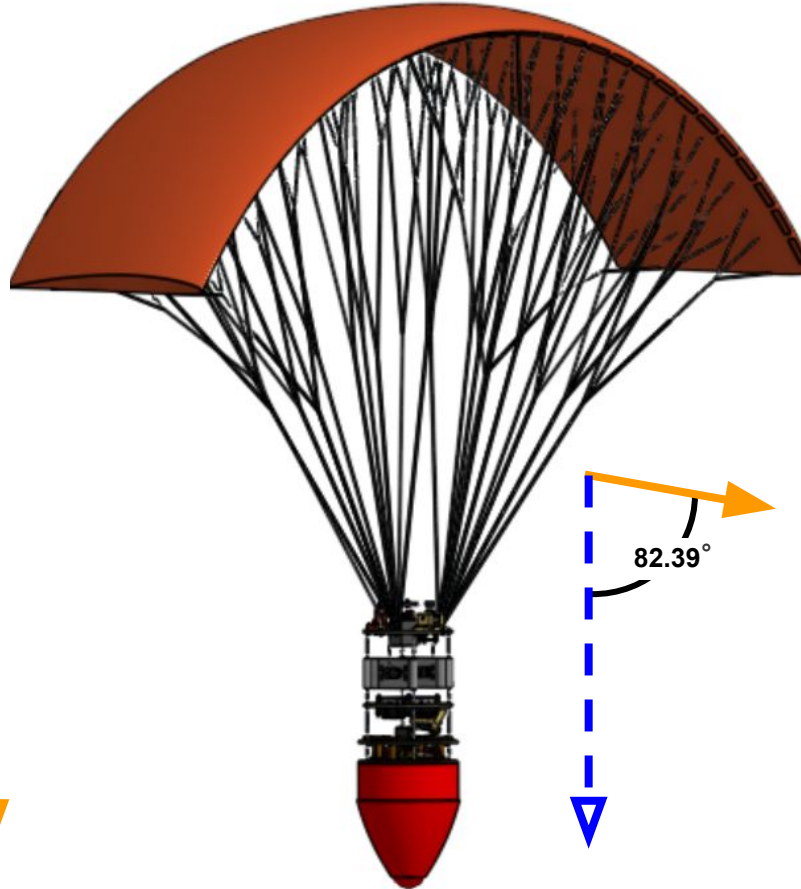
RQ#	Requirement
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.
F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile file.
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.



# System Level CanSat Configuration Trade & Selection (1 of 6)



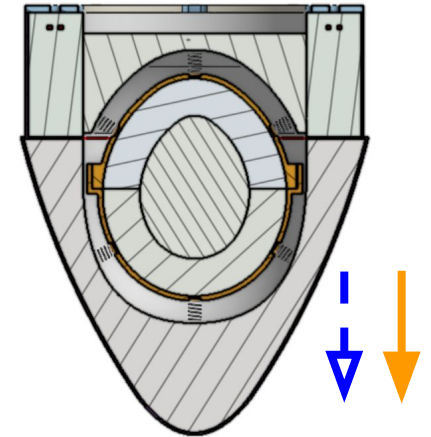
**Parachute (Stowed)  
Descent Configuration**



**Paraglider (Deployed)  
Descent Configuration**

**Design 1**

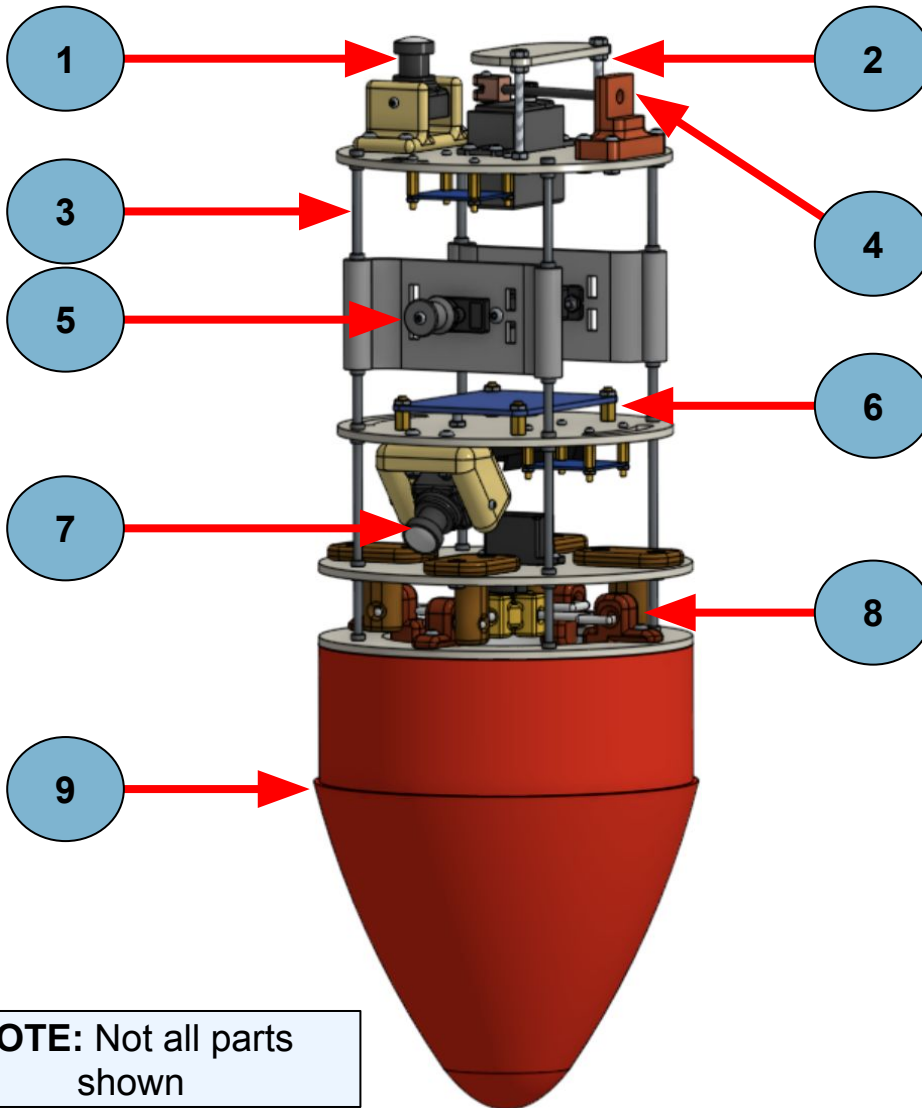
Nadir Direction	
Direction of Travel	



**Instrument Descent  
Configuration**



# System Level CanSat Configuration Trade & Selection (2 of 6)



## Design 1

#	Part
1	Upward Facing Camera
2	Paraglider Resting Plate
3	M3 Aluminum Threaded Rods
4	Release Mechanism
5	Paraglider Steering Mechanism
6	PCB
7	Downward Facing Camera
8	Instrument Release Mechanism
9	Nose Cone & Instrument Stowing Location

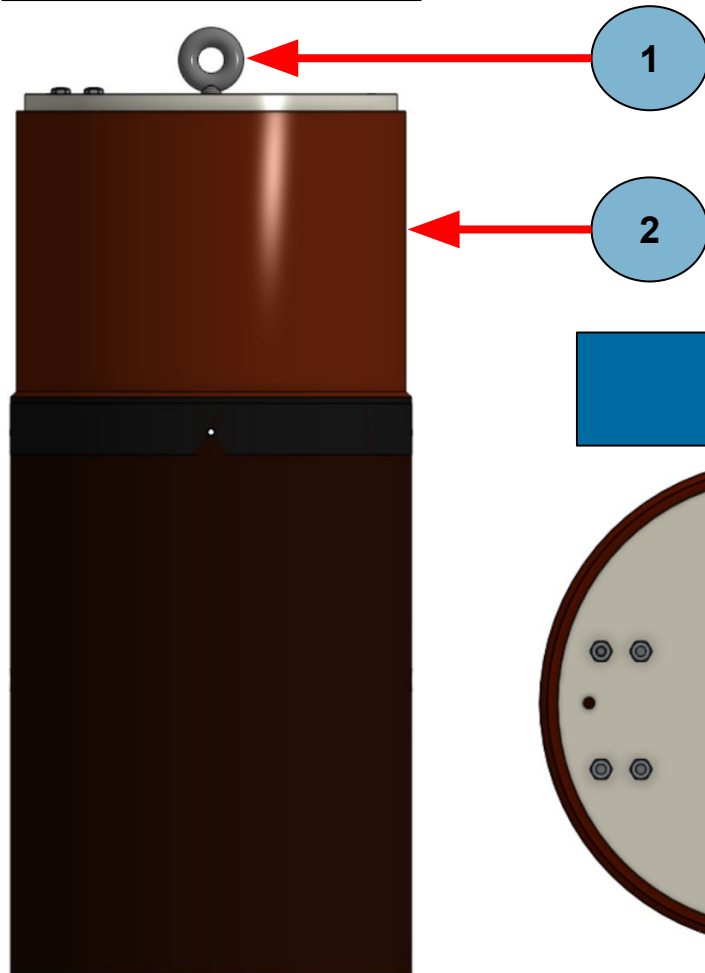
**NOTE:** Not all parts shown



# System Level CanSat Configuration Trade & Selection (3 of 6)



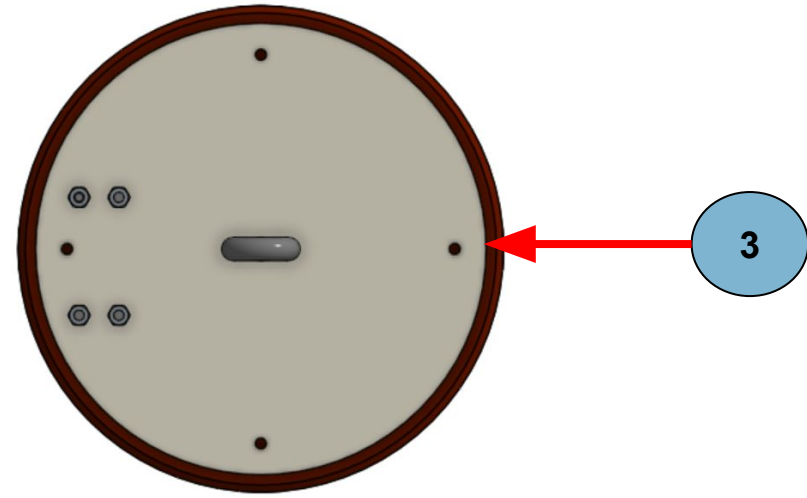
Front View



Design 1

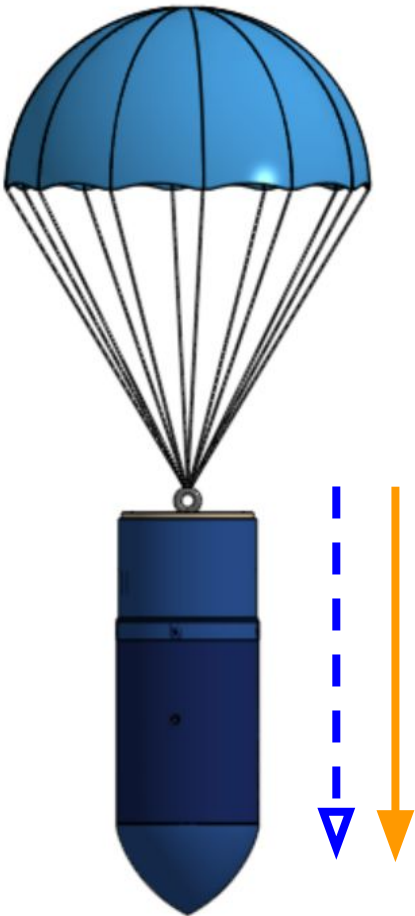
#	Part
1	1/4 Inch Eye Bolt
2	3D Printed PETG Container
3	6mm Plywood Container Plate

Top View

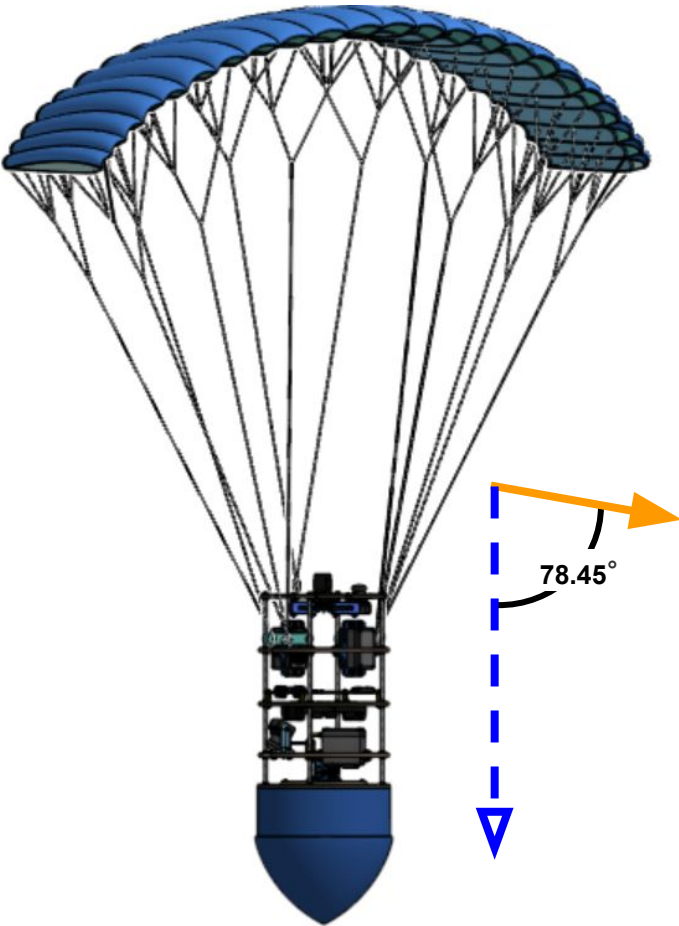




# System Level CanSat Configuration Trade & Selection (4 of 6)



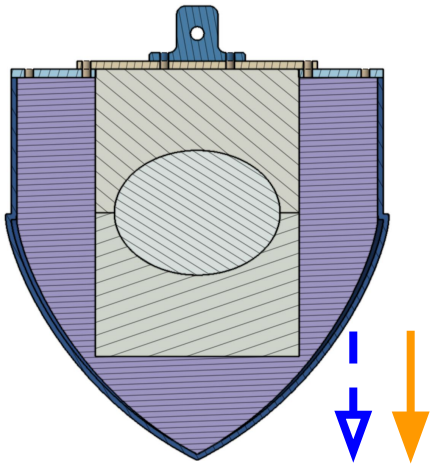
**Parachute (Stowed)  
Descent Configuration**



**Paraglider (Deployed)  
Descent Configuration**

**Design 2**

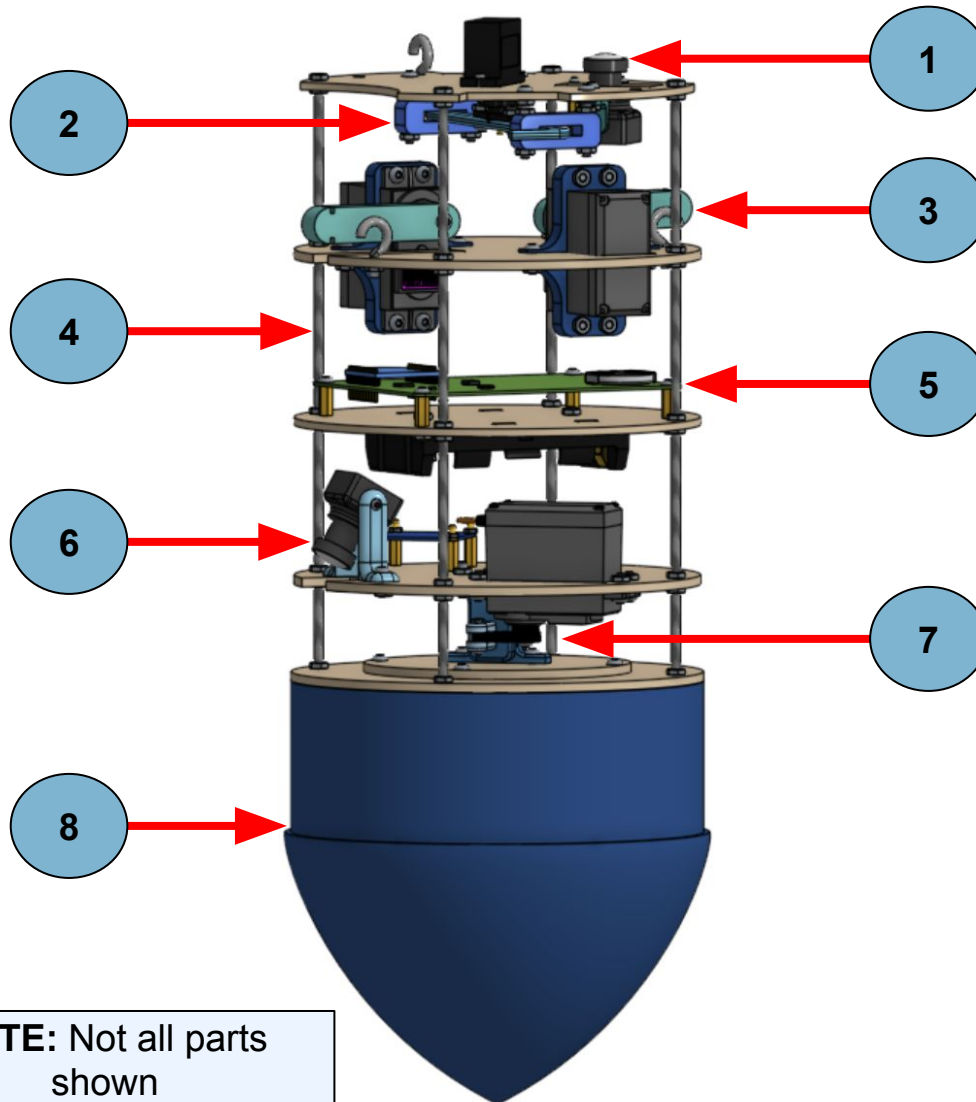
Nadir Direction	
Direction of Travel	



**Instrument Descent  
Configuration**



# System Level CanSat Configuration Trade & Selection (5 of 6)



**Design 2**

#	Part
1	Upward Facing Camera
2	Release Mechanism
3	Paraglider Steering Mechanism
4	M3 Zinc Plated Steel Threaded Rods
5	PCB
6	Downward Facing Camera
7	Instrument Release Mechanism
8	Nose Cone & Instrument Stowing Location

**NOTE:** Not all parts shown

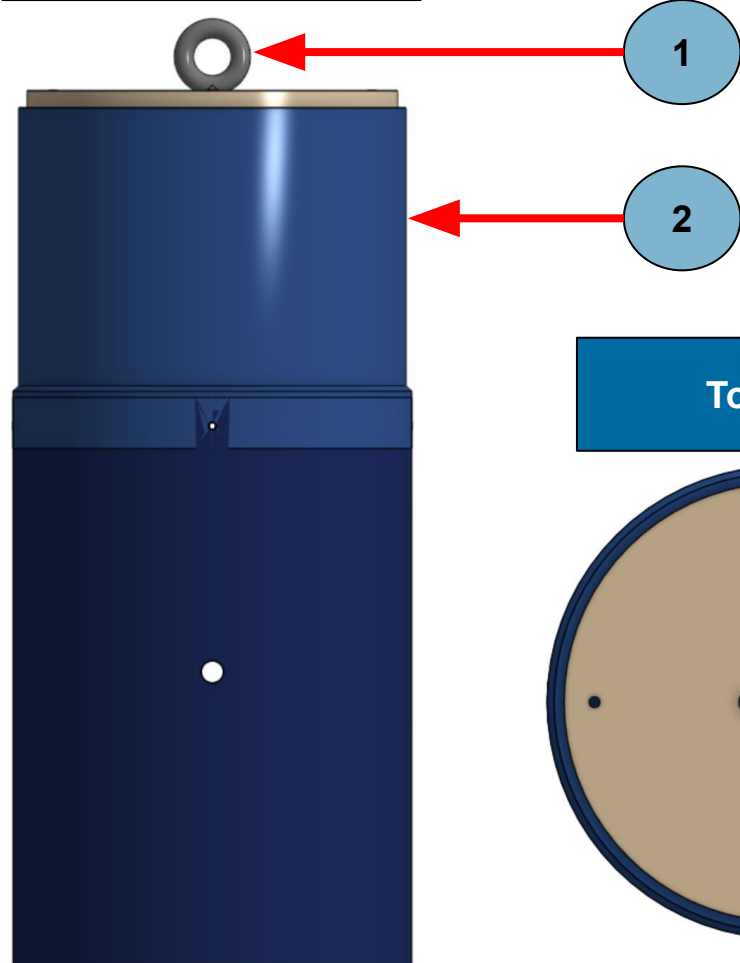


# System Level CanSat Configuration Trade & Selection (6 of 6)

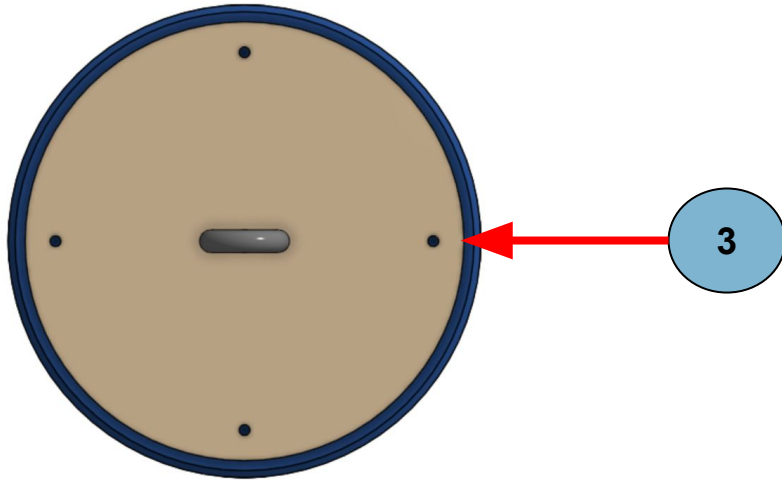


Front View

Design 2



Top View



#	Part
1	¼ Inch Eye Bolt
2	Fiberglass Composite Layup Container
3	6mm Plywood Container Plate

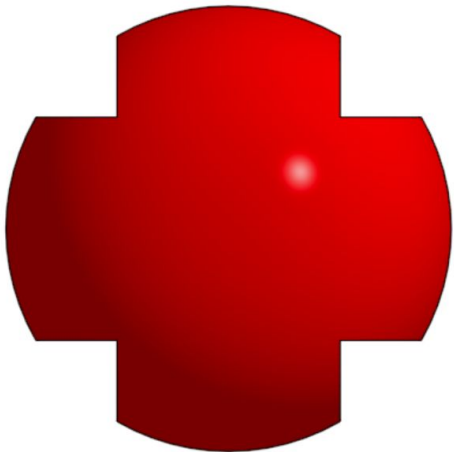


# System Level Configuration Selection (1 of 5)

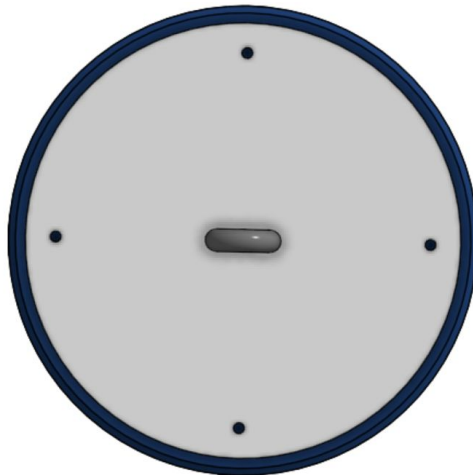


Part	Design 1	Design 2	Selection & Reasoning	Final Design
Container Parachute	Cruciform Parachute	Hemispheric Parachute	<b>Design 1:</b> Improved Stability	
Container	3D Printed PETG Container	Fiberglass Composite Layup Container	<b>Design 2:</b> Lower Mass Superior Strength	

Parachute Top View




Container Top View



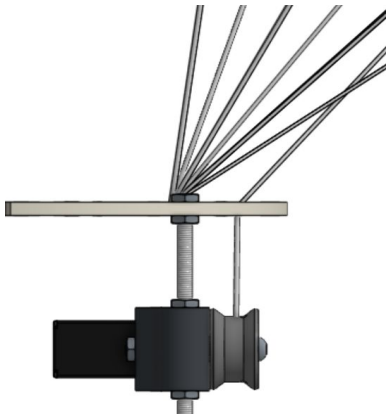


# System Level Configuration Selection (2 of 5)

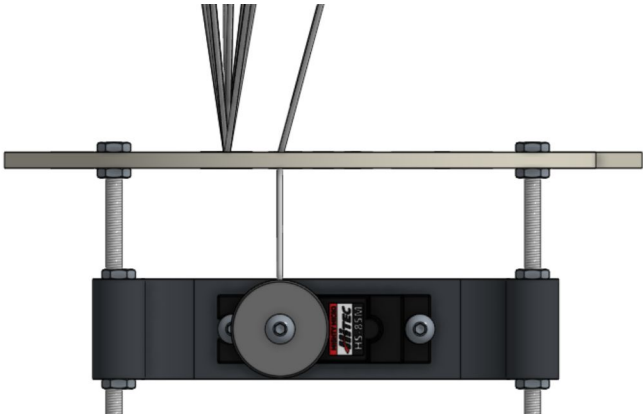


Part	Design 1	Design 2	Selection & Reasoning	Final Design
Paraglider	NACA 4412 Airfoil 45x5 mm Cell Openings Hollow Interior	NACA 2412 Airfoil 42x25 mm Cell Openings Ribbed Interior	<b>Design 1 &amp; 2:</b> 4412 Airfoil & Ribbed Interior Yield Superior Stability and Gliding Capability	
Steering System	Turning Spools for Steering Servos Mounted Vertically	Arms for Steering Servos Mounted Horizontally	<b>Design 1:</b> More Efficient for Pulling Paraglider Lines	

**Steering System  
Front View**



**Steering System Side View**



**NOTE:** Not all parts shown

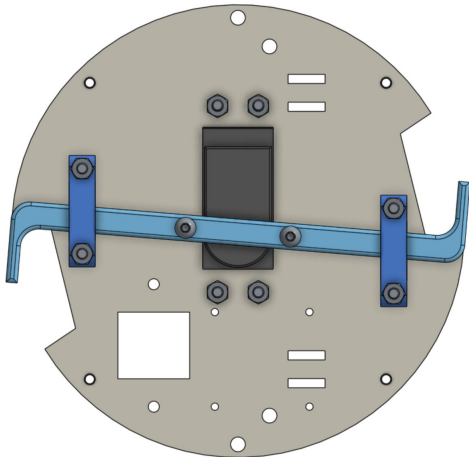


# System Level Configuration Selection (3 of 5)

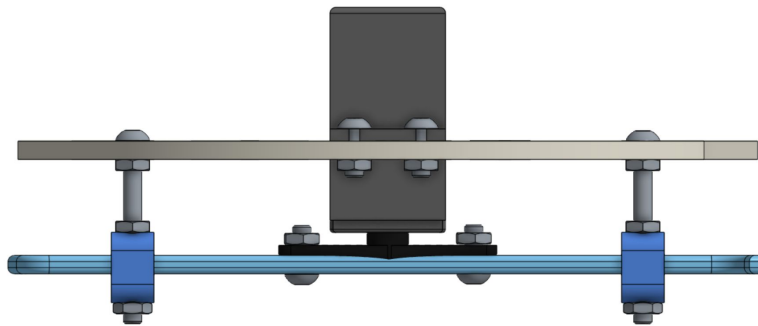


Part	Design 1	Design 2	Selection & Reasoning	Final Design
Container Release Mechanism	One Pin Removal Release	Double Sided Arm Release	<b>Design 2:</b> Increased Stability	
Descent Control Pointing Camera	Single Piece Raised Mount on Back Plate of Payload	Two Piece Mount Sunken into Back Plate of Payload	<b>Design 2:</b> Lower Mass More Space Efficient	

**Container Release Mechanism Top View**



**Container Release Mechanism Front View**



**NOTE:** Not all parts shown

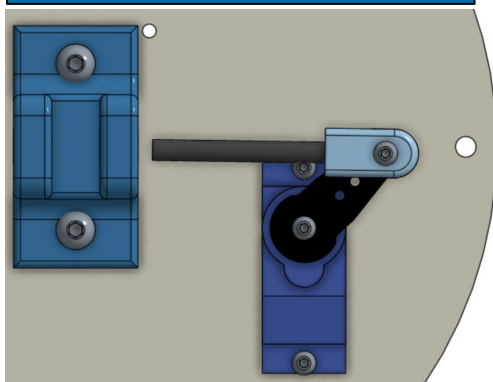


# System Level Configuration Selection (4 of 5)

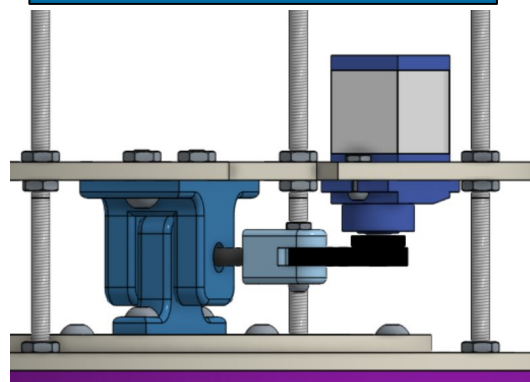


Part	Design 1	Design 2	Selection & Reasoning	Final Design
Body Structure	Four Base Plates with Resting Plate for Stowed Paraglider	Five Base Plates Stowed with Paraglider Resting on Top Plate	<b>Design 1 &amp; 2:</b> Four Base Plates with Design 1 Steering & Design 2 Orientations: Reduced Mass & More Space Efficient Design	
Instrument Release Mechanism	Four Hooks Rotating to Release	Single Pin Pulls to Release	<b>Design 2:</b> Lower Mass Space Efficient Fewer Points of Failure	

**Instrument Release Mechanism Top View**



**Instrument Release Mechanism Front View**



**NOTE:** Not all parts shown

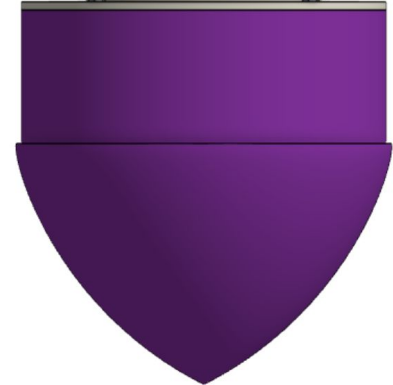
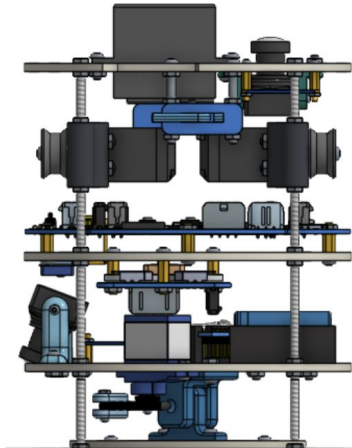


# System Level Configuration Selection (5 of 5)

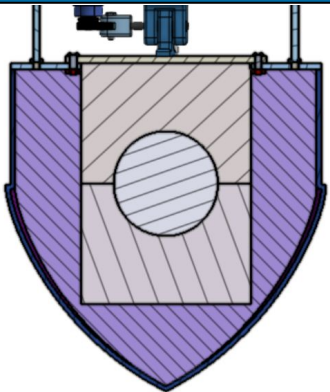


Part	Design 1	Design 2	Selection & Reasoning
Ground Pointing Camera	Single Piece Mounted to Bottom of Plate	Two Pieces Mounted to Top of Plate	<b>Design 2:</b> Less Massive Clearer Viewing Angle
Nose Cone	Power Series Nose Cone	Ogive Nose Cone	<b>Design 2:</b> Less Massive
Instrument Protection	Egg in Case Suspended by Springs	TPU Insert in Nose Cone & Urethane Foam Holder	<b>Design 2:</b> Less Massive More Protection

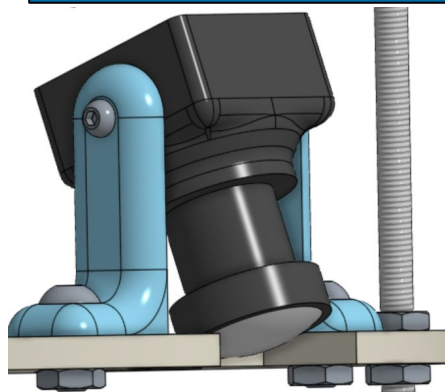
## Final Design



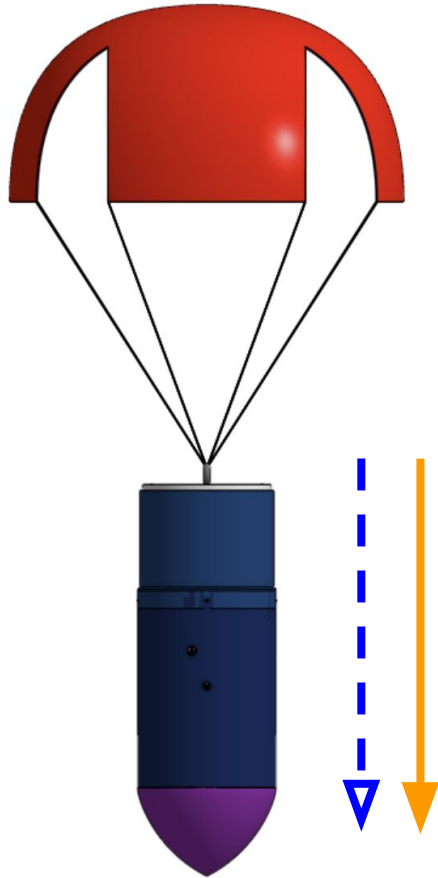
### Instrument Protection Section View



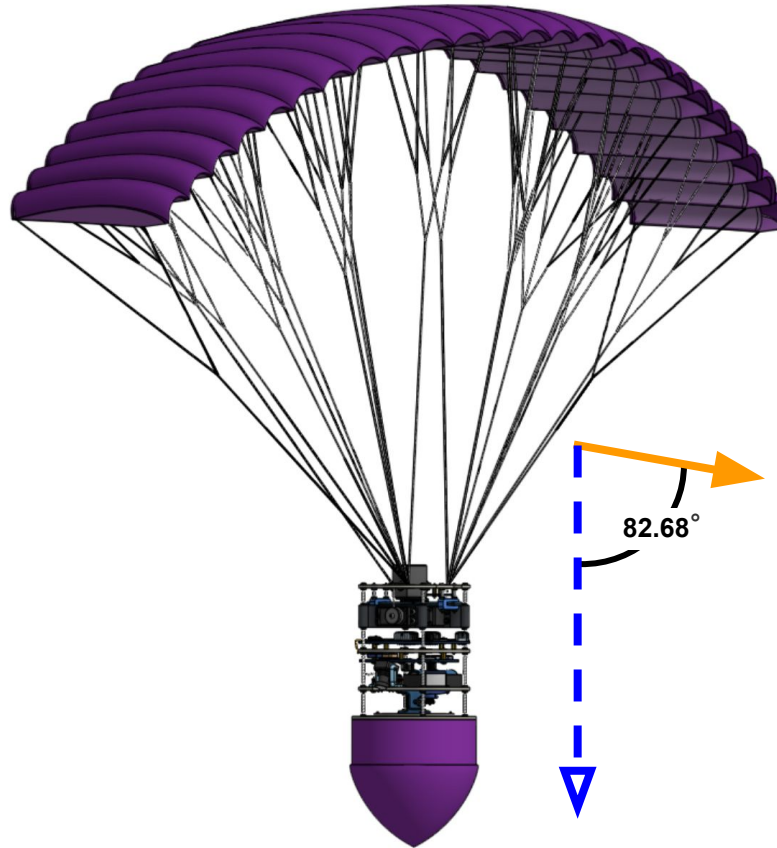
### Downward Camera Side View



**NOTE:** Not all parts shown



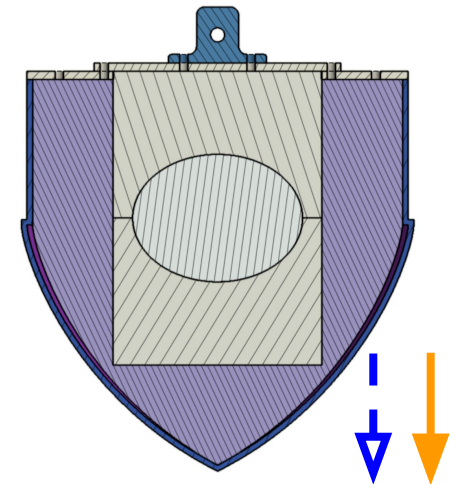
**Parachute (Stowed)  
Descent Configuration**



**Paraglider (Deployed)  
Descent Configuration**

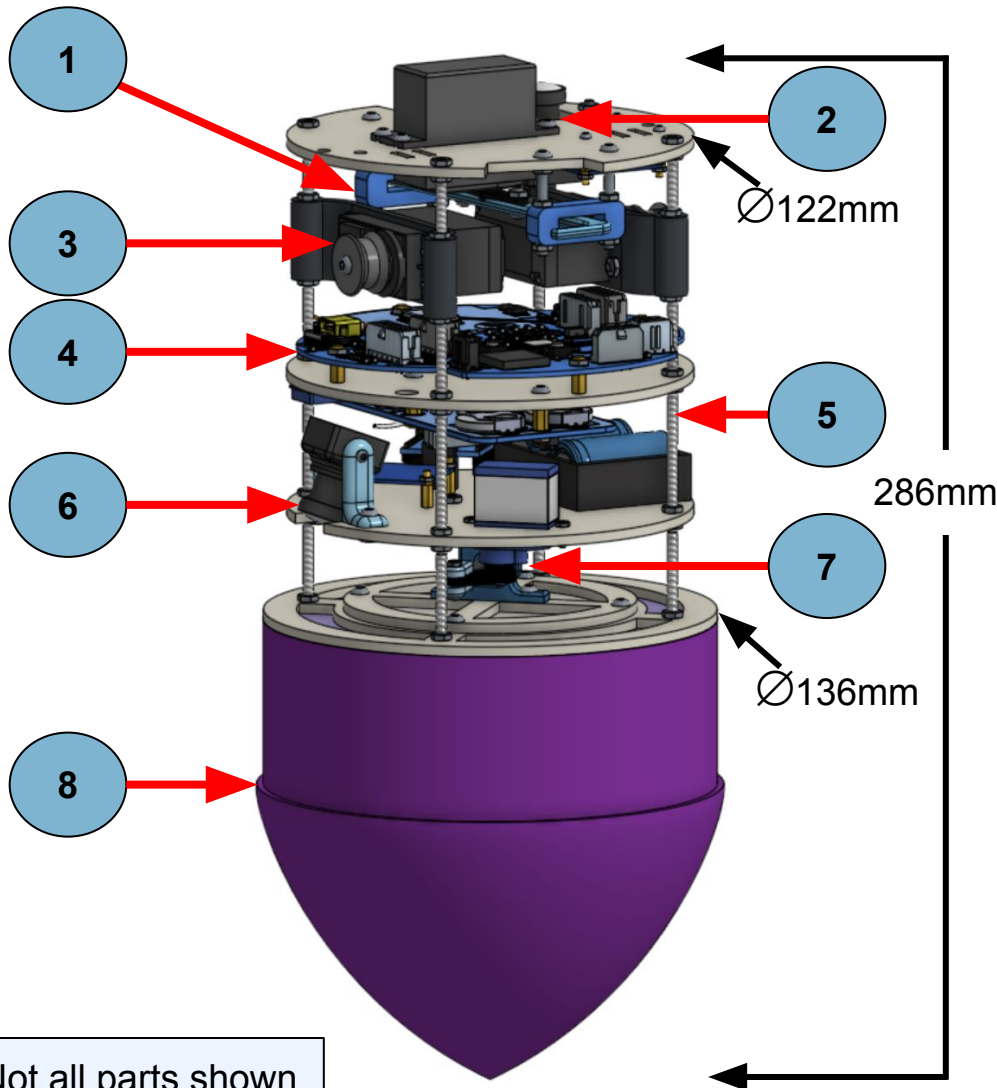
**Final Design**

Nadir Direction	
Direction of Travel	



**Instrument Descent  
Configuration**

# Physical Layout (2 of 18)



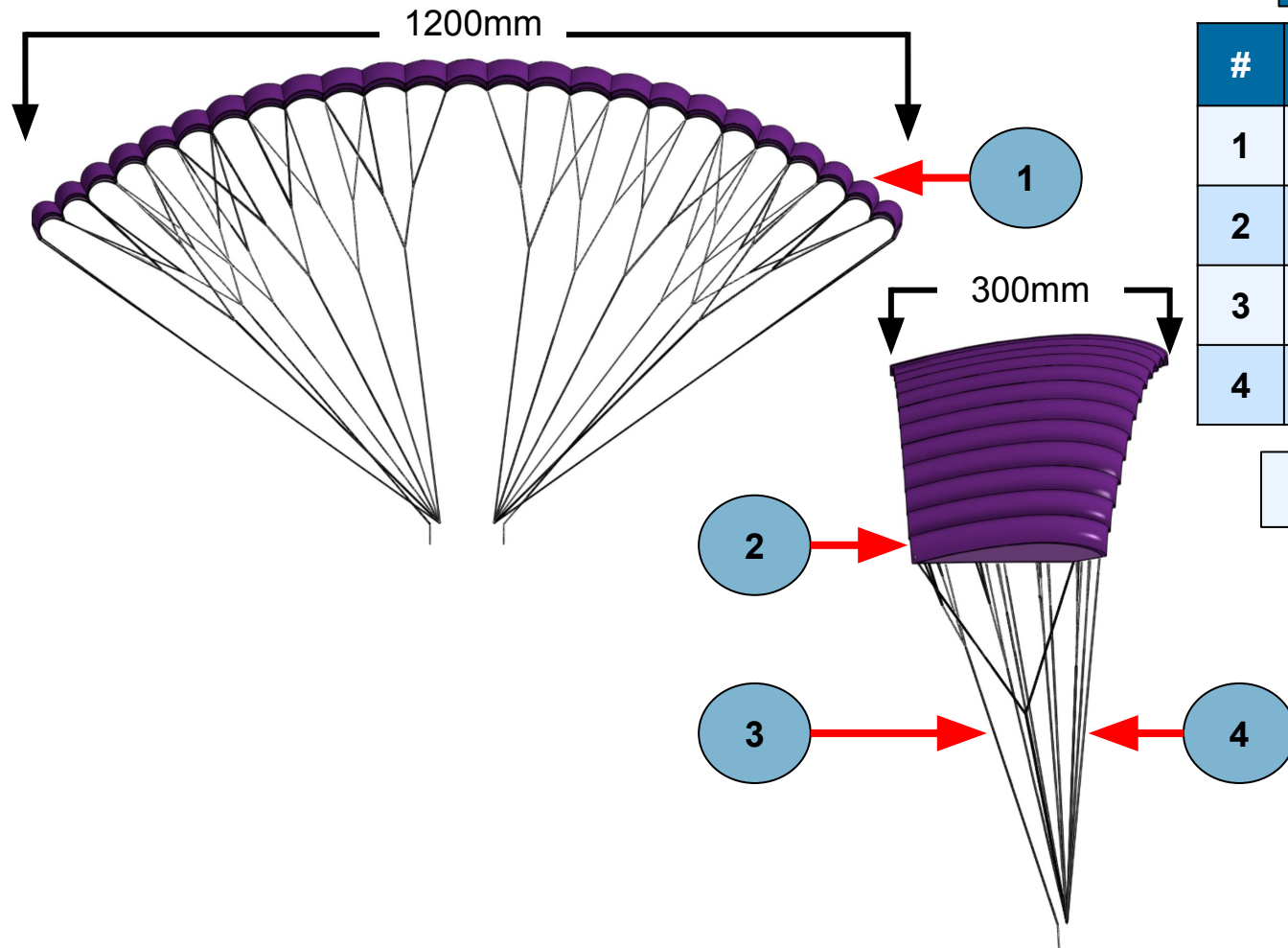
**NOTE:** Not all parts shown

## Final Design

#	Part
1	Release Mechanism
2	Upward Facing Camera
3	Paraglider Steering Mechanism
4	Main Flight Computer PCB
5	M3 Zinc Plated Steel Thread Rods
6	Downward Facing Camera
7	Instrument Release Mechanism
8	Nose Cone & Instrument Stowing Location

## Paraglider Design

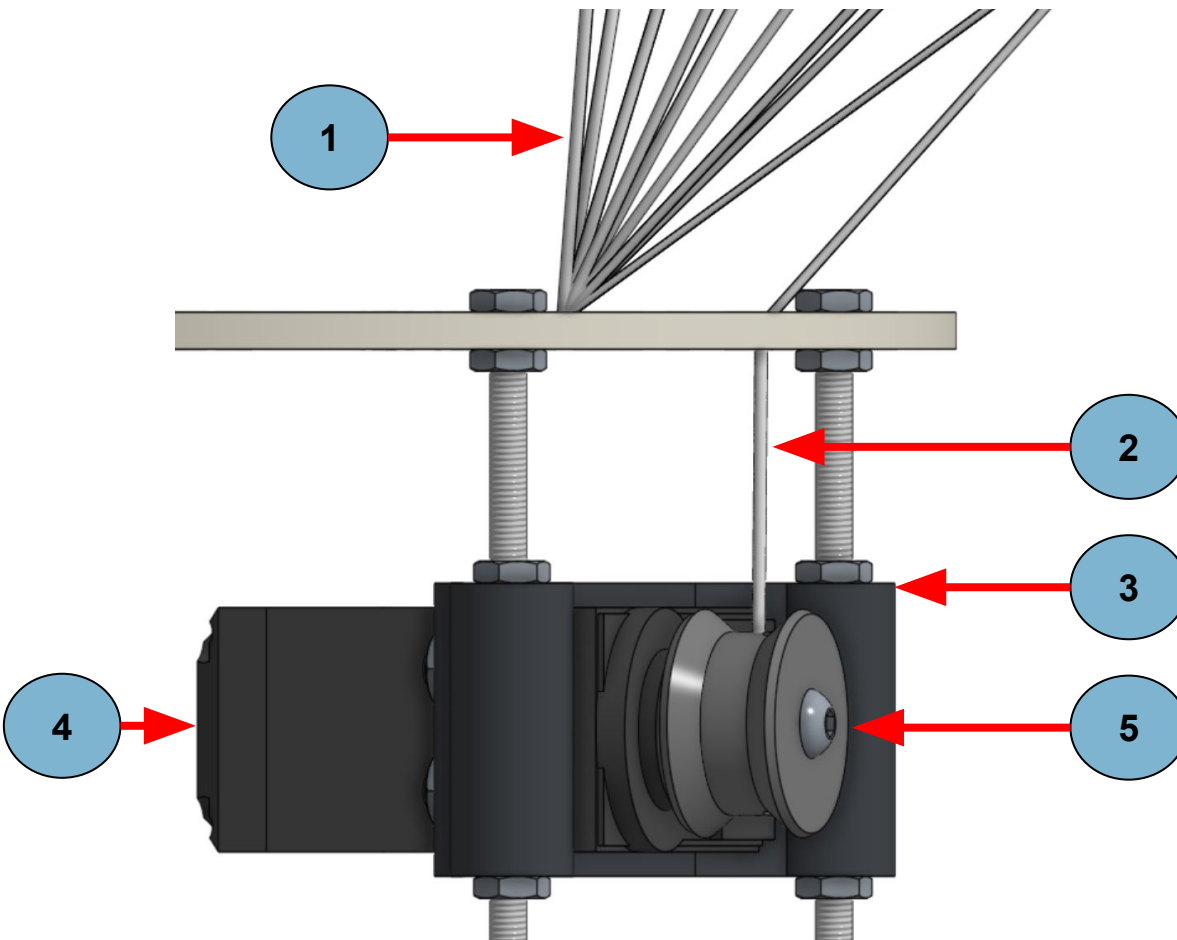
## Final Design



#	Part
1	Silnylon Paraglider Wing
2	NACA 4412 Airfoil
3	Kevlar Brake Lines
4	Kevlar Stability Lines

**NOTE:** Not all parts shown

## Paraglider Attachment and Steering



## Final Design

#	Part
1	Kevlar Stability Lines
2	Kevlar Brake Lines
3	3D Printed PETG Steering Servo Mount
4	LS-955CR Servo
5	3D Printed PETG Turning Spool

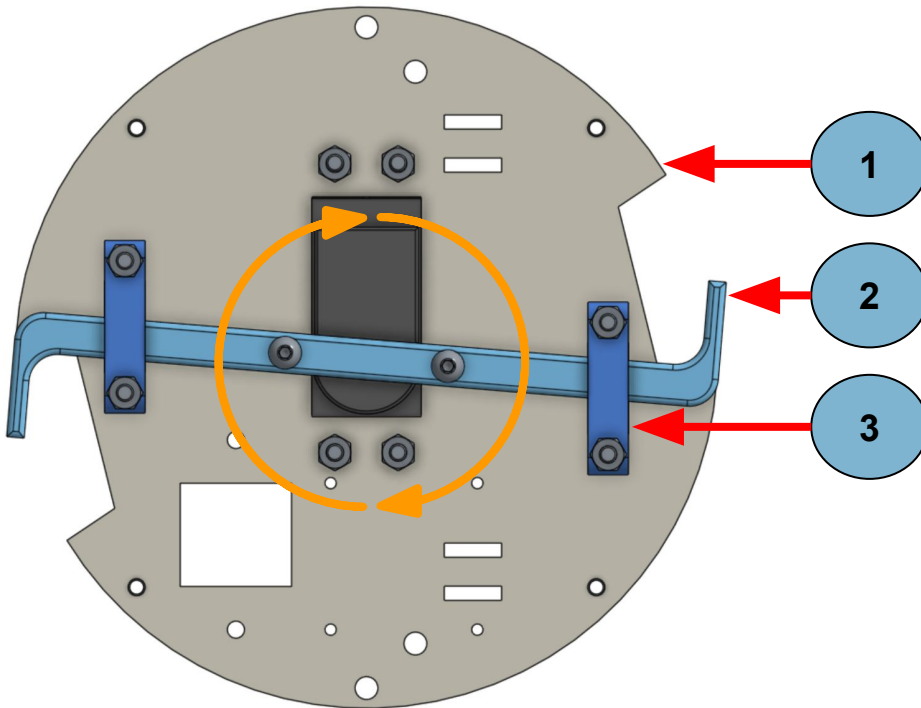
**NOTE:** Not all parts shown

# Physical Layout (5 of 18)

## Release Mechanism

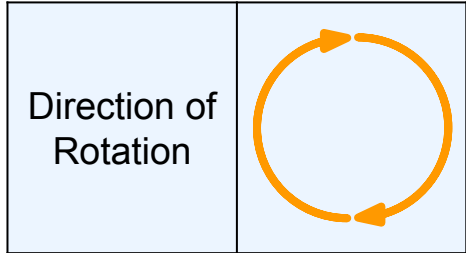
## Final Design

### Top View



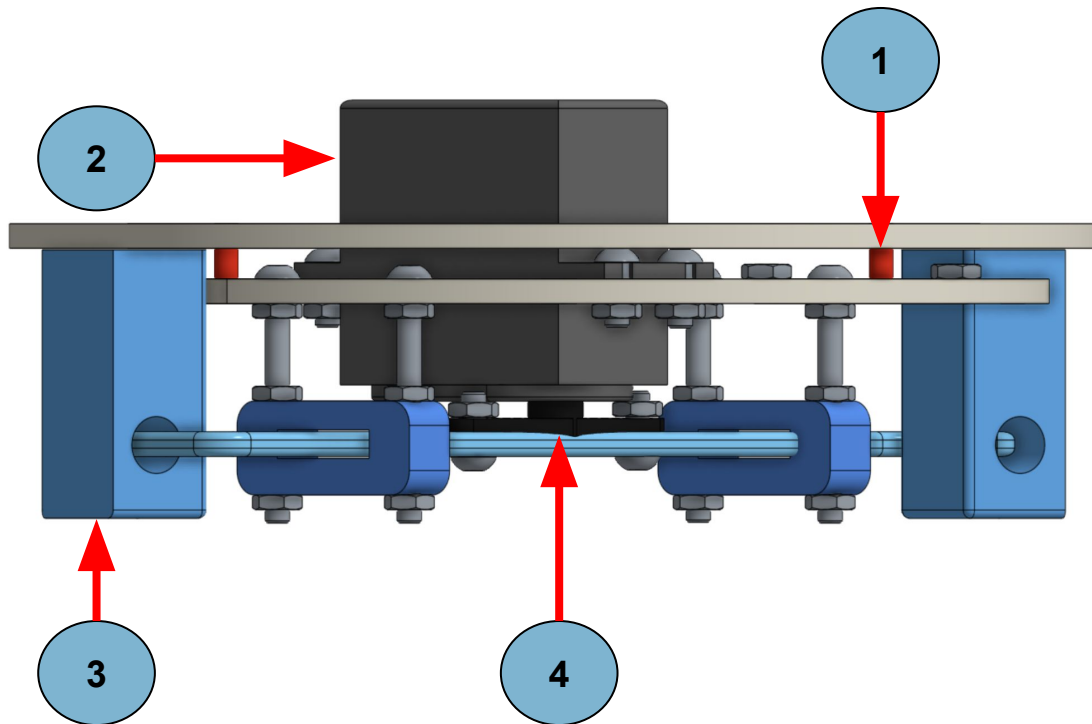
#	Part
1	Fiberglass Composite Plywood Back Plate
2	Forged Carbon Fiber Release Mechanism Arm
3	3D Printed PETG Release Mechanism Arm Support

**NOTE:** Not all parts shown



## Release Mechanism

### Side View



## Final Design

#	Part
1	Carbon Fiber Rotation Prevention Rod
2	FS5106B Servo
3	Forged Carbon Fiber Container Integration Piece
4	Double Sided Servo Horn

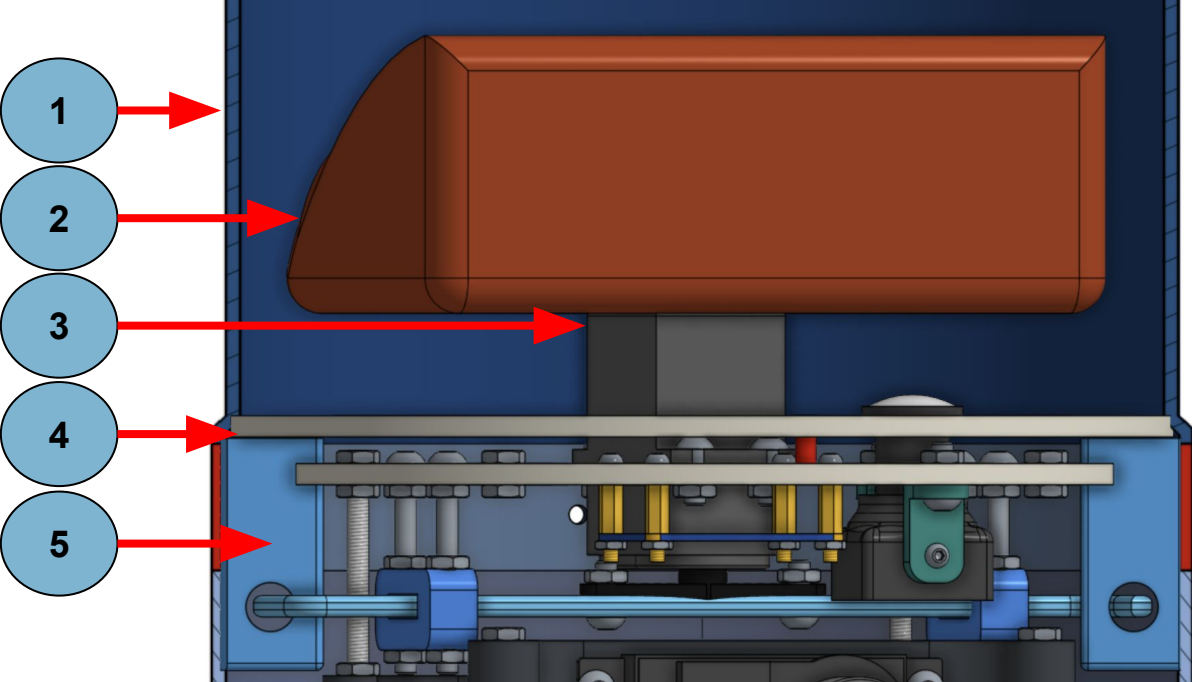
**NOTE:** Not all parts shown

# Physical Layout (7 of 18)

## Release Mechanism Container Integration

## Final Design

### Side Section View



#	Part
1	Fiberglass Composite Layup Container
2	Stowed Paraglider
3	FS5106B Servo
4	Fiberglass Composite Plywood Container Integration Plate
5	Forged Carbon Fiber Container Integration Piece

**NOTE:** Not all parts shown



# Physical Layout (8 of 18)

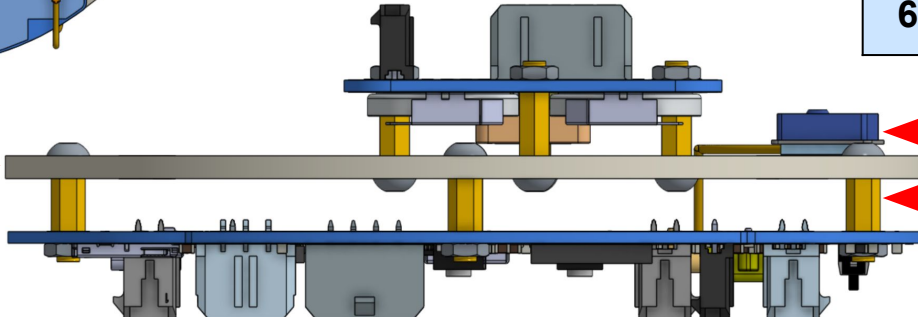
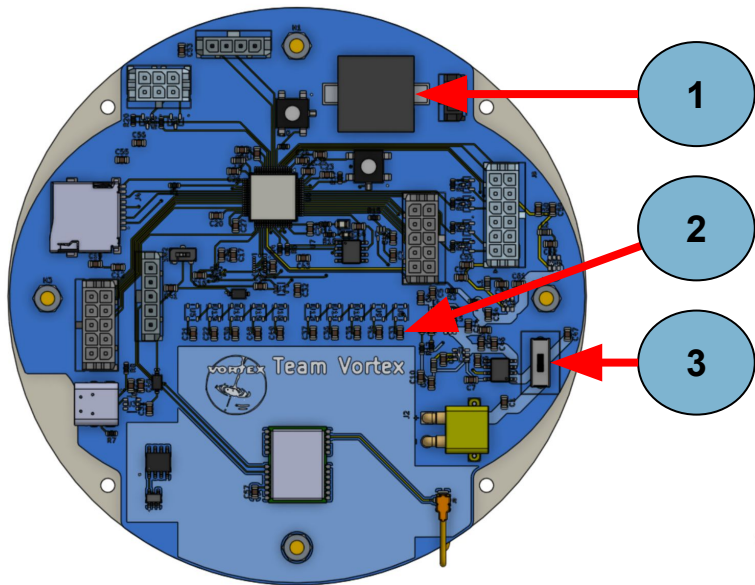


PCB

Final Design

Top View

Side View



#	Part
1	Buzzer
2	LED Power Indicator
3	Power Switch
4	Fiberglass Composite Plywood Electrical Component Plate
5	Patch GPS Antenna
6	Standoffs

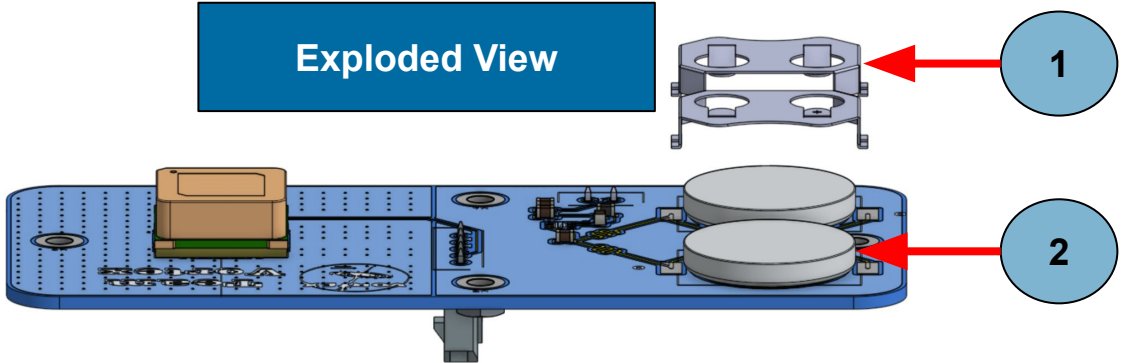
**NOTE:** Not all parts shown

# Physical Layout (9 of 18)

## PCB

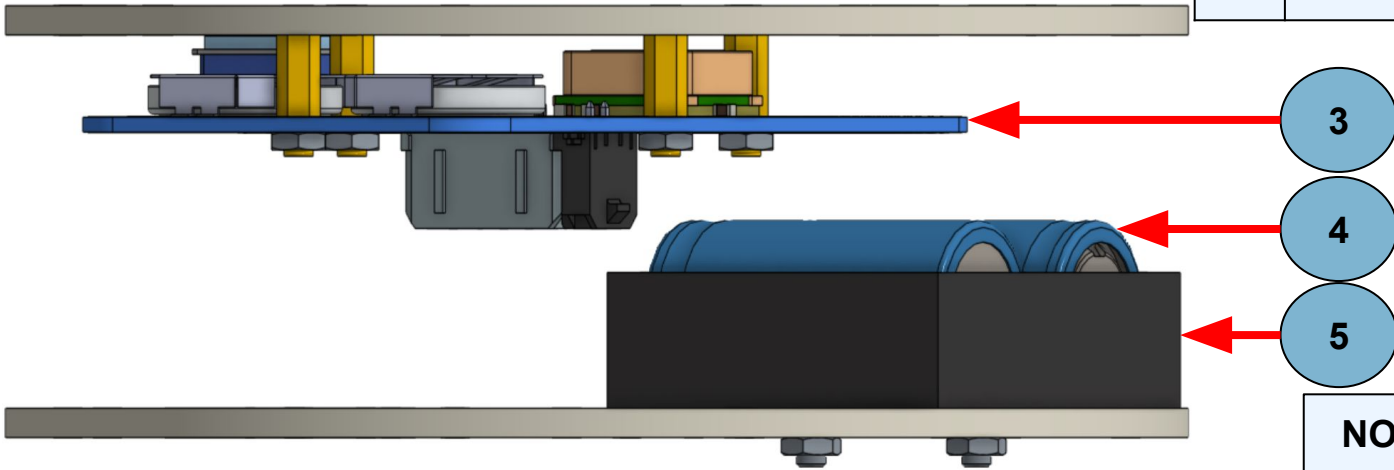
## Final Design

### Exploded View



#	Part
1	Coin Cell Battery Holder
2	Coin Cell Batteries
3	GPS PCB
4	18350 Batteries
5	18350 Battery Holder

### Side View



**NOTE:** Not all parts shown

# Physical Layout (10 of 18)

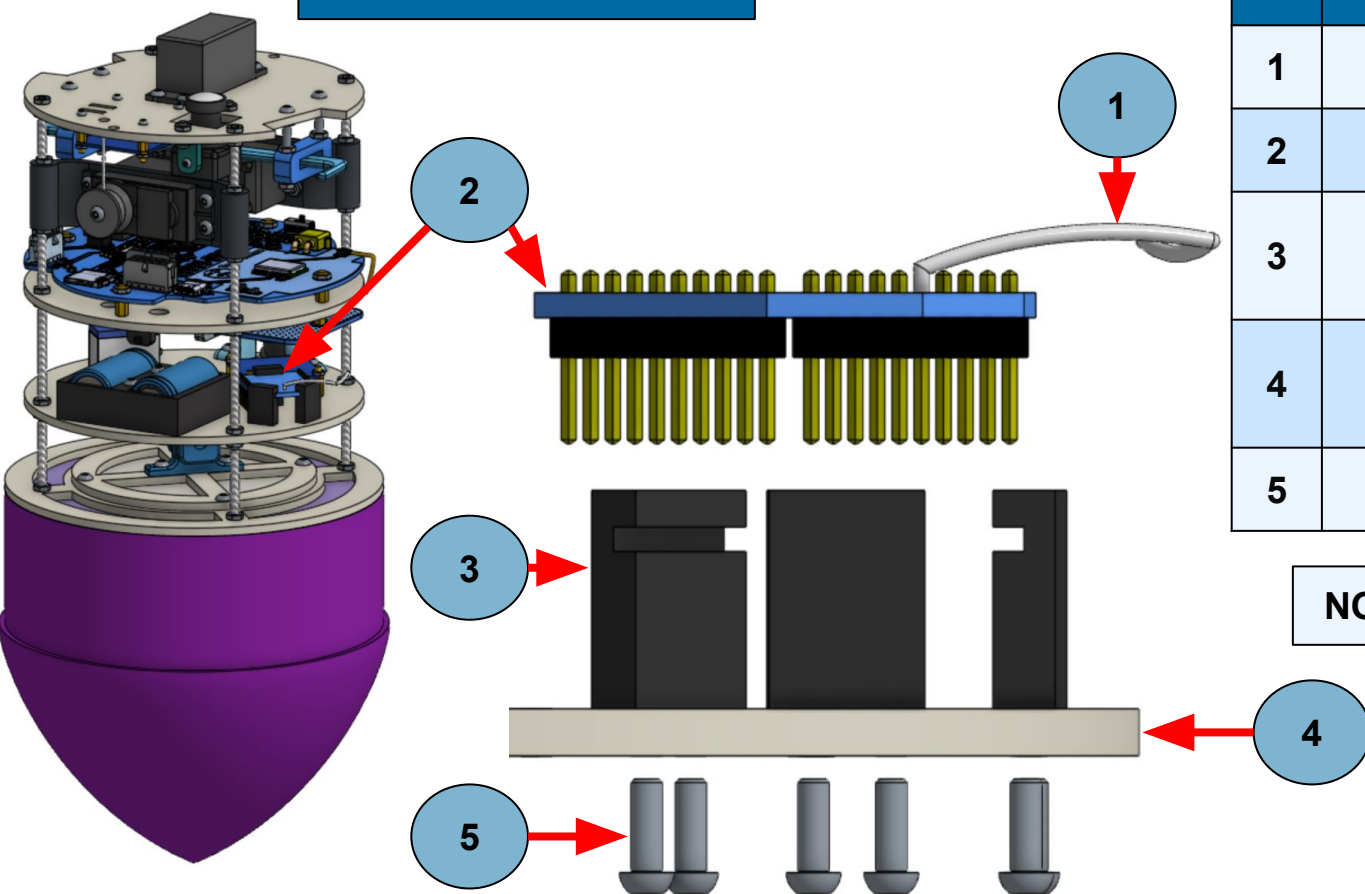
**XBEE**

**Final Design**

**Exploded View**

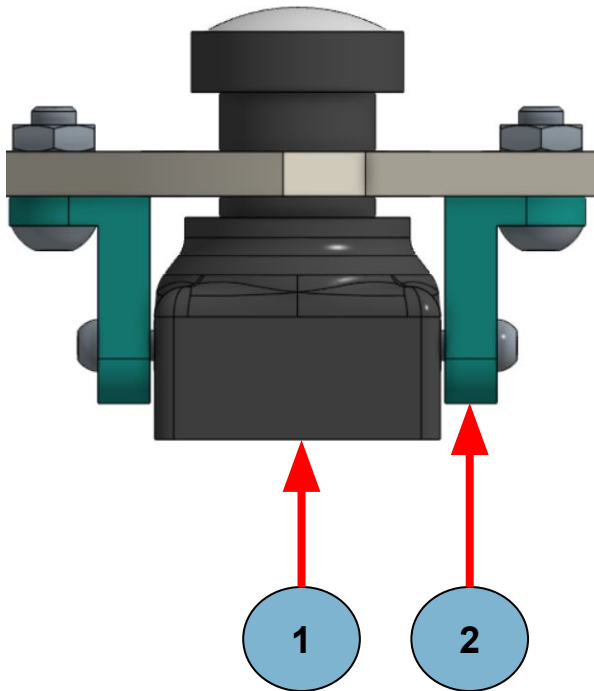
#	Part
1	XBEE Radio Antenna
2	XBEE Radio
3	3D Printed PETG Mounting Brackets
4	Fiberglass Composite Plywood Component Plate
5	M3 Bolts

**NOTE:** Not all parts shown

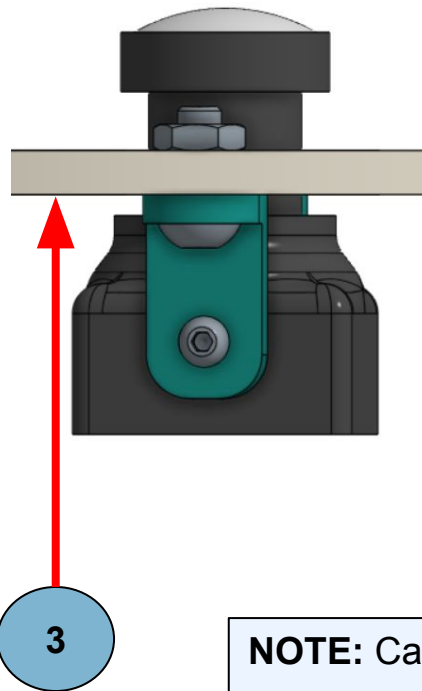


## Upward Facing Camera

### Front View



### Side View



## Final Design

#	Part
1	Upward Facing Camera
2	3D Printed PETG Upward Camera Mount
3	Fiberglass Composite Plywood Back Plate

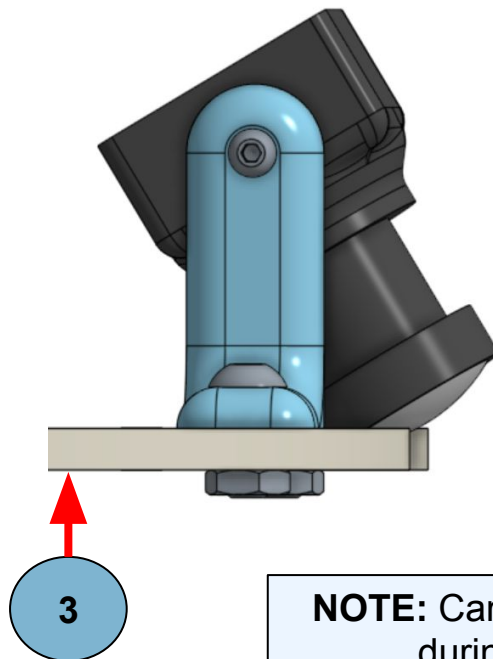
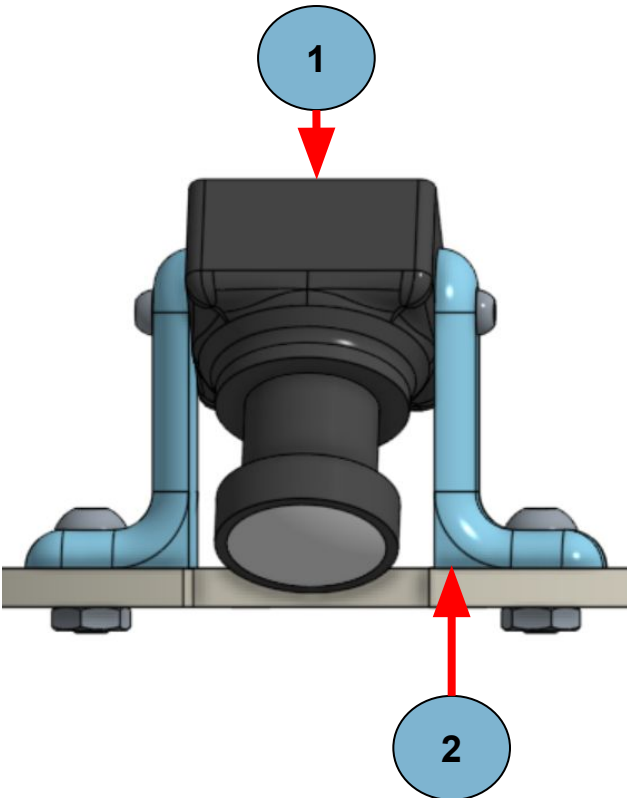
**NOTE:** Not all parts shown

**NOTE:** Camera angle enables clear view of paraglider during descent

## Downward Facing Camera

### Front View

### Side View



## Final Design

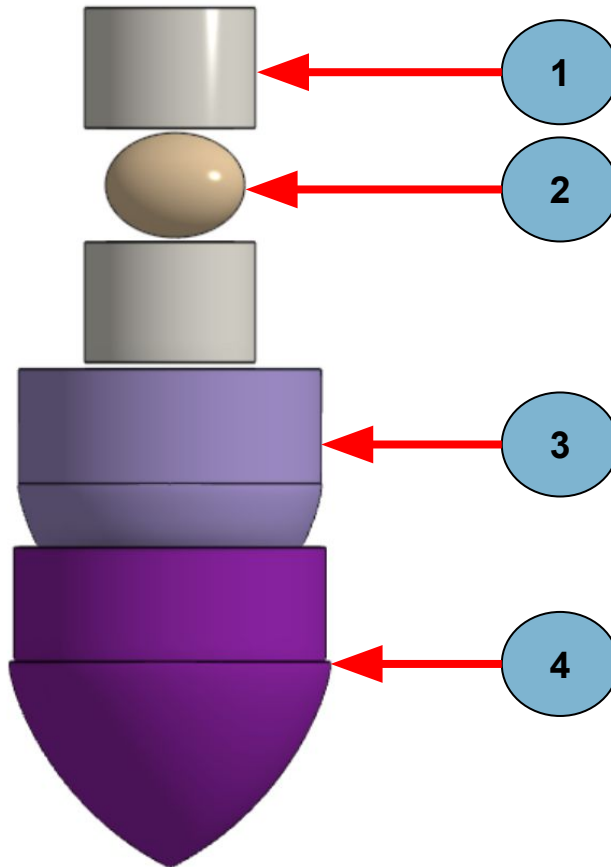
#	Part
1	Downward Facing Camera
2	3D Printed PETG Downward Camera Mount
3	Fiberglass Composite Plywood Nose Release Mounting Plate

**NOTE:** Not all parts shown

**NOTE:** Camera angle enables clear view of ground during descent and instrument release

## Instrument Protection

### Exploded View



## Final Design

#	Part
1	Urethane Foam Egg Holder
2	Hen's Egg
3	TPU Nose Cone Insert
4	Fiberglass Composite Layup Ogive Nose Cone

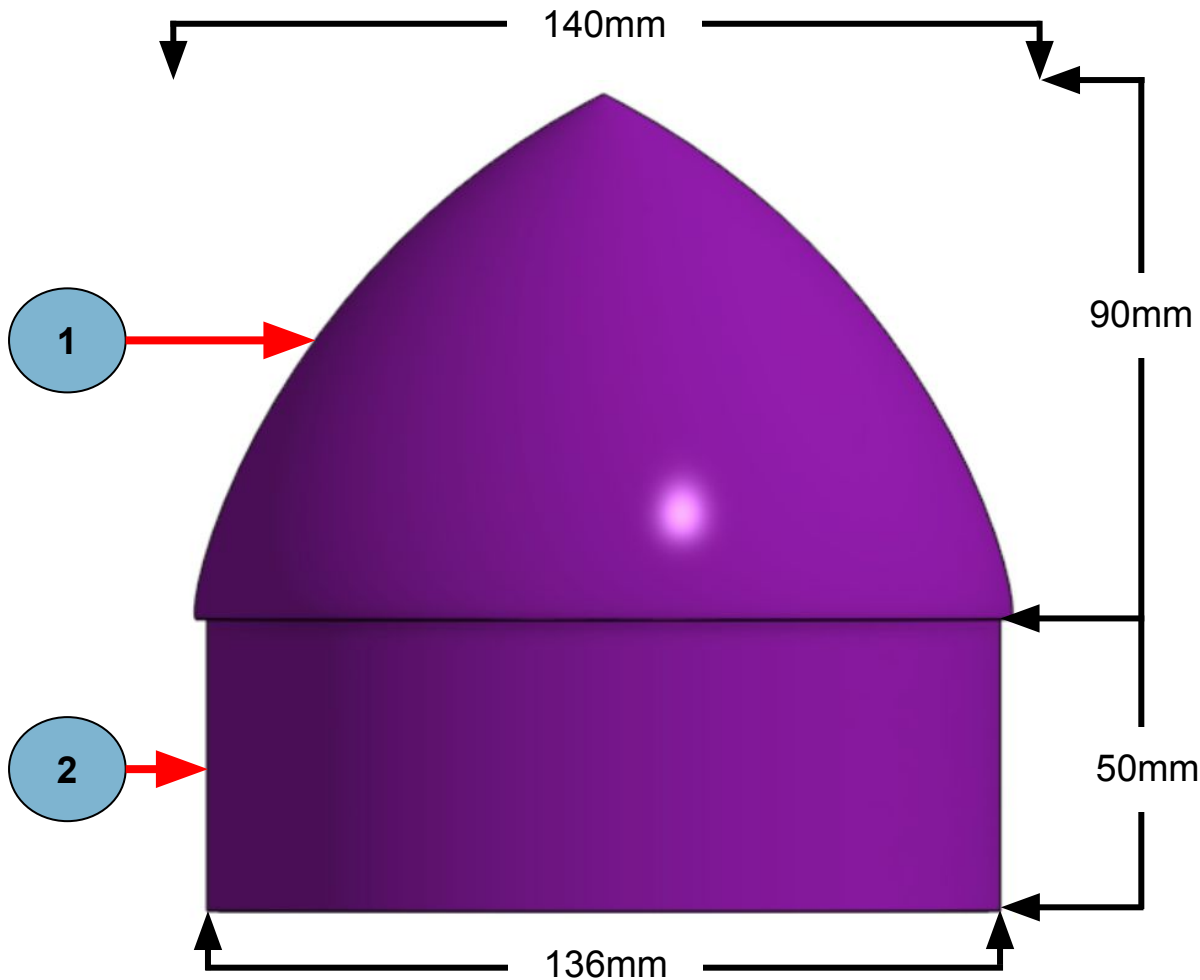
**NOTE:** Not all parts shown



# Physical Layout (14 of 18)



## Nose Cone



## Final Design

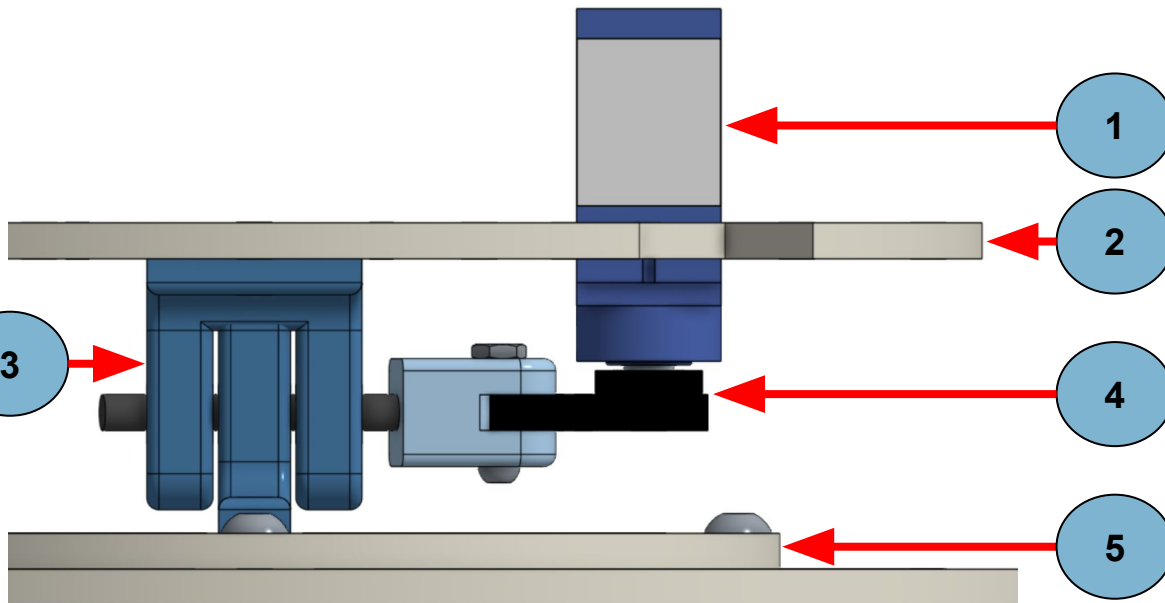
#	Part
1	Fiberglass Composite Layup Ogive Nose Cone
2	Fiberglass Composite Layup Nose Cone Shoulder

**NOTE:** Not all parts shown

**NOTE:** Nose cone is manufactured as a single piece with no openings

## Instrument Release Mechanism

### Locked Configuration



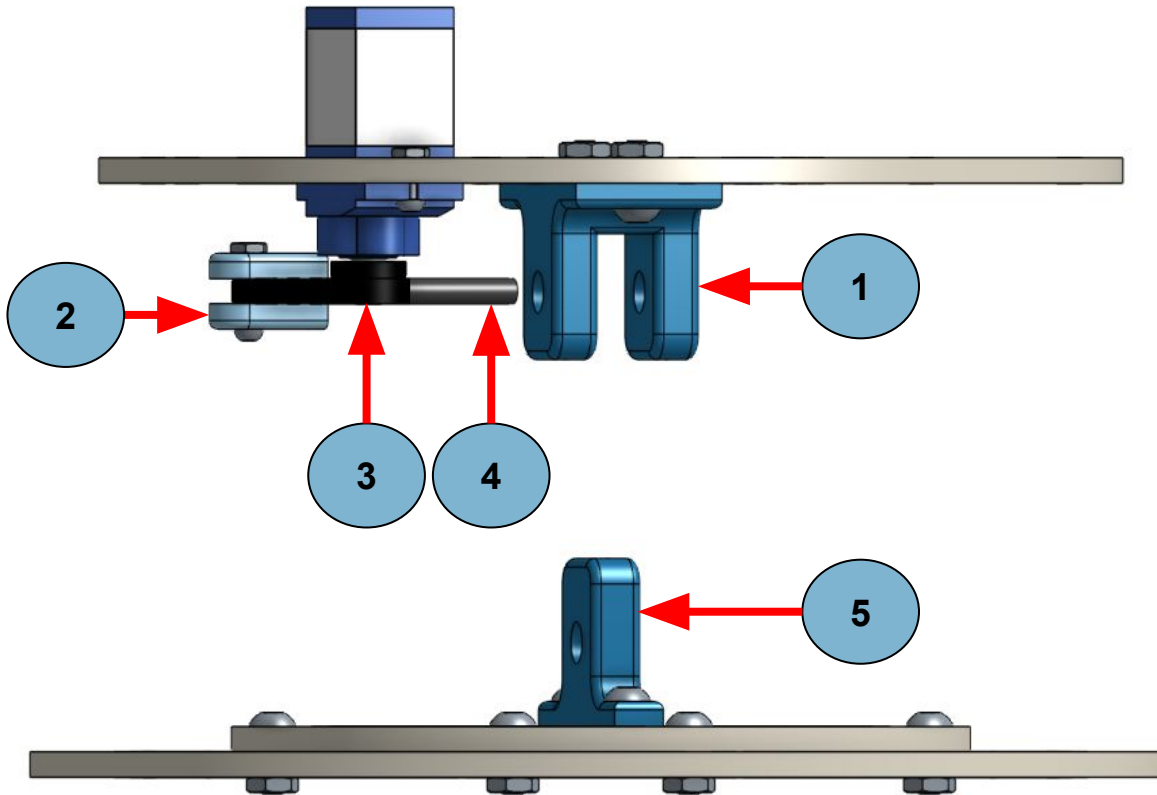
## Final Design

#	Part
1	MG92B Servo
2	Fiberglass Composite Plywood Nose Release Mounting Plate
3	3D Printed PETG Nose Cone Release Payload Attachment Point
4	Servo Horn
5	Fiberglass Composite Plywood Nose Release Integration Plate

**NOTE:** Not all parts shown

## Instrument Release Mechanism

### Released Configuration



## Final Design

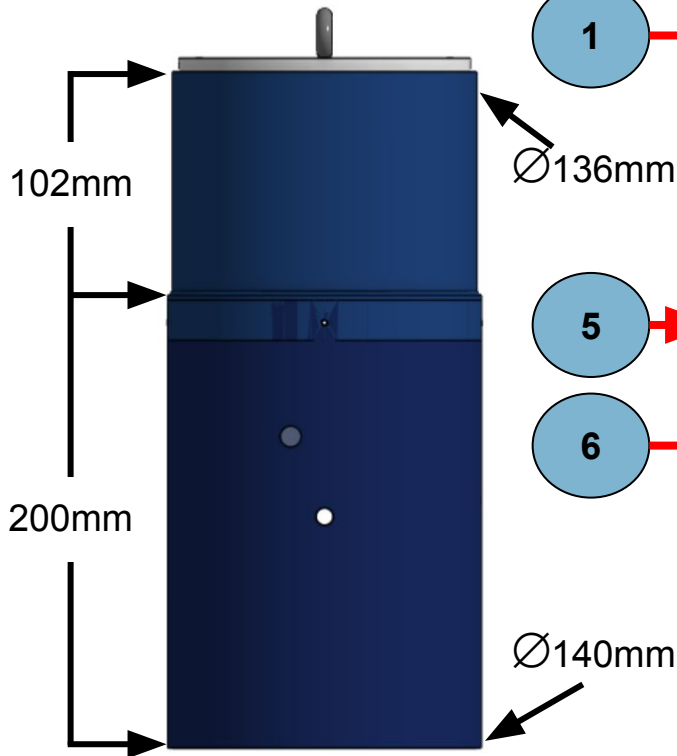
#	Part
1	3D Printed PETG Nose Cone Release Payload Attachment Point
2	3D Printed PETG Carbon Fiber Rod Adapter
3	Servo Horn
4	Carbon Fiber Nose Release Pin
5	3D Printed PETG Nose Cone Release Nose Attachment Point

**NOTE:** Not all parts shown

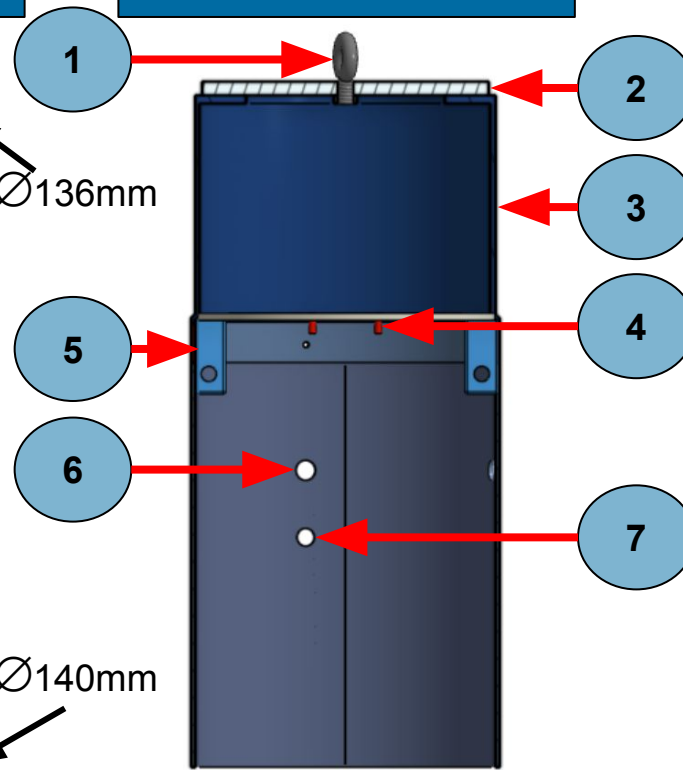
# Physical Layout (17 of 18)

## Fiberglass Composite Layup Container

### Front View



### Sliced View



**NOTE:** Container wall thickness is 2mm

## Final Design

#	Part
1	¼ Inch Eye Bolt
2	6mm Plywood Container Plate
3	Container Shoulder
4	Carbon Fiber Rotation Prevention Rod
5	Forged Carbon Fiber Container Integration Piece
6	9.5mm Power Switch Access Hole
7	Vent Hole

**NOTE:** Not all parts shown

## Launch Configuration

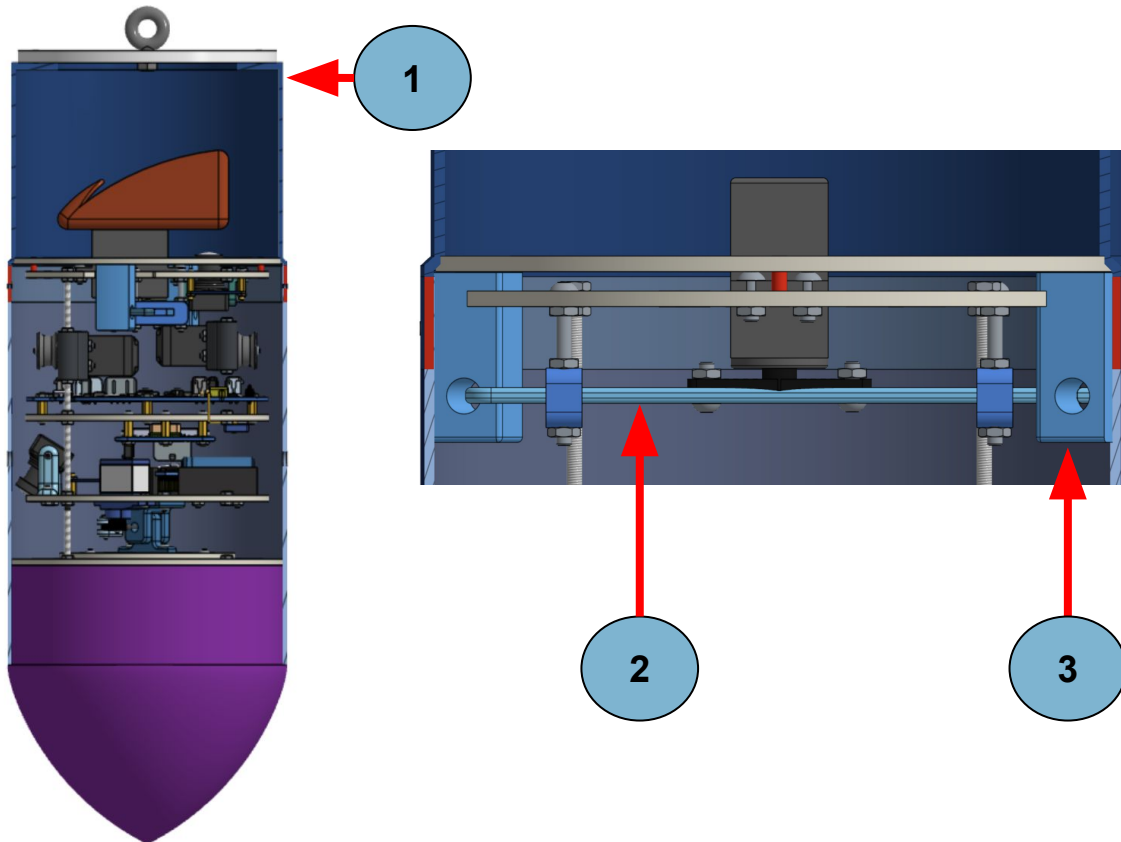
## Final Design

### Stowed Payload Configuration

### Stowed Release Mechanism

#	Part
1	Fiberglass Composite Layup Container
2	Forged Carbon Fiber Release Mechanism Arm
3	Forged Carbon Fiber Container Integration Piece

**NOTE:** Not all parts shown

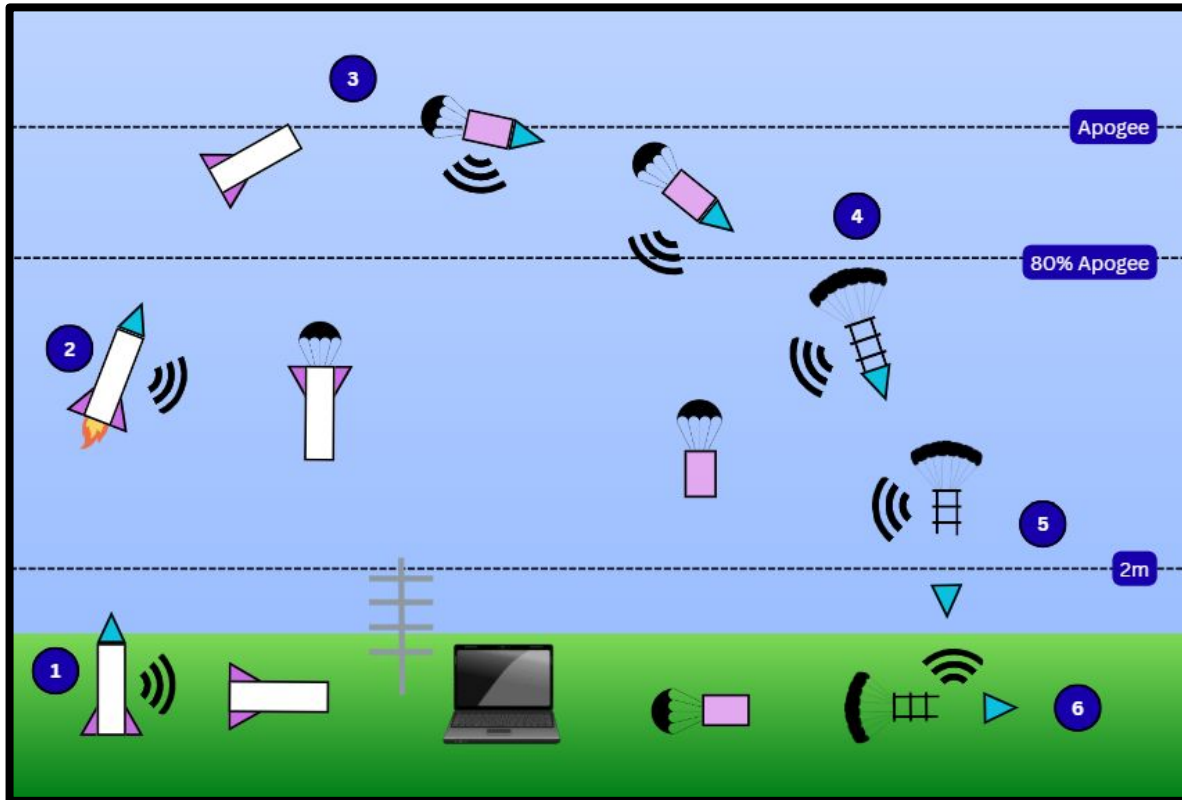




# System Concept of Operations



**NOTE:** Symbol indicates the transmission of telemetry to the ground station



## CONOPS

1. CanSat is integrated into rocket on launchpad

2. Rocket is ascending

3. At apogee the container separates from rocket and deploys a parachute. Descends at a rate of no more than 15m/s

4. At 80% of apogee the payload releases from the container and deploys a paraglider. Descends at an average rate of 5m/s

5. At 2m from the ground the nose cone, holding the egg, detaches from the payload. Descends at a rate of < 5m/s

6. Payload has landed



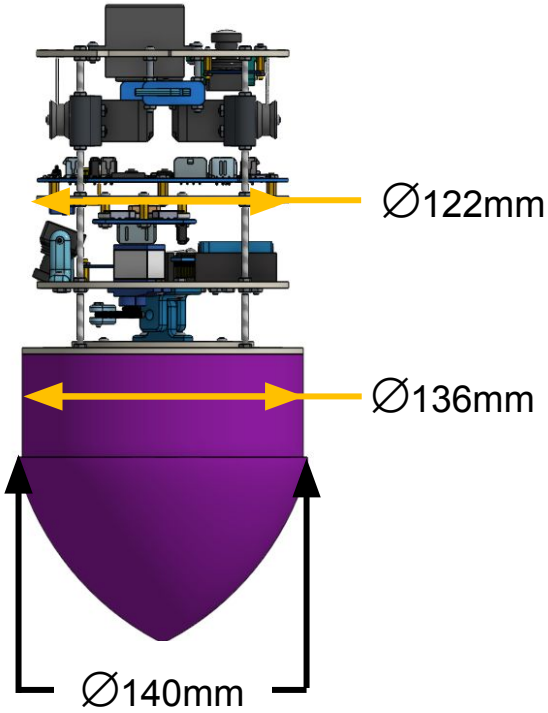
# Launch Vehicle Compatibility (1 of 2)



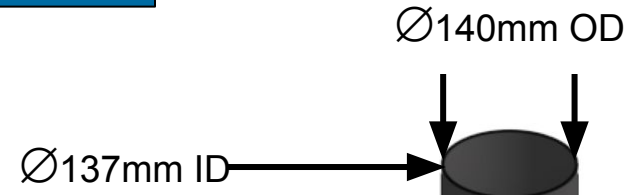
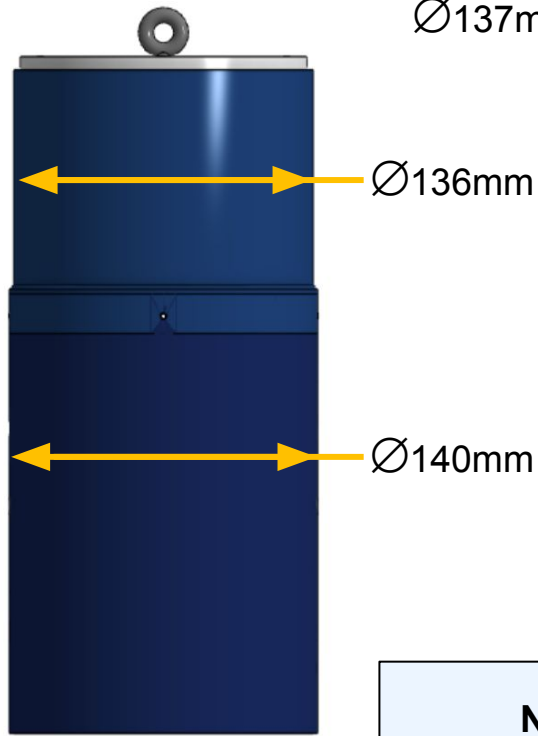
**NOTE:** All mechanical parts are within the 122mm base plate circumference ( $\pm 0.5\text{mm}$ )

## Rocket Integration

**NOTE:** Not all parts shown



**NOTE:** Nose cone is symmetrical across thrust axis



**NOTE:**  
ID: Inner Diameter  
OD: Outer Diameter



# Launch Vehicle Compatibility (2 of 2)



**NOTE:** Payload edge to rocket body clearance is 0.5mm

## Rocket Integration

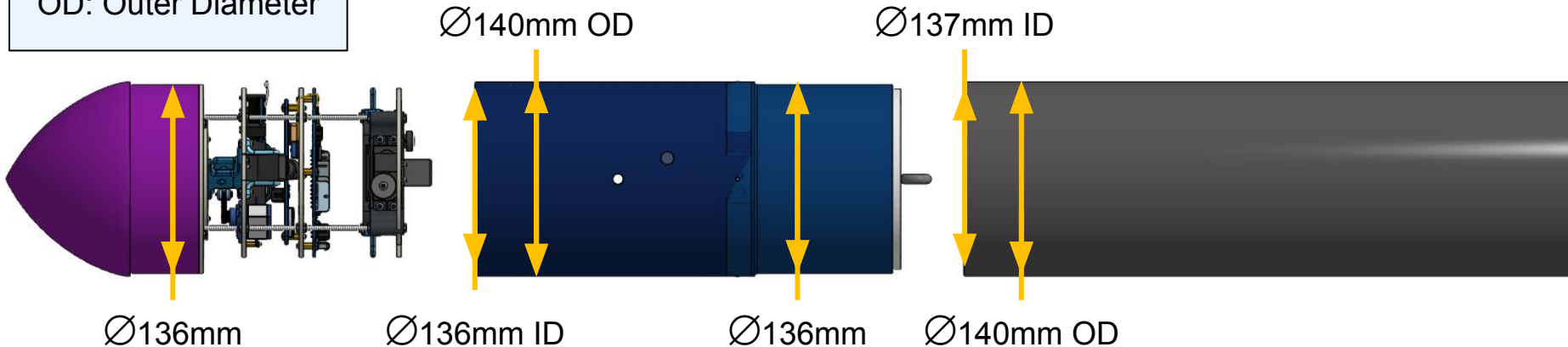
**NOTE:** Not all parts shown

## Rocket Integration Side View



**NOTE:**  
ID: Inner Diameter  
OD: Outer Diameter

## Rocket Integration Exploded View





# Sensor Subsystem Design

**Kenny Briggs**



# Sensor Subsystem Overview



Component	Description	Slide Number
BMP390	Temperature, pressure, and altitude sensor	50 - 55
Voltage Divider	Measures battery voltage	56 - 58
CT427-HSN830MR	Measures battery current	59 - 61
NEO-M9N	GPS sensor	62 - 64
BMI088	Acceleration and gyro sensor	65 - 70
RunCam Split 4 V2	Captures payload release and paraglider deployment	71 - 73
MCP7940MT-I/SN	Determines time of instrument release	74 - 76
RunCam Split 4 V2	Captures ground and instrument release	77 - 79



# Payload Air Pressure Sensor Trade & Selection (1 of 3)



Name	Pressure Relative Accuracy (Pa)	Sampling Rate (Hz)	Multi-Use (Temperature) (Y/N)	Price (\$)
ENS220S-BLG	± 2.5	970	N	2.92
2511020213301	± 2.5	200	N	3.92
<b>BMP390</b>	<b>± 3</b>	<b>200</b>	<b>Y</b>	<b>3.15</b>

## Final Selection

### BMP390

#### Reasoning:

- Median sampling rate at 200Hz
- Best pressure accuracy at ± 50Pa
- Low \$3.15 price
- Multi-use with temperature sensor



Source: Digikey



# Payload Air Pressure Sensor Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Pressure Absolute Accuracy (Pa)	> 6	3 - 5.9	1 - 2.9	< 1
Sampling Rate (Hz)	< 100	101 - 299	300 - 599	> 600
Multi-Use (Temperature) (Y/N)	N	-	-	Y
Price (\$)	> 3	1 - 3	< 1	-



# Payload Air Pressure Sensor Trade & Selection (3 of 3)



Factors	Weight	ENS220S-BLGT		2511020213301		BMP390	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Pressure Absolute Accuracy	2	4	8	4	8	2	4
Sampling Rate	4	8	32	2	8	2	8
Multi-Use (Temperature)	8	1	8	1	8	8	64
Price	4	2	8	1	4	1	4
<b>Total</b>		<b>56</b>		<b>28</b>		<b>80</b>	



# Payload Air Temperature Sensor Trade & Selection (1 of 3)



Name	Temperature Relative Accuracy (°C)	Sampling Rate (Hz)	Multi-Use (Pressure) (Y/N)	Price (\$)
<b>BMP390</b>	<b>± 1.5</b>	<b>200</b>	<b>Y</b>	<b>3.15</b>
TMP275	± 1	26.7	N	1.43
TC74A0-3.3VCTTR	± 2	8	N	1.15

## Final Selection

**BMP390**

### Reasoning:

- Best sampling rate at 200Hz
- Median temperature accuracy at ± 1.5°C
- Multi-use with pressure sensor



Source: Digikey



# Payload Air Temperature Sensor Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factors	1	2	4	8
Temperature Absolute Accuracy (°C)	$> \pm 5$	$\pm 2.1 - \pm 5$	$\pm 1 - \pm 2$	$< \pm 1$
Sampling Rate (Hz)	$< 10$	11 - 100	$> 100$	-
Multi-Use (Pressure) (Y/N)	N	-	-	Y
Price (\$)	$> 3$	2 - 3	$< 2$	-



# Payload Air Temperature Sensor Trade & Selection (3 of 3)



Factors	Weight	BMP390		TMP275		TC74A0-3.3VCTTR	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Temperature Absolute Accuracy	1	4	4	8	8	4	4
Sampling Rate	8	4	32	2	16	1	8
Multi-Use (Pressure)	2	8	16	1	2	1	2
Price	4	1	4	4	16	4	16
<b>Total</b>		<b>56</b>		<b>42</b>		<b>30</b>	



# Payload Battery Voltage and Current Sensor Trade & Selection (1 of 6)



## Battery Voltage Sensor Trade & Selection

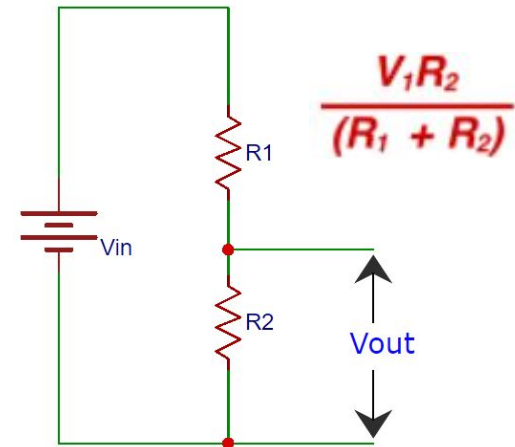
Name	Max Voltage (V)	Accuracy (%)	Mass (g)	Price (\$)
<b>Voltage Divider</b>	<b>25</b>	<b>± 1</b>	<b>&lt; 0.01</b>	<b>0.20</b>
INA219BIDR	26	± 0.5	0.076	1.98
ZXCT1041E5TA	20	± 1	0.015	1.38

### Final Selection

#### Voltage Divider

##### Reasoning:

- Lowest cost at \$0.20
- Lowest mass at < 0.01g
- High max voltage at 25V



Source: Circuit Digest



# Payload Battery Voltage and Current Sensor Trade & Selection (2 of 6)



## Unweighted Figures of Merit

Factors	1	2	4	8
Max Voltage (V)	< 10	10 - 25	> 25	-
Accuracy (%)	> $\pm 2$	$\pm 1 - \pm 2$	< $\pm 1$	-
Mass (g)	> 0.01	-	-	< 0.01
Price (\$)	> 2	1 - 2	< 1	-



# Payload Battery Voltage and Current Sensor Trade & Selection (3 of 6)



Factors	Weight	Voltage Divider		INA219BIDR		ZXCT1041E5TA	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Max Voltage	2	4	8	4	8	2	4
Accuracy	4	2	8	4	16	2	8
Mass	8	8	64	1	8	1	8
Price	1	4	4	2	2	2	2
<b>Total</b>		<b>84</b>		<b>34</b>		<b>22</b>	



# Payload Battery Voltage and Current Sensor Trade & Selection (4 of 6)



Battery Current Sensor Trade & Selection				
Name	Current Limit (A)	Accuracy (%)	Price (\$)	Response Time (ns)
GO 10-SMS	10	$\pm 1.3$	3.59	2000
<b>CT427-HSN830MR</b>	<b>30</b>	<b><math>\pm 0.5</math></b>	<b>3.31</b>	<b>300</b>
CZ3705	86.4	$\pm 1$	8.61	1000

## Final Selection

**CT427-HSN830MR**

### Reasoning:

- Second highest current limit at 30A
- Highest accuracy at 0.5%
- Fastest response time at 300ns
- Lowest price at \$3.31

**NOTE:** CT427 is a Magnetoresistive Bidirectional current sensor



Source: DigiKey



# Payload Battery Voltage and Current Sensor Trade & Selection (5 of 6)



## Unweighted Figures of Merit

Factor	1	2	4	8
Current Limit (A)	< 8	8 - 9	10 - 15	> 15
Accuracy (%)	> $\pm 1$	$\pm 0.6 - \pm 1$	< $\pm 0.5$	-
Price (\$)	> 5	3 - 5	2 - 3	< 2
Response Time (ns)	> 1000	500 - 1000	300 - 500	< 300



# Payload Battery Voltage and Current Sensor Trade & Selection (6 of 6)



Factor	Weight	GO 10-SMS		CT427-HSN830MR		CZ3705	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Current Limit	4	4	16	8	32	8	32
Accuracy	8	1	8	4	32	2	16
Price	2	2	4	2	4	1	2
Response Time	4	1	4	4	16	1	4
<b>Weighted Total</b>		<b>32</b>		<b>84</b>		<b>54</b>	



# Payload GNSS Sensor Trade & Selection (1 of 3)



Name	Circular Error Probable (m)	Antenna Inclusion (Y/N)	Price (\$)	Start Times (s)
CD-PA1616D	3	Y	19.95	Hot - 1 Warm - 33
<b>NEO-M9N</b>	<b>2</b>	<b>N</b>	<b>27.00</b>	<b>Hot - 2 Warm - 26</b>
M10578-A3	2.5	N	17.48	Hot - 1 Warm - 25

## Final Selection

**NEO-M9N**

### Reasoning:

- Highest accuracy at 2m CEP
- Fast warm start times
- LNA / SAW filter inclusion

**NOTE:** Separate GPS patch antenna is used



Sources: Digikey



# Payload GNSS Sensor Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factors	1	2	4	8
Circular Error Probable (m)	> 5	3 - 5	1 - 2.99	< 1
Antenna Inclusion (Y/N)	N	Y	-	-
Price (\$)	> 15	10 - 15	< 10	-
Start Times (s)	-	> 2 Hot > 30 Warm	1 - 2 Hot 20 - 30 Warm	< 1 Hot < 20 Warm



# Payload GNSS Sensor Trade & Selection (3 of 3)



Factors	Weight	CD-PA1616D		NEO-M9N		M10578-A3	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Circular Error Probable	8	2	16	4	32	4	32
Antenna Inclusion	2	2	4	1	2	1	2
Price	1	1	1	2	2	1	1
Start Times	4	2	8	4	16	4	16
<b>Total</b>		<b>29</b>		<b>52</b>		<b>51</b>	

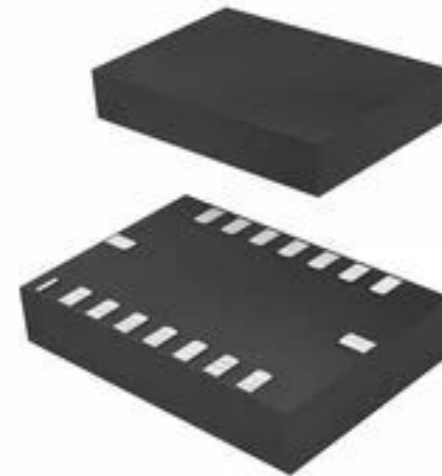


# Payload Acceleration Sensor Trade & Selection (1 of 3)



Name	Maximum Data Range (g)	Startup Time (ms)	Current Draw ( $\mu$ A)	Price (\$)
BMI270	$\pm 10$	2	970	3.73
ICM-42670-P	$\pm 16$	10	550	3.66
<b>BMI088</b>	<b><math>\pm 24</math></b>	<b>1</b>	<b>200</b>	<b>5.23</b>

Final Selection
<b>BMI088</b>
<p><b>Reasoning:</b></p> <ul style="list-style-type: none"> <li>• Highest max acceleration range at <math>\pm 24g</math></li> <li>• Fastest startup time at 1ms</li> <li>• Lowest Current Draw at 200<math>\mu</math>A</li> </ul>



Source: Digikey



# Payload Acceleration Sensor Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factors	1	2	4	8
Maximum Data Range (g)	$< \pm 10$	$\pm 10 - \pm 15$	$\pm 16 - \pm 20$	$> \pm 20$
Startup Time (ms)	$> 10$	3 - 9	1 - 3	$< 1$
Current Draw ( $\mu\text{A}$ )	$> 1000$	750 - 1000	500 - 749	$< 500$
Price (\$)	$> 4$	3 - 4	$< 3$	-



# Payload Acceleration Sensor Trade & Selection (3 of 3)



Factors	Weight	BMI270		ICM-42670-P		BMI088	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Maximum Data Range	8	2	16	4	32	8	64
Startup Time	4	4	16	1	4	4	16
Current Draw	1	2	2	4	4	8	8
Price	2	2	4	2	4	1	2
<b>Total</b>		<b>38</b>		<b>44</b>		<b>90</b>	



# Payload Rotation Rate Sensor Trade & Selection (1 of 3)



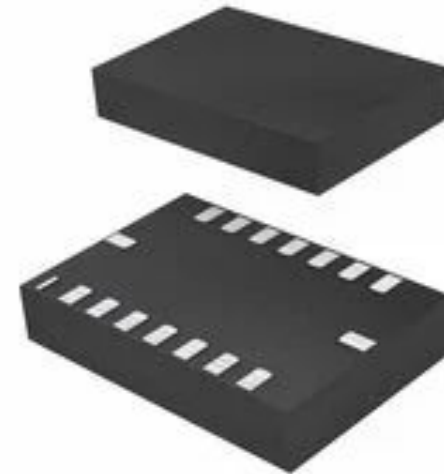
Name	Maximum Range (°/s)	Sensitivity (LSB/°/s)	Data Rate (Hz)	Price (\$)	Current Draw (mA)
IAM-20380	± 2000	16.4	8000	14.89	6.1
A3G4250D	± 245	114	966	16.31	6.1
<b>BMI088</b>	<b>± 2000</b>	<b>16.4</b>	<b>2000</b>	<b>5.23</b>	<b>0.2</b>

## Final Selection

**BMI088**

### Reasoning:

- High Maximum Range at ± 2000°/s
- Median data rate at 2000Hz
- Lowest current draw at 0.2mA
- Lowest cost at \$5.23



Source: Digikey



# Payload Rotation Rate Sensor Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factors	1	2	4	8
Maximum Range ( $^{\circ}/s$ )	$< \pm 200$	$\pm 200 - \pm 500$	$\pm 501 - \pm 1000$	$> \pm 1000$
Sensitivity (LSB/ $^{\circ}/s$ )	$< 10$	10 - 50	51 - 100	$> 100$
Data Rate (Hz)	$< 100$	101 - 500	501 - 1000	$> 1000$
Price (\$)	$> 15$	10 - 15	5 - 10	$< 5$
Current Draw (mA)	$> 5$	3 - 5	1 - 2	$< 1$



# Payload Rotation Rate Sensor Trade & Selection (3 of 3)



Factors	Weight	IAM-20380		A3G4250D		BMI088	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Maximum Range	8	8	64	2	16	8	64
Sensitivity	2	2	4	8	16	2	4
Data Rate	4	8	32	4	16	8	32
Price	1	2	2	1	1	8	8
Current Draw	2	1	2	1	2	8	16
<b>Total</b>		<b>104</b>		<b>51</b>		<b>124</b>	



# Payload Release Camera Trade & Selection (1 of 3)



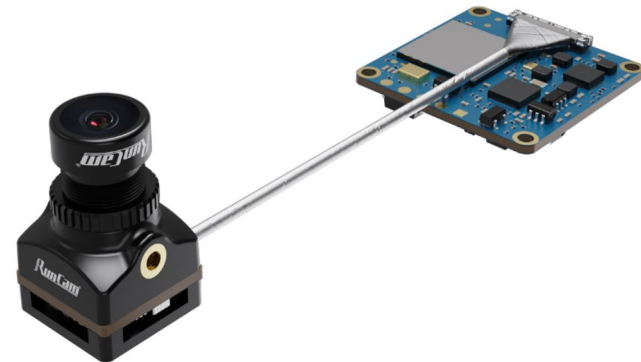
Name	Resolution (Pixels)	Current Draw (mA)	Included Video Storage (Y/N)	Price (\$)
<b>RunCam Split 4 V2</b>	<b>3840 x 2160</b>	<b>450</b>	<b>Y</b>	<b>83.99</b>
UCAM-III	640 x 480	90	N	54.95
PTC08	640 x 480	85	N	39.95

## Final Selection

### RunCam Split 4 V2

#### Reasoning:

- Highest resolution (3840 x 2160)
- Independent video storage
- Flexible mounting method
- Live compilation capability



Source: RunCam



# Payload Release Camera Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Resolution (Pixels)	-	$\leq 480$	$\geq 1080$	-
Current Draw (mA)	-	$> 90$	50 - 89	$< 50$
Included Video Storage (Y/N)	N	-	-	Y
Price (\$)	$> 60$	41 - 60	25 - 40	$< 25$



# Payload Release Camera Trade & Selection (3 of 3)



Factor	Weight	RunCam Split 4 V2		UCAM-III		PTC08	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Resolution	4	4	16	2	8	2	8
Current Draw	2	2	4	2	4	4	8
Included Video Storage	4	8	32	1	4	1	4
Price	8	1	8	2	16	4	32
<b>Total</b>		<b>60</b>		<b>32</b>		<b>52</b>	



# Instrument Release Sensor Trade and Selection (1 of 3)



Name	Accuracy (PPM)	Price (\$)	Current Draw ( $\mu$ A)
DS3231	$\pm 2$	12.89	70
<b>MCP7940MT-I/SN</b>	<b><math>\pm 20</math></b>	<b>0.67</b>	<b>1</b>
ISL1208IB8Z-TK	$\pm 20$	2.82	6

## Final Selection

**MCP7940MT-I/SN**

### Reasoning:

- Lowest price at \$0.67
- Low current draw at 1 $\mu$ A
- Decent time drift accuracy at  $\pm 20$  PPM



Source: Digikey



# Instrument Release Sensor Trade and Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Accuracy (PPM)	> 15	10 - 15	5 - 9	< 5
Price (\$)	> 10	5 - 10	1 - 4	< 1
Current Draw ( $\mu$ A)	> 20	10 - 20	1 - 9	< 1



# Instrument Release Sensor Trade and Selection (3 of 3)



Factor	Weight	DS3231		MCP7940MT-I/SN		ISL1208IB8Z-TK	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Accuracy	1	8	8	1	1	1	1
Price	4	1	4	8	32	4	16
Current Draw	2	1	2	4	8	4	8
<b>Weighted Total</b>		<b>14</b>		<b>41</b>		<b>25</b>	



# Ground Camera Trade & Selection (1 of 3)



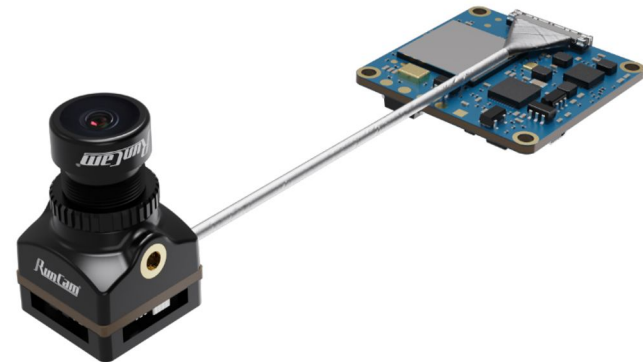
Name	Resolution (Pixels)	Current Draw (mA)	Included Video Storage (Y/N)	Price (\$)
<b>RunCam Split 4 V2</b>	<b>3840 x 2160</b>	<b>450</b>	<b>Y</b>	<b>83.99</b>
UCAM-III	640 x 480	90	N	54.95
PTC08	640 x 480	85	N	39.95

## Final Selection

### RunCam Split 4 V2

#### Reasoning:

- Highest resolution (3840 x 2160)
- Independent video storage
- Flexible mounting method
- Live compilation capability



Source: RunCam



# Ground Camera Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Resolution (Pixels)	-	$\leq 480$	$\geq 1080$	-
Current Draw (mA)	-	$> 90$	50 - 90	$< 50$
Included Video Storage (Y/N)	N	-	-	Y
Price (\$)	$> 60$	41 - 60	25 - 40	$< 25$



# Ground Camera Trade & Selection (3 of 3)



Factor	Weight	RunCam Split 4 V2		UCAM-III		PTC08	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Resolution	4	4	16	2	8	2	8
Current Draw	2	2	4	2	4	4	8
Included Video Storage	4	8	32	1	4	1	4
Price	8	1	8	2	16	4	32
<b>Total</b>		<b>60</b>		<b>32</b>		<b>52</b>	



---

# Descent Control Design

**Andrew Levrett, William Goudy**



# Descent Control Overview

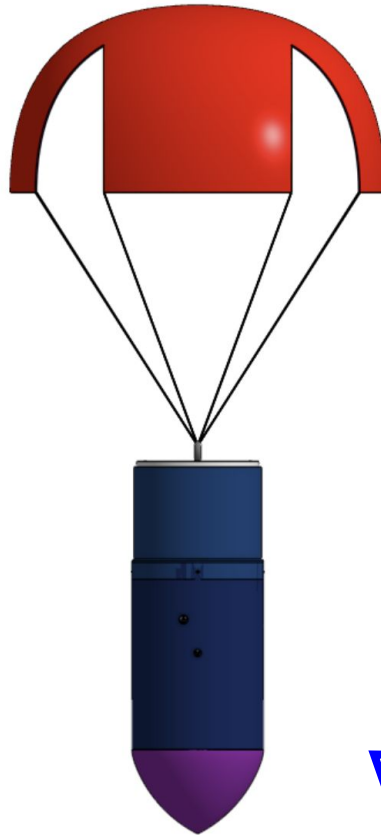


## Final Design

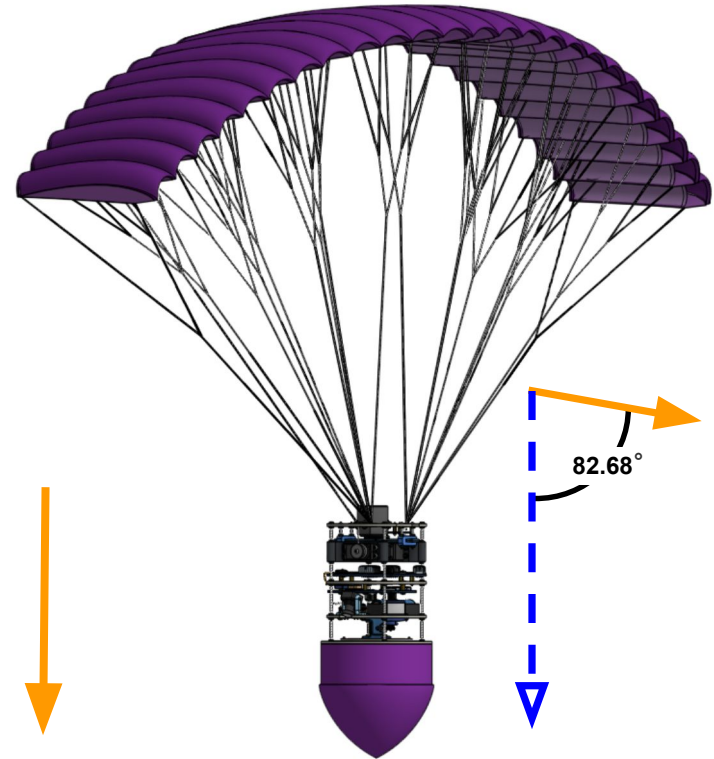
Descent Control Mechanism	Altitude Range	Descent Rate (m/s)
Parachute	Apogee - 80% Apogee	13.69
Paraglider	80% Apogee - Ground	3.29
Nosecone	2m - Ground	4.89

Nadir Direction	
Direction of Travel	

### Parachute Descent



### Paraglider Descent





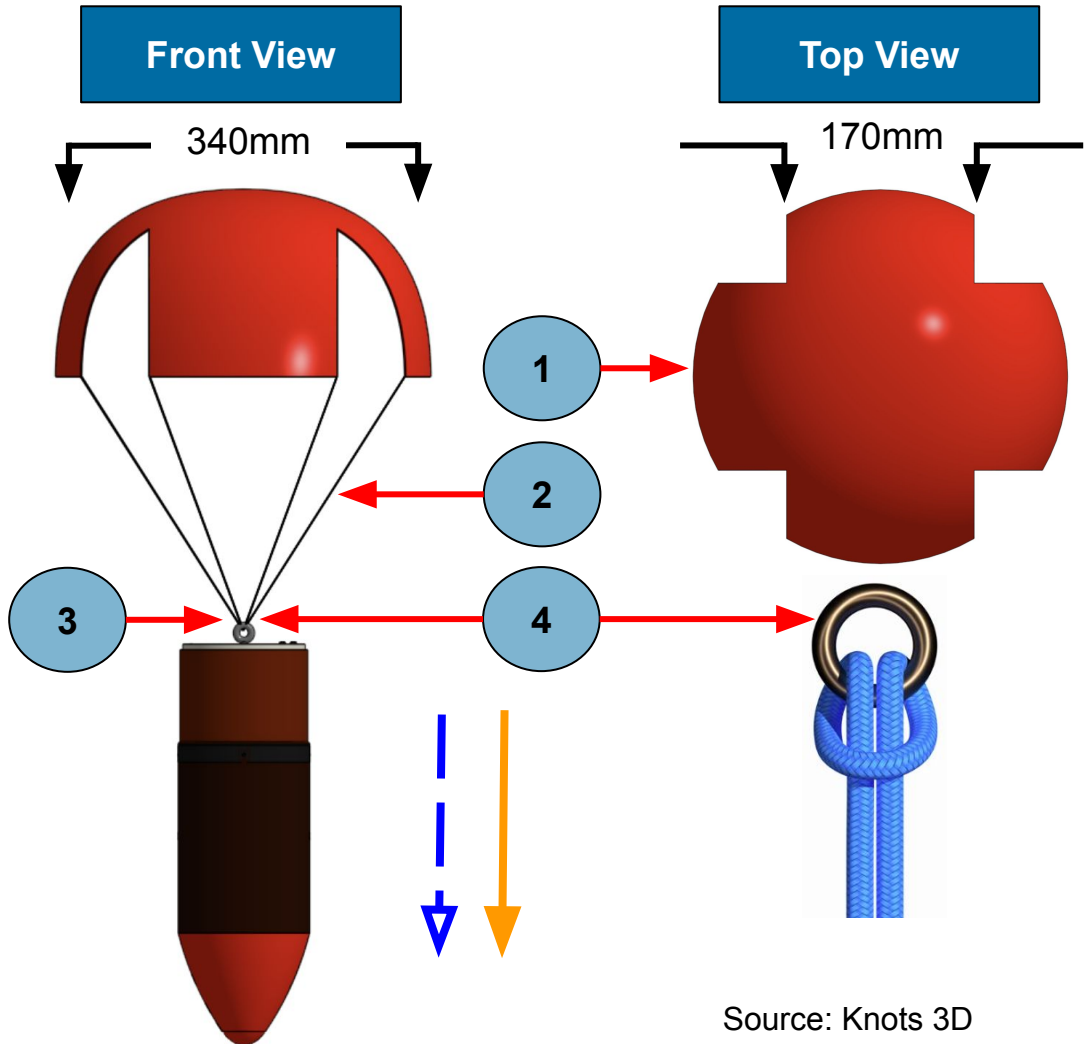
# Container Parachute Descent Control Strategy Selection and Trade (1 of 8)



## Design 1: Cruciform Parachute

#	Description
1	Silnylon Cruciform Parachute
2	Kevlar Parachute Lines
3	¼ Inch Eye Bolt
4	Cow Hitch Knot

Nadir Direction	
Direction of Travel	

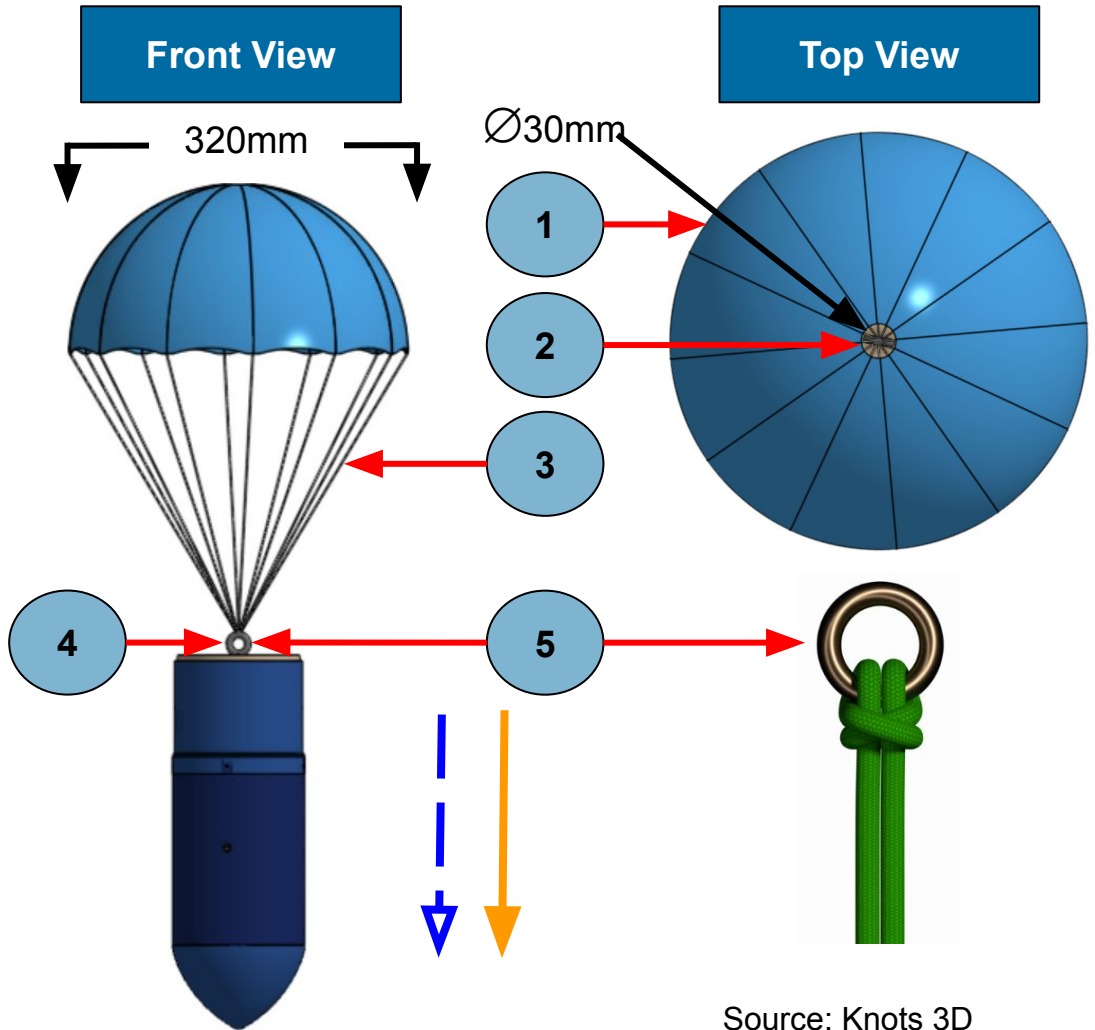


Source: Knots 3D

## Design 2: Hemispheric Parachute

#	Description
1	Ripstop Nylon Hemispherical Parachute
2	Vent Hole
3	Fishing Line Parachute Lines
4	¼ Inch Eye Bolt
5	Bull Hitch Knot

Nadir Direction	
Direction of Travel	





# Container Parachute Descent Control Strategy Selection and Trade (3 of 8)



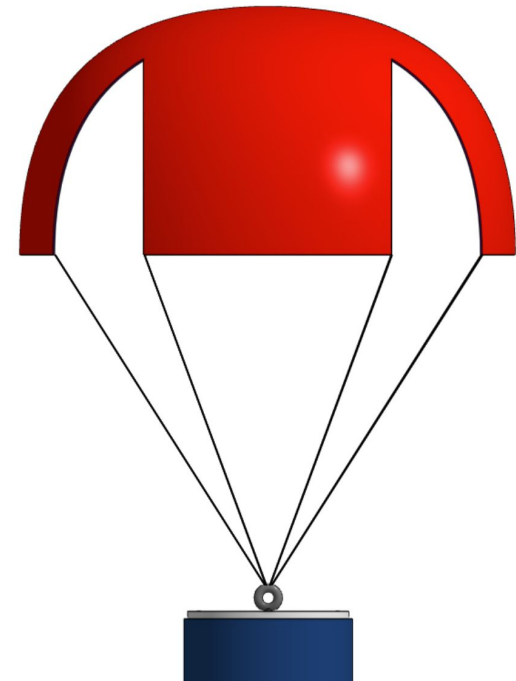
Name	Drag Coefficient	Area of Fabric Required (cm <sup>2</sup> )	Projected Vent Ratio (%)	Line Attachment Points
Design 1	1.17	1526.84	16.67	8
Design 2	1.47	1580.22	3.64	12

## Final Selection

### Design 1: Cruciform Parachute

#### Reasoning:

- Large vent area from Design 1 prevents uneven pressure distributions, creating a more stable descent
- Less line attachment points reduces the chance of tangling during launch





# Container Parachute Descent Control Strategy Selection and Trade (4 of 8)



## Unweighted Figures of Merit

Factor	1	2	4	8
Drag Coefficient	< 1	1.0 - 1.2	1.21 -1.4	> 1.4
Area of Fabric Required (cm <sup>2</sup> )	> 2000	1551-2000	1500 - 1550	< 1500
Projected Vent Ratio (%)	< 1	1 - 5	6 - 10	> 10
Line Attachment Points	> 20	11 - 20	5 - 10	< 5



# Container Parachute Descent Control Strategy Selection and Trade (5 of 8)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Drag Coefficient	1	2	2	8	8
Area of Fabric Required	4	4	16	2	8
Projected Vent Ratio	8	4	32	2	16
Line Attachment Points	2	4	8	2	4
<b>Weighted Total</b>		<b>58</b>		<b>36</b>	

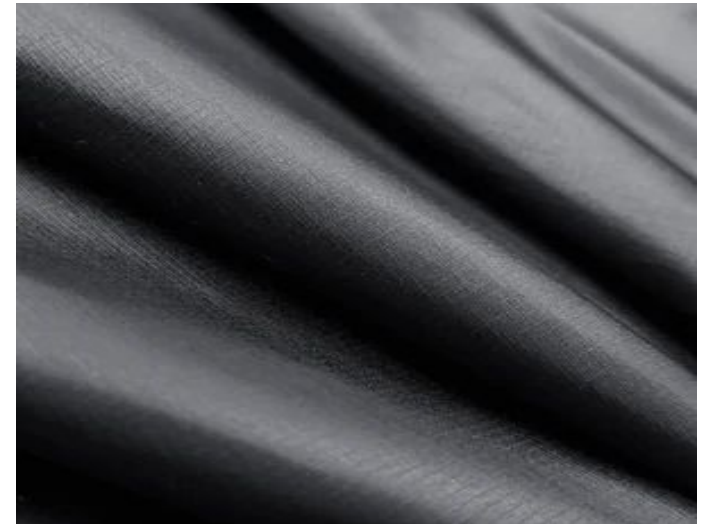


# Container Parachute Descent Control Strategy Selection and Trade (6 of 8)



Material	Tear Strength (N)	Areal Density (g/m <sup>2</sup> )	Hydrostatic Head (mm)
<b>0.77 oz Silnylon</b>	<b>9</b>	<b>26</b>	<b>2000</b>
40D Ripstop Nylon	23	48	1000

Final Selection
<b>0.77 oz Silnylon</b>
<p><b><u>Reasoning:</u></b></p> <ul style="list-style-type: none"><li>• Lower areal density allows for a lower mass</li><li>• Greater hydrostatic head gives more resistance to moisture in the air</li></ul>



Source: Emma Kites



# Container Parachute Descent Control Strategy Selection and Trade (7 of 8)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tear Strength (N)	< 10	10 - 19	20 - 30	> 30
Areal Density (g/m <sup>2</sup> )	> 50	40 - 50	30 - 39	< 30
Hydrostatic Head (mm)	< 1000	1000 - 1499	1500 - 2000	> 2000



# Container Parachute Descent Control Strategy Selection and Trade (8 of 8)



Factor	Weight	0.77 oz Silnylon		40D Ripstop Nylon	
		Unweighted	Weighted	Unweighted	Weighted
Tear Strength	1	1	1	4	4
Areal Density	4	8	32	2	8
Hydrostatic Head	2	4	8	2	4
<b>Weighted Total</b>		<b>41</b>		<b>16</b>	

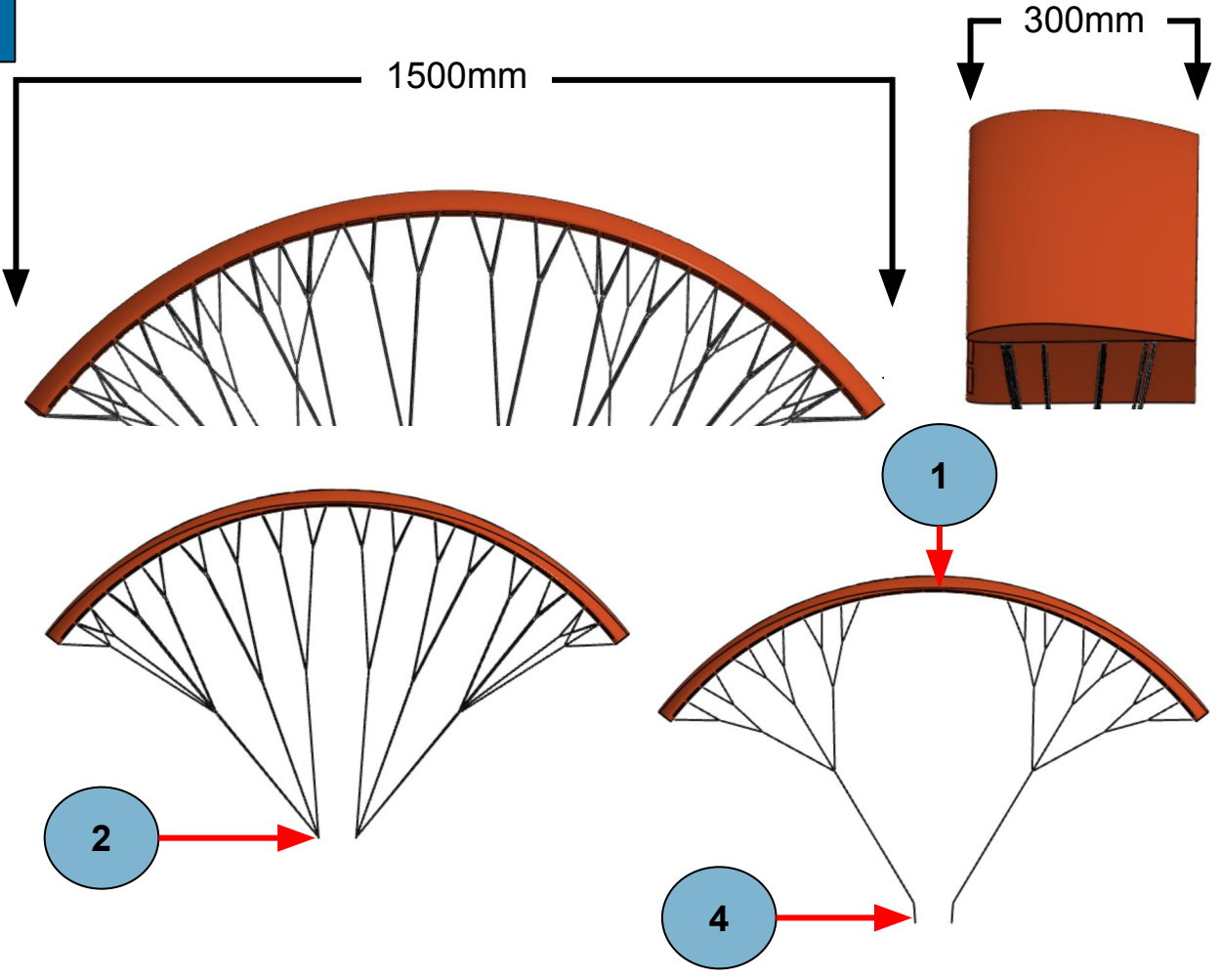


# Payload Steering Control Strategy Selection and Trade (1 of 10)



## Design 1: NACA 4412 Airfoil

#	Description
1	40D Ripstop Nylon Wing
2	Fishing Line Stability Lines
3	Cell Openings
4	Fishing Line Brake Lines



**NOTE:** Not all parts shown

**NOTE:** Steering is active

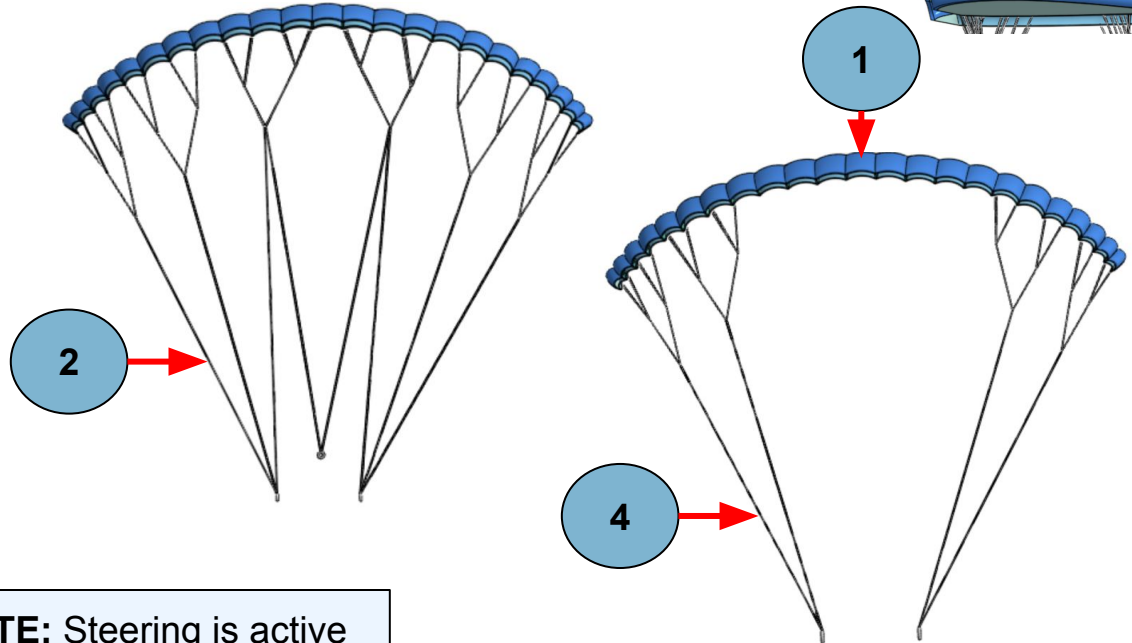
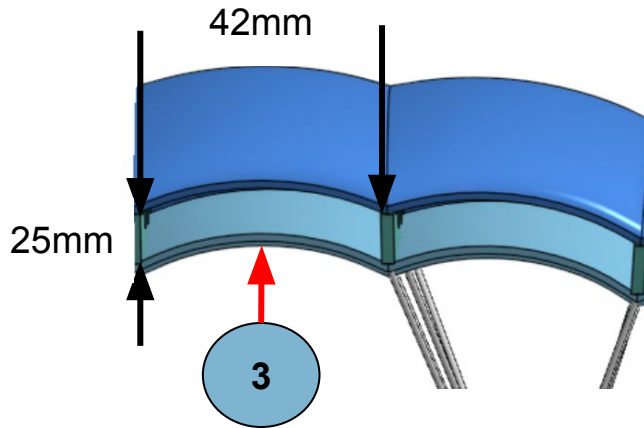
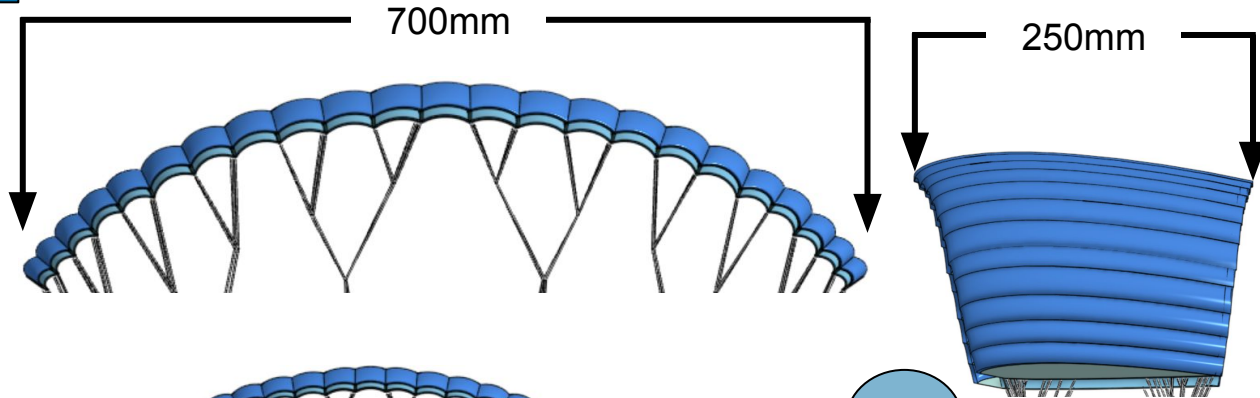


# Payload Steering Control Strategy Selection and Trade (2 of 10)



## Design 2: NACA 2412 Airfoil

#	Description
1	Silnylon Wing
2	Kevlar Stability Lines
3	Cell Openings
4	Kevlar Brake Lines



**NOTE:** Not all parts shown

**NOTE:** Steering is active



# Payload Steering Control Strategy Selection and Trade (3 of 10)



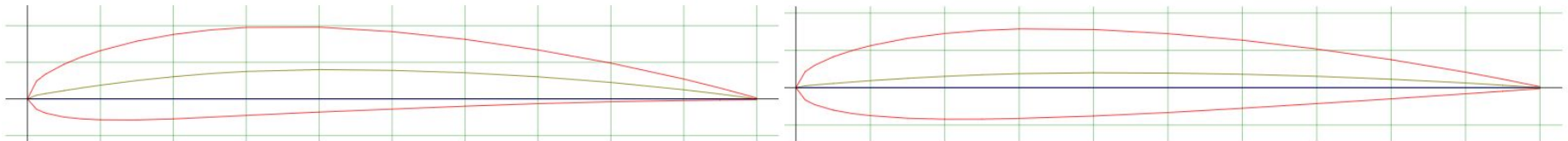
## Airfoil Glide Ratio Comparison

### Design 1

Airfoil	Average Glide Ratio
NACA 4412	7.8

### Design 2

Airfoil	Average Glide Ratio
NACA 2412	11.9



Source: Airfoil Tools

**NOTE:** Glide Ratio calculated from airfoil data. Values are an average of the lift to drag ratio in an angle of attack range from  $0^\circ$  to  $10^\circ$ . Selections made based on airfoil behavior at low AOA and low speed glide.



# Payload Steering Control Strategy Selection and Trade (4 of 10)



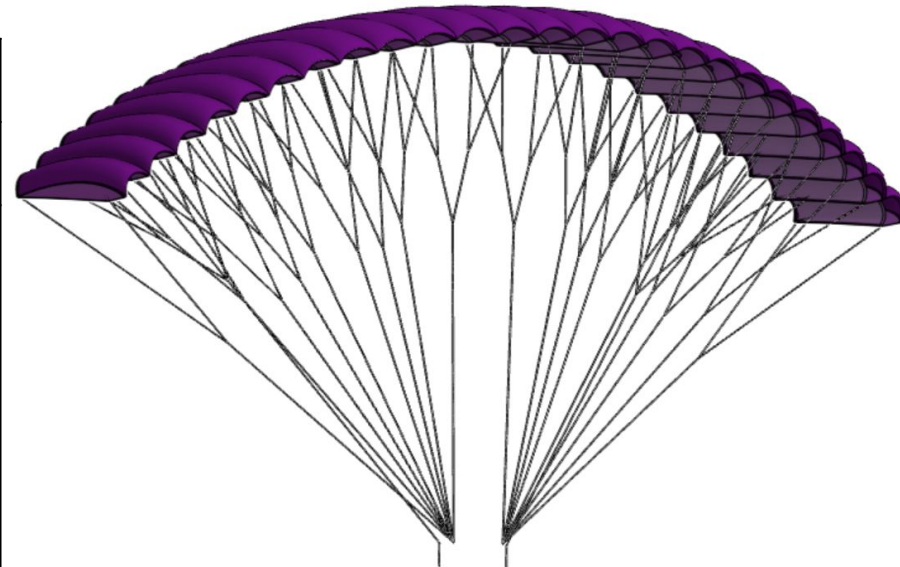
Name	Glide Ratio	Aspect Ratio	Cell Opening Area (mm <sup>2</sup> )
Design 1	7.8	4.5	225
Design 2	11.9	2.8	1050

## Final Selection

### Combination 1 & 2

#### Reasoning:

- Design 1 glide and aspect ratios ideal for maneuverability and stability at low speeds
- Design 2 cell opening area and structural supports allow paraglider to maintain airfoil shape during descent



**NOTE:** Not all parts shown



# Payload Steering Control Strategy Selection and Trade (5 of 10)



## Unweighted Figures of Merit

Factor	1	2	4	8
Glide Ratio	> 8	7 - 8	4 - 6.9	2 - 3.9
Aspect Ratio	< 2	2 - 3.9	4 - 5	> 5
Cell Opening Area (mm <sup>2</sup> )	< 300	300 - 499	500 - 700	> 700



# Payload Steering Control Strategy Selection and Trade (6 of 10)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Glide Ratio	4	4	16	1	4
Aspect Ratio	2	4	8	2	4
Cell Opening Area	1	1	1	8	8
<b>Weighted Total</b>		<b>25</b>		<b>32</b>	

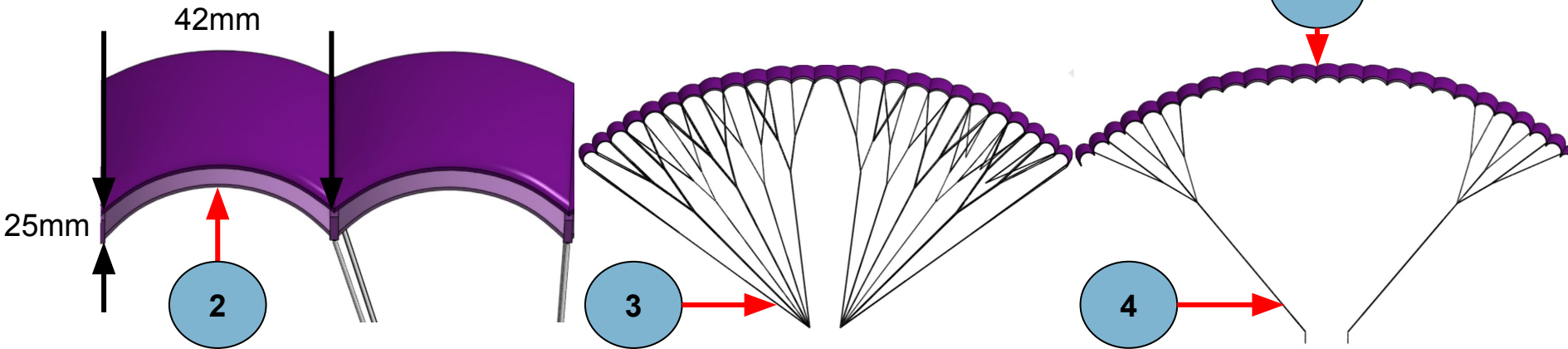
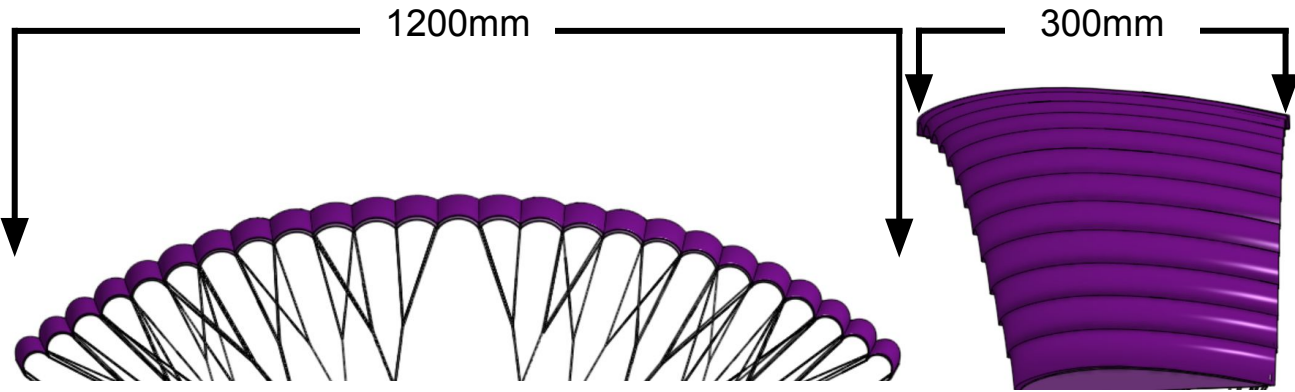


# Payload Steering Control Strategy Selection and Trade (7 of 10)



## Final Design: NACA 4412 Airfoil

#	Description
1	Silnylon Wing
2	Cell Openings
3	Kevlar Stability Lines
4	Kevlar Brake Lines



**NOTE:** Not all parts shown

**NOTE:** Steering is active

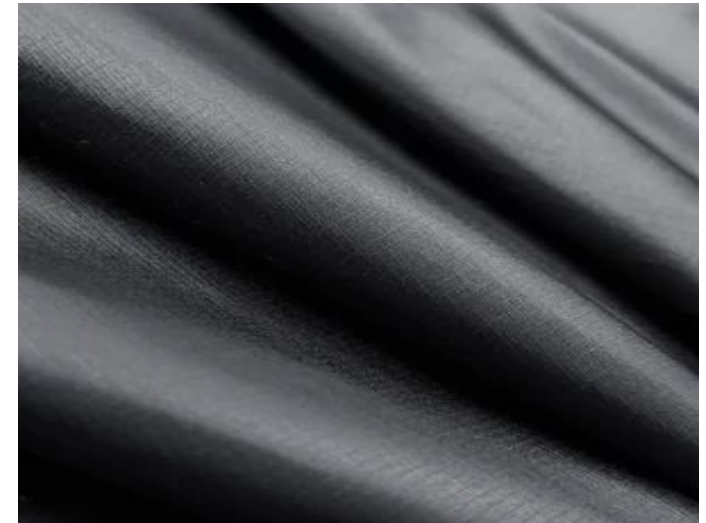


# Payload Steering Control Strategy Selection and Trade (8 of 10)



Material	Tear Strength (N)	Areal Density (g/m <sup>2</sup> )	Hydrostatic Head (mm)
<b>0.77 oz Silnylon</b>	<b>9</b>	<b>26</b>	<b>2000</b>
40D Ripstop Nylon	23	48	1000

Final Selection
<b>0.77 oz Silnylon</b>
<p><b><u>Reasoning:</u></b></p> <ul style="list-style-type: none"><li>• Lower areal density allows for a lower mass</li><li>• Greater hydrostatic head gives more resistance to moisture in the air</li></ul>



Source: Emma Kites



# Payload Steering Control Strategy Selection and Trade (9 of 10)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tear Strength (N)	< 10	10 - 19	20 - 30	> 30
Areal Density (g/m <sup>2</sup> )	> 50	40 - 50	30 - 39	< 30
Hydrostatic Head (mm)	< 1000	1000 - 1499	1500 - 2000	> 2000



# Payload Steering Control Strategy Selection and Trade (10 of 10)



Factor	Weight	0.77 oz Silnylon		40D Ripstop Nylon	
		Unweighted	Weighted	Unweighted	Weighted
Tear Strength	1	1	1	4	4
Areal Density	4	8	32	2	8
Hydrostatic Head	2	4	8	2	4
<b>Weighted Total</b>		<b>41</b>		<b>16</b>	



# Para-Glider Descent Speed Control Strategy Selection and Trade (1 of 6)

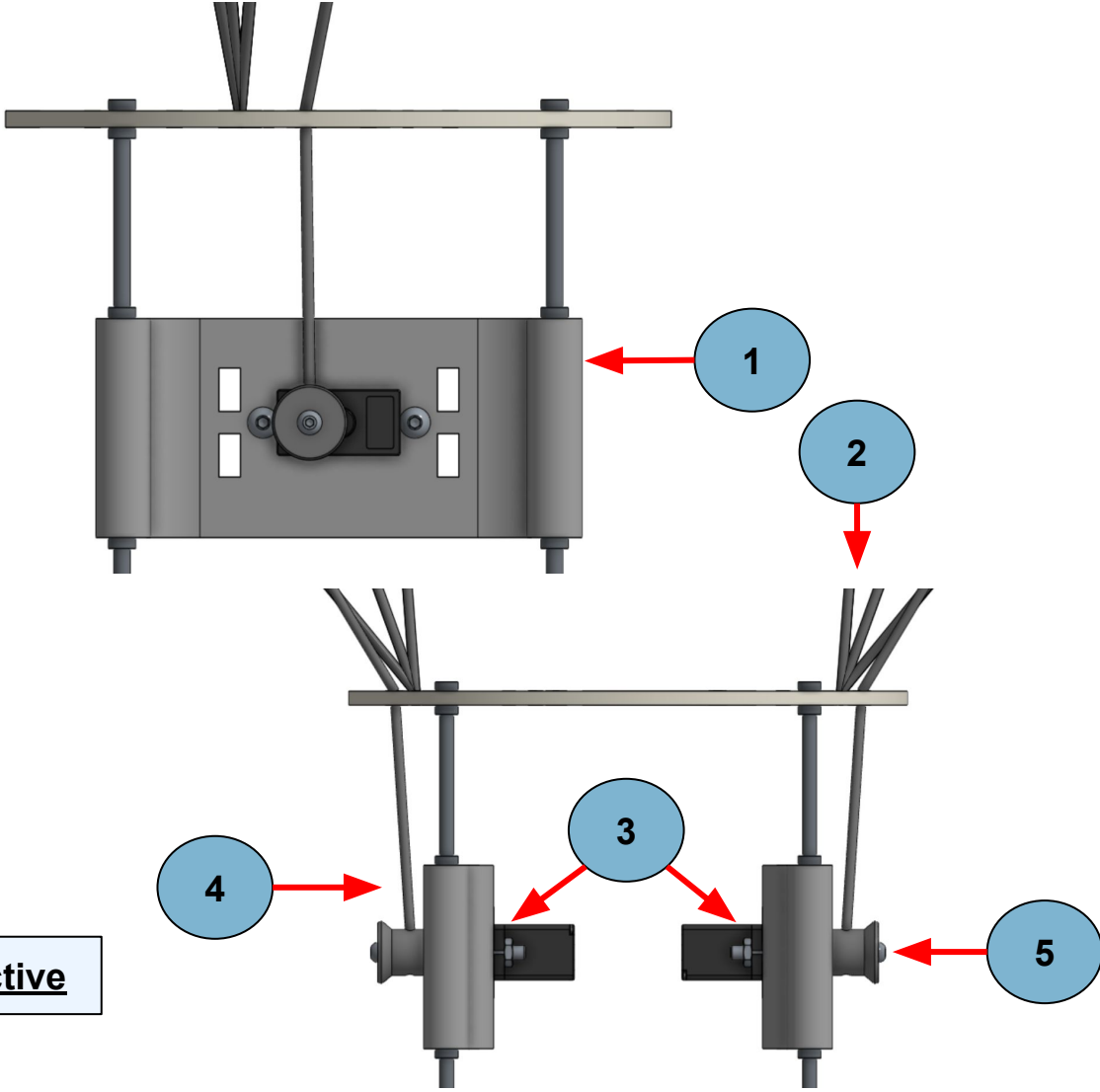


## Design 1

#	Description
1	3D Printed PETG Servo Mounts
2	Fishing Line Stability Lines
3	Servos
4	Fishing Line Brake Lines
5	3D Printed PETG Turning Spool

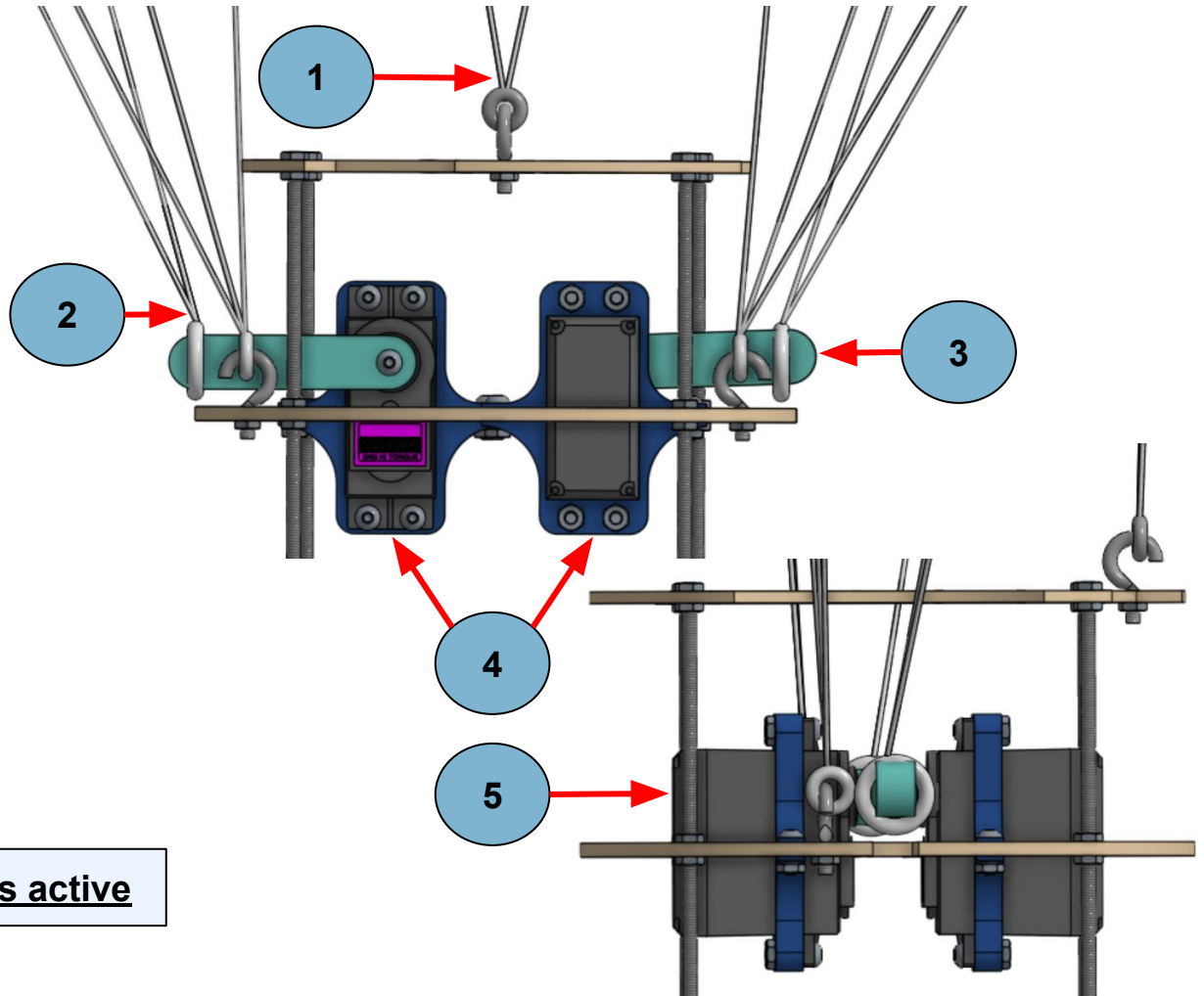
**NOTE:** Not all parts shown

**NOTE:** Descent speed control is active



## Design 2

#	Description
1	Kevlar Stability Lines
2	Kevlar Brake Lines
3	3D Printed PLA Turning Arm
4	3D Printed PLA Servo Mounts
5	Servos



**NOTE:** Not all parts shown

**NOTE:** Descent speed control is active



# Para-Glider Descent Speed Control Strategy Selection and Trade (3 of 6)



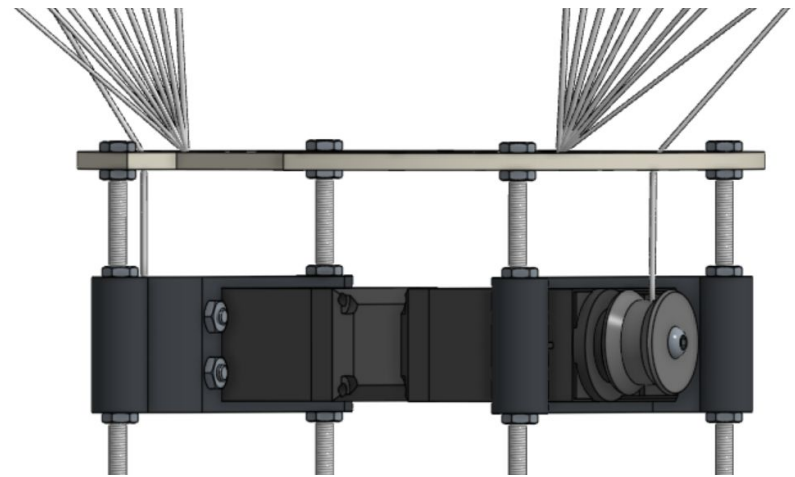
Name	Maximum Brake Line Displacement (mm)	Mass (g)	Heat Deflection Temperature (°C)	Bending Strength (MPa)
Design 1	350	32	69	64
Design 2	100	52	57	76

## Final Selection

### Design 1: Turning Spools

#### Reasoning:

- Larger range of motion allows for sharper turns
- Less mass while still maintaining performance capabilities



**NOTE:** Not all parts shown



# Para-Glider Descent Speed Control Strategy Selection and Trade (4 of 6)



## Unweighted Figures of Merit

Factor	1	2	4	8
Maximum Brake Line Displacement (mm)	<100	100-200	201-300	>300
Mass (g)	> 50	40 - 49.9	30 - 39.9	< 30
Heat Deflection Temperature (°C)	< 55	55 - 59.9	60 - 64.9	> 65
Bending Strength (MPa)	< 65	65 - 69.9	70 - 74.9	> 75

### NOTE:

- “Heat Deflection Temperature” and “Bending Strength” refer to material qualities of the servo attachments



# Para-Glider Descent Speed Control Strategy Selection and Trade (5 of 6)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Maximum Brake Line Displacement	8	8	64	2	16
Mass	4	4	16	1	4
Heat Deflection Temperature	1	8	8	2	2
Bending Strength	2	1	2	8	16
<b>Weighted Total</b>		<b>90</b>		<b>38</b>	



# Para-Glider Descent Speed Control Strategy Selection and Trade (6 of 6)

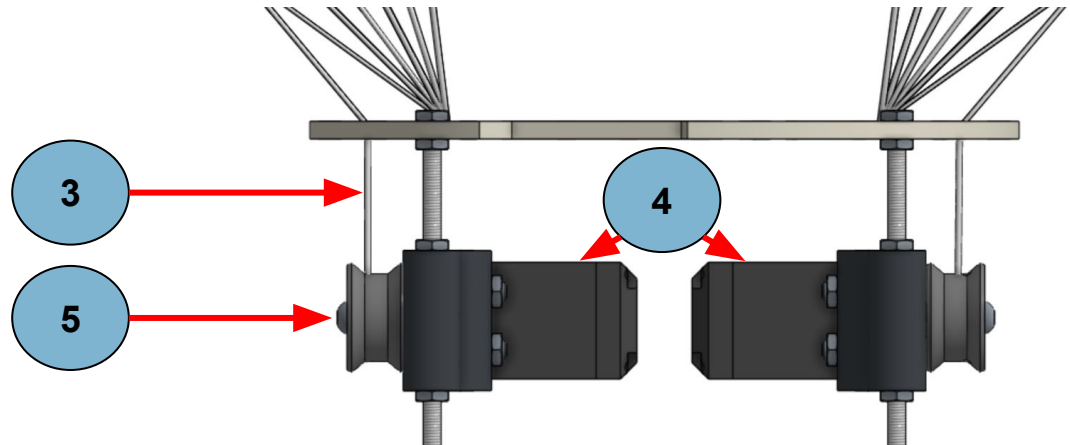
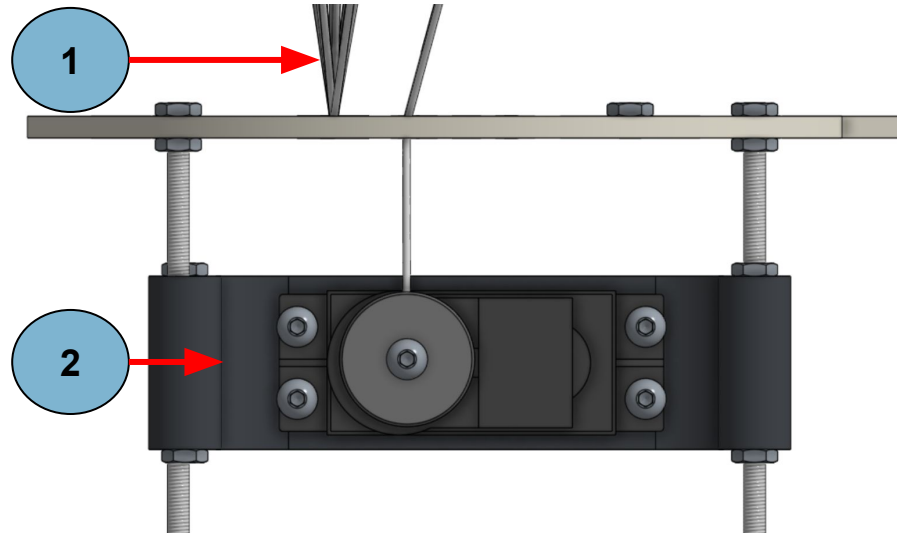


## Final Design

#	Description
1	Kevlar Stability Lines
2	3D Printed PETG Servo Mounts
3	Kevlar Brake Lines
4	LS-955CR Servos
5	3D Printed PETG Turning Spool

**NOTE:** Not all parts shown

**NOTE:** Descent speed control is active





# Descent Rate Estimates (1 of 4)



## Parachute Descent

### Formula

$$V_c = \sqrt{\frac{2W}{\rho S C_d}}$$

**Estimated Descent  
Rate:  
13.69 m/s**

Variable	Value
<b>W:</b> Weight (N)	10.73
<b><math>\rho</math>:</b> Air Density (kg/m <sup>3</sup> )	1.129
<b>S:</b> Planform Area (m <sup>2</sup> )	0.0867
<b>Cd:</b> Drag Coefficient	1.17



# Descent Rate Estimates (2 of 4)



## Paraglider Descent

### Formula

$$v_y = \sin(\alpha) \sqrt{\frac{2W}{S\rho(c_D \sin(\alpha) + c_L \cos(\alpha))}}$$

**Estimated Descent  
Rate:  
3.29 m/s**

Variable	Value
$\alpha$ : Angle of Attack (°)	7.61
<b>W</b> : Weight (N)	8.60
<b>S</b> : Wing Planform Area (m <sup>2</sup> )	0.3438
$\rho$ : Air Density (kg/m <sup>3</sup> )	1.129
$c_L$ : Lift Coefficient	0.0710
$c_D$ : Drag Coefficient	0.0095



# Descent Rate Estimates (3 of 4)



## Nose Cone Descent

### Formula

$$v_n = \sqrt{|v_0^2 - 2gx|}$$

**Estimated Descent  
Rate:  
4.89 m/s**

Variable	Value
<b>v<sub>0</sub></b> : Initial Velocity (Paraglider Descent Rate) (m/s)	3.29
<b>g</b> : Acceleration Due to Gravity (m/s <sup>2</sup> )	9.81
<b>x</b> : Distance to Ground (m)	2



# Descent Rate Estimates (4 of 4)

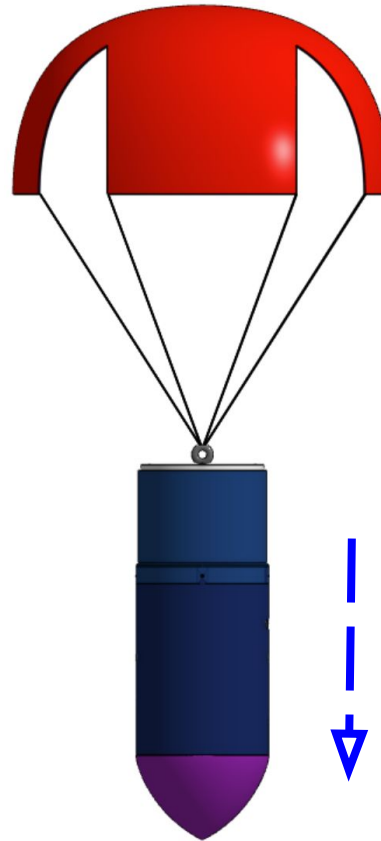


## Descent Overview

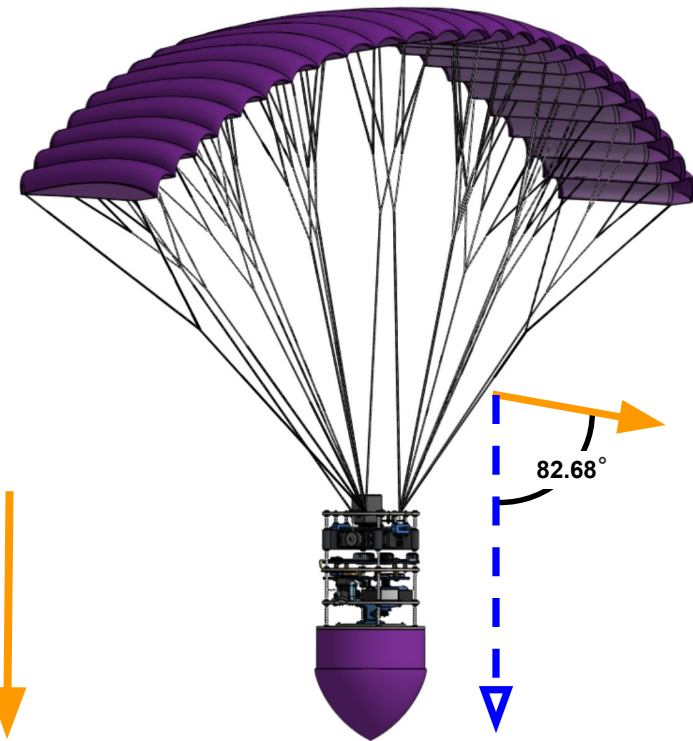
Estimated Parachute Descent Velocity	13.69 m/s
Estimated Paraglider Descent Velocity	3.29 m/s
Estimated Nose Cone Descent Velocity	4.89 m/s

Nadir Direction	
Direction of Travel	

## Parachute Descent



## Paraglider Descent

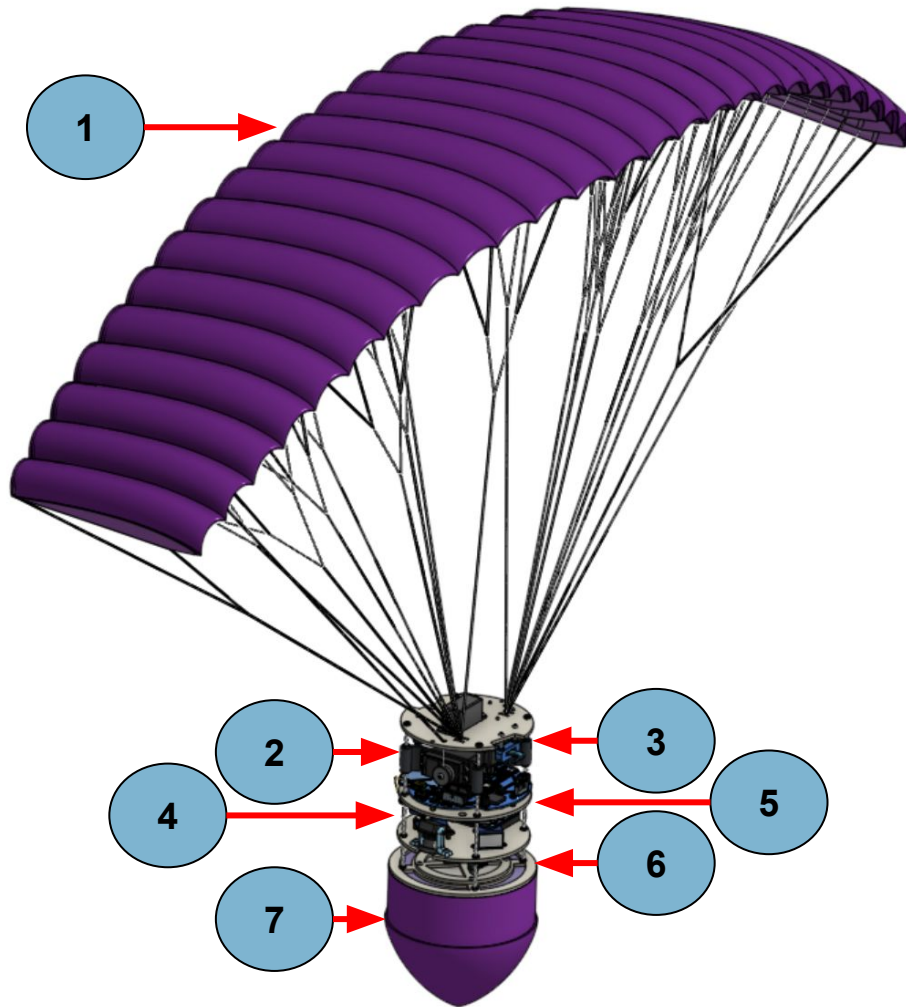




---

# Mechanical Subsystem Design

**Eshton Moyer, Rebekah Langford, Julien  
Bynum**

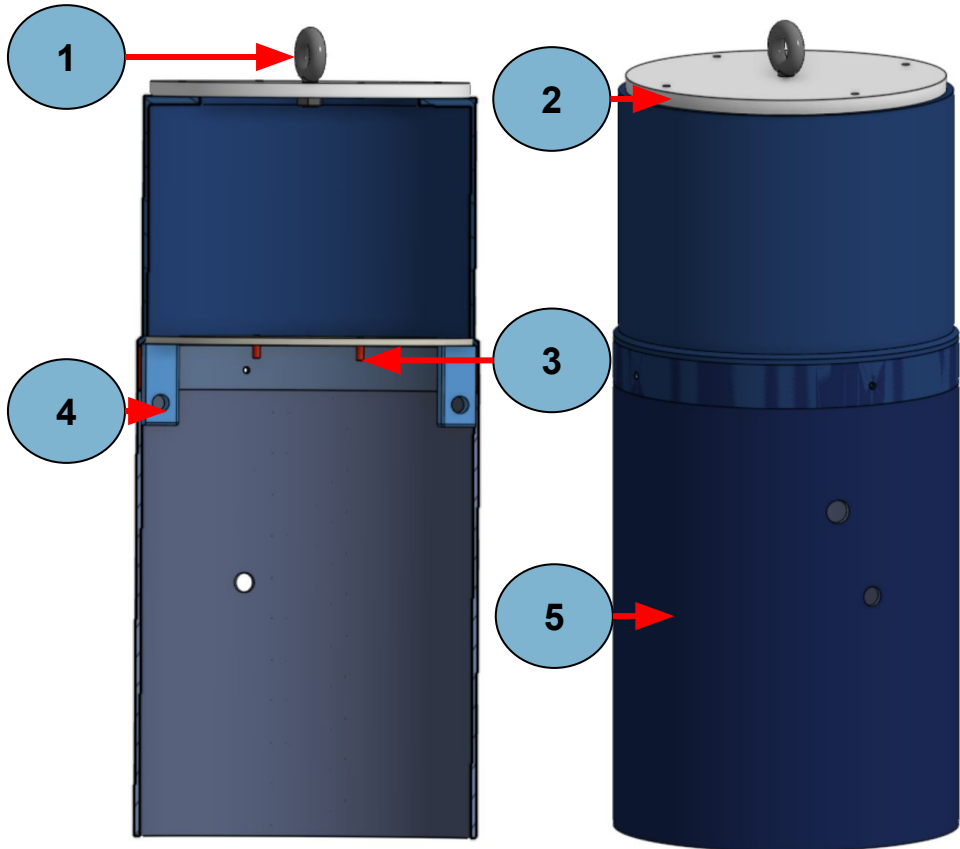


## Final Design Overview

#	Part	Description
1	Paraglider	NACA 4412 Silnylon Paraglider, Kevlar Stability & Brake Lines
2	Descent Control Mechanism	3D Printed PETG Steering Servo Mount & Turning Spool
3	Container Release Mechanism	Forged Carbon Fiber Arm & Supports
4	Body Structure	Fiberglass Composite Plywood Plates & M3 Zinc Plated Steel Threaded Rods
5	Electrical Components	Cameras, Buzzer, PCB, Batteries, Radio, GPS, etc.
6	Instrument Release Mechanism	3D Printed PETG Payload & Nose Attachment Points, Carbon Fiber Pin
7	Nose Cone	Fiberglass Composite Layup Ogive Nose Cone



# Mechanical Subsystem Overview (2 of 2)

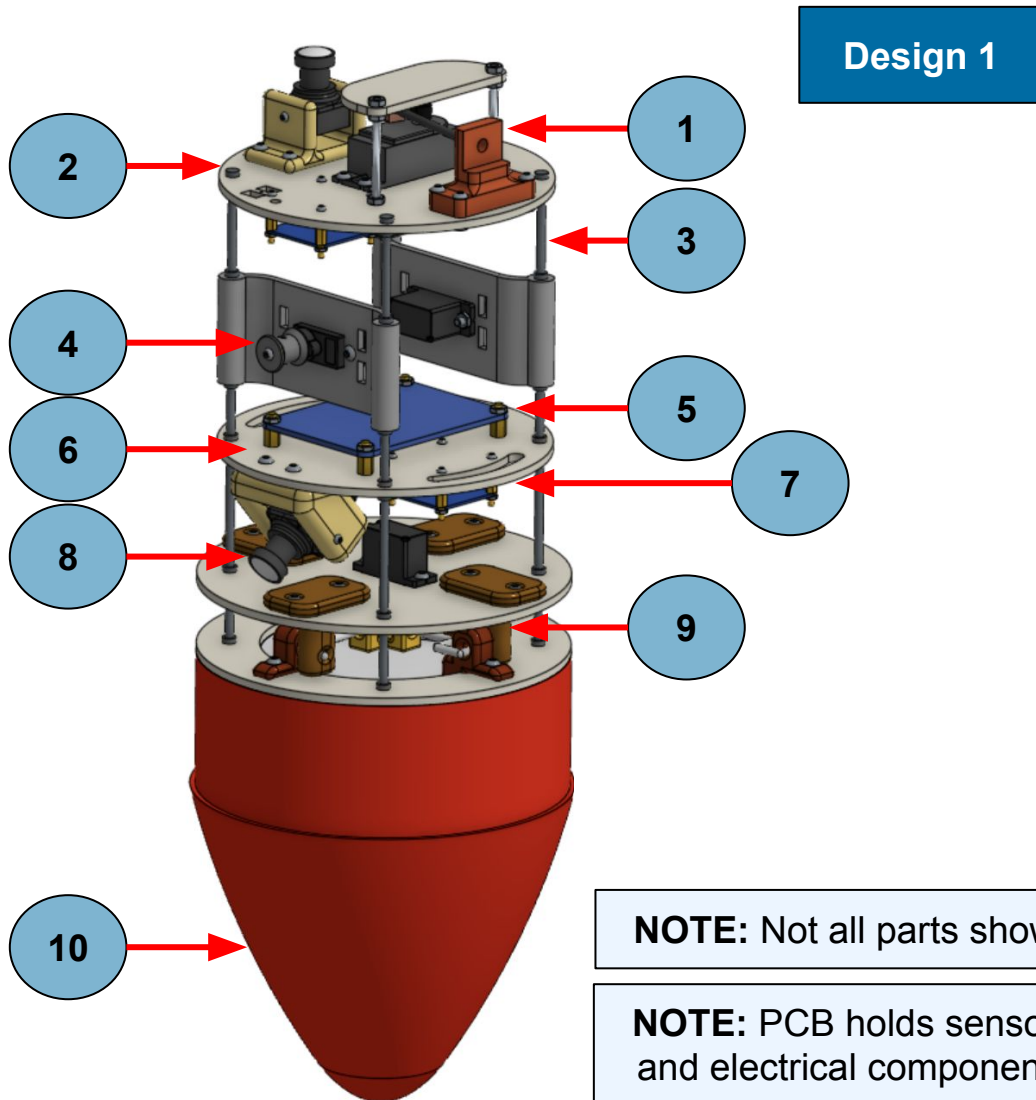


## Final Design Overview

#	Part	Description
1	Parachute Attachment Point	¼ Inch Eye Bolt
2	Container Plate	6mm Fiberglass Composite Plywood Plate
3	Rotation Prevention Rod	Carbon Fiber Rods
4	Container Integration Pieces	Forged Carbon Fiber Components Epoxied to Container Wall
5	Container	Fiberglass Composite Layup Walls



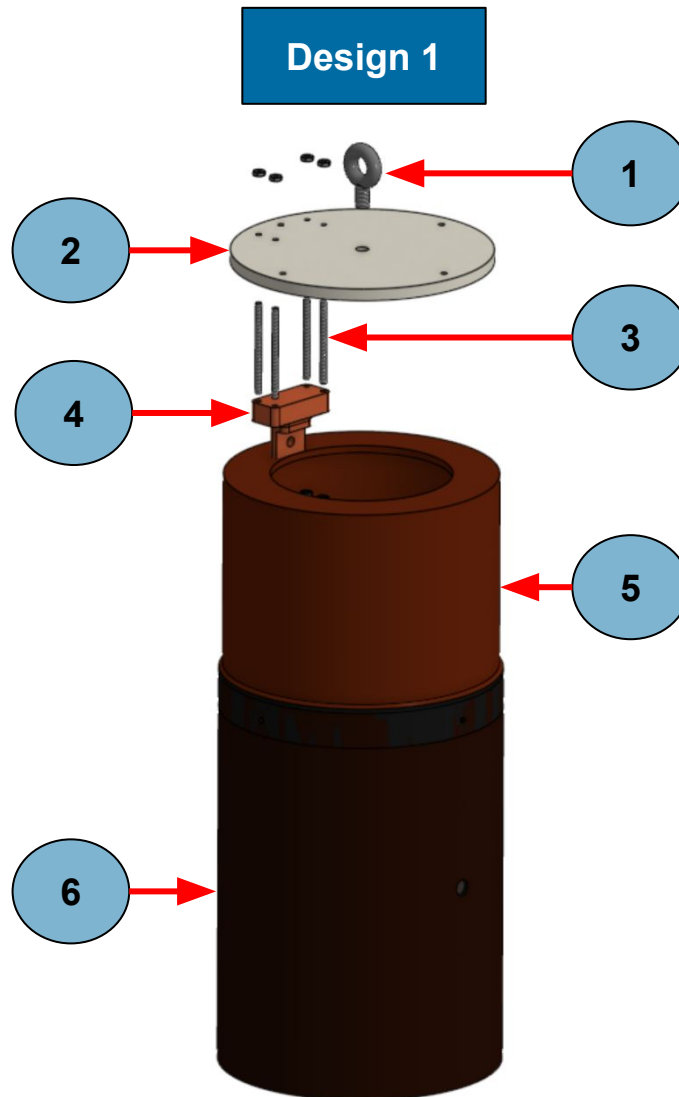
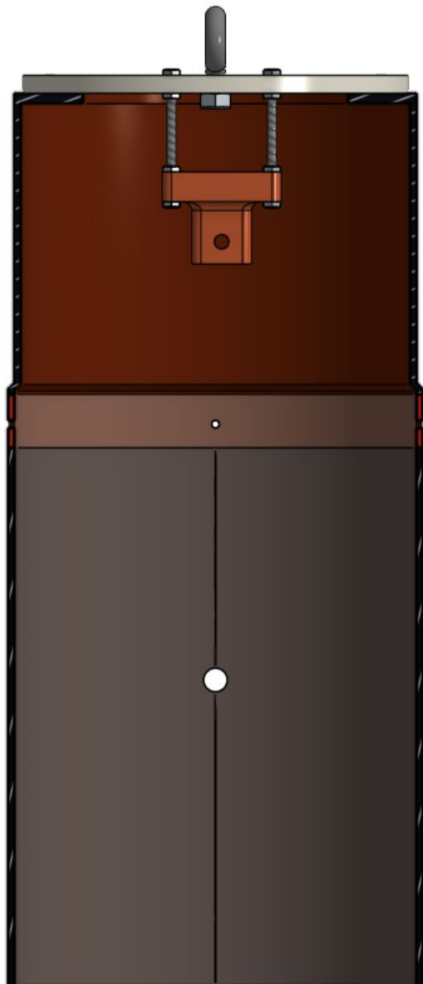
# CanSat Mechanical Layout of Components Trade & Selection (1 of 13)



#	Part
1	Payload Release Mechanism
2	Top Camera and PCB
3	6061-T6 Aluminum Structural Rods
4	Steering Mechanism
5	PCB
6	3D Printed PETG Plates
7	Batteries
8	Bottom Camera and PCB
9	Instrument Release Mechanism
10	Nose Cone



# CanSat Mechanical Layout of Components Trade & Selection (2 of 13)



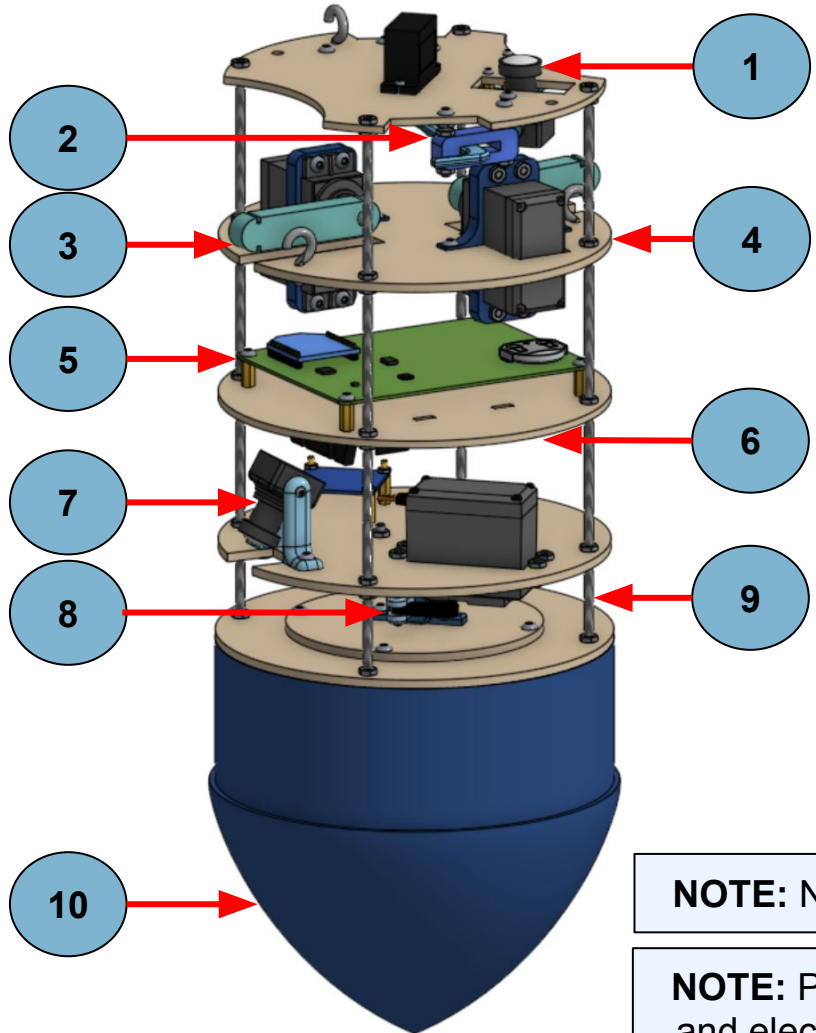
#	Part
1	1/4 Inch Eye Bolt
2	6mm Plywood Plate
3	M3 Aluminum Threaded Rods
4	Release Pin Holder
5	Container Shoulder
6	3D Printed PETG Container



# CanSat Mechanical Layout of Components Trade & Selection (3 of 13)



**Design 2**



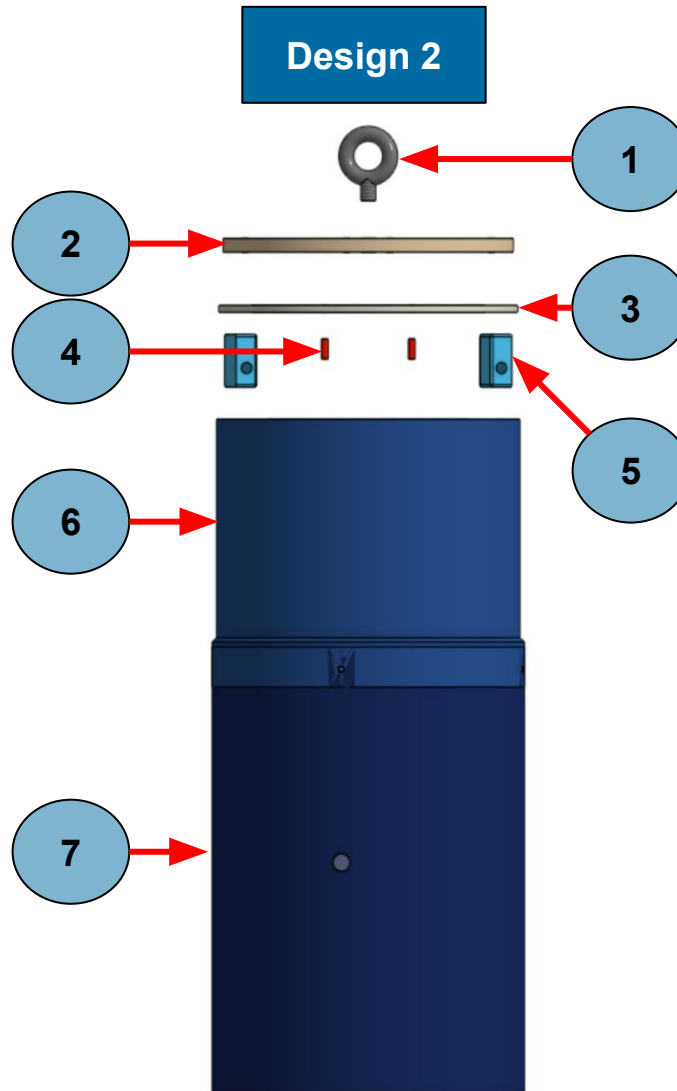
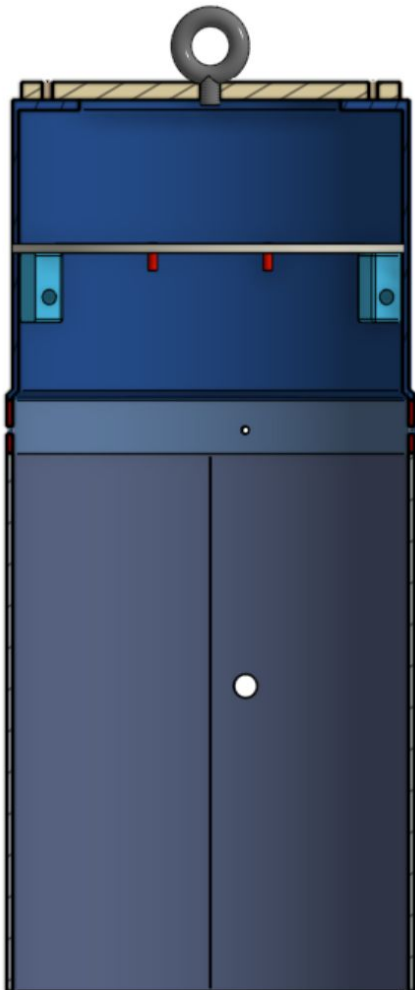
**NOTE:** Not all parts shown

**NOTE:** PCB holds sensors and electrical components

#	Part
1	Top Camera & PCB
2	Payload Release Mechanism
3	Steering Mechanism
4	Fiberglass Composite Plywood Plates
5	PCB
6	Batteries
7	Bottom Camera & PCB
8	Instrument Release Mechanism
9	Zinc Plated Steel Structural Rods
10	Nose Cone



# CanSat Mechanical Layout of Components Trade & Selection (4 of 13)



#	Part
1	¼ Inch Eye Bolt
2	6mm Plywood Plate
3	Fiberglass Composite Plywood Plate
4	Rotation Prevention Rods
5	Container Integration Piece
6	Container Shoulder
7	Fiberglass Composite Layup Container



# CanSat Mechanical Layout of Components Trade & Selection (5 of 13)



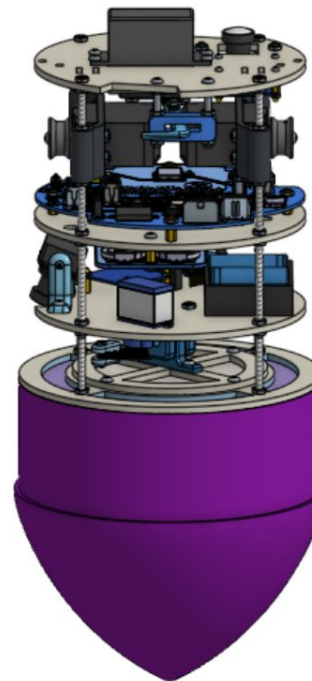
Name	Space Utilization (%)	Center of Gravity (cm)	Structural Mass (g)	Stability (Calibers)
Design 1	10	22	196.2	1.68
Design 2	15	12	185.4	1.49

## Final Selection

### Design 1: Four Base Plates

#### Reasoning:

- Higher stability for rocket integration
- Open layout for positioning of components





# CanSat Mechanical Layout of Components Trade & Selection (6 of 13)



## Unweighted Figures of Merit

Factor	1	2	4	8
Space Utilization (%)	< 15	15 - 24	25 - 40	> 40
Center of Gravity (cm)	> 30	20 - 30	10 - 19	< 10
Structural Mass (g)	> 200	190 - 200	180 - 189	< 180
Stability (Calibers)	< 1.4	1.4 - 1.5	1.51 - 1.6	> 1.6

### NOTE:

- “Space Utilization” refers to the percent volume of the container that is occupied by the payload
- “Center of Gravity” refers to the distance in mm that the center of gravity of the payload is from the tip of the nose cone
- “Stability” refers to the static margin of the rocket while the payload is inserted



# CanSat Mechanical Layout of Components Trade & Selection (7 of 13)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Space Utilization	2	1	2	2	4
Center of Gravity	1	2	2	4	4
Structural Mass	4	2	8	4	16
Stability	8	8	64	2	16
<b>Weighted Total</b>		<b>76</b>		<b>40</b>	



# CanSat Mechanical Layout of Components Trade & Selection (8 of 13)



Material	Tensile Strength (MPa)	Density (g/cm <sup>3</sup> )	Cost per kg (\$)
6061-T6 Aluminum	310	2.70	3.00
<b>Zinc Plated Steel</b>	<b>650</b>	<b>7.85</b>	<b>1.20</b>

Final Selection
<b>Zinc Plated Steel</b>
<b><u>Reasoning:</u></b> <ul style="list-style-type: none"><li>• Higher tensile strength</li><li>• Lower cost</li></ul>



Source: Platt



# CanSat Mechanical Layout of Components Trade & Selection (9 of 13)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tensile Strength (MPa)	< 200	201 - 400	401 - 700	> 700
Density (g/cm <sup>3</sup> )	> 10.0	8.0 - 9.9	4.0 - 7.9	< 4.0
Cost per kg (\$)	> 5.00	4.01 - 5.00	3.00 - 4.00	< 3.00



# CanSat Mechanical Layout of Components Trade & Selection (10 of 13)



Factor	Weight	6061-T6 Aluminum		Zinc Plated Steel	
		Unweighted	Weighted	Unweighted	Weighted
Tensile Strength	8	2	16	4	32
Density	4	8	32	4	16
Cost per kg	2	2	4	8	16
<b>Weighted Total</b>		<b>52</b>		<b>64</b>	



# CanSat Mechanical Layout of Components Trade & Selection (11 of 13)



Material	Tensile Strength (MPa)	Density (g/cm <sup>3</sup> )	Elastic Modulus (GPa)
3D Printed PETG	45	1.28	1.9
<b>Fiberglass Composite Plywood</b>	<b>100</b>	<b>1.6</b>	<b>11.5</b>

Final Selection
<b>Fiberglass Composite Plywood</b>
<p><b><u>Reasoning:</u></b></p> <ul style="list-style-type: none"><li>• Higher tensile strength</li><li>• Higher elastic modulus means a more rigid design</li></ul>



Source: CFRT



# CanSat Mechanical Layout of Components Trade & Selection (12 of 13)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tensile Strength (MPa)	< 30	31 - 60	61 - 100	> 100
Density (g/cm <sup>3</sup> )	> 2	1.5 - 2	1.0 - 1.49	< 1.0
Elastic Modulus (GPa)	< 1	1 - 6	6.1 - 10	> 10



# CanSat Mechanical Layout of Components Trade & Selection (13 of 13)



Factor	Weight	3D Printed PETG		Fiberglass Composite Plywood	
		Unweighted	Weighted	Unweighted	Weighted
Tensile Strength	2	2	4	4	8
Density	8	4	32	2	16
Elastic Modulus	4	2	8	8	32
<b>Weighted Total</b>		<b>44</b>		<b>56</b>	

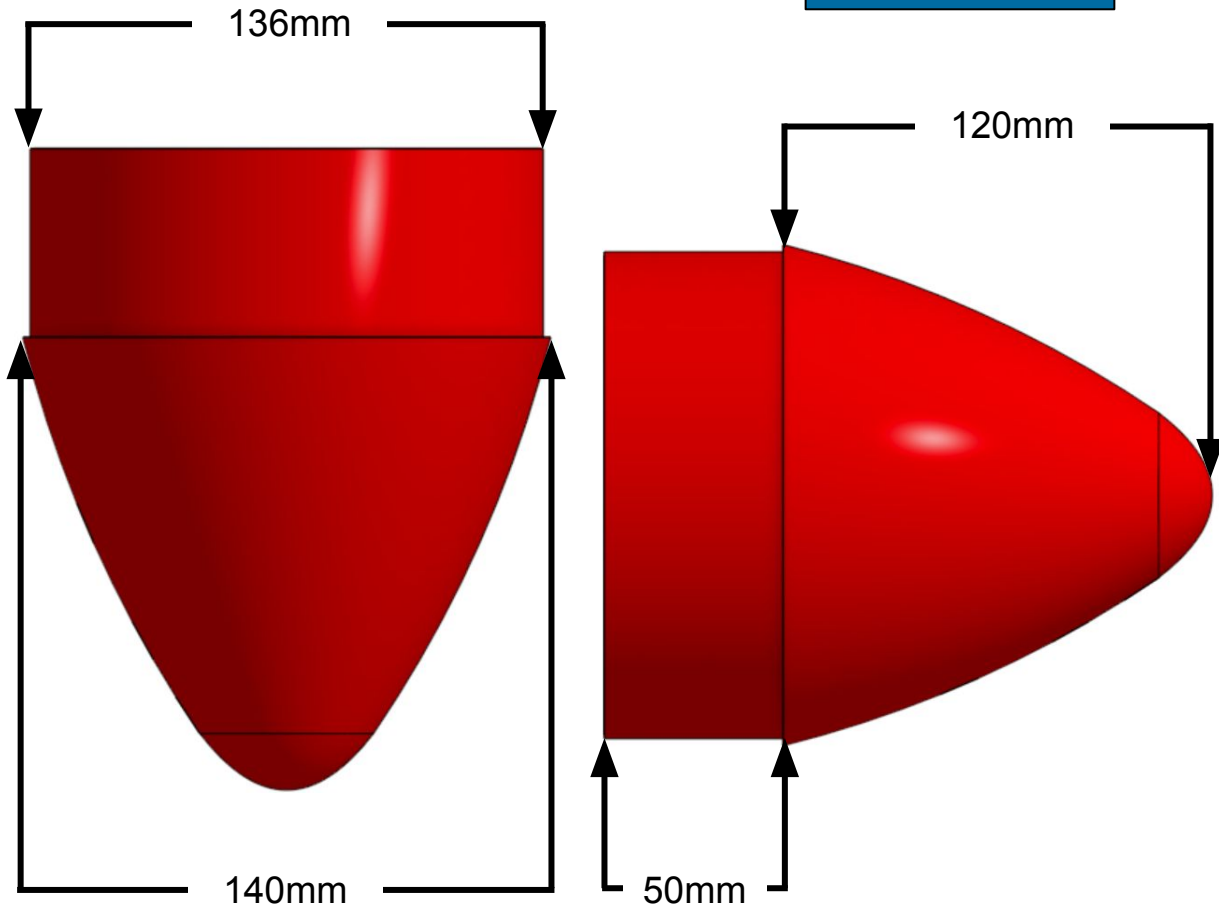


# Nose Cone Design Trade & Selection (1 of 8)



**Design 1**

**NOTE:** Nose cone material is fiberglass composite layup and the shape is power series with a shape parameter of 0.5



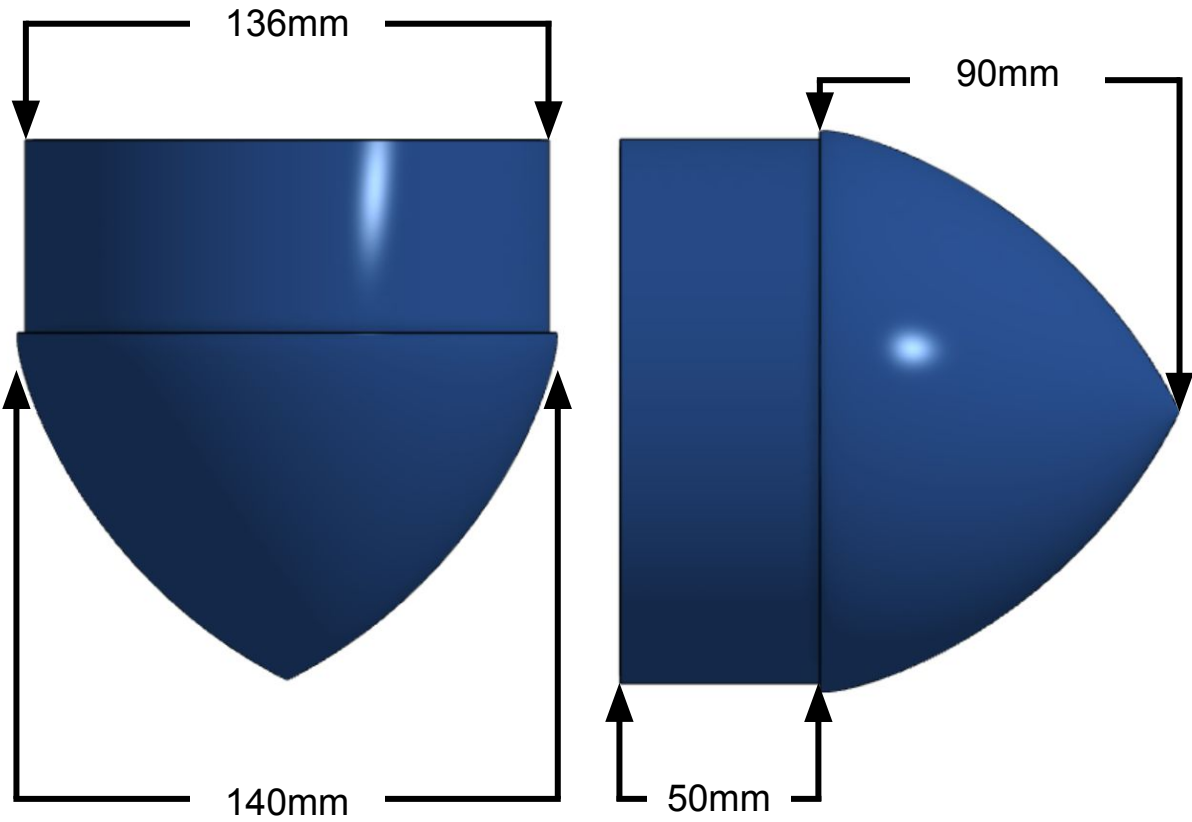
Dimension	Description
50mm	Nose Cone Shoulder Length
120mm	Nose Cone Length
136mm	Nose Cone Shoulder Exterior Diameter
140mm	Nose Cone Exterior Diameter



# Nose Cone Design Trade & Selection (2 of 8)



**Design 2**



**NOTE:** Nose cone material is 3D printed PETG and the shape is ogive

Dimension	Description
50mm	Nose Cone Shoulder Length
90mm	Nose Cone Length
136mm	Nose Cone Shoulder Exterior Diameter
140mm	Nose Cone Exterior Diameter



# Nose Cone Design Trade & Selection (3 of 8)



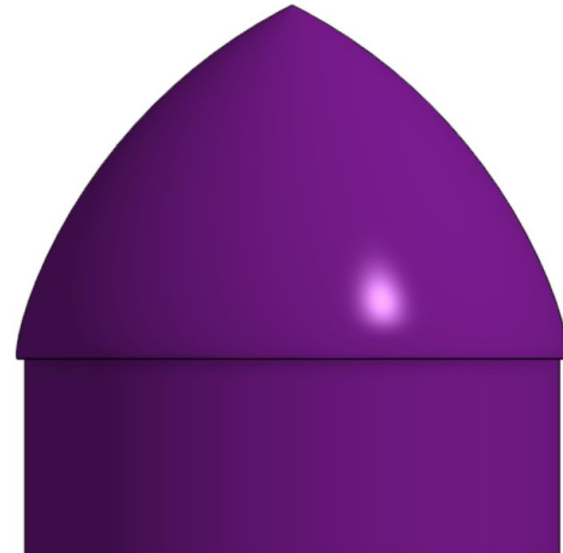
Name	Mass (g)	Cost (\$)	Drag Coefficient	Rocket Stability (Calibers)
Design 1	90	7.05	0.014	1.08
Design 2	122	1.6	0.017	1.26

## Final Selection

**Combination: Fiberglass Ogive Nose Cone**

### Reasoning:

- Lower mass and higher strength
- Low cost of materials





# Nose Cone Design Trade & Selection (4 of 8)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 150	125 - 150	100 - 124	< 100
Cost (\$)	> 3	2.01 - 3	1 - 2	< 1
Drag Coefficient	> 0.02	0.016 - 0.02	0.01 - 0.015	< 0.01
Rocket Stability (Calibers)	< 1	1 - 1.2	1.21 - 1.4	> 1.4



# Nose Cone Design Trade & Selection (5 of 8)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	8	64	4	32
Cost	4	1	4	4	16
Drag Coefficient	2	4	8	2	4
Rocket Stability	1	2	2	4	4
<b>Weighted Total</b>		<b>78</b>		<b>56</b>	



# Nose Cone Design Trade & Selection (6 of 8)



Material	Tensile Strength (MPa)	Density (g/cm <sup>3</sup> )	Elastic Modulus (GPa)
3D Printed PETG	45	1.28	1.9
<b>Fiberglass Composite</b>	<b>200</b>	<b>1.9</b>	<b>25</b>

Final Selection
<b>Fiberglass Composite</b>
<p><b>Reasoning:</b></p> <ul style="list-style-type: none"><li>• Higher elastic modulus making it more rigid</li><li>• Higher tensile strength</li></ul>



Source: SMI Composites



# Nose Cone Design Trade & Selection (7 of 8)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tensile Strength (MPa)	< 30	31 - 60	61 - 100	> 100
Density (g/cm <sup>3</sup> )	> 2	1.5 - 2	1.0 - 1.49	< 1.0
Elastic Modulus (GPa)	< 1	1 - 6	6.1 - 10	> 10



# Nose Cone Design Trade & Selection (8 of 8)



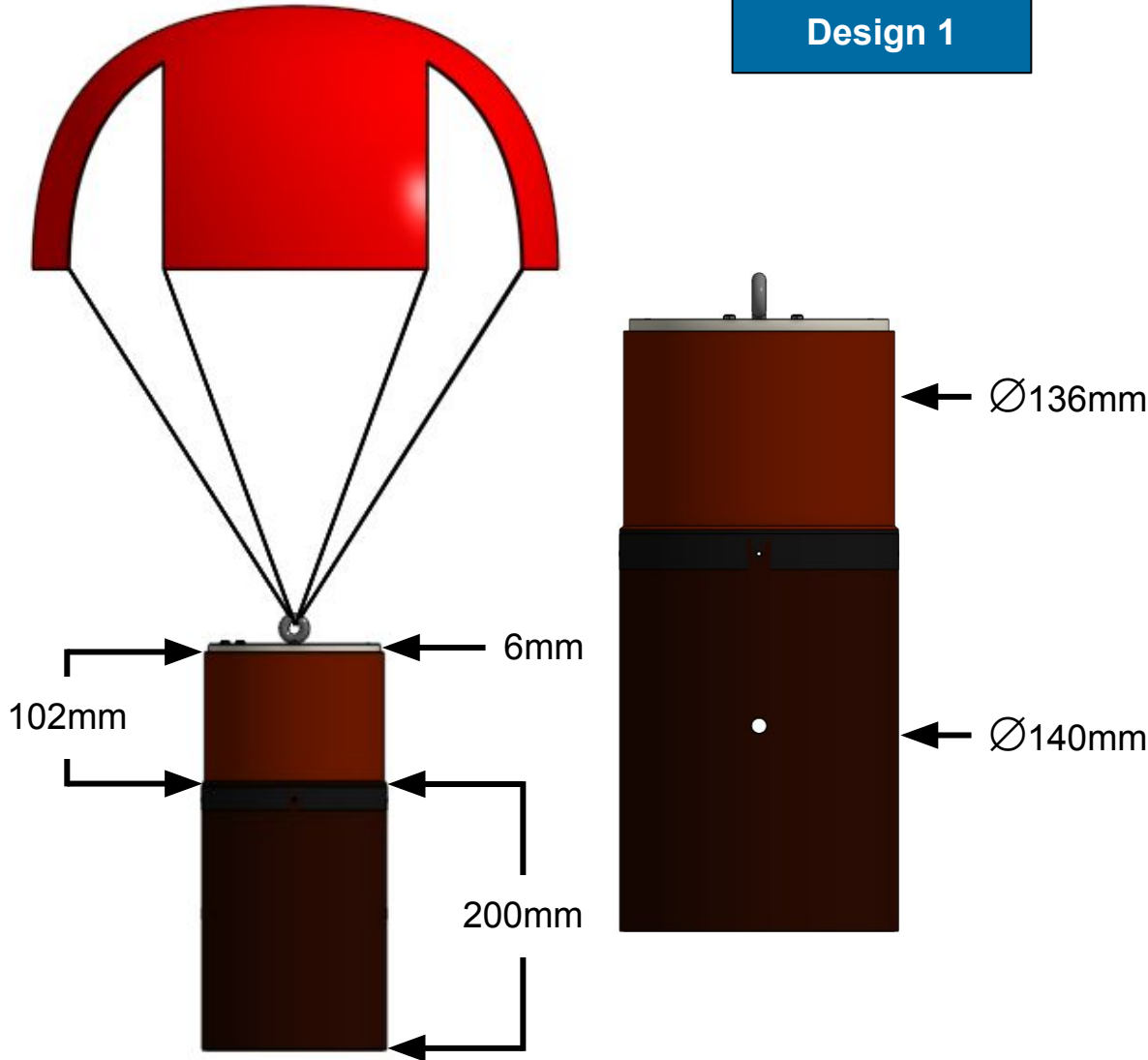
Factor	Weight	3D Printed PETG		Fiberglass Composite	
		Unweighted	Weighted	Unweighted	Weighted
Tensile Strength	4	2	8	8	32
Density	8	4	32	2	16
Elastic Modulus	2	2	4	8	16
<b>Weighted Total</b>		<b>44</b>		<b>64</b>	



# Container Design and Configuration Trade & Selection (1 of 10)



Design 1



**NOTE:** Container material is 3D printed PETG

Dimension	Description
102mm	Container Shoulder Length
6mm	Plywood Plate Thickness
200mm	Container Length
136mm	Container Shoulder Diameter
140mm	Container Diameter

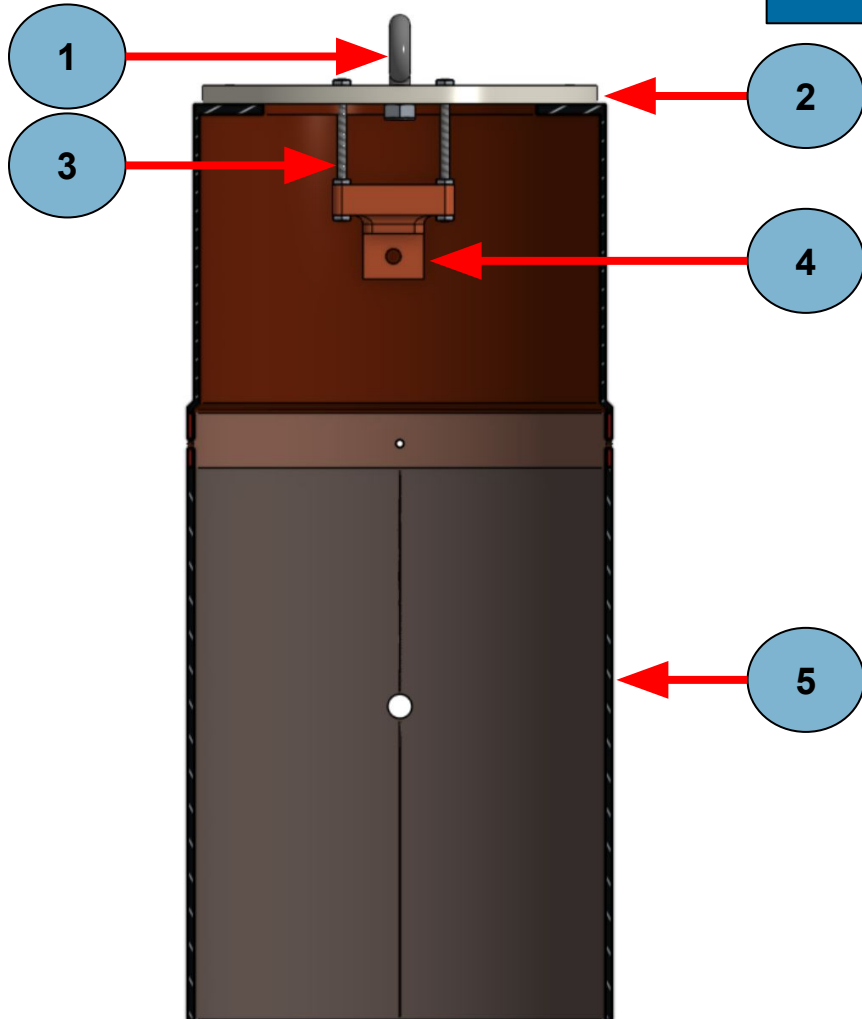
**NOTE:** Container Wall Thickness is 2mm



# Container Design and Configuration Trade & Selection (2 of 10)



Design 1



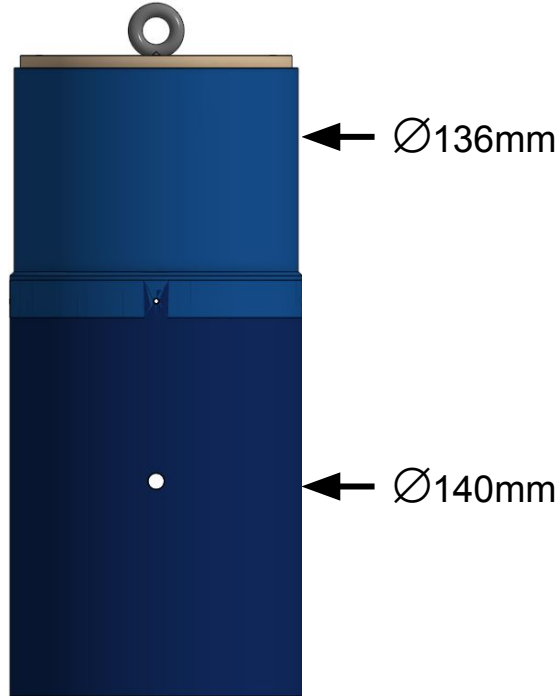
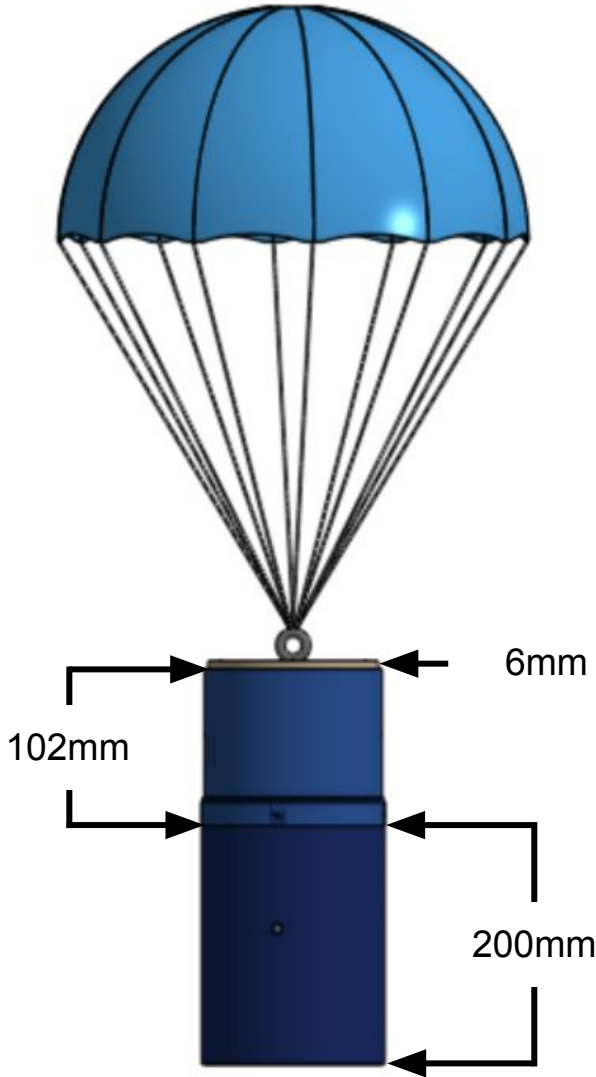
#	Description
1	1/4 Inch Eye Bolt
2	6mm Plywood Plate
3	Aluminum Threaded Rods
4	3D Printed PETG Pin Holder
5	3D Printed PETG Container



# Container Design and Configuration Trade & Selection (3 of 10)



## Design 2

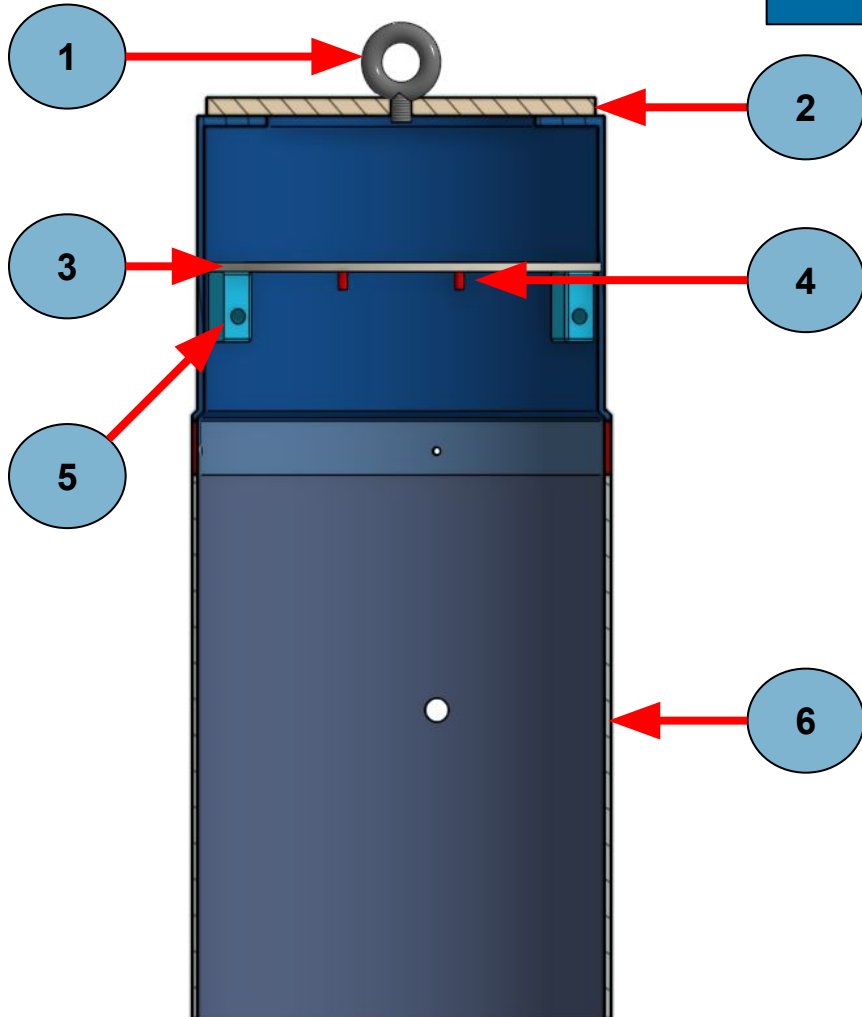


**NOTE:** Container material is fiberglass composite layup

Dimension	Description
102mm	Container Shoulder Length
6mm	Plywood Plate Thickness
200mm	Container Length
136mm	Container Shoulder Diameter
140mm	Container Diameter

**NOTE:** Container Wall Thickness is 2mm

Design 2



#	Description
1	¼ Inch Eye Bolt
2	6mm Plywood Plate
3	Fiberglass Composite Plywood Plate
4	Rotation Prevention Rods
5	Container Integration Piece
6	Fiberglass Composite Layup Container



# Container Design and Configuration Trade & Selection (5 of 10)



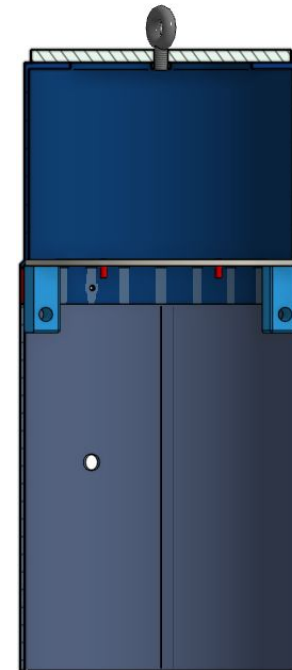
Name	Added Mass (g)	Vertical Clearance (mm)	Security	Obstructed Volume (cm <sup>3</sup> )
Design 1	32.2	72	1	61
<b>Design 2</b>	<b>8.9</b>	<b>53.6</b>	<b>2</b>	<b>7</b>

## Final Selection

### Design 2: Wall Mounted Supports

#### Reasoning:

- Lower added mass
- Increased security in stowed configuration
- Lower obstructed volume allowing for more paraglider storage space





# Container Design and Configuration Trade & Selection (6 of 10)



## Unweighted Figures of Merit

Factor	1	2	4	8
Added Mass (g)	> 40	25 - 40	10 - 24	< 10
Vertical Clearance (mm)	< 45	45 - 59	60 - 75	> 75
Security	1	2	3	4
Obstructed Volume (cm <sup>3</sup> )	> 50	30 - 50	10 - 29	< 10

### NOTE:

- “Vertical Clearance” refers to the distance from top of payload to top of container
- “Security” refers to the number of contact points between payload and container
- “Obstructed Volume” refers to the volume used by container obstructing paraglider



# Container Design and Configuration Trade & Selection (7 of 10)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Added Mass	8	2	16	8	64
Vertical Clearance	4	4	16	2	8
Security	2	1	2	2	4
Obstructed Volume	1	1	1	8	8
<b>Weighted Total</b>		<b>35</b>		<b>84</b>	



# Container Design and Configuration Trade & Selection (8 of 10)



Material	Tensile Strength (MPa)	Density (g/cm <sup>3</sup> )	Elastic Modulus (GPa)
3D Printed PETG	45	1.28	1.9
<b>Fiberglass Composite</b>	<b>200</b>	<b>1.9</b>	<b>25</b>

Final Selection
<b>Fiberglass Composite</b>
<p><b><u>Reasoning:</u></b></p> <ul style="list-style-type: none"><li>• Higher elastic modulus making it more rigid</li><li>• Higher tensile strength</li></ul>



Source: SMI Composites



# Container Design and Configuration Trade & Selection (9 of 10)



## Unweighted Figures of Merit

Factor	1	2	4	8
Tensile Strength (MPa)	< 30	31 - 60	61 - 100	> 100
Density (g/cm <sup>3</sup> )	> 2	1.5 - 2	1.0 - 1.49	< 1.0
Elastic Modulus (GPa)	< 1	1 - 6	6.1 - 10	> 10

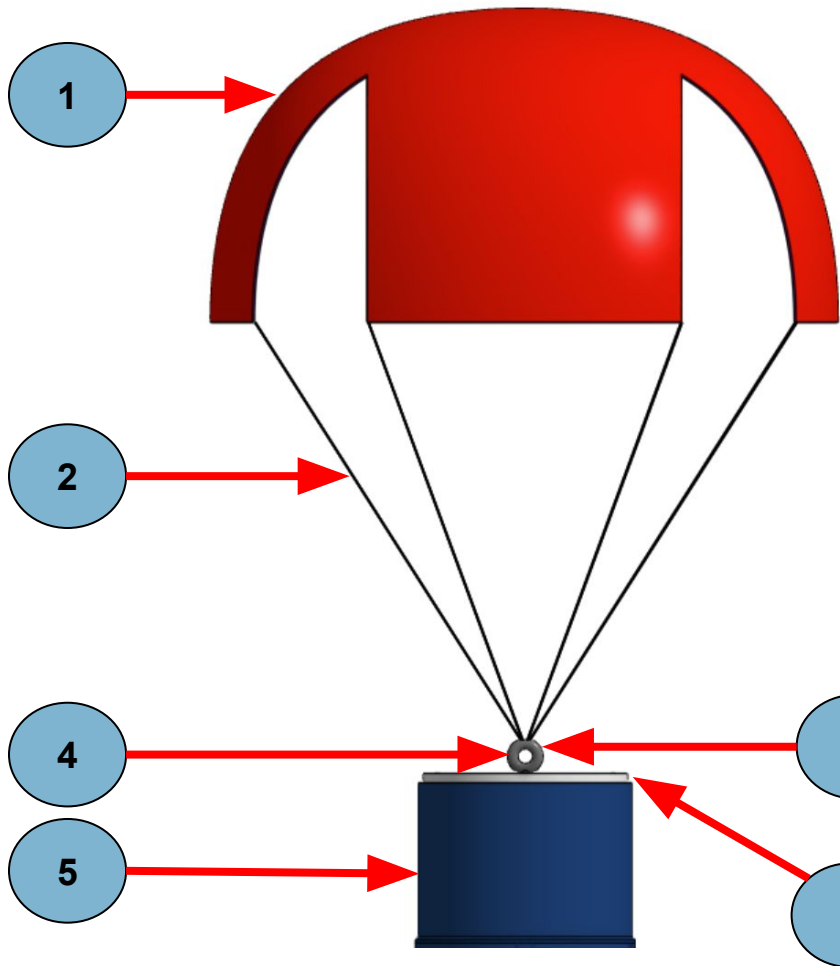


# Container Design and Configuration Trade & Selection (10 of 10)

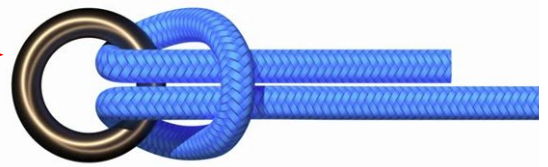


Factor	Weight	3D Printed PETG		Fiberglass Composite	
		Unweighted	Weighted	Unweighted	Weighted
Tensile Strength	4	2	8	8	32
Density	8	4	32	2	16
Elastic Modulus	2	2	4	8	16
<b>Weighted Total</b>		<b>44</b>		<b>64</b>	

## Final Design



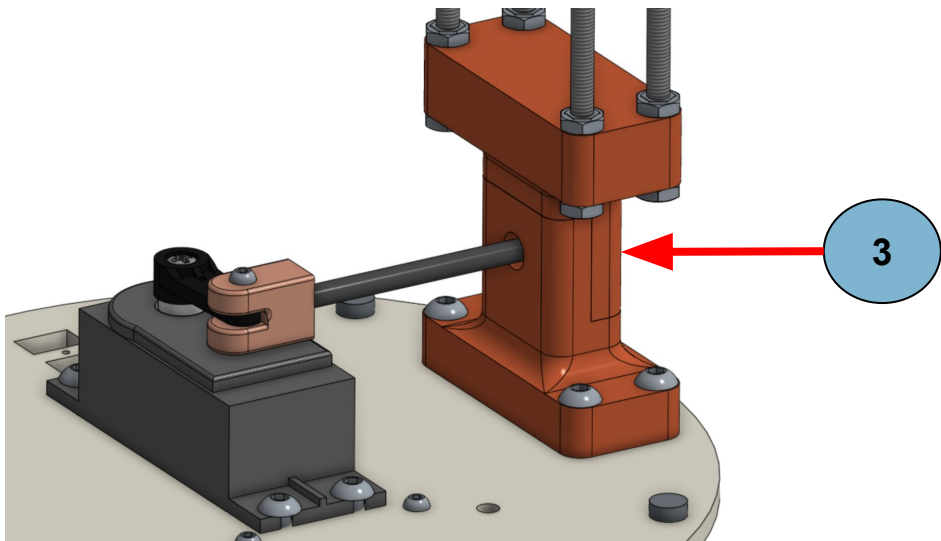
#	Part
1	Silnylon Cruciform Parachute
2	Kevlar Parachute Lines
3	Cow Hitch Knot
4	1/4 Inch Eye Bolt
5	Fiberglass Composite Layup Container
6	6mm Plywood Container Plate



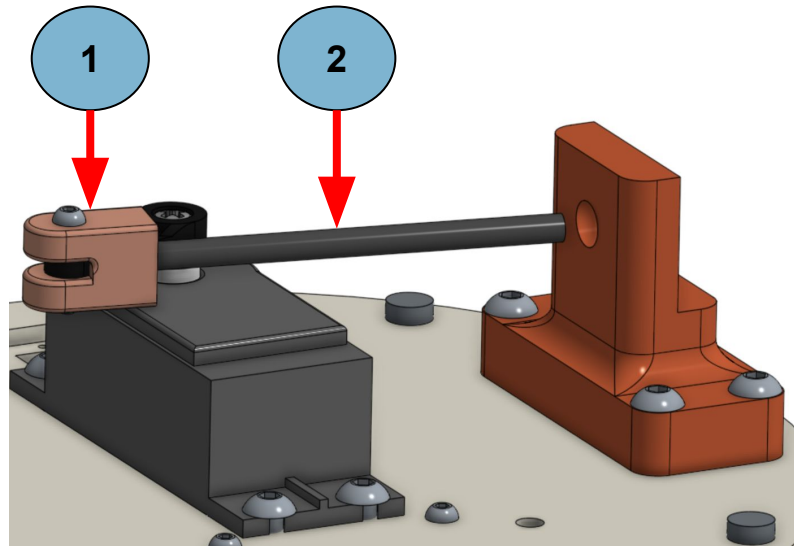
Source: Knots 3D

## Design 1

### Locked Configuration



### Released Configuration



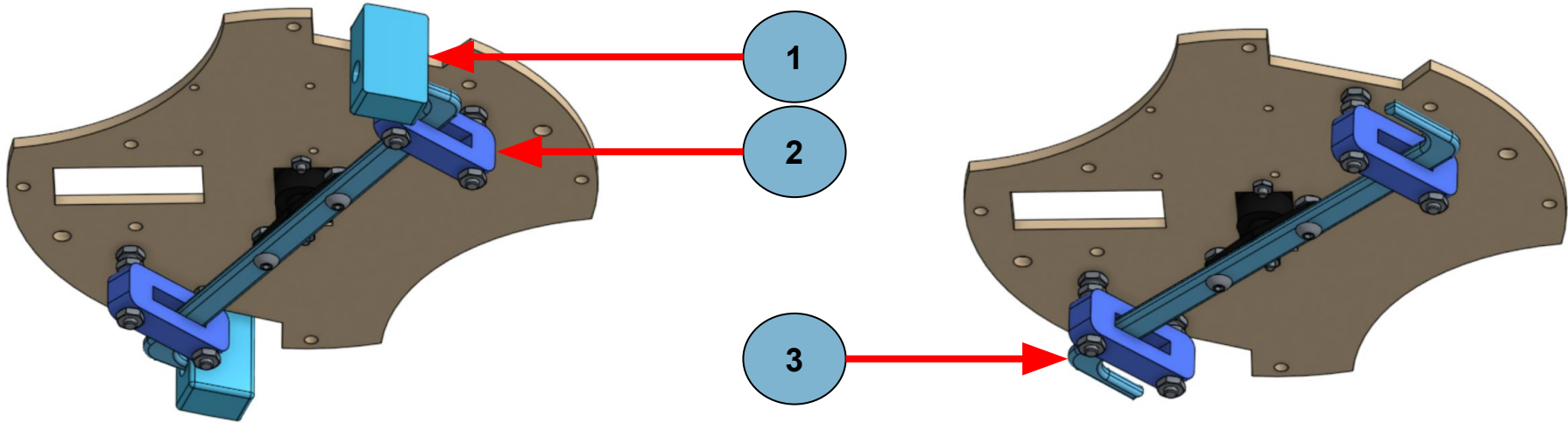
**NOTE:** Not all parts shown

#	Part
1	3D Printed PETG Carbon Fiber Rod Adapter
2	Carbon Fiber Release Mechanism Pin
3	3D Printed PETG Release Mechanism Container Attachment Point

## Design 2

### Locked Configuration

### Released Configuration



**NOTE:** Not all parts shown

#	Part
1	Forged Carbon Fiber Container Integration Piece
2	3D Printed PETG Release Mechanism Arm Support
3	Forged Carbon Fiber Release Mechanism Arm



# Payload Release Trade & Selection (3 of 5)



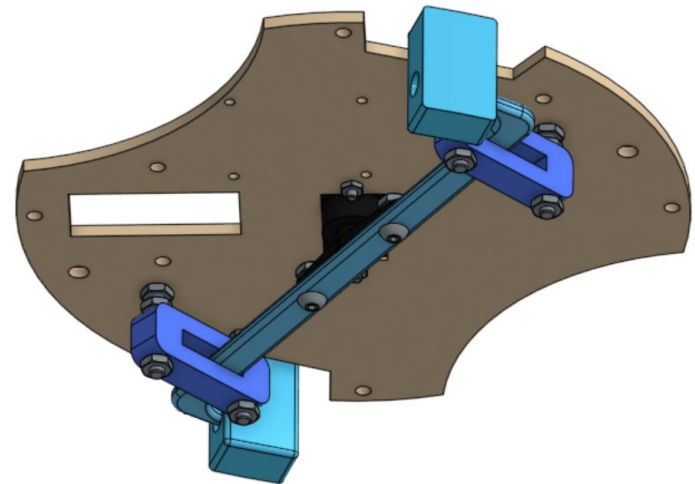
Name	Mass (g)	Tensile Strength of Arm Holder (MPa)	Tensile Strength of Arm (MPa)	Points of Contact
Design 1	77	35	1600	1
<b>Design 2</b>	<b>34</b>	<b>192</b>	<b>192</b>	<b>2</b>

## Final Selection

### Design 2: Double Sided Arm Release

#### Reasoning:

- Less massive design
- More payload security due to more contact points and centered design
- Stronger structural components



**NOTE:** Not all parts shown



# Payload Release Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 75	50 - 75	25 - 49	< 25
Tensile Strength of Arm Holder (MPa)	< 50	50 - 99	100 - 150	> 150
Tensile Strength of Arm (MPa)	< 500	500 - 999	1000 - 1500	> 1500
Points of Contact	1	2	3	≥ 4



# Payload Release Trade & Selection (5 of 5)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	1	8	4	32
Tensile Strength of Arm Holder	1	1	1	8	8
Tensile Strength of Arm	2	8	16	1	2
Points of Contact	4	1	4	2	8
<b>Weighted Total</b>		<b>29</b>		<b>50</b>	



# Para-Glider Stow Configuration Trade & Selection (1 of 5)



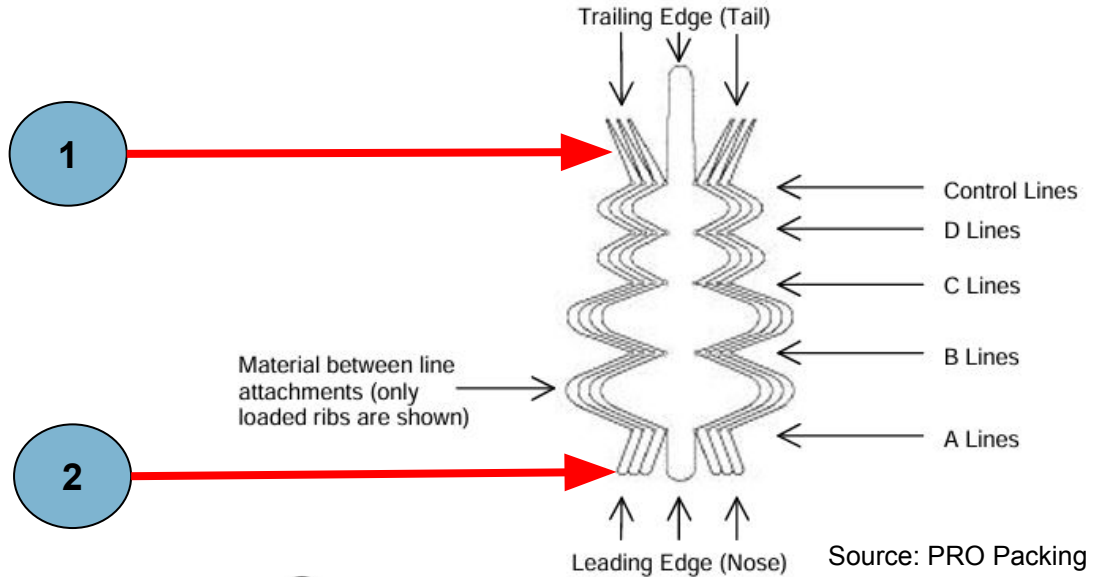
#	Description
1	Trailing Edge
2	Leading Edge
3	Stowed Paraglider in Container
4	Paraglider Resting Plate

**NOTE:** Not all parts shown

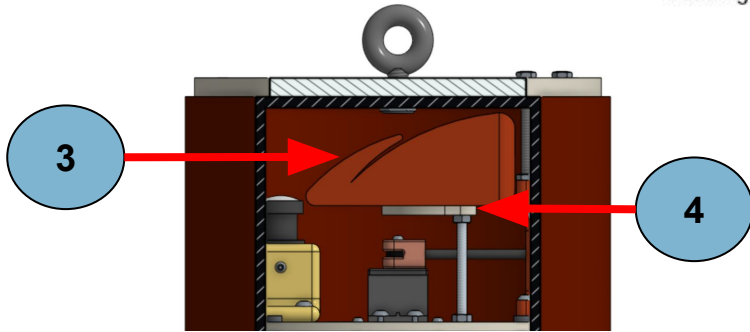
## Proper Ram-Air Orientation (PRO) Packing Technique

Paraglider is folded along the seams of each cell opening and then gently rolled at the trailing edge to allow easy inflation of the airfoil after deployment.

### Design 1



Source: PRO Packing

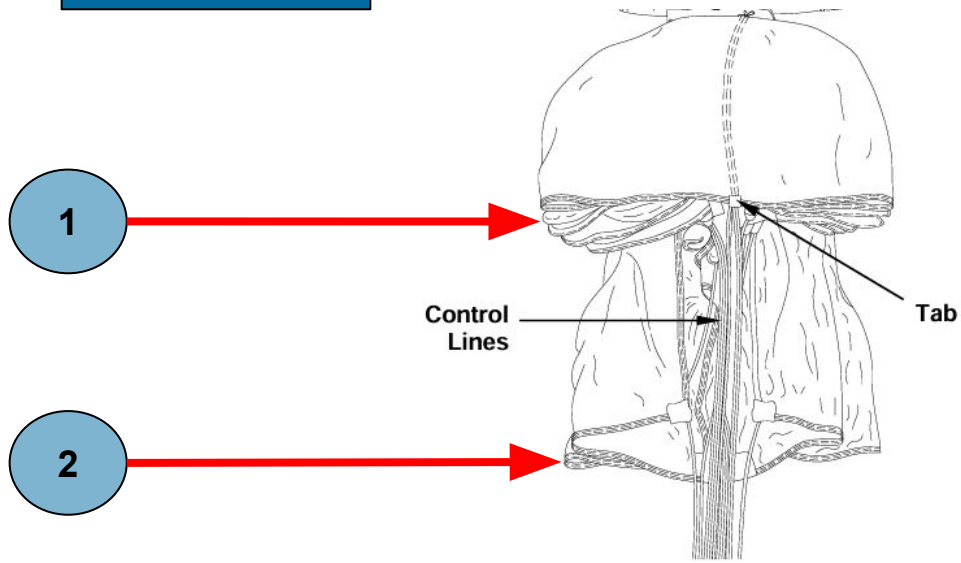


**NOTE:** Paraglider not to scale

**NOTE:** Trailing edge will be gently rolled such that the paraglider can be inserted into the container. Design configuration does not include deployment bag.

#	Description
1	Trailing Edge
2	Leading Edge
3	Stowed Paraglider in Container

## Design 2

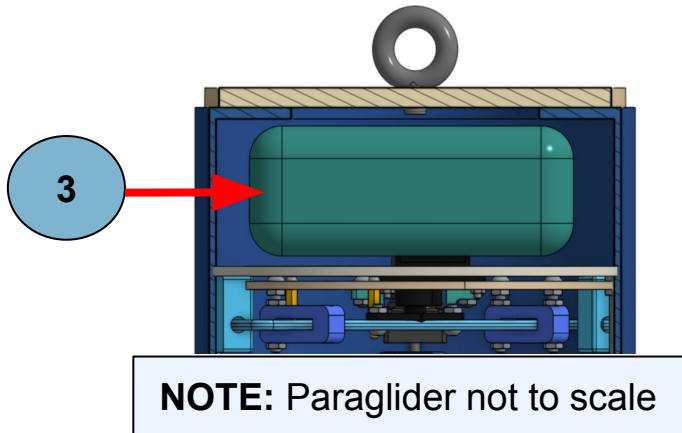


Source: Flat Packing

**NOTE:** Not all parts shown

### Flat Packing Technique

Paraglider is arranged in flat, parallel layers and the folded into a small bundle to minimize the space required for stowing.



**NOTE:** Leading edge is folded over such that the paraglider can be inserted into the container. Design configuration does not include deployment bag.



# Para-Glider Stow Configuration Trade & Selection (3 of 5)



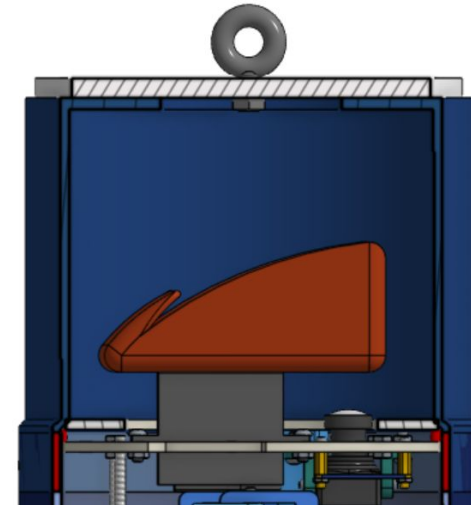
Name	Required Stowing Space (g/cm <sup>3</sup> )	Cell Orientation (Degrees from Direction of Travel)	Minimum Time to Full Deployment (s)
Design 1	~49	~30	2
Design 2	~66	~180	3

## Final Selection

### Design 1: PRO Packing Technique

#### Reasoning:

- Smooth deployment
- Ideal cell orientation
- Less required packing space
- Does not interfere with release mechanism



**NOTE:** Paraglider not to scale



# Para-Glider Stow Configuration Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Required Stowing Space (g/cm <sup>3</sup> )	> 1400	700 - 1400	350 - 699	< 350
Cell Orientation (Degrees from Direction of Travel)	> 150	100 - 150	50 - 99	< 50
Minimum Time to Full Deployment (s)	> 5	4.1 - 5	3 - 4	< 3



# Para-Glider Stow Configuration Trade & Selection (5 of 5)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Required Stowing Space	4	8	32	8	32
Cell Orientation	8	8	64	2	16
Minimum Time to Full Deployment	4	8	32	4	16
<b>Weighted Total</b>		<b>128</b>		<b>64</b>	

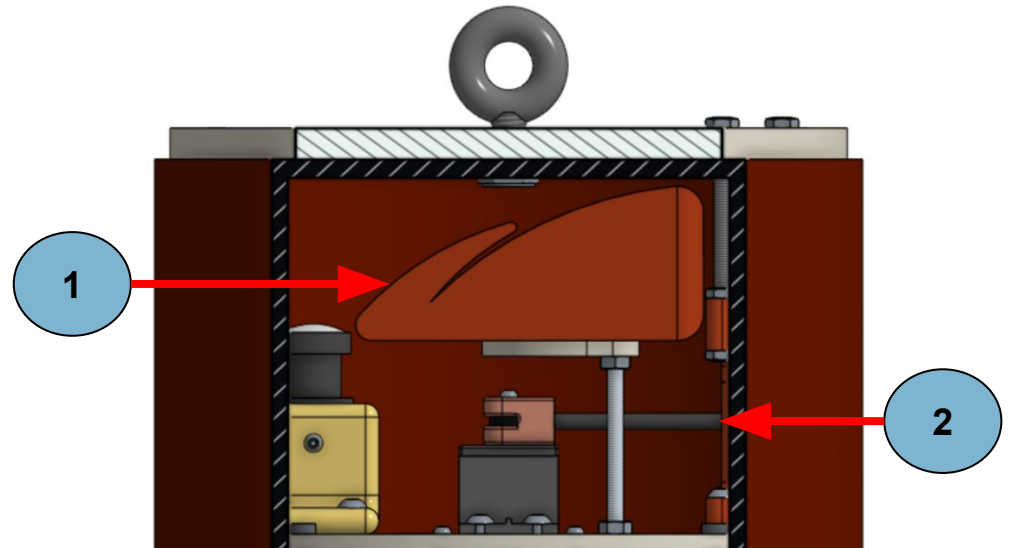
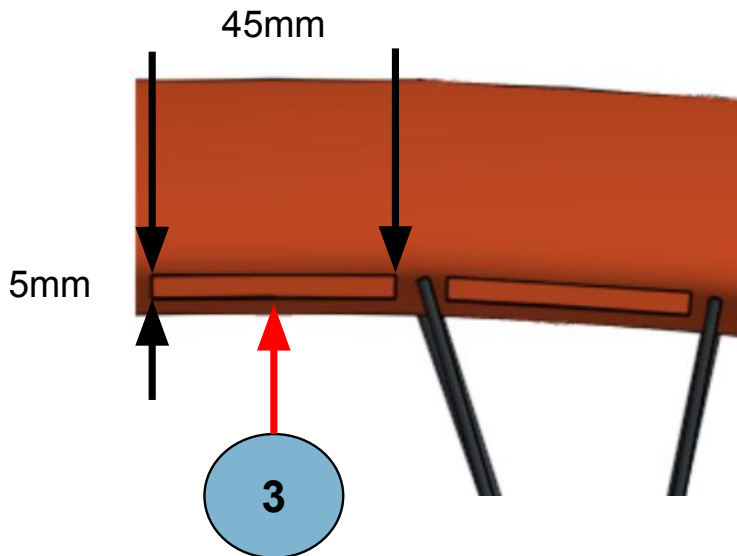
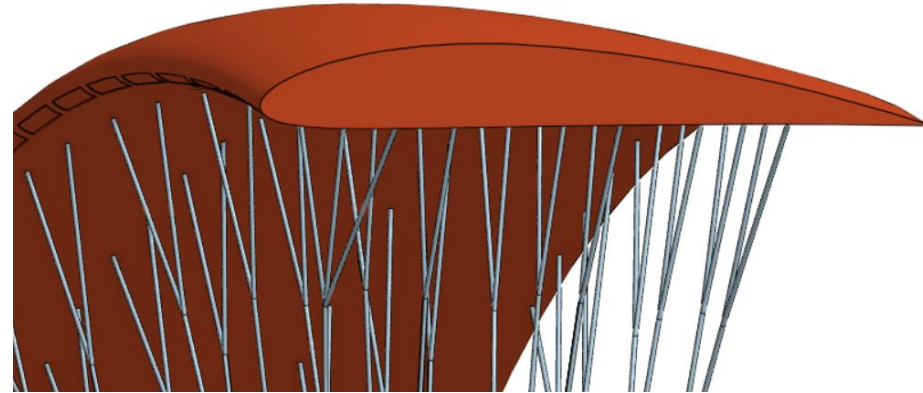


# Para-Glider Deployment Configuration Trade & Selection (1 of 5)



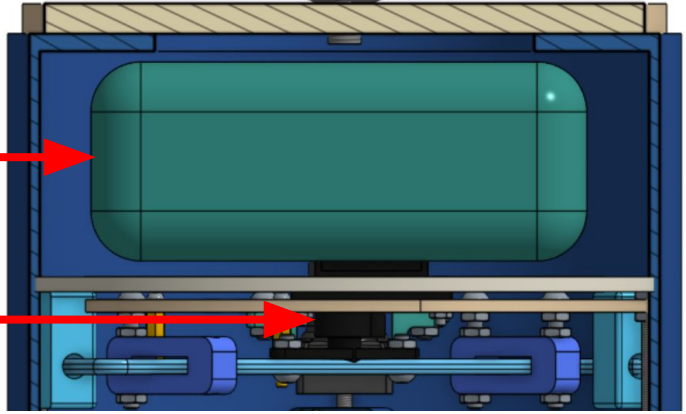
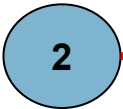
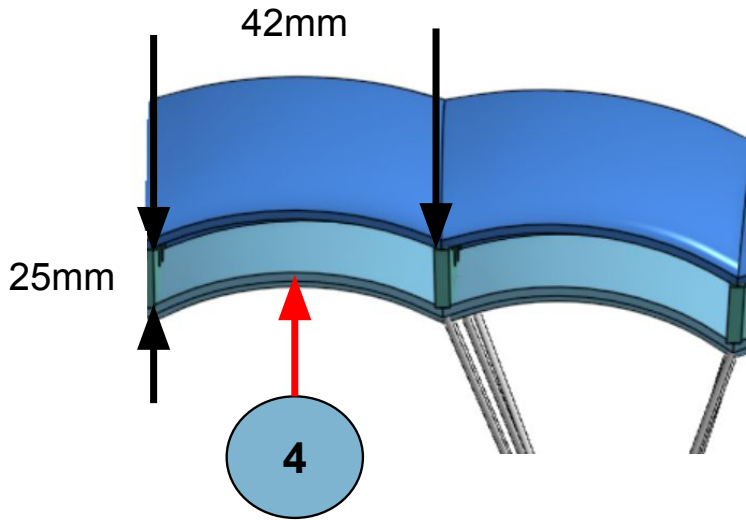
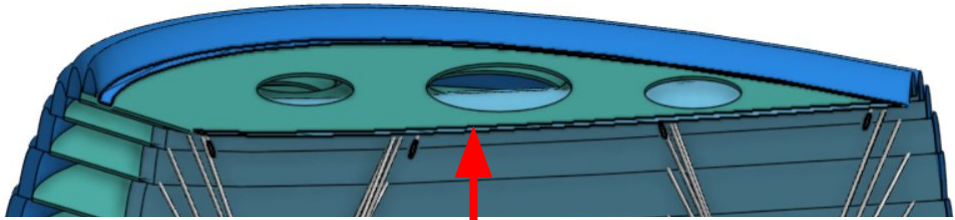
## Design 1

#	Description
1	Stowed Paraglider in Container
2	Release Mechanism
3	Cell Opening



## Design 2

#	Description
1	Cell Interior Structure
2	Stowed Paraglider in Container
3	Release Mechanism
4	Cell Opening





# Para-Glider Deployment Configuration Trade & Selection (3 of 5)



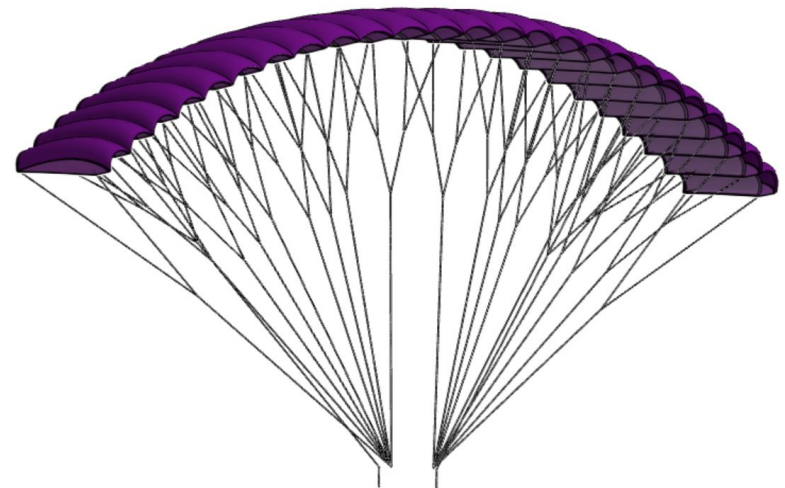
Name	Minimum Time to Full Deployment (s)	Cell Opening Area (mm <sup>2</sup> )	Cell Orientation (Degrees from Direction of Travel)
Design 1	2	225	~30
Design 2	3	1050	~180

## Final Selection

### Combination 1 & 2

#### Reasoning:

- Design 1 has faster inflation time due to more ideal cell orientation
- Design 2 internal structure and cell opening size from allows airfoil to be inflated quickly and consistently during descent



**NOTE:** Not All Parts Shown



# Para-Glider Deployment Configuration Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Minimum Time to Full Deployment (s)	> 5	4 - 5	3 - 3.9	< 3
Cell Opening Area (mm <sup>2</sup> )	< 300	300 - 499	500 - 700	> 700
Cell Orientation (Degrees from Direction of Travel)	> 150	100 - 150	50 - 99	< 50



# Para-Glider Deployment Configuration Trade & Selection (5 of 5)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Minimum Time to Full Deployment	4	8	32	4	16
Cell Opening Area	4	1	4	8	32
Cell Orientation	8	8	64	2	16
<b>Weighted Total</b>		<b>100</b>		<b>64</b>	



# Descent Control Pointing Camera Mount Trade & Selection (1 of 5)



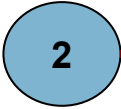
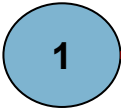
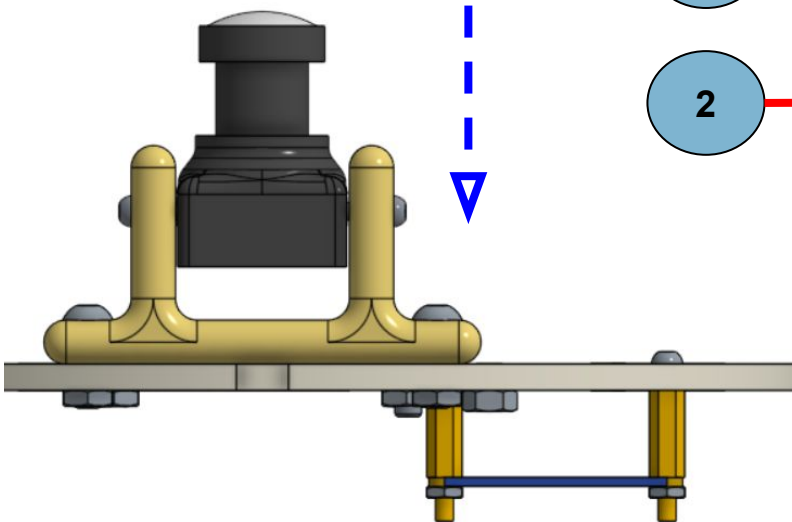
## Design 1

**NOTE:** Camera angle enables clear view of paraglider during descent

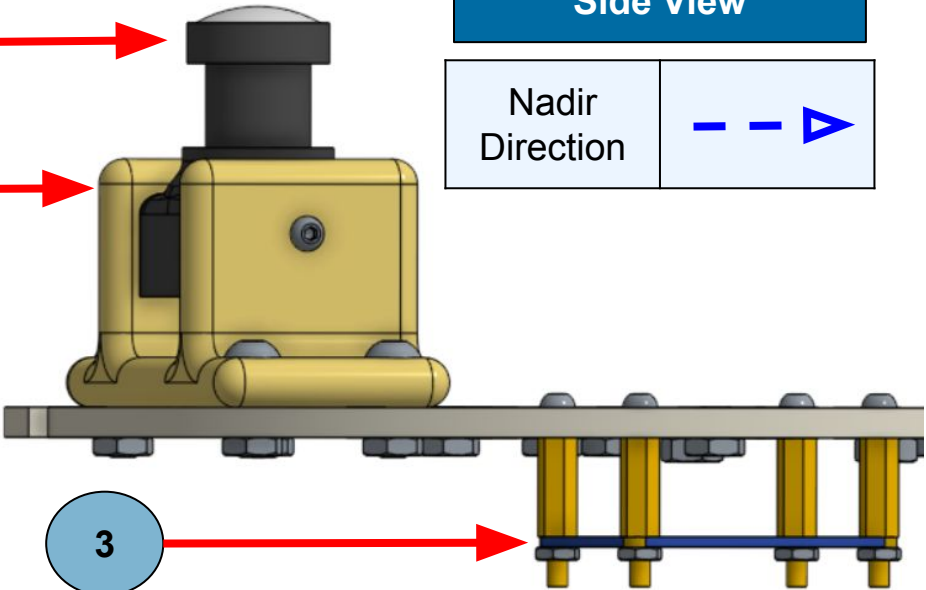
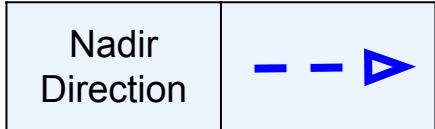
**NOTE:** Not all parts shown

#	Description
1	Upward Facing Camera
2	3D Printed PLA Upward Camera Mount
3	Upward Facing Camera PCB

### Front View



### Side View





# Descent Control Pointing Camera Mount Trade & Selection (2 of 5)

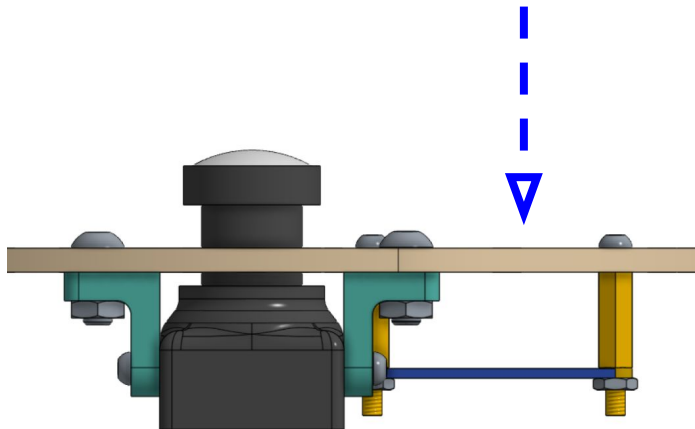


## Design 2

**NOTE:** Camera angle enables clear view of paraglider during descent

**NOTE:** Not all parts shown

## Front View

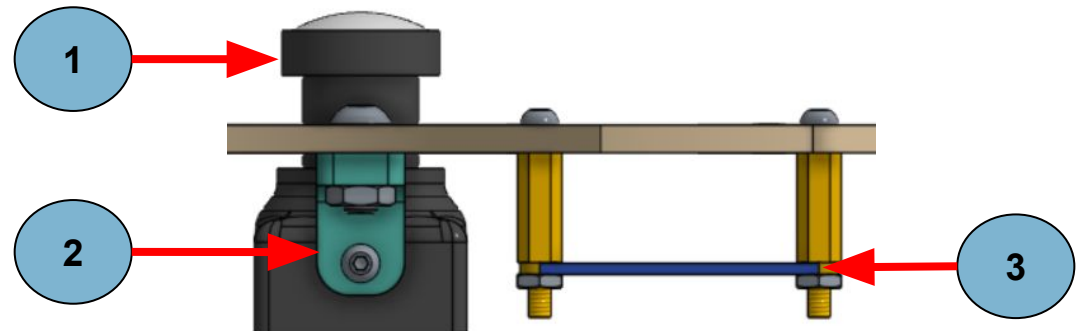


## Description

#	Description
1	Upward Facing Camera
2	3D Printed PETG Upward Camera Mount
3	Upward Facing Camera PCB

## Side View

Nadir  
Direction



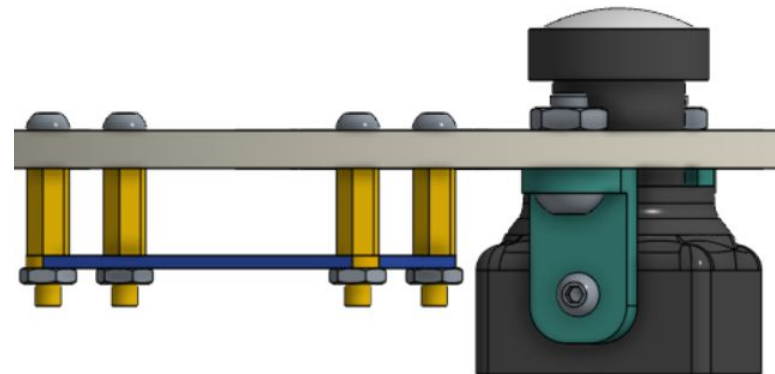


# Descent Control Pointing Camera Mount Trade & Selection (3 of 5)



Name	Mass (g)	Heat Deflection Temperature (°C)	Number of Fasteners
Design 1	10.99	57	4
<b>Design 2</b>	<b>1.22</b>	<b>69</b>	<b>2</b>

Final Selection
<b>Design 2: Two Piece PETG Mount</b>
<p><b>Reasoning:</b></p> <ul style="list-style-type: none"><li>• Less massive design</li><li>• Higher heat deflection temperature</li></ul>



**NOTE:** Not all parts shown



# Descent Control Pointing Camera Mount Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 15	10 - 15	5 - 9	< 5
Heat Deflection Temperature (°C)	< 50	50 - 59	60 - 65	> 65
Number of Fasteners	1	2	3	4



# Descent Control Pointing Camera Mount Trade & Selection (5 of 5)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	4	2	8	8	32
Heat Deflection Temperature	2	2	4	8	16
Number of Fasteners	1	8	8	2	2
<b>Weighted Total</b>		<b>20</b>		<b>50</b>	



# Ground Pointing Camera Mount Trade & Selection (1 of 5)



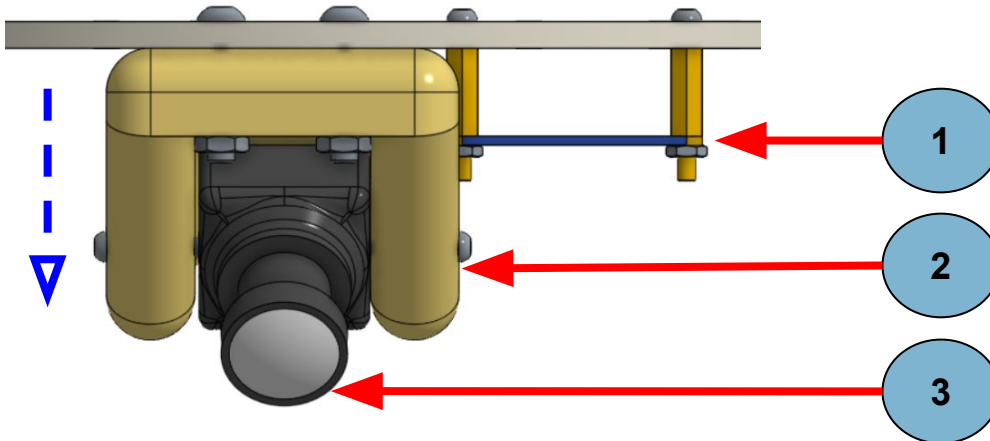
**NOTE:** Camera angle enables clear view of ground during descent and instrument release

**NOTE:** Not all parts shown

Nadir  
Direction



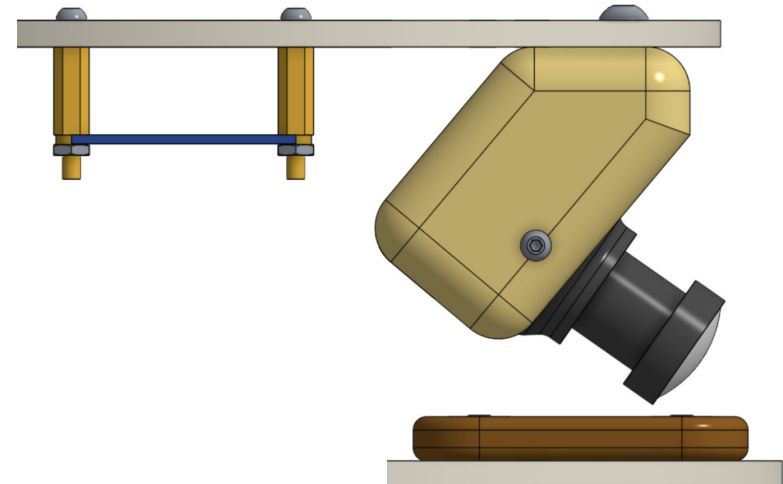
Front View



Design 1

#	Description
1	Downward Facing Camera PCB
2	3D Printed PLA Downward Camera Mount
3	Downward Facing Camera

Side View





# Ground Pointing Camera Mount Trade & Selection (2 of 5)



**NOTE:** Camera angle enables clear view of ground during descent and instrument release

**NOTE:** Not all parts shown

Nadir  
Direction

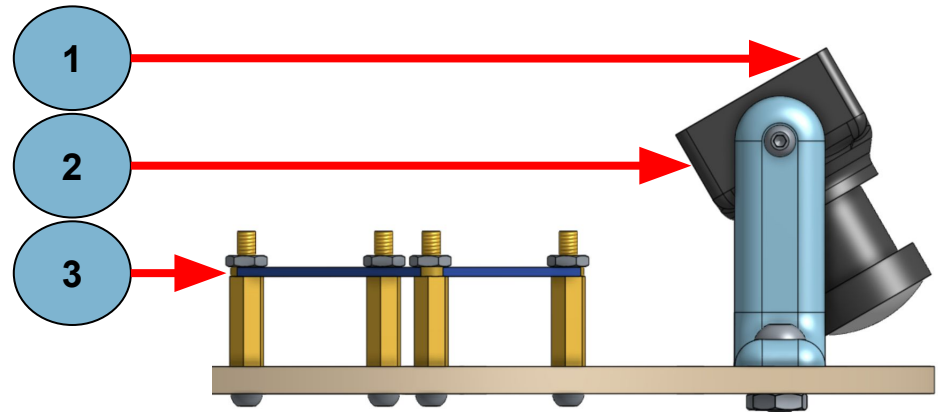
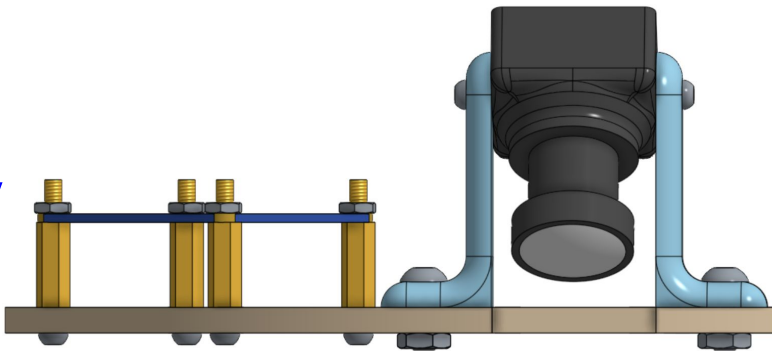


Front View

Design 2

#	Description
1	Downward Facing Camera
2	3D Printed PETG Downward Camera Mount
3	Downward Facing Camera PCB

Side View





# Ground Pointing Camera Mount Trade & Selection (3 of 5)



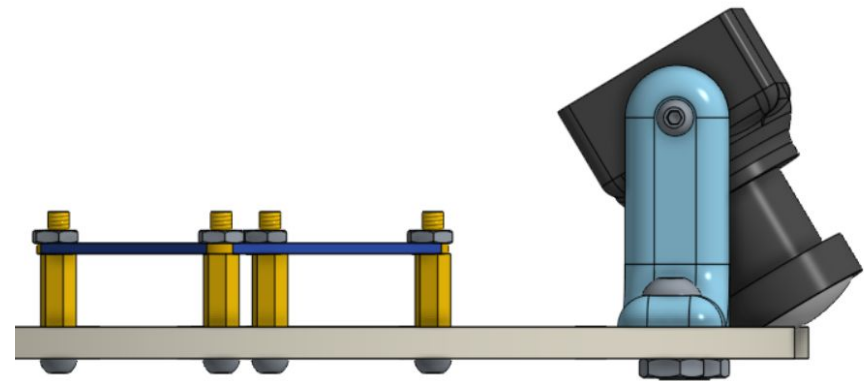
Name	Mass (g)	Heat Deflection Temperature (°C)	Viewing Angle (%)
Design 1	19.26	57	55.55
<b>Design 2</b>	<b>3.26</b>	<b>69</b>	<b>90.00</b>

## Final Selection

### Design 2: Two Piece PETG Mount

#### Reasoning:

- Less massive design
- Larger viewing angle will result in better footage of the ground during descent and instrument release



**NOTE:** Not all parts shown



# Ground Pointing Camera Mount Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 15	10 - 15	5 - 9	< 5
Heat Deflection Temperature (°C)	< 50	50 - 59	60 - 65	> 65
Viewing Angle (%)	< 40	40 - 59	60 - 80	> 80

**NOTE:** “Percent Viewing Angle” refers to the amount of the camera frame that is not blocked by payload structure



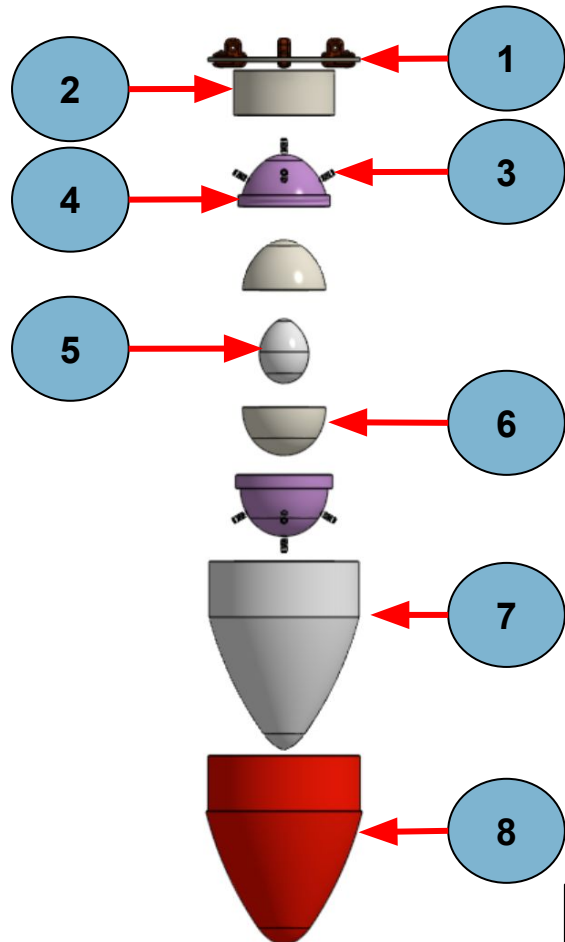
# Ground Pointing Camera Mount Trade & Selection (5 of 5)



Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	4	1	4	8	32
Heat Deflection Temperature	2	2	4	8	16
Viewing Angle	1	2	2	8	8
<b>Weighted Total</b>		<b>10</b>		<b>56</b>	

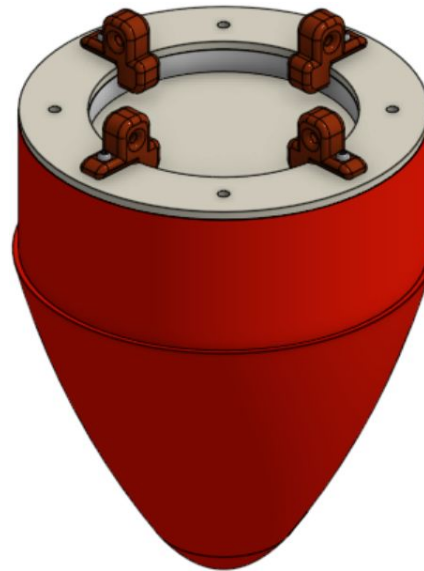
# Egg Instrument Design Trade & Selection (1 of 5)

## Exploded View



## Design 1

**NOTE:** Egg is accessible through a hole in the nose plate



**NOTE:** Not all parts shown

#	Part
1	Fiberglass Composite Nose Release Plate
2	Styrofoam Lid
3	Springs
4	3D Printed PETG Egg Case
5	Hen's Egg
6	Egg Styrofoam
7	Nose Styrofoam
8	Fiberglass Composite Layup Power Series Nose Cone

# Egg Instrument Design Trade & Selection (2 of 5)

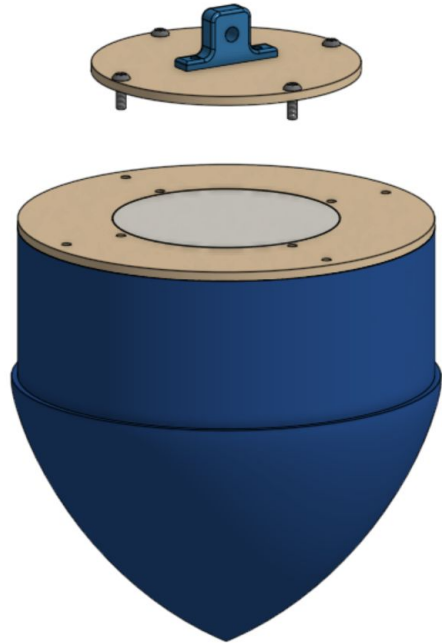
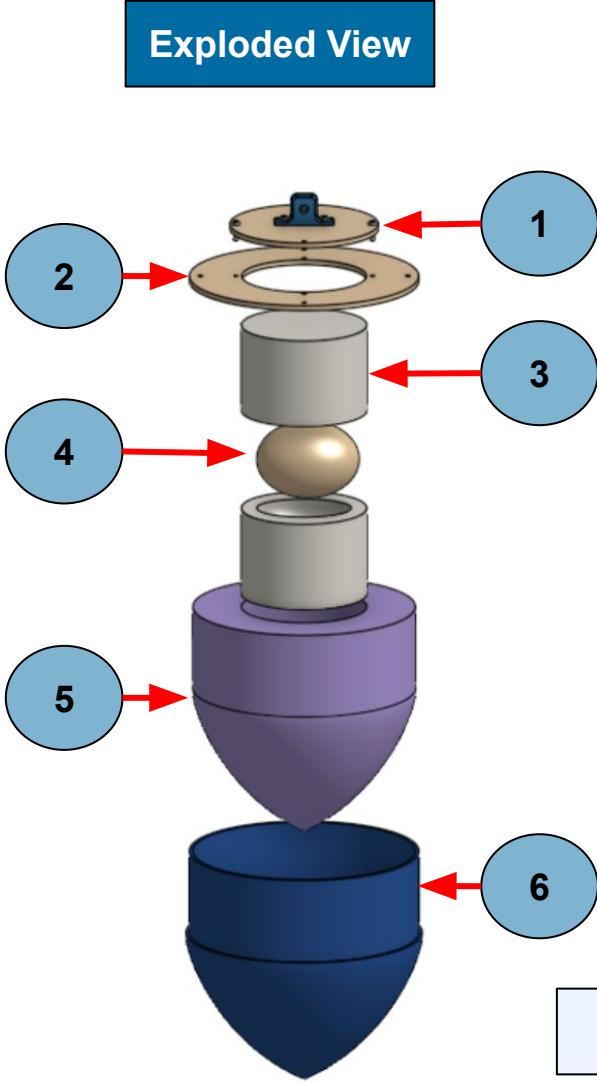
**Exploded View**

**Design 2**

**NOTE:** Egg is accessible through a hole in the nose plate

**NOTE:** Not all parts shown

#	Part
1	Fiberglass Composite Plywood Nose Release Integration Plate
2	Fiberglass Composite Nose Plate
3	Urethane Foam Egg Holder
4	Hen's Egg
5	TPU Nose Cone Insert
6	3D Printed PETG Ogive Nose Cone





# Egg Instrument Design Trade & Selection (3 of 5)



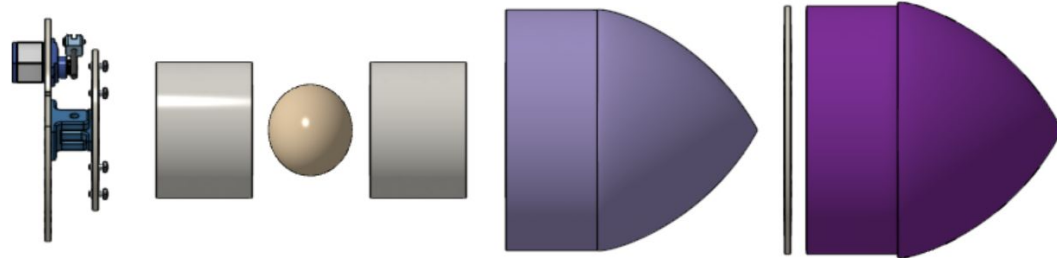
Name	Mass (g)	Volume (cm <sup>3</sup> )	Elastic Modulus (MPa)	Assembly Steps
Design 1	136	1571	20	6
<b>Design 2</b>	<b>90.6</b>	<b>1345</b>	<b>0.9</b>	<b>4</b>

## Final Selection

### Design 2: Urethane Egg Holder

#### Reasoning:

- Low mass while offering high cushioning ability due to lower elastic modulus
- Simple but effective design offering quick assembly and disassembly



**NOTE:** Not all parts shown



# Egg Instrument Design Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 125	100 - 125	75 - 99	< 75
Volume (cm <sup>3</sup> )	< 1000	1000 - 1200	1201 - 1500	> 1500
Elastic Modulus (MPa)	> 10	7.5 - 10	5 - 7.4	< 5
Assembly Steps	> 8	5 - 8	2 - 4	< 2

**NOTE:** “Elastic Modulus” refers to the elastic modulus of the cushioning material for the design (Styrofoam and Urethane for designs 1 and 2 respectively)



# Egg Instrument Design Trade & Selection (5 of 5)

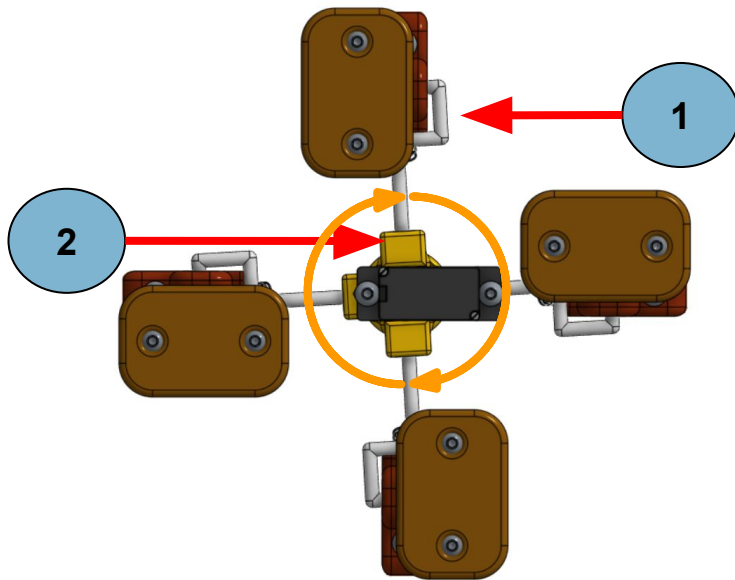


Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	8	1	8	4	32
Volume	2	8	16	4	8
Elastic Modulus	4	1	4	8	32
Assembly Steps	1	2	2	4	4
<b>Weighted Total</b>		<b>30</b>		<b>76</b>	

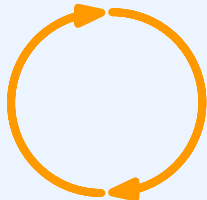
# Egg Instrument Release Trade & Selection (1 of 5)

**NOTE:** Not all parts shown

**Top View**



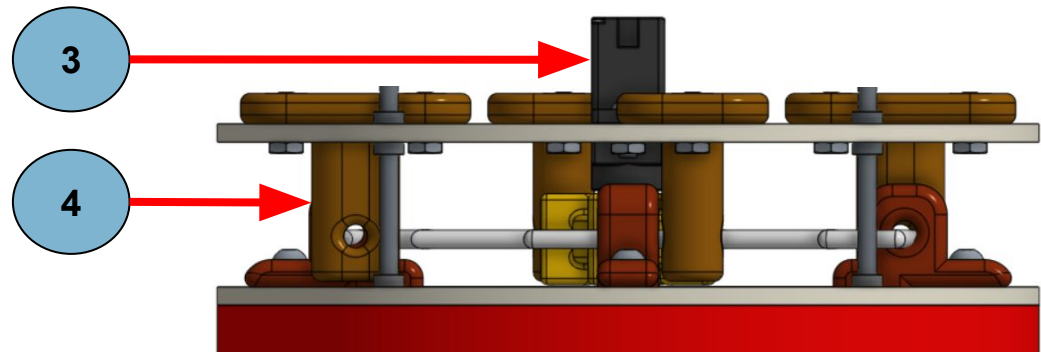
Direction of Rotation



**Design 1**

#	Part
1	3D Printed PLA Nose Release Arms
2	3D Printed PLA Servo Adapter
3	Servo
4	3D Printed PLA Nose Release Arm Holders

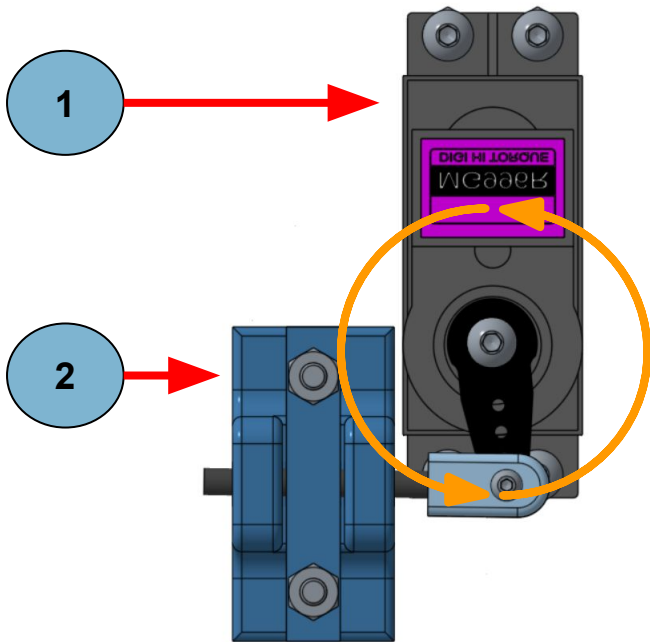
**Front View**



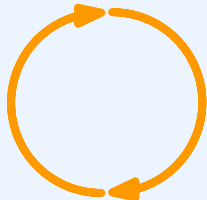
# Egg Instrument Release Trade & Selection (2 of 5)

**NOTE:** Not all parts shown

**Top View**



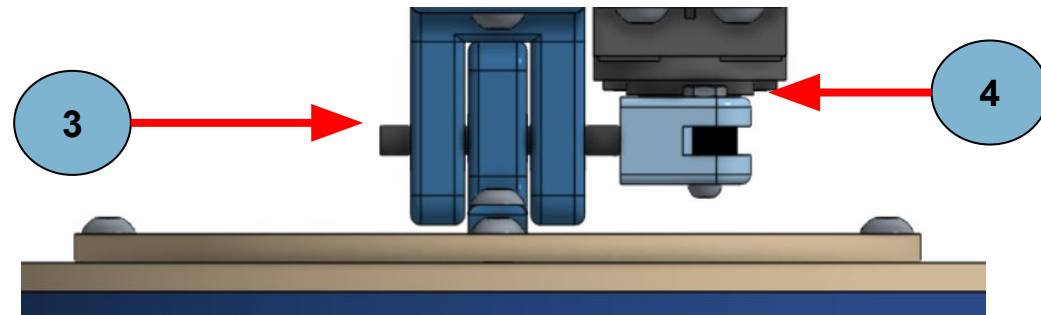
Direction of Rotation



**Design 2**

#	Part
1	Servo
2	3D Printed PETG Nose Cone Release Payload Attachment Point
3	Carbon Fiber Nose Release Pin
4	3D Printed PETG Carbon Fiber Rod Adapter

**Front View**





# Egg Instrument Release Trade & Selection (3 of 5)



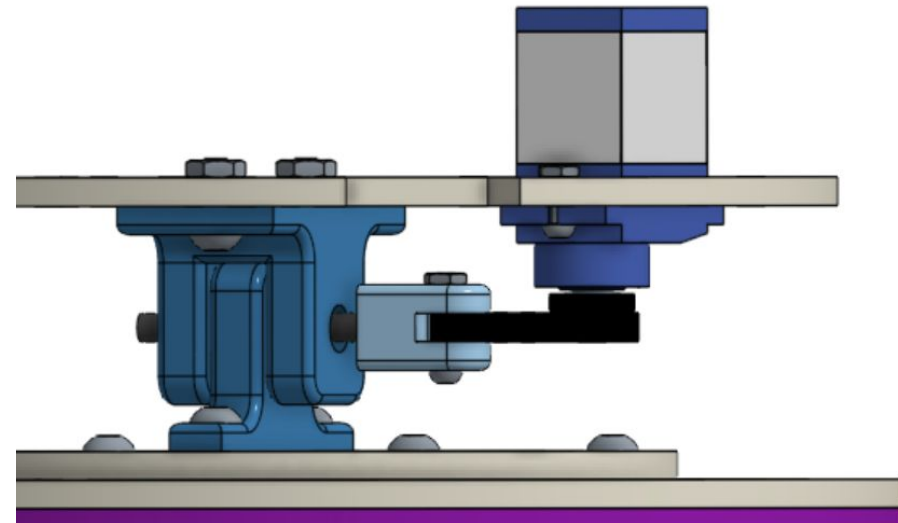
Name	Mass(g)	Tensile Strength of Arm (MPa)	Points of Contact
Design 1	53	52	4
<b>Design 2</b>	<b>28</b>	<b>1379</b>	<b>1</b>

## Final Selection

### Design 2: Single Pin Release

#### Reasoning:

- Less massive design
- Higher tensile strength of arm





# Egg Instrument Release Trade & Selection (4 of 5)



## Unweighted Figures of Merit

Factor	1	2	4	8
Mass (g)	> 40	31 - 40	20 - 30	< 20
Tensile Strength of Arm (MPa)	< 100	100 - 599	600 - 1100	> 1100
Points of Contact	1	2	3	$\geq 4$



# Egg Instrument Release Trade & Selection (5 of 5)



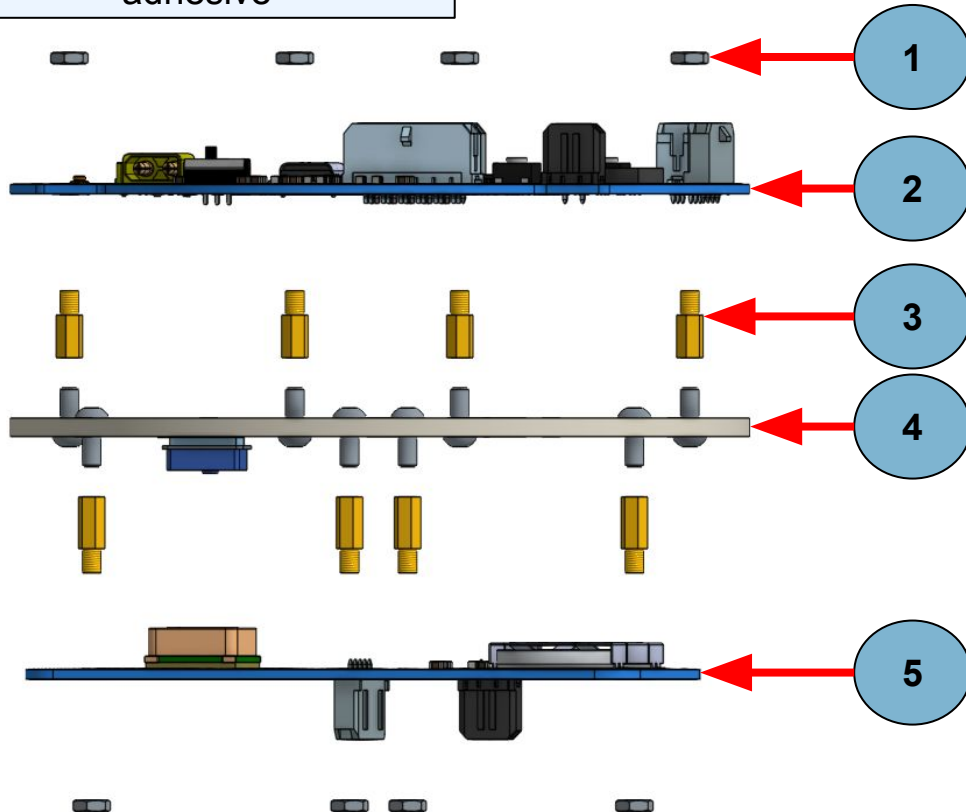
Factor	Weight	Design 1		Design 2	
		Unweighted	Weighted	Unweighted	Weighted
Mass	4	1	4	4	16
Tensile Strength of Arm	2	1	2	8	16
Points of Contact	1	8	8	1	1
<b>Weighted Total</b>		<b>14</b>		<b>33</b>	

**NOTE:** Not all parts shown

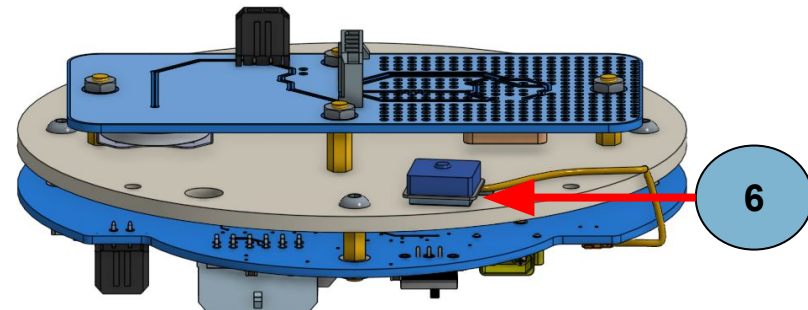
**NOTE:** GPS Antenna is secured using high performance double sided adhesive

## PCB and Battery Mounting

### Exploded View



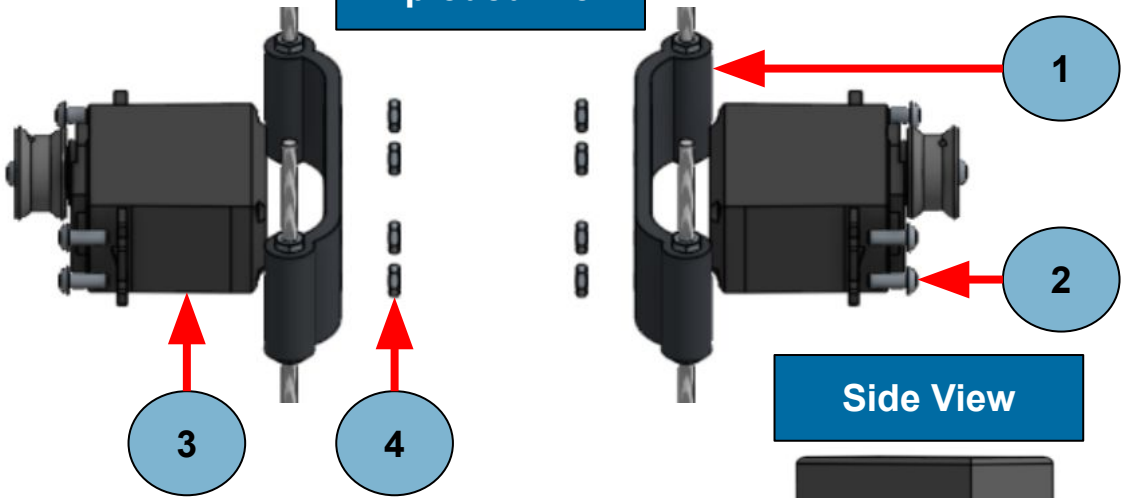
#	Part
1	M3 Nuts
2	Main Flight Computer PCB
3	M3 Standoffs
4	Fiberglass Composite Plywood Electrical Component Plate
5	GPS PCB
6	Patch GPS Antenna



**NOTE:** Not all parts shown

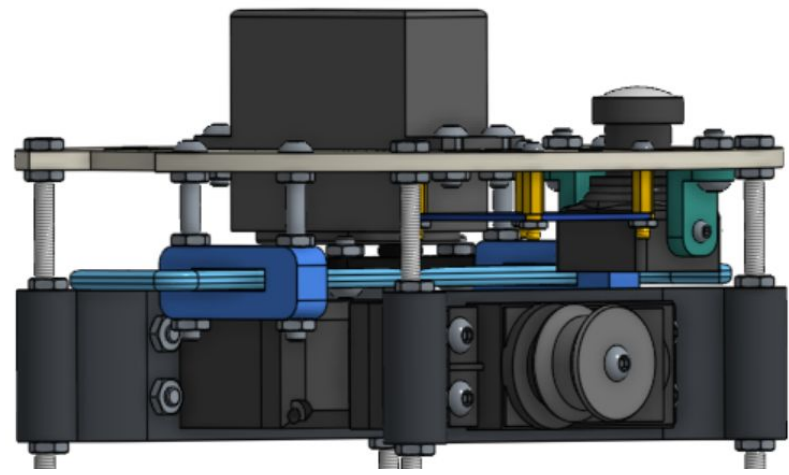
## Steering Servos Mounting

### Exploded View



#	Part
1	3D Printed PETG Steering Servo Mount
2	M3 Bolts
3	LS-955CR Servo
4	M3 Nuts

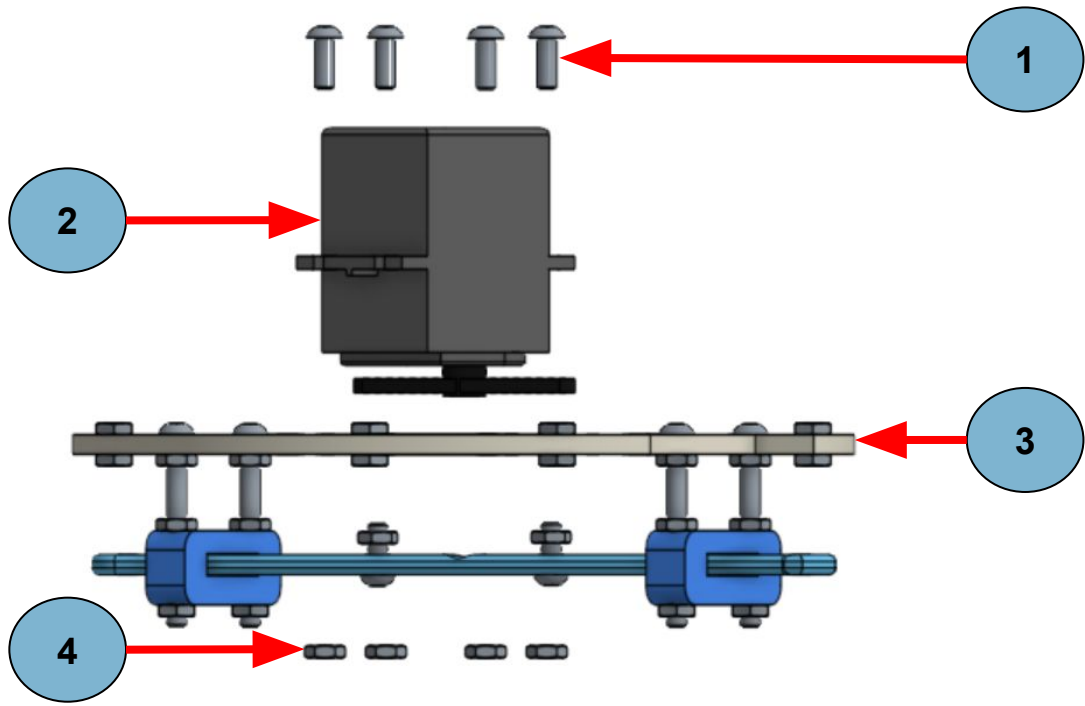
### Side View



**NOTE:** Not all parts shown

## Release Servo Mounting

**Exploded View**

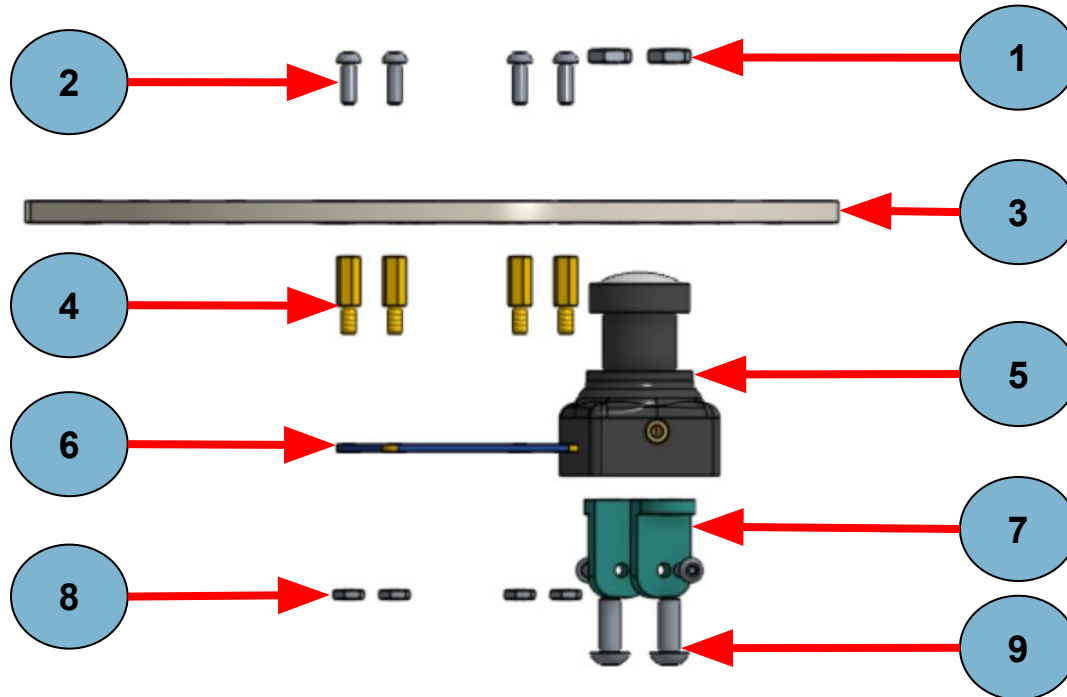


#	Part
1	M3 Bolts
2	FS5106B Servo
3	Fiberglass Composite Plywood Plate
4	M3 Nuts

**NOTE:** Not all parts shown

## Upward Facing Camera and PCB

### Exploded View

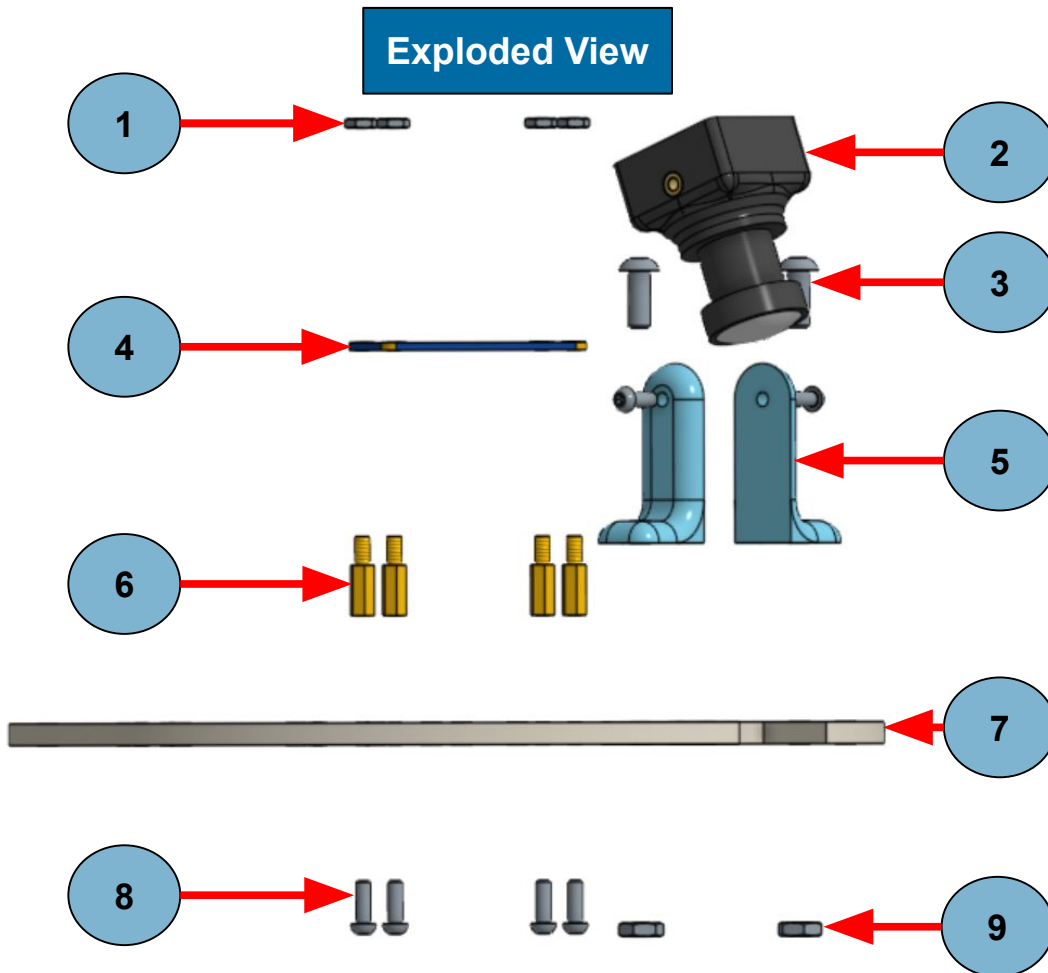


#	Part
1	M3 Nuts
2	M2 Bolts
3	Fiberglass Composite Plywood Plate
4	M2 Standoffs
5	Upward Facing Camera
6	Upward Facing Camera PCB
7	3D Printed PETG Upward Facing Camera Mount
8	M2 Nuts
9	M3 Bolts

**NOTE:** Not all parts shown

## Downward Facing Camera and PCB

Exploded View

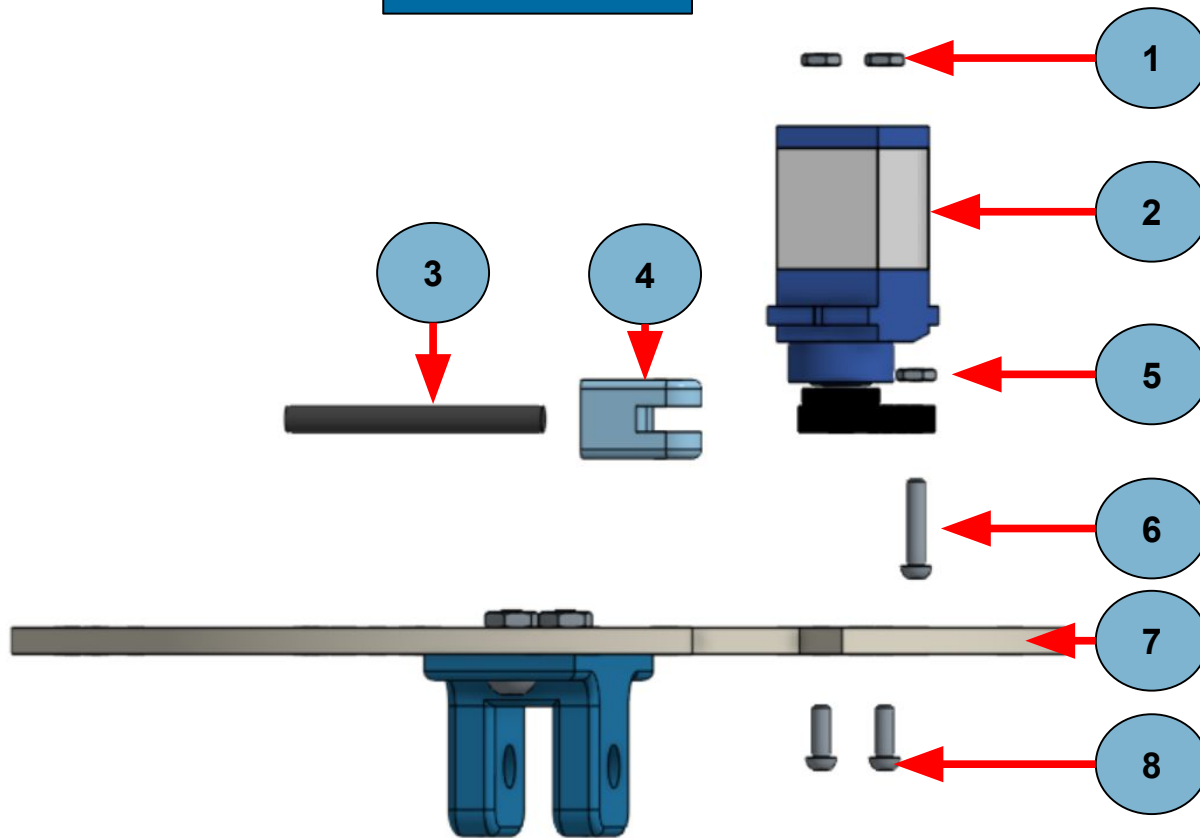


#	Part
1	M2 Nuts
2	Downward Facing Camera
3	M3 Bolts
4	Downward Facing Camera PCB
5	3D Printed PETG Downward Facing Camera Mount
6	M2 Standoffs
7	Fiberglass Composite Plywood Plate
8	M2 Bolts
9	M3 Nuts

**NOTE:** Not all parts shown

## Instrument Release Servo Mounting

Exploded View

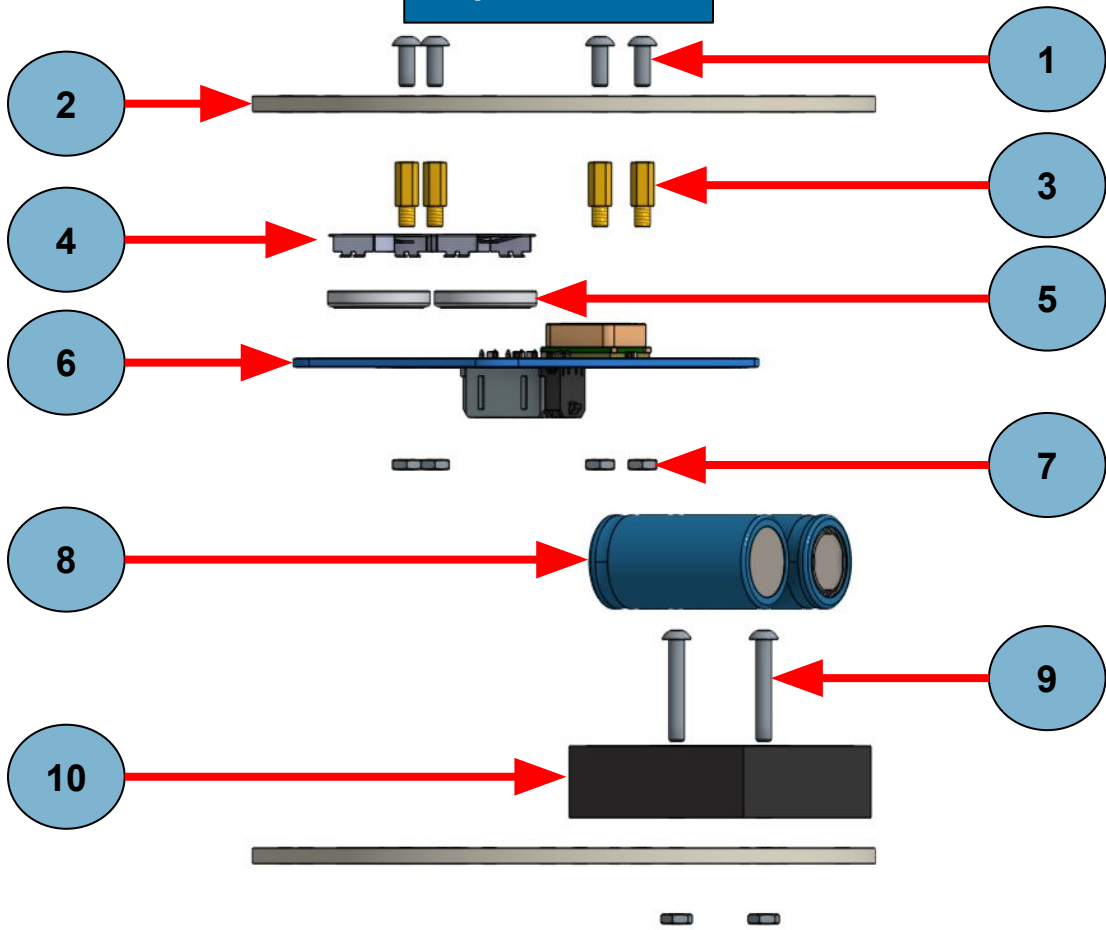


#	Part
1	M3 Nuts
2	MG92B Servo
3	Carbon Fiber Pin
4	3D Printed PETG Servo Adapter
5	M2 Nut
6	M2 Bolt
7	Fiberglass Composite Plywood Plate
8	M3 Bolts

**NOTE:** Not all parts shown

## Battery Mounting

**Exploded View**

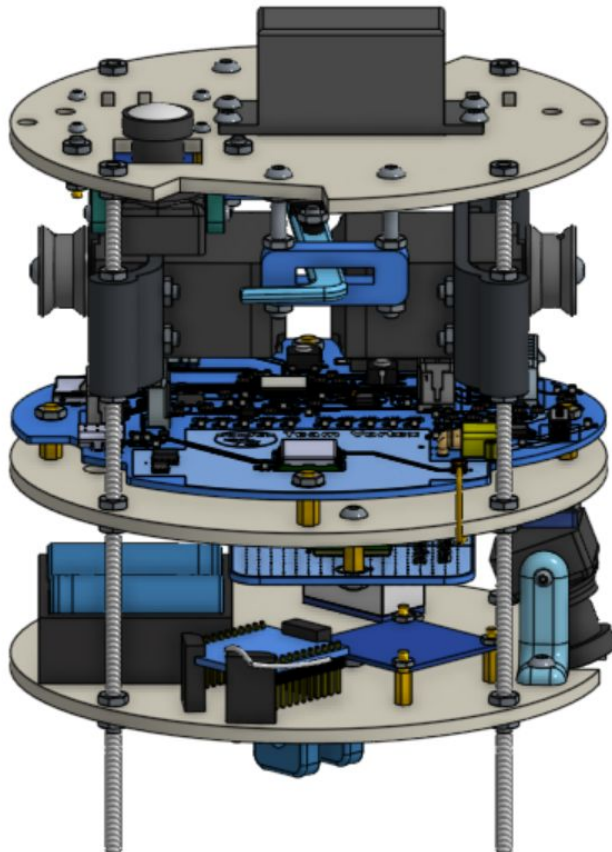


#	Part
1	M3 Bolts
2	Fiberglass Composite Plywood Plate
3	M3 Standoffs
4	Coin Cell Battery Holders
5	Coin Cell Batteries
6	GPS PCB
7	M3 Nuts
8	18350 Batteries
9	M3 Bolts
10	18350 Battery Holder

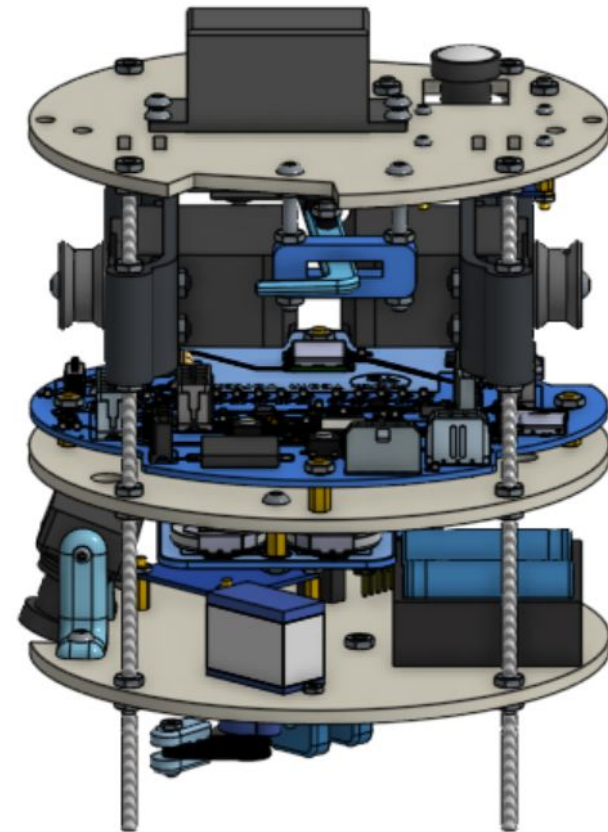
**NOTE:** Not all parts shown

## Full System Views

Front View



Back View





# Mass Budget (1 of 11)



Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
RunCam Split 4 V2	10.2	2	20.4	± 0.31	Datasheet
XBEE Chip & Breakout	17	1	17	± 0.51	Datasheet
PCBs	50	1	50	± 1.5	Estimate
MG92B Servo	14	1	14	± 0.42	Datasheet
FS5106 Servo	43	1	43	± 1.29	Datasheet
LS-955CR Servo	56	2	112	± 3.36	Datasheet
Vapcell A11 18350	26	2	52	± 1.44	Datasheet
BMI088	0.67	1	0.67	± 0.02	Datasheet
BMP390	0.3	1	0.3	± 0.01	Datasheet



# Mass Budget (2 of 11)



Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
STM32H562RI T6 MCU	3	1	3	$\pm 0.09$	Datasheet
MIC5365-3.3YC 5-TR LDO	0.02	1	0.02	$\sim 0$	Datasheet
EAST1818RGB ICA0 LED	0.5	10	5	$\pm 0.02$	Datasheet
LTST-C194TBK T LED	0.23	2	0.46	$\pm 0.01$	Datasheet
L1SP-PRP2003 500000 LED	2.11	2	4.22	$\pm 0.06$	Datasheet
Capacitors	0.2	50	10	$\pm 0.01$	Datasheet
Resistors	0.2	30	6	$\pm 0.01$	Datasheet
Inductors	0.5	3	1.5	$\pm 0.01$	Datasheet



# Mass Budget (3 of 11)



Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
USB4085-GF-A USBC 2.0	0.91	1	0.91	$\pm 0.02$	Datasheet
USBLC6-2SC6	0.02	1	0.02	$\sim 0$	Datasheet
NEO-M9N	8	1	8	$\pm 0.24$	Datasheet
SAM-M10Q	5.6	1	5.6	$\pm 0.17$	Datasheet
SMA Connector	3.8	1	3.8	$\pm 0.11$	Datasheet
Voltage Regulators	0.02	2	0.04	$\sim 0$	Datasheet
Current Sensor	0.02	1	0.02	$\sim 0$	Datasheet
MicroSD Reader	0.73	1	0.73	$\pm 0.02$	Datasheet
MOSFETs	2	1	2	$\pm 0.06$	Datasheet



# Mass Budget (4 of 11)



Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
JSTs	0.5	10	5	$\pm 0.14$	Datasheet
XT30	2	1	2	$\pm 0.06$	Datasheet
Switches	1.5	2	3	$\pm 0.09$	Datasheet
Push Buttons	1	2	2	$\pm 0.03$	Datasheet
Buzzer	4.5	1	4.5	$\pm 0.14$	Datasheet
Battery Holders	12	1	15	$\pm 0.45$	Datasheet
Coin Cell	3.4	1	3.4	$\pm 0.1$	Datasheet
Coin Cell Holder	0.8	1	0.8	$\pm 0.02$	Datasheet
Magnetometer	1	1	2	$\pm 0.06$	Datasheet
SMA Antenna	5.48	1	5.48	$\pm 0.36$	Datasheet



# Mass Budget (5 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
Silnylon Cruciform Parachute	5.65	1	5.65	± 0.99	Estimate
Kevlar Parachute Lines	0.52	N/A	0.52	± 0.14	Estimate
Fiberglass Composite Container	110.10	1	110.10	± 12.61	Estimate
6mm Plywood Container Plate	53.94	1	53.94	± 2.7	Estimate
¼ Inch Eye Bolt	15.96	1	15.96	± 0.8	Estimate
Container Integration Plate	11.07	1	11.07	± 1.66	Estimate



# Mass Budget (6 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
Forged Carbon Fiber Container Integration Piece	10.31	2	20.62	± 2.06	Estimate
Forged Carbon Fiber Release Mechanism Arm	3.71	1	3.71	± 0.37	Estimate
3D Printed PETG Release Mechanism Arm Support	1.76	2	3.52	± 0.11	Prusa Slicer
Back Plate	19.56	1	19.56	± 2.93	Estimate
3D Printed PETG Upward Camera Mount	0.45	2	0.90	± 0.03	Prusa Slicer



# Mass Budget (7 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
Silnylon Paraglider Wing	24.39	1	24.39	$\pm 2.44$	Estimate
Kevlar Brake & Stability Lines	2.75	N/A	2.75	$\pm 0.08$	Estimate
3D Printed PETG Steering Servo Mount	6.02	2	12.04	$\pm 0.36$	Prusa Slicer
3D Printed PETG Turning Spool	1.64	2	3.28	$\pm 0.10$	Prusa Slicer
Electrical Component Plate	23.42	1	23.42	$\pm 3.51$	Estimate
Hen's Egg	59	1	59	$\pm 5$	Mission Guide



# Mass Budget (8 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
3D Printed PETG Downward Camera Mounts	0.88	2	1.76	± 0.05	Prusa Slicer
Nose Release Mounting Plate	22.60	1	22.60	± 3.39	Estimate
3D Printed PETG Carbon Fiber Rod Adapter	0.70	1	0.70	± 0.02	Prusa Slicer
3D Printed PETG Nose Cone Release Payload Attachment Point	3.92	1	3.92	± 0.12	Prusa Slicer



# Mass Budget (9 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
3D Printed PETG Nose Cone Release Nose Attachment Point	1.60	1	1.60	$\pm 0.05$	Prusa Slicer
Carbon Fiber Nose Release Pin	0.32	1	0.32	$\pm 0.03$	Estimate
Urethane Foam Egg Holder	36.7	1	36.7	$\pm 1.84$	Estimate
TPU Nose Cone Insert	51.7	1	51.7	$\pm 10.34$	Estimate
M3 Zinc Plated Steel Threaded Rods	8.12	4	32.48	$\pm 3.25$	Estimate



# Mass Budget (10 of 11)



Structural Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
Fiberglass Composite Layup Ogive Nose Cone	99.57	1	99.57	± 10.00	Estimate
Nose Release Integration Plate	6.84	1	6.84	± 1.03	Estimate
Nose Plate	14.24	1	14.24	± 2.14	Estimate
M3 Nuts & Bolts	1.04	46	47.84	± 3.08	Estimate
Carbon Fiber Rotation Prevention Rod	0.09	2	0.18	± 0.02	Estimate



# Mass Budget (11 of 11)



Total Mass of Payload (g)	Total Mass with Container (g)
876.90	1004.27

Total Mass (g)	Mass Allowed (g)	Mass Margin (g)
1004.27	1000	$1000 - 1004.27 = -4.27$

The total mass is 1004.27g which is within  $1000g \pm 10g$ , therefore compliant with the mission guide. Potential for error could be due to errors in material density calculations, error in predictions of thickness of fiberglass composite parts, inaccurate parts information.

Ways to Add Mass	Ways to Remove Mass
Increase infill of 3D printed components	Decrease infill of 3D printed components
Use denser materials for load bearing parts	Reduce base plate surface area
Increase nose cone thickness	Use lighter alternative materials
Increase length of payload body	Decrease length of payload body



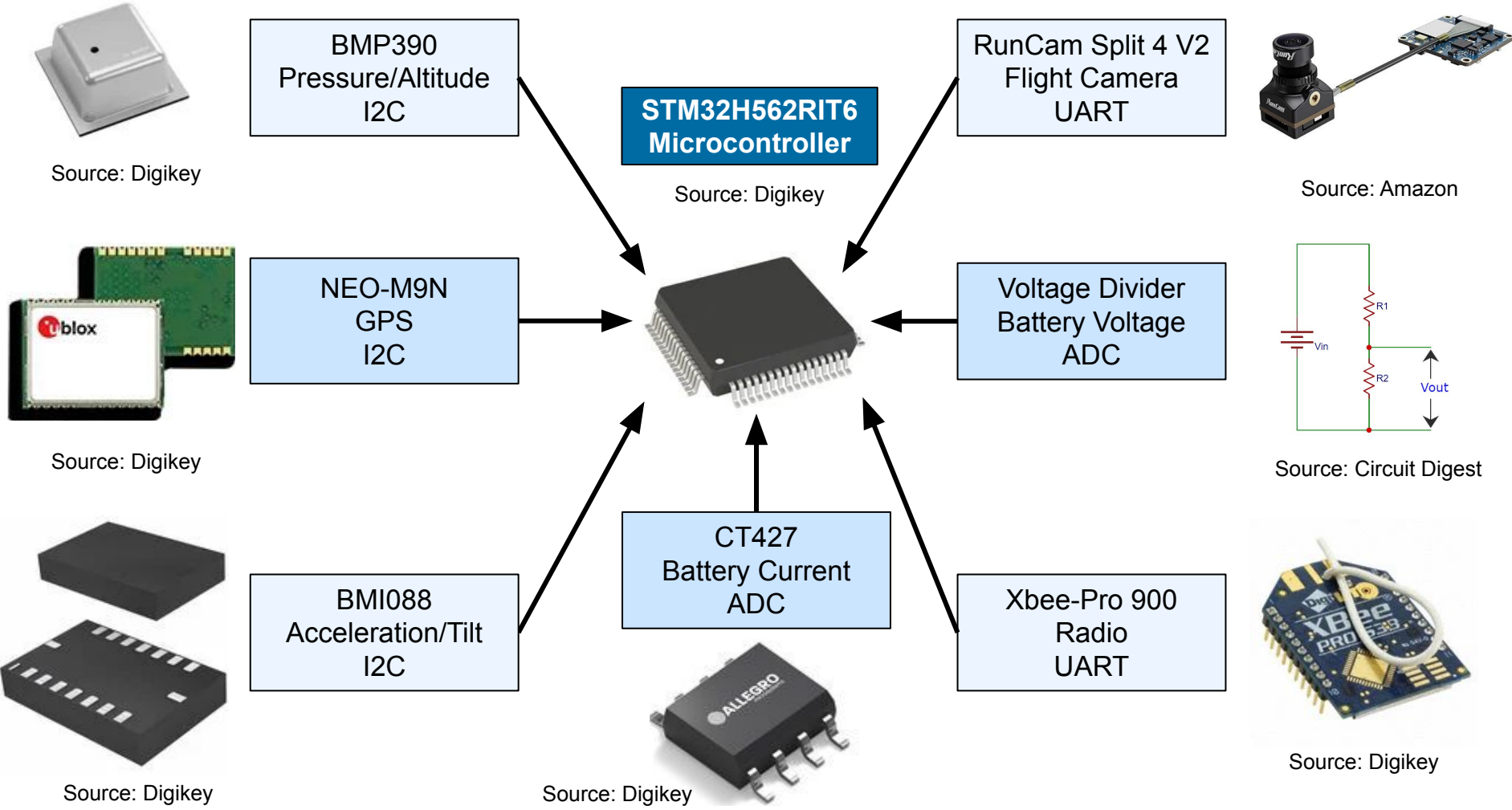
---

# Communication and Data Handling (CDH) Subsystem Design

**Kenny Briggs, Ethan Denoncourt**



# Payload Command Data Handler (CDH) Overview





# Payload Processor & Memory Trade & Selection (1 of 6)



## Processor Trade & Selection

Name	Pin Count (GPIO, ADC, DAC)	Speed (MHz)	Volatile Memory (KB)	Floating Point (Y/N)	Boot Time (ms)	Price (\$)
ESP32-S2FN4R2	43, 2, 8	240	128	N	320	2.94
STM32G070KBT6	29, 2, 0	64	128	N	480	2.05
<b>STM32H562RIT6</b>	<b>53, 2, 1</b>	<b>250</b>	<b>2000</b>	<b>Y</b>	<b>170</b>	<b>4.57</b>

### Final Selection

**STM32H562RIT6**

#### Reasoning:

- Most GPIO pins at 53
- Highest program memory at 2MB
- Highest speed at 250MHz
- Fastest 170ms boot time



Source: Digikey



# Payload Processor & Memory Trade & Selection (2 of 6)



## Unweighted Figures of Merit

Factors	1	2	4	8
Pin Count (GPIO, ADC, DAC)	< 20, < 1, < 1	20 - 30, < 2, > 1	31 - 59, 2, > 1	> 60, > 2, > 1
Speed (MHz)	< 5	5 - 199	200 - 399	> 400
Volatile Memory (KB)	< 100	100 - 400	401 - 800	> 800
Floating Point (Y/N)	-	N	-	Y
Boot Time (ms)	> 500	300 - 500	100 - 299	< 100
Price (\$)	> 5.00	3.00 - 5.00	2.00 - 3.00	< 2.00



# Payload Processor & Memory Trade & Selection (3 of 6)



Factors	Weight	ESP32-S2FN4R2		STM32G070KBT6		STM32H562RIT6	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Pin Count	8	4	32	2	16	4	32
Speed	4	4	16	2	8	4	16
Volatile Memory	2	2	4	2	4	8	16
Floating Point	4	2	8	2	8	8	32
Boot Time	4	2	8	2	8	4	16
Price	1	4	4	4	4	2	2
<b>Total</b>		<b>72</b>		<b>48</b>		<b>114</b>	



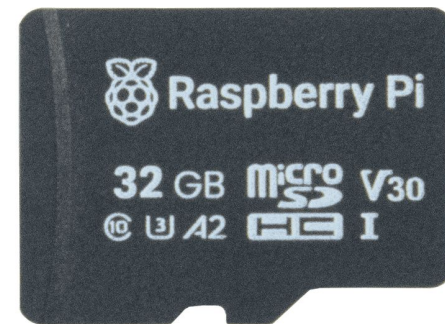
# Payload Processor & Memory Trade & Selection (4 of 6)



Memory Trade & Selection			
Name	Memory Size (KB)	Clock Frequency (MHz)	Price (\$)
CY15B016Q-SXET	0.016	16	2.32
FM24CL16B-G	0.016	1	1.60
<b>SC1628</b>	<b>32000</b>	<b>20</b>	<b>15.39</b>

Final Selection
<b>SC1628</b>
<p><b>Reasoning:</b></p> <ul style="list-style-type: none"> <li>• Highest Clock Frequency</li> <li>• Best memory size at 32GB</li> </ul>

**NOTE:** SC1628 uses an SDIO interface



Source: Cytron



# Payload Processor & Memory Trade & Selection (5 of 6)



## Unweighted Figures of Merit

Factor	1	2	4	8
Memory Size (KB)	< 4	4 - 8	9 - 16	> 16
Clock Frequency (MHz)	< 1	1 - 9	10 - 20	> 20
Price (\$)	> 2.00	1.51 - 2.00	1.00 - 1.50	< 1.00



# Payload Processor & Memory Trade & Selection (6 of 6)



Factor	Weight	CY15B016Q-SXET		FM24CL16B-G		SC1628	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Memory Size	8	4	32	4	32	8	64
Clock Frequency	1	4	4	2	2	4	4
Price	2	1	2	2	4	1	2
<b>Weighted Total</b>		<b>38</b>		<b>38</b>		<b>70</b>	



# Real Time Clock Trade & Selection (1 of 3)



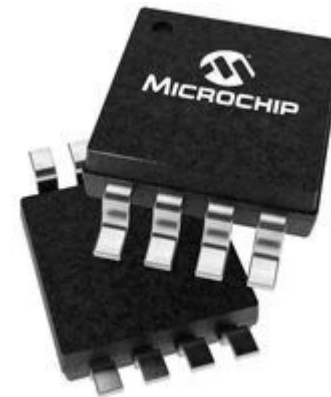
Name	Time Drift Accuracy (PPM)	Price (\$)	Current Draw ( $\mu$ A)
DS3231	$\pm 2$	12.89	70
<b>MCP7940MT-I/SN</b>	<b><math>\pm 20</math></b>	<b>0.67</b>	<b>1</b>
ISL1208IB8Z-TK	$\pm 20$	2.82	6

## Final Selection

**MCP7940MT-I/SN**

### Reasoning:

- Lowest price at \$0.67
- Low current draw at  $1\mu$ A
- Decent time drift accuracy at  $\pm 20$  PPM



Source: Digikey



# Real Time Clock Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Time Drift Accuracy (PPM)	> 15	10 - 15	5 - 9	< 5
Price (\$)	> 10	5 - 10	1 - 4	< 1
Current Draw ( $\mu$ A)	> 20	10 - 20	1 - 9	< 1



# Real Time Clock Trade & Selection (3 of 3)



Factor	Weight	DS3231		MCP7940MT-I/SN		ISL1208IB8Z-TK	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Time Drift Accuracy	1	8	8	1	1	1	1
Price	4	1	4	8	32	4	16
Current Draw	2	1	2	4	8	4	8
<b>Weighted Total</b>		<b>14</b>		<b>41</b>		<b>25</b>	



# Payload Antenna Trade & Selection (1 of 3)



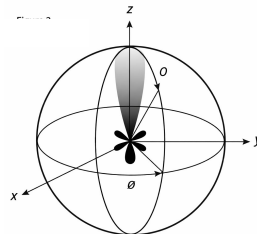
Name	Gain (dBi)	Range (km)	Antenna Length (mm)	Weight (g)	Price (\$)
A24-HASM-450	2.1	4.0	114.3	13.3	6.24
A09-HASM-675	2.15	10	150.0	18.0	30.25
<b>Integrated Wire</b>	<b>1.9</b>	<b>9.6</b>	<b>45.7</b>	<b>&lt; 1.0</b>	<b>0.00</b>

## Final Selection

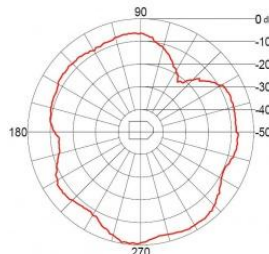
### Integrated Wire

#### Reasoning:

- Lowest length at 45.7mm
- Lowest weight at < 1.0g
- Lowest price at \$0.00

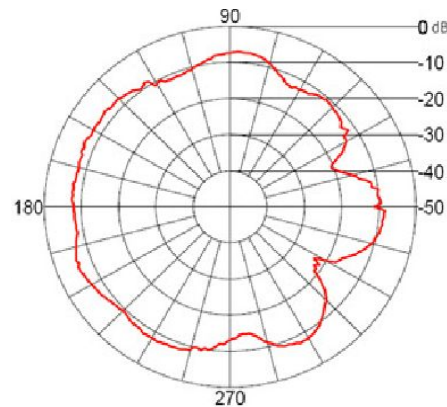


Source: Digi



Source: DigiKey

**NOTE:** All frequency ranges are compliant



Source: Digi International



Source: DigiKey



# Payload Antenna Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Gain (dBi)	< 1.0	1.0 - 1.5	1.6 - 2.0	> 2.0
Range (km)	< 1.0	1.0 - 5.0	5.1 - 9.0	> 9.0
Antenna Length (mm)	> 100.0	60.0 - 100.0	30.0 - 59.9	< 30.0
Mass (g)	> 30.0	15.0 - 30.0	5.0 - 14.9	< 5.0
Price (\$)	> 10.00	6.00 - 10.00	1.00 - 5.99	< 1.00



# Payload Antenna Trade & Selection

## (3 of 3)



Factor	Weight	A24-HASM-450		A09-HASM-675		Integrated Wire	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Gain	8	8	64	8	64	4	32
Range	4	2	8	8	32	8	32
Antenna Length	2	1	2	1	2	4	8
Mass	8	4	32	2	16	8	64
Price	1	2	2	1	1	8	8
<b>Weighted Total</b>		<b>108</b>		<b>115</b>		<b>144</b>	



# Payload Radio Configuration



## Radio

XBEE-PRO 900HP



Source: Digikey

## Transmission Control

Transmission of telemetry will only begin when the CXON command is received

Transmission of telemetry will cease when the CXOFF command is received

XBEE radio will not be in broadcast mode

Simulation mode (SIM) will be independent of the transmission control

Flight states will be independent of the transmission control

Transmission of telemetry will continue after landing unless CXOFF command is received

NETID	Baud Rate
1093	9600

Transmission Frequency	Sampling Frequency
1Hz	1Hz



# Payload Telemetry Format (1 of 3)



## Telemetry Format

<TEAM\_ID>, <MISSION\_TIME>, <PACKET\_COUNT>, <MODE>, <STATE>, <ALTITUDE>, <TEMPERATURE>, <PRESSURE>, <VOLTAGE>, <CURRENT>, <GYRO\_R>, <GYRO\_P>, <GYRO\_Y>, <ACCEL\_R>, <ACCEL\_P>, <ACCEL\_Y>, <GPS\_TIME>, <GPS\_ALTITUDE>, <GPS\_LATITUDE>, <GPS\_LONGITUDE>, <GPS\_SATS>, <CMD\_ECHO>

## Example Packet

“1093,13:39:12,2,F,LAUNCH\_PAD,0.0,30.1,9550.5,10.4,2.53,0,0,0,0,0,0,13:39:11,0.4,38.2201  
79.3601,6,CMD1093CAL”



# Payload Telemetry Format (2 of 3)



Telemetry	Description	Units
<TEAM_ID>	Team identification number	N/A
<MISSION_TIME>	UTC time starting once command was sent	hh:mm:ss ± 1s
<PACKET_COUNT>	Integer count of telemetry packets sent	N/A
<MODE>	Represents either Flight mode or Sim. mode	N/A
<STATE>	Represents the current flight state	N/A
<ALTITUDE>	The height measured from the launch pad, measured using air pressure	m ± 0.1
<TEMPERATURE>	The internal temperature of the payload	°C ± 0.1
<PRESSURE>	The air pressure	kPa ± 0.1
<VOLTAGE>	The battery voltage of the CanSat payload	V ± 0.1
<CURRENT>	The current from the battery	A ± 0.01
<GYRO_R>	Gyro reading of roll	°/s



# Payload Telemetry Format (3 of 3)



Telemetry	Description	Units
<GYRO_P>	Gyro reading of pitch	°/s
<GYRO_Y>	Gyro reading of yaw	°/s
<ACCEL_R>	Accelerometer reading of roll	°/s <sup>2</sup>
<ACCEL_P>	Accelerometer reading of pitch	°/s <sup>2</sup>
<ACCEL_Y>	Accelerometer reading of yaw	°/s <sup>2</sup>
<GPS_TIME>	GPS receiver time recorded in UTC time	hh:mm:ss ± 1s
<GPS_ALTITUDE>	GPS receiver altitude above mean sea level	m ± 0.1
<GPS_LATITUDE>	GPS receiver latitude degree readings	°North ± 0.0001
<GPS_LONGITUDE>	GPS receiver longitude degree readings	°West ± 0.0001
<GPS_SATS>	GPS receiver satellite count	N/A
<CMD_ECHO>	Commands received & processed by CanSat	N/A



# Payload Command Formats (1 of 2)



Commands	Argument(s)	Description	Example
CX	ON	Turns telemetry on	CMD,1093,CX,ON
	OFF	Turns telemetry off	CMD,1093,CX,OFF
ST	UTC	Sets the mission time to UTC time from the GPS module	CMD,1093,ST,UTC
SIM	ENABLE	Enable simulation mode	CMD,1093,SIM,ENABLE
	ACTIVATE	Activates simulation mode	CMD,1093,SIM,ACTIVATE
	DISABLE	Disables simulation mode	CMD,1093,SIM,DISABLE
SIMP	[float input]	Pressure input from SIM mode	CMD,1093,SIMP,101210
CAL	N/A	Calibrate the telemetered altitude to 0 meters	CMD,1093,CAL



# Payload Command Formats (2 of 2)



Commands	Device	Argument(s)	Description	Example
MEC	PROBE	ON	Releases the payload from container	CMD,1093,MEC,PROBE,ON
		OFF	Locks payload into container	CMD,1093,MEC,PROBE,OFF
MEC	EGG	ON	Release nose cone from payload	CMD,1093,MEC,EGG,ON
		OFF	Locks nose cone onto payload	CMD,1093,MEC,EGG,OFF
MEC	ACS	ON	Activates steering servos	CMD,1093,MEC,ACS,ON
		OFF	Deactivates steering servos	CMD,1093,MEC,ACS,OFF

**NOTE:** MEC commands are used primarily for testing purposes



---

# Electrical Power Subsystem (EPS) Design

**Aaron Watson**



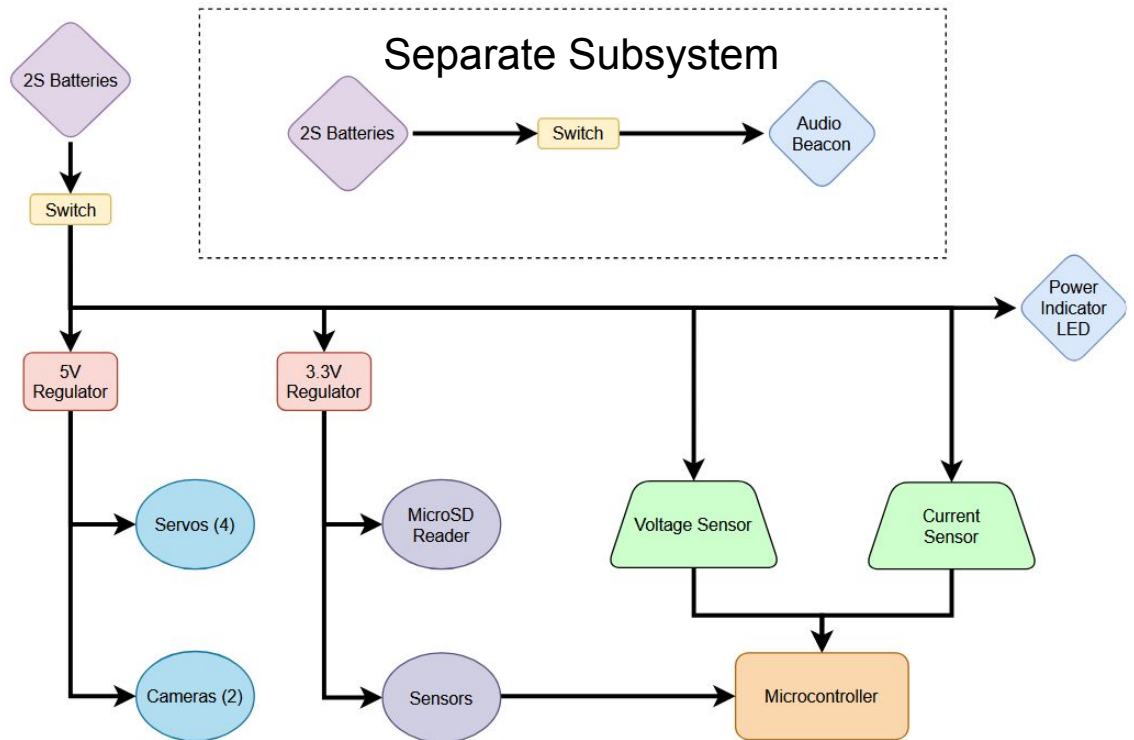
# EPS Overview



Components	Description
<b>Battery</b>	Provides power to the subsystem
<b>Switch</b>	Toggles power flow
<b>Regulator</b>	Changes voltage to be used safely
<b>Audio Beacon &amp; LED</b>	Provides auditory or visual signals for indication

**NOTE:**  
Low-Level components, including, but not limited to MOSFETs, resistors, and capacitors are not included

**NOTE: Batteries are non-LiPo**





# Payload Electrical Block Diagram

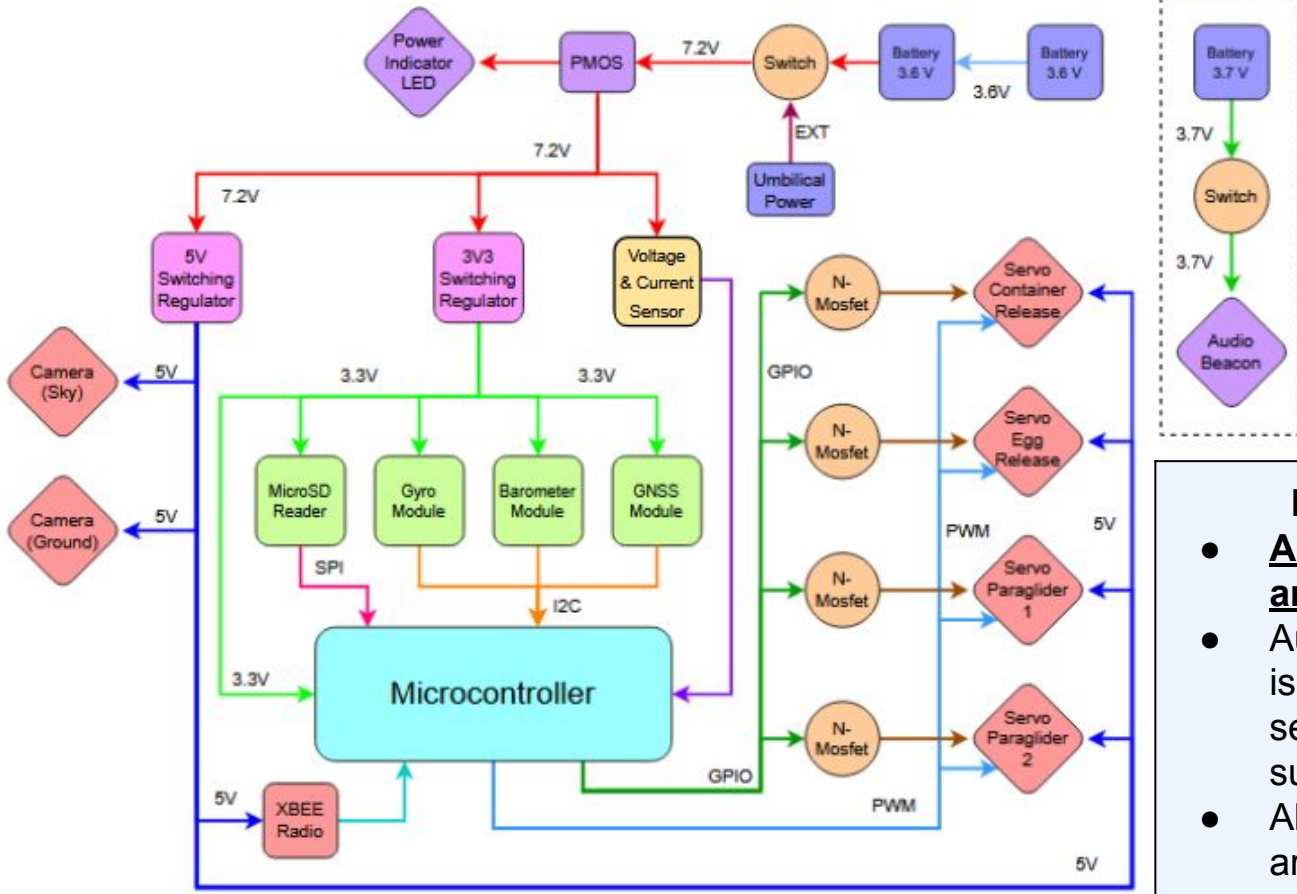


**Legend**  
Power

- 7.2 Volts
- 5 Volts
- 3.7 Volts
- 3.6 Volts
- 3.3 Volts

**Legend**  
Interfaces

- SPI
- UART
- I2C
- GPIO
- PWM
- ADC



Separate Subsystem

**NOTE:**

- All Batteries are non-LiPo
- Audio Beacon is on a separate subsystem
- All switches are easily accessible



# Payload Power Trade & Selection

## (1 of 3)



Name	Capacity (mAh)	Capacity (Wh)	Rechargeable (Y/N)	Max Current (A)	Mass (g)	Price (\$)
Vapcell A11 18350	1100	4.0	Y	10	26	12.99
SureFire SR123A CR123A	1550	4.65	N	3	22	5.48
Vapcell 14500 Yellow	1000	3.6	Y	3	25	14.60

### Final Selection

**Vapcell A11 18350**

#### Reasoning:

- Large capacity at 1100mAh / 4.0Wh
- Rechargeability
- Highest current output

#### Configuration:

Two batteries are connected in series

**NOTE: No LiPo batteries were traded**

**NOTE: Non-LiPo coin cell battery used for beacon subsystem**



Source: Vapcelltech



Source: DigiKey



# Payload Power Trade & Selection

## (2 of 3)



### Unweighted Figures of Merit

Factor	1	2	4	8
Capacity (mAh)	< 1500	1500 - 2500	2501 - 3500	> 3500
Rechargeable (Y/N)	-	N	Y	-
Max Current (A)	< 1	1 - 5	6 - 9	> 10
Mass (g)	> 50	36 - 50	25 - 35	< 25
Price (\$)	> 20	16 - 20	10 - 15	< 10



# Payload Power Trade & Selection

## (3 of 3)



Factors	Weight	Vapcell A11 18350		SureFire SR123A CR123A		Vapcell 14500 Yellow	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
mAh Capacity	8	1	8	2	16	1	8
Rechargeability	2	4	8	2	4	4	8
Max Current	4	8	32	2	8	2	8
Mass	2	4	8	8	16	4	8
Price	2	4	8	8	16	4	8
<b>Total</b>		<b>64</b>		<b>60</b>		<b>40</b>	



# Payload Power Budget (1 of 4)



Payload Power Budget							
Item	Voltage (V)	Active Current (mA)	Active Duration (h)	Idle Current (mA)	Idle Duration (h)	Energy (Wh)	Source
STM32H523RCT7	3.3	66.5	2	30.8	0	0.44	Datasheet
SAM-M10Q	3.3	10.0	2	4.5	0	0.07	Datasheet
BMP390	3.3	1.6	2	0.0014	0	0.01	Datasheet
BMI088	3.3	0.2	2	0.025	0	0.001	Datasheet
XBEE System	5	229.0	2	0.003	0	2.29	Datasheet
FS5106B (Main Release)	5	850.0	0.0028	0	1.9972	0.01	Estimate
MG92B (Nose Release)	5	850.0	0.0028	0	1.9972	0.01	Estimate
Hitec 32085S HS-85MG (1 of 2)	5	175.0	0.0333	0	1.9667	0.03	Estimate
Hitec 32085S HS-85MG (2 of 2)	5	175.0	0.0333	0	1.9667	0.03	Estimate



# Payload Power Budget (2 of 4)



Item	Voltage (V)	Active Current (mA)	Active Duration (h)	Idle Current (mA)	Idle Duration (h)	Energy (Wh)	Source
RunCam Split 4 V2 (Upward Camera)	5	450.0	0.1667	0	1.8333	0.38	Datasheet
RunCam Split 4 V2 (Downward Camera)	5	450.0	0.1667	0	1.8333	0.38	Datasheet
LEDS	3.3	20.0	2	0	0	0.13	Estimate
<b>Energy Subtotal (Wh): 3.080</b>							

**NOTE:** Assumed two hour flight time for power budget calculations



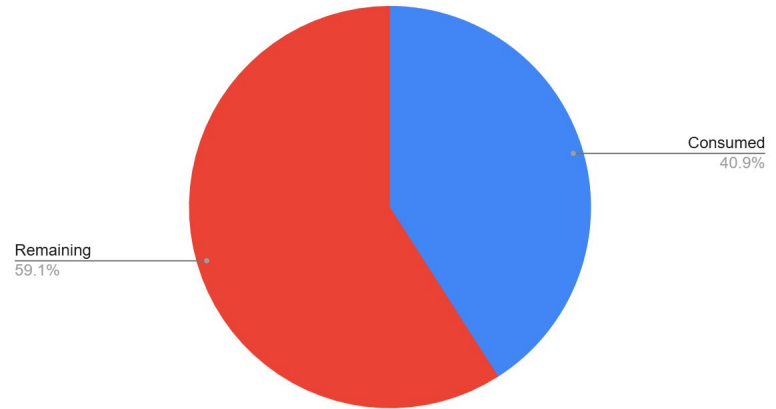
# Payload Power Budget (3 of 4)



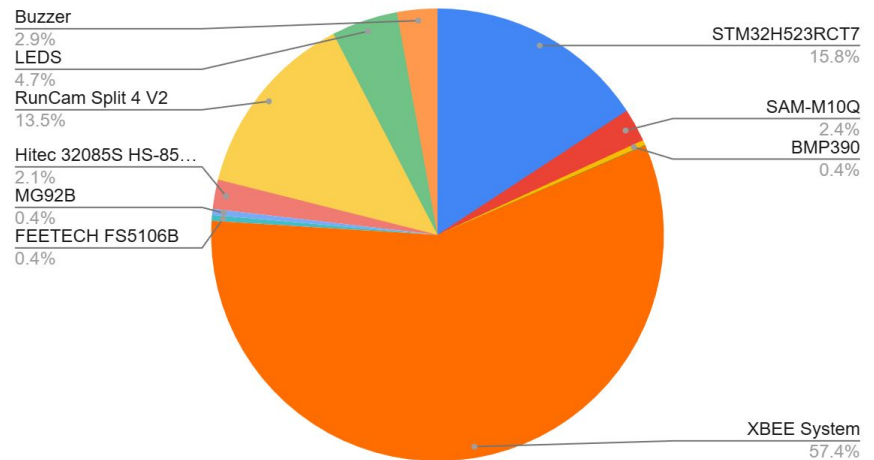
Energy Consumption Subtotal (Wh)	3.080
Power Supply Efficiency (%)	95
Total Energy Consumption (Wh)	3.242
Available Battery Energy (Wh)	7.920
Energy Margin (Wh)	4.678
Remaining Battery Percentage (%)	59.06

**NOTE:** Percentage usage by component applies to percent usage consumed

Battery Usage



Percent Usage by Component



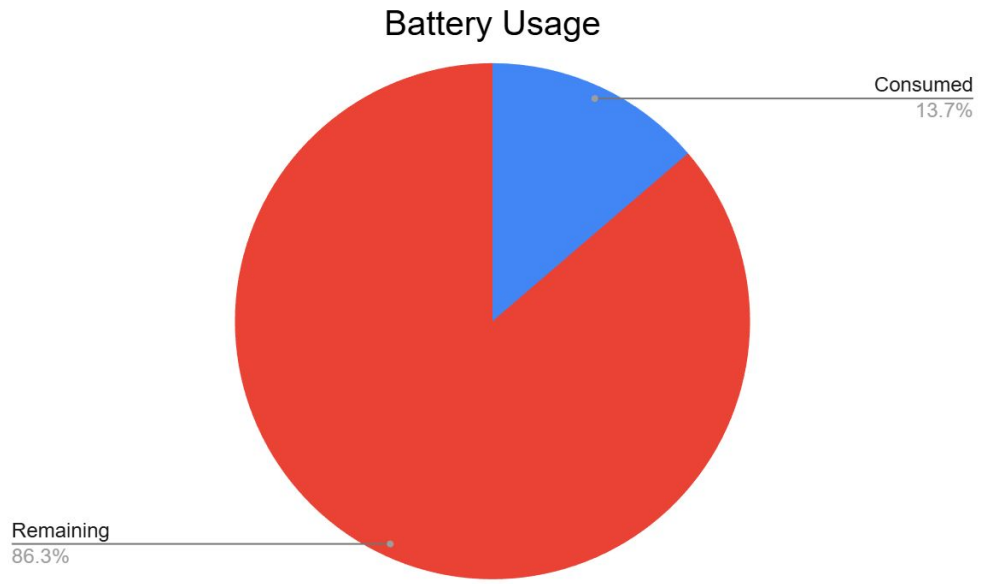


# Payload Power Budget (4 of 4)



Audio Beacon Subsystem Power Budget							
Item	Voltage (V)	Active Current (mA)	Active Duration (h)	Idle Current (mA)	Idle Duration (h)	Energy (Wh)	Source
Audio Beacon	5	8	2	0	0	0.08	Datasheet

Energy Consumption Subtotal (Wh)	0.08
Power Supply Efficiency (%)	95
Total Energy Consumption (Wh)	0.084
Available Battery Energy (Wh)	0.612
Energy Margin (Wh)	0.528
Remaining Battery Percentage (%)	86.27





---

# Flight Software (FSW) Design

**Ethan Denoncourt**



# FWS Overview



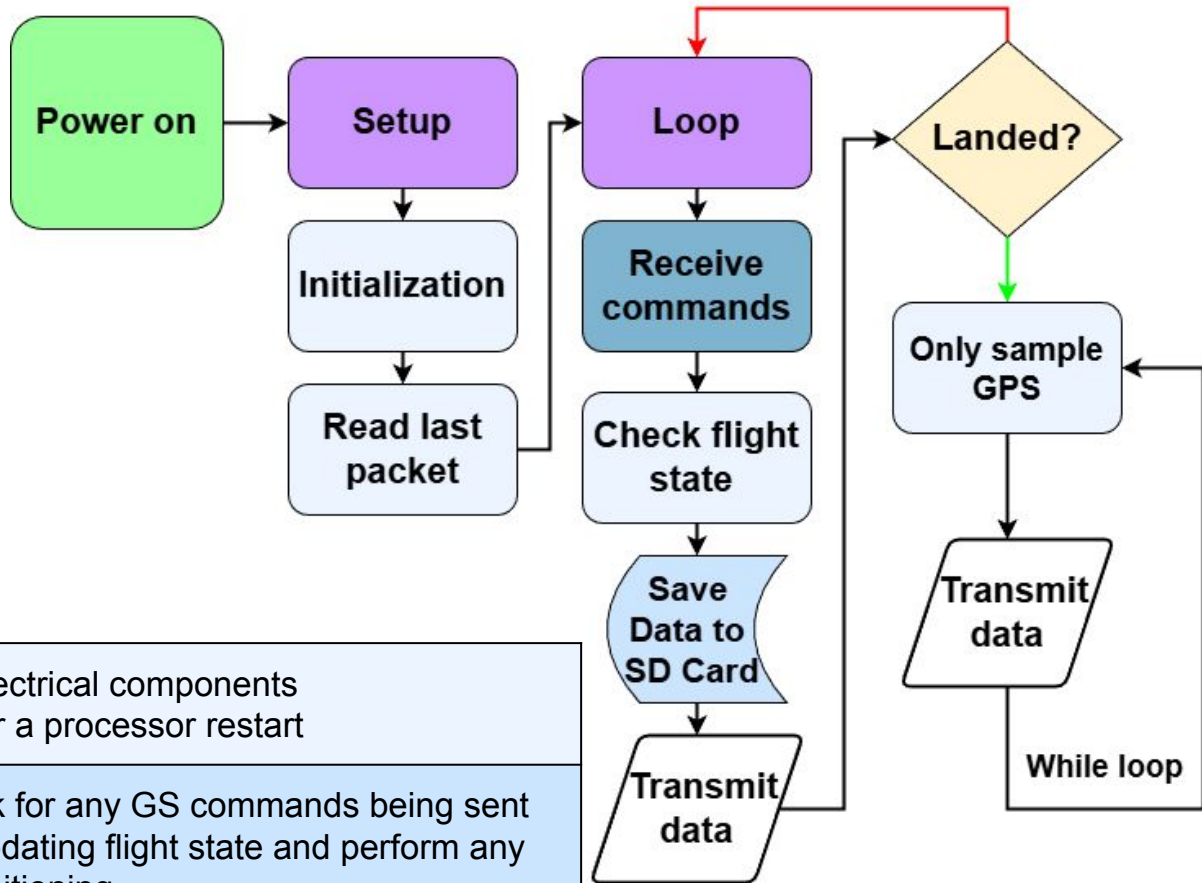
The FWS uses the Arduino IDE platform and C++ language



Source: Sparkfun



Source: github

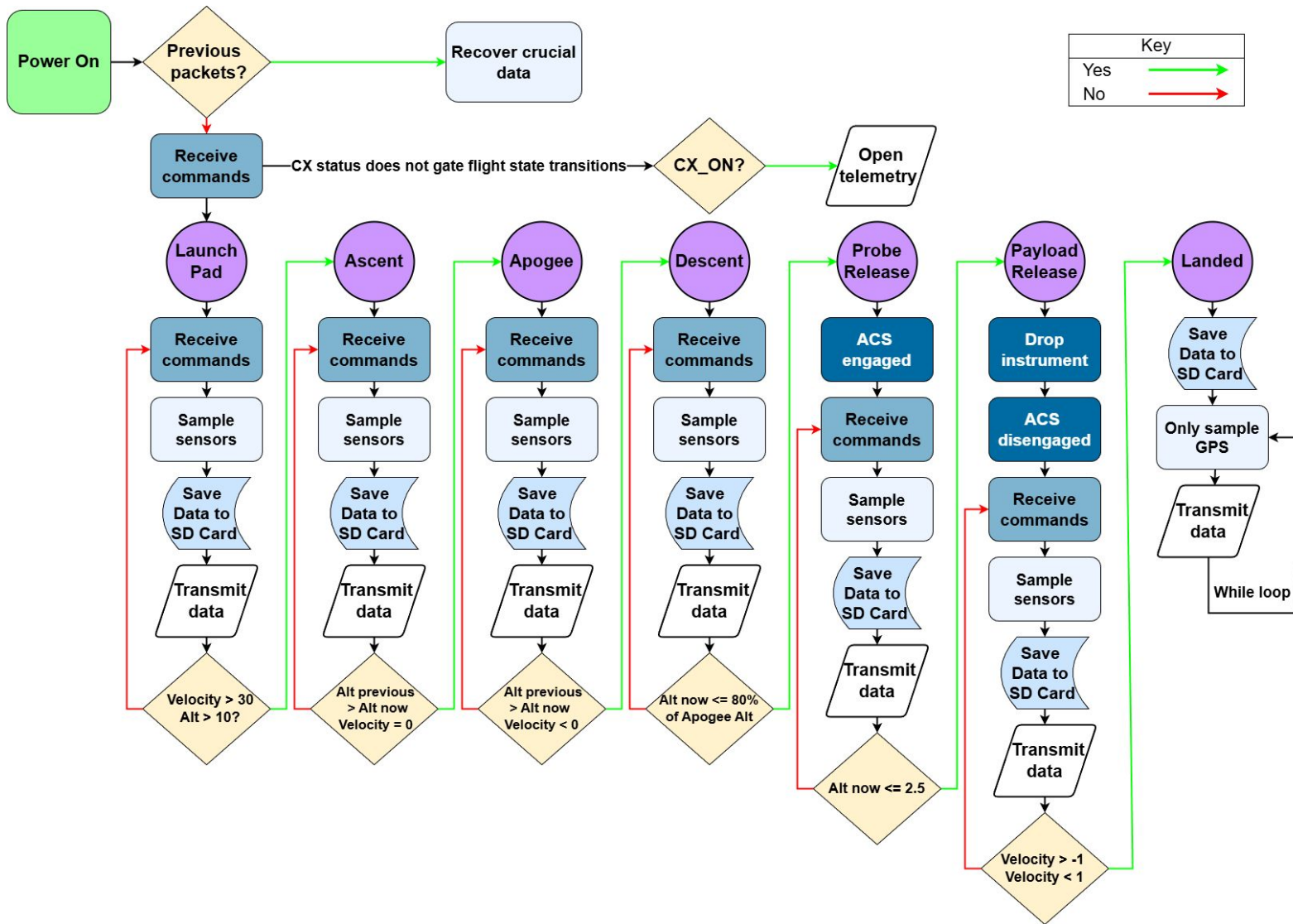


<b>Setup</b>	<b>Initialization</b> - Initialize all electrical components <b>Read last packet</b> - Check for a processor restart
<b>Loop</b>	<b>Receive commands</b> - Check for any GS commands being sent <b>Check flight state</b> - Keep updating flight state and perform any necessary actions upon transitioning <b>Save data</b> - Keep saving all data to SD card <b>Transmit data</b> - Send out packets of data to the GS
<b>Landed</b>	<b>GPS sampling</b> - Limit sampling to only the GPS



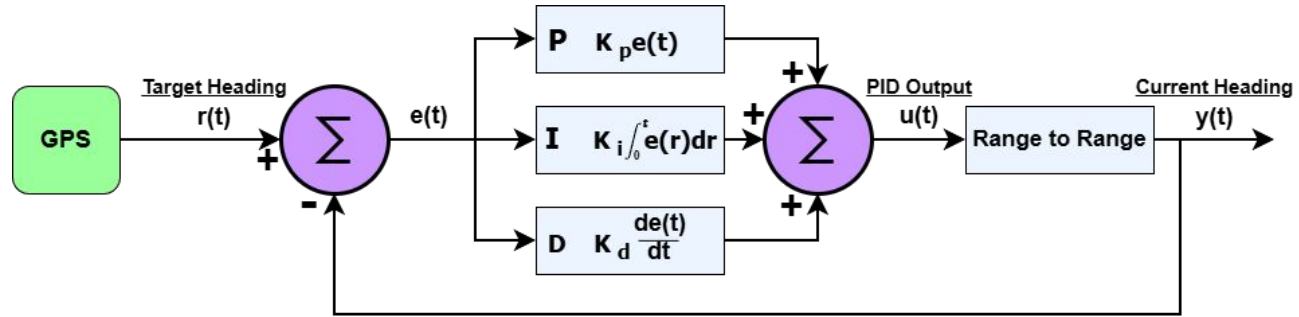
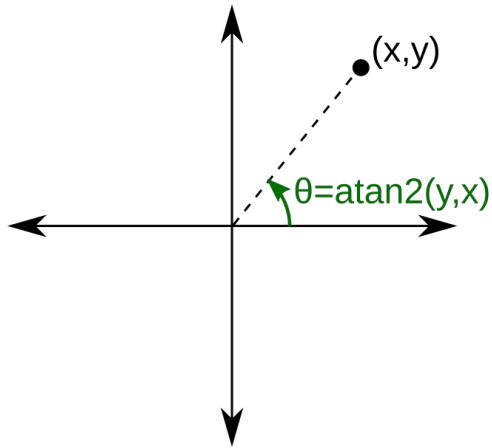
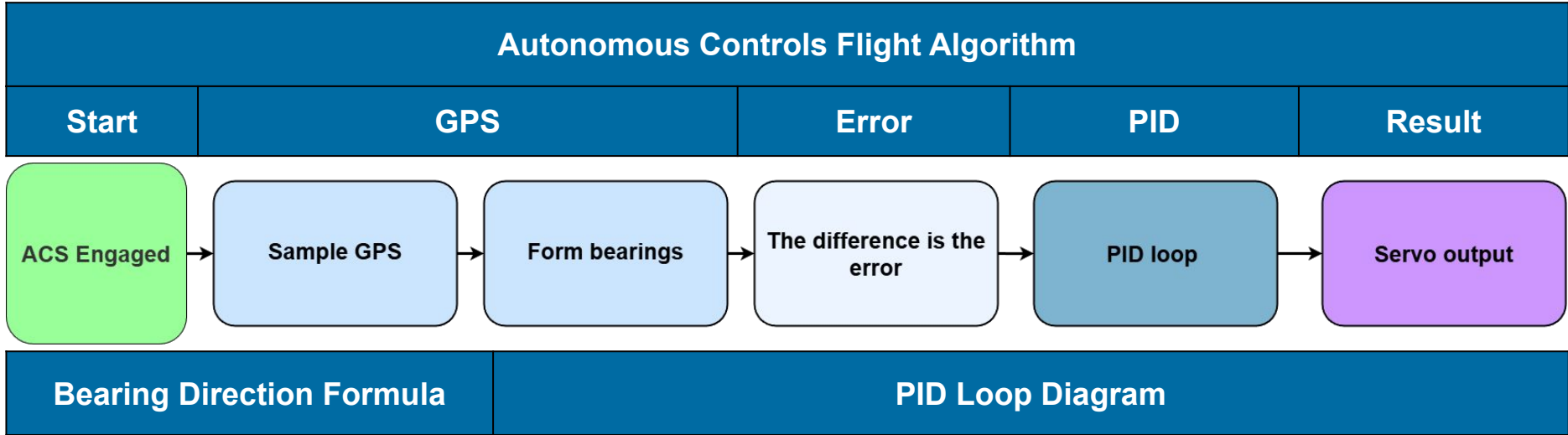


# Payload FSW State Diagram (1 of 3)





# Payload FSW State Diagram (2 of 3)

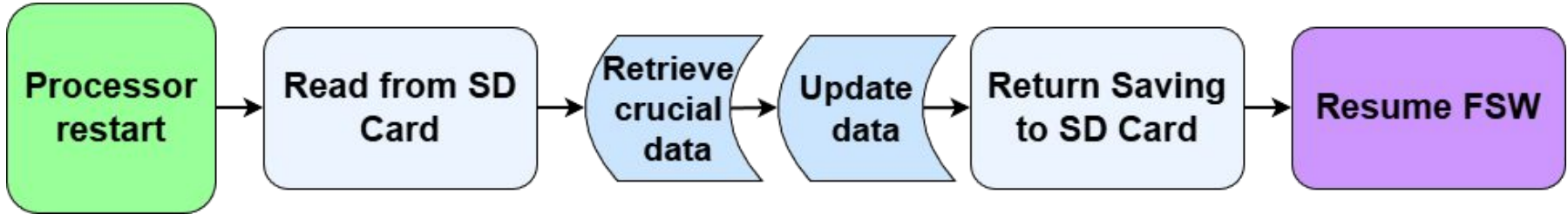




# Payload FSW State Diagram (3 of 3)



In the event of a processor restart the following will occur:



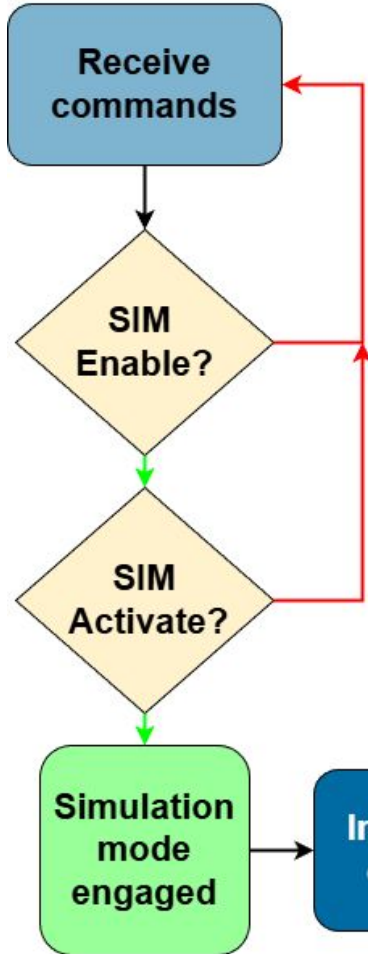
Crucial Data Used to Recover	Reasons for Processor Restart	Methods of Recovery
<ul style="list-style-type: none"> <li>- Flight state</li> <li>- Packet count</li> <li>- Launch-pad pressure</li> <li>- UTC mission time</li> <li>- Spool amount</li> <li>- CX defaults to on</li> </ul>	<p>Processor restart may occur when the microcontroller loses power or is disconnected</p>	<p>The program can read from the onboard SD Card, recover past data, and resume FSW</p>
Sampling Rate	Sending Rate	Saving Rate
Collect sensor data at 1Hz	Transmit data at 1Hz	Save data to SD card at 1Hz



# Simulation Mode Software



Key	
Yes	
No	

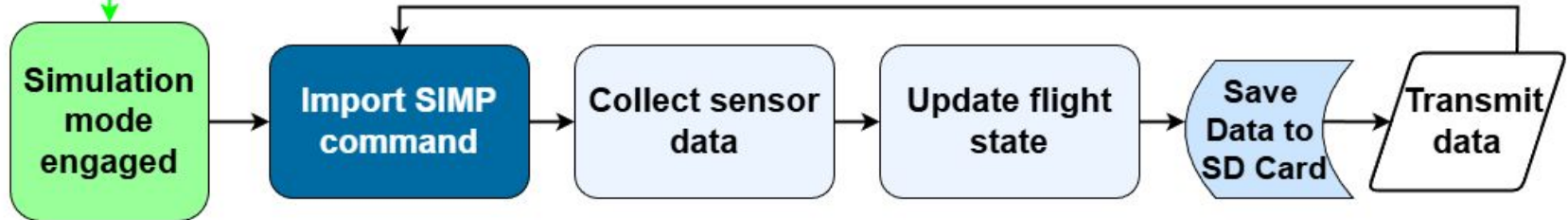


## Simulation Mode Commands

- Both SIM Enable and SIM Activate have to be commanded by the ground station to engage Sim Mode
- The SIMP command is used to import any desired pressure value

## Data Substitution

- Replace pressure sensor with imported pressure values
- The state machine works off imported pressure values and updates altitude accordingly, thus simulating flight
- Mechanisms activate based on flight state

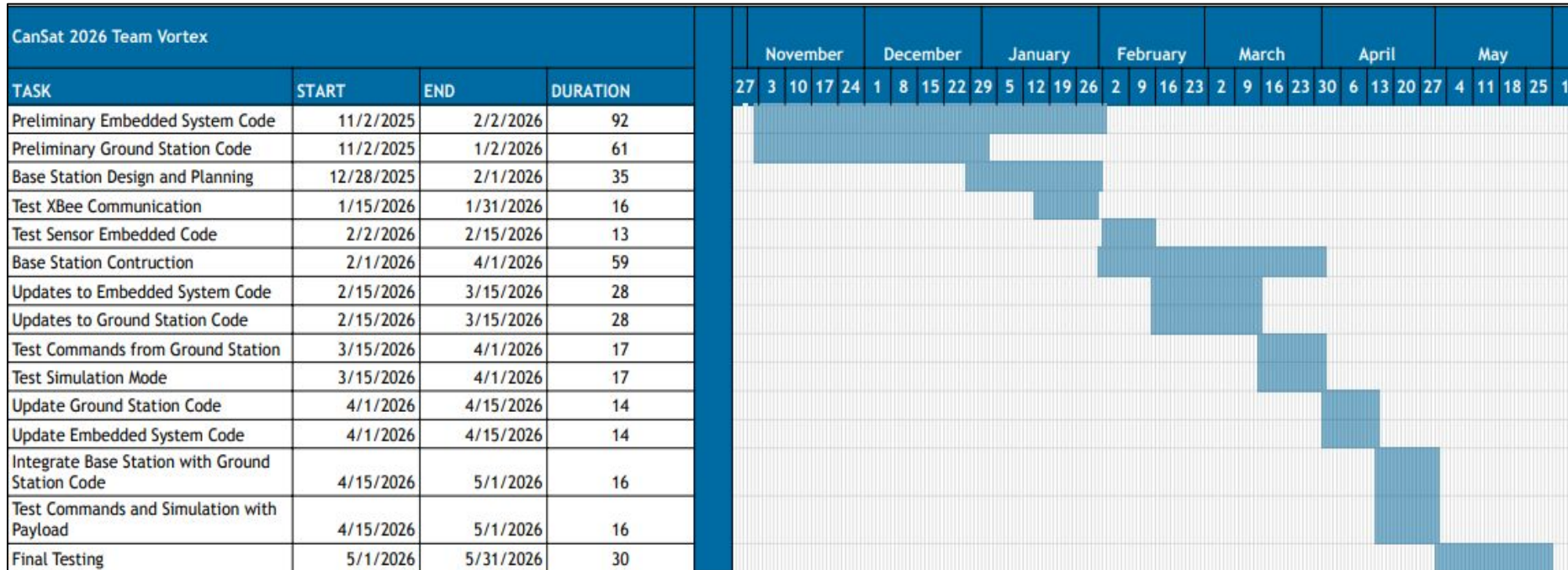




# Software Development Plan (1 of 2)



## Software Subsystem Development Sequence



## Prevention of Late Software Development

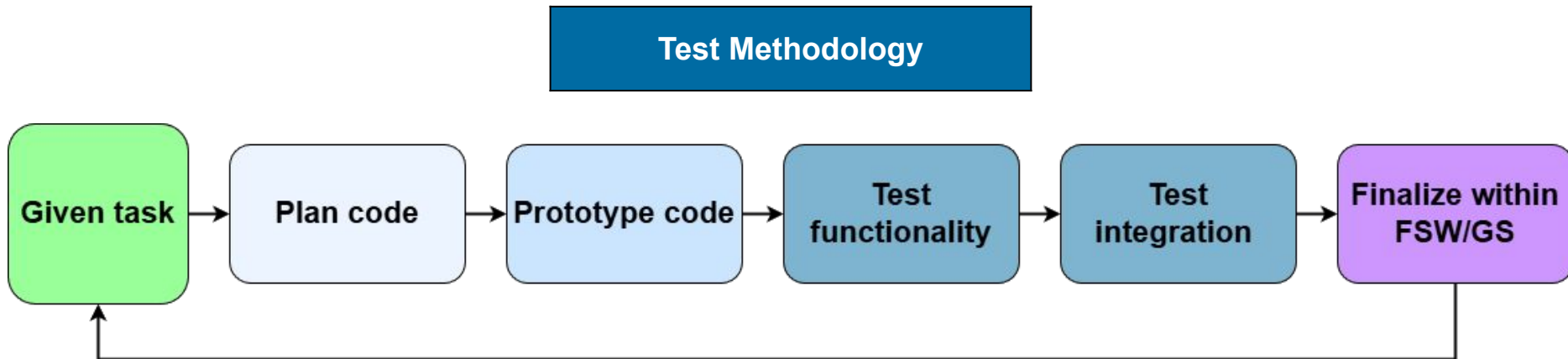
Prototyping and testing early is going to keep the software subteam from hindering the team's progress. Frequent communication between software and the other subteams will ensure project progression.



# Software Development Plan (2 of 2)



System	Embedded Software	Ground Station
Assigned	Ethan Denoncourt	Kayla Budziak
Environment	Arduino IDE	VS Code
Prototyping	Make sample code for everything to verify it can work then proceed to integrate	Create GS draft and test for accurate telemetry reception and command transmission





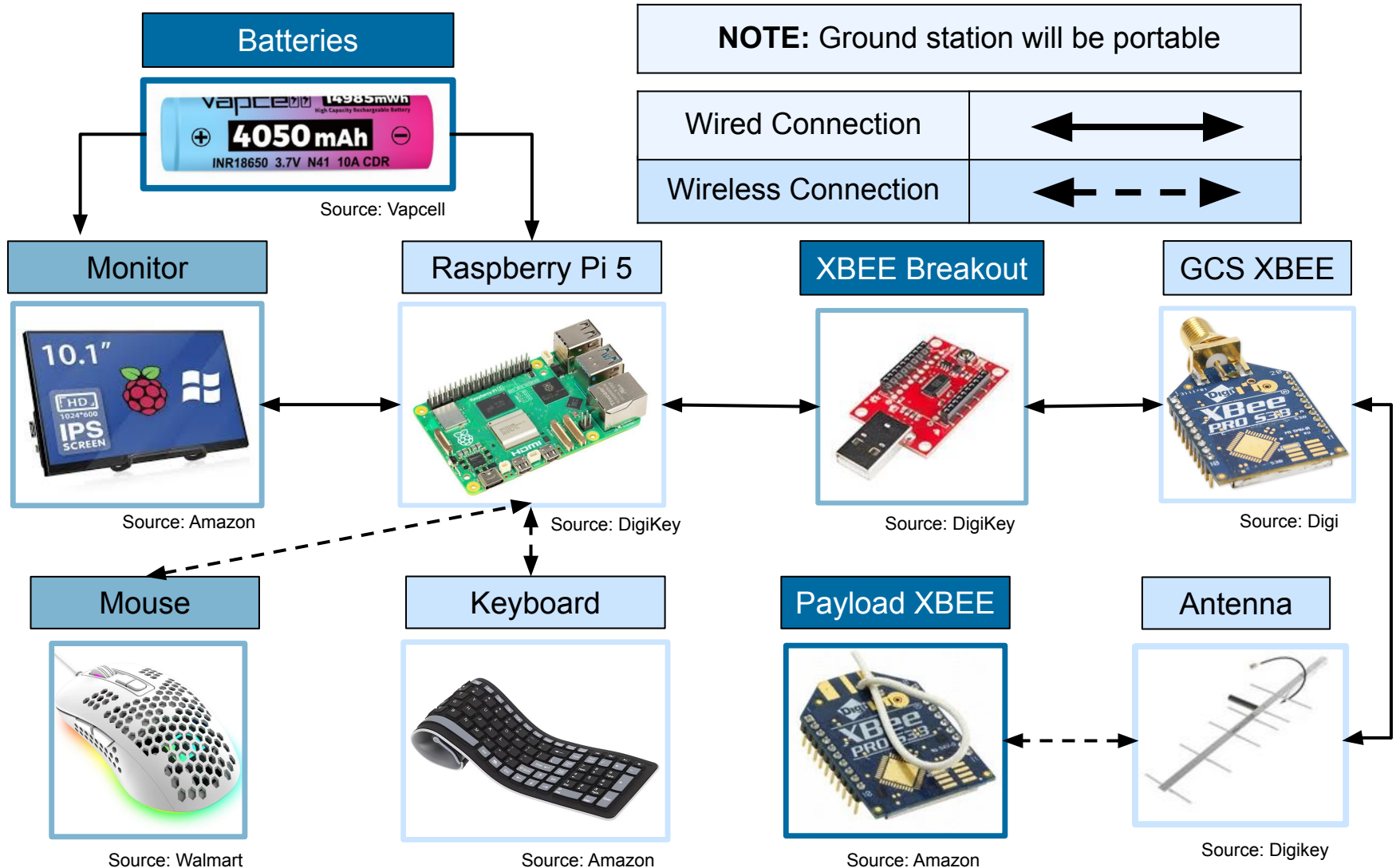
---

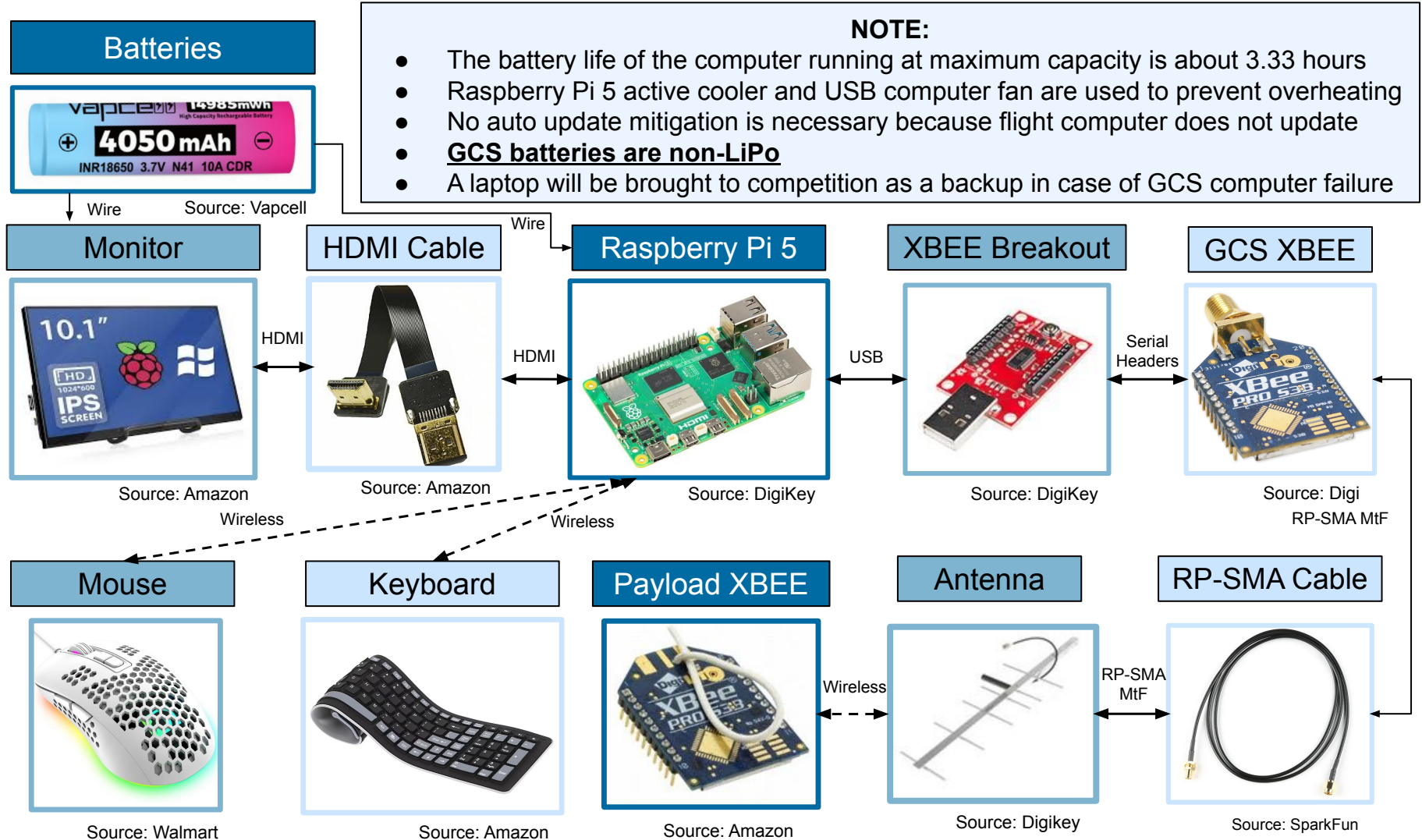
# Ground Control System (GCS) Design

**Kayla Budziak**



# GCS Overview







# GCS Antenna Trade & Selection (1 of 3)



Name	Gain (dBi)	Antenna Length (mm)	Horizontal Beamwidth (°)	Vertical Beamwidth (°)	Price (\$)
A09-Y8NF	8	410	65	60	45.00
A09-Y11NF	11	779.78	40	35	55.00
<b>PC906N</b>	<b>10.65</b>	<b>629</b>	<b>65</b>	<b>55</b>	<b>65.09</b>

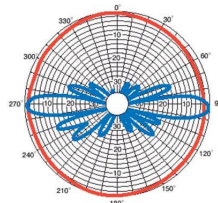
## Final Selection

### PC906N

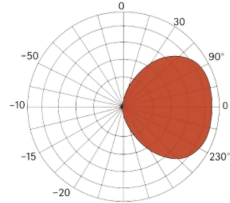
#### Reasoning:

- Good horizontal beamwidth at 65°
- Moderate vertical beamwidth at 55°

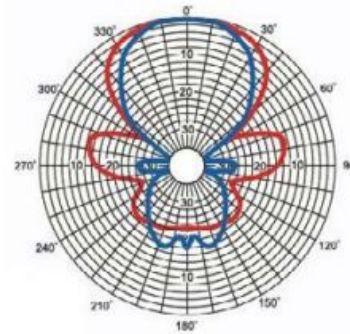
**NOTE:** All traded antennas are handheld



Source: C&F RF Antenna Inc



Source: Data Alliance



Source: TE Connectivity



Source: Digikey



# GCS Antenna Trade & Selection (2 of 3)



## Unweighted Figures of Merit

Factor	1	2	4	8
Gain (dBi)	< 4.0	4.0 - 8.5	8.6 - 10.5	> 10.5
Antenna Length (mm)	< 150	150 - 300	300.1 - 600	> 600
Horizontal Beamwidth (°)	< 45	45 - 55	56 - 65	> 65
Vertical Beamwidth (°)	< 40	40 - 50	51 - 60	> 60
Price (\$)	> 85.00	65.00 - 85.00	46.00 - 64.00	< 46.00



# GCS Antenna Trade & Selection (3 of 3)



Factor	Weight	A09-Y8NF		A09-Y11NF		PC906N	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Gain	8	2	16	8	64	8	64
Antenna length	2	2	4	1	2	8	16
Horizontal Beamwidth	4	4	16	1	4	4	16
Vertical Beamwidth	2	4	8	1	2	4	8
Price	1	8	8	2	2	2	2
<b>Weighted Total</b>		<b>52</b>		<b>74</b>		<b>106</b>	



# GCS Software (1 of 3)



FSW State:		CMD Echo:		Velocity (m/s):		
Mission Time						
Recieved Packets						
Lost Packets						
Payload Release						
Egg Release						
Temperature (°C)						
GPS Latitude (°N)						
GPS Longitude (°E)						
Satellites						
<b>SIM Enable</b>	<b>SIM Activate</b>					
<b>SIM Disable</b>	<b>ACS</b>					
<b>CX On</b>	<b>CX Off</b>					
<b>Calibrate</b>	<b>Set Time</b>					
<b>Release</b>	<b>Egg Drop</b>					

**NOTE:** There are no tabs in the GCS display and all units are SI



# GCS Software (2 of 3)



The GCS is coded in Python using Visual Studio (VS) Code

<b>COTS and Libraries</b>	<ul style="list-style-type: none"><li>• Graphs: pyqtgraph</li><li>• UI: PyQt5</li><li>• Serial Communication: pyserial</li><li>• CSV: csv</li><li>• Map: folium</li></ul>
<b>Plotting Software Design</b>	<p><b>Design</b></p> <ul style="list-style-type: none"><li>• Required altitude, voltage, current, acceleration, and rotation graphs are included</li><li>• Required mission time, received and lost packet counts, temperature, GPS position, and flight software state is included</li><li>• Additional live map, payload release state, egg release state, satellite count, command echo, and velocity were added</li></ul> <p><b>Real Time Plotting</b></p> <ul style="list-style-type: none"><li>• Graphs and tables will update at a rate of 1Hz as telemetry is received from the payload</li></ul>
<b>Commands</b>	<ul style="list-style-type: none"><li>• All descent mechanism will be able to be activated on command by pressing buttons on the GCS</li><li>• UTC time will be set within one second of UTC time prior to launch by clicking the “Set Time” button, which will read the time from the GPS’s built in UTC clock</li></ul>



# GCS Software (3 of 3)



<b>Calibration</b>	<ul style="list-style-type: none"><li>• Calibration command is sent to the payload when the “Calibrate” button is pressed on the GCS</li><li>• Sets altitude to zero and calibrates roll, pitch, and yaw axes</li></ul>
<b>Simulation Mode</b>	<ul style="list-style-type: none"><li>• Simulation mode will be entered when SIM ENABLE and SIM ACTIVATE buttons on the GCS are subsequently pressed</li><li>• GCS will transmit pressure data to simulate altitude at a rate of 1 Hz to the payload while in simulation mode</li></ul>
<b>Telemetry Data Recording</b>	<p><b>Packet Reception</b></p> <ul style="list-style-type: none"><li>• When a packet is received, data is separated by index</li><li>• Data is appended onto its respective variable specific list</li></ul> <p><b>Updating Data</b></p> <ul style="list-style-type: none"><li>• Received packet count increases by one each time a packet is received</li><li>• Lost packet count increases by one when a packet is not received</li><li>• Data table shows the most recently received data point for each category</li><li>• Graphs show the ten most recently received data points</li></ul>
<b>CSV File Creation</b>	<ul style="list-style-type: none"><li>• csv file is opened when GCS program is run</li><li>• Telemetry will simultaneously be displayed on the UI and saved to a csv file</li><li>• The csv file will be saved locally and presented to the judges after flight</li><li>• csv file includes all data transmitted from the payload</li><li>• csv file will be uploaded to a USB to be presented to the judges on flight day</li></ul>



---

# CanSat Integration and Test

**Kayla Budziak**



# CanSat Integration and Test Overview



Subject of Testing	Method of Testing	Passing Requirements
Subsystem	Individual subsystems will be tested as outlined in subsystem level testing	Subsystem testing will pass if it meets the passing requirements outlined in subsystem level testing
Integration	Subsystems will be constructed onto the final payload and tested for functionality as a whole unit	Integration testing will pass if the subsystems interact with one another as intended
Environmental	Required environmental tests as outlined in the mission guide will be performed	Environmental testing will pass if the CanSat survives all tests without structural or electrical damage
Simulation	A file of pressure values will be read by and simulation mode will be run from the GCS	Simulation testing will pass if the CanSat goes through and reacts to the appropriate flight stages with the simulation data



# Subsystem Level Testing Plan



Subsystem	Method of Testing	Passing Requirements
Sensors	Sensors are angled, accelerated, and moved in space	All sensors return realistic data
CDH	Commands are sent from the ground station to the CanSat	Commands are read and the proper function is performed
EPS	Ensure proper voltage is going into each component and confirm a 2 hr battery life	The proper amount of voltage going into each component and the battery life is long enough
Radio Communication	Test XBEE communication using XCTU, then test range by increasing the distance between XBEE's	The XBEE's can send messages through XCTU and continue sending packets at a distance
FSW	Test real time clock, commands, and flight state changes	The clock is accurate, and flight states change and trigger mechanisms at the right times
Mechanical	Test release mechanisms, parachute and paraglider deployment, and steering controls	Parachute and paraglider deploy and servos move properly to trigger the appropriate mechanisms
Descent Control	Test descent speed of the payload and the descent speed of the egg	Payload descends at a rate of around 5 m/s and the egg at 2 m/s



# Integrated Level Functional Test Plan



Subsystem	Method of Testing	Passing Requirements
Descent Testing	Drop deployed payload from a high location and confirm an average velocity of 5 m/s	The descent of the payload is within the averaged range from the data received by the ground station
Communications	Test that telemetry and commands are properly send between XBEE radios	Telemetry is continuously received by the ground station at a rate of 1Hz
Mechanisms	Test that release mechanisms function at flight conditions and that steering servos work	All release mechanisms perform their specific functions and steering servos trigger properly
Deployment	Test that container properly separates from rocket	Container separates from rocket without interferences



# Environmental Test Plan



Test	Method of Testing	Passing Requirements
Drop Test	Power CanSat and verify telemetry is being received, then raise the CanSat so the cord is slack and release the CanSat	The drop test passes if the CanSat does not lose power, telemetry is still being received, and there is no damage to the payload
Thermal Test	Power CanSat and verify telemetry is being received, then place the payload in an insulated box and maintain a temperature from 55°C-60°C for two hours	The thermal test passes if the electrical components still function properly, the structure of the CanSat is still stable, and telemetry is still being transmitted
Vibration Test	Power CanSat and verify telemetry is being received, and place the payload on the sander and wait 5 seconds, repeat 4 times	The vibration test passes if all electrical and structural components remain intact and telemetry is received
Fit Check	Integrate payload into the container and check clearances and accessibility to the power switch	The fit check passes if the payload fits fully within the container and the power switch is accessible while payload is integrated into the container
Vacuum Test	Power CanSat and confirm telemetry is being received, then suspend CanSat in the vacuum chamber and start vacuum, stopping when peak altitude is reached	The vacuum test passes if release mechanisms trigger at their respective conditions, and telemetry is received for the duration of the test



# Simulation Test Plan



Subsystem	Method of Testing	Passing Requirements
Ground Station	Test that ground station is properly sending pressure values to the payload and updating related data displays simultaneously	The altitude graph is updating in relation to the pressure values and the flight state changes are showing in the data display
Flight Software	Test that pressure values are received and flight states update properly in relation to those pressure values	Pressure data is received from the ground station and flight states update at the appropriate conditions
Payload	Ensure that release mechanisms trigger in their respective phases of flight	All mechanisms function in response to flight state changes



# Mission Operations & Analysis

**Kayla Budziak**



# Overview of Mission Sequence of Events (1 of 2)



Flight Day Roles		
Role	Responsibility	Assigned Member(s)
Mission Control Officer	Manages the team at the time of the launch, verifies the ground station is ready, and counts down to launch	Kayla Budziak
Ground Station Crew	Monitors the ground station's reception of telemetry and issues commands to the CanSat	Ethan Denoncourt, Aaron Watson, Julien Bynum
Recovery Crew	Tracks the CanSat and recovers it once it has landed and presents it to the judges	Eshton Moyer, Will Goudy
CanSat Crew	Prepares the CanSat, integrates it onto the rocket, and verifies its status	Brooke Petrosky, Andrew Levrett, Rebekah Langford, Kenny Briggs



# Overview of Mission Sequence of Events (2 of 2)



Flight Day Schedule	
Event	Assigned Member(s)
Arrival	All
Check-In	Mission Control Officer
Ground Station Setup	Ground Station Crew
CanSat Assembly and Testing	CanSat Crew
CanSat Integration and Launch	CanSat Crew
CanSat Recovery	Recovery Crew
Flight Data Analysis	Ground Station Crew
Submission	Recovery Crew, Ground Station Crew
PFR	All



# Mission Operations Manual Development Plan



Task	Description	Completion
Flight Roles	Deciding which role each person will have on flight day	12/31/2025
Ground Station Setup	Establish the procedure for setting up the ground station	2/20/2026
Pre-Flight Testing	Determine what tests would be necessary to perform on flight day	3/20/2026
CanSat Integration	Establish the procedure for integrating the CanSat into the container and onto the rocket	3/20/2026
Flight Process	Determine how we will monitor the flight of the CanSat and when to send commands if necessary	4/20/2026
Recovery Process	Establish a system for recovering the CanSat based on the most recent GPS coordinates	4/20/2026

**NOTE:** The mission operations manual will be edited after each test launch if necessary



# CanSat Location and Recovery



## CanSat Location and Recovery

In order to recover the CanSat after launch, the recovery crew will listen for the payload audio beacon. Additional visual components, such as the brightly colored paraglider and nose cone, will help the recovery crew fine the CanSat in the field. Return information will be displayed on the CanSat in the event the recovery team is unable to locate the payload.

Component	Visibility
Audio Beacon	Plays 90dB noise
Paraglider	Brightly colored to be visible in field
Container	Brightly painted to be visible in field
Nose Cone	Brightly painted to be visible in field
Parachute	Brightly colored to be visible in field

## Recovery Information

CanSat Team #1093: Vortex  
601 John Wright Drive, Huntsville AL  
35805  
Kayla Budziak, kab0321@uah.edu,  
256-824-6595



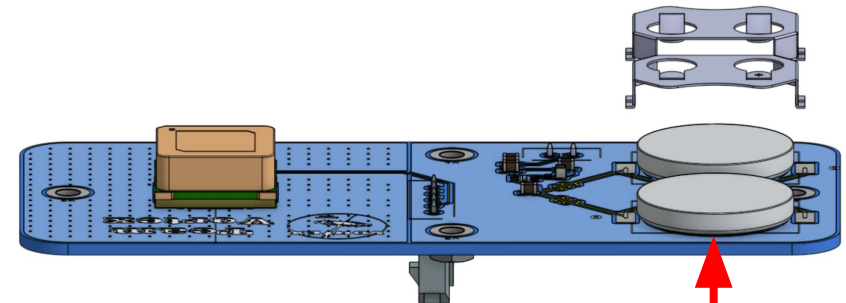
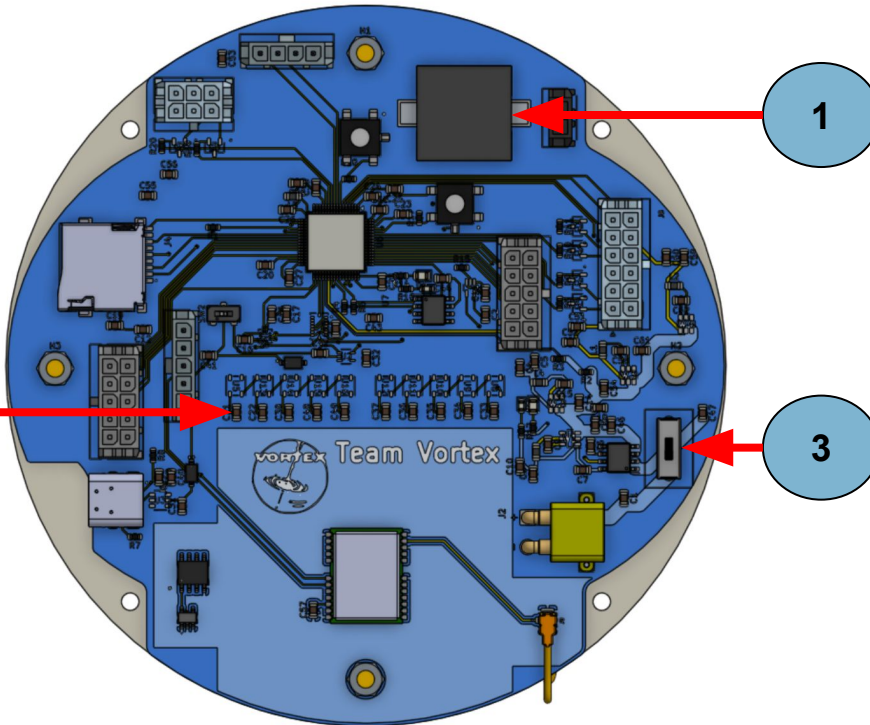
# CanSat Beacon Design (1 of 2)



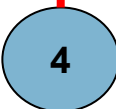
**NOTE:** Not all parts shown

Number	Part
1	Audio Beacon
2	LED Power Indicator
3	Power Switch
4	Coin Cell Batteries

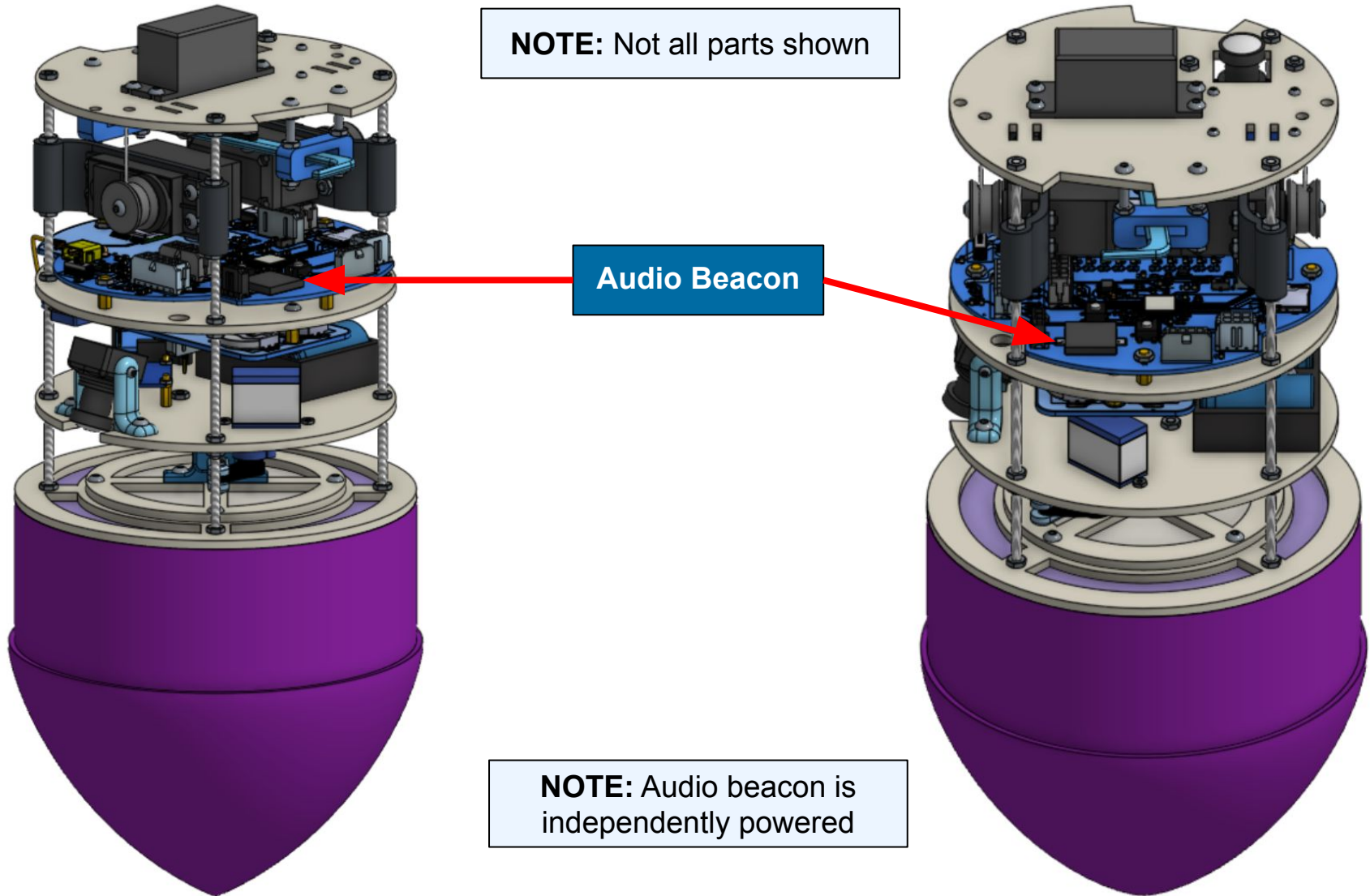
Top View



Exploded View



# CanSat Beacon Design (2 of 2)





---

# Requirements Compliance

**Kayla Budziak**



# Requirements Compliance Overview



We are compliant with 82 of 87 mission requirements, partially compliant with 5 of 87 mission requirements, and not compliant with 0 of 87 mission requirements.

RQ#	Description	Compliance	Notes
S8	CanSat structure must survive 15 Gs vibration.	Partial	Needs Testing
S9	CanSat shall survive 30 Gs shock.	Partial	Needs Testing
S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Partial	Needs Testing
S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Partial	Needs Testing
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial	Needs Testing



# Requirements Compliance (1 of 14)



RQ#	Requirement	Compliance	Slides	Notes
C1	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	45 - 47	
C2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	45 - 47	
C3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	45	
C4	After deployment, the CanSat payload and container shall descend at 15 m/s using a parachute that automatically deploys. Error is $\pm 3$ m/s.	Comply	45, 81, 106, 109	
C5	At 80% flight peak altitude, the payload shall be released from the container.	Comply	45, 81, 231	
C6	At 80% peak altitude, the payload shall deploy a paraglider descent control system.	Comply	45, 81, 231	



# Requirements Compliance (2 of 14)



RQ#	Requirement	Compliance	Slides	Notes
C7	The payload shall descend at 5 meters/second averaged over the entire descent within $\pm 3$ meters/sec with the paraglider descent control system.	Comply	45, 81, 107, 109	
C8	The payload shall steer toward a target location.	Comply	232	
C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	213, 233	
C10	The payload shall record video of the release of the payload from the container and the deployment of the paraglider descent control system.	Comply	37, 160 - 162	
C11	A second video camera shall point at the ground.	Comply	38, 165 - 167	
C12	The payload shall release a protected hens egg when the payload is 2 meters $\pm 0.5$ m above the ground without breaking the egg.	Comply	45, 81, 170 - 172, 175 - 177, 231	



# Requirements Compliance (3 of 14)



RQ#	Requirement	Compliance	Slides	Notes
C13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat battery and electronics.	Comply	220 - 221, 228, 257 - 258	
C14	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.	Comply	280 - 281	
S1	The CanSat and container mass shall be 1000 grams $\pm$ 10 grams.	Comply	198	
S2	The nose cone shall be symmetrical along the thrust axis.	Comply	46	
S3	Nose cone radius shall be exactly 70 mm.	Comply	40, 46, 126 - 127	
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	40, 126 - 127	



# Requirements Compliance (4 of 14)



RQ#	Requirement	Compliance	Slides	Notes
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	40	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	40	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	40, 126 - 127	
S8	CanSat structure must survive 15 Gs vibration.	Partial	N/A	Needs Testing
S9	CanSat shall survive 30 G shock.	Partial	N/A	Needs Testing
S10	The container shoulder length shall be 90 to 120 mm.	Comply	43, 134, 136	
S11	The container shoulder diameter shall be 136 mm.	Comply	43, 46 - 47, 134, 136	
S12	Above the shoulder, the container diameter shall be 140 mm.	Comply	43, 46 - 47, 134, 136	



# Requirements Compliance (5 of 14)



RQ#	Requirement	Compliance	Slides	Notes
S13	The container wall thickness shall be at least 2 mm when 3D printed and must not flex or be deformed when under stress.	Comply	43	
S14	The container length above the shoulder shall be 200 mm $\pm$ 5%.	Comply	43, 134, 136	
S15	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	45 - 47	
S16	The CanSat container can be used to restrain any deployable parts of the CanSat payload but shall allow the CanSat to slide out of the payload section freely.	Comply	44, 47, 150 - 152	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	34 - 36, 180, 187	
S18	The CanSat container shall meet all dimensions in section F.	Comply	43	



# Requirements Compliance (6 of 14)



RQ#	Requirement	Compliance	Slides	Notes
S19	The CanSat container materials shall meet all requirements in section F.	Comply	18, 21 - 22, 43	
S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 m/s.	Partial	N/A	Needs Testing
S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Partial	N/A	Needs Testing
M1	No pyrotechnical or chemical actuators are allowed.	Comply	111	
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.	Comply	N/A	N/A
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial	N/A	Needs Testing



# Requirements Compliance (7 of 14)



RQ#	Requirement	Compliance	Slides	Notes
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	186	
E1	Lithium polymer batteries are not allowed.	Comply	220 - 222, 239	
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.	Comply	222, 239	
E3	An easily accessible power switch through the container is required.	Comply	43	
E4	The container shall have small access holes for power switches of no more than 10 mm.	Comply	43	
E5	Power indicator is required.	Comply	34, 256	
E6	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Comply	225 - 227	



# Requirements Compliance (8 of 14)



RQ#	Requirement	Compliance	Slides	Notes
E7	The audio beacon shall operate on a separate battery.	Comply	220 - 222, 228	
E8	The audio beacon shall have an easily accessible power switch through the container.	Comply	43	
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	213	
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	213	
X3	XBEE radios shall not use broadcast mode.	Comply	213	
X4	The CanSat shall transmit telemetry once per second.	Comply	213, 233	
X5	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	214 - 216	



# Requirements Compliance (9 of 14)



RQ#	Requirement	Compliance	Slides	Notes
SN1	CanSat payload shall measure its altitude using air pressure.	Comply	215	
SN2	CanSat payload shall measure its internal temperature.	Comply	215	
SN3	CanSat payload shall measure its battery voltage.	Comply	215	
SN4	CanSat payload shall track its position using GPS.	Comply	216	
SN5	CanSat payload shall measure its acceleration and rotation rates.	Comply	215 - 216	
SN6	CanSat payload shall video record the deployment of the paraglider at 80% peak altitude.	Comply	37, 160 - 162	
SN7	CanSat payload shall video record the ground during descent.	Comply	38, 165 - 167	
SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Comply	38, 165 - 167	



# Requirements Compliance (10 of 14)



RQ#	Requirement	Compliance	Slides	Notes
SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	71, 77	
SN10	CanSat payload shall measure its battery current.	Comply	59, 214 - 215	
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.	Comply	245	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	245	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	214 - 215, 244	
G4	Each team shall develop their own ground station.	Comply	238 - 239, 243	
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Comply	243 - 244	



# Requirements Compliance (11 of 14)



RQ#	Requirement	Compliance	Slides	Notes
G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	215 - 216, 243	
G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Comply	243 - 244	
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Comply	243 - 244	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	239	
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.	Comply	238	



# Requirements Compliance (12 of 14)



RQ#	Requirement	Compliance	Slides	Notes
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.	Comply	234, 245	
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.	Comply	234, 245	
G13	The ground station shall use a table top or handheld antenna.	Comply	240	
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.	Comply	243	
G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Comply	243	



# Requirements Compliance (13 of 14)



RQ#	Requirement	Compliance	Slides	Notes
G16	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.	Comply	243, 245	
G17	The ground station shall be able to activate all mechanisms on command.	Comply	217 - 218, 243 - 245	
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.	Comply	214 - 215	
F2	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	214 - 215, 233	
F3	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	244	



# Requirements Compliance (14 of 14)



RQ#	Requirement	Compliance	Slides	Notes
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 file.	Comply	234, 245	
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.	Comply	234, 245	
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	234	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	217 - 218	
F8	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Comply	233	



---

# Management

**Kayla Budziak**



# CanSat Budget – Hardware (1 of 6)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
0.77oz Silnylon	\$13.56 /yd	2yd	\$27.12	Estimate	Amazon	
TPU Components	\$0.02 /g	51.72g	\$1.03	Estimate	Amazon	
Kevlar Line	\$10.99	1	\$10.99	Estimate	Amazon	
Thread	\$8.07	1	\$8.07	Estimate	Amazon	
Carbon Fiber Rods	\$1.80	2	\$3.60	Estimate	Amazon	
Urethane Foam Egg Holder	\$10.35	1	\$10.35	Actual	Apogee Rockets	
Press in Threaded Silver Inserts	\$6.04	2	\$12.08	Actual	Digikey	
Eye Bolt & Nut	\$4.00	1	\$4.00	Actual	McMaster	
Grommets	\$11.00	1	\$11.00	Actual	McMaster	
Threaded Rods	\$7.48	2	\$14.96	Estimate	McMaster	<b>X</b>
LS-955CR	\$18.65	2	\$37.30	Estimate	Mouser	



# CanSat Budget – Hardware (2 of 6)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
Nuts & Bolts	\$9.99	1	\$9.99	Estimate	Amazon	X
Chopped Carbon Fiber	\$0.08 per g	11.21g	\$0.90	Estimate	Amazon	
Fiberglass Layup	\$41.99	1	\$41.99	Estimate	Rock West Composites	X
Birch Plywood	\$0.20 per g	136.43g	\$27.29	Estimate	Amazon	X
PETG Filament	\$0.01 per g	4.57g	\$0.05	Estimate	Amazon	
CT427-HSN830MR	\$3.31	1	\$3.31	Actual	Digikey	
NEO-M9N	\$27.00	1	\$27.00	Actual	Digikey	
BMI088	\$5.23	1	\$5.23	Actual	Digikey	
RunCam Split 4 V2	\$82.99	2	\$165.98	Actual	RunCam	
STM32H562RIT6	\$4.57	1	\$4.57	Actual	Digikey	
FM24CL16B-G	\$1.60	1	\$1.60	Actual	Digikey	



# CanSat Budget – Hardware (3 of 6)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
XBEE-PRO 900HP	\$55.66	1	\$55.66	Actual	Digikey	<b>X</b>
Vapcell A11 18350	\$12.99	1	\$12.99	Actual	VapcellTech	
MCP7940MT-I/SN	\$0.67	1	\$0.67	Actual	Digikey	
BMP390	\$3.15	1	\$3.15	Actual	Digikey	
FS5106B Servo	\$21.19	1	\$21.19	Actual	Digikey	
MG92B Servo	\$11.95	1	\$11.95	Actual	Adafruit	
XBEE Breakout	\$14.50	1	\$14.50	Actual	Sparkfun	<b>X</b>
SAM-M10Q	\$31.50	1	\$31.50	Actual	Digikey	
SMA RF Antenna 2J	\$27.10	1	\$27.10	Actual	Digikey	
MSD-1-A	\$0.36	1	\$0.36	Actual	Digikey	
RFPC-SMA28-F	\$1.73	1	\$1.73	Actual	Digikey	



# CanSat Budget – Hardware (4 of 6)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
MLX90395KDC-BB A-001-RE	\$3.70	1	\$3.70	Actual	Mouser	
USBLC6-2SC6	\$0.36	1	\$0.36	Actual	Digikey	
USB4085-GF-A	\$0.88	1	\$0.88	Actual	Digikey	
Linear Voltage Regulator	\$0.12	1	\$0.12	Actual	Digikey	
AP63205WU-7	\$0.71	1	\$0.71	Actual	Mouser	
AP63205WU-7	\$0.96	1	\$0.96	Actual	Mouser	
Coin Cell	\$11.18	1	\$11.18	Actual	Digikey	
Coin Holder	\$0.38	1	\$0.38	Actual	Digikey	
JSTs	\$2.00	1	\$2.00	Estimate	Digikey	
MOSFETs	\$1.60	1	\$1.60	Estimate	Digikey	
534-1098 Holders	\$5.56	1	\$5.56	Actual	Mouser	



# CanSat Budget – Hardware (5 of 6)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
Resistors	\$1.60	1	\$1.60	Estimate	Digikey	
Capacitors	\$3.00	1	\$3.00	Estimate	Digikey	
EG1218	\$0.84	3	\$2.32	Actual	Digikey	
Inductors	\$3.00	1	\$3.00	Estimate	Digikey	
EAST1818RGBICA 0	\$0.94	5	\$4.70	Actual	Digikey	
LEDs	\$3.00	1	\$3.00	Estimate	Digikey	
PCBs	\$5.00	2	\$10.00	Actual	JLPCB	
AP.12F.07.0045A	\$14.29	1	\$14.29	Actual	Digikey	
I-PEX MHFI Connector	\$1.03	1	\$1.03	Actual	Digikey	
<b>Total Hardware Cost: \$634.72</b>						



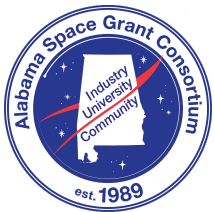
# CanSat Budget – Hardware (6 of 6)



Hardware Cost Totals	
Mechanical Subteam	\$174.93
Electrical Subteam	\$459.79
Total Cost of Payload	\$634.72

Project Budget	Hardware Cost	Budget Margin
\$1000	\$634.72	\$365.28

Total Mission Cost	
Total Cost of Payload	\$634.72
Total Other Costs	\$3872.49
Total Cost of Competition	\$4507.21



**NOTE:** Funding provided by Alabama Space Grant Consortium





# CanSat Budget – Other Costs (1 of 2)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
Raspberry Pi 5	\$64	1	\$64	Actual	Digikey	
Raspberry Pi Screen	\$54.99	1	\$54.99	Actual	Amazon	
Keyboard	\$26.31	1	\$26.31	Actual	Amazon	
Mouse	\$9.99	1	\$9.99	Actual	Amazon	X
Batteries	\$15.99	2	\$31.98	Actual	Vapcell	
HDMI FFC Cable	\$18.99	1	\$18.99	Actual	Amazon	
HDMI Adapter	\$11.99	1	\$11.99	Actual	Walmart	
Raspberry Pi Pico 2	\$5.00	1	\$5.00	Actual	Digikey	
LEDs	\$13.99	1	\$13.99	Actual	Amazon	
Yagi Antenna	\$65.09	1	\$65.09	Actual	Master Electronics	X



# CanSat Budget – Other Costs (2 of 2)



Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
XBEE-PRO 900HP and Breakout	\$70.16	1	\$70.16	Actual	Sparkfun	X
Hotel (per person)	\$150	10	\$1500	Estimate	N/A	
Travel (per person)	\$100	10	\$1000	Estimate	N/A	
Food (per person)	\$100	10	\$1000	Estimate	N/A	
<b>Total Other Costs: \$3872.49</b>						

Total Mission Cost	
Total Cost of Payload	\$634.72
Total Other Costs	\$3872.49
Total Cost of Competition	\$4507.21



**NOTE:** Funding provided by Alabama Space Grant Consortium





# Program Schedule Overview (1 of 2)



## Competition Timeline

Assigned: Full Team

CanSat 2026 Team Vortex				November							December					January				February				March				April				May						
TASK	START	END	DURATION	27	3	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1			
Team Formation	10/28/2025	11/2/2025	5	█																																		
MCR Phase	10/28/2025	12/1/2025	34	█																																		
PDR Phase	12/1/2025	2/21/2026	82								█																											
PDR Due	1/30/2026	1/30/2026	0																																			
PDR Presentations	2/2/2026	2/20/2026	18																																			
Test Launch 1 Phase	2/21/2026	3/15/2026	22																																			
CDR Phase	3/16/2026	4/25/2026	40																																			
CDR Due	3/27/2026	3/27/2026	0																																			
CDR Presentations	4/6/2026	4/24/2026	18																																			
Test Launch 2 Phase	4/25/2026	5/11/2026	16																																			
Environmental Testing Phase	5/11/2026	6/4/2026	24																																			
Environmental Testing Due	5/22/2026	5/22/2026	0																																			
Competition Phase	6/5/2026	6/7/2026	2																																			

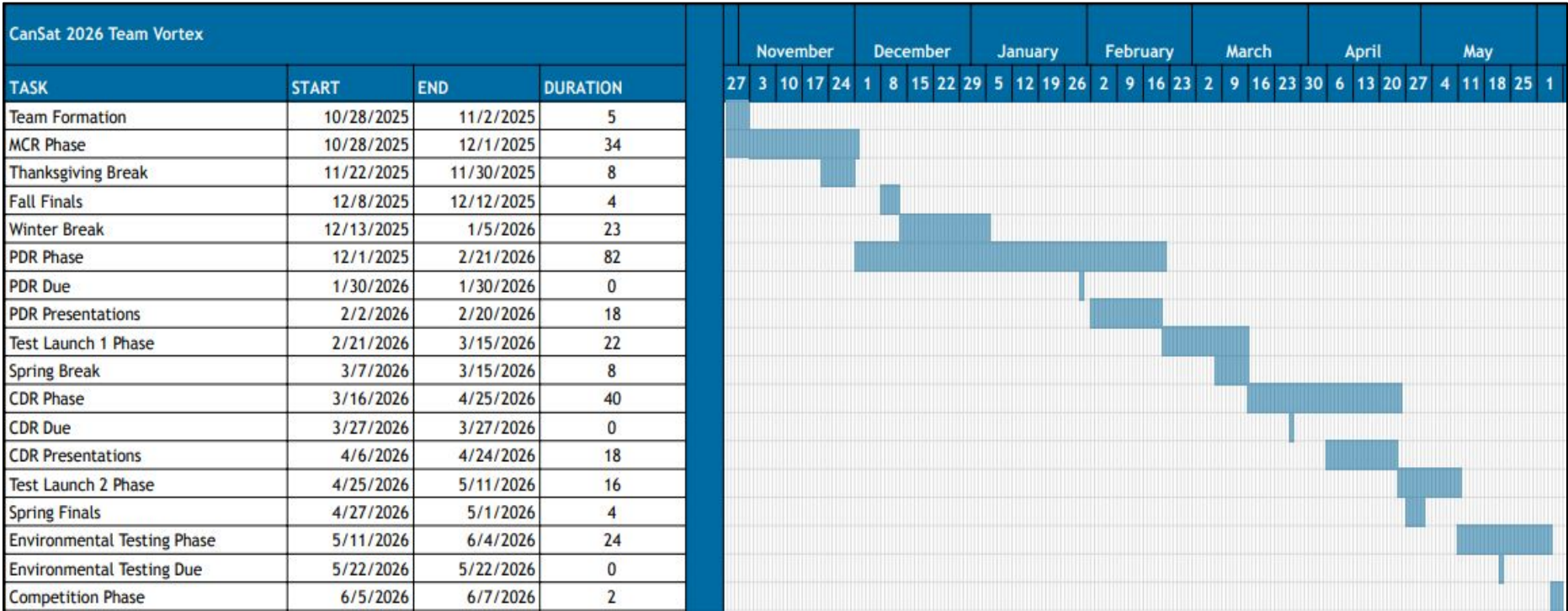


# Program Schedule Overview (2 of 2)



## Full Project Timeline

Assigned: Full Team









# Detailed Program Schedule (3 of 3)



## Software Timeline

Assigned: Kayla Budziak, Ethan Denoncourt

CanSat 2026 Team Vortex																															
TASK	START	END	DURATION	November					December					January					February				March			April			May		
				27	3	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4
Preliminary Embedded System Code	11/2/2025	2/2/2026	92	[Task bar]																											
Preliminary Ground Station Code	11/2/2025	1/2/2026	61	[Task bar]																											
Base Station Design and Planning	12/28/2025	2/1/2026	35	[Task bar]																											
Test XBee Communication	1/15/2026	1/31/2026	16	[Task bar]																											
Test Sensor Embedded Code	2/2/2026	2/15/2026	13	[Task bar]																											
Base Station Construction	2/1/2026	4/1/2026	59	[Task bar]																											
Updates to Embedded System Code	2/15/2026	3/15/2026	28	[Task bar]																											
Updates to Ground Station Code	2/15/2026	3/15/2026	28	[Task bar]																											
Test Commands from Ground Station	3/15/2026	4/1/2026	17	[Task bar]																											
Test Simulation Mode	3/15/2026	4/1/2026	17	[Task bar]																											
Update Ground Station Code	4/1/2026	4/15/2026	14	[Task bar]																											
Update Embedded System Code	4/1/2026	4/15/2026	14	[Task bar]																											
Integrate Base Station with Ground Station Code	4/15/2026	5/1/2026	16	[Task bar]																											
Test Commands and Simulation with Payload	4/15/2026	5/1/2026	16	[Task bar]																											
Final Testing	5/1/2026	5/31/2026	30	[Task bar]																											



# Conclusions (1 of 4)



## Mechanical Conclusions

### Major Accomplishments

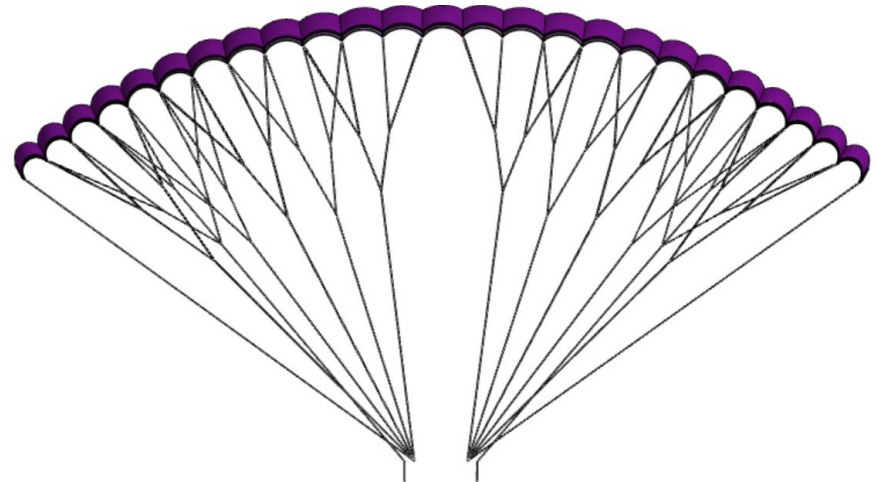
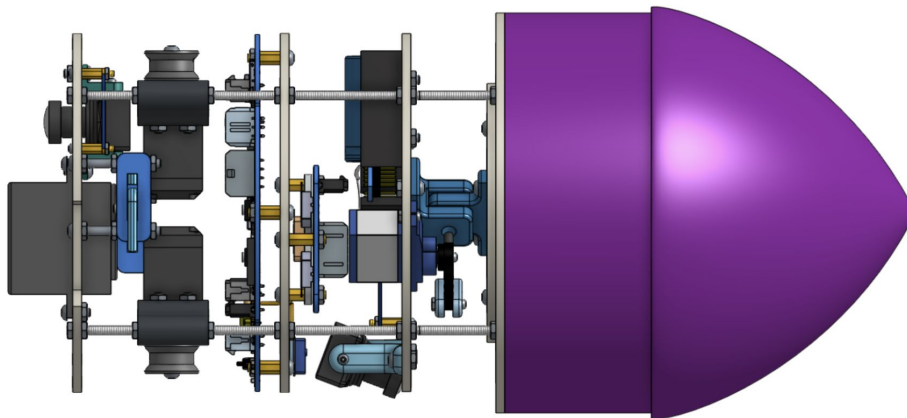
- Two unique designs have been created
- A final payload has been designed
- Calculations to verify descent rate compliance have been achieved

### Major Unfinished Work

- Construction of first prototype and integrating electrical components
- Testing systems and ensuring validity of assumptions made during design
- Parts manufacturing and defining better ways to construct strong, lightweight components

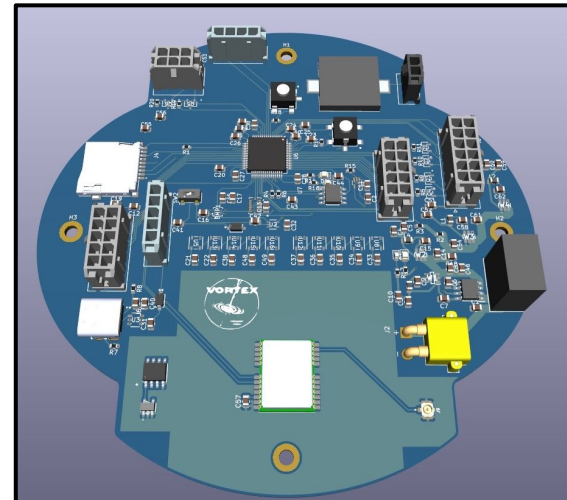
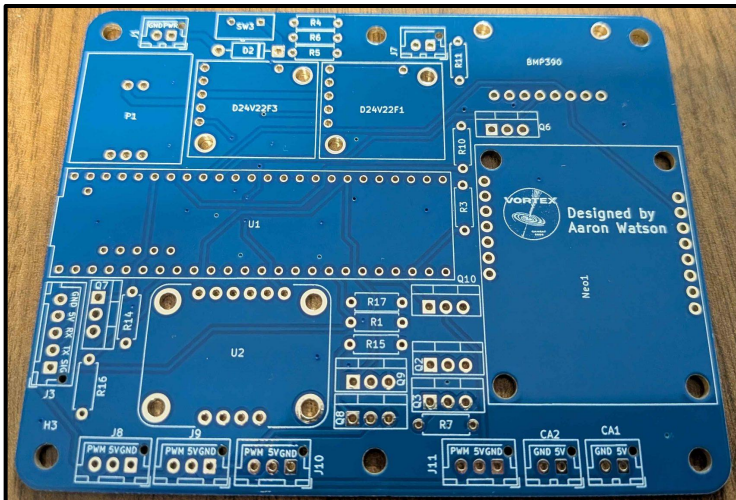
### Readiness to Proceed

Preliminary manufacturing procedures have been discussed and a schedule is in place to ensure timely completion and testing of prototypes



## Electrical Conclusions

<p><b>Major Accomplishments</b></p>	<ul style="list-style-type: none"> <li>• Traded and chosen sensors for all electrical components &amp; ordered parts</li> <li>• Completed the power budget</li> <li>• Completed the schematic and have designed PCBs</li> <li>• THT PCB has been ordered and has arrived</li> </ul>
<p><b>Major Unfinished Work</b></p>	<ul style="list-style-type: none"> <li>• Still need to order SMD PCB</li> <li>• Sensor testing still needs to be conducted</li> </ul>
<p><b>Readiness to Proceed</b></p>	<p>Parts have been ordered and will be assembled on arrival with ordered PCBs in order to complete assembly in time and integrate with other subsystems</p>

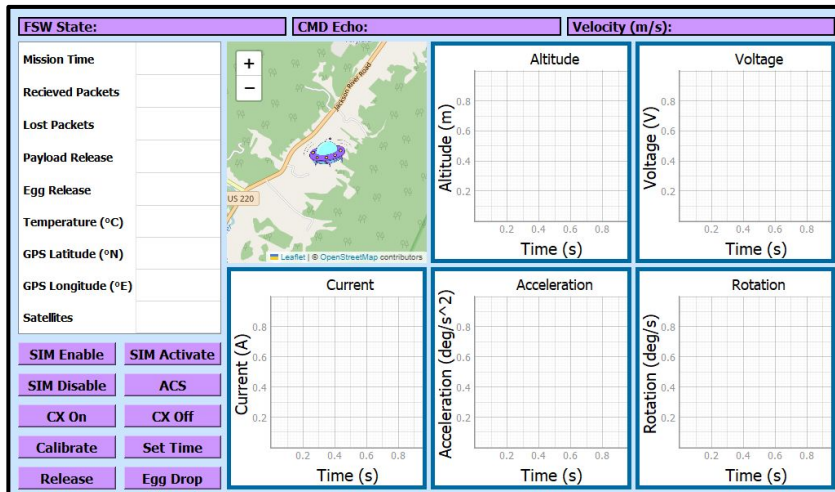




# Conclusions (3 of 4)



Software Conclusions	
Major Accomplishments	<ul style="list-style-type: none"> <li>• Payload and ground station antennas have been chosen</li> <li>• Significant progress has been made on FSW</li> <li>• Significant progress for GCS UI</li> </ul>
Major Unfinished Work	<ul style="list-style-type: none"> <li>• Test radio communication between XBEE radios and antenna range</li> <li>• Test commands from the ground station with the FSW and payload</li> <li>• Complete FSW and GCS programs</li> </ul>
Readiness to Proceed	Software is in compliance with all mission requirements and is adhering to a timeline for software to be fully developed and tested before competition



```

2097 ////////////////////////////////////////////////////////////////////////////////////////////////////////////////// VOID LOOP
2098 //
2099 void loop() {
2100   commandChecker(fd);
2101   altitudeCalibration(fd);
2102   sampleData(fd);
2103   if ((millis() - fd.gpsNewTime) > fd.gpsTimeInterval) {
2104     newGPSData(fd);
2105     fd.gpsNewTime = millis();
2106   }
2107   apogeeDetection(fd);
2108   updateFlightState(fd);
2109   if (fd.deployParaglider) {
2110     // myServo.writeMicroseconds(###);
2111   }
2112   if (fd.manualParaglider) {
2113     // myServo.writeMicroseconds(###);
2114   }
2115   if (fd.eggDrop) {
2116     // myServo.writeMicroseconds(###);
2117   }
2118   if (flightState == PROBE_RELEASE){
2119     autonomousControls(fd);
2120     switch (fd.direction) {
2121       case 1: // LEFT
2122         serial.print("Left");
2123         // myServo.writeMicroseconds(fd.servoOutput);
2124     }
2125   }
2126 }

```



# Conclusions (4 of 4)



## Team Conclusions

<p><b>Major Accomplishments</b></p>	<ul style="list-style-type: none"> <li>• All subteams have made significant progress on their designated tasks</li> <li>• Subteams on schedule according to both their individual and team timelines</li> <li>• Subteams are in consistent communication</li> <li>• Initial parts have been ordered and have arrived</li> </ul>
<p><b>Major Unfinished Work</b></p>	<ul style="list-style-type: none"> <li>• All three subteams still need to test their components</li> <li>• Subteams have yet to begin integrating with one another</li> </ul>
<p><b>Readiness to Proceed</b></p>	<p>All subteams are proceeding according to the schedule in the timelines and consistent communication shows readiness to integrate in the prototyping phase</p>

