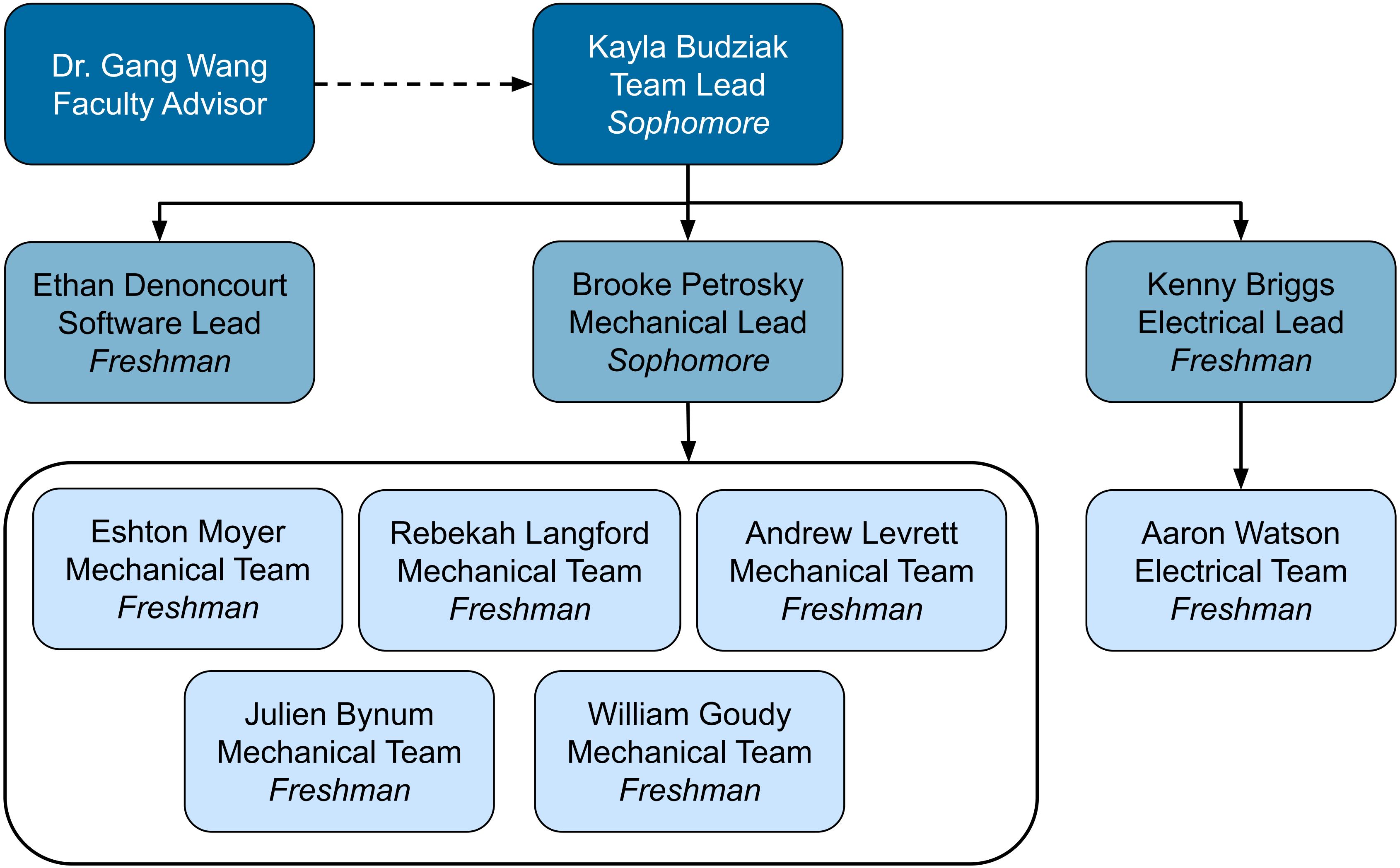
CanSat 2026
Critical Design Review (CDR)
Version 2.0

Team #1093

Vortex

Presentation Outline

Team Organization



Acronyms (1 of 6)

Acronym	Meaning	Acronym	Meaning
3D	Three Dimensional	C	Celcius
A	Amperes	CAL	Calibrate
AC	Alternating Current	CDH	Communication & Data Handling
ACCEL_P	Accelerometer Pitch	CDR	Critical Design Review
ACCEL_R	Accelerometer Roll	cm	Centimeter
ACCEL_Y	Accelerometer Yaw	CMD	Command
ACS	Autonomous Control System	CONOPS	Concept of Operations
ADC	Analog to Digital Converter	COTS	Commercial Off-the-Shelf
AL	Alabama	CSV	Comma Separated Values
Alt	Altitude	CX	Communication
BNO	Bosch Nine-Axis Orientation	D	Denier

Acronyms (2 of 6)

Acronym	Meaning	Acronym	Meaning
dB	Decibel	ft	Feet
dBi	Decibel Relative to Isotropic	g	Gram
dBm	Decibel-Milliwatt	G	Gravitational Acceleration
deg	Degree	GB	Gigabyte
E	East	GCS	Ground Control System
EPS	Electrical Power Subsystem	GHz	Gigahertz
etc	Et Cetera	GNSS	Global Navigation Satellite System
EXT	External	GPIO	General-Purpose Input/Output
FFC	Flat Flexible Cable	GPS	Global Positioning System
FPS	Frames per Second	GUI	Graphics User Interface
FSW	Flight Software	GYRO	Gyroscope

Acronyms (3 of 6)

Acronym	Meaning	Acronym	Meaning
GYRO_P	Gyroscope Pitch	I2C	Inter-Integrated Circuit
GYRO_R	Gyroscope Roll	ID	Inner Diameter
GYRO_Y	Gyroscope Yaw	ID	Identification
h	Hour	IDE	Integrated Development Environment
HDMI	High Definition Multimedia Interface	IMU	Inertial Measurement Unit
Hex	Hexagon	INR	Lithium Nickel Manganese Cobalt Oxide
hh:mm:ss	Hours, Minutes, Second	JST	Japanese Solderless Terminal
HP	High Performance	kg	Kilogram
hPa	Hectopascal	km	Kilometer
Hz	Hertz	kPa	Kilopascals
I/O	Input Output	Lat	Latitude

Acronyms (4 of 6)

Acronym	Meaning	Acronym	Meaning
LED	Light Emitting Diode	MHz	Megahertz
LiPo	Lithium Polymer	mm	Millimeter
Long	Longitude	MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
LSB	Least Significant Bit	ms	Millisecond
M	Metric	MtF	Male to Female
m	Meter	mV	Millivolt
mA	Milliamperes	mWh	Milliwatt-Hour
mAh	Milliampere-Hour	N	Newton
Max	Maximum	N	North
MEC	Mechanism	N-MOSFET	N-Channel Metal-Oxide-Semiconductor Field-Effect Transistor
mg	Milligram	N/A	Not Applicable

Acronyms (5 of 6)

Acronym	Meaning	Acronym	Meaning
NACA	National Advisory Committee for Aeronautics	PID	Proportional-Integral-Derivative
NETID	Network Identification	PRO	Proper Ram-Air Orientation
Ni-Cad	Nickel-Cadmium	Proc	Procedure
Ni-MH	Nickel-Metal Hydroxide	PWM	Pulse Width Modulation
ns	Nanosecond	R	Resistance
OD	Outer Diameter	RP	Reverse Polarity
Pa	Pascals	RSSI	Received Signal Strength Index
PANID	Personal Area Network Identifier	RQ#	Requirement Number
PCB	Printed Circuit Board	Rqmts	Requirements
PDR	Preliminary Design Review	RTC	Real Time Clock
PETG	Polyethylene Terephthalate Glycol	s	Second

Acronyms (6 of 6)

Acronym	Meaning	Acronym	Meaning
SATS	Satellites	TPU	Thermoplastic Polyurethane
SD	Secure Digital	U.FL	Ultra Small Surface Mount Coaxial Connector
Servo	Servomotor	UART	Universal Asynchronous Receiver/Transmitter
SI	International System of Units	UI	User Interface
SIM	Simulation	USB	Universal Serial Bus
SIMP	Simulation Pressure	UTC	Coordinated Universal Time
SMA	SubMiniature Version A	V	Volts
SMD	Service Mount Device	VA	Virginia
SPI	Serial Peripheral Interface	VS	Visual Studio
ST	Set Time	Wh	Watt-Hour
THT	Through Hole Technology	XCTU	Xbee Configuration and Test Utility

System Overview

Kayla Budziak, Brooke Petrosky

Mission Summary

Mission Objectives	
1	Design a CanSat that will function as the nose cone to a rocket during launch.
2	CanSat ejects from rocket at apogee, deploys a parachute, & descends at an average of 15 m/s.
3	At 80% of peak altitude the payload releases from the container & deploys a para-glider, descending 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 releases from the payload & descends at about 5 m/s.
6	A video camera will record the separation of the payload from the container, & the subsequent steering functions of the para-glider.
7	A second camera will record the ground during descent & capture the egg release.
8	The CanSat shall collect & transmit telemetry to the ground station at a rate of 1Hz.
Additional Objectives	
9	The base station bonus challenge is being attempted.
10	The team hopes to gain skills that will help long term in future engineering projects and careers.

Summary of Changes Since PDR (1 of 4)

Mechanical Subsystem			
Part	**PDR**	**CDR**	**Rationale**
Parachute	340mm Silnylon Cruciform Parachute	360mm 40D Ripstop Nylon Hemispherical Parachute	Parachute has a higher drag coefficient and larger diameter for slower descent with a 40D Ripstop Nylon canopy due to material unavailability.
Para-Glider	Cord Length: 300mm Material: Silnylon	Cord Length: 400mm Material: 40D Ripstop Nylon	Para-Glider has an increased cord length that will improve stability and is made with a 40D Ripstop Nylon wing due to material unavailability.
Para-Glider Lines	Three rows of lines connected to every cell	Two rows of lines connected to every other cell	Optimized line management will prevent tangling and improve control when steering.
Payload Body Structure	Circular base plates with payload body length of 146mm	Optimized base plates with payload body length 184mm	Base plates with a decreased surface area have a lower mass.

Summary of Changes Since PDR (2 of 4)

Mechanical Subsystem			
Part	**PDR**	**CDR**	**Rationale**
Steering Servo Mounts	3D printed PETG servo mounts	3D printed PETG servo mounts with added stability bar	Stability bar connects both servo mounts and improves structural integrity.
Egg Protection	Urethane foam egg holder and TPU insert	Urethane foam egg holder and polyurethane spray foam insert	Polyurethane spray foam insert is lower in mass than TPU insert without compromising egg's protection.
Electrical Subsystem			
Microcontroller	STM32H562RIT6	Teensy 4.1	Production delays caused a need to switch to a simpler electrical system.
Gyroscope	BMI088	BNO055	Switched to a breakout IMU for simpler design and programming requirements.
Batteries	Vapcell A11	Vapcell H16	New batteries have same mass but higher capacity. They have lower but ample current discharge.

Summary of Changes Since PDR (3 of 4)

Electrical Subsystem			
Part	**PDR**	**CDR**	**Rationale**
Current Sensor	CT427	ACS724	Switched to a breakout current sensor for simpler design and programming requirements.
RTC	MCT7940	NEO-M9N	RTC is integrated with GPS to reduce part count.
Primary PCB Design	SMD	THT	Faster design and acquisition of components, reduced complexity of software and electrical system.
Software Subsystem			
Landed-State Sampling	Only sample GPS	Sample all sensors	The difference in sampling to save power is negligible, and sampling all sensors in all states limits potential points of failure.
Ascent to Apogee Transition	Altitude and velocity as determiners	Only velocity as a determiner	This will ensure the apogee flight-state will not loop back on itself, but rather go to the descent flight-state immediately.

Summary of Changes Since PDR (4 of 4)

Software Subsystem			
Part	**PDR**	**CDR**	**Rationale**
Processor Restart	Read last packet	Check only flight state	It is only necessary to check the flight state to determine if a processor restart has occurred, and this will also allow for easier testing and limit potential errors.
Location Widget	Map with the current GPS location	3D flight path graph with coordinates and altitude	Provides an improved visual of payload location relative to target location without sacrificing any information.
Port Dropdown	No port dropdown	Port dropdown that allows the user to to select port in use	Allows port to change between devices more dynamically which allows the GCS to be run on multiple devices.
GCS Audio	No audio	Audio plays when buttons are pressed	The added audio function serves as an additional indicator that the button was pressed and a command was sent.

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 ± 3 m/s.
C5-C6	At 80% flight peak altitude, the payload shall be released from the container and deploy a para-glider descent control system.
C7	The payload shall descend at 5 m/s averaged over the entire descent within ± 3 m/s with the para-glider 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 para-glider 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 2m ± 0.5m 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 ± 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 para-glider 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)

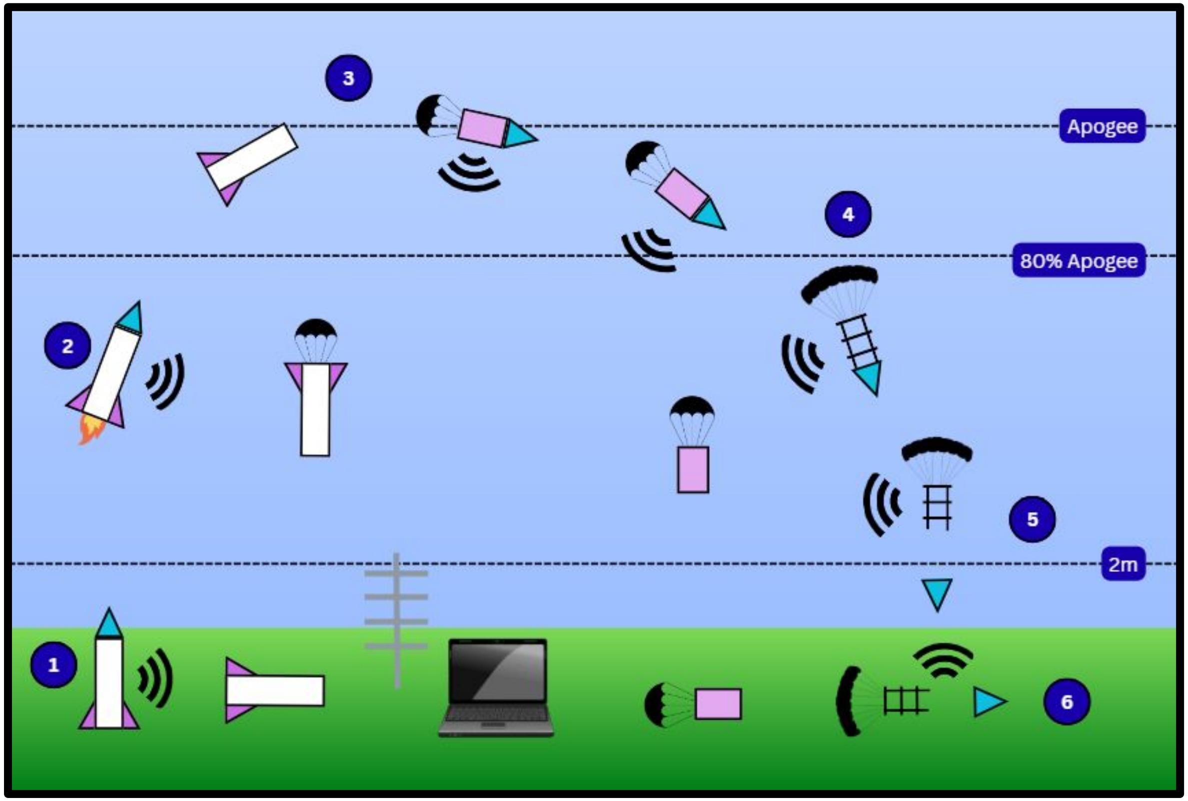
RQ#	Requirement
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.
F4	The flight software shall support simulated flight mode where the ground station 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 Concept of Operations (1 of 2)

Pre-Launch Activities	• Ensure that all components are connected and secured onto the payload and the payload is powered on • Run the GCS program and confirm that telemetry is being received • Fold para-glider and stow payload in the container, then lock the release arm into the container by sending the lock command from the GCS • Send necessary commands to set time and calibrate altitude
Post-Launch Activities	• Record latest GPS coordinate received by the GCS and recover the CanSat from that location and recover container by looking for parachute • Inspect payload for damage and document landed state • Retrieve the SD cards from the microcontroller and cameras and analyze flight data • Remove egg from nose cone and check egg for cracks • Upload CSV file to USB and submit the USB to the judges

Flight Day Roles			
Mission Control Officer	**CanSat Crew**	**Ground Station Crew**	**Recovery Crew**
Kayla Budziak	Brooke Petrosky, Andrew Levrett, Rebekah Langford, Kenny Briggs	Ethan Denoncourt, Aaron Watson, Julien Bynum	Eshton Moyer, William Goudy

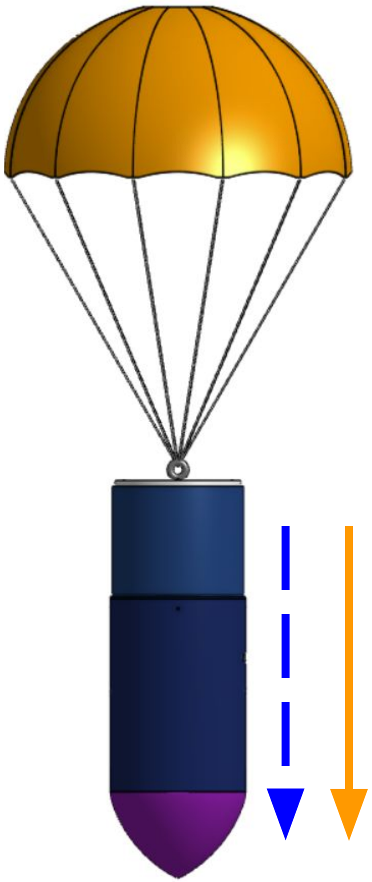
NOTE: Symbol indicates the transmission of telemetry to the ground station at a rate of 1Hz



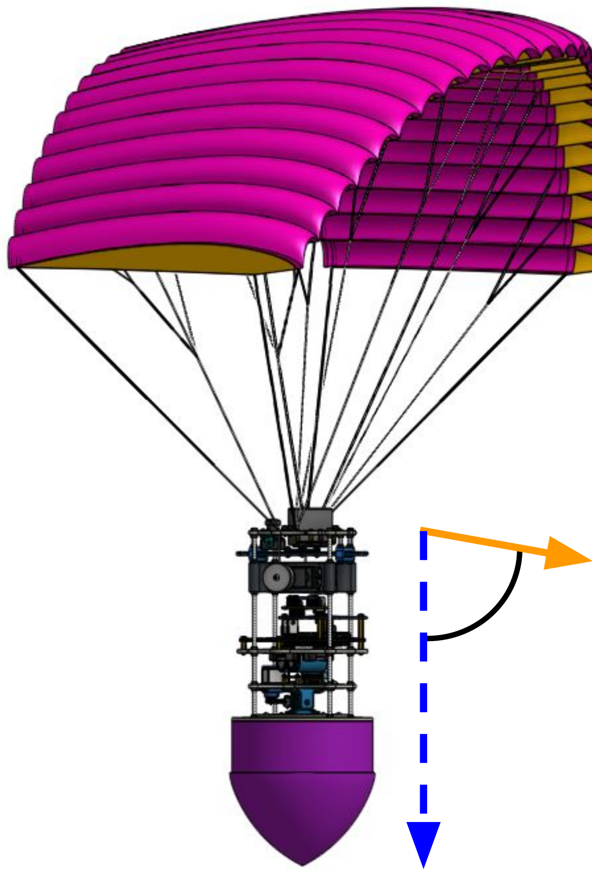
Launch and Descent Operations
1. CanSat is integrated into rocket on launchpad.
2. Rocket is ascending.
3. At apogee the container separates from rocket and deploys a parachute. Descends at an average rate of 15m/s.
4. At 80% of apogee the payload releases from the container and deploys a para-glider to steer towards a target location. 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 an average rate of 5m/s.
6. Payload has landed.

CanSat Physical Layout (1 of 4)

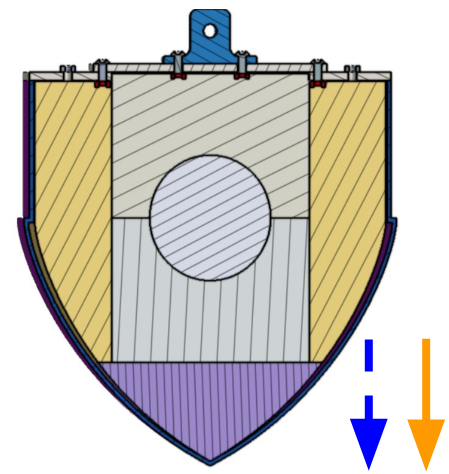
Descent Configurations	
Nadir Direction	
Direction of Travel	



Parachute (Stowed) Descent Configuration

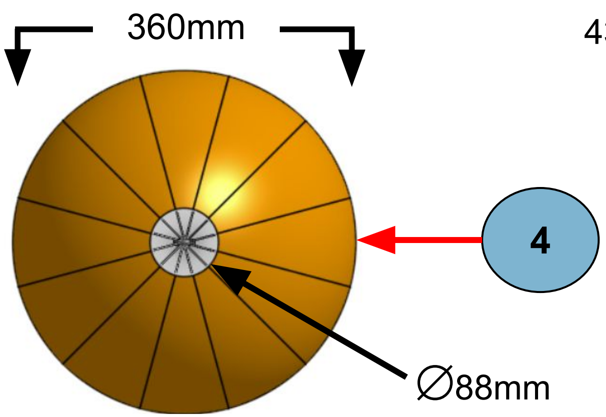


Para-Glider (Deployed) Descent Configuration



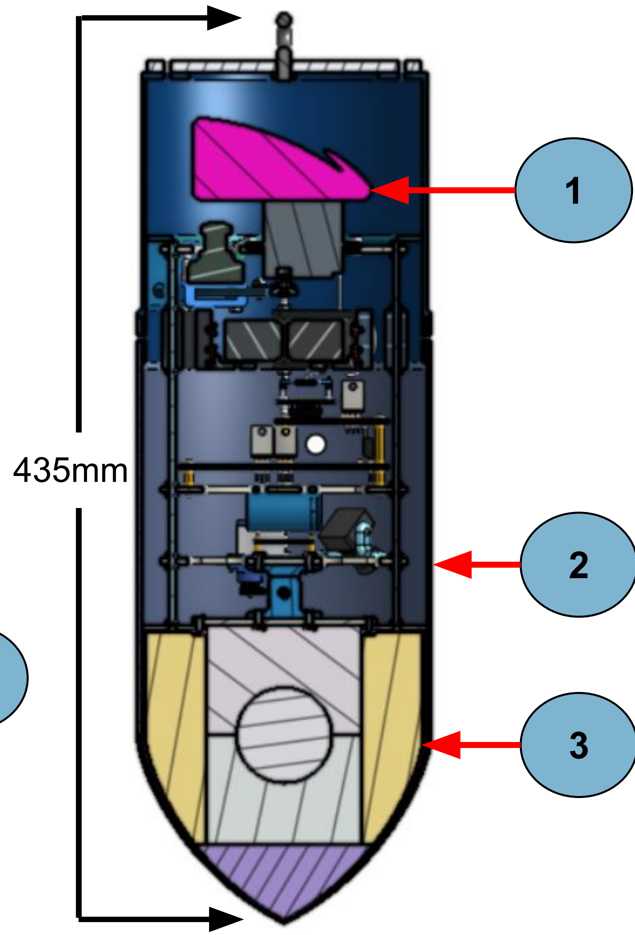
Instrument Descent Configuration

#	Description
1	Stowed Para-Glider
2	Container
3	Instrument Protection
4	Hemispherical Parachute

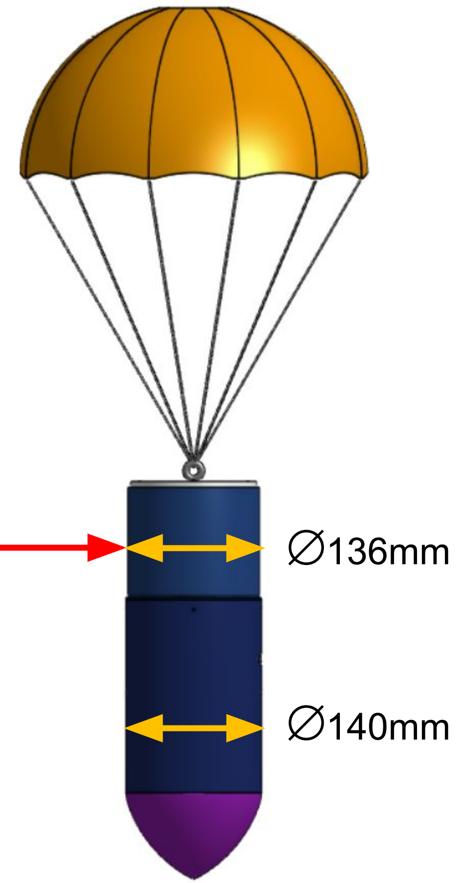


NOTE: Not all parts shown

Stowed Configuration Section View

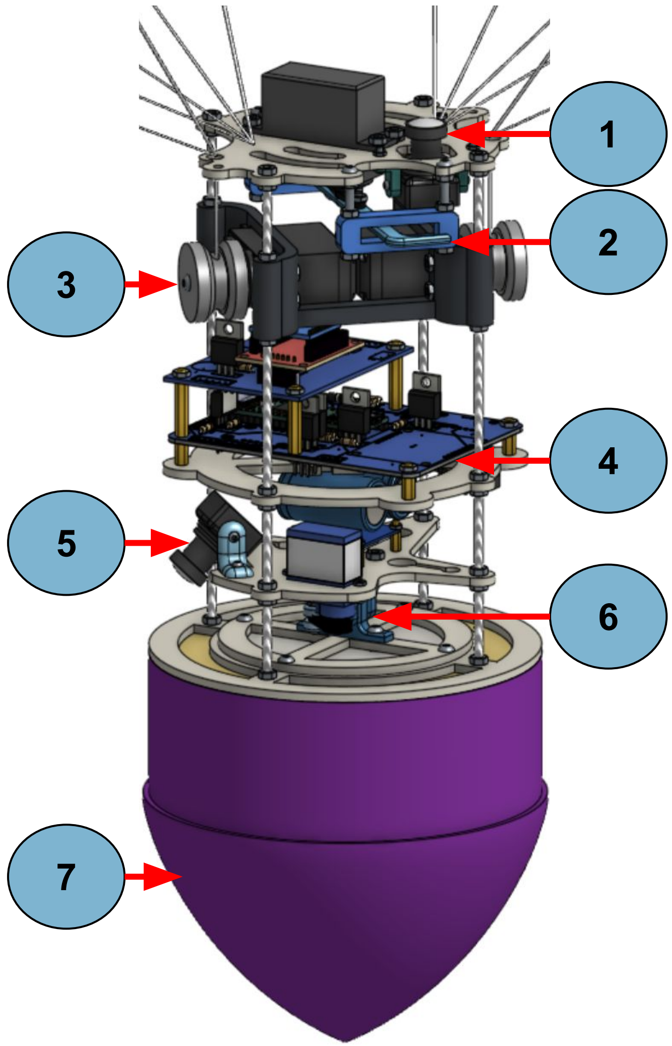


Stowed Configuration Full View



CanSat Physical Layout (3 of 4)

#	Description
1	Upward Camera
2	Release Mechanism
3	Para-Glider Steering
4	PCB
5	Downward Camera
6	Instrument Release Mechanism
7	Fiberglass Composite Ogive Nose Cone



Deployed Configuration

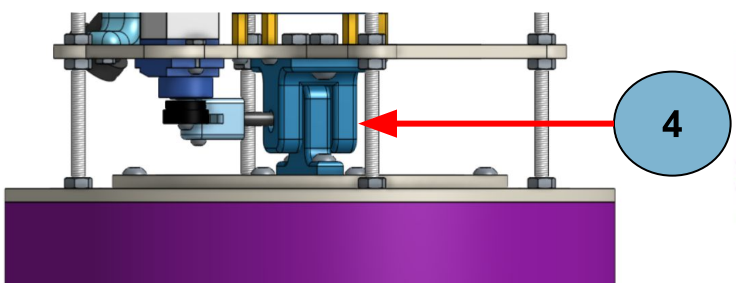
NOTE: Not all parts shown

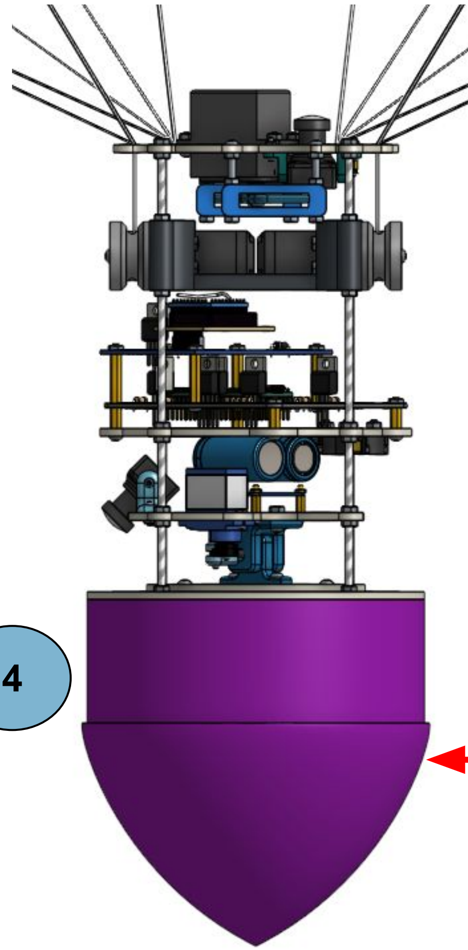
CanSat Physical Layout (4 of 4)

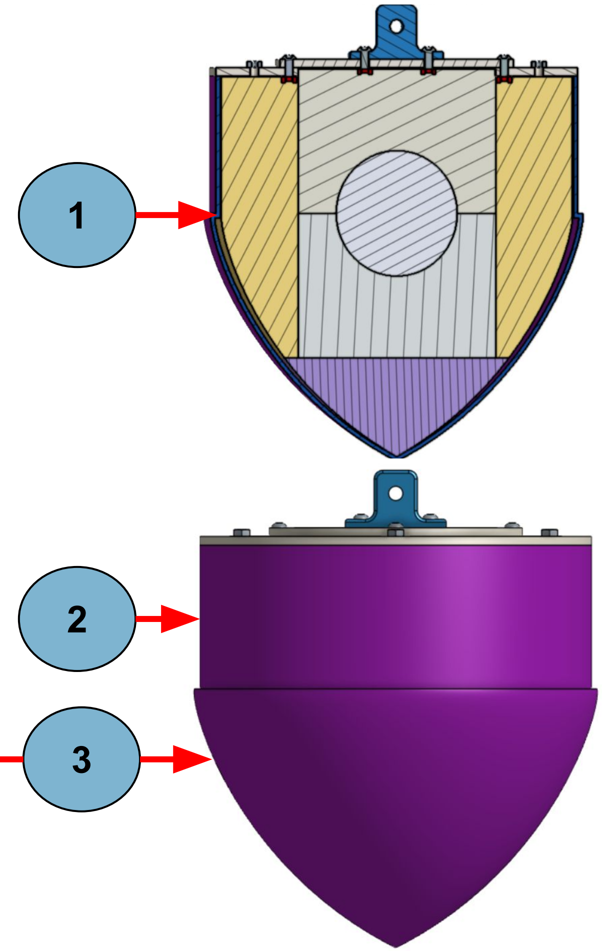
#	Description
1	Instrument Protection Section View
2	Instrument Stowed in Nose Cone
3	Nose Cone
4	Instrument Release Mechanism

Payload Configuration Pre-Instrument Release

Instrument Configuration







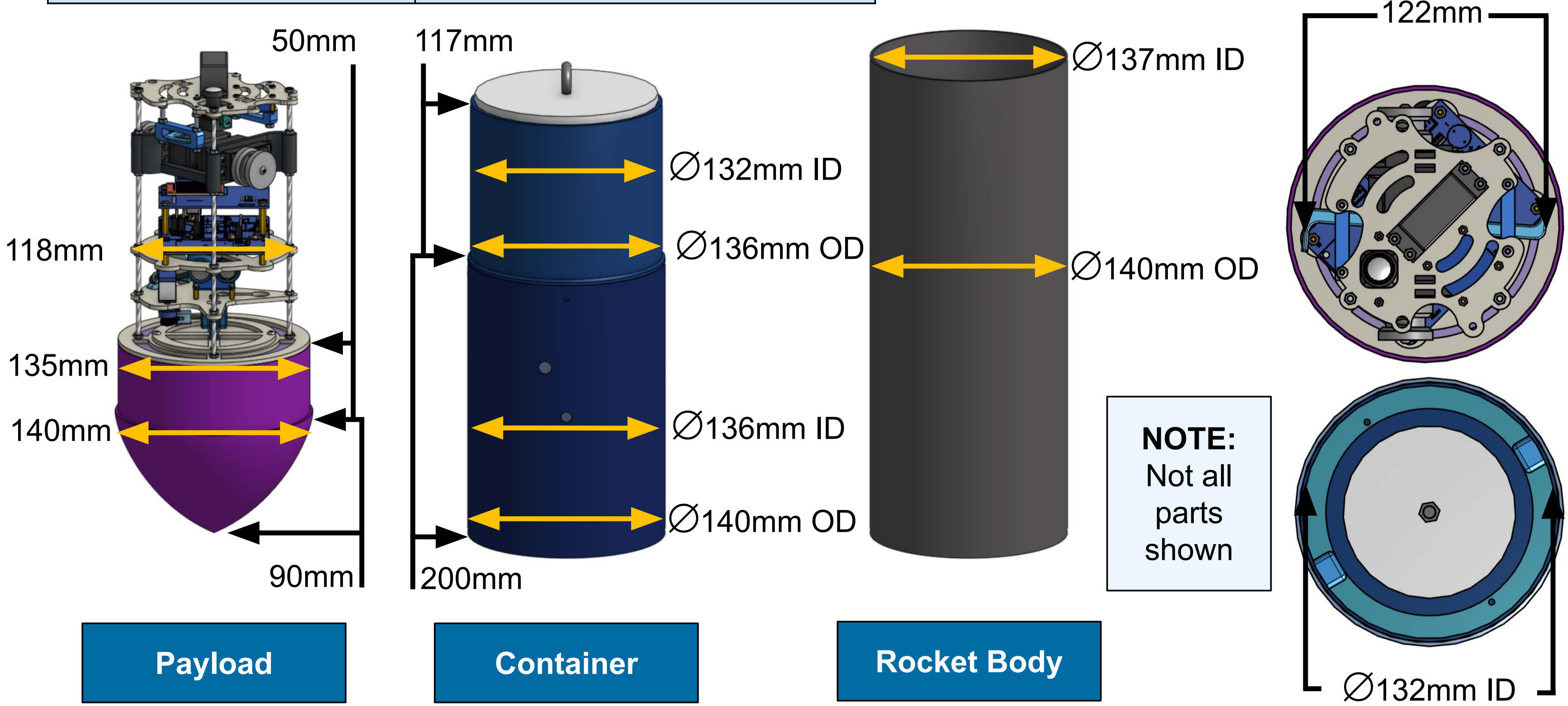
NOTE: Not all parts shown

Launch Vehicle Compatibility

Clearance (Minimum)	Description
0.5mm	Payload-Container
0.5mm	Container-Rocket

NOTE:

- Nose cone is symmetrical along thrust axis
- All dimensions are within compliance



Sensor Subsystem Design

Kenny Briggs

Sensor Subsystem Overview

Component	Description	Slides
BMP390	Temperature, pressure, and altitude sensor which determines correct height for instrument release	30, 31, 40
Voltage Divider	Measures battery voltage	33
ACS724LLCTR-30AU	Measures battery current	29
NEO-M9N	GPS sensor and RTC which determines if payload is in drop zone	32, 39
BNO055	Acceleration and gyro sensor	35, 36
RunCam Split 4 V2	Captures payload release and para-glider deployment	37
RunCam Split 4 V2	Captures ground and instrument release	38

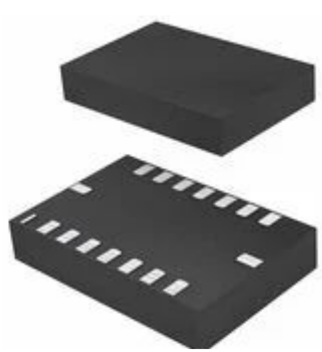
Sensor Changes Since PDR

PDR Component	CDR Component	Rationale for Change
CT427-HSN830MR	ACS724LLCTR-30AU	The battery current sensor was changed for simpler integration with software and a faster shipping time, which allowed for more testing leading into our test flights.

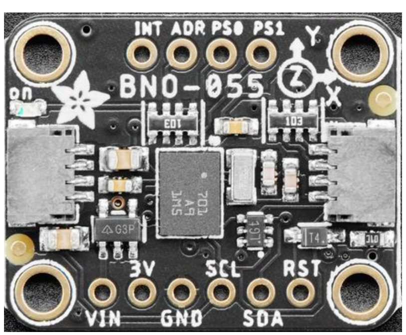
Source: Digikey

Source: Digikey

PDR Component	CDR Component	Rationale for Change
BMI088	BNO055	Acceleration and gyro sensor was changed to the BNO055 for a faster arrival time. The BNO055 also relieves work from the flight computer by computing sensor data and outputting orientation values which helps with descent control.



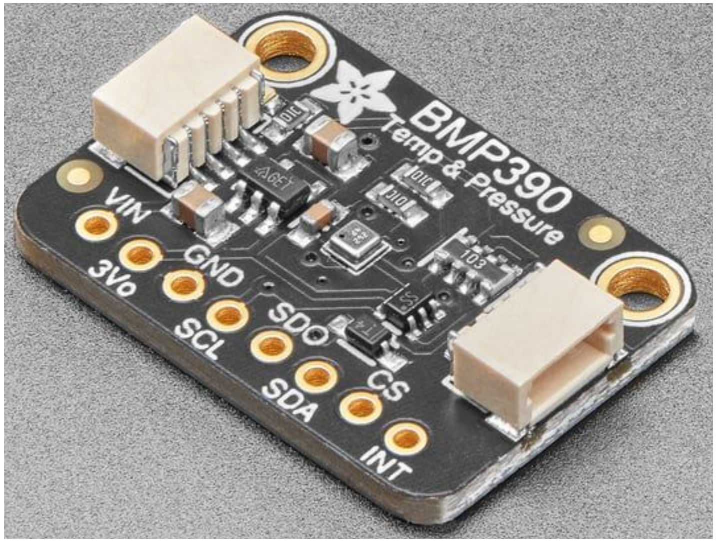
Source: Digikey



Source: Adafruit

Payload Air Pressure Sensor Summary

BMP390						
Range (hPa)	Sensitivity (Pa)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
300 - 1200	±3	3.3	1.6	I2C	1.8	10.95

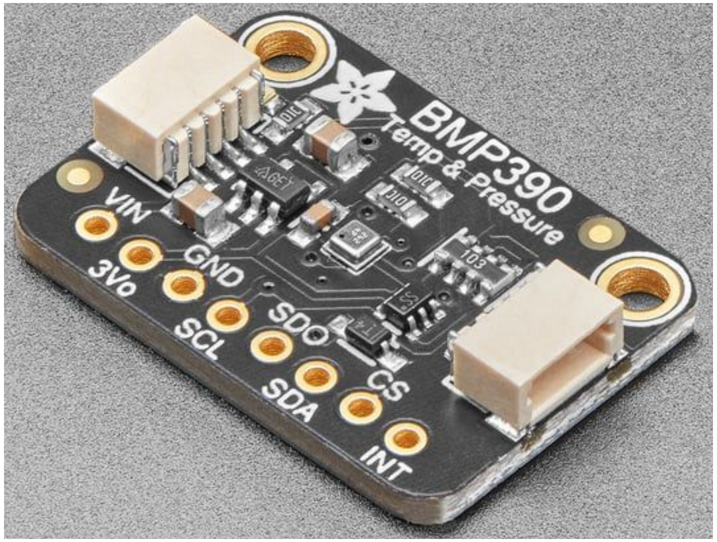


Data Format		
Variable Type	Telemetry	Data
float	PRESSURE	x.x kPa
Data Processing		
pressure_kPa = bmp.pressure / (1000);		

Source: Adafruit

Payload Air Temperature Sensor Summary

BMP390						
Range (°C)	Sensitivity (°C)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
-40 - 85	±0.5	3.3	1.6	I2C	1.8	10.95



Data Format		
Variable Type	Telemetry	Data
float	TEMPERATURE	xx.x °C
Data Processing		
temperature = bmp.temperature;		

Source: Adafruit

Payload GNSS Sensor Summary

NEO-M9N						
Altitude Range (m)	Sensitivity (dBm)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
0 - 80000	-167	5	36	I2C	7.74	70.95

Source: Sparkfun

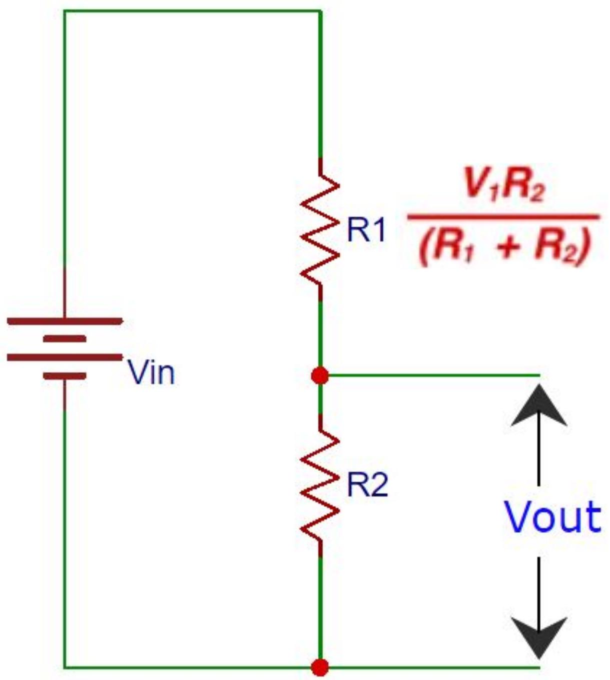
Data Format		
Variable Type	Telemetry	Data
double	GPS_TIME GPS_ALTITUDE GPS_LATITUDE GPS_LONGITUDE GPS_SATS	xx:xx:xx x.x meters xx.xxxx °North xx.xxxx °East xx

Data Processing

```
GPS_Hour = myGNSS.getHour();
GPS_Minutes = myGNSS.getMinute();
GPS_Seconds = myGNSS.getSecond();
New_Lat = (myGNSS.getLatitude() / (pow(10,7)));
New_Long = (myGNSS.getLongitude() / (pow(10,7)));
GPS_Altitude = myGNSS.getAltitude();
GPS_Satellites = myGNSS.getSIV();
```

Payload Voltage and Current Sensor Summary (1 of 2)

Voltage Divider						
Range (V)	Sensitivity (%)	Operating Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
0 - 9.9	±2	7.2	0.12	ADC	0.01	0.20



Source: Circuit Digest

Data Format		
Variable Type	Telemetry	Data
float	VOLTAGE	x.x V

Data Processing

```
rawSensorValue = analogRead(fd.batteryPin);
VoltageInput = ((fd.rawSensorValue /
ADC_RESOLUTION_CV) * fd.ADC_REF);
battery_Voltage = fd.VoltageInput * 3;
```

Payload Voltage and Current Sensor Summary (2 of 2)

ACS724LLCTR-30AU						
Range (A)	Sensitivity (mV/A)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
0 - 30	133	5	14	ADC	1.1	9.95

Source: Pololu

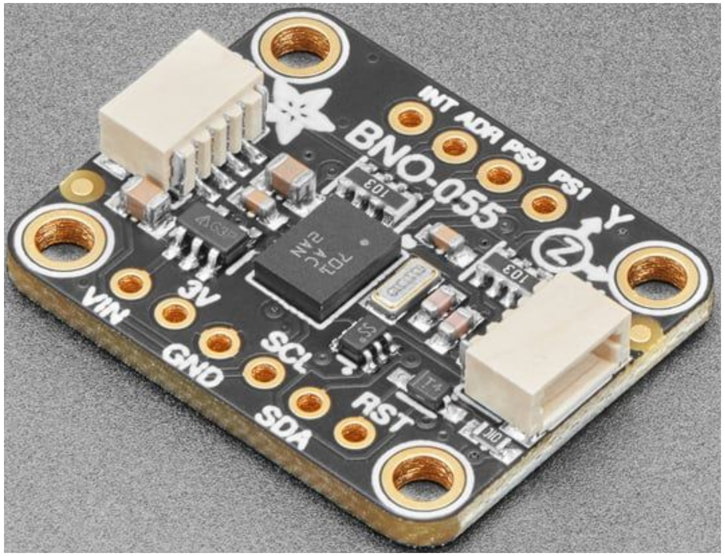
Data Format		
Variable Type	Telemetry	Data
float	CURRENT	x.xx A

Data Processing

```
Zero_Point = 5 / 10;
CurrentSensorValue = analogRead(fd.CurrentPin);
VoltageCurrent = ((fd.CurrentSensorValue /
ADC_RESOLUTION_CV) * fd.ADC_REF);
current = (fd.VoltageCurrent - fd.Zero_Point) / Sensitivity;
```

Payload Rotation Rate Sensor Summary

BNO055						
Range (°/s)	Sensitivity (LSB/°/s)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
±2000	16.0	3.3	12.3	I2C	3.41	29.95



Source: Adafruit

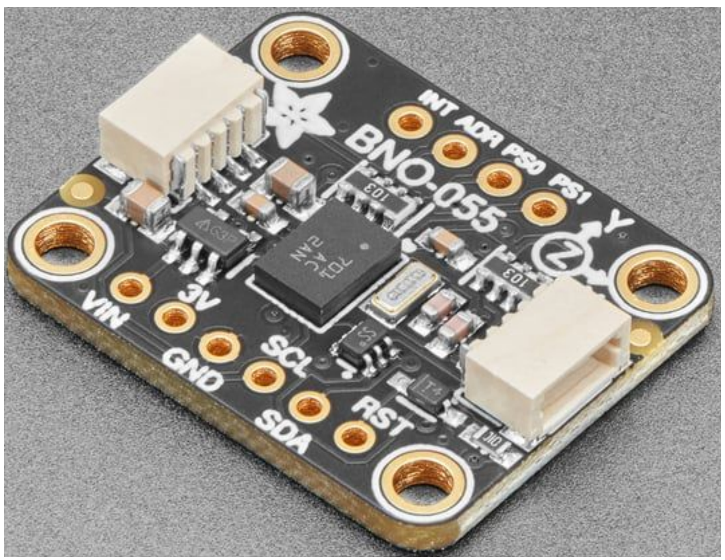
Data Format		
Variable Type	Telemetry	Data
float	GYRO_R GYRO_P GYRO_Y	xx.xx°/s

Data Processing

```
imu::Vector<3> gyro = bno.getVector
(Adafruit_BNO055::VECTOR_GYROSCOPE);
gx = gyro.x();
gy = gyro.y();
gz = gyro.z();
```

Payload Acceleration Sensor Summary

BNO055						
Range (g)	Sensitivity (LSB/mg)	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
±16	1	3.3	12.3	I2C	3.41	10.95



Source: Adafruit

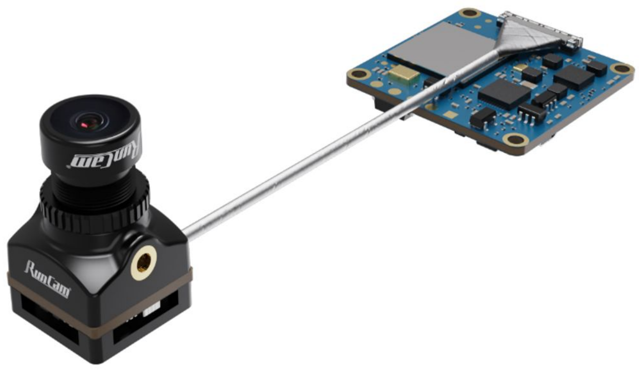
Data Format		
Variable Type	Telemetry	Data
float	ACCEL_R ACCEL_P ACCEL_Y	xx.xx °/s^2

Data Processing

```
float deltaAccel = (millis() - Pgt) / 1000.0f;
if (deltaAccel > 0.0f) {
  ax = (gx - Pgx) / deltaAccel;
  ay = (gy - Pgy) / deltaAccel;
  az = (gz - Pgz) / deltaAccel; }
```

Payload Release Camera Summary

RunCam Split 4 V2								
Resolution (Pixels)	Field of View (°)	Resolution Range (Pixels)	Video Storage	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
3840 x 2160	140	1920 x 1080 - 3840 x 2160	Integrated SD	5	450	UART	10.2	82.99



Source: RunCam

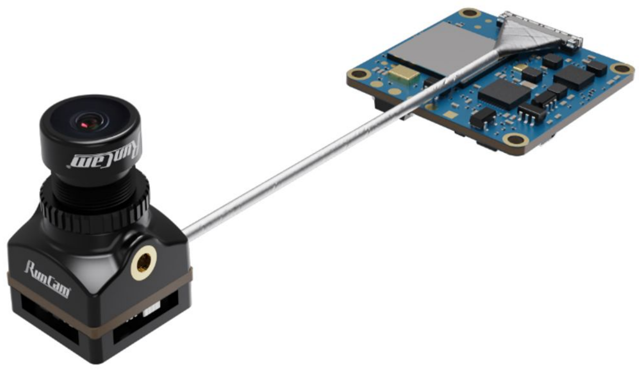
Data Format		
Variable Type	Telemetry	Data
N/A	N/A	N/A

Data Processing

```
int TopCamera = 31;
digitalWrite(TopCamera, HIGH);
digitalWrite(TopCamera, LOW);
```

Payload Ground Camera Summary

RunCam Split 4 V2								
Resolution (Pixels)	Field of View (°)	Resolution Range (Pixels)	Video Storage	Voltage (V)	Current (mA)	Interface	Mass (g)	Price ($)
3840 x 2160	140	1920 x 1080 - 3840 x 2160	Integrated SD	5	450	UART	10.2	82.99



Source: RunCam

Data Format		
Variable Type	Telemetry	Data
N/A	N/A	N/A

Data Processing

```
int BottomCamera = 30;
digitalWrite(BottomCamera, HIGH);
digitalWrite(BottomCamera, LOW);
```

Egg Release Sensors (1 of 2)

NEO-M9N (GPS)
Telemetry Measured to Determine Egg Release
Within Drop Zone - GPS Location from NEO-M9N

Source: Sparkfun

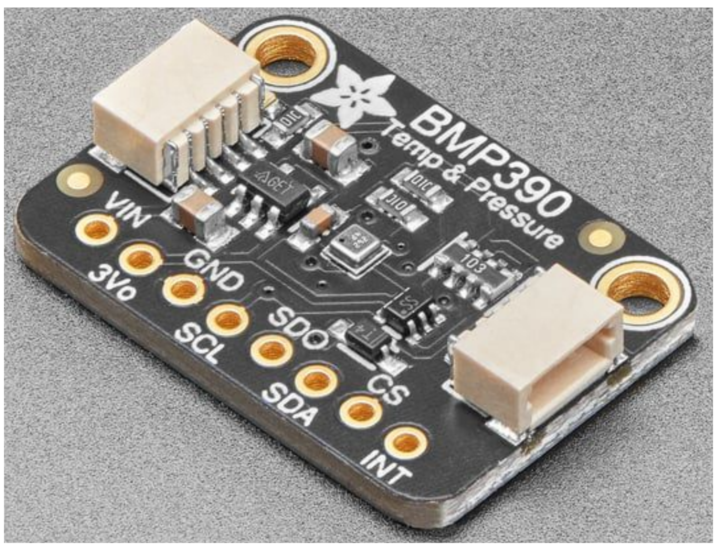
Data Format		
Variable Type	**Telemetry**	**Data**
double double	GPS_LATITUDE GPS_LONGITUDE	xx.xxxx °North xx.xxxx °East

Data Processing

```
if ((altitude <= 2.5) && (Distance <= 2) ){
  flightState = PAYLOAD_RELEASE;
  digitalWrite(fd.BottomSMosfet, HIGH); delay(300);
  BottomS.write(0); delay(300);
  digitalWrite(fd.BottomSMosfet, LOW); delay(200);
}
```

Egg Release Sensors (2 of 2)

BMP390 (Pressure Sensor)
Telemetry Measured to Determine Egg Release
At 2m Altitude - Altitude Reading from BMP390



Source: Sparkfun

Data Format		
Variable Type	**Telemetry**	**Data**
float	ALTITUDE	x.x m

Data Processing

```
if ((altitude <= 2.5) && (Distance <= 2) ){
  flightState = PAYLOAD_RELEASE;
  digitalWrite(fd.BottomSMosfet, HIGH); delay(300);
  BottomS.write(0); delay(300);
  digitalWrite(fd.BottomSMosfet, LOW); delay(200);
}
```

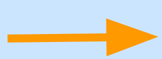
Descent Control Design

Andrew Levrett, William Goudy

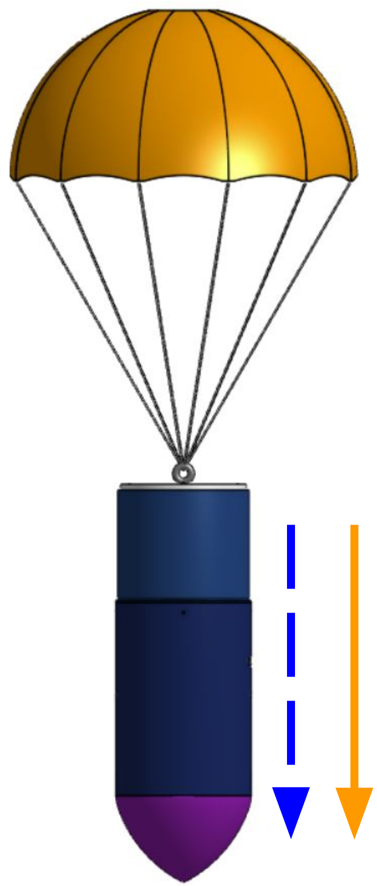
Descent Control Overview

Descent Control Mechanism	Altitude Range	Descent Rate (m/s)
Parachute	Apogee - 80% Apogee	12.41
Para-Glider	80% Apogee - Ground	5.00
Nosecone	2m - Ground	3.77

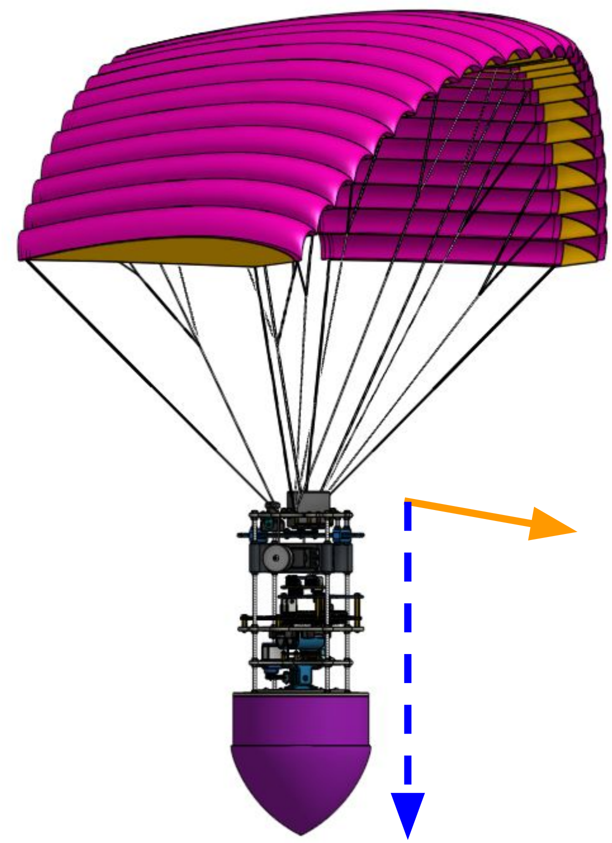
NOTE: During test launch 2, the parachute descent rate was 10.4 m/s and the para-glider descent rate was 7.1 m/s

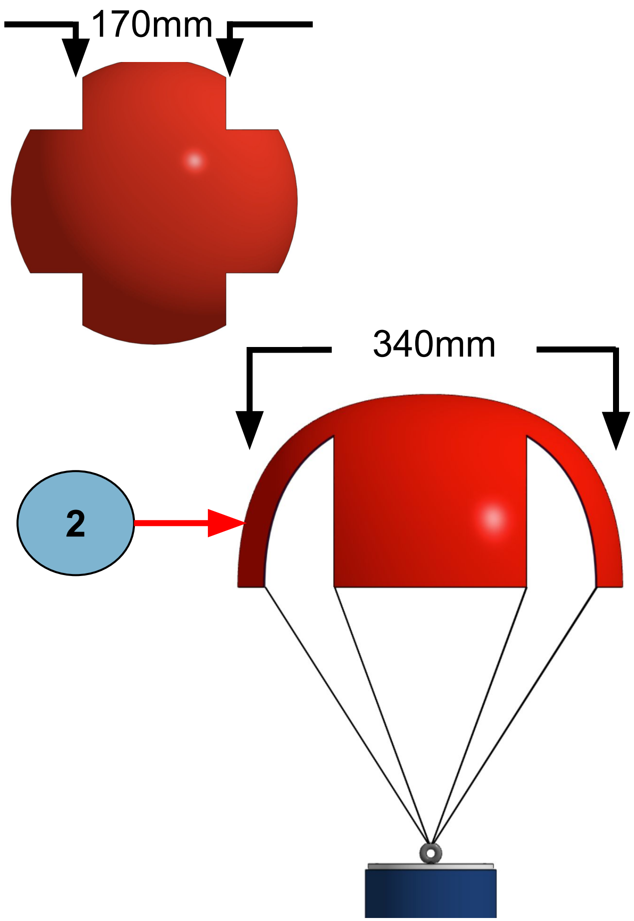
Nadir Direction	
Direction of Travel	

Parachute Descent



Para-Glider Descent

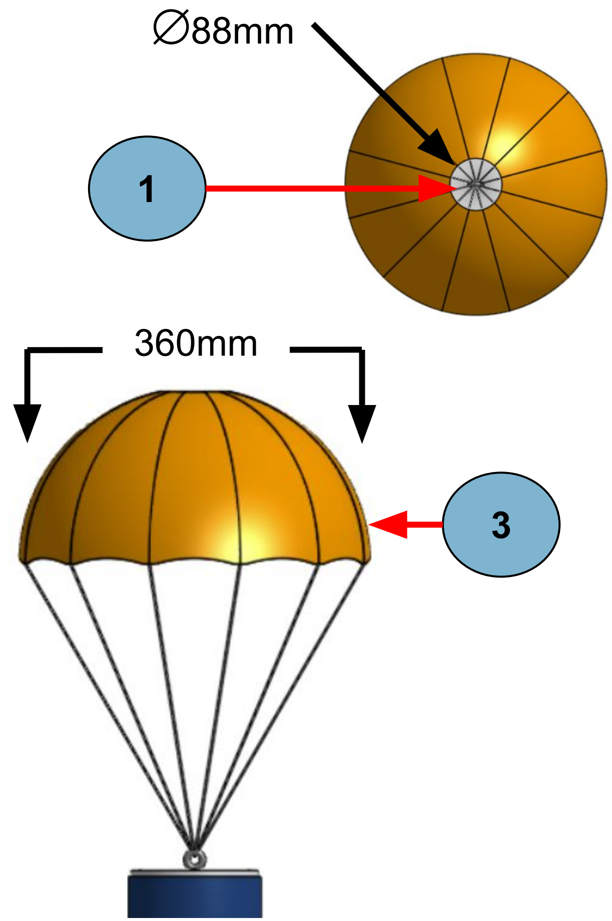




Parachute Design	
1	Vent Hole
2	Silnylon Cruciform Parachute
3	40D Ripstop Nylon Hemispherical Parachute

Rationale for Change

Hemispherical parachute has a higher drag coefficient (1.47) than the cruciform (1.17) and larger diameter for slower descent. Canopy is 40D Ripstop Nylon due to material unavailability.

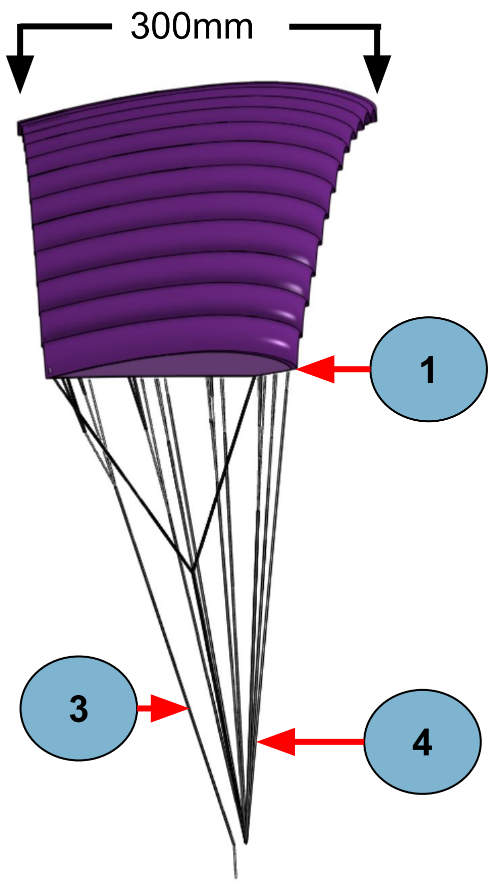


PDR Design
340mm Cruciform Parachute

NOTE: Not all parts shown

CDR Design
360mm Hemispherical Parachute

Descent Control Changes Since PDR (2 of 3)

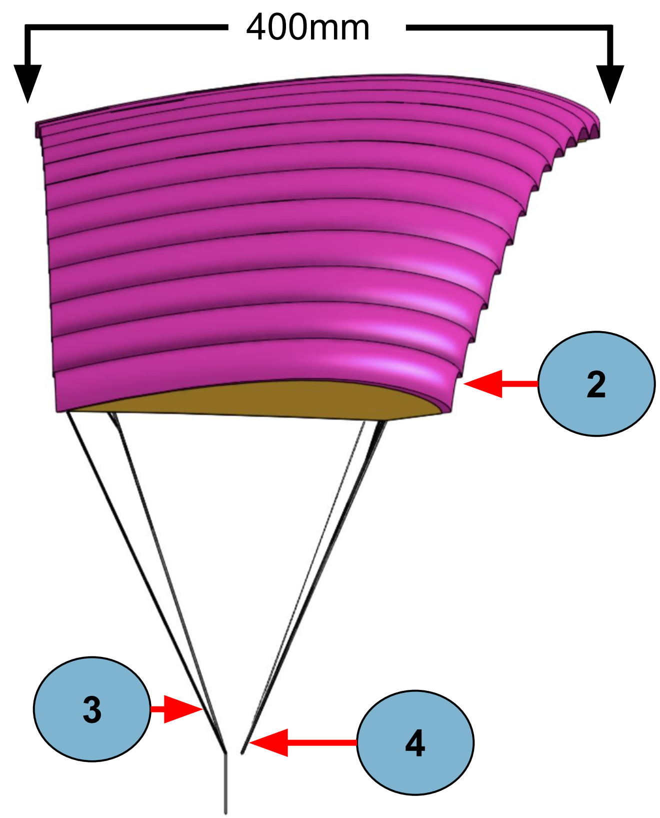


Para-Glider Cord Length & Material	
1	NACA 4412 Silnylon Wing
2	NACA 4412 40D Ripstop Nylon Wing
3	Kevlar Brake Lines
4	Kevlar Stability Lines

Rationale for Change

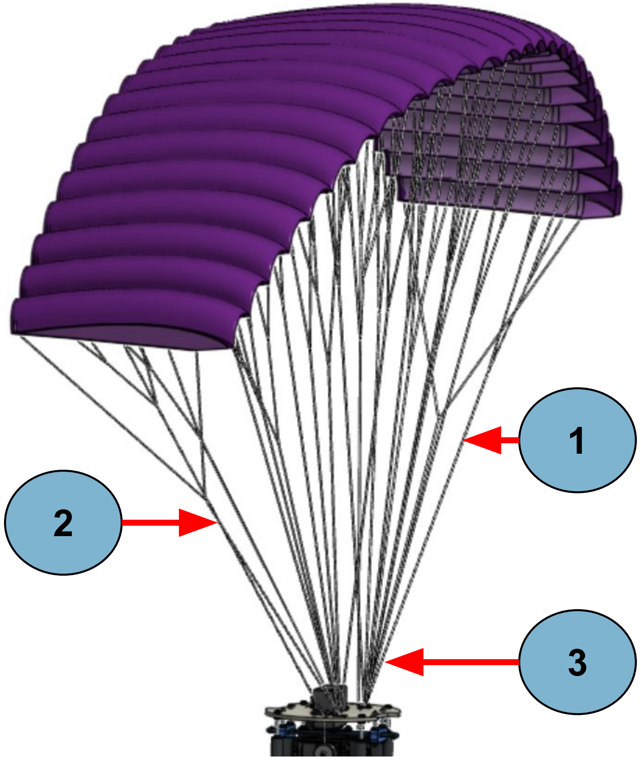
An increased cord length for improves stability. Wing is 40D Ripstop Nylon due to material unavailability.

NOTE: Not all parts shown



PDR Design
Cord Length 300mm, Silnylon

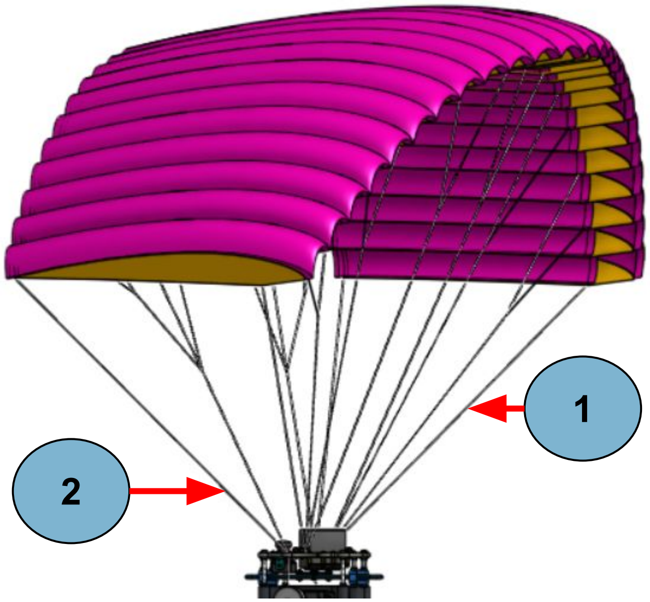
CDR Design
Cord Length 400mm, Ripstop Nylon



Para-Glider Lines	
1	Kevlar Stability Lines, Airfoil Front
2	Kevlar Brake Lines, Airfoil Rear
3	Kevlar Stability Lines Middle

Rationale for Change
Optimized line management prevents tangling and improves control when steering.

NOTE: Not all parts shown



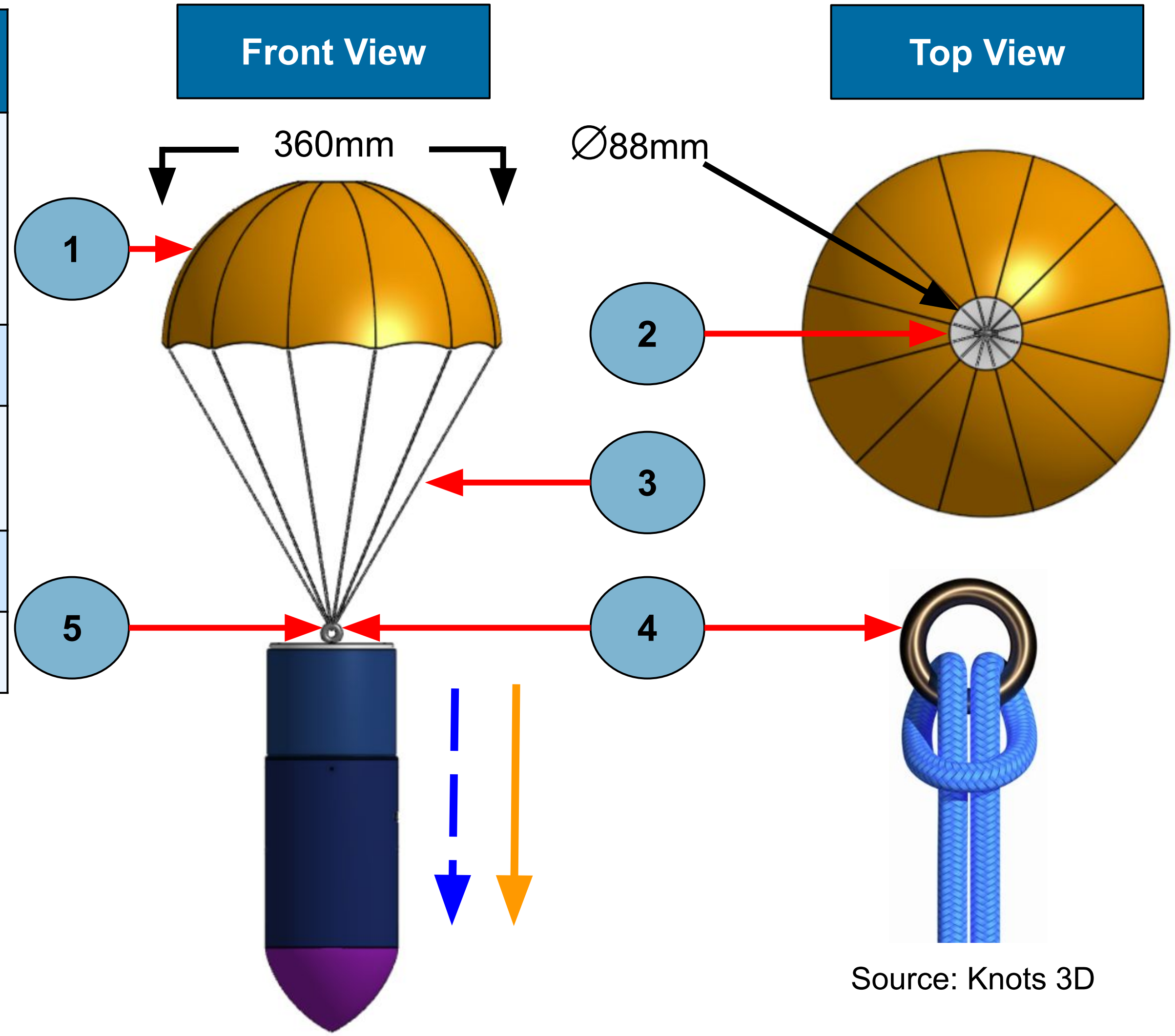
PDR Design
3 Rows of Lines on Every Cell

CDR Design
2 Rows of Alternating Lines

Container Parachute Descent Control Summary

#	Description
1	Neon Orange 40D Ripstop Nylon Hemispherical Parachute
2	Vent Hole
3	Kevlar Parachute Lines
4	Cow Hitch Knot
5	¼ Inch Eye Bolt

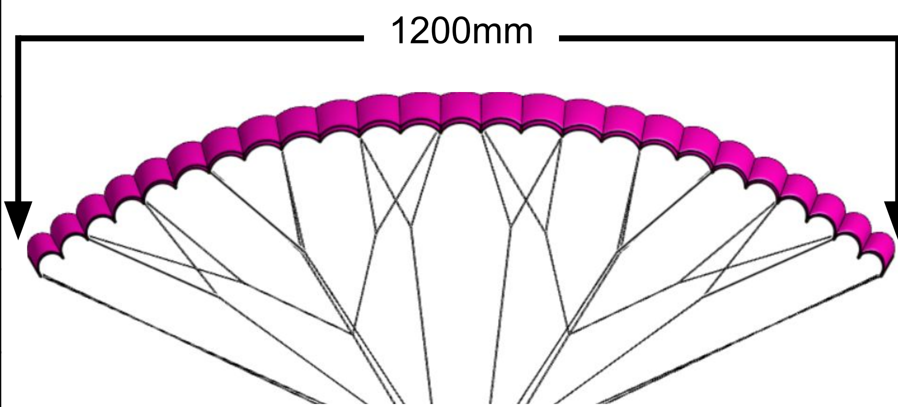
Nadir Direction	
Direction of Travel	

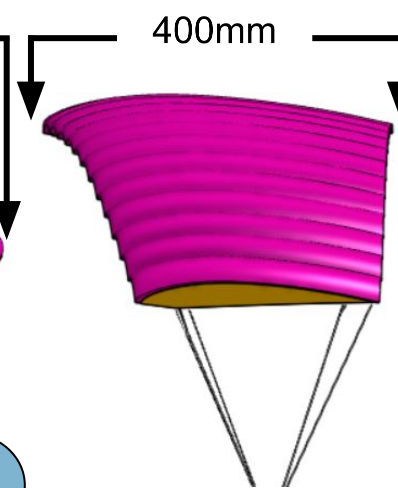


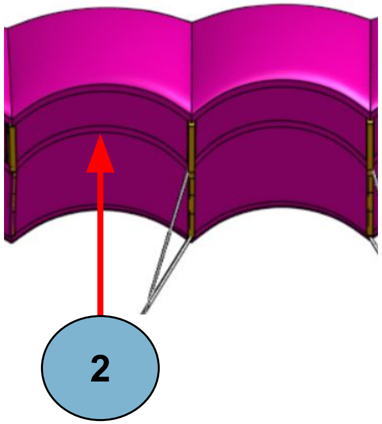
Source: Knots 3D

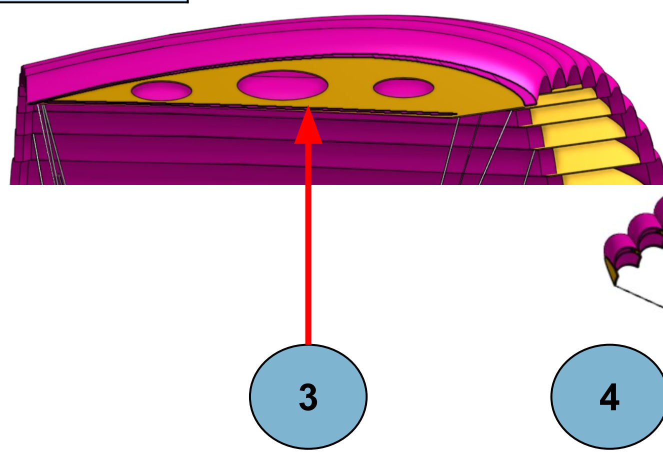
Para-Glider Descent Control Summary

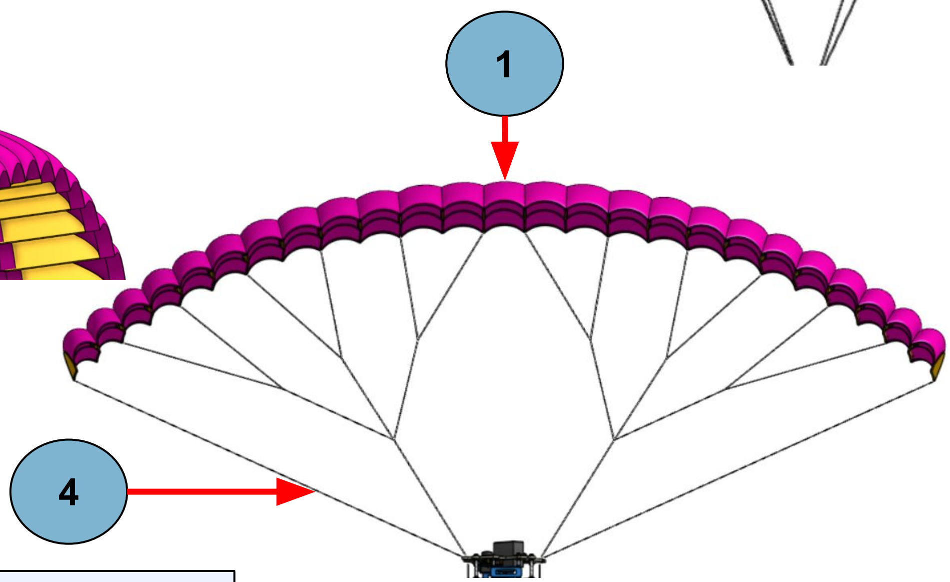
#	Description
1	Neon Orange & Neon Pink 40D Ripstop Nylon Wing
2	Cell Openings
3	NACA 4412 Airfoil
4	Kevlar Brake Lines









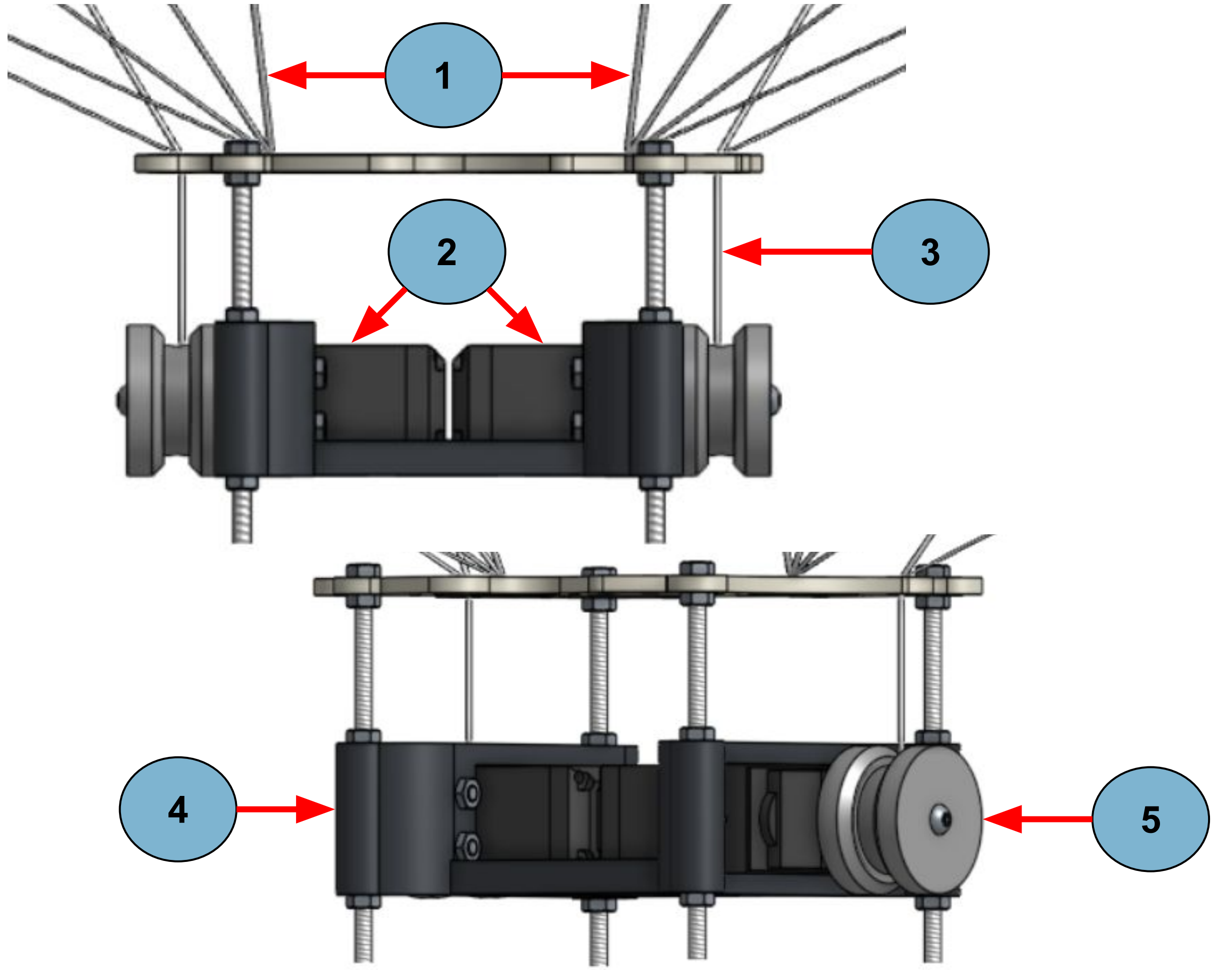


NOTE: Not all parts shown

<u>**NOTE: Steering is active**</u>

Para-Glider Descent Speed Control Design

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



NOTE: Not all parts shown

NOTE: Descent speed control is active

Parachute Descent Equation

No derivation, equation obtained from established source.

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

Source: NASA

Estimated Descent Rate: 12.41m/s

Variable	Value
W: Weight (N)	9.9
ρ: Air Density (kg/m^3)	1.129
S: Planform Area (m^2)	0.077459
Cd: Drag Coefficient	1.47

Descent Rate Estimates (2 of 3)

Para-Glider Descent Equation Derivation

Initialize system at equilibrium.

Assumptions:
System is in equilibrium.

$$\Sigma F_y = 0 = \frac{1}{2} c_D S \rho v^2 sin\alpha + \frac{1}{2} c_L S \rho v^2 cos\alpha - W$$

$$W = \frac{1}{2} S \rho v^2 (c_D sin\alpha + c_L cos\alpha)$$

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

Find velocity in the direction of travel.

$$v_y = v sin(\alpha)$$

Find y component of velocity.

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

Estimated Descent Rate:
5.00m/s

Variable	Value
α: Angle of Attack (°)	16.95
W: Weight (N)	8.602
S: Wing Planform Area (m^2)	0.4800
ρ: Air Density (kg/m^3)	1.129
c_L: Lift Coefficient	0.1031
c_D: Drag Coefficient	0.0314

Descent Rate Estimates (3 of 3)

Nose Cone Descent Equation Derivation

Descent rate was determined using kinematics.

$$v_f^2 = v_0^2 - 2gx$$

$$v_f = \sqrt{\left|v_0^2 - 2gx\right|}$$

Assumptions:
Velocity at release is equal to para-glider descent velocity.

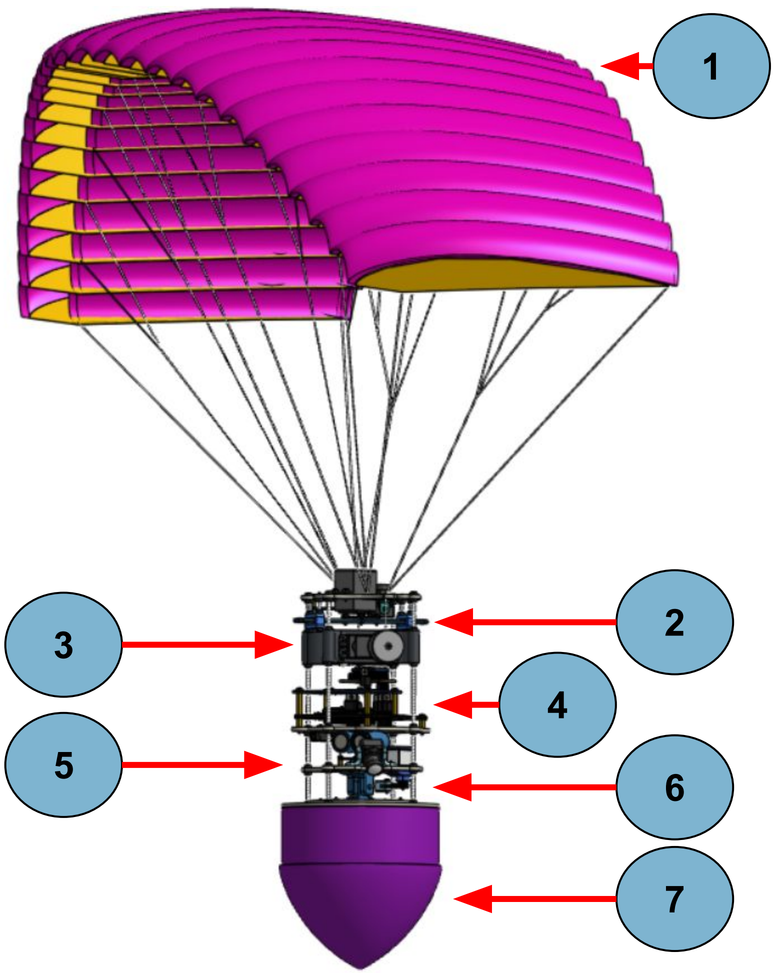
Estimated Descent Rate:
3.77m/s

Variable	Value
v_0: Initial Velocity (Para-Glider Descent Rate) (m/s)	5.00
g: Acceleration Due to Gravity (m/s^2)	9.81
x: Distance to Ground (m)	2

Mechanical Subsystem Design

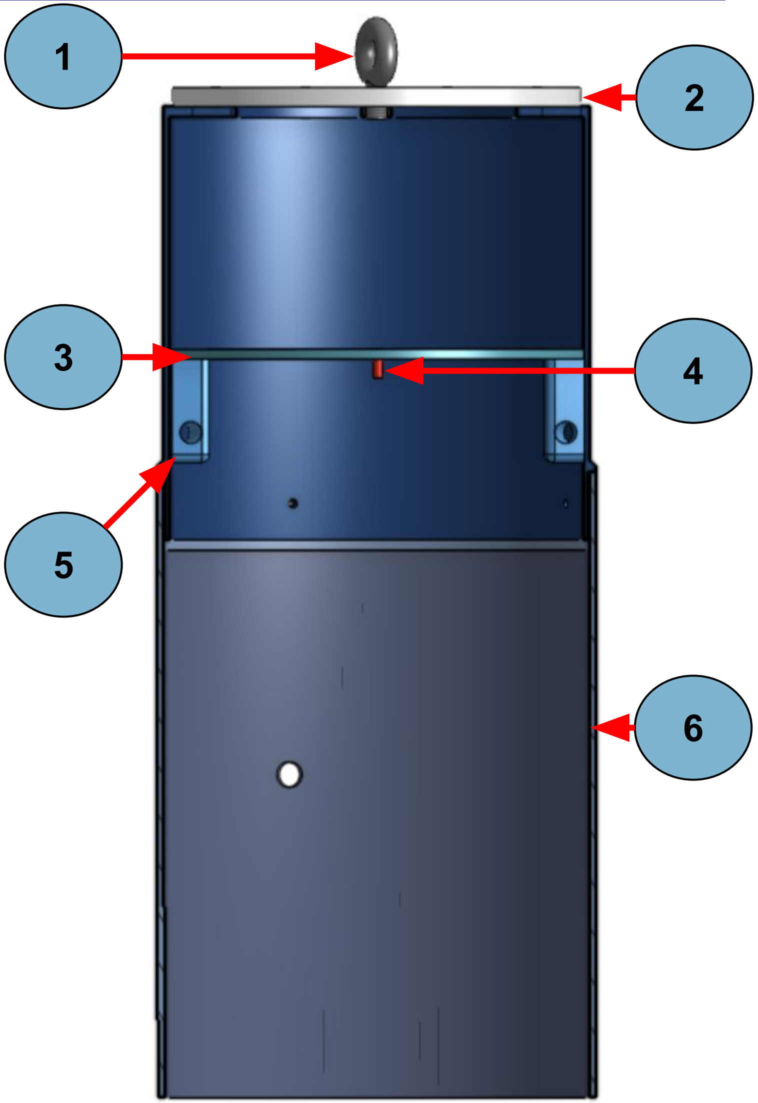
Eshton Moyer, Julien Bynum, Rebekah Langford

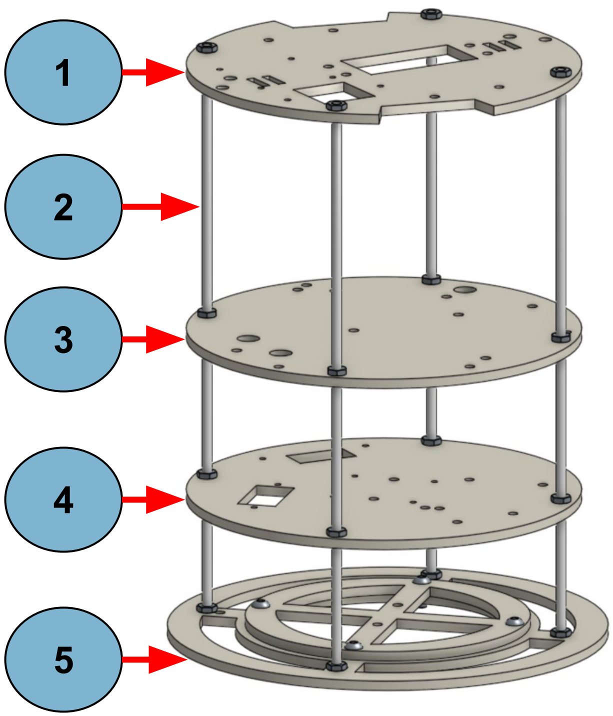
#	Part	Description
1	Para-Glider	40D ripstop nylon para-glider with kevlar lines
2	Container Release Mechanism	Forged carbon fiber arm and supports
3	Descent Control Mechanism	PETG steering servo mount and turning spool
4	Electrical Components	Camera, buzzer, PCB, batteries, radio, GPS, etc.
5	Body Structure	Fiberglass composite plywood plates and M3 zinc plated steel threaded rods
6	Instrument Release Mechanism	Carbon fiber rod attachment point
7	Nose Cone	Fiberglass composite layup ogive nose cone



Mechanical Subsystem Overview (2 of 2)

#	Part	Description
1	Parachute Attachment Point	¼ inch eye bolt
2	Container Plate	6mm plywood plate
3	Container Integration Plate	3D printed PETG plate epoxied to container walls
4	Rotation Prevention Rod	Carbon fiber rods
5	Container Integration Pieces	3D printed PETG pieces epoxied to container walls and container integration plate
6	Container	2mm fiberglass composite layup walls

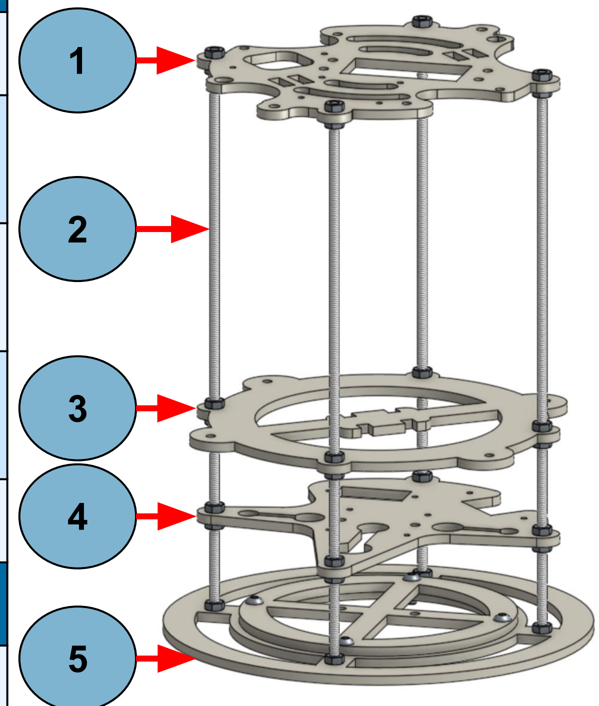




Payload Body Structure	
1	Back Plate
2	M3 Zinc Plated Steel Threaded Rods
3	Electrical Component Mounting Plate
4	Nose Cone Release Mounting Plate
5	Nose Cone Plate

Rationale for Change
Base plates with decreased surface area are 30g lighter.

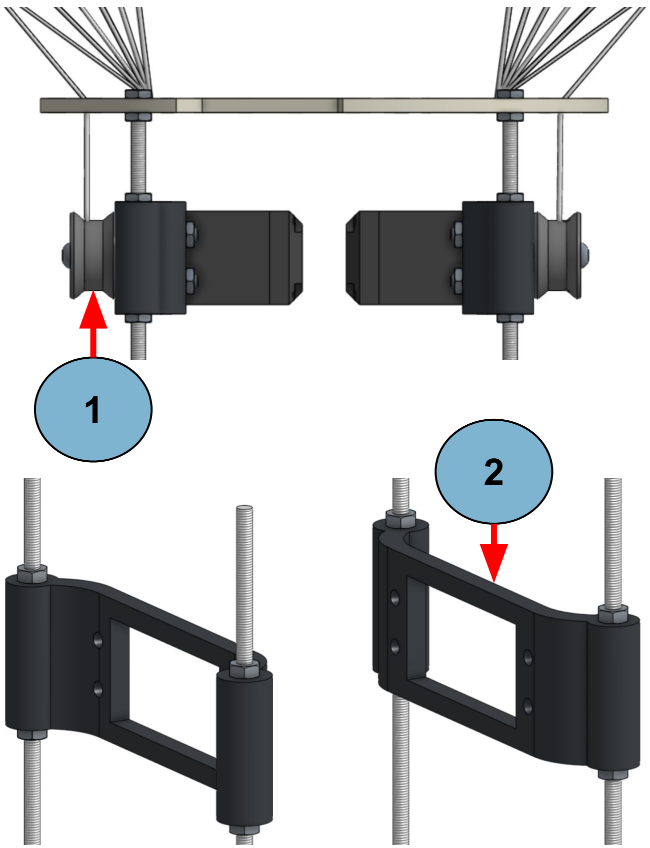
NOTE: Not all parts shown



NOTE: Length of Payload Body is 146mm

NOTE: Length of Payload Body is 184mm

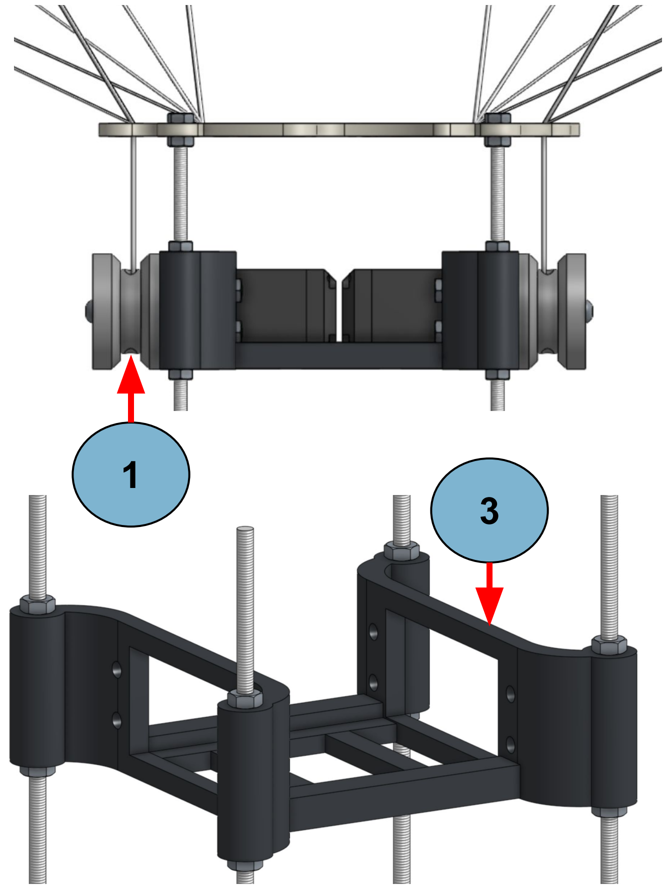
PDR Design	→	CDR Design
Circular Base Plates		Optimized Base Plates



Para-Glider Descent Speed Control Strategy	
1	3D Printed PETG Turning Spool
2	3D Printed PETG Servo Mounts
3	3D Printed PETG Servo Mounts with Stability Bar

Rationale for Change
Stability bar connects both servo mounts and improves structural integrity.

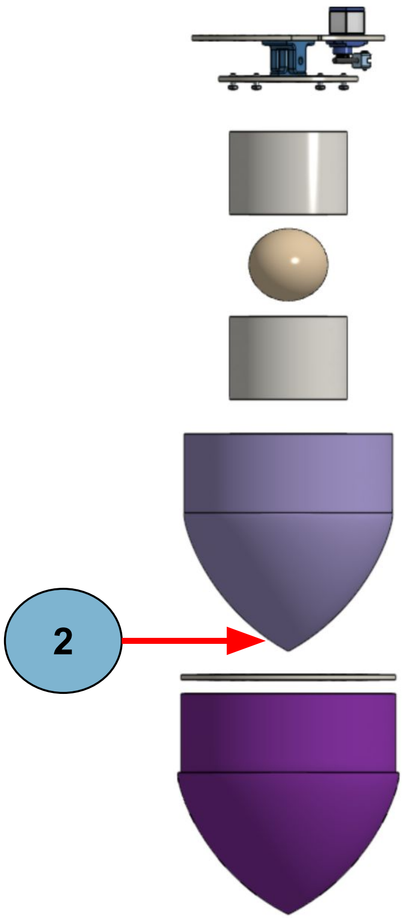
NOTE: Not all parts shown



PDR Design
Separate Servo Mounts

CDR Design
Servo Mounts with Stability Bar

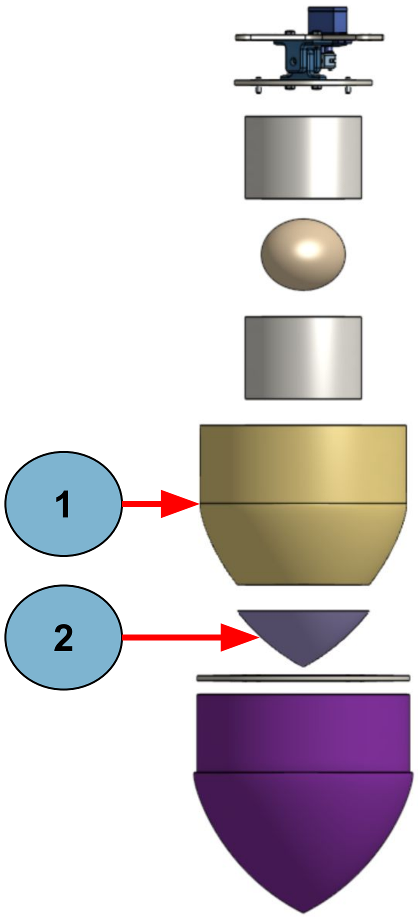
Mechanical Subsystem Changes Since PDR (3 of 3)



Egg Protection	
1	Polyurethane Spray Foam Insert
2	TPU Insert

Rationale for Change
Polyurethane spray foam insert with small TPU insert is 40g lighter than large TPU insert without compromising egg's protection.

NOTE: Not all parts shown

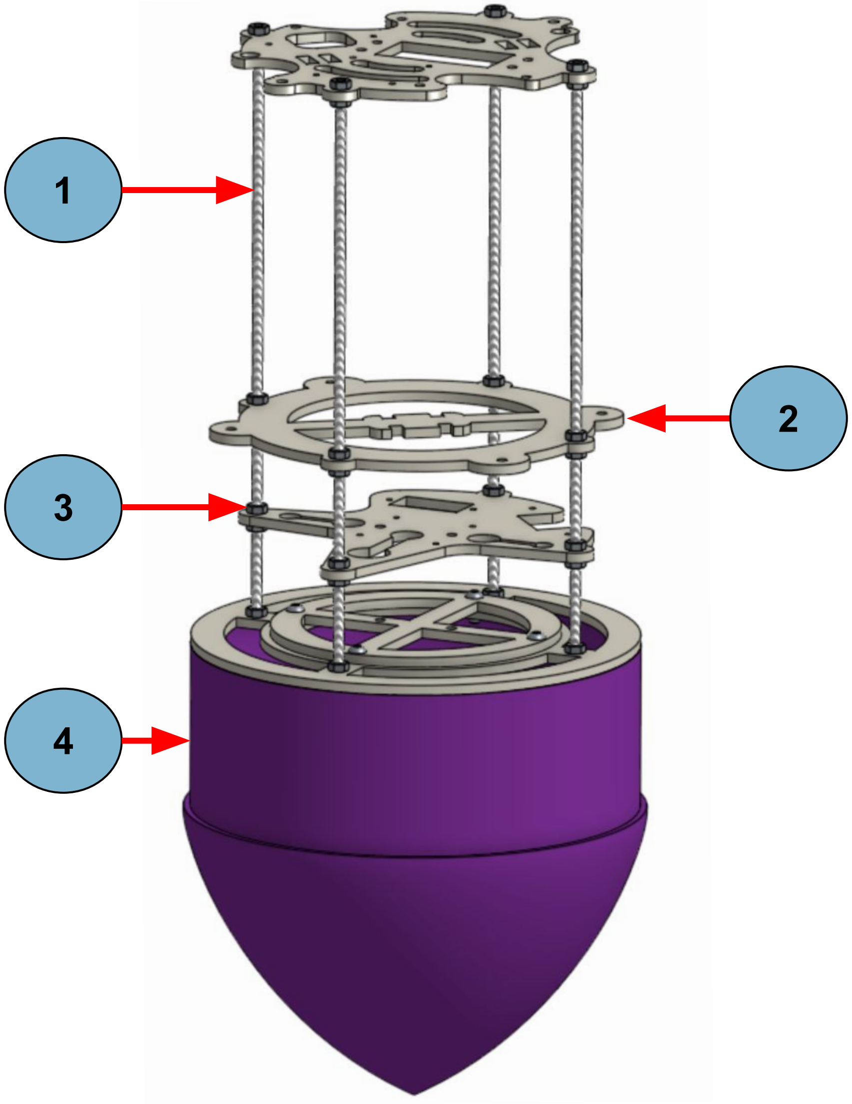


PDR Design
TPU Insert

CDR Design
Polyurethane Spray Foam Insert

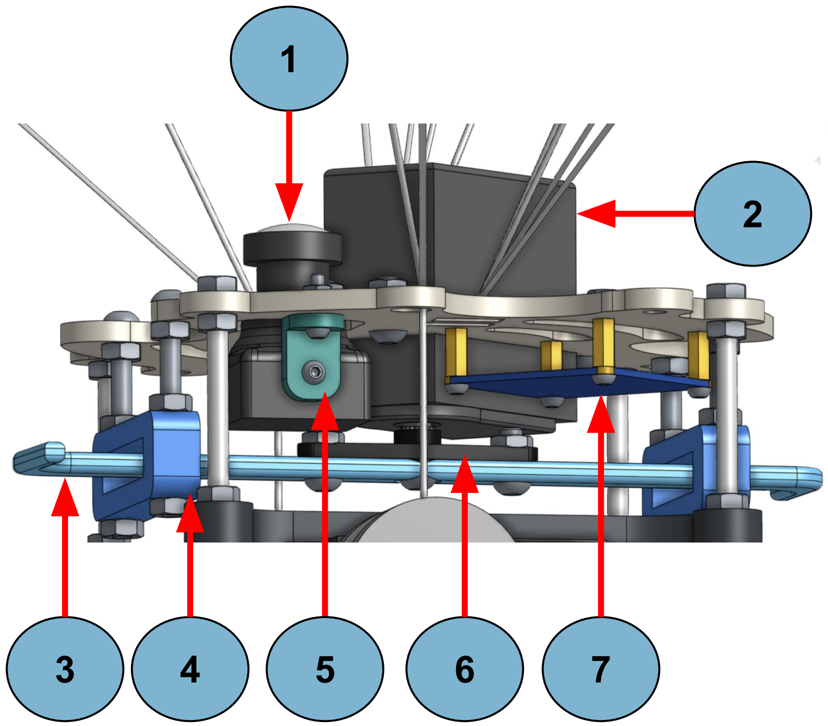
CanSat Mechanical Layout of Components (1 of 6)

Payload Body Structure	
#	**Description**
1	Four M3 Zinc Plated Steel Threaded Rods
2	Five Fiberglass Composite Plywood Plates
3	M3 Hex Nuts
4	Fiberglass Composite Ogive Nose Cone



NOTE: Not all parts shown

Back Plate	
#	Description
1	RunCam Split 4 V2 Upward Camera
2	Miuzei 25 kg Servo
3	Forged Carbon Fiber Release Mechanism Arm
4	3D Printed PETG Release Mechanism Arm Support
5	3D Printed PETG Camera Mount
6	Servo Horn
7	Upward Camera PCB Mounted on M2 Standoffs

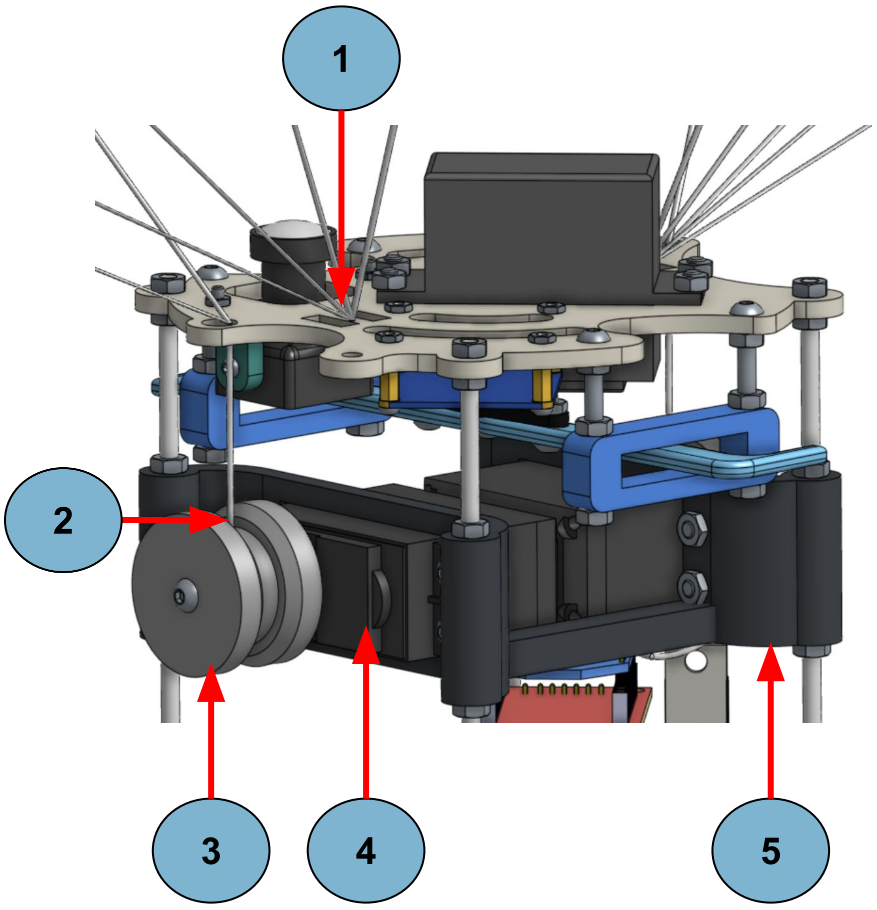


NOTE: Not all parts shown

CanSat Mechanical Layout of Components (3 of 6)

Para-Glider Steering

#	Description
1	Fixed Para-Glider Lines Attachment Point
2	Brake Para-Glider Lines Attachment Point
3	3D Printed PETG Turning Spool
4	LS-955CR Servo
5	3D Printed PETG Servo Mounts with Stability Bar



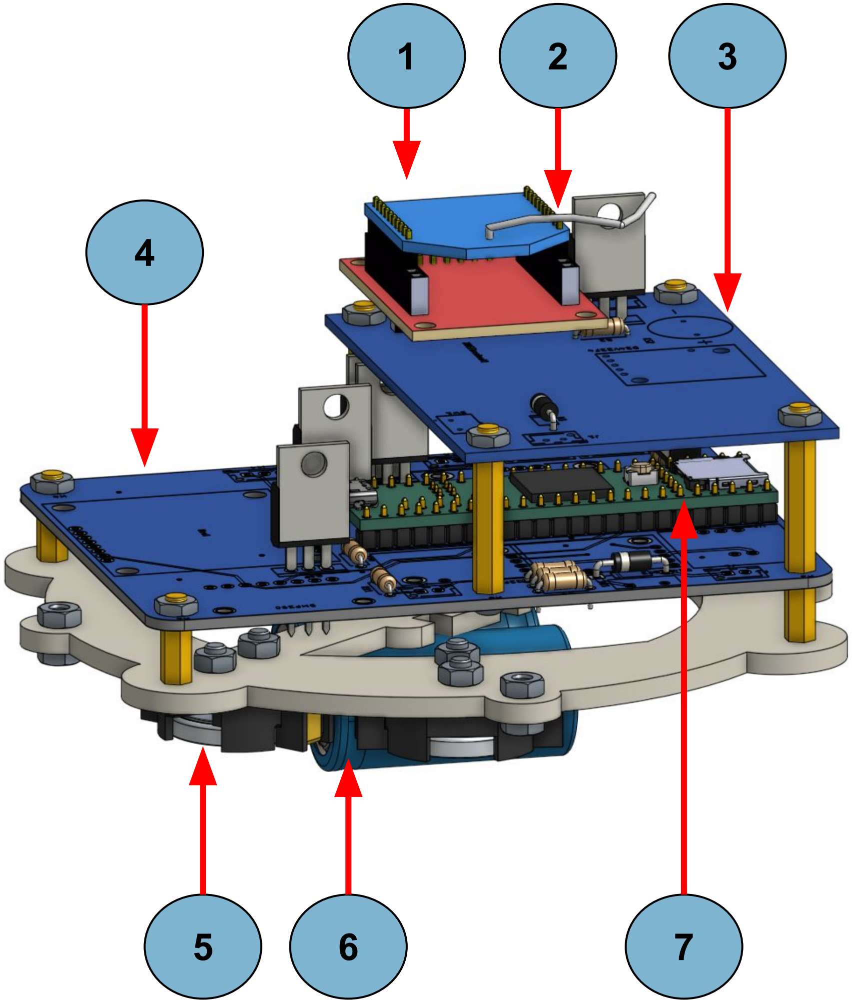
NOTE: Not all parts shown

CanSat Mechanical Layout of Components (4 of 6)

Electrical Component Mounting	
#	**Description**
1	XBEE Radio
2	XBEE Radio Antenna
3	Secondary PCB
4	Primary PCB
5	Coin Cell Batteries
6	18350 Battery Pack
7	Teensy 4.1 Microcontroller

NOTE: LED power indicators are located on PCB

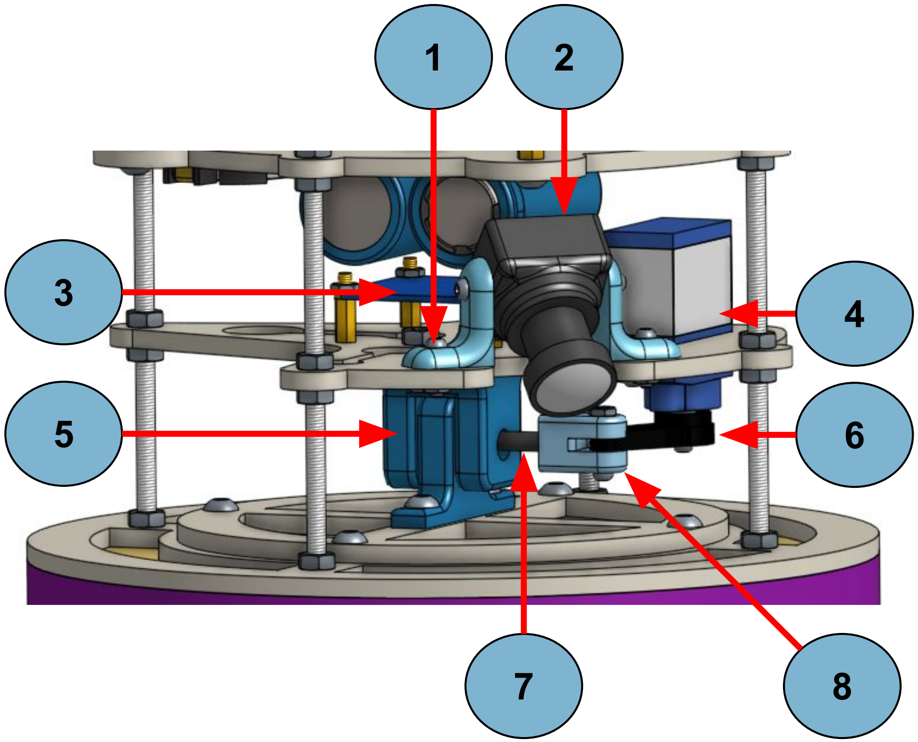
NOTE: Not all parts shown



CanSat Mechanical Layout of Components (5 of 6)

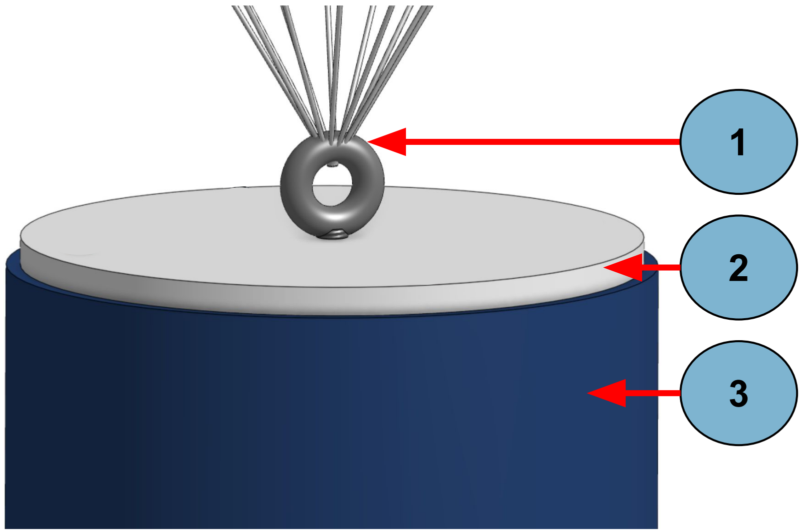
Instrument Release Mechanism	
#	**Description**
1	3D Printed PETG Downward Camera Mount
2	RunCam Split 4 V2 Downward Camera
3	Downward Camera PCB Mounted on M2 Standoffs
4	MG92B Servo
5	3D Printed PETG Pin Holders
6	Servo Horn
7	Carbon Fiber Rod
8	3D Printed PETG Adapter

NOTE: Not all parts shown



CanSat Mechanical Layout of Components (6 of 6)

Container	
#	**Description**
1	Tether Attachment Point, ¼ Inch Eye Bolt
2	6mm Plywood Container Plate Epoxied to Container Shoulder
3	Fiberglass Composite Layup Container



NOTE: Not all parts shown

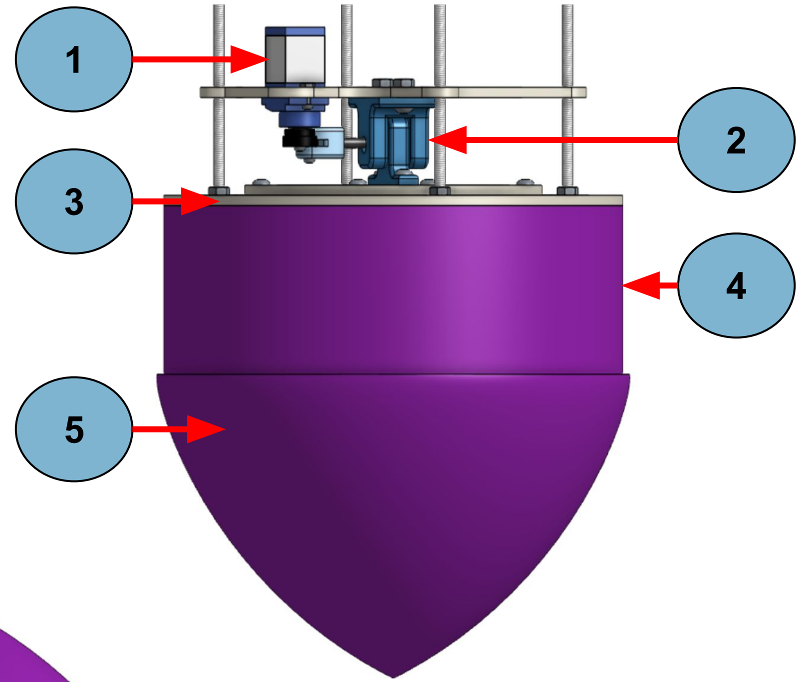
Nose Cone Design (1 of 2)

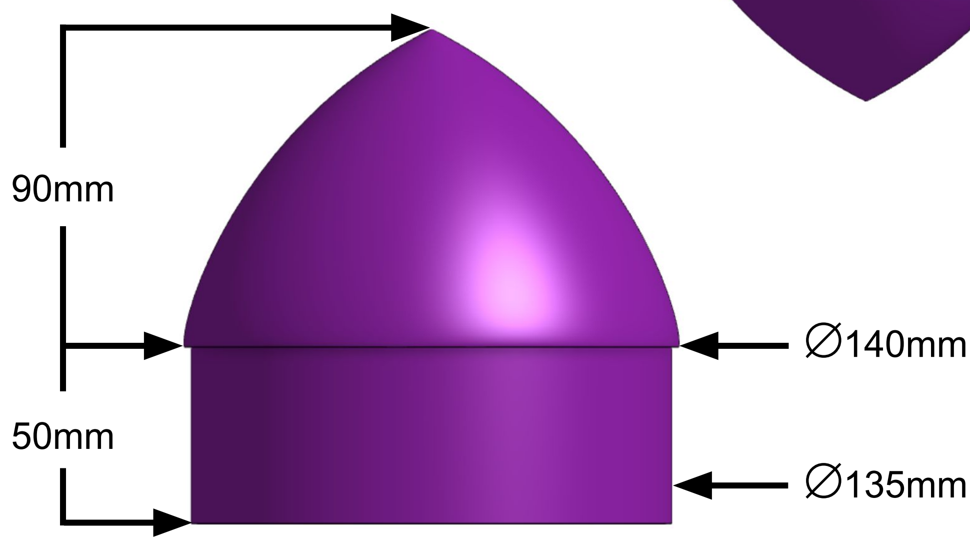
#	Description
1	MG92B Servo
2	Instrument Release Mechanism
3	Nose Cone Plate
4	Fiberglass Composite Nose Cone Shoulder
5	Fiberglass Composite Ogive Nose Cone

NOTE: Not all parts shown

NOTE:

- Nose cone is manufactured as a single piece with no openings
- Nose cone is epoxied to the nose cone plate which is attached to the instrument release mechanism



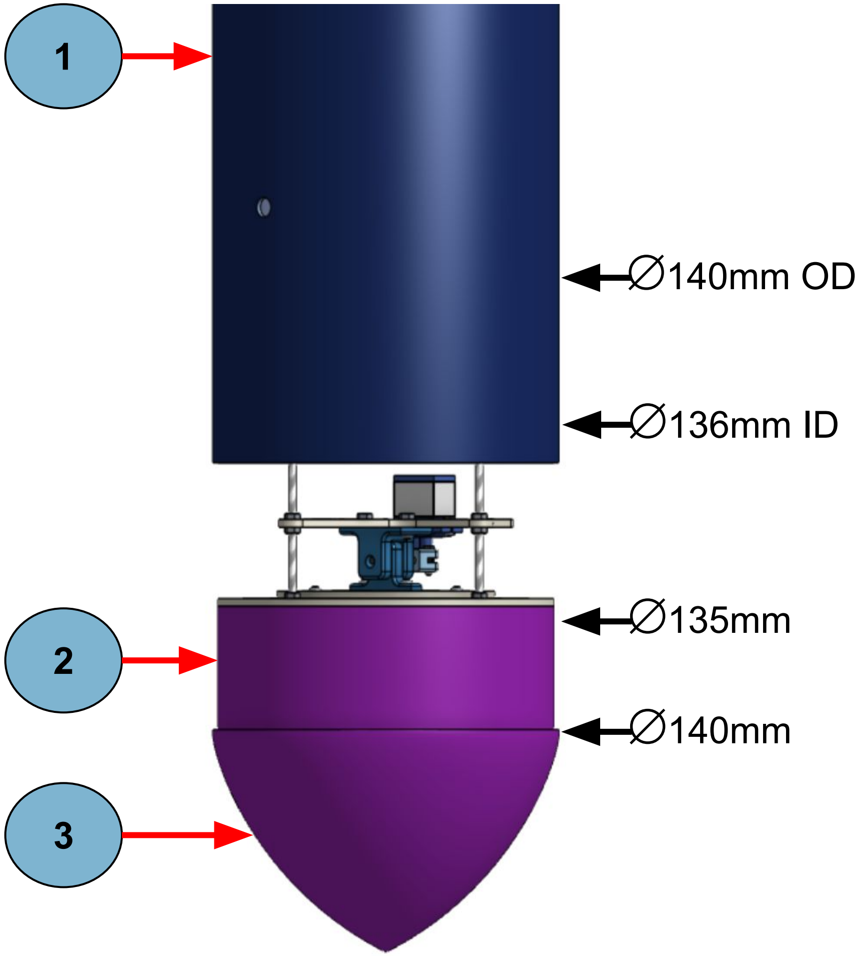


Nose Cone Design (2 of 2)

#	Description
1	Container
2	Nose Cone Shoulder
3	Fiberglass Composite Ogive Nose Cone

NOTE:
- Nose cone drag coefficient is 0.017 (Source: OpenRocket)
- Nose cone shoulder fits into container with a tolerance 0.5mm
- Nose cone wall thickness is 1.5mm

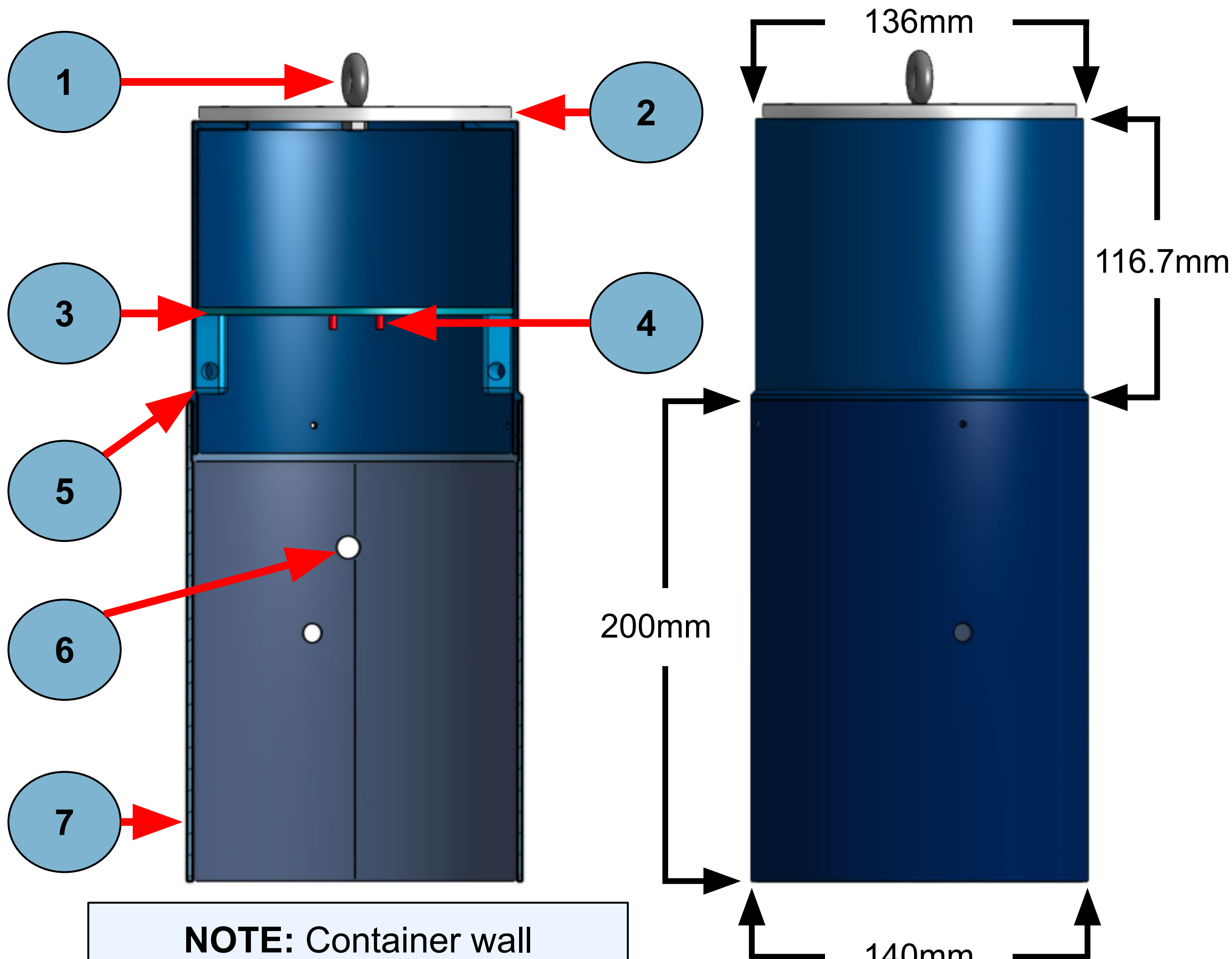
NOTE: Not all parts shown



Container Design

#	Description
1	¼ Inch Eye Bolt
2	6mm Plywood Plate
3	Fiberglass Composite Plywood Plate
4	Rotation Prevention Rods
5	Container Integration Piece
6	9mm Diameter Switch Access Hole
7	Fiberglass Composite Layup Container

NOTE: Not all parts shown



NOTE: Container wall thickness is 2mm

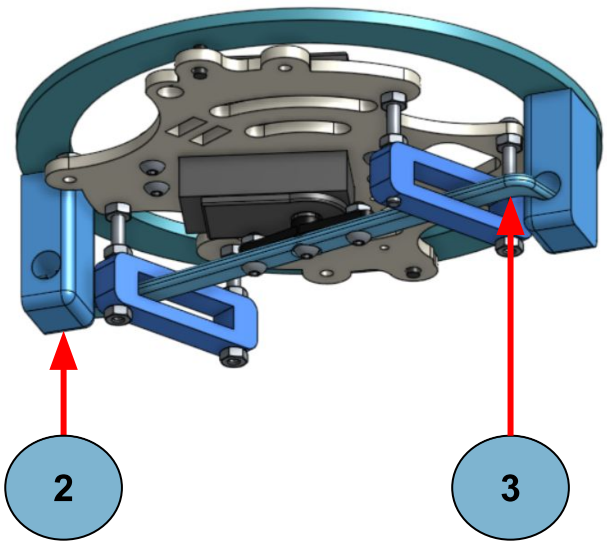
Payload Pre-Deployment Configuration

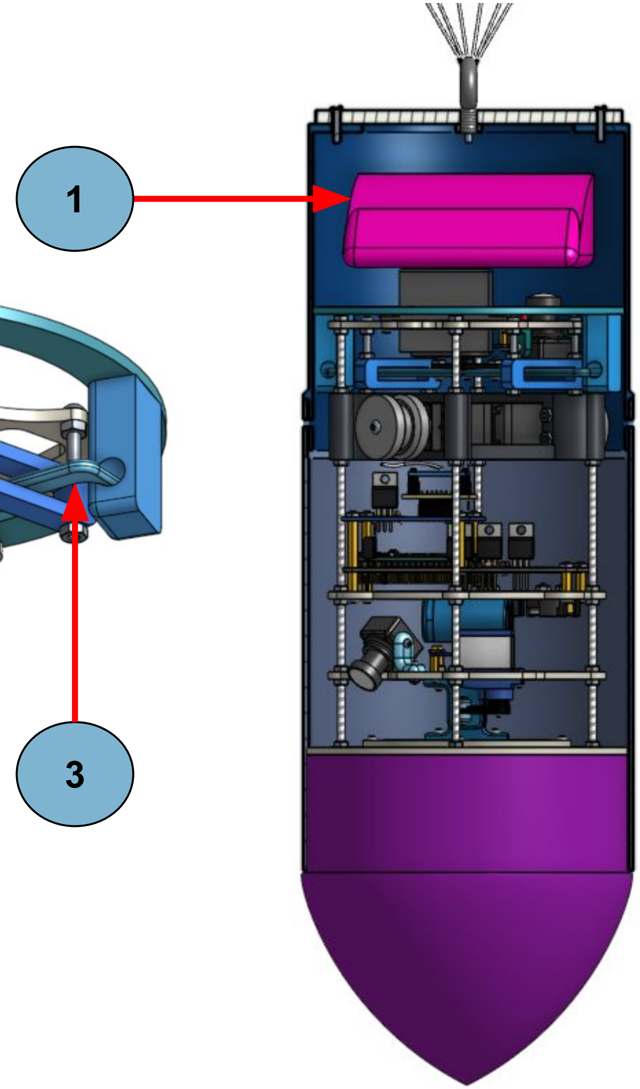
#	Description
1	PRO Packed Para-Glider
2	3D Printed PETG Container Integration Piece
3	Forged Carbon Fiber Release Mechanism Arm

NOTE:

- Payload is secured to the container by a forged carbon fiber release arm
- The arm turns to lock into the two forged carbon fiber container integration pieces

NOTE: Not all parts shown



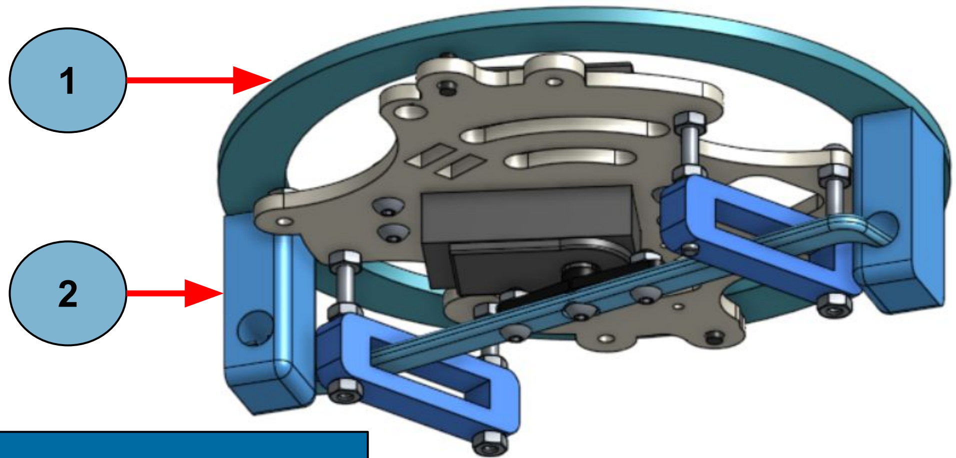


Payload Release

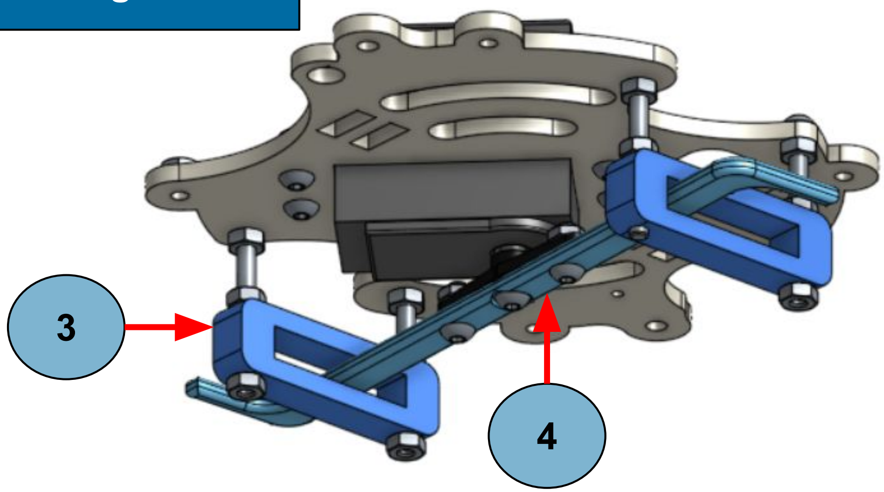
#	Description
1	Container Integration Plate
2	3D Printed PETG Container Integration Piece
3	3D Printed PETG Release Mechanism Arm Support
4	Forged Carbon Fiber Release Arm

NOTE: Not all parts shown

Stowed Configuration



Deployed Configuration



NOTE:

- Payload releases from container when it reaches 80% apogee or when command is sent from ground station.
- Servo rotates Forged Carbon Fiber Release Arm so that the payload is released from container

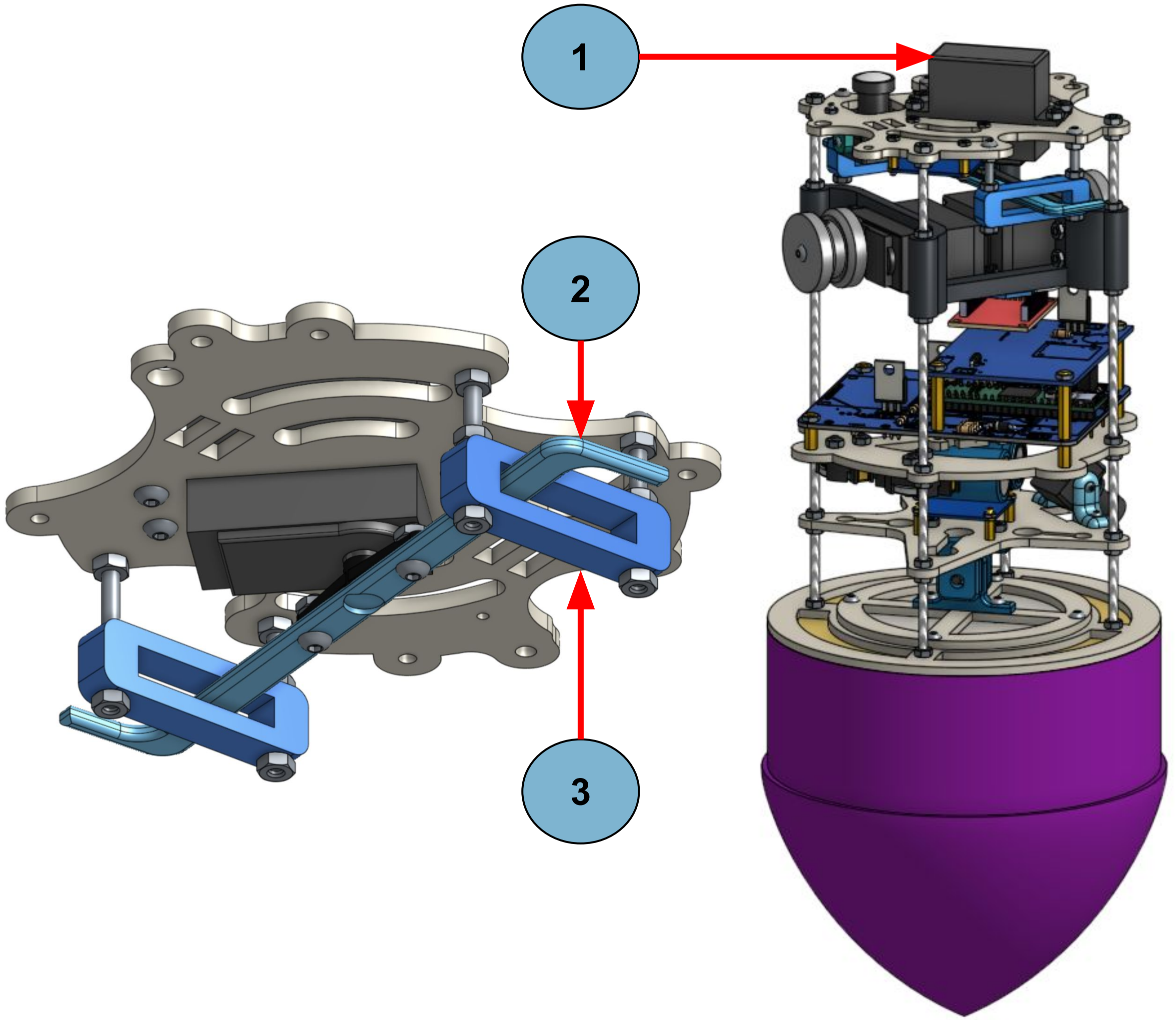
Payload Deployment Configuration

#	Description
1	Miuzei 25 kg Servo
2	Forged Carbon Fiber Release Arm
3	3D Printed PETG Release Mechanism Arm Support

NOTE:

- To deploy, the forged carbon fiber release mechanism arm is rotated 18° and remains in this orientation during payload descent
- After deployment, no changes to structure occur

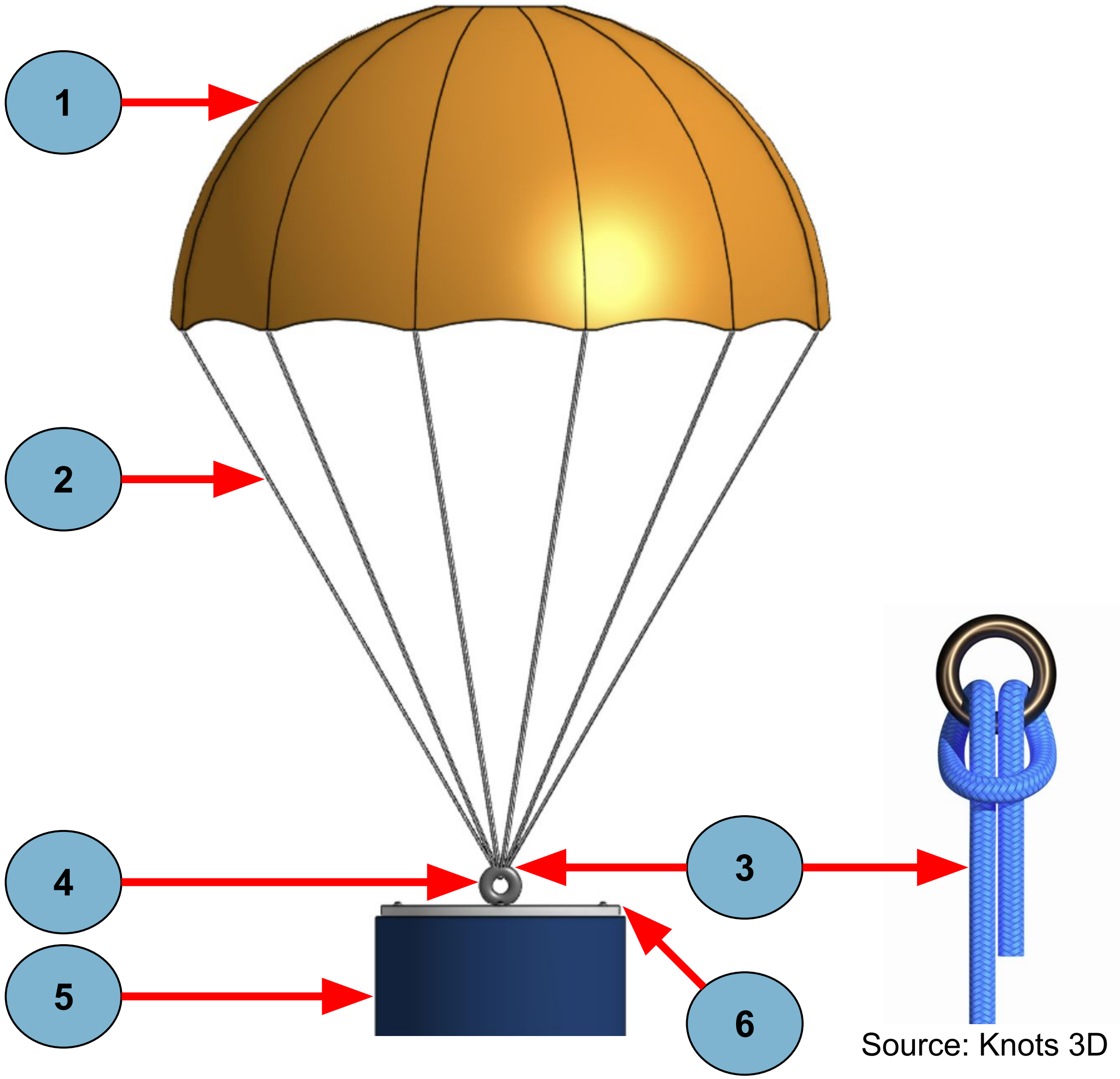
NOTE: Not all parts shown



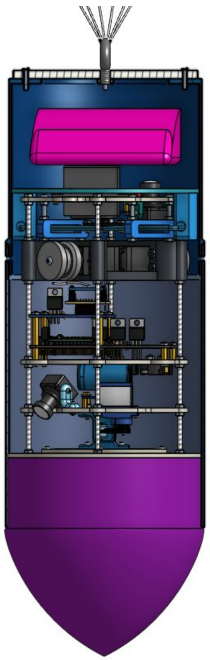
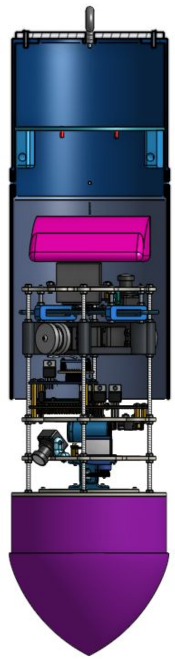
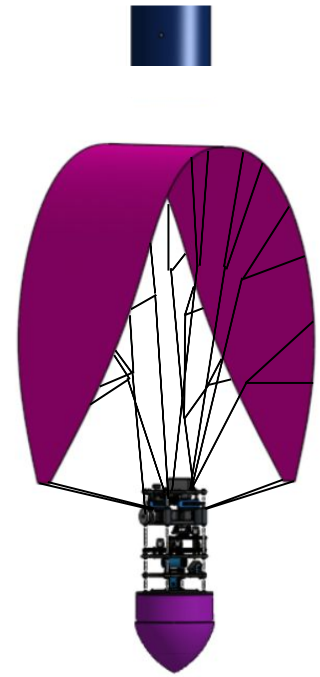
Parachute Attachment to Container

#	Description
1	Neon Orange Ripstop Nylon Hemispherical Parachute
2	Kevlar Parachute Lines
3	Cow Hitch Knot
4	¼ Inch Eye Bolt
5	Fiberglass Composite Layup Container
6	6mm Plywood Container Plate

NOTE: Not all parts shown

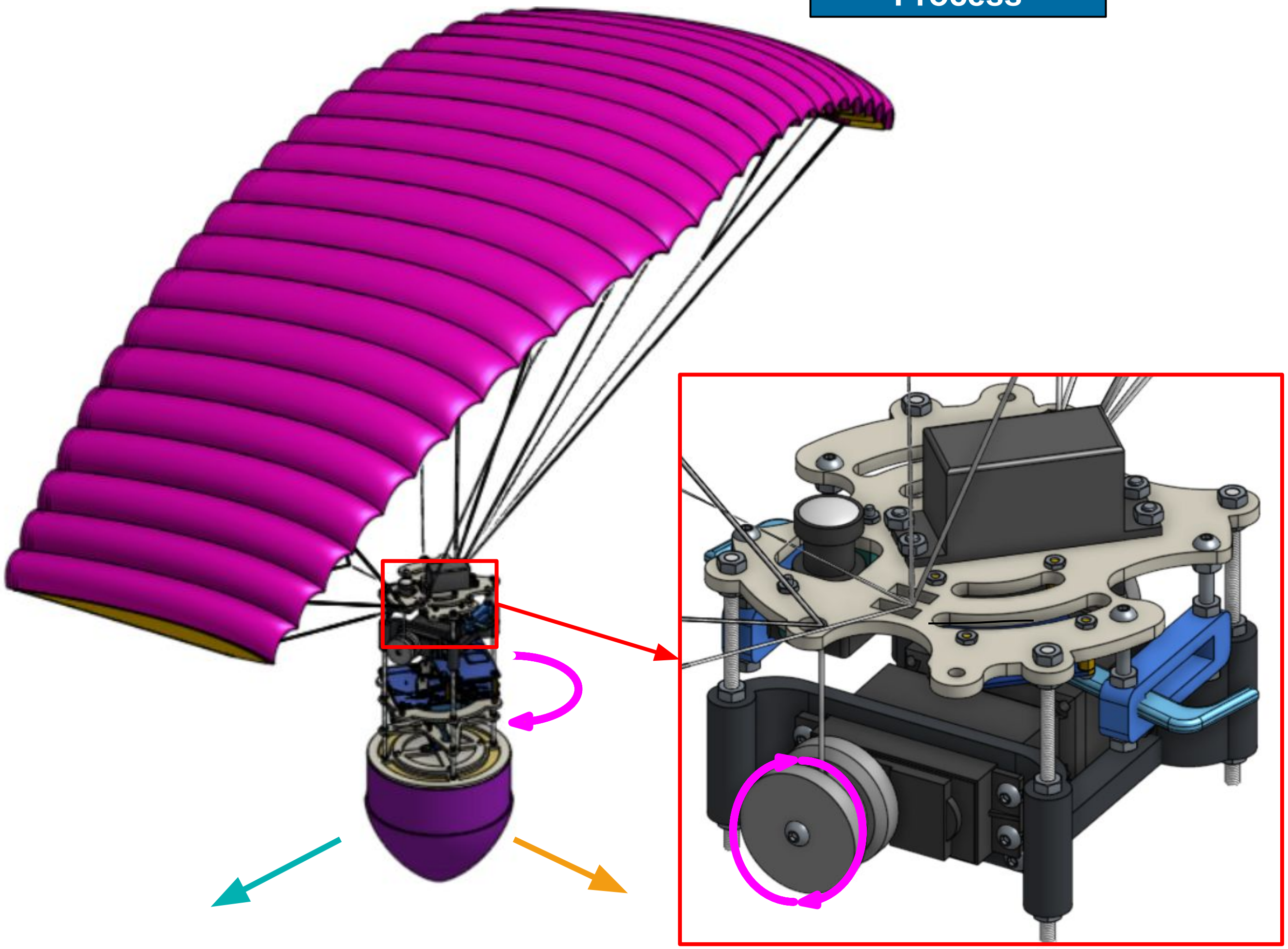


Para-Glider Deployment

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
				
Payload releases from container & begins to fall	Payload exits container, pulling para-glider out	Para-Glider fully exits container	Para-Glider cells catch air & inflate, beginning airfoil formation	Para-Glider airfoil is fully formed, controlled descent is initiated

Payload Steering

Steering Process



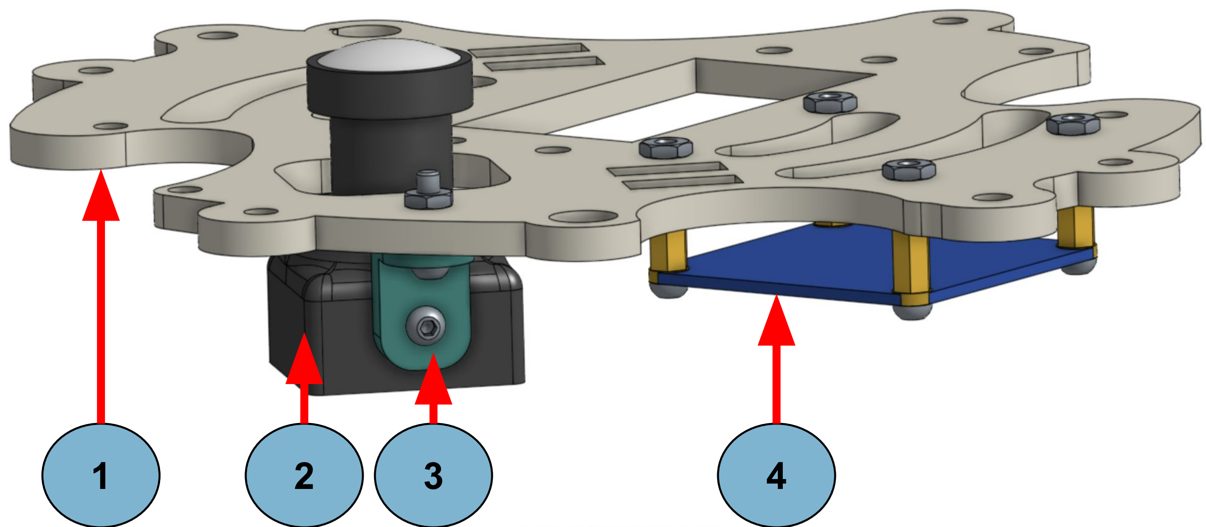
Direction of Rotation	
Direction of Travel	
Direction of Target	

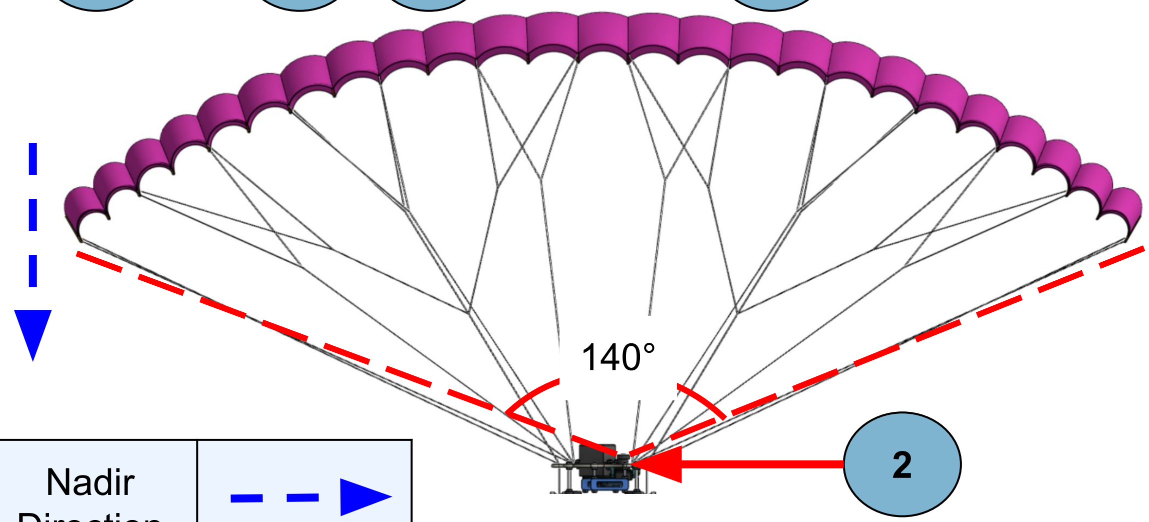
NOTE: Pulleys on each side turn, pulling & shortening the brake lines, manipulating the para-glider wing & payload to turn in the direction of the pulley

Release Camera Pointing

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

NOTE: Field of view allows for a clear view of the para-glider during descent





NOTE: Not all parts shown

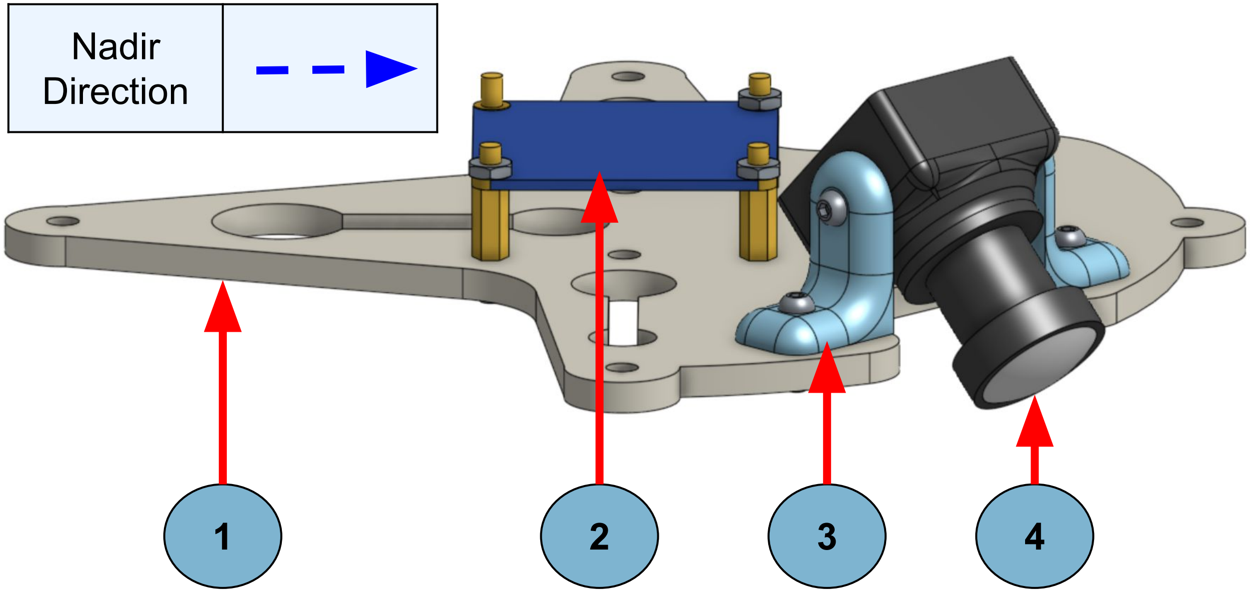
Nadir Direction	– – ▶

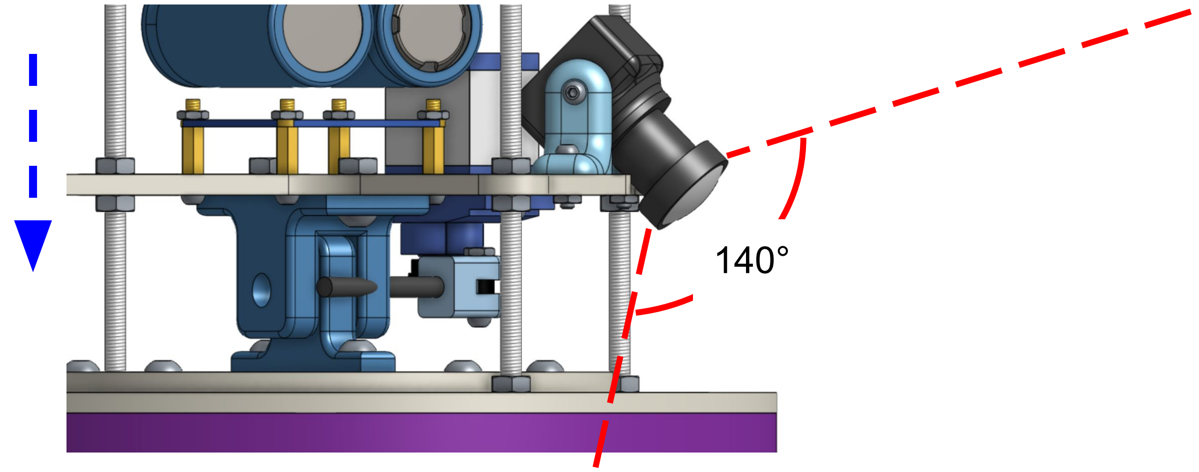
Ground Camera Pointing

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

NOTE: Field of view includes a clear view of the ground during descent and instrument release

NOTE: Not all parts shown

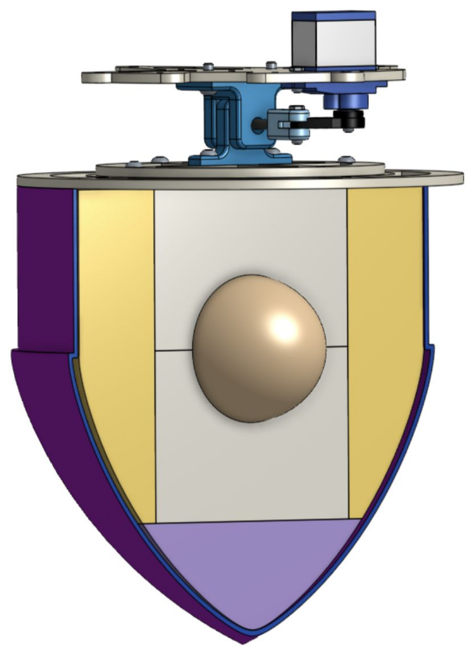


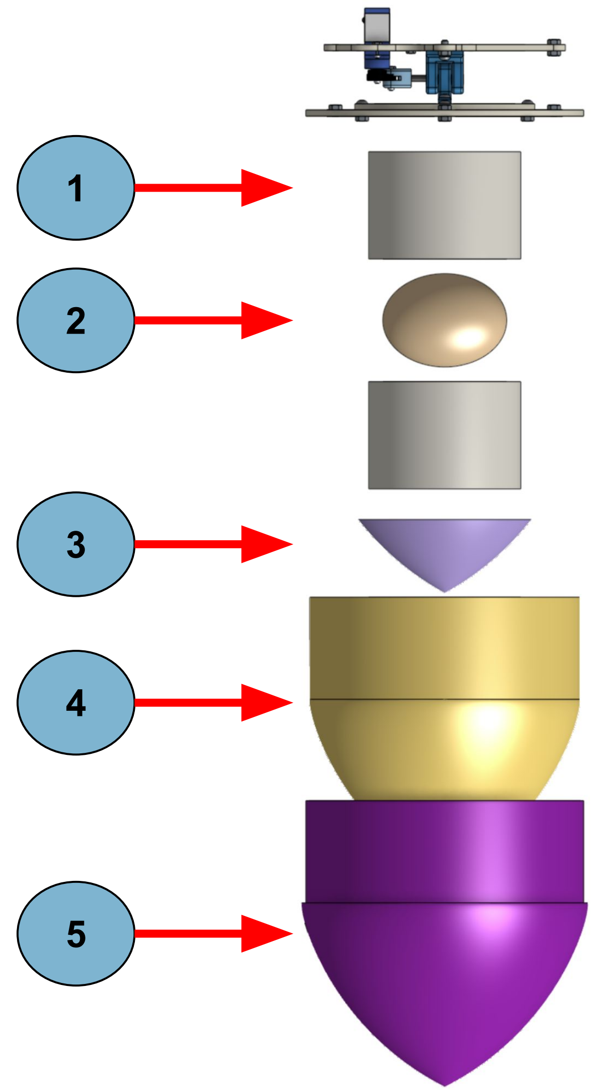


Egg Container Design (1 of 2)

#	Description
1	Urethane Foam Egg Holder
2	Hen's Egg
3	TPU Insert
4	Polyurethane Spray Foam
5	Fiberglass Nose Cone

NOTE:
- Protective measures include: urethane foam, polyurethane spray foam, and TPU insert
- Hens egg is mounted in nose cone which is secured to the payload with PETG pin holders and a carbon fiber rod

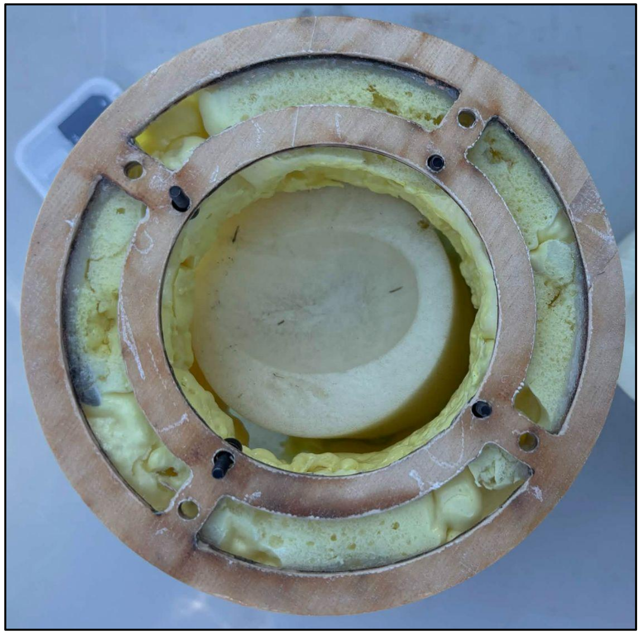




NOTE: Not all parts shown

Egg Container Design (2 of 2)

Test Flight 2 Results
During our second test flight, our egg successfully survived landing at a velocity of approximately 7m/s.

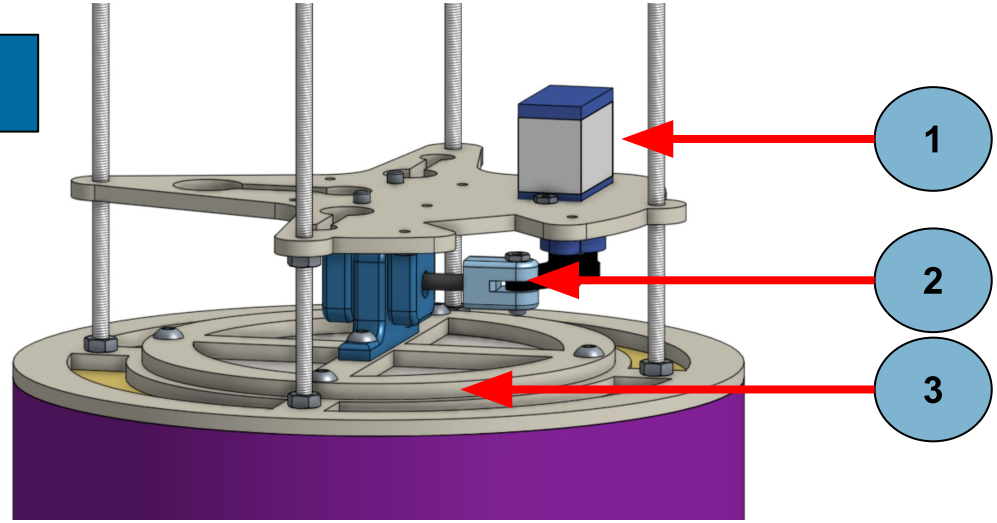

Egg Container Release Design

#	Description
1	MG92B Servo
2	Carbon Fiber Rod and PETG Adapter
3	Nose Cone Integration Plate
4	PETG Pin Holders
5	Epoxied Nose Plate

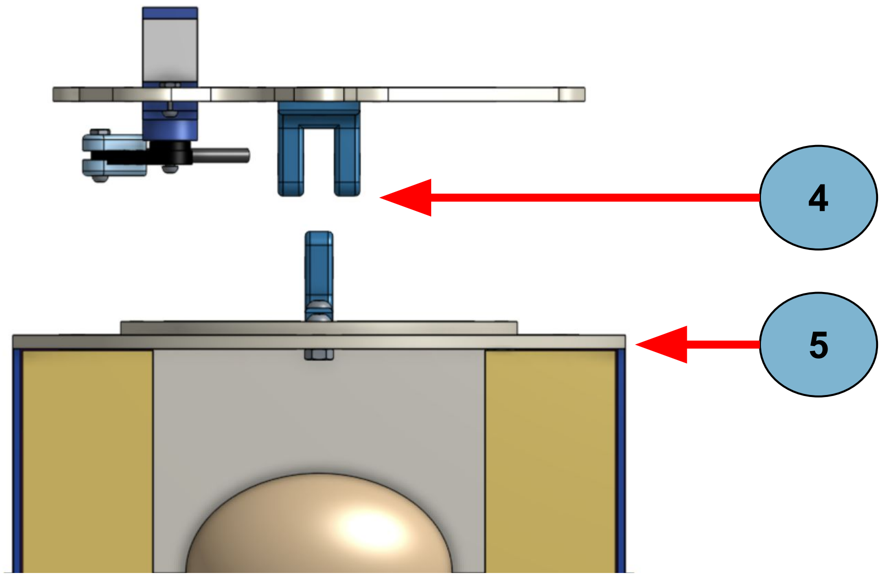
NOTE: Servo actuates and pulls the carbon fiber rod from the PETG Pin Holders to release the Egg Container.

NOTE: Not all parts shown

Locked



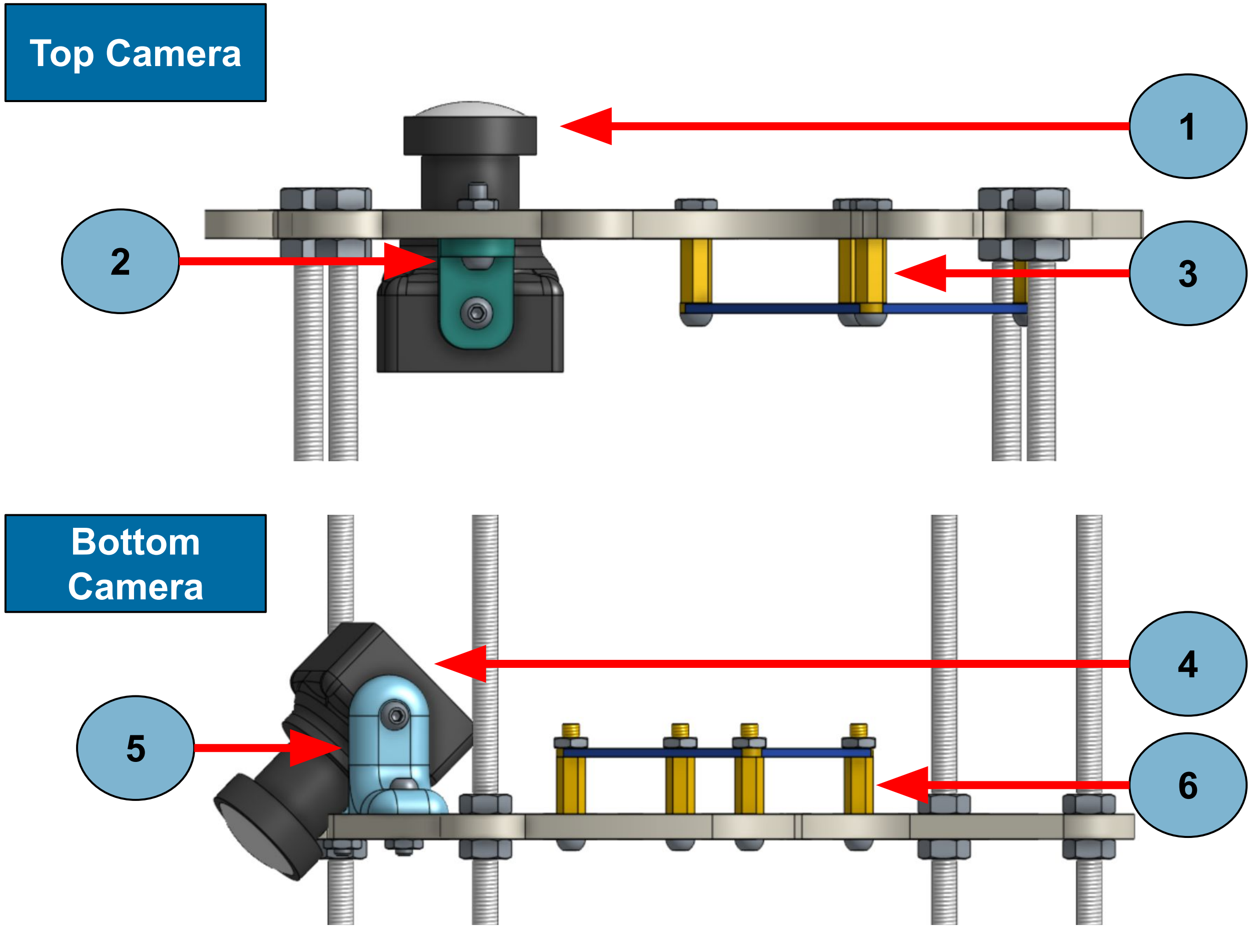
Released



Structure Survivability (1 of 6)

Camera Mounting

#	Description
1	Upward Camera
2	PETG Upward Camera Mount
3	Upward Camera PCB Standoffs
4	Downward Camera
5	PETG Downward Camera Mount
6	Downward Camera PCB Standoffs



NOTE: Cameras secured using screws, nuts, and 3D printed PETG mounts.

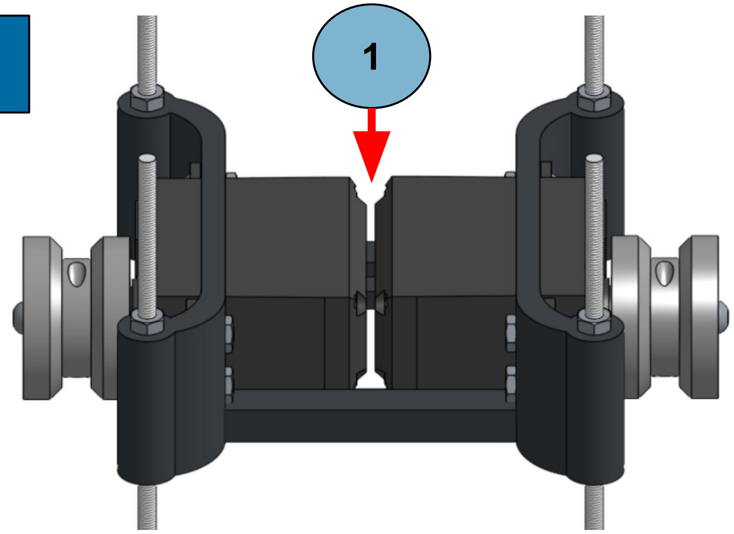
NOTE: Not all parts shown

Steering Servos Mounting

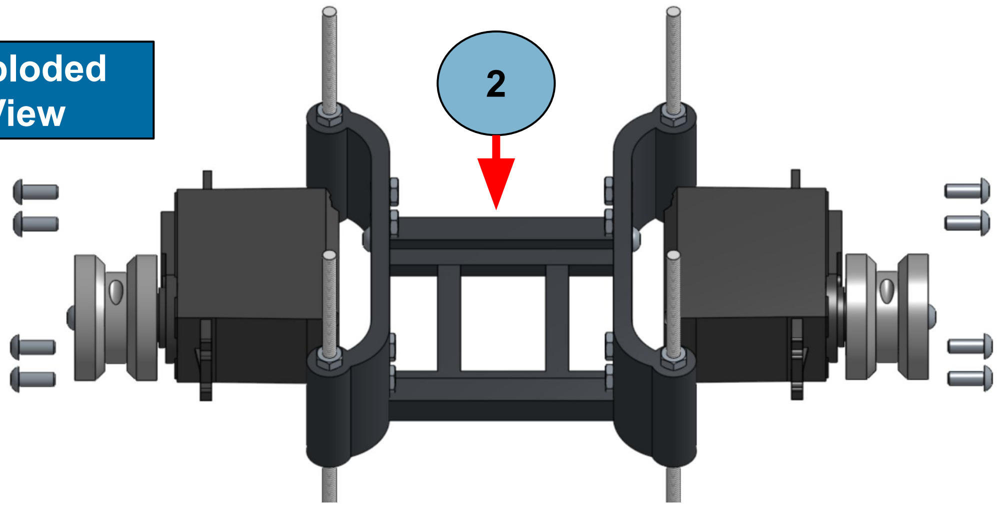
#	Description
1	LS-955CR Servos
2	3D Printed PETG Servo Mount

NOTE: LS-955CR Servos secured using screws, nuts, and 3D printed PETG mounts.

Front View



Exploded View



NOTE: Not all parts shown

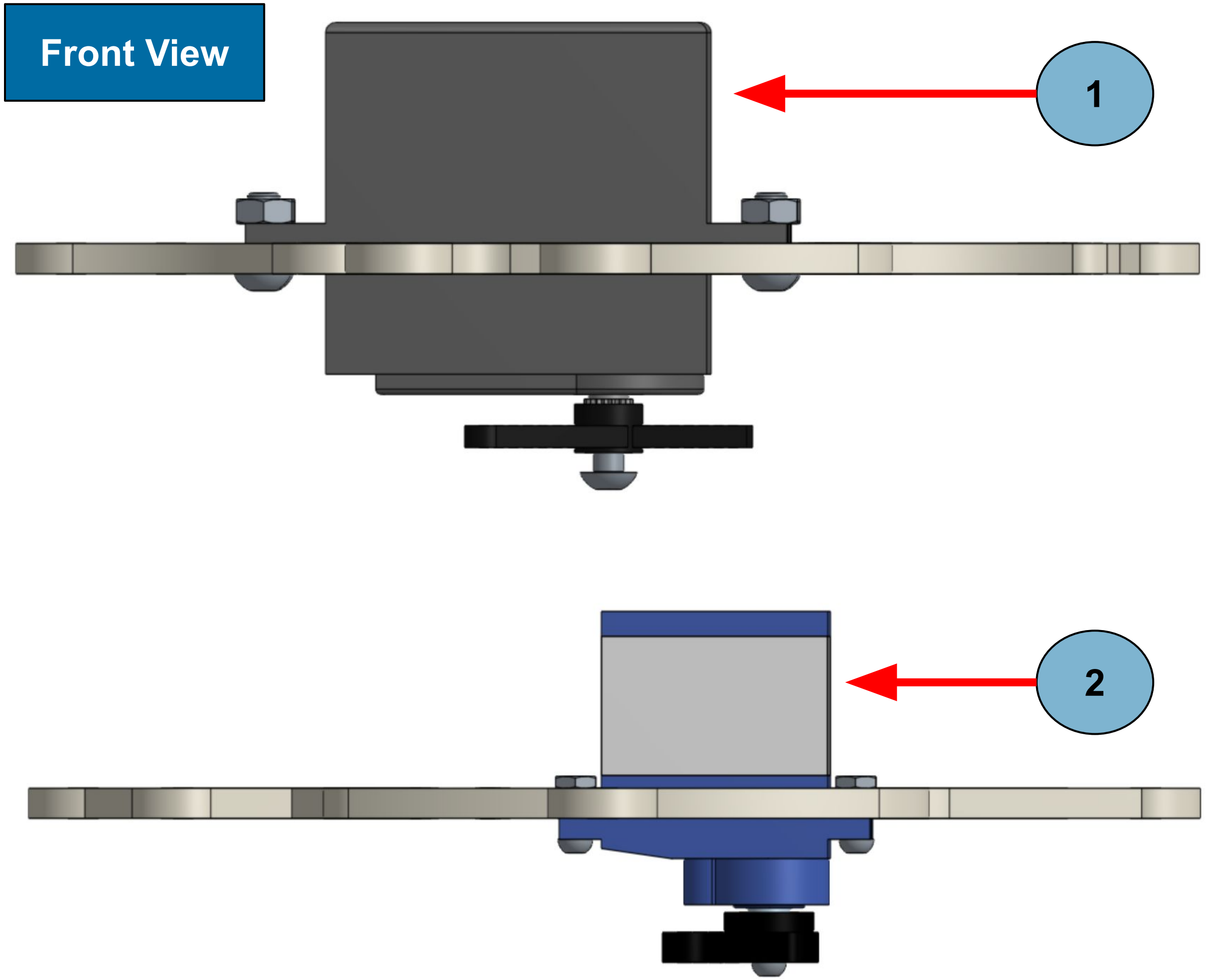
Structure Survivability (3 of 6)

Payload and Instrument Mounting

#	Description
1	Miuzei 25 kg Servo
2	MG92B Servo

NOTE: The Miuzei 25 kg Servo and the MG92B Servo are secured with nuts and screws inserted through the fiberglass composite plywood mounting plates

Front View



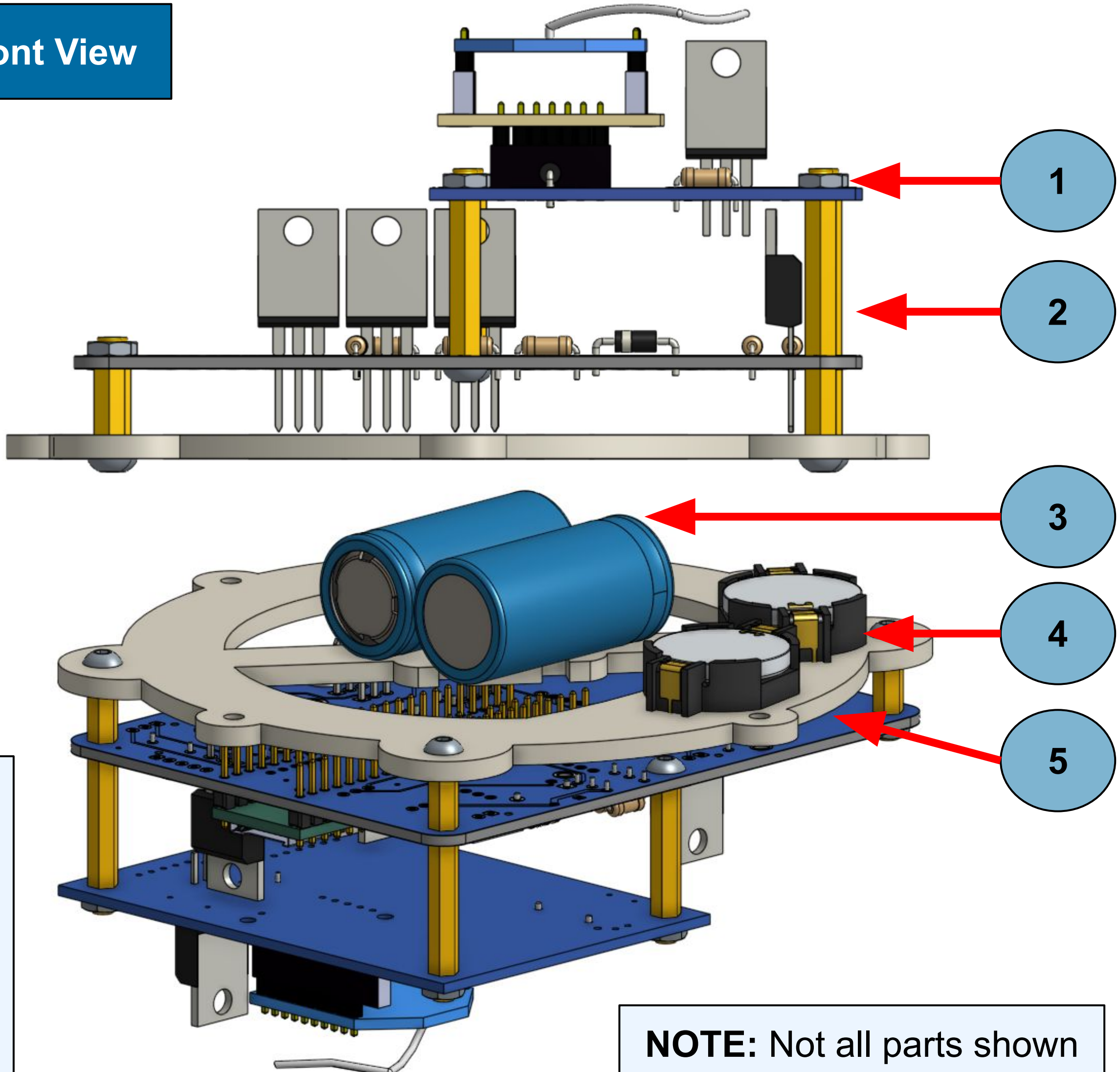
NOTE: Not all parts shown

Batteries and PCB Mounting

#	Description
1	Nuts
2	Standoffs
3	18350 Batteries
4	Coin Cell Batteries
5	Fiberglass Composite Plywood Mounting Plate

NOTE:
- PCBs secured on standoffs which are screwed through fiberglass composite plywood mounting plate
- Batteries secured with high performance double sided tape and zip ties

Front View



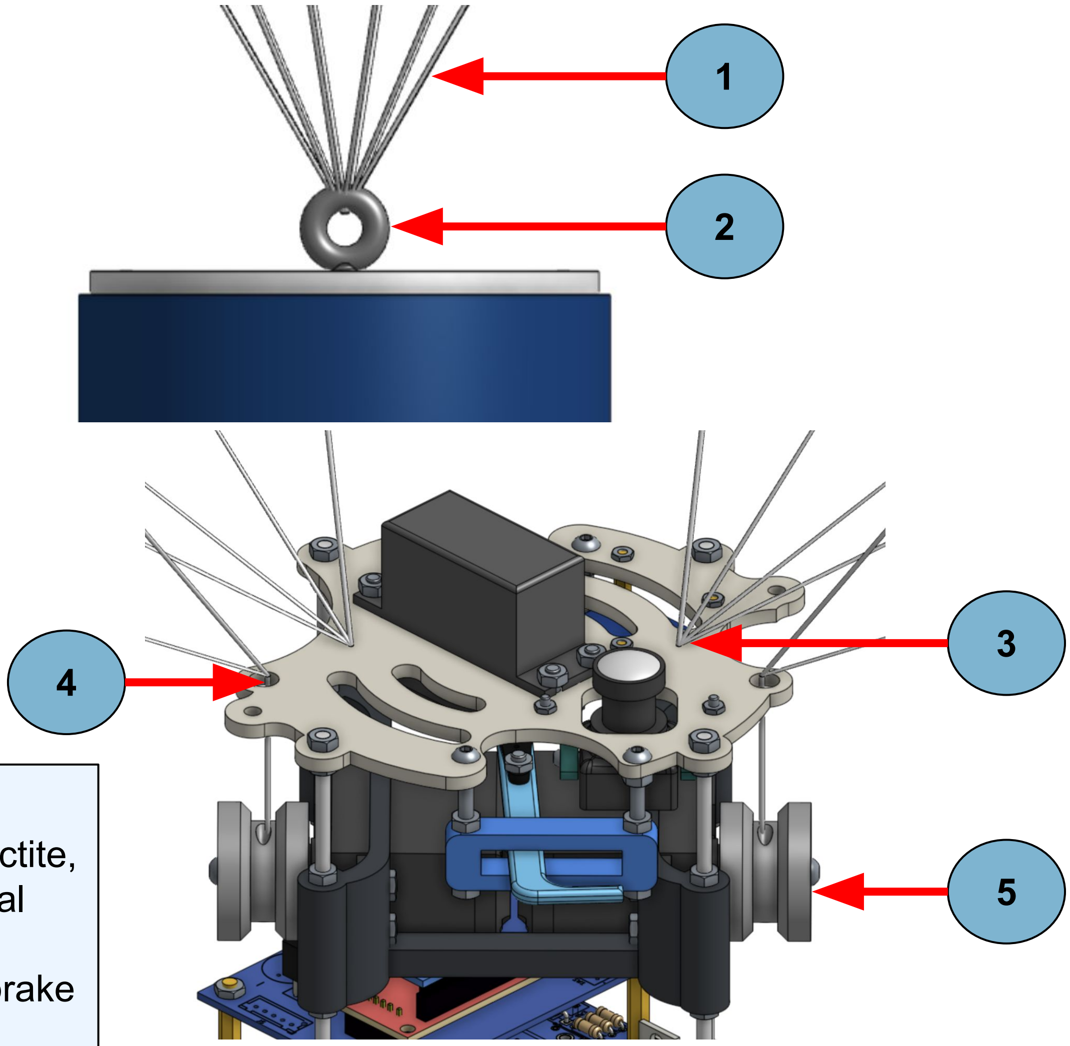
NOTE: Not all parts shown

Structure Survivability (5 of 6)

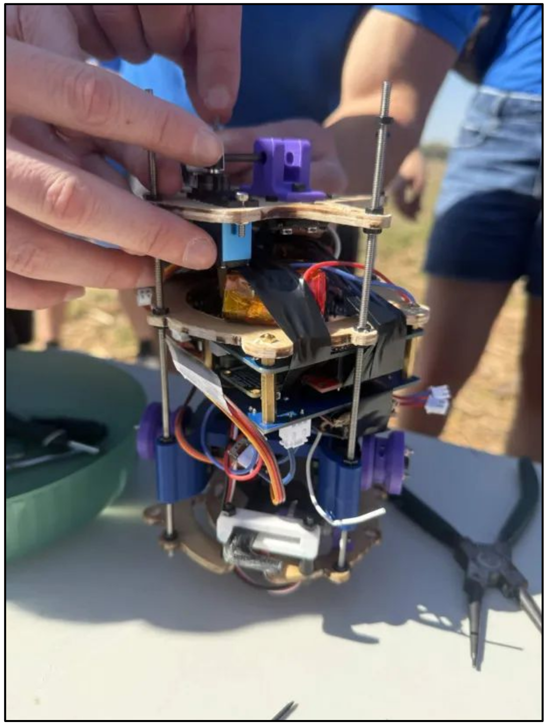
Descent Control Attachment Points

#	Description
1	Parachute Strings
2	Eye Bolt
3	Fixed Para-Glider Lines
4	Brake Para-Glider Lines
5	Turning Spools

NOTE:
- Mechanical components secured with Loctite, and electrical parts fastened with electrical tape to survive shock and acceleration
- Fixed lines tied onto the back plate and brake lines tied onto the turning spools



Test Flight 2 Results
For test flight 2, the PCB, sensors, and batteries were secured using zip ties, electrical tape, and kapton tape. Similarly, nuts and bolts were secured using loctite. The body structure and PCBs were undamaged after flight, and all sensors stayed connected during and after flight, though cameras lost connection.



Mass Budget (1 of 9)

Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
RunCam Split 4 V2	14.20	2	28.40	± 0.01	Measured
XBEE & Breakout	8.35	1	8.35	± 0.01	Measured
Primary PCB	27.94	1	27.94	± 0.01	Measured
Buzzer PCB	15.18	1	15.18	± 0.01	Measured
MG92B Servo	16.68	1	16.68	± 0.01	Measured
Miuzei 25 kg Servo	68.64	1	68.64	± 0.01	Measured
LS-955CR Servo	55.68	2	111.36	± 0.01	Measured
Vapcell A11 18350	26.56	2	53.12	± 0.01	Measured

Mass Budget (2 of 9)

Electrical Components					
Item	Unit Mass (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
BMP390	2.32	1	2.32	± 0.01	Measured
BNO-055	3.41	1	3.41	± 0.01	Measured
Teensy 4.1	8.46	1	8.46	± 0.01	Measured
Voltage Regulators	2.72	3	8.16	± 0.01	Measured
Current Sensor	1.59	1	1.59	± 0.01	Measured
NEO-M9N	7.74	1	7.74	± 0.01	Measured
Resistors	0.12	12	1.44	± 0.01	Measured
Mosfets	1.98	6	11.88	± 0.01	Measured
Diodes	0.72	2	1.44	± 0.01	Measured
JSTs	0.29	13	3.77	± 0.01	Measured

Mass Budget (3 of 9)

Electrical Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
Coin Cell	3.32	2	6.64	± 0.01	Measured
Coin Cell Holder	0.79	2	1.58	± 0.01	Measured
Buzzer	4.36	1	4.36	± 0.01	Measured
Pin Headers	0.08	85	6.80	± 0.01	Measured

Mass Budget (4 of 9)

Structural Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
40D Ripstop Nylon Cruciform Parachute with Kevlar Lines	13.67	1	13.67	± 0.01	Measured
6mm Plywood Container Plate	42.97	1	42.97	± 0.01	Measured
¼ Inch Eye Bolt	13.41	1	13.41	± 0.01	Measured
3D Printed PETG Container Integration Plate and Pieces	12.31	1	12.31	± 0.01	Measured
Back Plate	18.02	1	18.02	± 0.01	Measured

Mass Budget (5 of 9)

Structural Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
Electrical Component Plate	19.80	1	19.80	± 0.01	Measured
Nose Release Mounting Plate	16.30	1	16.30	± 0.01	Measured
Nose Release Integration Plate	10.50	1	10.50	± 0.01	Measured
Nose Plate	18.46	1	18.46	± 0.01	Measured
Forged Carbon Fiber Release Mechanism Arm	8.10	1	8.10	± 0.01	Measured
Fiberglass Composite Container	90.10	1	90.10	± 12.61	Estimate

Mass Budget (6 of 9)

Structural Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
3D Printed PETG Release Mechanism Arm Support	4.60	2	9.2	± 0.01	Measured
3D Printed PETG Upward Camera Mount	1.23	2	2.46	± 0.01	Measured
3D Printed PETG Downward Camera Mounts	1.57	2	3.14	± 0.01	Measured
40D Ripstop Nylon Para-Glider with Kevlar Lines	72.62	1	72.62	± 0.01	Measured
Hen's Egg	59	1	59	± 5	Mission Guide

Mass Budget (7 of 9)

Structural Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
3D Printed PETG Steering Servo Mount	20.69	1	20.69	± 0.01	Measured
3D Printed PETG Turning Spool	7.33	2	14.66	± 0.01	Measured
Carbon Fiber Rod and 3D Printed PETG Adapter	1.76	1	1.76	± 0.01	Measured
3D Printed PETG Nose Cone Release Payload Attachment Point	4.55	1	4.55	± 0.01	Measured

Mass Budget (8 of 9)

Structural Components					
Item	**Unit Mass (g)**	**Quantity**	**Total Mass (g)**	**Uncertainty (g)**	**Source**
3D Printed PETG Nose Cone Release Nose Attachment Point	4.66	1	4.66	± 0.01	Measured
Urethane Foam Egg Holder	24.37	1	24.37	± 0.01	Measured
Fiberglass Composite Layup Ogive Nose Cone	90.35	1	90.35	± 0.01	Measured
Standoffs	1.73	6	10.38	± 0.01	Measured
M3 Zinc Plated Steel Threaded Rods	7.07	4	28.28	± 0.01	Measured

Mass Budget (9 of 9)

Total Mass of Payload (g)		Total Mass with Container (g)
862.54		1009.02
Total Mass (g)	**Mass Allowed (g)**	**Mass Margin (g)**
1009.02	1000	1000 - 1009.02 = -9.02

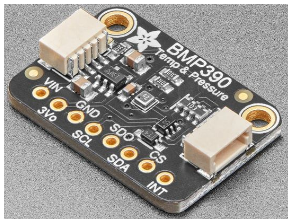
The total mass is 1009.02g which is within 1000g ± 10g, therefore compliant with the mission guide. Potential for error could be due to errors in material density calculations, error in predictions of thickness of fiberglass composite parts, inaccurate parts information.

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

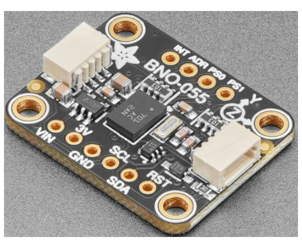


Source: Adafruit

BMP390
Pressure/Altitude
I2C

Source: Sparkfun

NEO-M9N
GPS + RTC
I2C

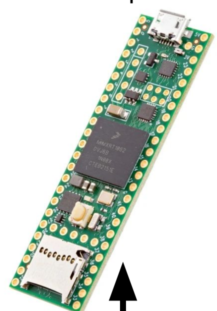


Source: Adafruit

BNO055
Acceleration/Tilt
I2C

Teensy 4.1 Microcontroller

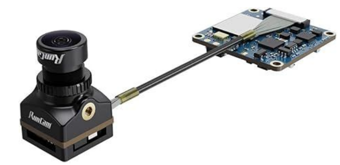
Source: Sparkfun



ACS724LLCTR
Battery Current
ADC

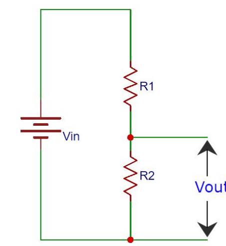
Source: Pololu

RunCam Split 4 V2
Flight Camera
UART



Source: Amazon

Voltage Divider
Battery Voltage
ADC



Source: Circuit Digest

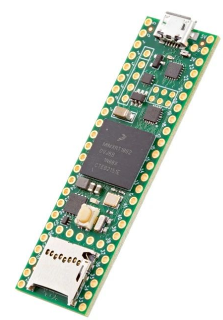
Xbee-Pro 900
Radio
UART

Source: Digikey

CDH Changes Since PDR

PDR Component	CDR Component	Rationale for Change
STM32H562RIT6	Teensy 4.1	Production delays caused a need to switch to a simpler electrical system. Includes integrated micro SD card slot for simple data storage.

Source: Digikey



Source: Digikey

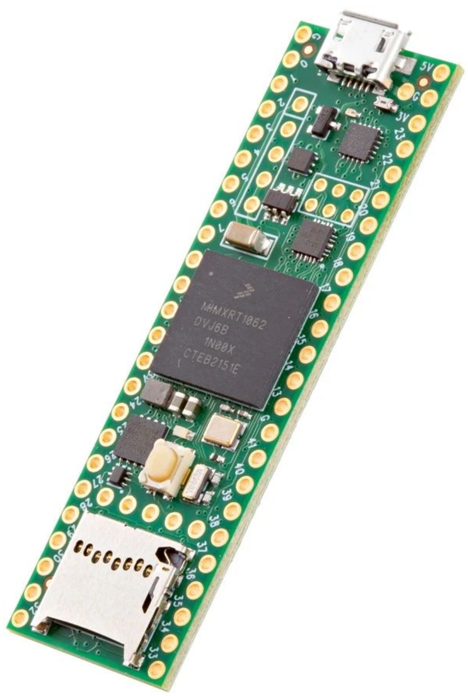
PDR Component	CDR Component	Rationale for Change
MCP7940MT-I/SN	NEO-M9N Integrated RTC	Allows for easier power system and comes with rechargeable battery backup for RTC lowering complexity of the system.

Source: Digikey

Source: Sparkfun

Payload Processor and Memory Summary (1 of 2)

Teensy 4.1			
Processor Speed (MHz)	Data Bus Width (bits)	Power Consumption (mWh)	Boot Time (ms)
600	32	160	20



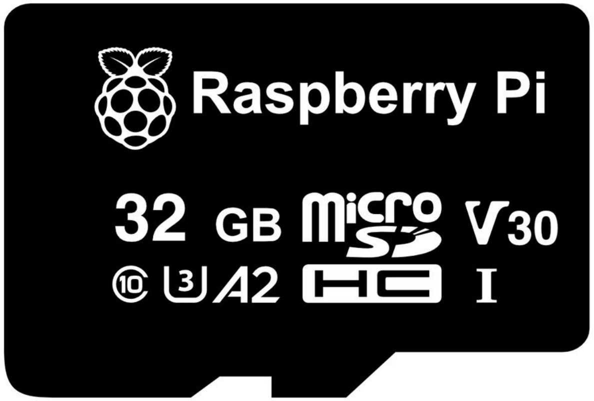
Source: Sparkfun

Data Interfaces		
UART	I2C	SPI
8	2	3
Pin Protocols		
Digital I/O	PWM	Analog
55	35	18

Payload Processor and Memory Summary (2 of 2)

Mission Data Storage
Storage Device
SC1628 Micro SD Card
Storage Size
32 GB

Video Storage
Storage Device
LSMICRO128GU3 SD Card
Storage Size
128 GB per Camera



Source: PiShop

Source: Amazon

Payload Real-Time Clock

NEO-M9N Integrated RTC						
Time Pulse Accuracy (ns)	**Antenna Connection**	**Voltage (V)**	**Added Current (mA)**	**Interface**	**Mass (g)**	**Added Price ($)**
30	U.FL	5	0	I2C	7.74	0

Source: Sparkfun

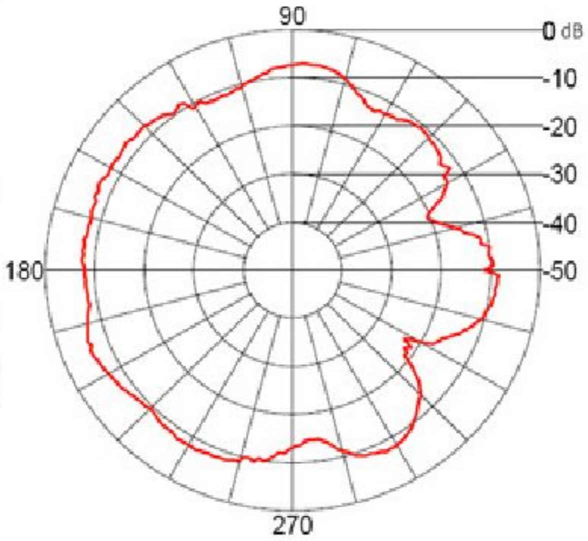
Data Format		
Variable Type	**Telemetry**	**Data**
double	MISSION_TIME	hh:mm:ss ± 1s

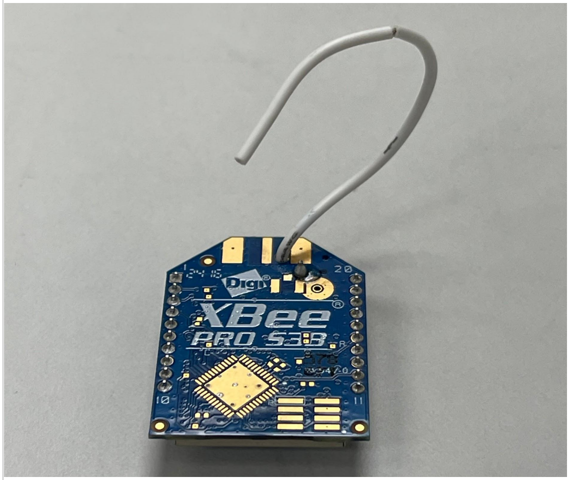
Data Processing

```
if(fd.missionTimeBool){
        fd.mth = fd.GPS_Hour;
        fd.mtm = fd.GPS_Minutes;
        fd.mts = fd.GPS_Seconds;
    }
```

Payload Antenna Selection

Integrated Wire				
Gain (dBi)	Transmitting Range (km)	Antenna Length (mm)	Weight (g)	Frequency Band (MHz)
1.9	9.6	45.7	< 1.0	902 to 928





Source: DigiKey

Source: Digi International

Payload Radio Configuration (1 of 2)

Radio
XBEE-PRO 900HP

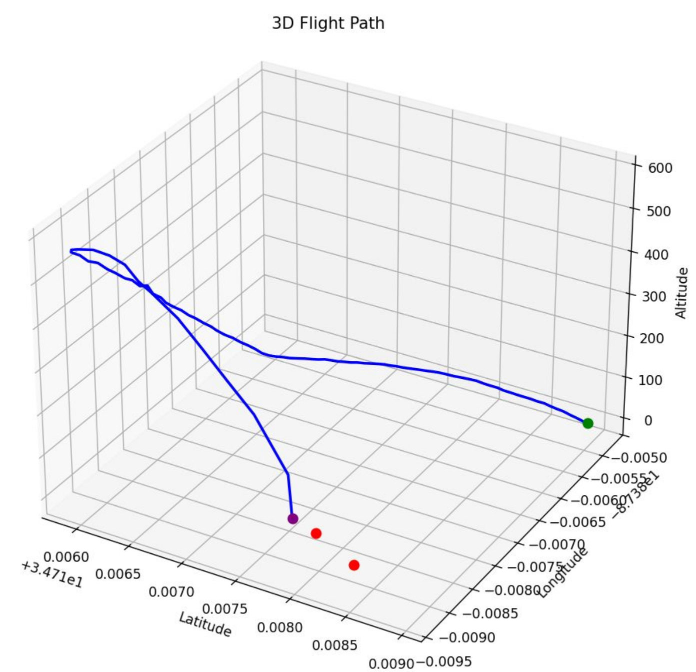
Source: Digikey

Transmission Control
Transmission of telemetry will only begin when the CX,ON command is received
Transmission of telemetry will cease when the CX,OFF 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 CX,OFF command is received

Transmit Power (dBm)	NETID	Baud Rate	Frequency Range (MHz)	Transmission Frequency (Hz)	Sampling Frequency (Hz)
24	1093	115200	902 - 928	1	1

Payload Radio Configuration (2 of 2)

Packet Reception from Test Launch 2	
Packets Sent	1465
Packets Lost	32
Packet Reception Rate	97.8%



Launch Coordinate	● (purple)
Landing Coordinate	● (green)
Target Coordinate Range	● (red)

Test Flight 2 CSV File

```
1093,0.00:0.00:0.00,991,F,ASCENT,570.35,36.4,92853.7
,7.15,0.02,-12.7,9.5,40.7,-42.61,5.68,-8.52,18:36:49,
735585.00,34.71622,-87.38921,12.00,CMD,1093,CAL
1093,0.00:0.00:0.00,992,F,APOGEE,577.81,36.4,92770.5,
7.15,0.02,-0.4,20.1,29.6,75.00,87.50,-50.00,18:36:50,
750269.00,34.71609,-87.38925,12.00,CMD,1093,CAL
1093,0.00:0.00:0.00,993,F,DESCENT,575.15,36.4,92800.1,
7.14,0.02,-1.4,20.6,55.2,352.27,1068.18,130.68,18:36:51,
758200.00,34.71597,-87.38930,11.00,CMD,1093,CAL
```

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>,, <CX_STATUS>

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,,CXON”

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	$°/s^2$
<ACCEL_P>	Accelerometer reading of pitch	$°/s^2$
<ACCEL_Y>	Accelerometer reading of yaw	$°/s^2$
<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	°East ± 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	Starts the transmission of telemetry	CMD,1093,CX,ON
	OFF	Ends the transmission of telemetry	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 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 Design

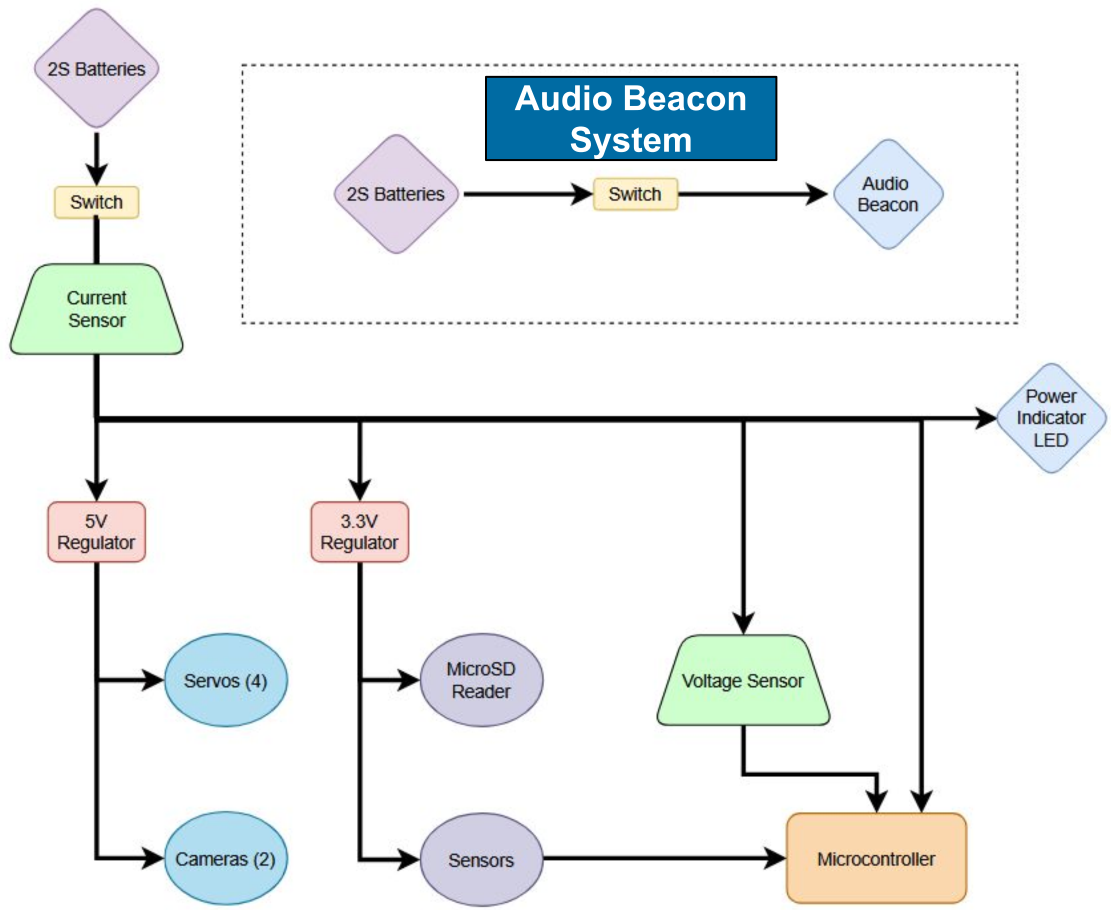
Aaron Watson

EPS Overview

Components	Description
Battery	Provides power to the subsystem
Switch	Toggles power flow
Regulator	Changes voltage to be used safely
Audio Beacon & LED	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



EPS Changes Since PDR

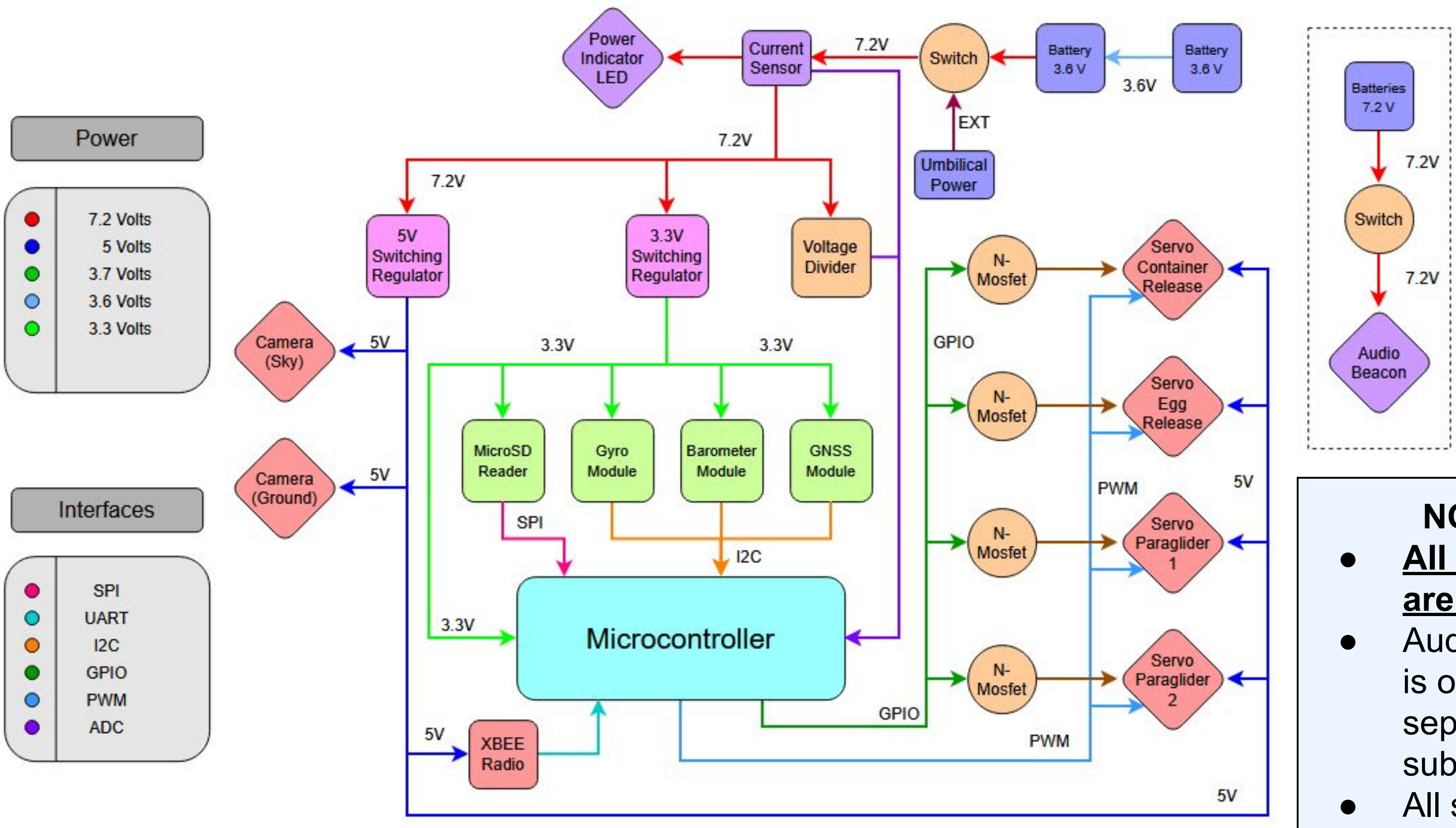
PDR Component	CDR Component	Rationale for Change
Vapcell A11 18350	Vapcell H16 18350	Higher capacity while maintaining ample current discharge rate for payload current use.

Source: VapcellTech

Source: VapcellTech

NOTE: Batteries are non-LiPo

Payload Electrical Block Diagram



NOTE:

- **<u>All Batteries are non-LiPo</u>**
- Audio Beacon is on a separate subsystem
- All switches are easily accessible

Payload Power Source

Vapcell H16 18350						
Cell Voltage (V)	Capacity (mAh)	Capacity (Wh)	Max Current (A)	Chemistry	Mass (g)	Price ($)
3.6	1600	5.76	5	INR	26	12.99

Configuration		
# of Cells	Connection	Total Voltage
2	Series	7.2
Total Capacity (Wh)		
11.52		

NOTE: Batteries are non-LiPo

Source: Vapcell

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
Teensy 4.1	5	160	2	100	0	1.60	Estimate
NEO-M9N	5	36	2	19	0	0.36	Datasheet
BNO055	3.3	12.3	2	0.4	0	0.08	Datasheet
BMP390	3.3	1.6	2	0.0014	0	0.01	Datasheet
ACS724LLCTR-30AU	5	14	2	7	0	0.14	Datasheet
XBEE System	5	229	2	0.003	0	2.29	Estimate
RunCam Split 4 V2 (Upward Camera)	5	450	0.5	0	1.5	1.13	Estimate
RunCam Split 4 V2 (Downward Camera)	5	450	0.5	0	1.5	1.13	Estimate
Miuzei 25 kg	5	850	0.0028	0	1.9972	0.01	Estimate
MG92B	5	850	0.0028	0	1.9972	0.01	Estimate

Payload Power Budget (2 of 4)

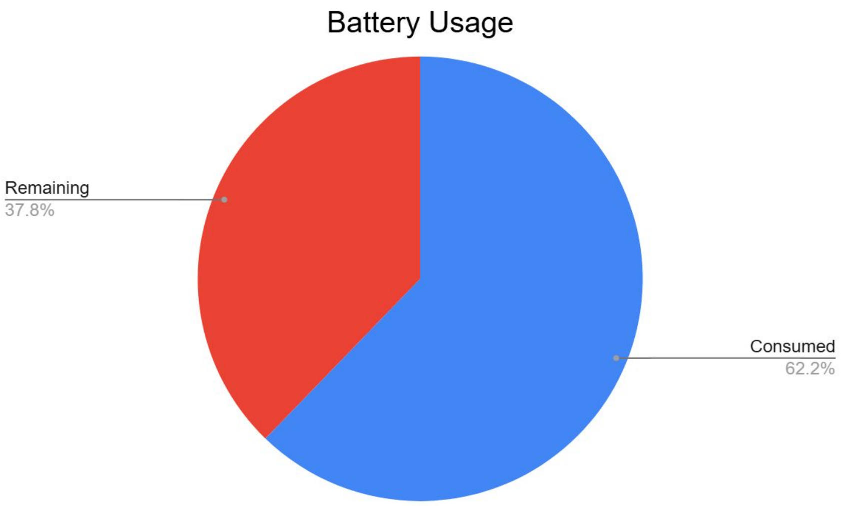
Payload Power Budget							
Item	Voltage (V)	Active Current (mA)	Active Duration (h)	Idle Current (mA)	Idle Duration (h)	Energy (Wh)	Source
LS-955CR (1 of 2)	5	175	0.0333	0	1.9667	0.03	Estimate
LS-955CR (2 of 2)	5	175	0.0333	0	1.9667	0.03	Estimate
Energy Subtotal (Wh): 6.81							

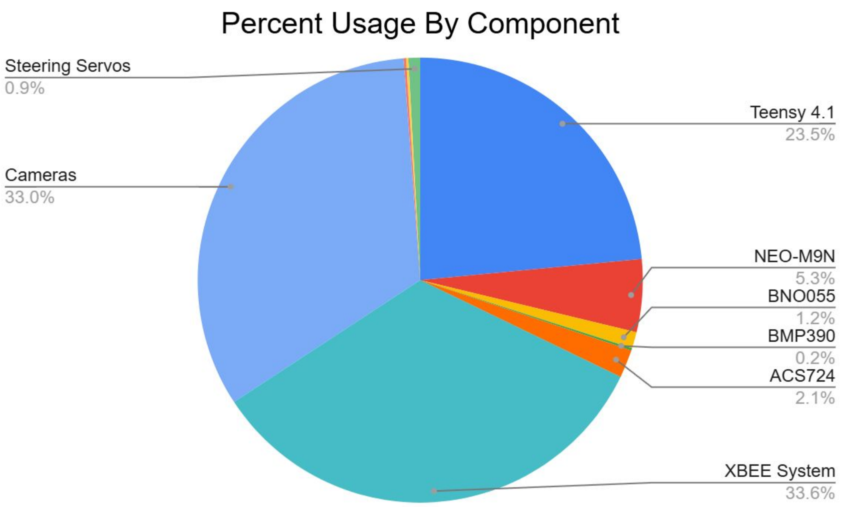
Payload Power Budget (3 of 4)

Energy Consumption Subtotal (Wh)	6.81
Power Supply Efficiency (%)	95
Total Energy Consumption (Wh)	7.17
Available Battery Energy (Wh)	11.52
Energy Margin (Wh)	4.35
Remaining Battery Percentage (%)	37.74

NOTE:

- Percentage usage by component applies to percent consumed
- Test flight revealed remaining battery percentage to be around 85% remaining over a 25 minute flight time

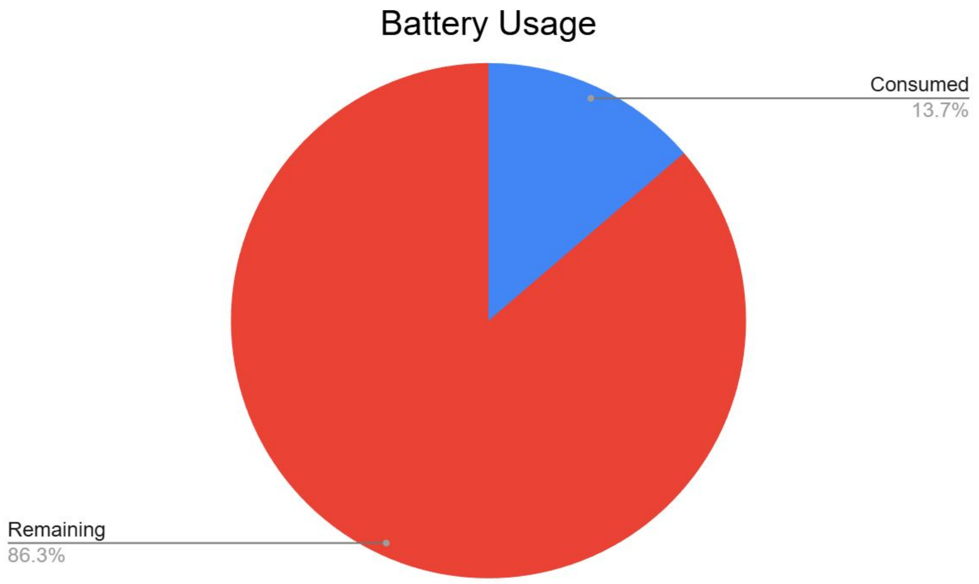




Payload Power Budget (4 of 4)

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

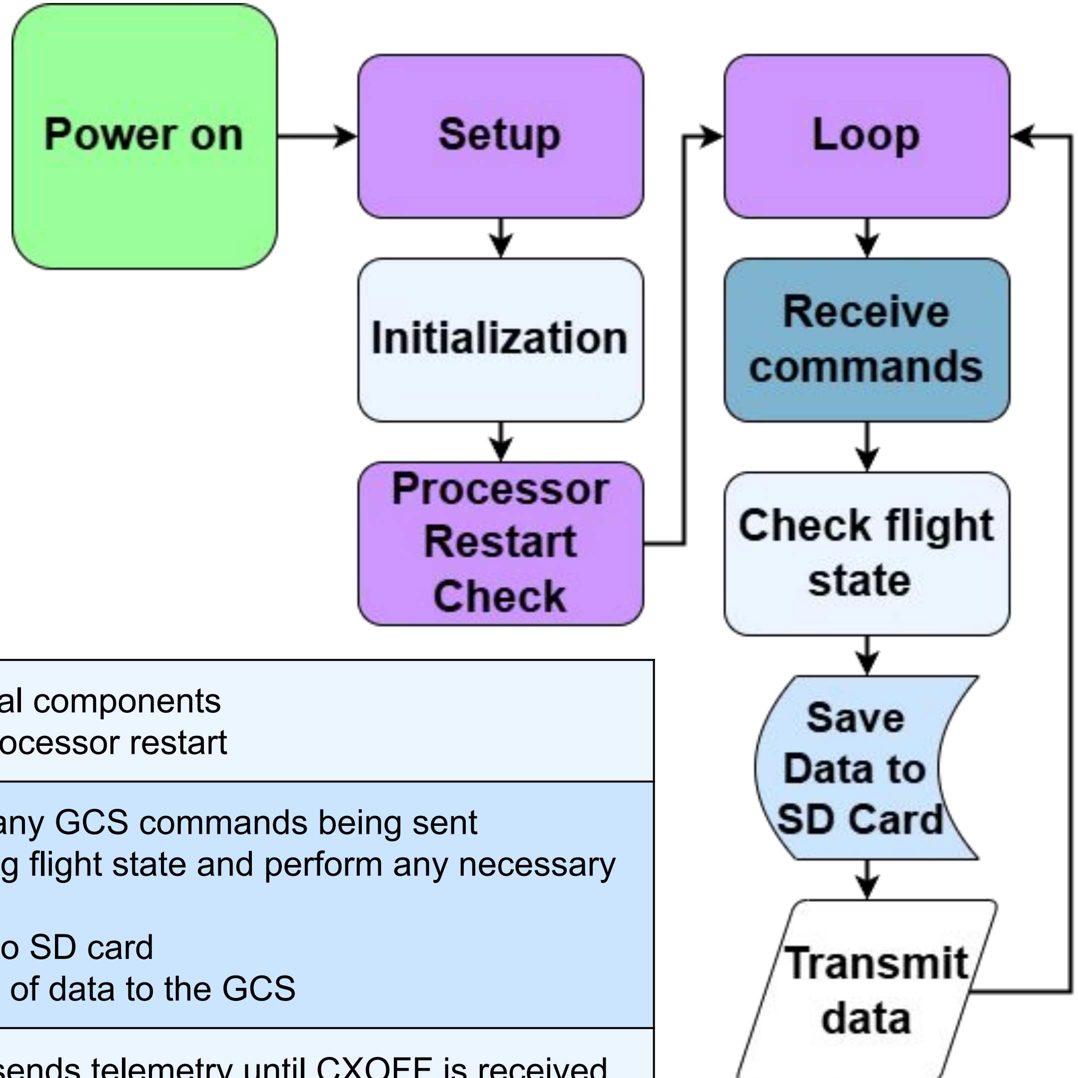
Ethan Denoncourt

FSW Overview

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

Source: Sparkfun

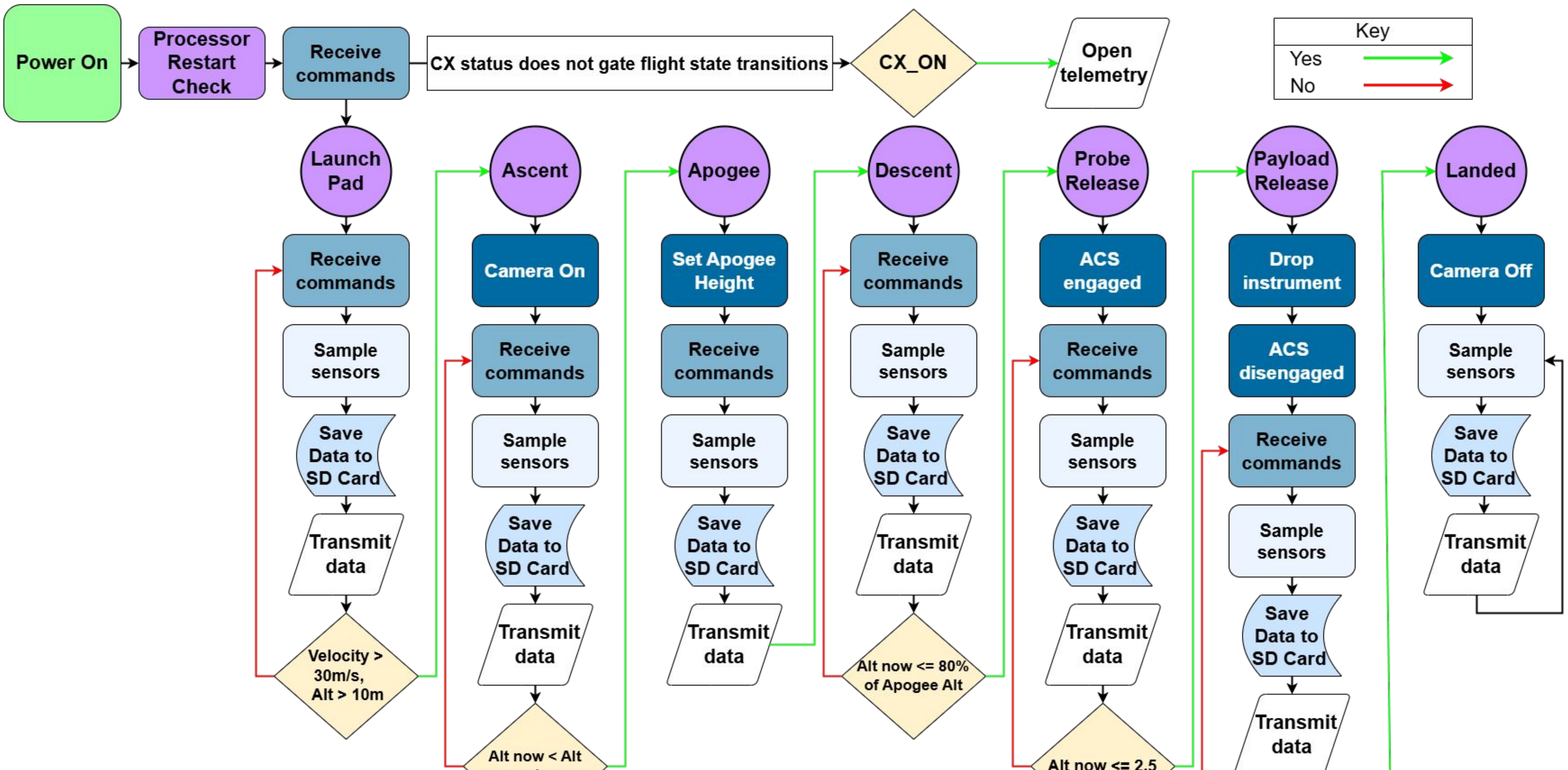
Source: github



Setup	**Initialization** - Initialize all electrical components **Read last packet** - Check for a processor restart
Loop	**Receive commands** - Check for any GCS commands being sent **Check flight state** - Keep updating flight state and perform any necessary actions upon transitioning **Save data** - Keep saving all data to SD card **Transmit data** - Send out packets of data to the GCS
Landed	**Sampling** - Sample sensors and sends telemetry until CXOFF is received

FSW Changes Since PDR

Flight Software			
Part	**PDR**	**CDR**	**Rationale**
Landed-State Sampling	Only sample GPS	Sample all sensors	The difference in sampling to save power is negligible, and sampling all sensors in all states limits potential points of failure.
Ascent to Apogee Transition	Altitude and velocity as determiners	Only velocity as a determiner	This will ensure the apogee flight-state will not loop back on itself, but rather go to the descent flight-state immediately.
Processor Restart	Read last packet	Check only flight state	It is only necessary to check the flight state to determine if a processor restart has occurred, and this will also allow for easier testing and limit potential errors.



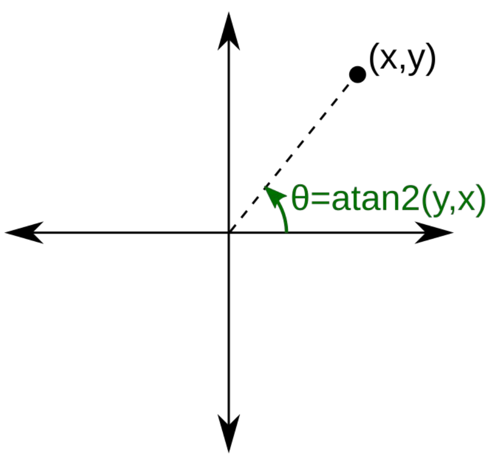
NOTE: All mechanism actuations use MOSFETS for power management

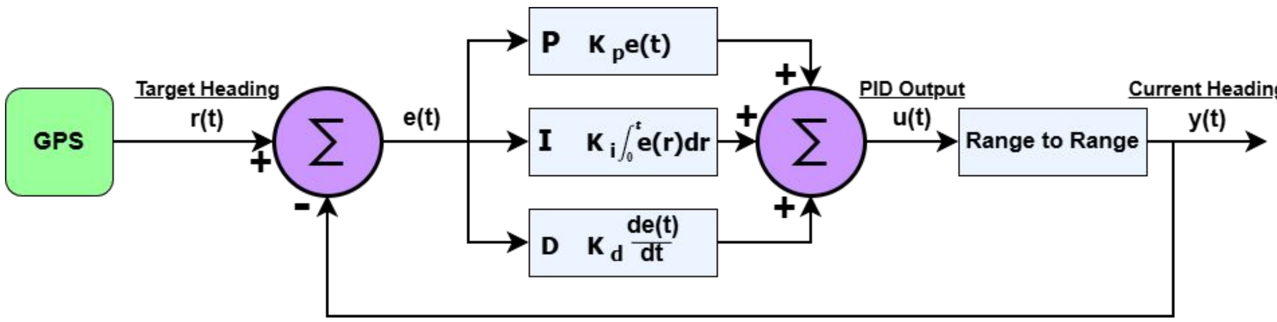
Payload CanSat FSW State Diagram (2 of 3)

Autonomous Controls Flight Algorithm

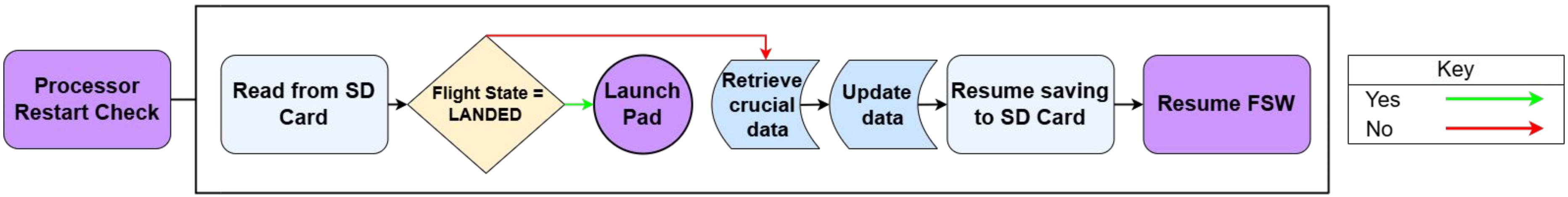
Start	GPS		Error	PID	Result
ACS Engaged →	Sample GPS →	Calculate direction →	Angle between the vectors →	PID loop →	Servo output

Bearing Direction Formula	PID Loop Diagram





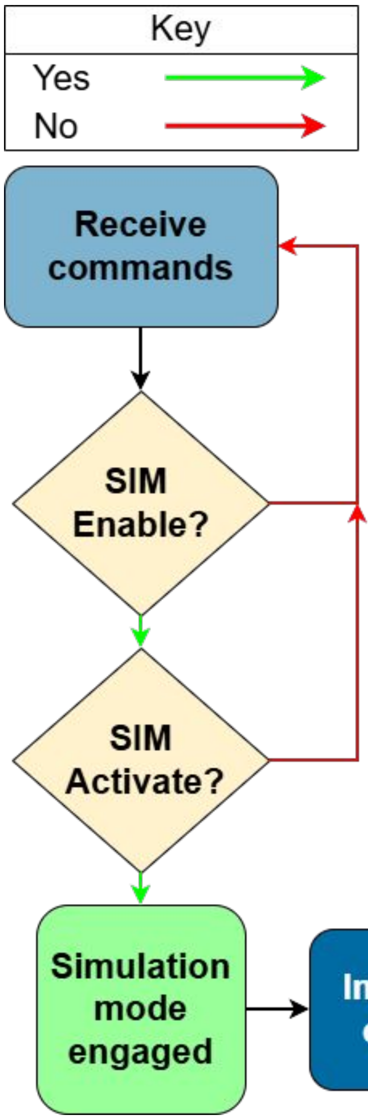
In the event of a processor restart the following will occur:



Crucial Data Used to Recover	Reasons for Processor Restart	Methods of Recovery
- Flight state - Packet count - Launch-pad pressure - UTC mission time - Spool amount - CX_ON command	Processor restart may occur when the microcontroller loses power or is disconnected	By saving crucial data to an SD card, the FSW may access, retrieve, and update itself to return back to where it left off.

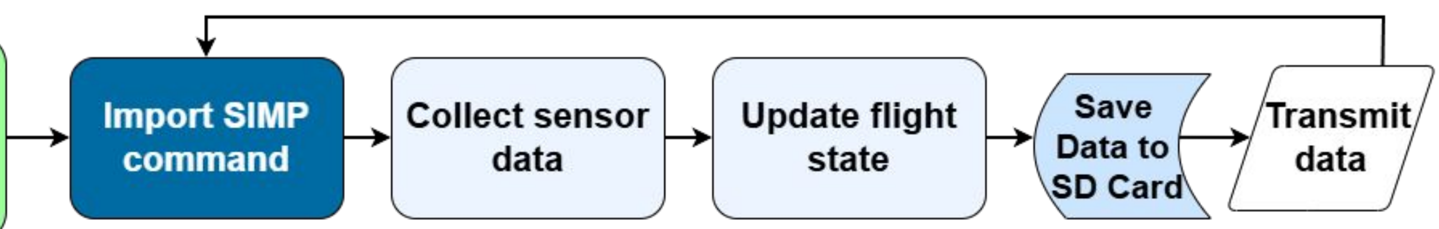
Sampling Rate	Sending Rate	Saving Rate
Collect sensor data at 1 Hz	Transmit data at 1Hz	Save data to SD card at 1Hz

Simulation Mode Software



Simulation Mode Commands
● Both SIM ENABLE and SIM ACTIVATE have to be commanded by the ground station to engage Simulation 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

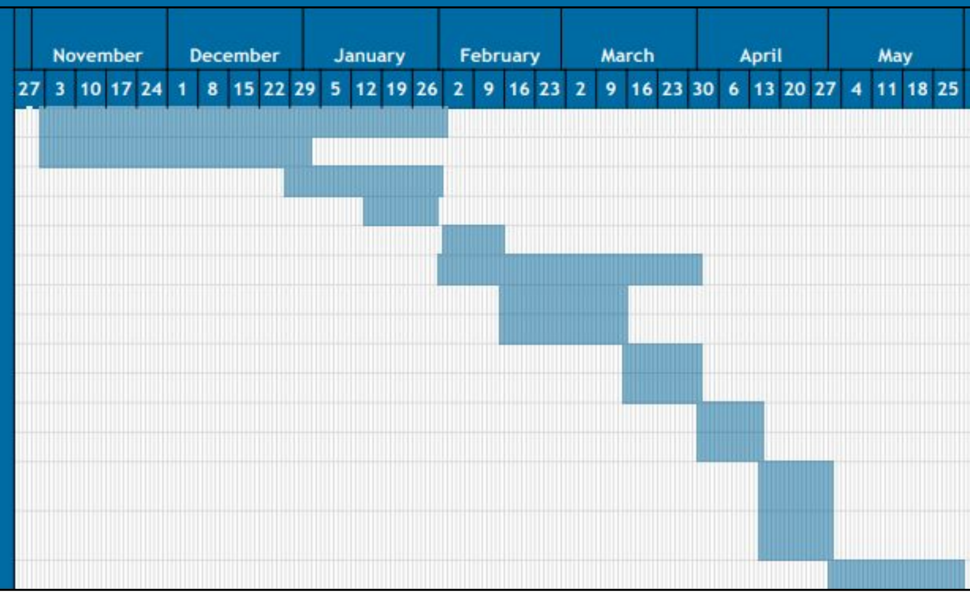


Software Development Plan (1 of 2)

Software Subsystem Development Sequence

CanSat 2026 Team Vortex

TASK	START	END	DURATION
Preliminary Embedded System Code	11/2/2025	2/2/2026	92
Preliminary Ground Station Code	11/2/2025	1/2/2026	61
Base Station Design and Planning	12/28/2025	2/1/2026	35
Test XBee Communication	1/15/2026	1/31/2026	16
Test Sensor Embedded Code	2/2/2026	2/15/2026	13
Base Station Contruction	2/1/2026	4/1/2026	59
Updates to Embedded System Code	2/15/2026	3/15/2026	28
Updates to Ground Station Code	2/15/2026	3/15/2026	28
Test Commands from Ground Station	3/15/2026	4/1/2026	17
Test Simulation Mode	3/15/2026	4/1/2026	17
Update Ground Station Code	4/1/2026	4/15/2026	14
Update Embedded System Code	4/1/2026	4/15/2026	14
Integrate Base Station with Ground Station Code	4/15/2026	5/1/2026	16
Test Commands and Simulation with Payload	4/15/2026	5/1/2026	16
Final Testing	5/1/2026	5/31/2026	30



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.

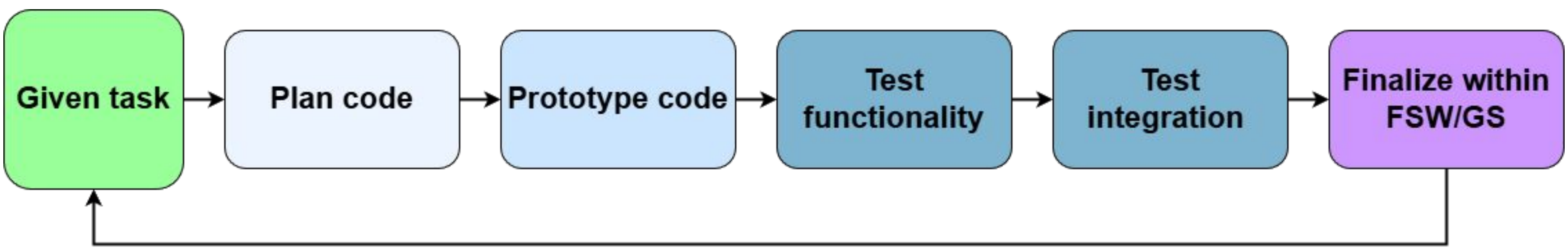
Progress since PDR

Everything has been prototyped and tested for FSW except processor reset. Ground station completed to meet mission guide compliance.

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 GCS draft and test for accurate telemetry reception and command transmission

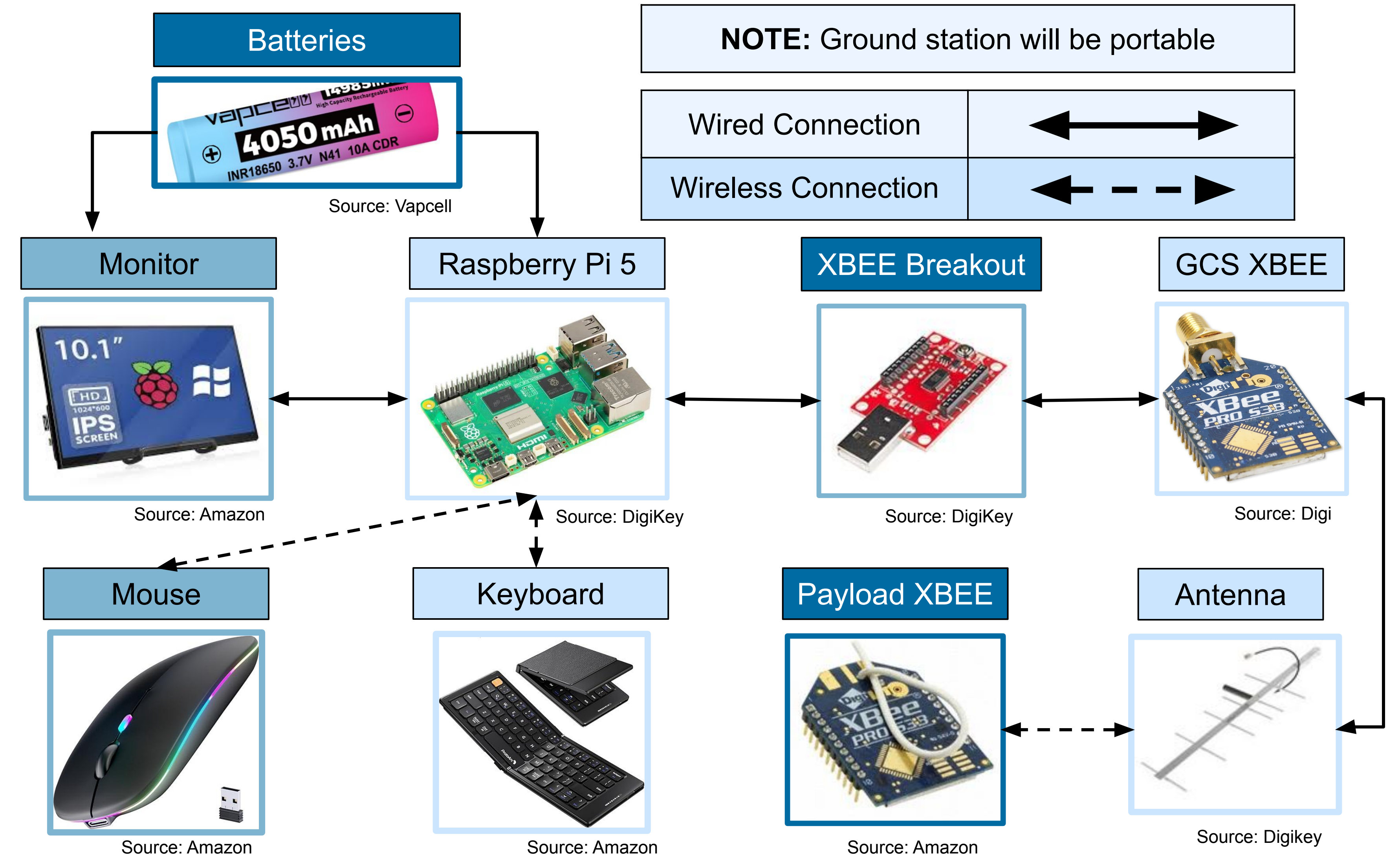
Test Methodology



Ground Control System (GCS) Design

Kayla Budziak

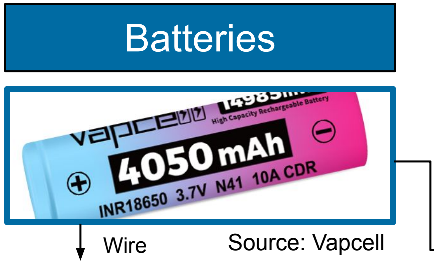
GCS Overview



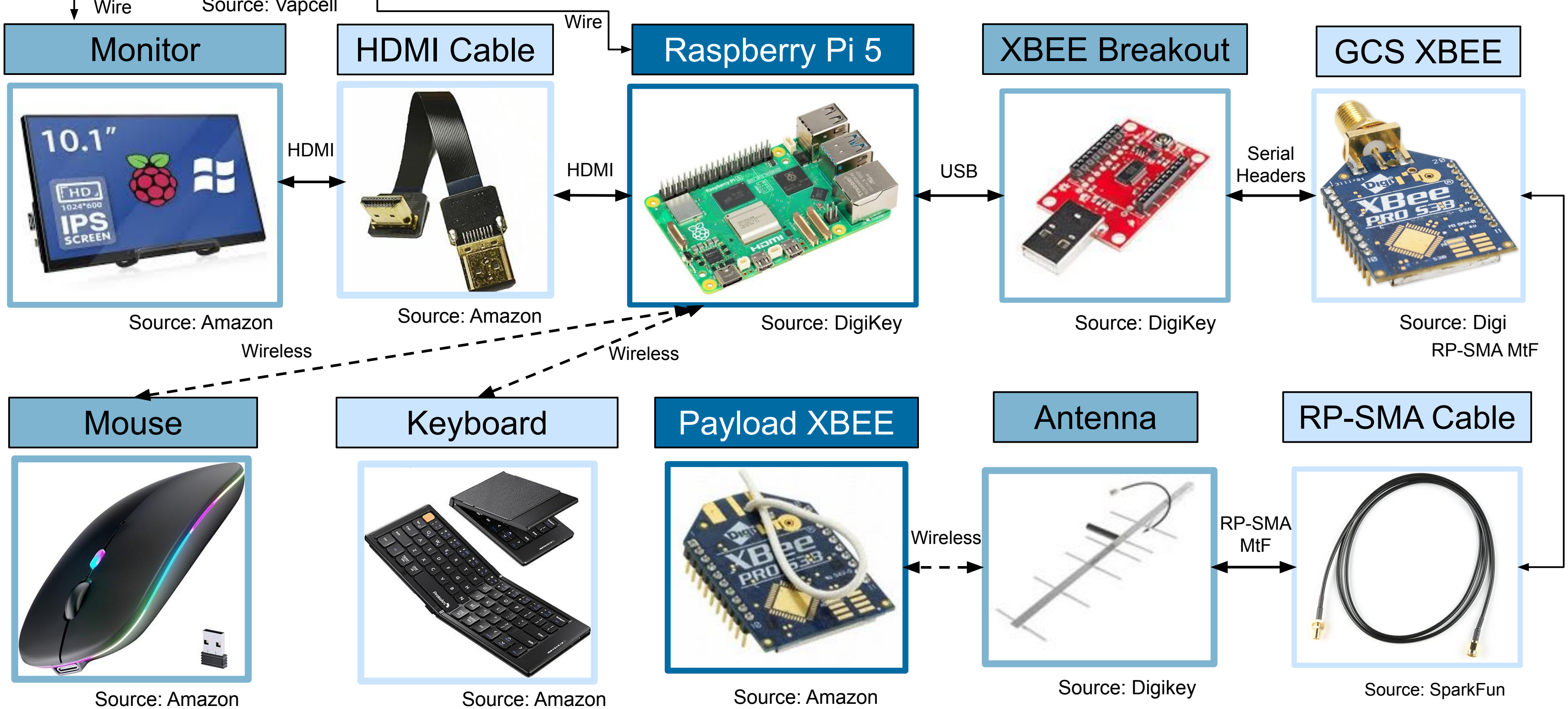
GCS Changes Since PDR

Ground Control System			
Component	**PDR**	**CDR**	**Rationale**
Location Widget	Widget displayed a map with the current GPS location	Widget displays a 3D flight path graph with GPS coordinates and altitude	The 3D graph gives a better visual of where the payload is without sacrificing any information as well as giving a visual for the target coordinate.
Port Dropdown	No port dropdown	Port dropdown that allows the user to select XBEE port in use	This allows the port to change between devices more dynamically which allows the GCS to be run on multiple devices without edits to the code.
Audio	No Audio	Audio plays when buttons are pressed	The added audio function serves as an additional indicator that the button was pressed and a command was sent.

GCS Design

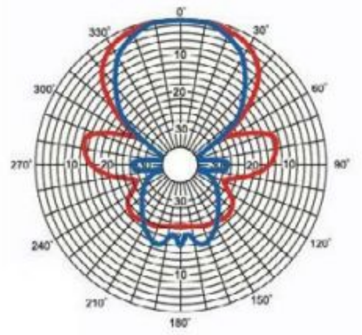


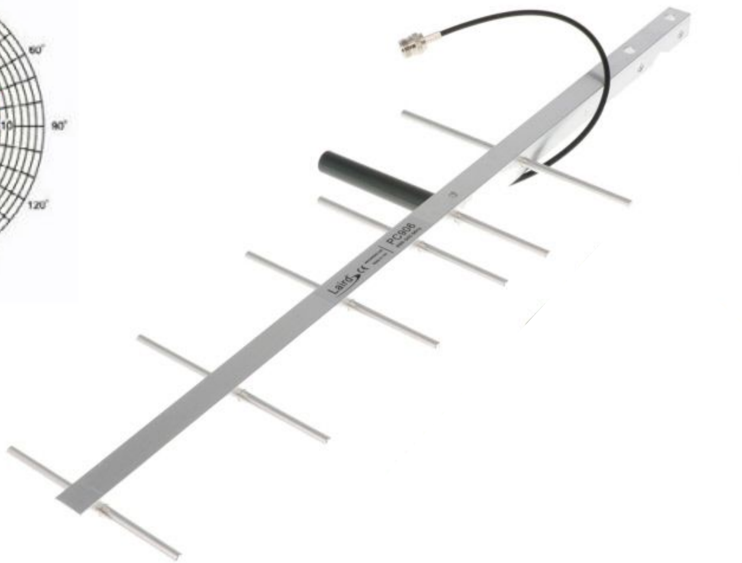
- The battery life of the computer running at maximum capacity is about 3.33 hours
- Raspberry Pi 5 active cooler and USB computer fan are used to prevent overheating
- Auto update mitigation isn’t necessary because GCS computer has no auto updates
- **<u>GCS batteries are non-LiPo</u>**
- A laptop will be brought to competition as a backup in case of GCS computer failure



PC906N					
Gain (dBi)	Antenna Length (mm)	Horizontal Beamwidth (°)	Vertical Beamwidth (°)	Price ($)	Handheld/ Tabletop
10.65	629	65	55	65.09	Handheld

Source: TE Connectivity





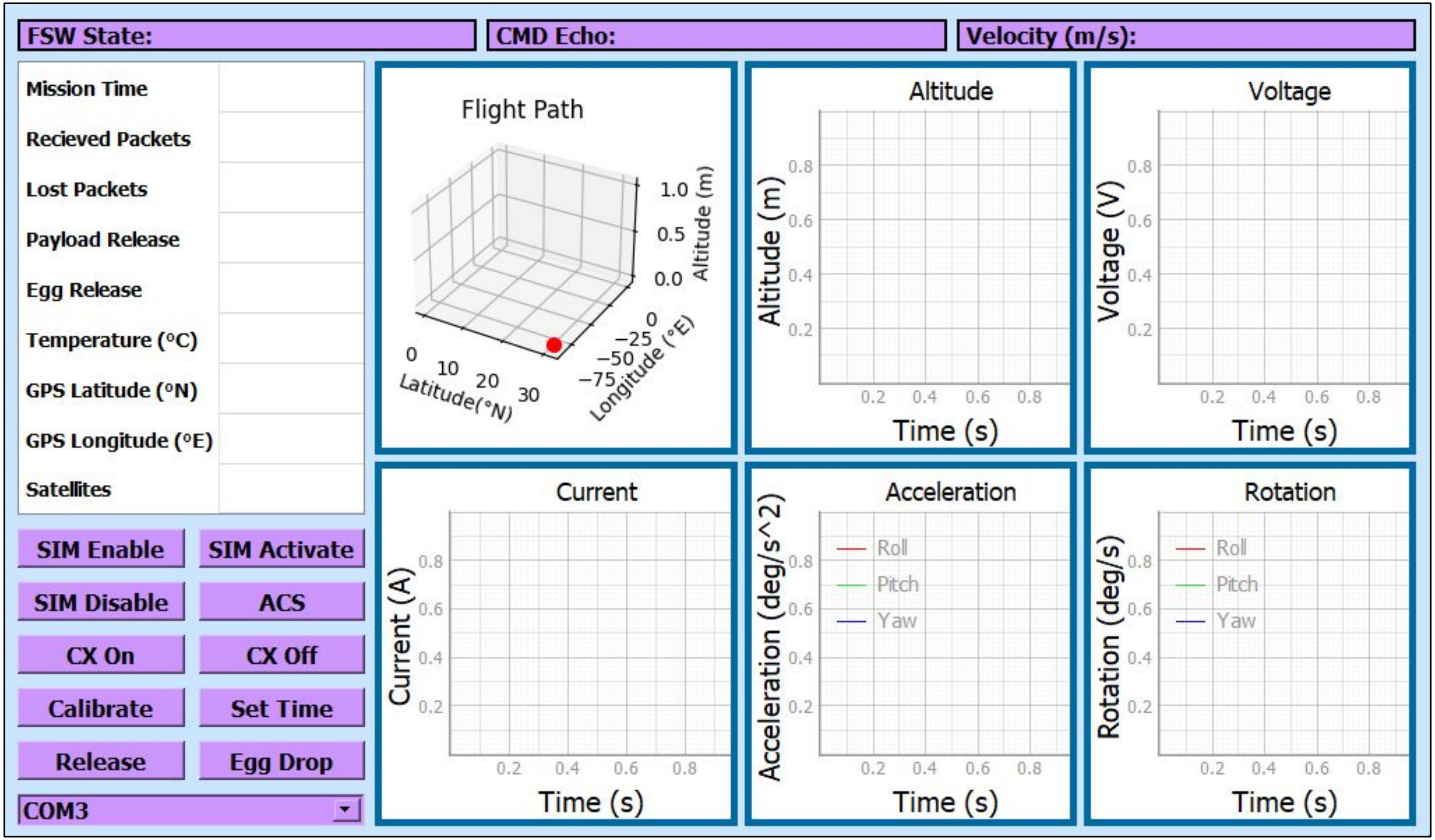
Source: Digikey

Construction
Antenna is already equipped with handle and scope and will not need assembly on launch site
RP-SMA cable will be attached to both the antenna and XBEE radio on launch site

GCS Antenna (2 of 2)

Link Budget	
P_t (Transmitter Power)	24 dBm
G_t (Transmitter Gain)	1.9 dBi
L_{fs} (Free-space Path Loss)	91.67 dB
G_r (Receiver Gain)	10.65 dBi
L_s (System Loss)	0.7 dB
RSSI (Received Signal Strength Index)	**-55.8 dBm**

Link Margin	
RSSI (Received Signal Strength Index)	-55.8 dBm
R_s (Receiver Sensitivity)	-101 dBm
Link Margin	**45.2 dBm**



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

GCS Software (2 of 4)

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

COTS and Libraries	• Graphs: pyqtgraph and matplotlib • UI: PyQt5 • Serial Communication: pyserial • Audio: playsound and pygame • CSV: csv
Plotting Software Design	**Design** • Required altitude, voltage, current, acceleration, and rotation graphs are included • Required mission time, received and lost packet counts, temperature, GPS position, and flight software state is included • Additional 3D flight path, payload release state, egg release state, satellite count, command echo, port dropdown, and velocity were added **Real Time Plotting** • Graphs and tables will update at a rate of 1Hz as telemetry is received from the payload
Commands	• All descent mechanism will be able to be activated on command by pressing buttons on the GCS • 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

GCS Software (3 of 4)

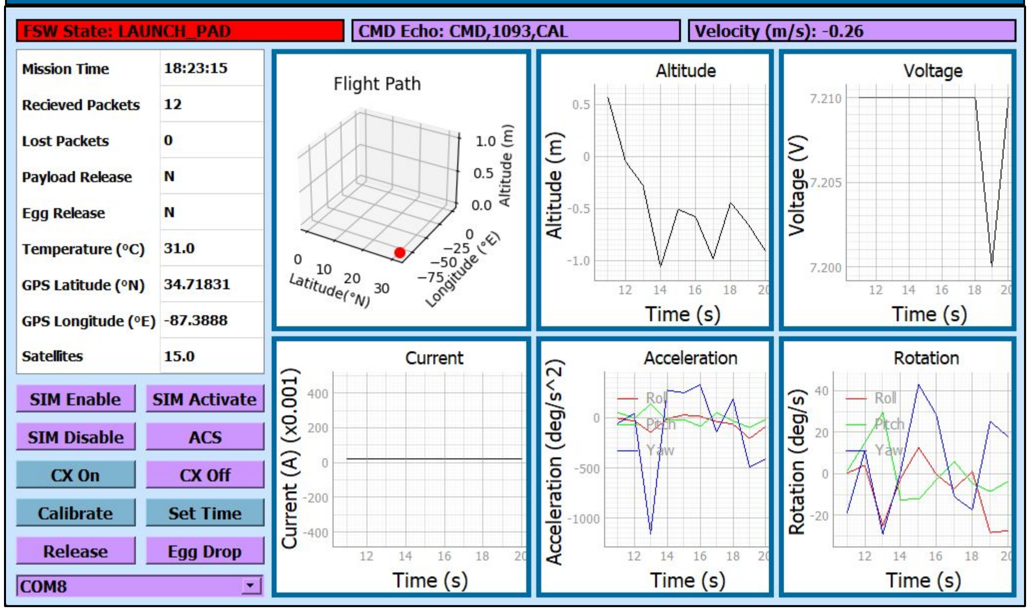
Calibration	● Calibration command is sent to the payload when the “Calibrate” button is pressed on the GCS ● Calibrates altitude to zero
Simulation Mode	● Simulation mode will be entered when SIM ENABLE and SIM ACTIVATE buttons on the GCS are subsequently pressed ● GCS will transmit pressure data to simulate altitude at a rate of 1 Hz to the payload while in simulation mode
Telemetry Data Recording	**Packet Reception** ● When a packet is received, data is separated by index ● Data is appended onto its respective variable specific list **Updating Data** ● Received packet count increases by one each time a packet is received ● Lost packet count increases by one when a packet is not received ● Data table shows the most recently received data point for each category ● Graphs show the ten most recently received data points
CSV File Creation	● csv file is opened when GCS program is run ● Telemetry will simultaneously be displayed on the UI and saved to a csv file ● The csv file will be saved locally and presented to the judges after flight ● csv file includes all data transmitted from the payload ● csv file will be uploaded to a USB to be presented to the judges on flight day

GCS Software (4 of 4)

Progress Since PDR

- Optimization of UI design
- Successful packet reception during range tests
- Successful testing of command transmission
- Successful testing of GCS plotting and data updates in test flight 1 and test flight 2

GCS on Launchpad from Test Launch 2



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 the GCS and pressure values will be sent to the payload while in simulation mode.	Simulation testing will pass if the CanSat goes through and reacts to the appropriate flight stages with the simulation data.

NOTE: Specific testing plans are detailed in the following slides

Subsystem Level Testing Plan (1 of 5)

Subsystem	Component	Method of Testing	Passing Requirements
Sensors	All Sensors	Power sensors, run test code, and ensure good wire connections. Perform individual tests using a breadboard to test functionality.	All sensors output correct data.
CDH	Teensy 4.1, XBEE	From the GCS, send telemetry commands using the XBEE: CX,ON and CX,OFF to toggle reception of telemetry.	Data is being transmitted to the GCS when 'ON' and stop when 'OFF'.
CDH	Teensy 4.1, XBEE, GPS	From the GCS, send the mission time command using the XBEE: ST,UTC to set the time.	The mission time is accurate to the real UTC time by ± 1s.
CDH	Teensy 4.1, XBEE, All Servo Mechanisms	From the GCS, send the simulation commands using the XBEE: SIM,ENABLE and SIM,ACTIVATE to engage simulation mode. Then transmit pressure packets. Send the SIM,DISABLE command to disengage the simulation mode.	Once SIM,ENABLE and SIM,ACTIVATE have been sent, servos should actuate at mission required times in reference to the pressure packets transmitted at 1Hz. SIM,DISABLE should return the user back to flight mode.

Subsystem Level Testing Plan (2 of 5)

Subsystem	Component	Method of Testing	Passing Requirements
CDH	Teensy 4.1, XBEE, BMP390	From the GCS, send the calibrate command using the XBEE: CAL to reset the base pressure value.	The received altitude value from the XBEE is calibrated to zero.
	Teensy 4.1, XBEE, PROBE_RELEASE servo	From the GCS, send the PROBE command using the XBEE: PROBE,ON to lock payload into container and PROBE,OFF to unlock payload from container.	The payload physically locks itself into the container when PROBE,ON is sent. The payload physically unlocks itself from the container when PROBE,OFF is sent.
	Teensy 4.1, XBEE, Instrument Release servo	From the GCS, send the EGG command using the XBEE: EGG,ON to lock the nose cone to the payload. EGG,OFF to release the nose cone from the payload.	The payload physically locks itself to the nose cone when EGG,ON is sent.The payload releases the nose cone when EGG,OFF is sent.
	Teensy 4.1, XBEE, ACS servos	From the GCS, send the ACS command using the XBEE: ACS,ON to turn the servos. ACS,OFF to deactivate servo actuation.	The ACS servos actuate after transmitting the ACS,ON command. The ACS servos stop turning after transmitting ACS,OFF.

Subsystem Level Testing Plan (3 of 5)

Subsystem	Component	Method of Testing	Passing Requirements
EPS	Batteries, Sensors	Battery Life: Turn on power system while installed in CanSat. Send CX ON command and wait for 2 hours. Ensure telemetry is communicated throughout the time period and CanSat is still powered.	All components receive power for entire 2 hours. Batteries still output enough voltage to power system.
		Voltages: By using voltage setting on multimeter measure voltage output from each regulator as well as each sensor to check for correct values.	All regulators output correct voltages and all sensors receive correct voltages.
Radio Communication	Base Station XBEE, Yagi Antenna, Payload XBEE, Integrated Wire	Range testing by pointing the yagi antenna in the direction of the payload XBEE's integrated wire antenna while increasing the distance between the XBEEs.	Receiving telemetry packets from a distance comparable to flight.
FSW Communication	Teensy 4.1, BMP390, all servos	Vacuum test the payload for FSW flight state changes and mechanism actuations.	Observing the CanSat actuating at appropriate flight states.

Subsystem Level Testing Plan (4 of 5)

Subsystem	Component	Method of Testing	Passing Requirements
Mechanisms	Payload Separation from Rocket	Conduct a test launch using a rocket identical to the one that will be used at competition with the full payload integrated with the rocket.	Payload & container fully separate from the rocket and initiate parachute aided descent.
	Release Mechanism	Integrated payload is placed in the vacuum chamber and the pressure is decreased simulating an increase in altitude to expected release apogee.	Release mechanism functions and payload fully deploys from container.
	Instrument Release Mechanism	Integrated payload is placed in the vacuum chamber and the pressure is decreased simulating an increase in altitude to expected release apogee.	Egg release mechanism functions and nose cone fully separates from payload.
	Instrument Survival	Instrument protection with egg inside is thrown off of the roof of a building.	Egg survives impact.

Subsystem Level Testing Plan (5 of 5)

Subsystem	Component	Method of Testing	Passing Requirements
Descent Control	Parachute Deployment	Perform test launch with payload integrated with a rocket identical to the one that will be used for competition.	Parachute fully deploys and visibly slows payload descent.
	Parachute Descent	Drop container with payload integrated from 500ft, record descent rate using sensors.	Parachute descent rate collected by sensors is between 12m/s & 18m/s.
	Para-Glider Deployment	Release payload from container 500ft.	Para-Glider fully inflates, steering & brake lines remain untangled & untwisted.
	Para-Glider Descent	Release payload attached to para-glider with sensor to record descent rate from 500ft, observe descent.	Para-Glider glides forward, descent rate remains between 3m/s & 8m/s.
	Steering	Raise steering system and para-glider on a drone to 500ft with a certain target landing destination and drop.	Pulley system function and accurately steers to the target location.

Integrated Level Functional Test Plan (1 of 2)

Subsystem	Method of Testing	Passing Requirements
Release Trigger	Perform fully integrated test launch of the payload with a rocket identical to the one that will be used at competition; observe CanSat separation from from rocket, payload release from container, and nose cone release from payload.	Release mechanism triggers and payload fully separates from container at 80% apogee. Instrument release mechanism triggers and nose cone fully separates from payload at 2m above the ground.
Mechanisms	Perform fully integrated test launch of the fully powered on payload with a rocket identical to the one that will be used at competition.	Structural and electrical components remain secured and intact throughout force of rocket launch.
Payload Release	.Perform fully integrated test launch of the fully powered on payload with a rocket identical to the one that will be used at competition.	CanSat fully separates from rocket body without sustaining damage & container parachute deploys and stays attached to container. Parachute remains attached to container when payload is released at 80% apogee.

Integrated Level Functional Test Plan (2 of 2)

Subsystem	Method of Testing	Passing Requirements
Ground Station Software	Perform fully integrated test launch of the fully powered on payload with a rocket identical to the one that will be used at competition. Observe the telemetry being displayed on the GCS through the flight. Send commands from the GCS to the payload.	Confirm that all tables and graphs are updating when packets are received by the ground station and that this data is accurate to the payload SD card. Confirm that commands are being received by the payload by observing the command echo.
Telemetry	Perform fully integrated test launch of the fully powered on payload with a rocket identical to the one that will be used at competition. Observe the telemetry being displayed on the ground station through the full flight.	Telemetry displayed on the ground station user interface is accurate when compared to the data from the ground station CSV file and the data from the payload SD card.
Antennas	Perform fully integrated test launch of the fully powered on payload with a rocket identical to the one that will be used at competition. Keep the yagi antenna pointed at the payload during flight and monitor packet reception on the GCS.	Confirm that at least 95% of packets are being received throughout the duration of the launch and packets are uncorrupted.

Environmental Test Plan (1 of 3)

Test	Method of Testing	Passing Requirements
Drop Test	Payload is fully powered on, transmitting telemetry, & stowed in container with parachute attached to container eyebolt, a ⅛ in thick and 61cm long non-stretching cord is secured to the parachute on one end with the other secured to a fixed point on a rigid structure from which it will be released with the secured point on the structure & secured point on the payload at the same height.	The CanSat does not lose power, continues to transmit telemetry, & there is no critical damage to the payload or separation of parts from the payload.
Thermal Test	CanSat is placed in a thermal chamber & powered on, the chamber is then sealed & brought to a temperature of 60°C using the heat source over a period of 2 hours. Temperature is monitored with the heat source powered off when the temperature of the chamber reaches 60°C & powered back on when it is at 55°C.	After two hours at temperature the CanSat continues to operate properly, mechanisms maintain functionality, & structural integrity of all components remains uncompromised.

Environmental Test Plan (2 of 3)

Test	Method of Testing	Passing Requirements
Vibration Test	An orbital sander is secured upside down to a bench vise with the powered on CanSat secured to where the sandpaper would be installed. The bench vise is secured to a stable table & is unable to move freely. The sander is powered on until it reaches full speed & let run for 5 seconds, this is done 5 consecutive times. During this time accelerometer data is being collected from the CanSat.	CanSat has not sustained significant structural damage & all components remain fully attached & functional. Accelerometer data continues to be collected throughout & after testing.
Fit Check (Dimensions Verification)	CanSat & all constituent mechanisms are inspected to verify clearances. CanSat is integrated with container to verify clearance & stability when integrated.	All mechanisms which initiate release are stable in locked positions & able to enter unlocked positions without jamming. CanSat fits inside of the containers & can be fully locked in place without prematurely deploying. All dimensions are in compliance with mission guide.

Environmental Test Plan (3 of 3)

Test	Method of Testing	Passing Requirements
Vacuum Test	Fully configured & powered on CanSat is secured in vacuum chamber while transmitting telemetry. Telemetry is monitored & vacuum is powered off once peak altitude in reached, CanSat is continuously monitored as air is gradually allowed to enter the chamber. All collected telemetry is saved.	CanSat continuously transmits telemetry without interruption & moves through all flight states corresponding to simulated altitudes in the vacuum chamber. Telemetry can be saved.
Simulation	Simulation mode software will be run from the GCS and the payload will be observed as it the simulation progresses through the duration of flight.	Pressure data is received by the payload from the ground station and flight states update at the appropriate conditions. All mechanisms function in response to flight state changes and trigger at appropriate times.

Test Procedures Descriptions (1 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
1	Turn on payload and place in a vacuum chamber. Activate vacuum chamber and let run for 5-15 seconds, then release pressure from chamber. Measure pressure and temperature using a different tool and compare reading between tool and BMP390.	SN1 SN2	Sensor outputs correct pressure and temperature readings in accordance with mission guide requirements.n
2	Turn payload on. Using multimeter measure battery voltage. Compare multimeter reading to saved voltage readings from voltage divider on SD card.	SN3	Voltage divider data matches multimeter reading.
3	Turn payload on. Check GPS coordinates from NEO-M9. Drive around campus and ensure GPS keeps satellite lock throughout test. Compare coordinates to GPS coordinates from a phone to check accuracy.	SN4	GPS reading from NEO-M9N matches readings from mobile phone GPS for whole duration of test.

Test Procedures Descriptions (2 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
4	Turn payload on and confirm that data received from the BNO055 is accurate when rotated and accelerated.	SN5	Accurate accelerations and orientation is received.
5	Make sure both cameras have micro SD cards installed. Turn payload on. Leave payload on for 10 minutes. Turn payload off. Remove SD cards and examine video.	SN6, SN7, SN8, SN9	All recordings from cameras are in color and at a resolution of at least 640 x 480. Upwards camera has view of para-glider. Downwards camera has view of nose cone containing egg and ground.
6	Turn payload on. Using multimeter measure battery current at full load. Compare multimeter reading to saved current readings from current sensor on SD card.	SN10	Current sensor reading matches multimeter reading.
7	Turn on payload. Ensure all systems are functioning properly. Leave payload on for 2 hours. Ensure payload remains powered for duration.	E6	Payload remained powered for full 2 hour duration and all systems continued to function properly.

Test Proc	Test Description	Rqmts	Pass Fail Criteria
8	Measure the major dimensions of the nose cone.	S3, S4 S7	Nose cone radius is 70 mm. Nose cone shoulder length is 50 mm. Nose cone height is at least 76 mm.
9	Measure the major dimensions of the container.	S10 S13 S14	Container shoulder length is 90 mm to 120 mm. Container shoulder diameter shall be 136 mm. Container thickness should be at least 2 mm and length is 200mm ±5%.
10	The orbital sander is powered on until it reaches full speed & let run for 5 seconds, this is done 4 consecutive times. During this time accelerometer data is being collected from the CanSat.	S8	Electrical and structural components should stay secured.
11	Integrated payload is attached to a rope tied to a rigid object. Payload is lifted as high as possible and dropped.	S9	Payload remains intact. Structural components survive.

Test Procedures Descriptions (4 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
12	While vacuum testing, the CAL command will be sent to zero the CanSat's altitude and in the same test, make sure to confirm mission time is being received accurately with a resolution of 1 second.	G1,G3, F3	The ground station receives mission time with a 1 second resolution and transmit the CAL command to zero the altitude of the CanSat on the launch pad prior to launch.
13	After conducting tests, the Base Station will be reviewed to confirm csv files of all sensor data retrieved.	G2	The Ground Station generates csv files of all sensor data.
14	Confirm visually while testing XBEE communication that plots and data displays are updating at a rate of 1Hz and in real time text format.	G5,G7, G8, X4, X5	Ground station plots and displays all required telemetry outlined in mission guide and is updating in real time at 1 Hz. Data is also saved in text format.

Test Proc	Test Description	Rqmts	Pass Fail Criteria
15	By disconnecting the power from the Teensy 4.1 while undergoing a test, then powering the system back on to confirm it.	F1, F2	All data will be recalled and packet count will increment per transmission.
16	Through the use of the ground station and a pre-made flight profile, the simulation commands will be sent to engage and the user will begin transmitting pressure packets at 1Hz to affect altitude and simulate a flight.	F4, F5, F6	The ground station sends the simulation commands to engage and uploads simulated pressure to simulate a flight.
17	Through the use of XCTU, the NETID will be registered as the team number and as well broadcast mode will not be used.	X2, X3	XBEE NETID/PANID is 1093 and not in broadcast mode.
18	Insert payload into the container to ensure that the nose cone on the payload matches the diameter of the container and is symmetric about the thrust axis.	C1	Nose cone on the payload aligns properly with the container.

Test Procedures Descriptions (6 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
19	Ensure that the diameter of the container shoulder is 136mm and is able to be inserted into the rocket with proper resistance.	C2	The container fits properly into the rocket.
20	Ensure that the connection between the container shoulder and the rocket body doesn't have too much resistance.	C3	The container ejects from the rocket after the ejection charge fires.
21	Drop test container with accurate mass to confirm parachute deploys while measuring descent rate.	C4	The container slows under the influence of the parachute to 15m/s ± 3 m/s.
22	Insert payload integrated into the container in a vacuum chamber, turn on the vacuum to simulate ascent. Slowly release the vacuum to simulate descent and observe if the payload deploys from the container at 80% of the peak altitude.	C5	The payload deploys from the container at 80% of the peak altitude.

Test Procedures Descriptions (7 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
23	Release payload from container at a high altitude to see if the parachute deploys and slows down the payload and steers to control descent.	C6	The parachute deploys and inflates properly.
24	Drop payload with para-glider at a high altitude so that it inflates and measures the descent rate using onboard sensors.	C7	The payload deploys a para-glider that creates an average descent rate of 5m/s ±3m/s
25	Release payload from a high altitude with a nearby GPS point assigned in the flight software. Observe the para-glider to see if it steers towards the GPS location.	C8	The payload deploys a para-glider and steers towards a set location.
26	Power on the base station and the payload and observe the rate at which packets are sent.	C9	Packets are sent at a rate of 1 Hz.

Test Procedures Descriptions (8 of 8)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
27	Power on the payload and release it from an altitude, once the payload lands remove the sd card and observe if the descent control system pointed camera was recording.	C10	Camera records video of the descent control system after the payload powers on.
28	Power on the payload and release it from an altitude, once the payload lands remove the sd card and observe if the ground pointed camera was recording.	C11	Camera records video of the ground after the payload powers on.
29	Power on the payload and release it from an altitude, observe if the egg release mechanism causes the egg to deploy at the proper altitude using on board footage and sensor data.	C12	Protected egg releases at 2m above the ground ±0.5m. The egg survives and is intact.
30	Power on separate audio beacon system and ensure that it functions properly.	C13	The audio beacon is on a separate power system beeps properly.

Simulation Test Plan

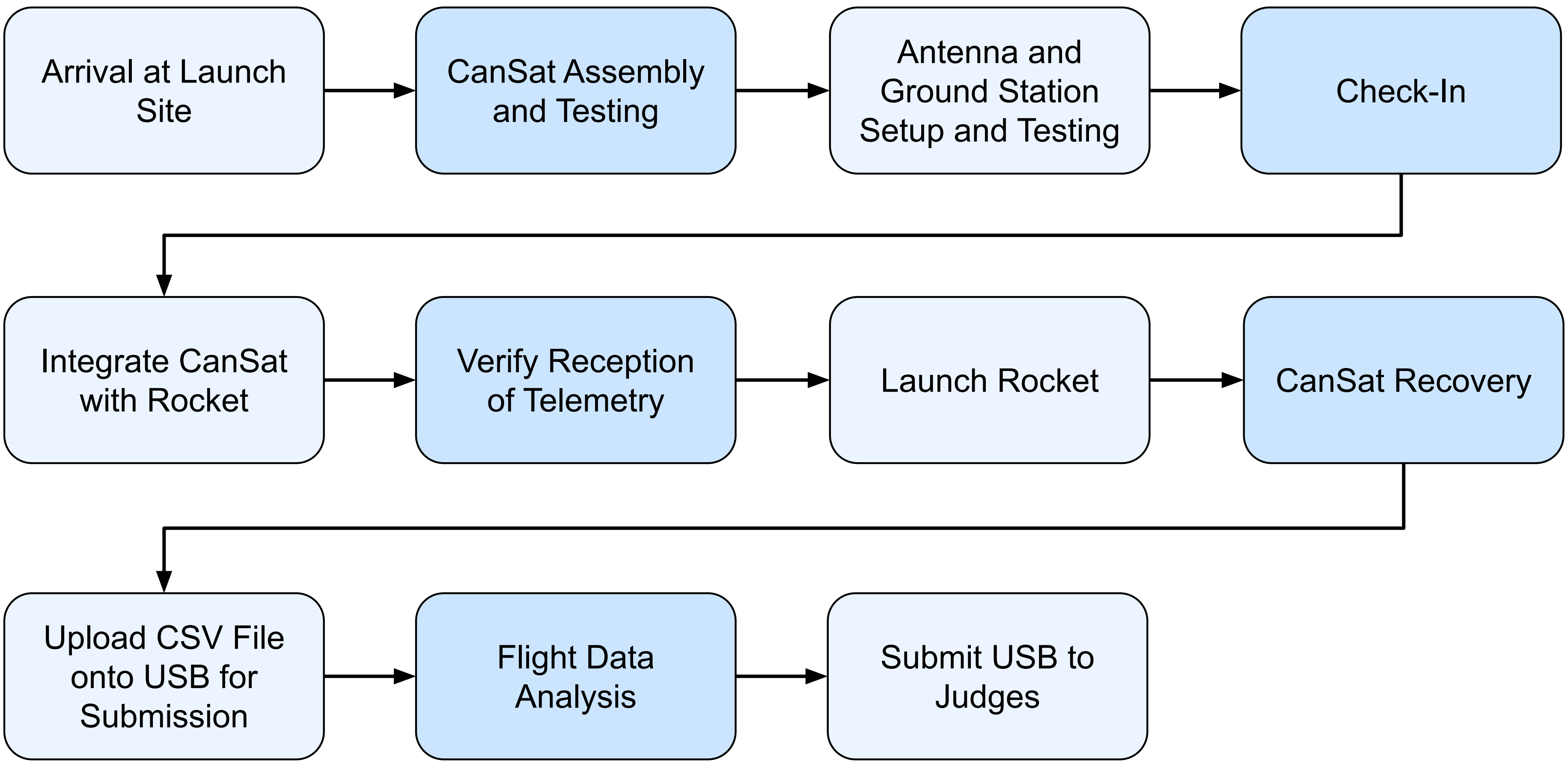
Subsystem	Method of Testing	Passing Requirements
Ground Station	Test that ground station is properly sending pressure values to the payload and updating related data displays simultaneously.	The altitude graph is updating in relation to the pressure values and the flight state changes are showing in 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. (main release at 80% of apogee, egg release at 2 meters above the ground)	All mechanisms function in response to flight state changes and trigger at appropriate times.

Mission Operations & Analysis

Kayla Budziak

Overview of Mission Sequence of Events (1 of 4)

Flight Day Sequence of Events



Overview of Mission Sequence of Events (2 of 4)

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, issues commands to the CanSat, and delivers telemetry data file to judges.	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, William Goudy
CanSat Crew	Tests the CanSat to ensure all mechanisms are functional before launch procedures begin. 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 (3 of 4)

Antenna and Ground Station Setup	
Step	**Description**
1	Power on base station computer and ensure that all components are getting power.
2	Connect GCS antenna to XBEE and tape in place, and plug XBEE into USB port on base station computer.
3	Run the GCS program on the base station computer.
4	Select correct port from dropdown, confirm that the port is connected by viewing messages in the terminal window of the GCS program.
5	Press “CX On” button and ensure telemetry is being received by the GCS.
6	Press “Set Time” and “Calibrate” buttons to set initial conditions for flight.
7	Monitor telemetry and ensure that all data seems accurate and an excessive number of packets are not being lost.

Overview of Mission Sequence of Events (4 of 4)

CanSat Assembly and Testing	
Step	**Description**
1	Confirm both coin cells and 18350 cells are fully charged and insert into payload.
2	Insert PCBs onto plates & plug into board.
3	Secure any loose parts such as JSTs and SD cards.
4	Switch the power switch to the ON position on each PCB.
5	Confirm power to all components, and test the XBEE to confirm telemetry is being sent.
6	Secure all plates, components, and nuts using Loctite, and ensure all mechanisms (release and descent) are functioning.
7	Fold para-glider and insert folded para-glider and payload into container, ensuring rotation prevention rods are lined up with the payload.
8	Actuate main release servo in order to lock payload into container.
9	Fold parachute and integrate container into the rocket body.
10	Prepare the rocket on the launchpad.

Field Safety Rules Compliance

Mission Operations Manual		
Section	**Progress**	**Description**
Team Organization and Roles	Complete	Describes team structure as well as flight day roles.
Packing List	In Progress	Breakdown of components each subteam is responsible for bringing to competition.
CanSat Preparation Process	In Progress	Breakdown of mechanical and electrical payload construction tasks as well as embedded code upload.
Ground Station Configuration	In Progress	Describes the setup of the base station including the antenna and GCS program.
CanSat Integration	In Progress	Describe the process of integrating the payload into the container and the container into the rocket.
Launch Preparation and Procedure	In Progress	Breakdown of launch day order of events and flight readiness review tests.

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 para-glider 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 90 dB sound for the duration of the flight
Para-Glider	Bright orange and pink to be visible in field
Container	Brightly painted to be visible in field
Nose Cone	Brightly painted to be visible in field
Parachute	Bright orange 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

Mission Rehearsal Activities (1 of 2)

Task	Mission Rehearsal Procedure	Date(s) Completed
Ground System Radio Link Check Procedures	Conduct a range test on the field between the XBEE on the payload integrated into the container and the ground station XBEE, ensure that packets are being consistently received.	3/7/2026, 3/21/2026
Powering On/Off the CanSat	Turn on the CanSat and ensure all components are getting power by observing LED's.	3/7/2026, 3/21/2026
Launch Configuration Preparations	Fold and stow the para-glider into the container, then lock the release arm into the container by using the manual release and lock commands from the GCS.	3/7/2026, 3/21/2026

Mission Rehearsal Activities (2 of 2)

Task	Mission Rehearsal Procedure	Date(s) Completed
Loading the CanSat in the Launch Vehicle	Fold the parachute and store it above the container, then gently place the container into the rocket body until the nose cone is flush with the rocket body.	3/7/2026, 3/21/2026
Telemetry Processing, Archiving, and Analysis	Confirm that packets are being received while payload is integrated into the rocket body, and confirm that packets are being saved to the CSV file. This CSV file is uploaded to a USB drive after flight.	3/7/2026, 3/21/2026
Recovery	Recover the payload, container, and nose cone from the field, and remove the SD cards from the microcontroller and cameras to analyze flight data.	3/7/2026, 3/21/2026




Requirements Compliance

Kayla Budziak

Requirements Compliance Overview

Requirements Compliance Overview		
Compliant	**Partially Compliant**	**Not Compliant**
87	0	0

Team Vortex is compliant with all 87 requirements, which was shown during our testing and two test launches

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	11, 21, 26	
C2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	21, 26	
C3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	11, 21	
C4	After deployment, the CanSat payload and container shall descend at 15 m/s using a parachute that automatically deploys. Error is ± 3 m/s.	Comply	11, 21, 42, 49	
C5	At 80% flight peak altitude, the payload shall be released from the container.	Comply	11, 21, 42	
C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Comply	11, 21, 42	

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 ± 3 meters/sec with the para-glider descent control system.	Comply	11, 21, 42, 50	
C8	The payload shall steer toward a target location.	Comply	11, 21, 48, 72, 120	
C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	11, 21, 100, 121	
C10	The payload shall record video of the release of the payload from the container and the deployment of the para-glider descent control system.	Comply	73	
C11	A second video camera shall point at the ground.	Comply	74	
C12	The payload shall release a protected hens egg when the payload is 2 meters ± 0.5 m above the ground without breaking the egg.	Comply	11, 21, 76	

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	108, 110, 115, 162	
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	187, 188	
S1	The CanSat and container mass shall be 1000 grams ± 10 grams.	Comply	92	
S2	The nose cone shall be symmetrical along the thrust axis.	Comply	26	
S3	Nose cone radius shall be exactly 70 mm.	Comply	26, 64, 65	
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	26, 64	

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	64	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	64	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	26, 64	
S8	CanSat structure must survive 15 Gs vibration.	Comply	143, 149	
S9	CanSat shall survive 30 G shock.	Comply	144, 149	
S10	The container shoulder length shall be 90 to 120 mm.	Comply	26, 66	
S11	The container shoulder diameter shall be 136 mm.	Comply	26, 66	
S12	Above the shoulder, the container diameter shall be 140 mm.	Comply	23, 23, 66	
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	66	

Requirements Compliance (5 of 14)

RQ#	Requirement	Compliance	Slides	Notes
S14	The container length above the shoulder shall be 200 mm ± 5%.	Comply	26, 66	
S15	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	11, 21, 26	
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	23, 26, 71	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	78-82	
S18	The CanSat container shall meet all dimensions in section F.	Comply	26, 66	
S19	The CanSat container materials shall meet all requirements in section F.	Comply	54, 66	

Requirements Compliance (6 of 14)

RQ#	Requirement	Compliance	Slides	Notes
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.	Comply	11, 21, 42, 51	
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.	Comply	145, 149	
M1	No pyrotechnical or chemical actuators are allowed.	Comply	53	
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.	Comply	144, 145, 149	
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	81	
E1	Lithium polymer batteries are not allowed.	Comply	108-111	

Requirements Compliance (7 of 14)

RQ#	Requirement	Compliance	Slides	Notes
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	109, 111	
E3	An easily accessible power switch through the container is required.	Comply	66	
E4	The container shall have small access holes for power switches of no more than 10 mm.	Comply	66	
E5	Power indicator is required.	Comply	61	
E6	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Comply	113-115	
E7	The audio beacon shall operate on a separate battery.	Comply	108, 110, 115	
E8	The audio beacon shall have an easily accessible power switch through the container.	Comply	66	

Requirements Compliance (8 of 14)

RQ#	Requirement	Compliance	Slides	Notes
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	100	
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	100	
X3	XBEE radios shall not use broadcast mode.	Comply	100	
X4	The CanSat shall transmit telemetry once per second.	Comply	21, 100, 121	
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	102-104	
SN1	CanSat payload shall measure its altitude using air pressure.	Comply	103	
SN2	CanSat payload shall measure its internal temperature.	Comply	103	

Requirements Compliance (9 of 14)

RQ#	Requirement	Compliance	Slides	Notes
SN3	CanSat payload shall measure its battery voltage.	Comply	103	
SN4	CanSat payload shall track its position using GPS.	Comply	104	
SN5	CanSat payload shall measure its acceleration and rotation rates.	Comply	103-104	
SN6	CanSat payload shall video record the deployment of the para-glider at 80% peak altitude.	Comply	73	
SN7	CanSat payload shall video record the ground during descent.	Comply	74	
SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Comply	74	
SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	37-38	
SN10	CanSat payload shall measure its battery current.	Comply	103	

Requirements Compliance (10 of 14)

RQ#	Requirement	Compliance	Slides	Notes
G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Comply	133	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	133-134	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	103	
G4	Each team shall develop their own ground station.	Comply	126, 128	
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Comply	131-133	
G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	131	

Requirements Compliance (11 of 14)

RQ#	Requirement	Compliance	Slides	Notes
G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Comply	131-132	
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Comply	131-132	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	128	
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	126	
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	122, 133	

Requirements Compliance (12 of 14)

RQ#	Requirement	Compliance	Slides	Notes
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	103, 122, 133, 136, 143,156	
G13	The ground station shall use a table top or handheld antenna.	Comply	129	
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	131	
G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Comply	131	
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	131, 133	

Requirements Compliance (13 of 14)

RQ#	Requirement	Compliance	Slides	Notes
G17	The ground station shall be able to activate all mechanisms on command.	Comply	106, 131-133	
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	103, 121	
F2	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	121	
F3	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	105, 132	
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	105, 122, 133, 136, 143,156	

Management

Kayla Budziak

Requirements Compliance (14 of 14)

RQ#	Requirement	Compliance	Slides	Notes
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	122, 133	
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	122, 133	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	106, 131-133, 162	
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	121	

Status of Procurements (1 of 3)

Component	Date Ordered	Status	Date Received
Teensy 4.1	1/18/2026	Arrived	1/27/2026
NEO-M9N	1/18/2026	Arrived	2/7/2026
BNO055	1/18/2026	Arrived	1/26/2026
BMP390	1/18/2026	Arrived	1/26/2026
ACS724LLCTR-30AU	1/18/2026	Arrived	2/2/2026
XBEE System	1/18/2026	Arrived	1/24/2026
RunCam Split 4 V2 (Upward Camera)	1/18/2026	Arrived	2/7/2026
RunCam Split 4 V2 (Downward Camera)	1/18/2026	Arrived	2/7/2026
Miuzei 25 kg (Main Release)	1/18/2026	Arrived	2/5/2026
PCBs	1/18/2026	Arrived	1/24/2026

Status of Procurements (2 of 3)

Component	Date Ordered	Status	Date Received
MG92B	1/18/2026	Arrived	2/5/2026
LS-955CR	1/18/2026	Arrived	2/5/2026
TPU Components	1/18/2026	Arrived	2/5/2026
Kevlar Line	1/18/2026	Arrived	2/5/2026
Birch Plywood	1/18/2026	Arrived	2/5/2026
PETG Filament	1/18/2026	Arrived	2/5/2026
Carbon Fiber Rods	1/18/2026	Arrived	2/5/2026
Thread	1/18/2026	Arrived	2/5/2026
Fiberglass Layup	1/18/2026	Arrived	2/5/2026
Nuts & Bolts	1/18/2026	Arrived	2/5/2026
Urethane Foam Egg Holder	1/18/2026	Arrived	2/5/2026

Status of Procurements (3 of 3)

Component	Date Ordered	Status	Date Received
Eye Bolt & Nut	1/18/2026	Arrived	2/5/2026
Threaded Rods	1/18/2026	Arrived	2/5/2026
Chopped Carbon Fiber	1/18/2026	Arrived	2/5/2026
40D Ripstop Nylon	3/16/2026	Arrived	3/21/2026
18350 Batteries	1/18/2026	Arrived	2/10/2026
Coin Cell Batteries	1/18/2026	Arrived	2/3/2026
Buzzer	1/18/2026	Arrived	2/3/2026
Coin Cell Holder	1/18/2026	Arrived	2/5/2026

CanSat Budget – Hardware (1 of 4)

Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
PCBs	$20.00	1	$20	Actual	JLCPCB	
Teensy 4.1	$29.95	1	$29.95	Actual	Sparkfun	
NEO-M9N	$70.95	1	$70.95	Actual	Sparkfun	
BMP390	$10.95	1	$10.95	Actual	Adafruit	
BNO055	$29.95	1	$29.95	Actual	Adafruit	
Buzzer	$1.47	1	$1.47	Actual	Mouser	
XBEE Radio	$55.66	1	$55.66	Actual	Digikey	
XBEE Breakout	$14.50	1	$14.50	Actual	Sparkfun	
5V Regulator	$18.95	2	$37.90	Actual	Pololu	
3.3V Regulator	$18.95	1	$18.95	Actual	Pololu	
TPU Components	$0.02 /g	3.3g	$0.07	Estimate	Amazon	
Kevlar Line	$10.99	2	$21.98	Estimate	Amazon	

CanSat Budget – Hardware (2 of 4)

Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
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	
RunCam Split 4 V2	$82.99	2	$165.98	Actual	RunCam	
MG92B Servo	$11.95	1	$11.95	Actual	Adafruit	
Miuzei 25 kg	$16.99	1	$16.99	Actual	Amazon	
LS-955CR	$18.65	2	$37.30	Estimate	Mouser	
Vapcell H16 18350	$6.50	2	$13.00	Actual	Vapcell	
Carbon Fiber Rods	$1.80	2	$3.60	Estimate	Amazon	
Thread	$8.07	1	$8.07	Estimate	Amazon	
Fiberglass Layup	$41.99	1	$41.99	Estimate	Rock West Composites	X
Nuts & Bolts	$9.99	1	$9.99	Estimate	Amazon	X

CanSat Budget – Hardware (3 of 4)

Item	Unit Price	Quantity	Total Price	Type	Source	Reuse
Urethane Foam Egg Holder	$10.35	1	$10.35	Actual	Apogee Rockets	
Eye Bolt & Nut	$4.00	1	$4.00	Actual	McMaster	
Threaded Rods	$7.48	2	$14.96	Estimate	McMaster	X
Chopped Carbon Fiber	$0.08 per g	11.21g	$0.90	Estimate	Amazon	
40D Ripstop Nylon	$8.95 per m	2	$17.90	Actual	Amazon	
Coin Cells	$9.27	2	$18.54	Actual	Digikey	
Total Hardware Cost: $715.19						

CanSat Budget – Hardware (4 of 4)

Hardware Cost Totals	
Mechanical Subteam	$227.39
Electrical Subteam	$487.80
Total Cost of Payload	$715.19

Project Budget	Hardware Cost	Budget Margin
$1000	$715.19	$284.81

Total Mission Cost	
Total Cost of Payload	$715.19
Total Other Costs	$3869.17
Total Cost of Competition	$4584.36

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	$64.00	1	$64.00	Actual	Digikey	
Raspberry Pi Screen	$54.99	1	$54.99	Actual	Amazon	
Keyboard	$26.99	1	$26.99	Actual	Amazon	
Mouse	$5.99	1	$5.99	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)	$150.00	10	$1500.00	Estimate	N/A	
Travel (per person)	$100.00	10	$1000.00	Estimate	N/A	
Food (per person)	$100.00	10	$1000.00	Estimate	N/A	
Total Other Costs: $3869.17						

Total Mission Cost	
Total Cost of Payload	$715.19
Total Other Costs	$3869.17
Total Cost of Competition	$4584.36

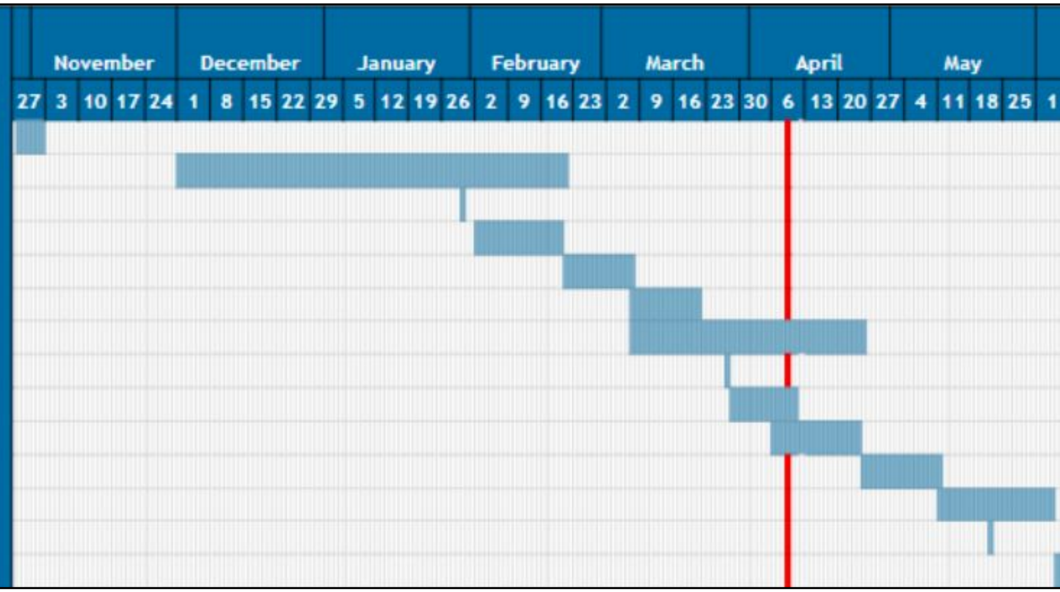
NOTE: Funding provided by Alabama Space Grant Consortium

Program Schedule Overview (1 of 2)

Competition Timeline
Assigned: Full Team
Percent Completion: 66%

CanSat 2026 Team Vortex

TASK	START	END	PROGRESS	DURATION
Team Formation	10/28/2025	11/2/2025	100%	5
PDR Phase	12/1/2025	2/21/2026	100%	82
PDR Due	1/30/2026	1/30/2026	100%	0
PDR Presentations	2/2/2026	2/20/2026	100%	18
Test Launch 1 Phase	2/21/2026	3/7/2026	100%	14
Test Launch 2 Phase	3/7/2026	3/21/2026	100%	14
CDR Phase	3/7/2026	4/25/2026	100%	49
CDR Due	3/27/2026	3/27/2026	100%	0
Test Launch 3 Phase	3/28/2026	4/11/2026	75%	14
CDR Presentations	4/6/2026	4/24/2026	50%	18
Test Launch 4 Phase	4/25/2026	5/11/2026	0%	16
Environmental Testing Phase	5/11/2026	6/4/2026	0%	24
Environmental Testing Due	5/22/2026	5/22/2026	0%	0
Competition Phase	6/5/2026	6/7/2026	0%	2

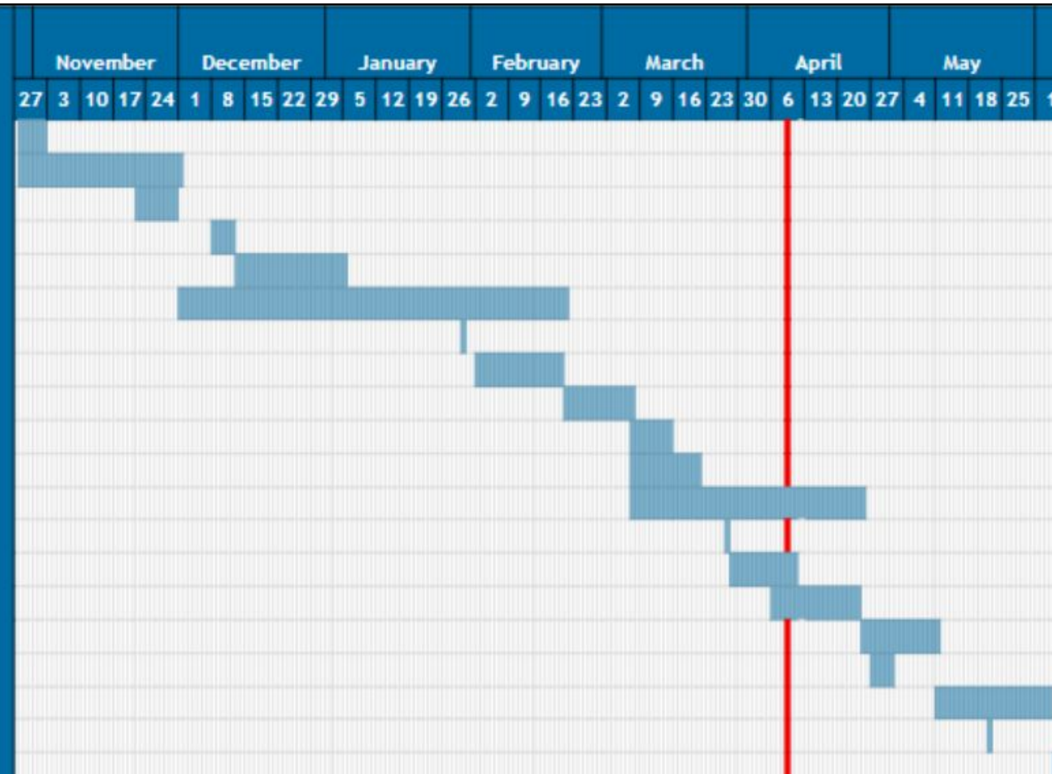


Program Schedule Overview (2 of 2)

Project Timeline
Assigned: Full Team
Percent Completion: 71%

CanSat 2026 Team Vortex

TASK	START	END	PROGRESS	DURATION
Team Formation	10/28/2025	11/2/2025	100%	5
MCR Phase	10/28/2025	12/1/2025	100%	34
Thanksgiving Break	11/22/2025	11/30/2025	100%	8
Fall Finals	12/8/2025	12/12/2025	100%	4
Winter Break	12/13/2025	1/5/2026	100%	23
PDR Phase	12/1/2025	2/21/2026	100%	82
PDR Due	1/30/2026	1/30/2026	100%	0
PDR Presentations	2/2/2026	2/20/2026	100%	18
Test Launch 1 Phase	2/21/2026	3/7/2026	100%	14
Spring Break	3/7/2026	3/15/2026	100%	8
Test Launch 2 Phase	3/7/2026	3/21/2026	100%	14
CDR Phase	3/7/2026	4/25/2026	100%	49
CDR Due	3/27/2026	3/27/2026	100%	0
Test Launch 3 Phase	3/28/2026	4/11/2026	75%	14
CDR Presentations	4/6/2026	4/24/2026	50%	18
Test Launch 4 Phase	4/25/2026	5/11/2026	0%	16
Spring Finals	4/27/2026	5/1/2026	0%	4
Environmental Testing Phase	5/11/2026	6/4/2026	0%	24
Environmental Testing Due	5/22/2026	5/22/2026	0%	0
Competition Phase	6/5/2026	6/7/2026	0%	2



Detailed Program Schedule (1 of 3)

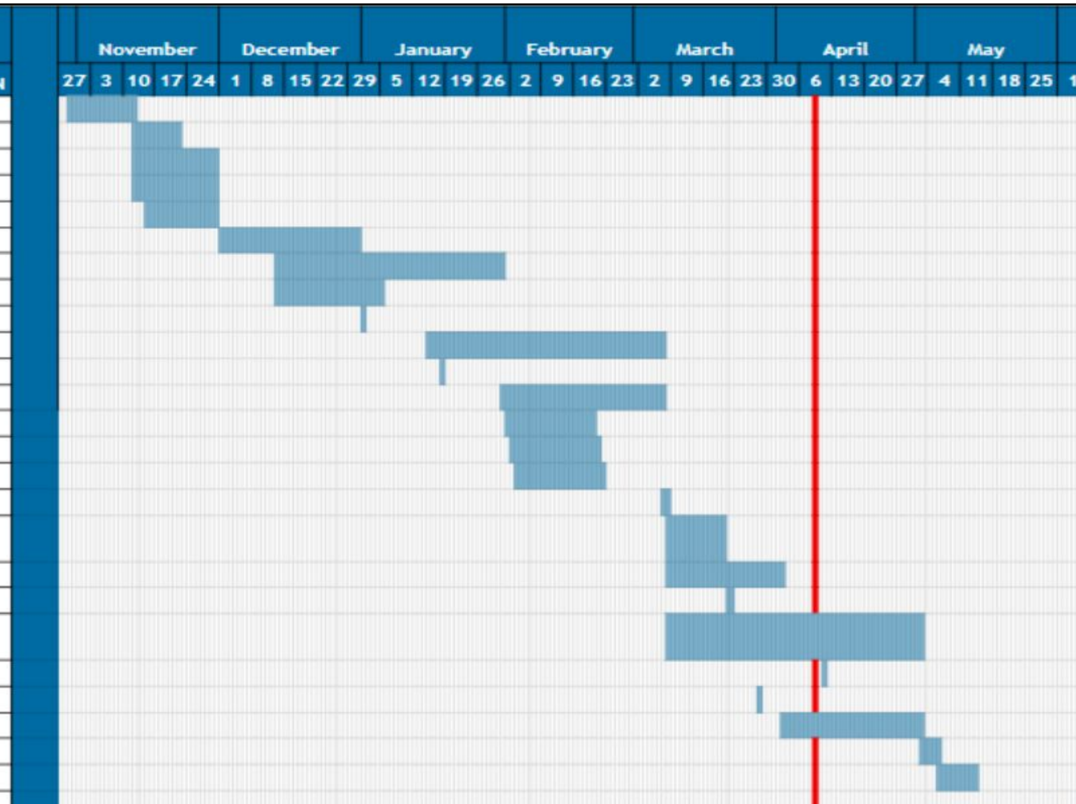
Mechanical Timeline

Assigned: Brooke Petrosky, Julien Bynum, William Goudy, Rebekah Langford, Andrew Levrett, Eshton Moyer

Percent Completion: 78%

CanSat 2026 Team Vortex: Mechanical

TASK	START	END	PROGRESS	DURATION
Independent Design CAD	10/29/2025	11/12/2025	100%	14
Mechanical Team Integration	11/12/2025	11/22/2025	100%	10
Parts Selection/Trade Studies	11/12/2025	11/30/2025	100%	18
Mass Budget & Actual Budget	11/12/2025	11/30/2025	100%	18
Electrical Integration Plan	11/15/2025	11/30/2025	100%	15
Redesigning & Refining Systems	12/1/2025	12/31/2025	100%	30
Presentation Refinement	12/13/2025	1/31/2026	100%	49
Electrical Integration	12/13/2025	1/5/2026	100%	23
Parts Order 1	1/1/2026	1/1/2026	100%	0
Prototype 1	1/15/2026	3/7/2026	100%	51
Parts Order 2	1/18/2026	1/18/2026	100%	0
Re-evalute Design & Refine	1/31/2026	03/07/2026	100%	35
Paraglider Testing	2/1/2026	2/20/2026	100%	19
Release Mechanism Testing	2/2/2026	2/21/2026	100%	19
Overall Systems Testing	2/3/2026	2/22/2026	100%	19
Test Launch 1	3/7/2026	3/8/2026	100%	1
Assess Damages & Make Changes	3/8/2026	3/20/2026	100%	12
Prototype 2	3/8/2026	4/2/2026	100%	25
Test Launch 2	3/21/2026	3/22/2026	100%	1
Review Design & Assess Points of Failure	3/8/2026	5/2/2026	75%	55
Test Launch 3	4/11/2026	4/11/2026	50%	0
Parts Order 3	3/28/2026	3/28/2026	0%	0
Retest Systems	4/2/2026	5/2/2026	0%	30
Test Launch 4	5/2/2026	5/6/2026	0%	4
Make Changes	5/6/2026	5/14/2026	0%	8
Launch Day	6/6/2026	6/6/2026	0%	0

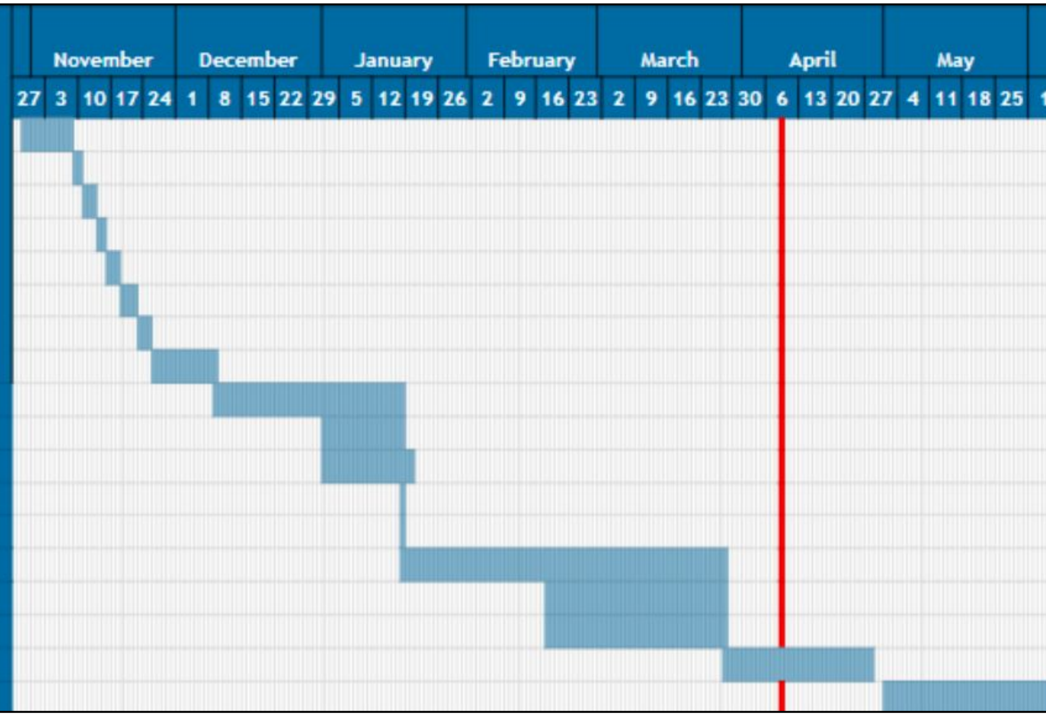


Detailed Program Schedule (2 of 3)

Electrical Timeline
Assigned: Kenny Briggs, Aaron Watson
Percent Completion: 75%

CanSat 2026 Team Vortex: Electrical

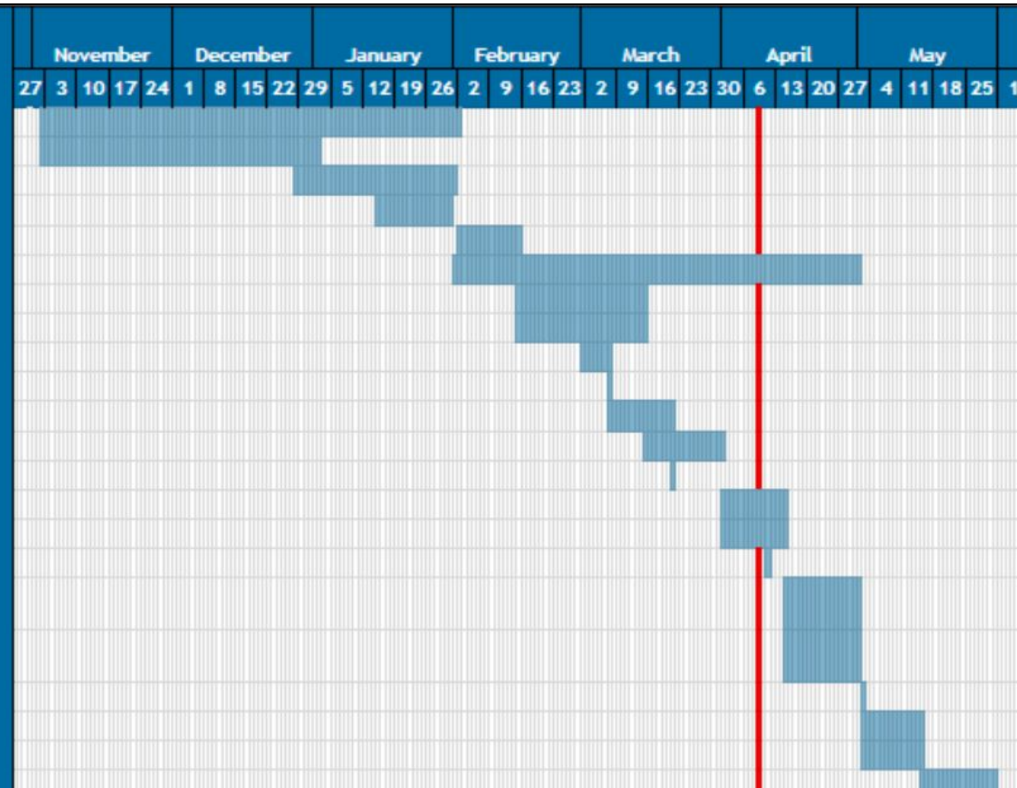
TASK	START	END	PROGRESS	DURATION
Sensor Trades	10/29/2025	11/8/2025	100%	10
Sensor Selections	11/9/2025	11/10/2025	100%	1
Power Budget	11/11/2025	11/13/2025	100%	2
Parts Selection	11/14/2025	11/15/2025	100%	1
Block Diagram	11/16/2025	11/18/2025	100%	2
Schematic	11/19/2025	11/22/2025	100%	3
PCB Design	11/23/2025	11/25/2025	100%	2
PCB Review	11/26/2025	12/9/2025	100%	13
Parts Order 1	12/9/2025	1/18/2026	100%	40
PCB Order 1	1/1/2026	1/18/2026	100%	17
Evaluation and Redesign	1/1/2026	1/20/2026	100%	19
Parts Order 2	1/18/2026	1/18/2026	100%	0
PCB Order 2	1/18/2026	1/18/2026	100%	0
Evaluation and Redesign	1/18/2026	3/28/2026	50%	69
Parts Order 3	2/18/2026	3/28/2026	0%	38
PCB Order 3	2/18/2026	3/28/2026	0%	38
Evaluation and Redesign	3/28/2026	4/28/2026	0%	31
Final Debugging	5/1/2026	6/5/2026	0%	35



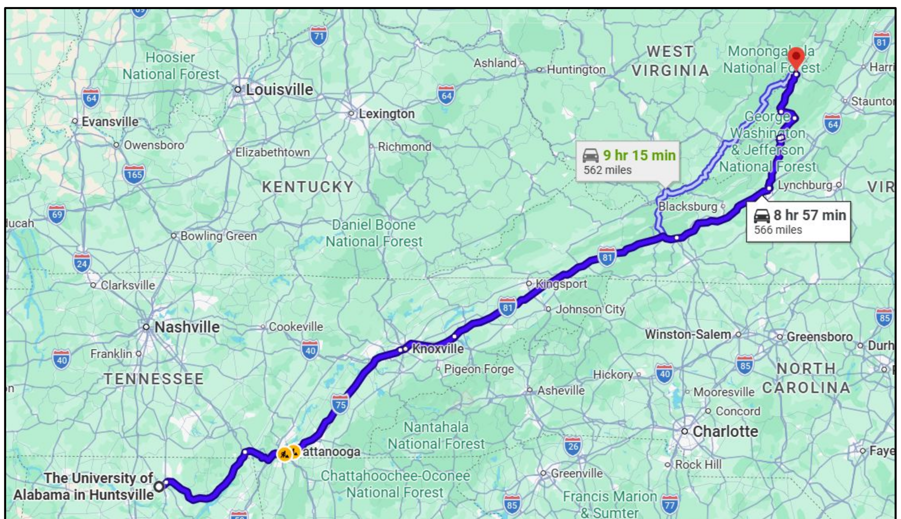
Software Timeline
Assigned: Ethan Denoncourt, Kayla Budziak
Percent Completion: 66%

CanSat 2026 Team Vortex: Software

TASK	START	END	PROGRESS	DURATION
Preliminary Embedded System Code	11/2/2025	2/2/2026	100%	92
Preliminary Ground Station Code	11/2/2025	1/2/2026	100%	61
Base Station Design and Planning	12/28/2025	2/1/2026	100%	35
Test XBee Communication	1/15/2026	1/31/2026	100%	16
Test Sensor Embedded Code	2/2/2026	2/15/2026	100%	13
Base Station Contruction	2/1/2026	5/1/2026	50%	89
Updates to Embedded System Code	2/15/2026	3/15/2026	100%	28
Updates to Ground Station Code	2/15/2026	3/15/2026	100%	28
Test Commands from Ground Station	3/1/2026	3/7/2026	100%	6
Test Launch 1	3/7/2026	3/7/2026	100%	0
Review Results and Make Changes	3/7/2026	3/21/2026	100%	14
Test Simulation Mode	3/15/2026	4/1/2026	100%	17
Test Launch 2	3/21/2026	3/21/2026	100%	0
Update Ground Station Code	4/1/2026	4/15/2026	75%	14
Update Embedded System Code	4/1/2026	4/15/2026	75%	14
Test Launch 3	4/11/2026	4/11/2026	50%	0
Integrate Base Station with Ground Station Code	4/15/2026	5/1/2026	0%	16
Test Commands and Simulation with Payload	4/15/2026	5/1/2026	0%	16
Test Launch 4	5/2/2026	5/2/2026	0%	0
Updates to Embedded System Code	5/2/2026	5/15/2026	0%	13
Updates to Ground Station Code	5/2/2026	5/15/2026	0%	13
Final Testing	5/15/2026	5/31/2026	0%	16



Transportation Plan
The team will travel in vans funded by the University of Alabama in Huntsville which will drive the team approximately 9 hours from Huntsville, AL to Monterey, VA. This van will also carry all hardware and equipment necessary to be brought to competition. This includes two complete CanSat payloads, a completed base station and related equipment, spare parts, and any necessary tools. Nothing will be shipped to ensure that no critical hardware is lost on the way to competition.



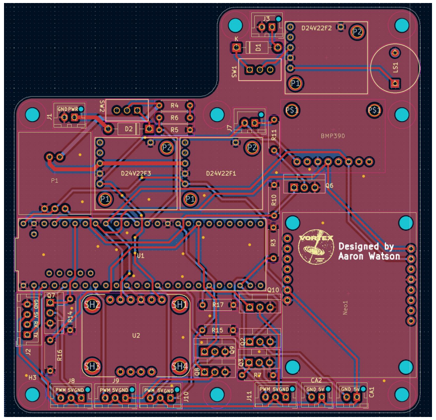
Source: Google Maps

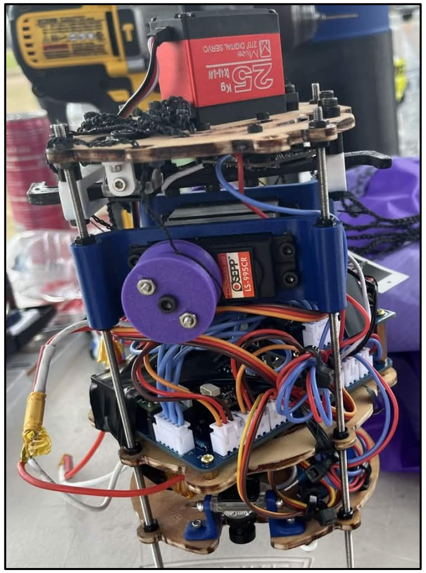
Source: Ford

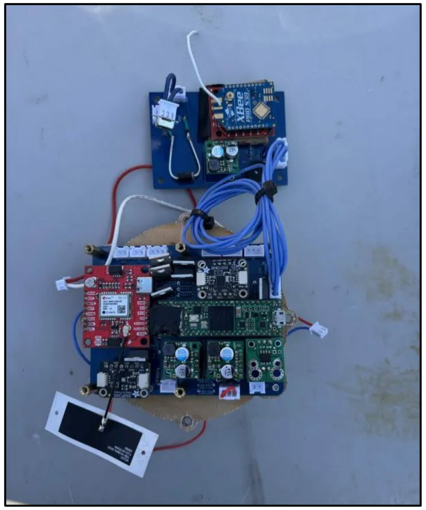
Mechanical Conclusions	
Major Accomplishments	• Electrical & software systems have been integrated with payload • First prototype has been designed, assembled, tested, & flown • Prototype has been evaluated & redesigned to mitigate challenges encountered during the first two test flights
Major Unfinished Work	• Second prototype needs to be constructed & new components and optimized systems must be tested
Testing Needed	• Second prototype mechanisms & descent control • Environmental testing

Conclusions (2 of 4)

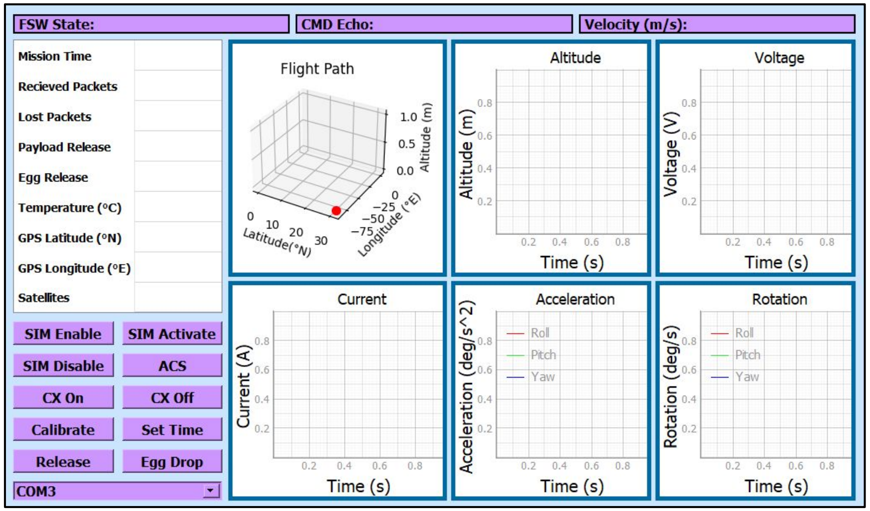
Electrical Conclusions	
Major Accomplishments	• Successfully changed to a THT PCB • Conducted sensor testing • Conducted camera testing • Tested the release mechanisms • Redesigned PCB to be more optimal for payload
Major Unfinished Work	• Reducing size of electrical subsystem on the payload • Testing changes made to electrical design in new PCB
Testing Needed	• Autonomous servo release for payload and egg using the BMP390 with new PCB • Sensors and cameras in launch conditions with new PCB







Software Conclusions	
Major Accomplishments	• GPS code works and coordinates are accurate • Telemetry, SD card, and all data is saved and transmitted properly • Servo code for ACS has been tested
Major Unfinished Work	• Processor reset code needs to be prototyped • Integration of the GCS program with the base station computer
Testing Needed	• ACS code being integrated with para-glider to improve steering performance • Test simulation mode with payload




```
//////////////////////////////////////////////////////////////////
//                                                    =============
void loop() {



  commandChecker(fd);

  altitudeCalibration(fd);

  sampleData(fd);

  UpdateFlightState(fd);

  newGPSData(fd);


  if(((millis()-fd.ACS_Time) > fd.ACS_Interval) && (flightSta
    autonomousControls(fd);
    fd.ACS_Time = millis();
  }

  if(fd.telemetryStatus && ((millis() - fd.telemetryTime) >=
    sendTelemetry(fd);
    fd.telemetryTime = millis();
    fd.packetCount ++;
  }

  if(((millis() - fd.SDCARDTimer) >= fd.SDCARDInterval)){
    saveToSDCARD(fd);
  }
}
```

```
1093,0.00:0.00:0.00,981,F,LAUNCH_PAD,1.11,36.
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```

Conclusions (4 of 4)

Team Conclusions	
Major Accomplishments	• Fully assembled a payload and integrated electrical and software components • Completed two test flights • Optimized the design based on information from two test launches
Major Unfinished Work	• Need to implement design changes into construction of payload • Must complete testing on optimized payload in next test flight
Readiness to Proceed	The team has completed two test launches with a complete system to simulate flight day conditions, the second test launch being largely successful and are in the process of optimizing designs.