CanSat 2023
Critical Design Review (CDR)
Version 1.0

1070

Obsidian

Presentation Outline

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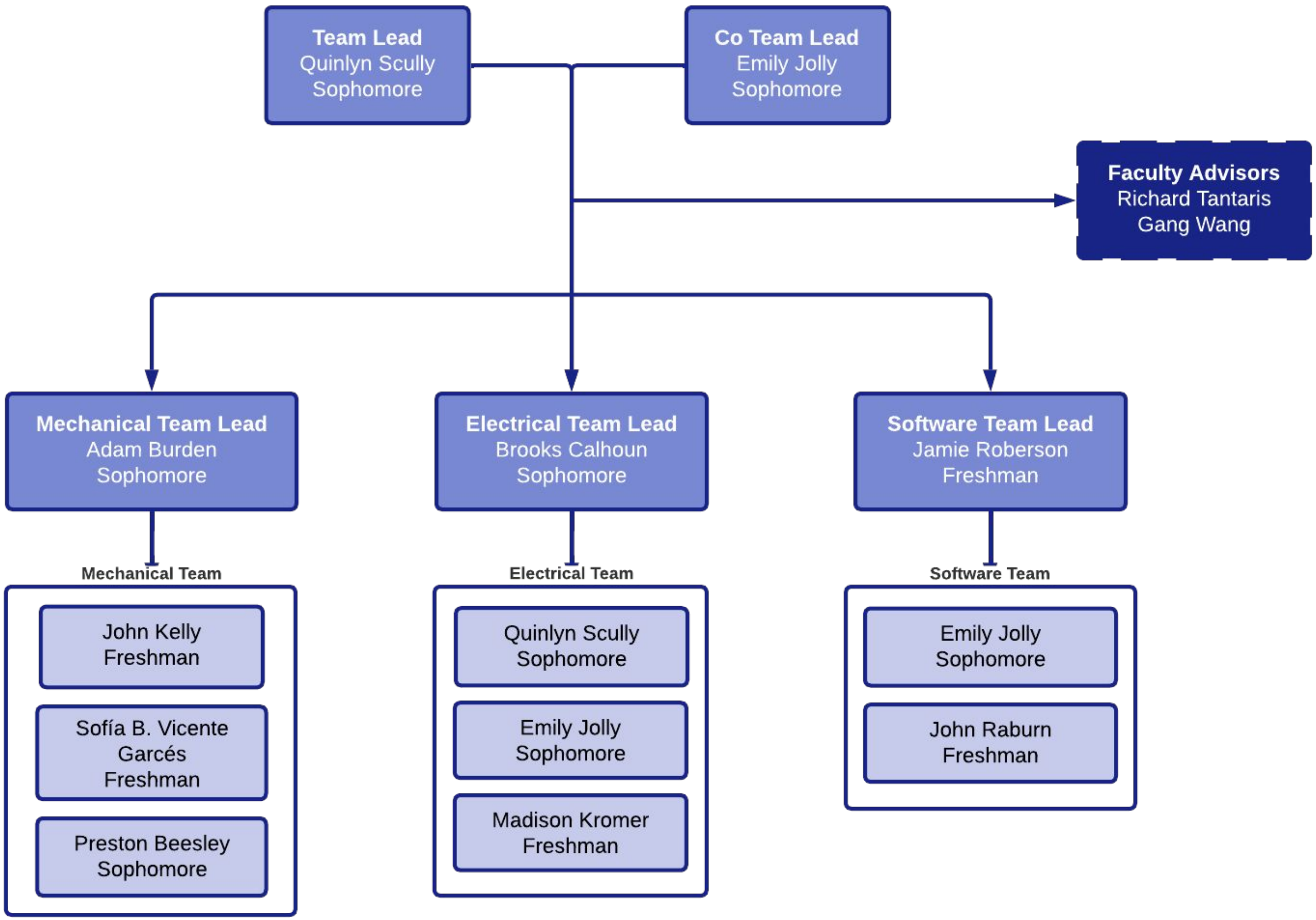
Team Organization



Acronyms (1/2)

Acronyms	Definition
3D	3-Dimensional
ADC	Analog-to-Digital Conversion
CDH	Communication Data Handling
CDR	Critical Design Review
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
CSV	Comma Separated Values
DS	Datasheet
EPS	Electrical Power Subsystem
FSA	Flight State - Ascent

Acronyms	Definition
FSD	Flight State - Descent
FSH	Flight State - Heat Shield
FSI	Flight State - Idle
FSL	Flight State - Landed
FSP	Flight State - Parachute
FSR	Flight State - Ready
FSW	Flight Software
GCS	Ground Control Station
GPIO	General-Purpose Input/Output
GPS	Global Positioning System

Acronyms (2/2)

Acronyms	Definition
HAR	Hardware Acceptance Review
I2C	Inter-Integrated Circuit
ISO	Isometric
ID	Identity
IDE	Integrated Development Environment
LED	Light Emitting Diode
MCR	Mission Concept Review
MOM	Mission Operations Manual
NETID	Network Identity
PCB	Printed Circuit Board

Acronyms	Definition
PDR	Preliminary Design Review
PET	Polyethylene Terephthalate
PETG	Polyethylene Terephthalate Glycol
PFR	Post Flight Review
PWM	Pulse Width Modulation
SD	Secure Digital
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver-Transmitter
UTC	Coordinated Universal Time

System Overview

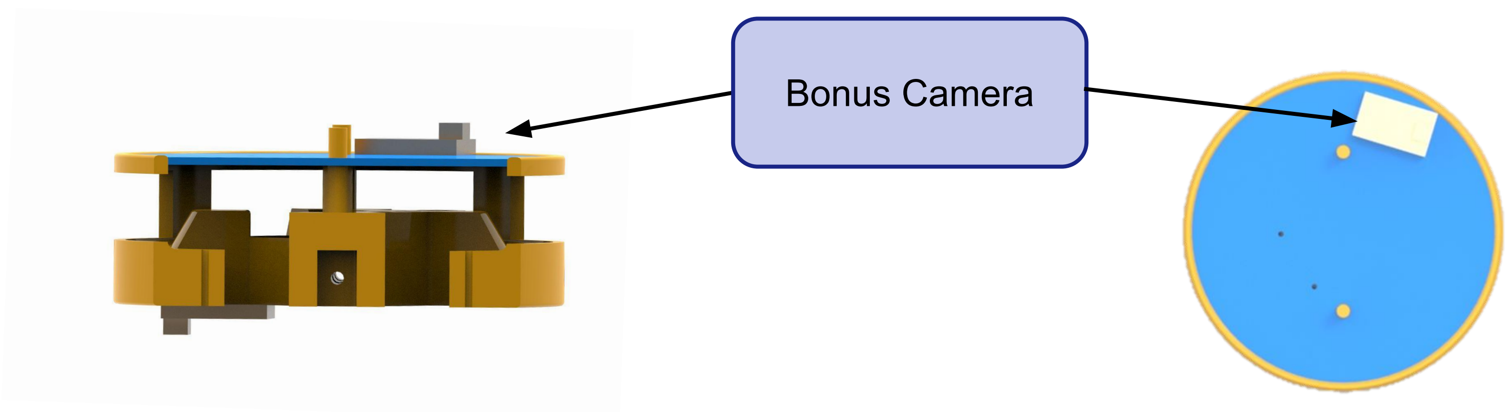
Quinlyn Scully and Adam Burden

Mission Summary (1/2)

	Mission Objectives
1	Design a CanSat that shall consist of a container and a probe simulating the landing sequence of a planetary probe.
2	The CanSat shall be launched to an altitude ranging from 670 meters to 725 meters above the launch site and deployed near apogee (peak altitude).
3	Once the CanSat is deployed from the rocket, the CanSat shall descend using a parachute at a rate of 15 m/s.
4	At 500 meters, the CanSat shall release a probe that shall open a heat shield that will also be used as an aerobraking device with a descent rate of 20 meters/second or less
5	When the probe reaches 200 meters, the probe shall deploy a parachute and slow the descent rate to 5 meters/second.
6	Once the probe has landed, it shall attempt to upright itself.
7	The CanSat must raise a flag 500 mm above the base of the probe when the probe is in the upright position.

Mission Summary (2/2)

Bonus Objective
A video camera shall be integrated into the container and point toward the probe. The camera shall record the event when the probe is released from the container. Video shall be in color with a minimum resolution of 640x480 pixels and a minimum of 30 frames per second. The video shall be recorded and retrieved when the container is retrieved.



Summary of Changes Since PDR

Component	PDR	CDR	Rationale
SD Card	Openlog, DEV-13712	SD+ Reader	Upgrade data storage device to pull data in case of reboot or malfunction
Aerobrake Mechanism	Used Rubber Bands	Transfer Shafts	Mechanism was slower with rubber bands
Flag Mechanism	Stem	Rotating Rod	Less complex and easier to make
Assembly Middle Plates	2 Plates	1 Plate	Mass savings (34 grams)
Aerobraking Panels	3D Printed	Bottle Cutouts	Mass Savings (78 grams)
CanSat	Taller	Shorter	Mass Savings (11 grams)
GCS	Self -made Graphs	CanvasJS	Easier to embed into website
GCS	React.js	Bootstrap	Easier to use, integrates with HTML better
FSW	Microcontroller requests backup from the ground station during hardware reset	Information is stored onboard for necessary variables during hardware reset	Reduces the risk for error and creates a restoration point for information

System Requirement Summary (1/2)

Requirement Number	Requirement
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.
7	The rocket airframe shall not be used as part of the CanSat operations.
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second ± 5 m/s.
12	All structures shall be built to survive 15 Gs of launch acceleration.
13	All structures shall be built to survive 30 Gs of shock.
14	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.

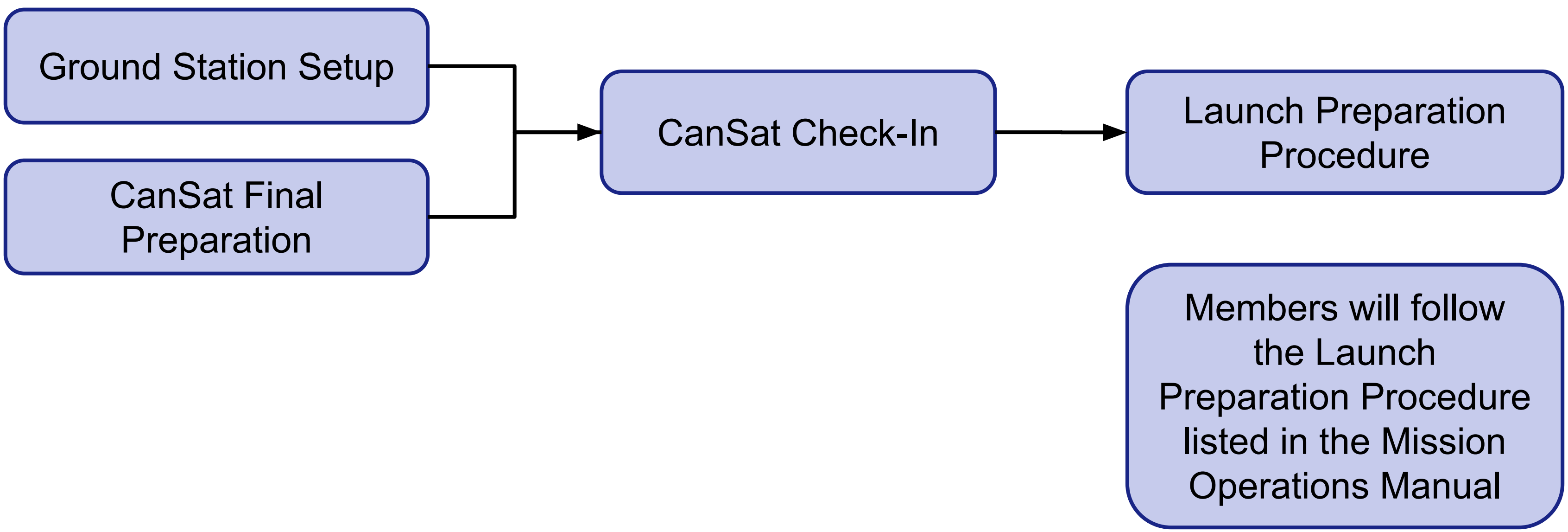
System Requirement Summary (2/2)

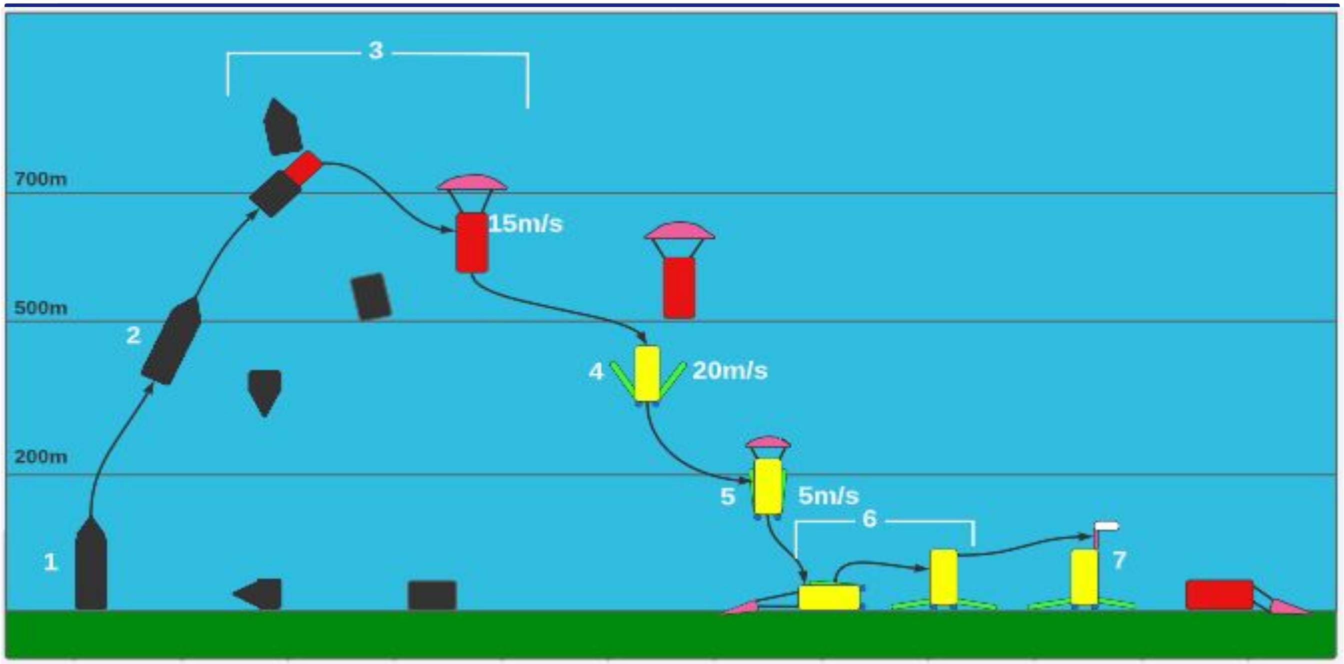
Requirement Number	Requirement
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.
32	The probe shall be released from the container when the CanSat reaches 500 meters.
33	The probe shall deploy a heat shield after leaving the container.
34	The heat shield shall be used as an aerobrake and limit the descent rate to 20 m/s or less.
35	At 200 meters, the probe shall release a parachute to reduce the descent rate to 5 m/s +/- 1 m/sec.
36	Once landed, the probe shall upright itself.
37	After uprighting, the probe shall deploy a flag 500 mm above the base of the probe when the probe is in the upright position.

System Concept of Operations (CONOPS) (1/3)

Pre-Launch

Team Assignments	
Mission Control Officer	Emily Jolly
Ground Station Crew	Jamie Roberson, John Raburn
Recovery Crew	Adam Burden, Preston Beesley
CanSat Cew	John Kelly, Adam Burden, Madison Kromer, Brooks Calhoun





Step	Description
1	The CanSat is powered on and waiting inside the rocket on the ground.
2	The CanSat ascends in the rocket to 700m.
3	At 700m the CanSat is released from the rocket and descends with a parachute at 15m/s to 500m.
4	At 500m the probe is released from the container and descends with the aerobrake deployed at 20m/s to 200m.
5	At 200m the probe deploys a parachute, retracts the aerobrake, and lands at 5m/s
6	When the probe is lying on the ground, the aerobrake opens 100 degrees, lifting the probe upright.
7	The probe extends the flagpole from the top. GPS and altitude data will help the recovery team find the probe. Data transmission is reduced.

Post Launch

CanSat Recovery → Data Analysis → Submit Thumb Drive

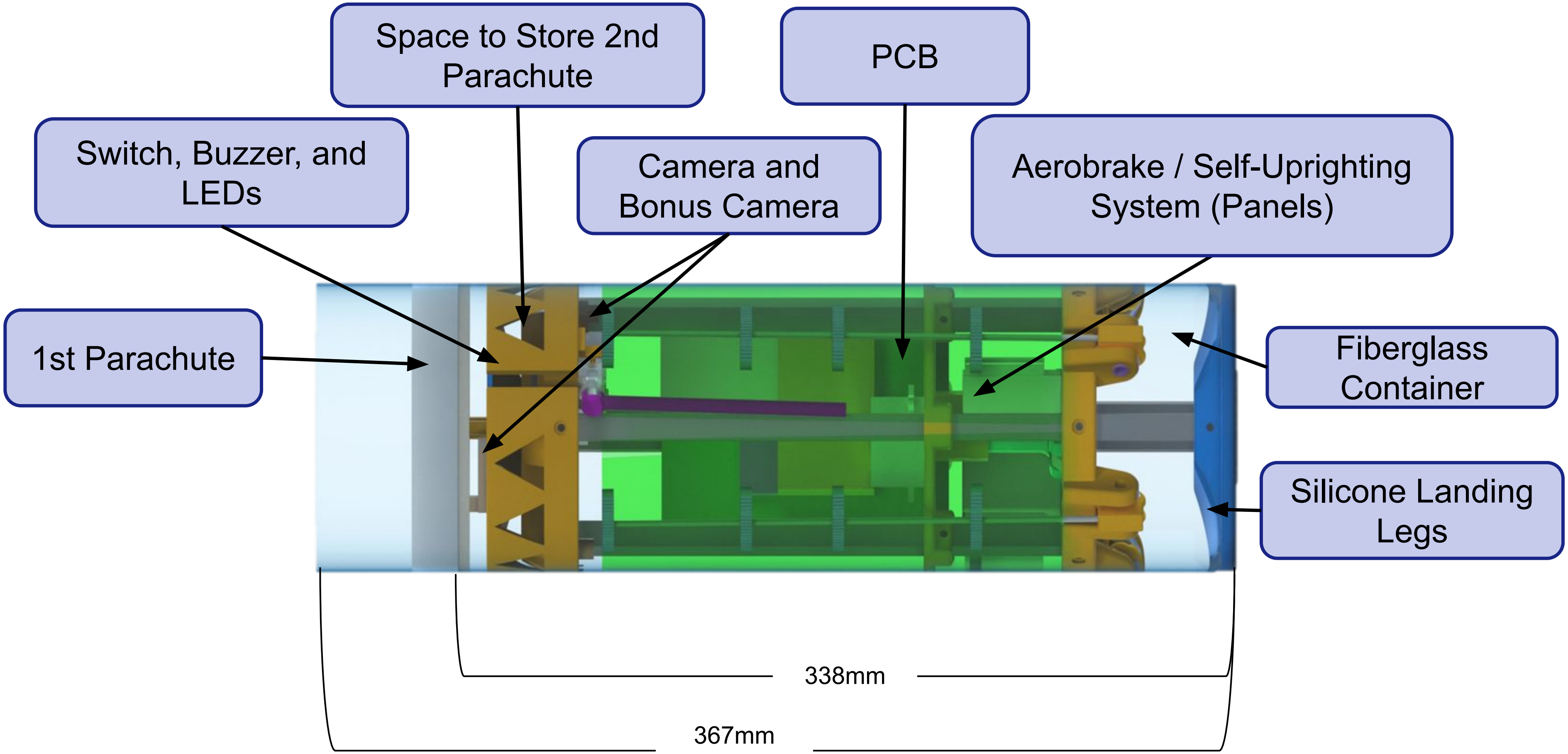
Performed by Recovery Crew. After recovery, Recovery Crew will report to check-in for final judging requirements

Ground Station Crew analyzes data and clears ground station setup

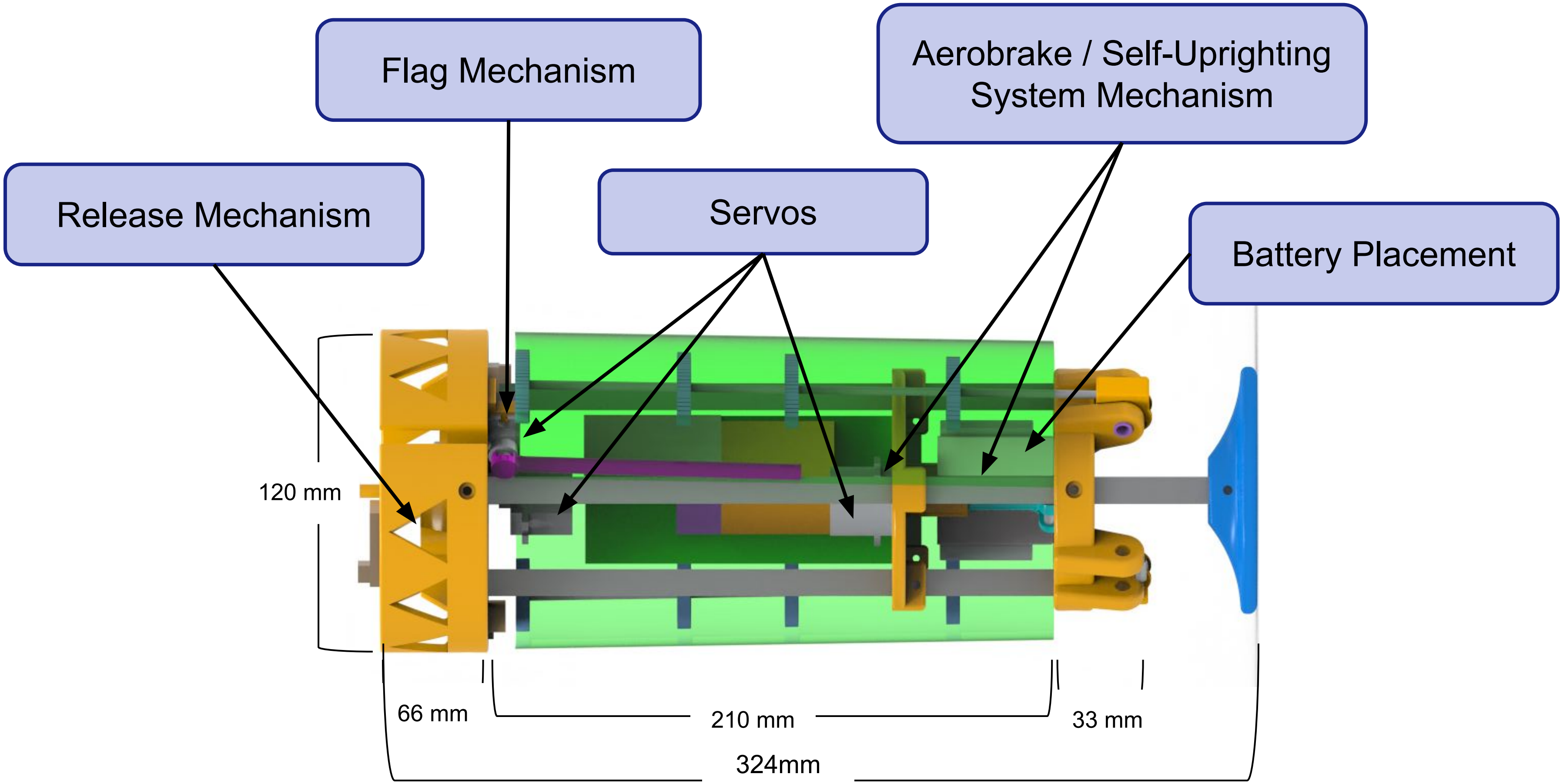
Ground Station Crew turns in thumb drive with telemetry data

CanSat Physical Layout (1/7)

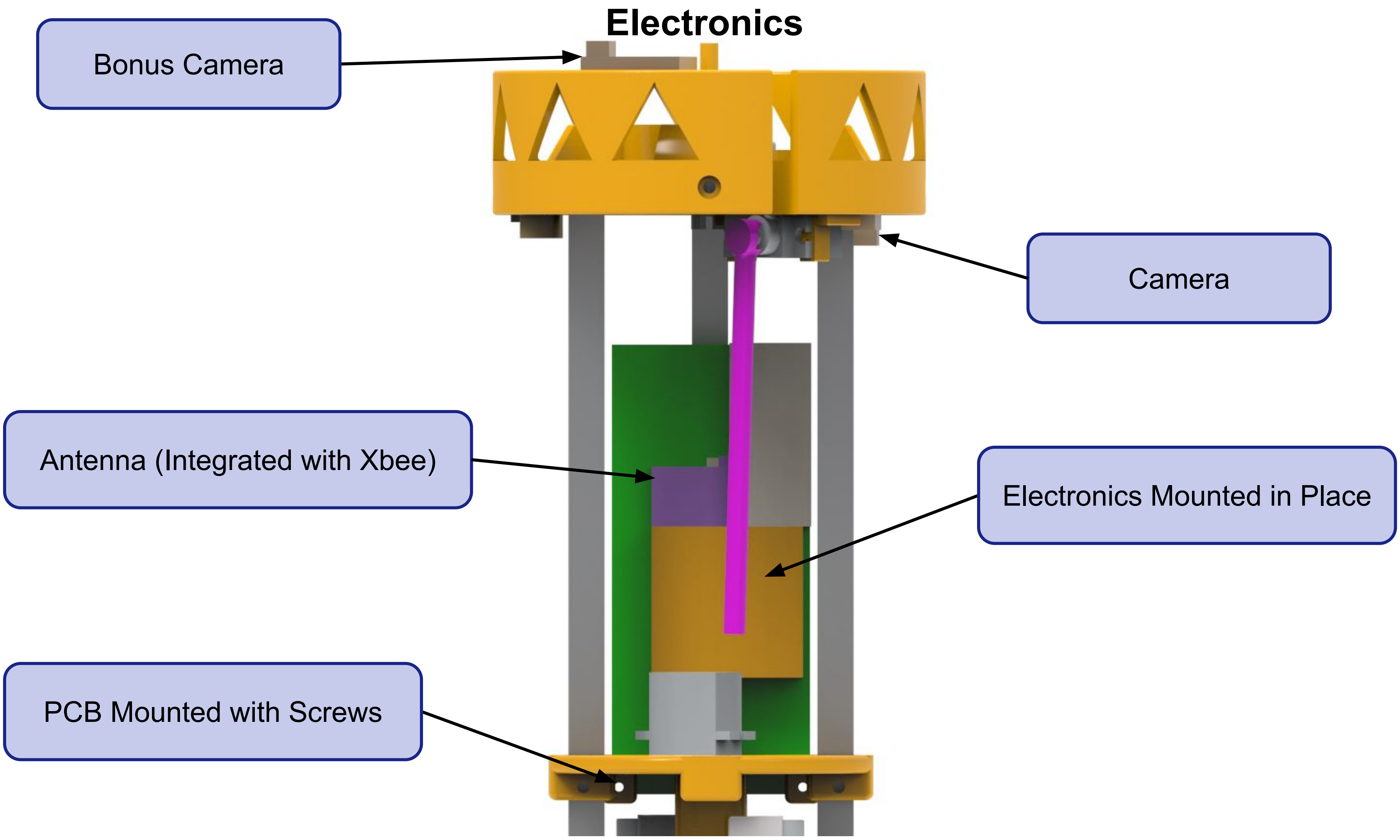
Stowed Configuration



Payload

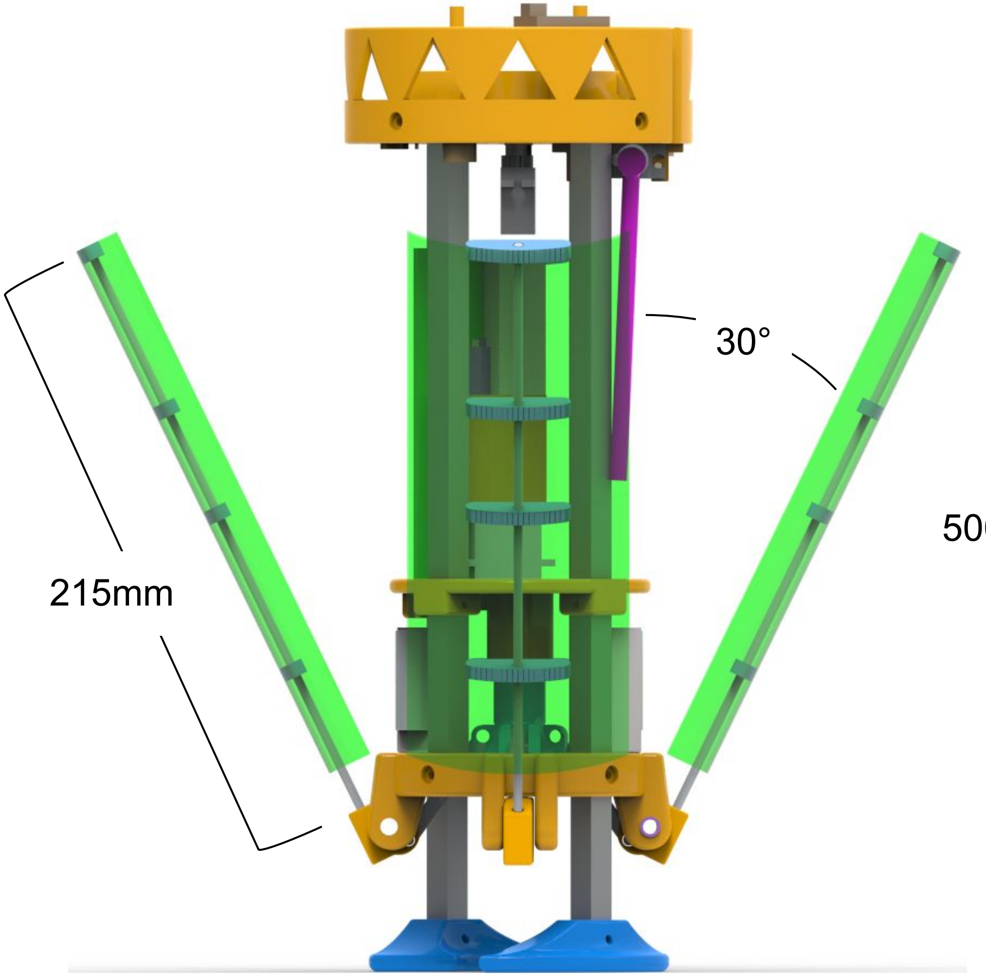

Flag Mechanism
Aerobrake / Self-Uprighting System Mechanism
Release Mechanism
Servos
Battery Placement
120 mm
66 mm
210 mm
33 mm
324mm

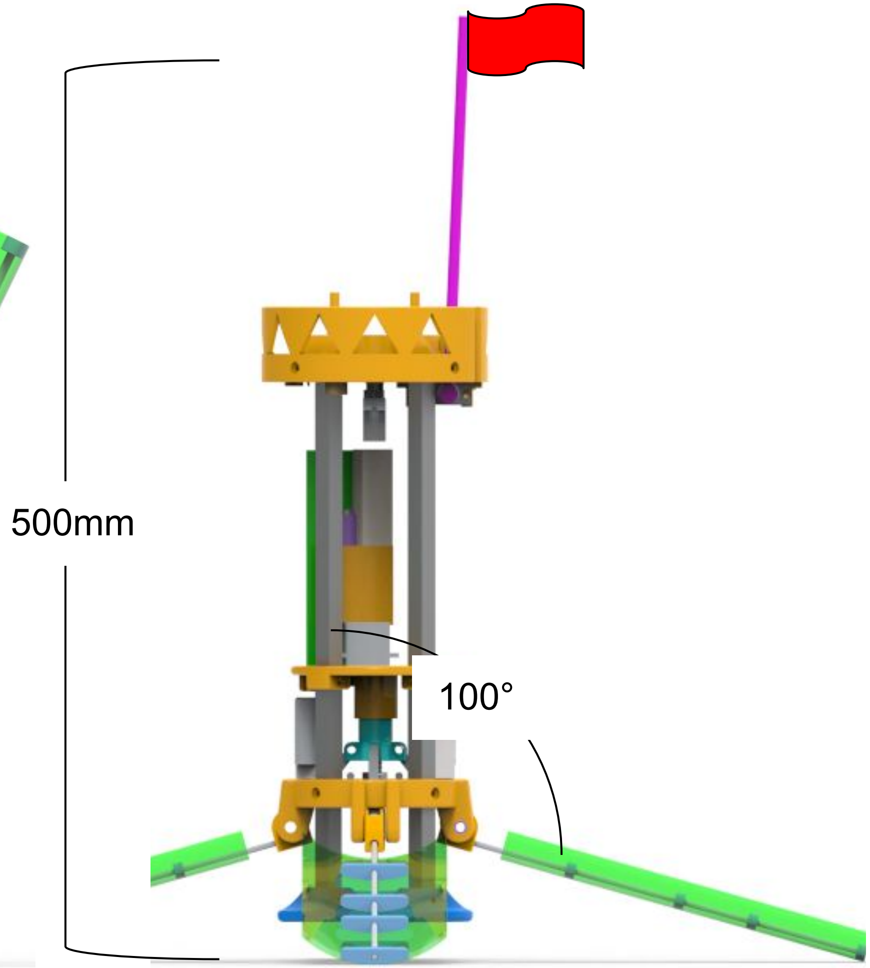
CanSat Physical Layout (3/7)



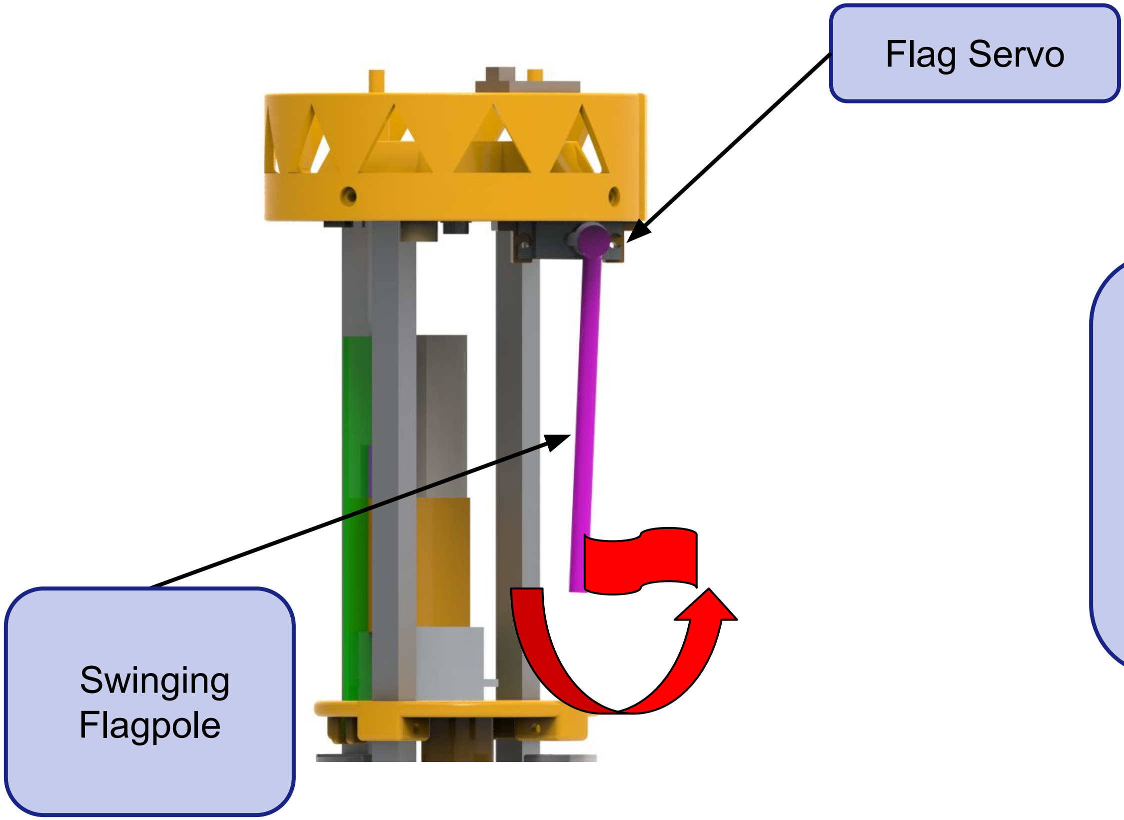
CanSat Physical Layout (4/7)

Deployed Configuration	Landed Configuration



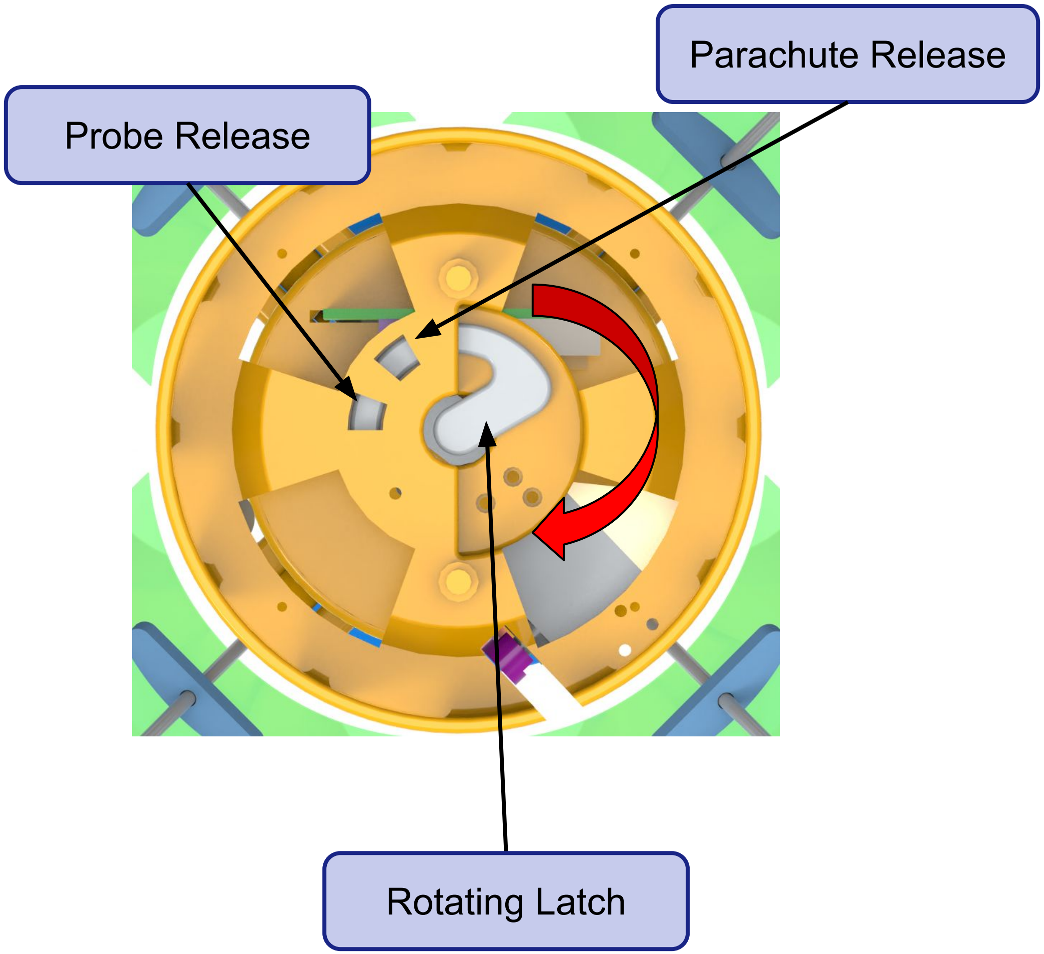


Flag Mechanism



The servo is directly connected to a 3D printed rod that is then rotated 180 degrees to an upright position after landing.

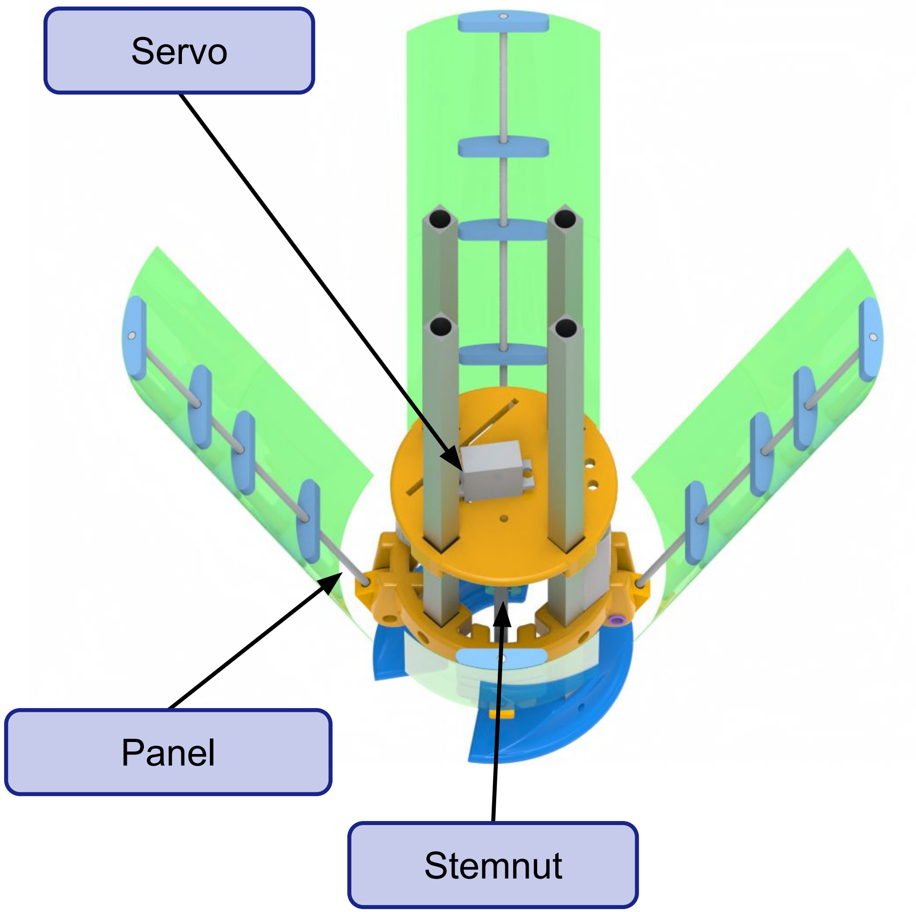
Release Mechanism



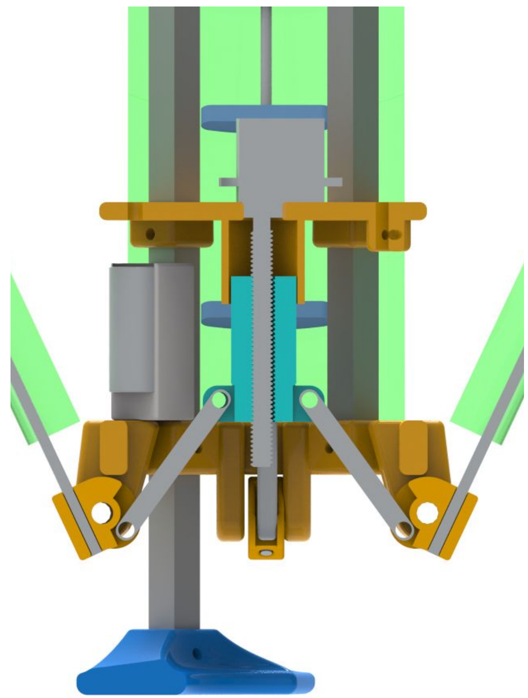
As the latch rotates, the probe and parachute releases are activated. The probe release frees the probe from the container. The parachute release frees the lid, which releases the 2nd parachute.

Aerobrake / Uprighting Mechanism

ISO VIEW

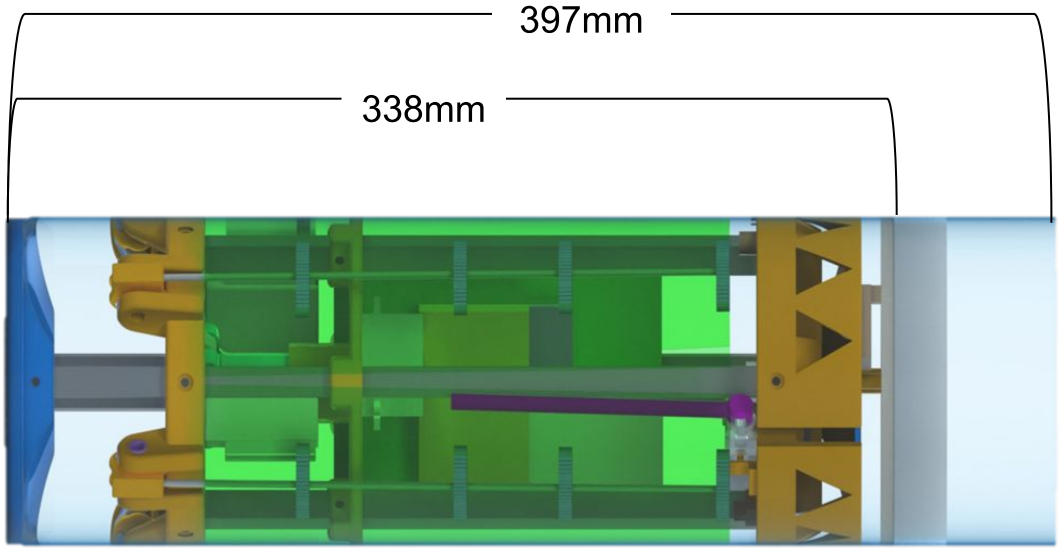


CROSS-SECTION VIEW

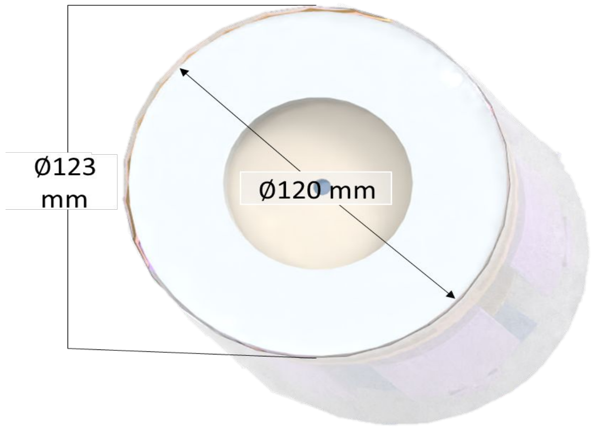


The servo rotates a threaded rod inside a stemnut, pushing up/down on the panel protrusion and causing it to fold/deploy.

Launch Vehicle Compatibility (1/2)

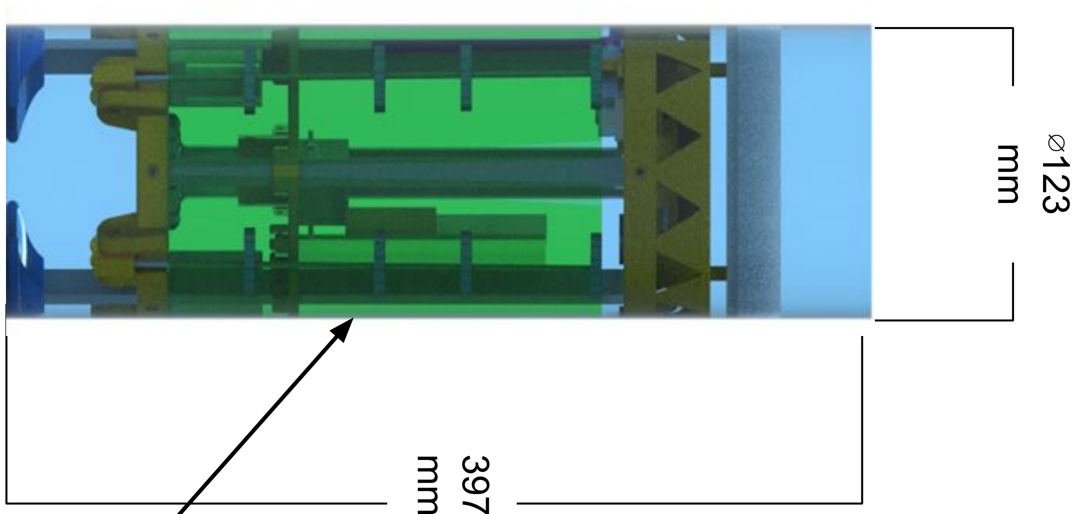


The design's length has a clearance of 37 mm (not including the container parachute) and its diameter has a clearance of 3 mm within its container.

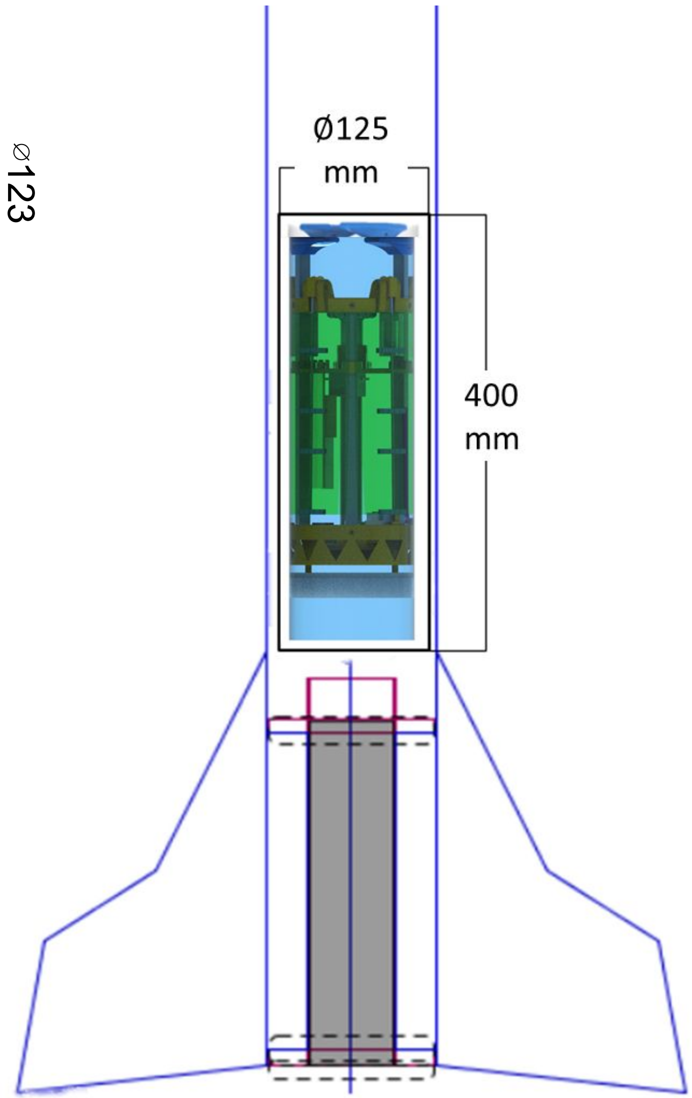


	Payload	Container	Clearance
Diameter	120 mm	123mm	3 mm
Height	360 mm	397mm	59 mm

Launch Vehicle Compatibility (2/2)



No Sharp Protrusions



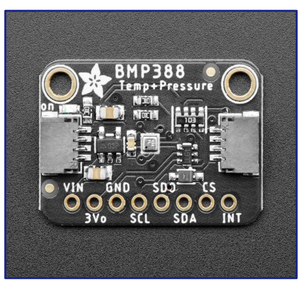
	Vehicle dimensions	CanSat container	Clearance
Height	400 mm	397 mm	3 mm
Diameter	125 mm	123 mm	2 mm

Sensor Subsystem Design

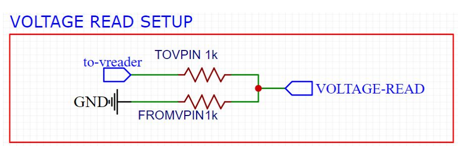
Brooks Calhoun

Sensor Subsystem Overview

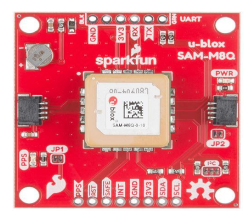
Component	Model/Type	Intended Purpose
Air Pressure	BMP388	Measure the Pressure of the Payload
Air Temperature	BMP388	Measure the Temperature of the Payload
Battery Voltage	ADC Pin	Measure the Battery Voltage of the Payload
Tilt	BNO055	Measure the Orientation and Tilt of the Payload
GPS	SAM-M8Q	Track the Location of the Payload
Camera	Mini Spy Camera	Record Video of Payload
Bonus Camera	Mini Spy Camera	Camera for Bonus Objective



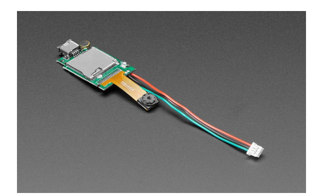
Source: Adafruit



Source: Adafruit

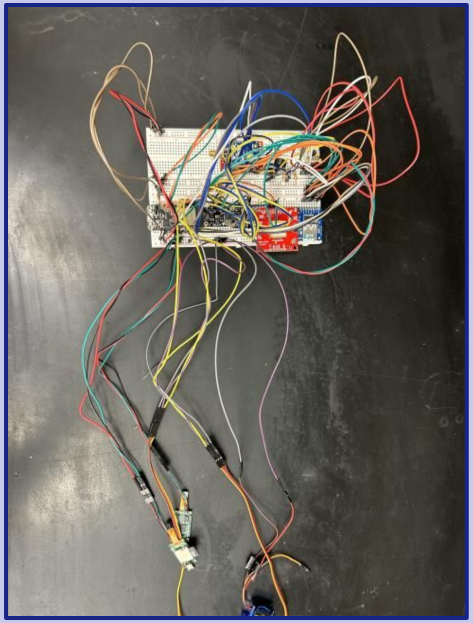


Source: Sparkfun

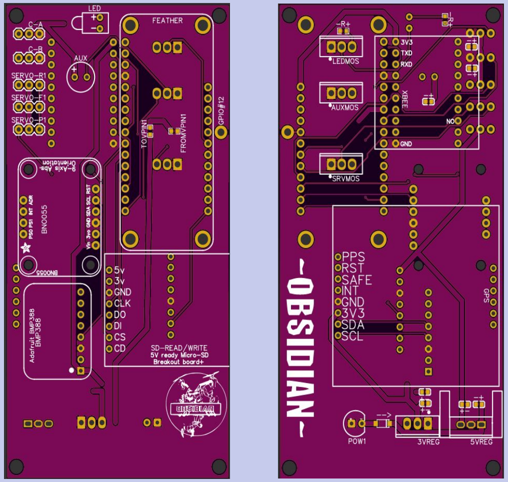

Source: Sparkfun

Sensor Changes Since PDR

Sensor Changes
No changes made



Full Breadboard



Outside/Front Inside/Back

PCB Prototype V4 Edit 3

Payload Air Pressure Sensor Summary

Model	Interface	Voltage (V)	Max Current (mA)	Relative Accuracy (Pa)	Resolution (m)	Size (mm)	Weight (g)	Cost
BMP388	I²C	3.3	0.8	8	0.66	21.6 x 16.6 x 3.0	2.0	$9.95

BMP388 Data Processing

Using "Adafruit_BMP3XX.h" library

BMP library uses predefined sea level pressure and measured pressure to calculate altitude

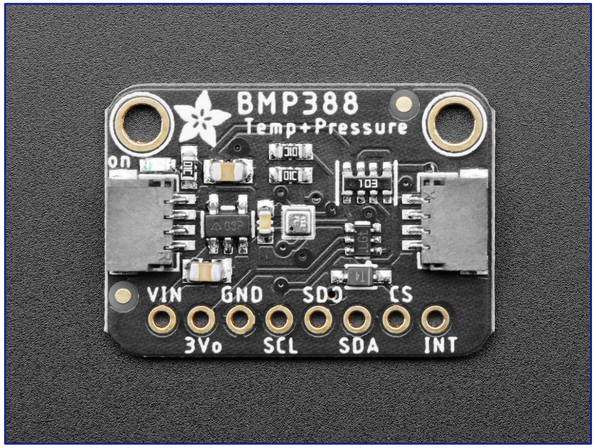
Uses I2C communication

Initial altitude read 5 times, and the average becomes the offset altitude.

calc_alt = read_alt - alt_offset;

pressure = bmp.pressure/1000.0;

Altitude and pressure updates each time telemetry is sent



Source: Adafruit

Accuracy
$\mp$ 8 Pa / $\mp$ 0.5 m

Data Format
Pressure: x.x kPa
Altitude: xxx.x m

Payload Air Temperature Sensor Summary

Model	Interface	Voltage (V)	Max Current (mA)	Temperature Range (°C)	Resolution (°C)	Size (mm)	Weight (g)	Cost
BMP388	I²C	3.3	0.8	-40 - 85	0.050	21.6 x 16.6 x 3.0	2.0	$9.95

BMP388 Data Processing

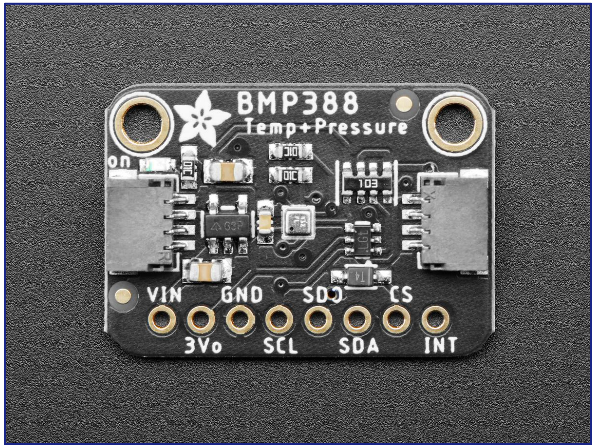
Using "Adafruit_BMP3XX.h" library

BMP library uses predefined sea level pressure

Uses I2C communication

temperature = bmp.temperature;

Temperature is updated each time telemetry is sent



Source: Adafruit

Accuracy
∓ 0.5 °C

Data Format
Temperature: x.x °C

Payload GPS Sensor Summary

Model	Interface	Voltage (V)	Max Current (mA)	Position Accuracy	Velocity Accuracy	Antenna	Size (mm)	Weight (g)	Cost
SAM-M8Q	UART, I²C	3.3	67	2.5 m	0.05 m/s	Internal	42.0 x 42.0 x 10.0	12.0	$42.95

SAM-M8Q Data Processing

Using “SparkFun_u-blox_GNSS_Arduino_Library.h” library
Using “u-blox_config_keys.h” and “u-blox_structs.h” libraries

SFE_UBLOX_GNSS myGNSS;

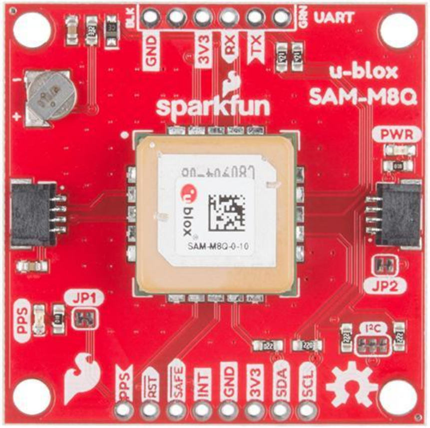
myGNSS.begin()

gps_hour = myGNSS.getHour();
gps_min = myGNSS.getMinute();
gps_sec = myGNSS.getSecond();

gps_time is the string concatenation of gps_hour, gps_min, and gps_sec.

gps_lat = myGNSS.getLatitude();
gps_long = myGNSS.getLongitude();
gps_alt = myGNSS.getAltitude();
gps_sat = myGNSS.getSIV();

Update each time telemetry is sent



Source: Sparkfun

Accuracy
Heading: ∓ 0.3 °
Velocity: 0.05 m/s
Time Pulse: 30 ns

Data Format
GPS Time: xx:xx:xx s
GPS Latitude: xx.xxxx°
GPS Longitude: xx.xxxx°
GPS Satellites: x satellites

Payload Voltage Sensor Summary

Model	Interface	Accuracy	Size (mm)	Weight (g)	Cost
ADC Pin	ADC	± 10 mV	1.0 x 1.0	negligible	$0.10

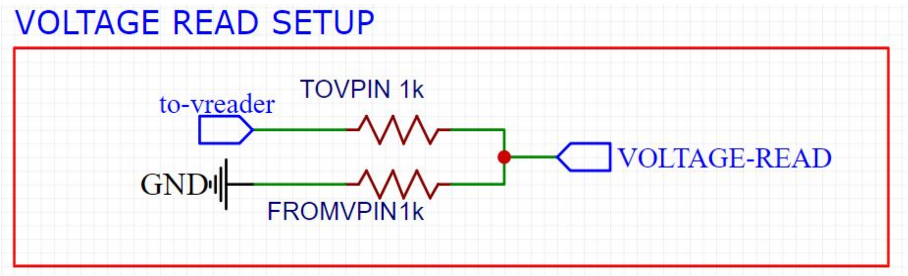
ADC Pin Data Processing

Using an on-board ADC pin we will acquire voltage data

The input will be transposed by voltage/ bitrate ~ V*5/4096

vread = analogRead(A2);

voltage = vread * (5/4096.0) * 2;



Accuracy
± 10 mV

Data Format
Voltage: x.x V

Payload Tilt Sensor Summary

Model	Interface	Voltage Input (V)	Current Consumption (mA)	Gyroscope Range	Size (mm)	Weight (g)	Cost
BNO055	I²C	3.3	12.3	±125°/s to ±2000°/s	20 x 27 x 4	2.0	$34.95

BNO055 Data Processing

Using "Adafruit_BNO055.h" library

```
Adafruit_BNO055 bno = Adafruit_BNO055(55);

sensors_event_t event;
bno.getEvent(&event);

bno.begin()

double roll = event.orientation.x;
double pitch = event.orientation.y;
double yaw = event.orientation.z;
```

Update roll, pitch, and yaw values each time telemetry is sent

Source: Adafruit

Accuracy
± 1° in all directions

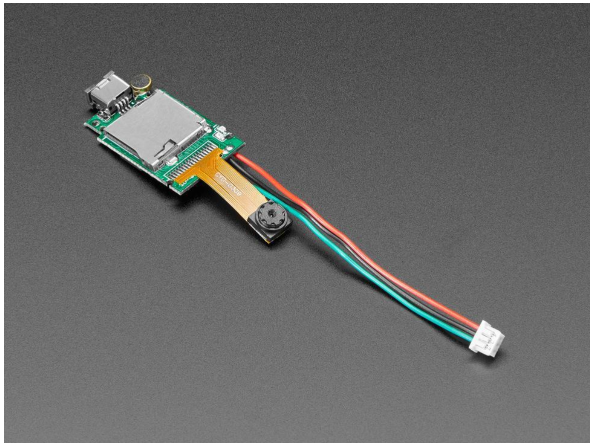
Data Format
X Orientation: xx.xx°
Y Orientation: xx.xx°

Camera Summary

Model	Interface	Voltage (V)	Operating Current (mA)	Resolution (Pixels)	Size (mm)	Weight (g)	Cost
Mini Spy Camera	PWM/GPIO	5.0	110	640 x 480	28.5 x 17 x 4.2	2.8	$12.50

Camera
Video Format: AVI
Video Resolution: 640 x 480
- Video in color

Integrated MicroSD Card
- MicroSD Maximum Support: 32 G



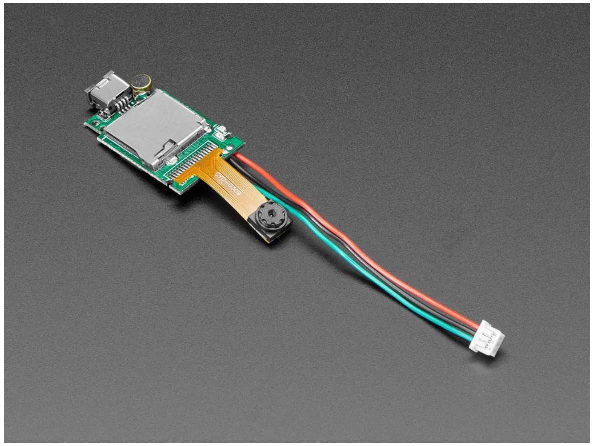
Source: Adafruit

Bonus Camera Summary

Model	Interface	Voltage (V)	Operating Current (mA)	Resolution (Pixels)	Size (mm)	Weight (g)	Cost
Mini Spy Camera	PWM/GPIO	5.0	110	640 x 480	28.5 x 17 x 4.2	2.8	$12.50

Bonus Camera
Video Format: AVI
Video Resolution: 640 x 480
- Video in color

Integrated MicroSD Card
- MicroSD Maximum Support: 32 G



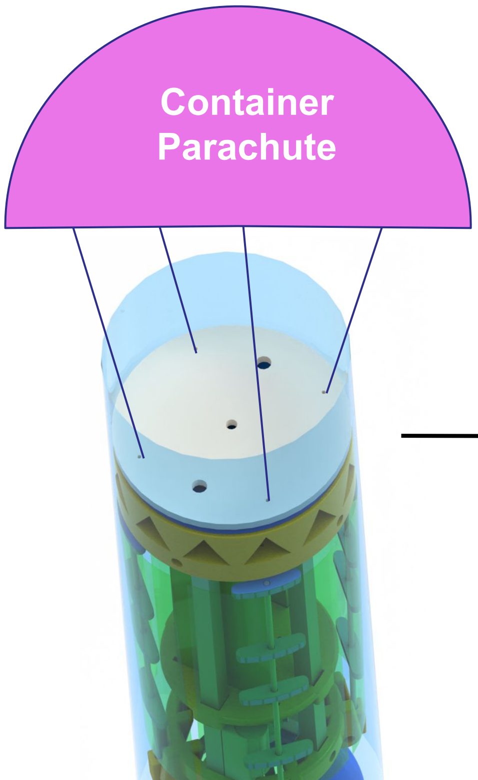
Source: Adafruit

Descent Control Design

Preston Beesley

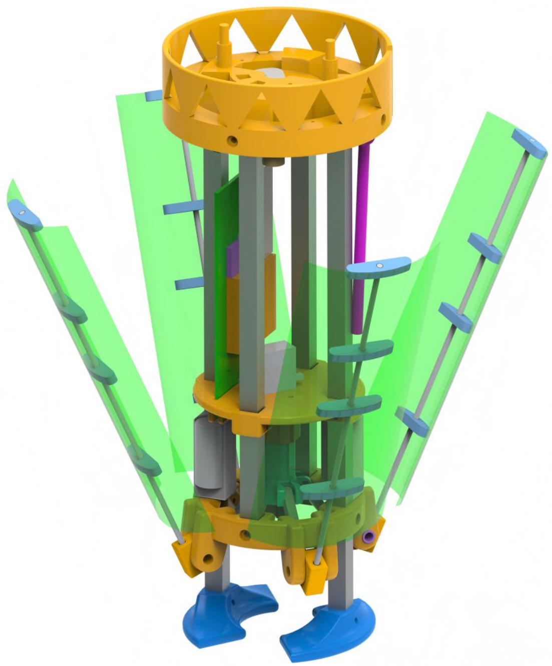
Descent Control Overview

700 m → 500 m



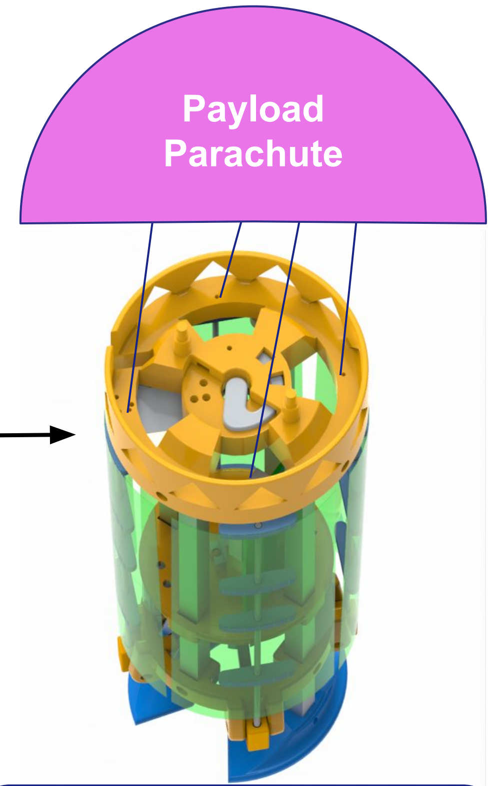
Parachute will deploy to slow CanSat down to 15 m/s

500 m → 200 m



Aerobrake will open panels to 30 degrees to slow descent rate to 20 m/s. Orientation will be passively controlled.

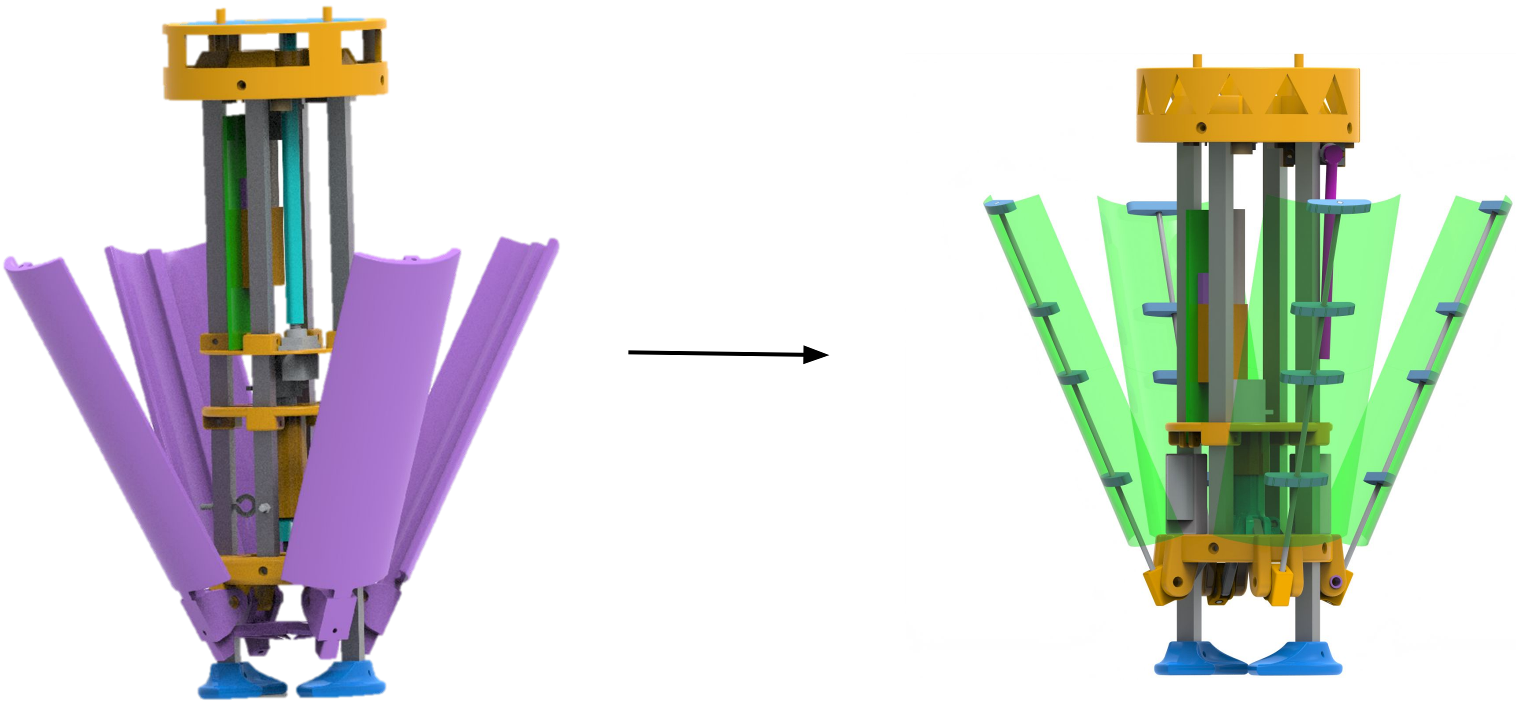
200 m → 0 m



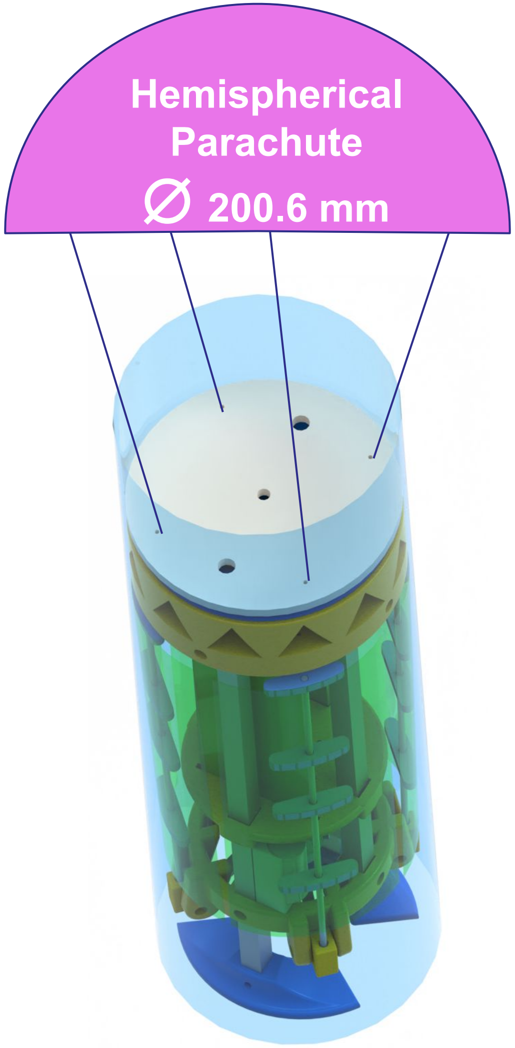
Payload will use a second parachute to slow the descent rate to 5m/s

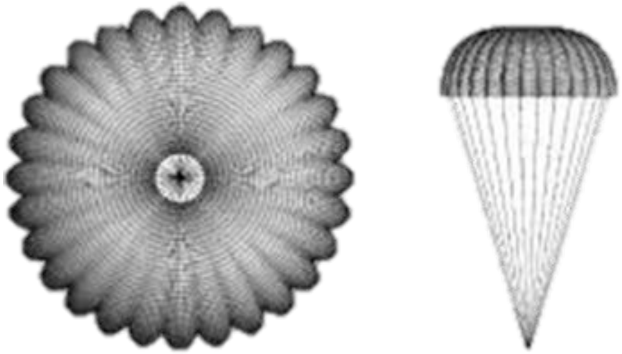
Descent Control Changes Since PDR

PDR	CDR	Rationale
3D Printed Panels	Plastic Bottle cut out for Aerobrake	Bottle cutouts are 70 grams lighter than previous configuration and are quicker to manufacture.



Container Descent Control Hardware Summary



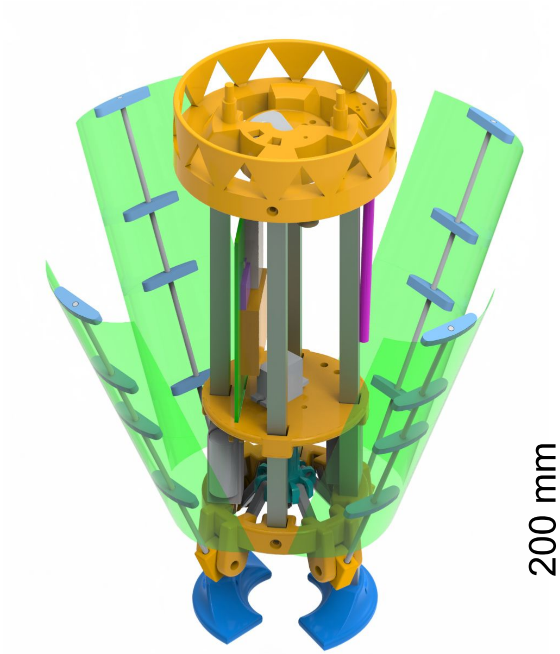


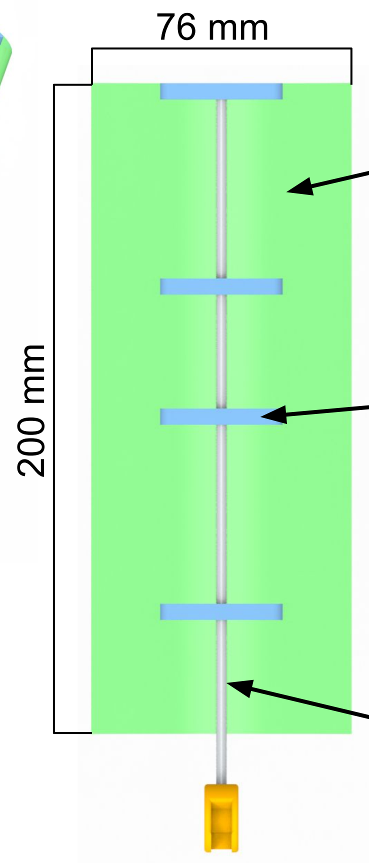
Source: Fan, Yuxin & Xia, Jian. (2014).

The container parachute will have a hemispherical shape and deploy when the CanSat is ejected from the rocket.
This parachute will slow the CanSat down to 15 m/s.
It will be attached to the container with paracord.

Container will be painted neon orange and parachute will be neon pink for high visibility.

Payload Aerobraking Descent Control Hardware Summary





Plastic Bottle Cutouts

3D printed PETG support.

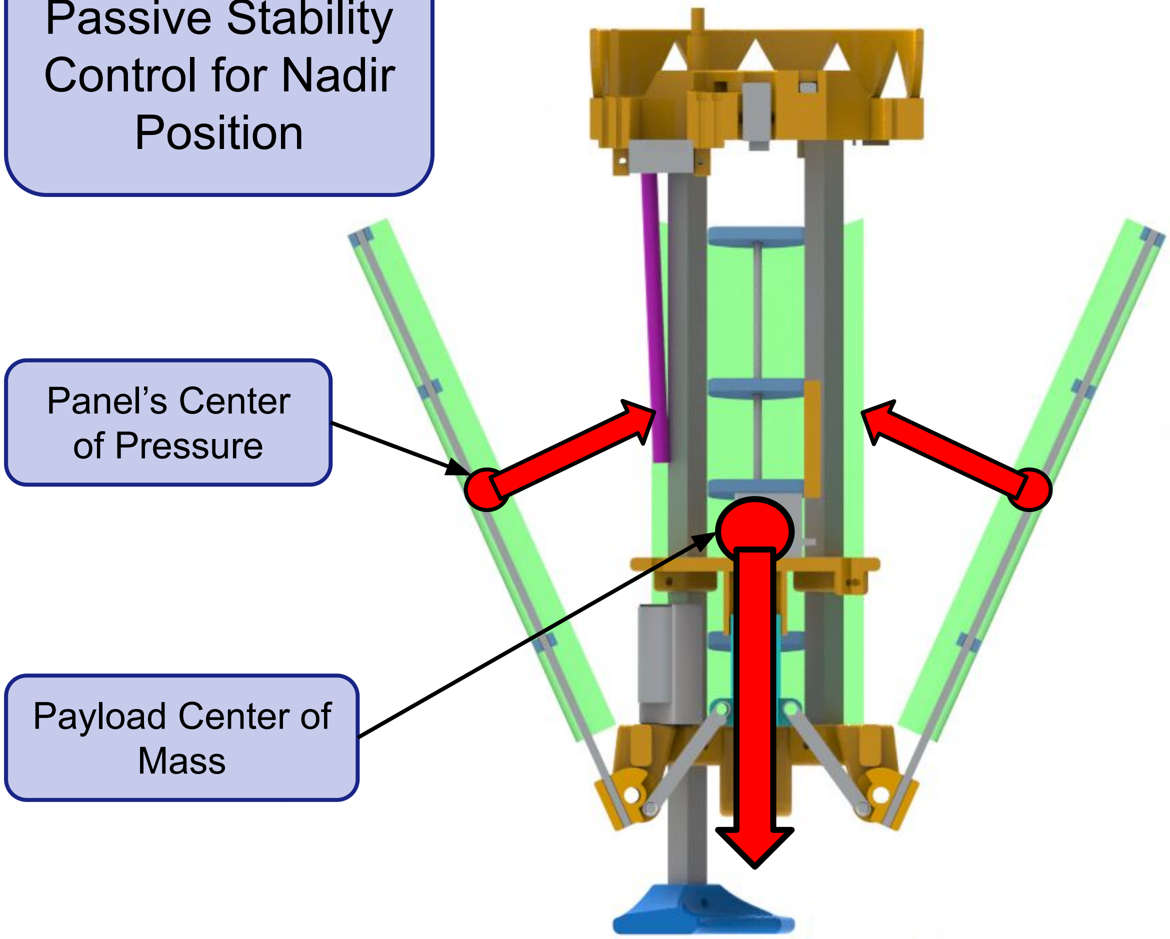
3mm Carbon Fiber Rod

The aerobrake panels will open to 30 degrees from vertical and create drag which will slow down the payload. The orientation will be passively controlled since the center of mass will be below the center of pressure.

The panels will be clear and uncolored.

Payload Descent Stability Control Design

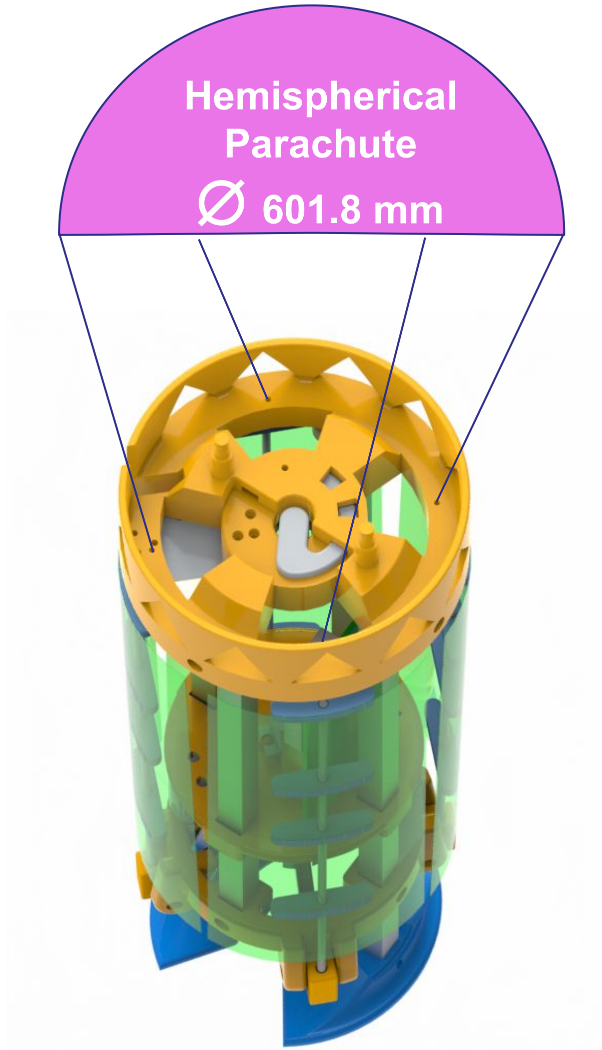
Passive Stability Control for Nadir Position

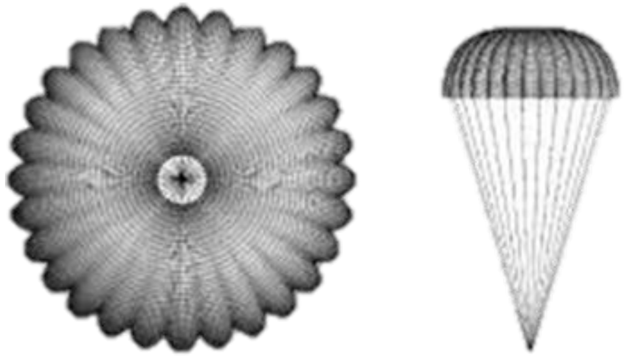


The orientation will be passively controlled since the center of mass will be below the center of pressure.

The Main source of drag will be the aerobrake panels. The center of mass of the payload will be below the centers of the panels. Thus, the drag force will keep the the payload pointing nadir and prevent tumbling.

Payload Parachute Descent Control Hardware Summary





Source: Fan, Yuxin & Xia, Jian. (2014).

The payload parachute will have a hemispherical shape and deploy when the payload reaches an altitude of 200 m.
This parachute will slow the payload down to 5 m/s.
It will be attached to the payload with paracord.

The Parachute will be neon pink for high visibility.

Descent Rate Estimates (1/4)

Container Parachute Descent Rate (700m → 500m):

Magnitude	Symbol	Value
Mass	m	0.7 kg
Parachute Drag Coefficient	C_D	1.42
Cross Sectional Area of Parachute	S	0.031605 m^2
Air Density	ρ	1.225 kg/m^3
Descent Velocity	v	15.806 m/s

$$F_D = W = 9.81m$$

$$F_D = \frac{1}{2} C_D \rho v^2 S = 9.81m$$

$$v = \sqrt{\frac{2(9.81)m}{C_D \rho S}}$$

$$\boxed{v = 15.806 \text{ m/s}}$$

Descent Rate Estimates (2/4)

Payload Aerobraking Descent Rate (500m → 200m):

Magnitude	Symbol	Value
Mass	m	0.61 kg
Payload with Aerobrake Drag Coefficient	C_D	0.59
Cross Sectional Area of Payload with Aerobrake	S	0.041710 m^2
Air Density	ρ	1.225 kg/m^3
Descent Velocity	v	19.925 m/s

$$F_D = W = 9.81m$$

$$F_D = \frac{1}{2} C_D \rho v^2 S = 9.81m$$

$$v = \sqrt{\frac{2(9.81)m}{C_D \rho S}}$$

$$\boxed{v = 19.925 \text{ m/s}}$$

Descent Rate Estimates (3/4)

Payload Parachute Descent Rate (200m → 0m):

Magnitude	Symbol	Value
Mass	m	0.61 kg
Parachute Drag Coefficient	C_D	1.42
Cross Sectional Area of Parachute	S	0.284442 m^2
Air Density	ρ	1.225 kg/m^3
Descent Velocity	v	4.918 m/s

$$F_D = W = 9.81m$$

$$F_D = \frac{1}{2} C_D \rho v^2 S = 9.81m$$

$$v = \sqrt{\frac{2(9.81)m}{C_D \rho S}}$$

$$\boxed{v = 4.918 \text{ m/s}}$$

Descent Rate Estimates Summary

Summary		
Component	Desired Velocity (m/s)	Area (m^2)
Container Parachute	15	0.0316
Payload Aerobrake	20	0.0505
Payload Parachute	5	0.2850

With these areas we can solve for the radii for both parachutes and the total area required on the surface per panel.

Container Parachute

$$r = \sqrt{\frac{A_p}{\pi}} = \sqrt{\frac{0.03162}{\pi}} = 100.3\ mm$$

Payload Parachute

$$r = \sqrt{\frac{A_p}{\pi}} = \sqrt{\frac{0.2846}{\pi}} = 300.9\ mm$$

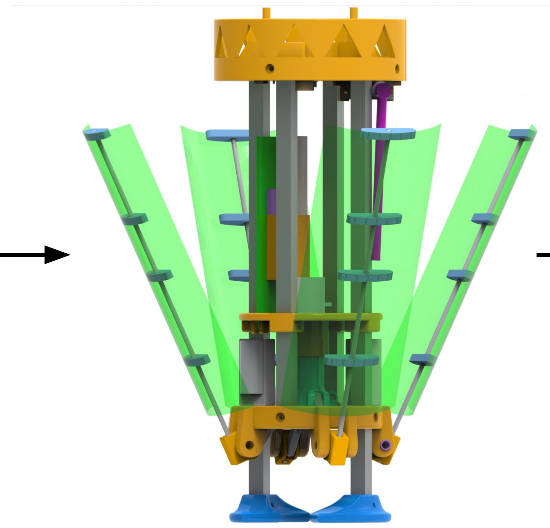
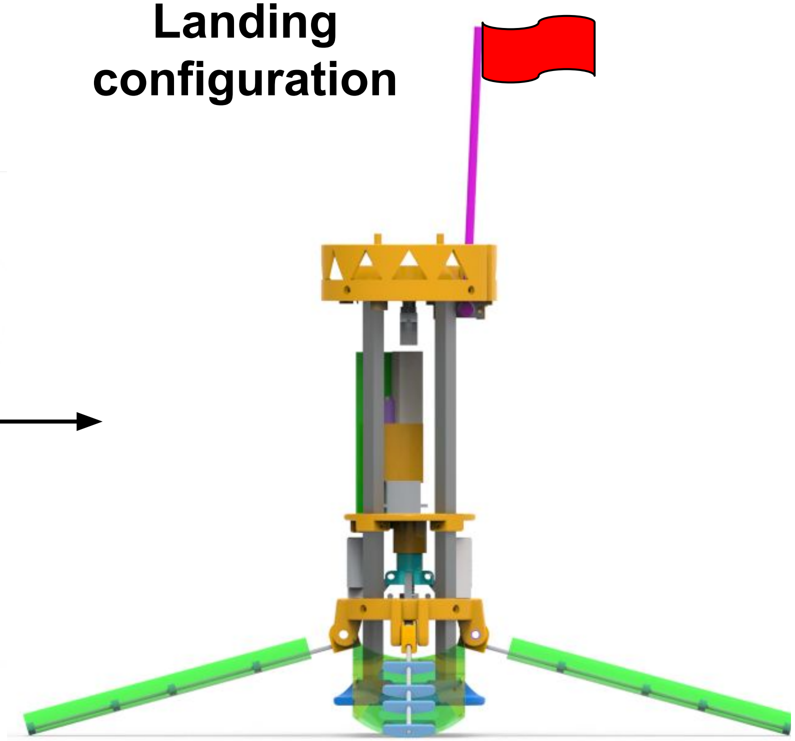
Area of Aerobrake per Panel

$$Area\ per\ Panel = \frac{Total\ Area}{Number\ of\ Panels} = \frac{.0505}{4} = 0.0126\ m^2$$

Mechanical Subsystem Design

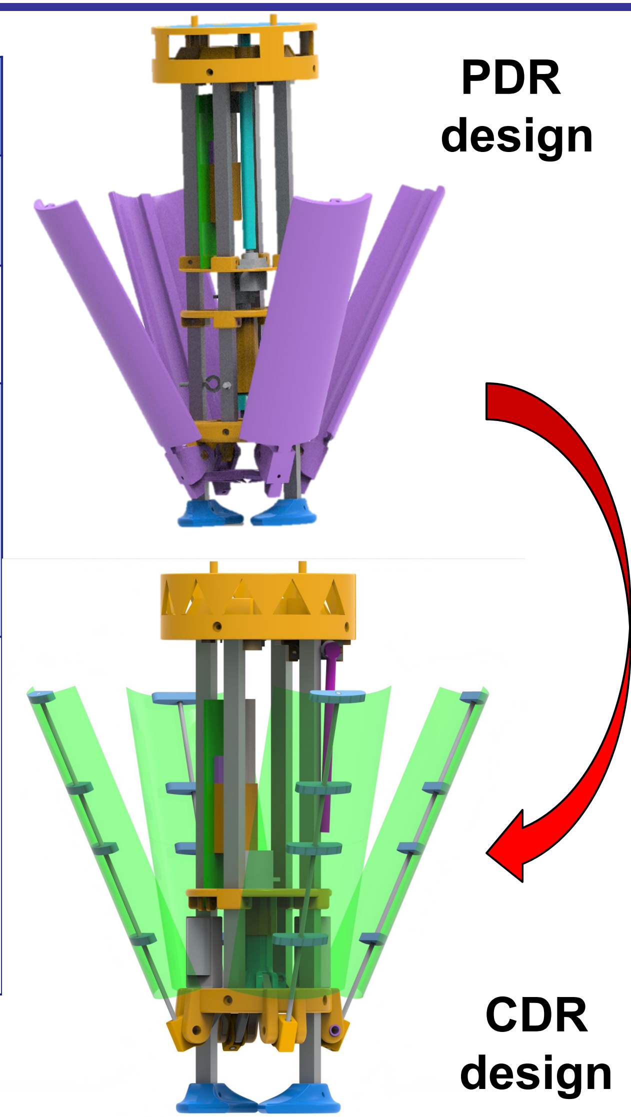
Sofia Vicente and John Kelly

Mechanical Subsystem Overview

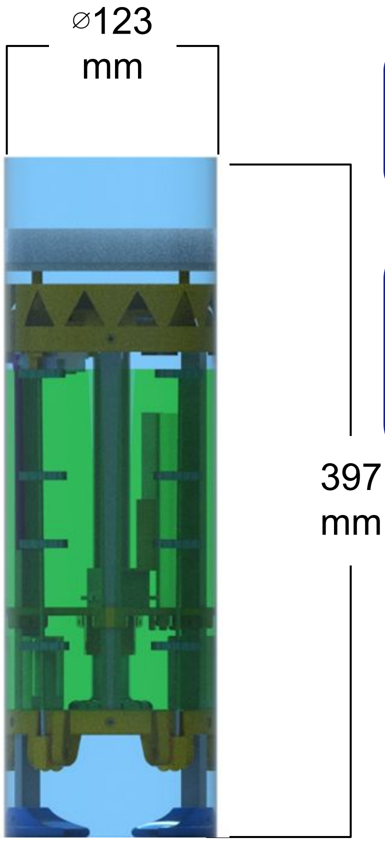
Container configuration	Deployed configuration	Landing configuration
		
After leaving the Rocket, the Parachute will deploy.	At 500m the release mechanism servo will release the container from the payload via a tied string.	After landing, the panels for the aerobrake will extend to 100 degrees to upright the CanSat. Flag servo will rotate until flag is fully extended.

Mechanical Subsystem Changes Since PDR

PDR	CDR	Rationale
2 Middle Plates	1 Middle Plate	Less weight (30 g)
3D Printed Panels	Plastic Panels	Less weight (61.2 g)
Flag Mechanism uses a stemnut and a threaded rod	Flag Mechanism consists of a servo that swings the flagpole to the upright position	• Less weight (6 g) • A more efficient and simple method.
Aerobrake/Uprighting Mechanism uses silicone rubber bands.	Aerobrake/Uprighting Mechanism has supports attached to it and to the panels.	• The silicone rubber bands could be affected by heat • Easier to build • Newer design requires less space (22 mm)

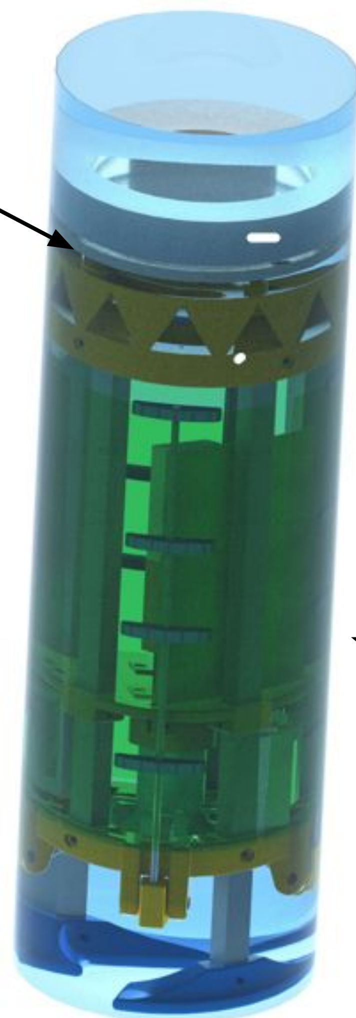


Container Mechanical Layout of Components



Plywood Holding Plate (Container Attachment Point)

The plywood holding plate will be attached to the container using superglue.



The plate will be attached to the container and the payload. To release itself, the payload will disconnect from the plywood holding plate.

Composite Fiberglass Shell

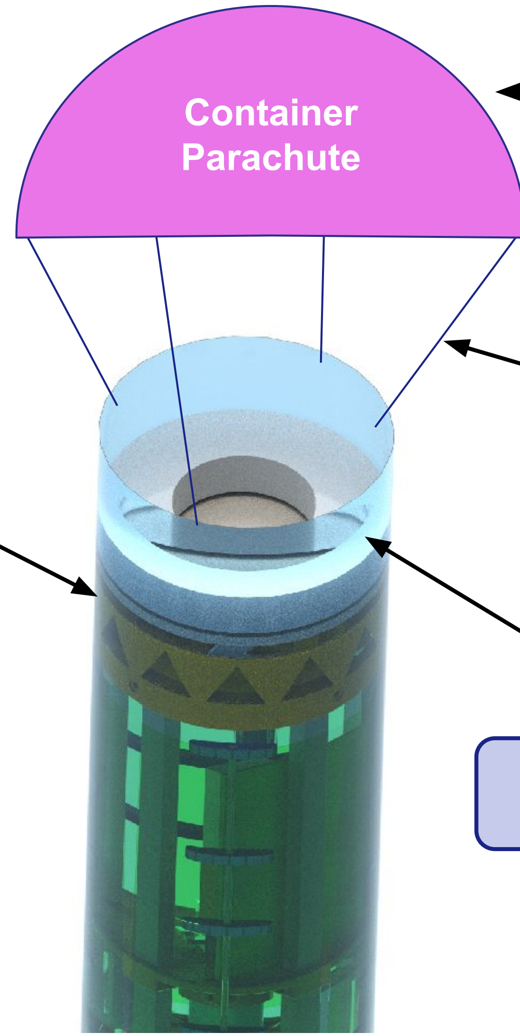
Container Parachute Attachment Mechanism

The parachute is being held in place by the container, the moment it leaves the rocket, it will deploy automatically as it will be in open air.

Neon Pink Nylon Parachute

Paracord Parachute Attachment Strings

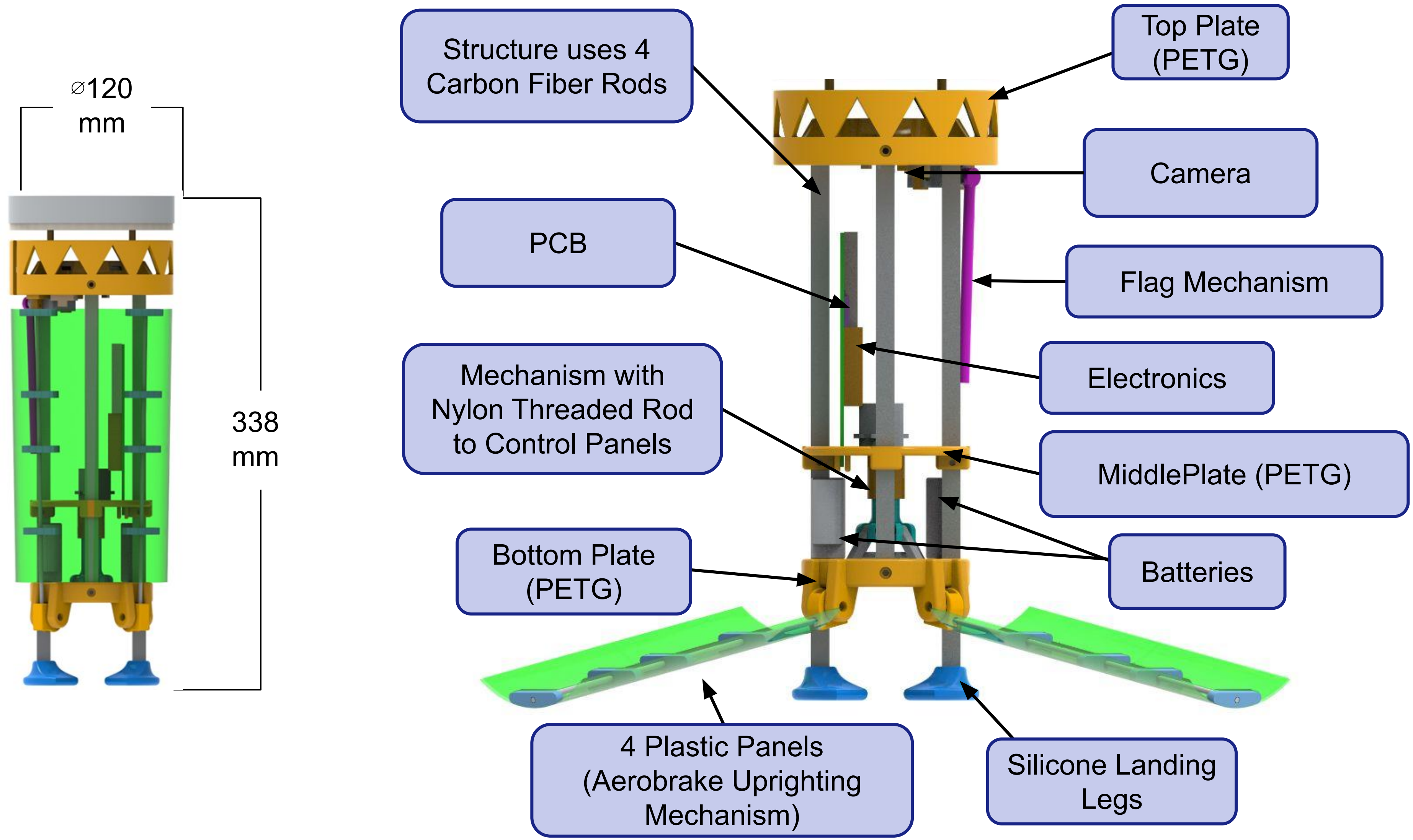
Plywood Holding Plate



Fiberglass Shell

- The container parachute will be made of nylon chord.
- The attachment string will be made of paracord.

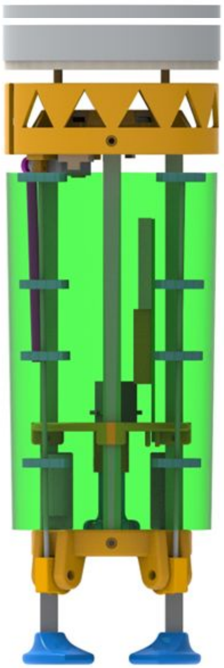
Payload Mechanical Layout of Components



Payload Pre Deployment Configuration

Payload Secured in the Container

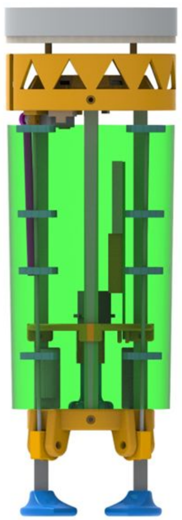
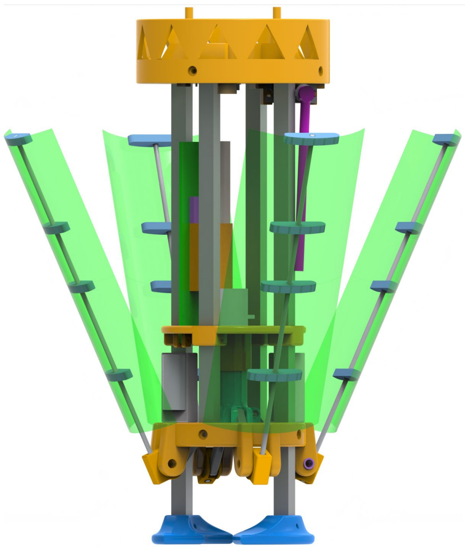
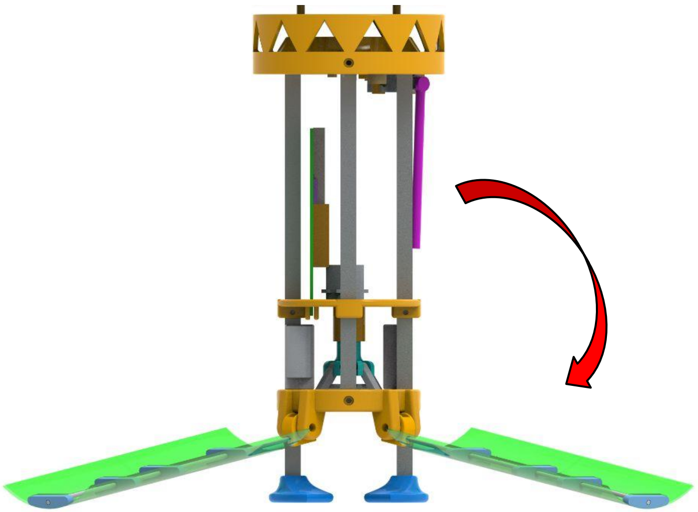
Payload in Container Configuration



The payload will be attached to the plywood holding plate attached to the container. This will keep it in place before its deployment.

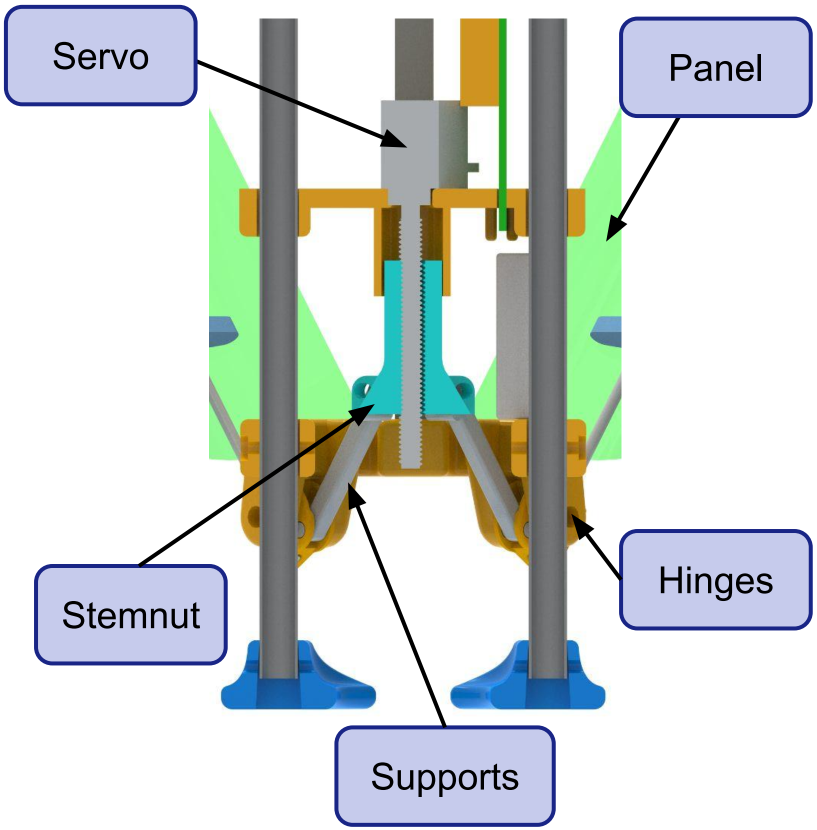
The panels will be kept in stowed configuration using its aerobrake mechanism (made up by a threaded rod and a servo).

Payload Aerobraking Deployment Configuration (1/2)

Container Configuration	Deployed Configuration	Landing Configuration
		

The panels will rotate 30º from the upright position they're in before being released from the container to achieve the aerobraking configuration. Next they will rotate to 100º with respect to their upright position to upright themselves.

Aerobrake Release Mechanism

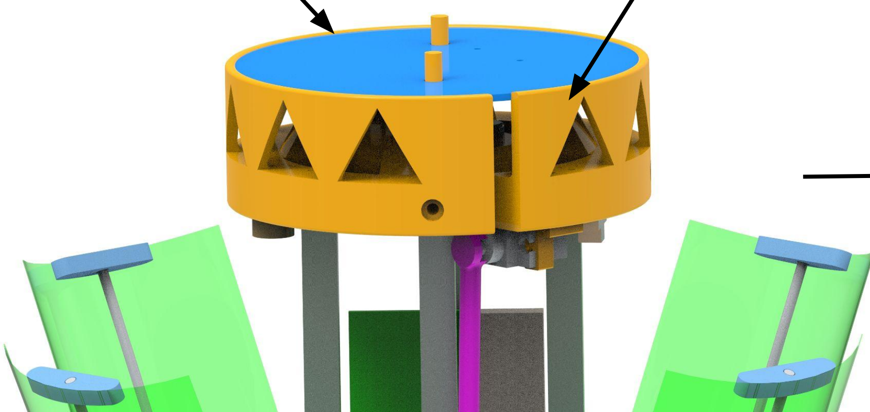


The servo rotates pushing the nut up (to deploy the panels) or down (to close the panels) thanks to the supports attached to the nut and the panels, that make the panels rotate around the hinges.

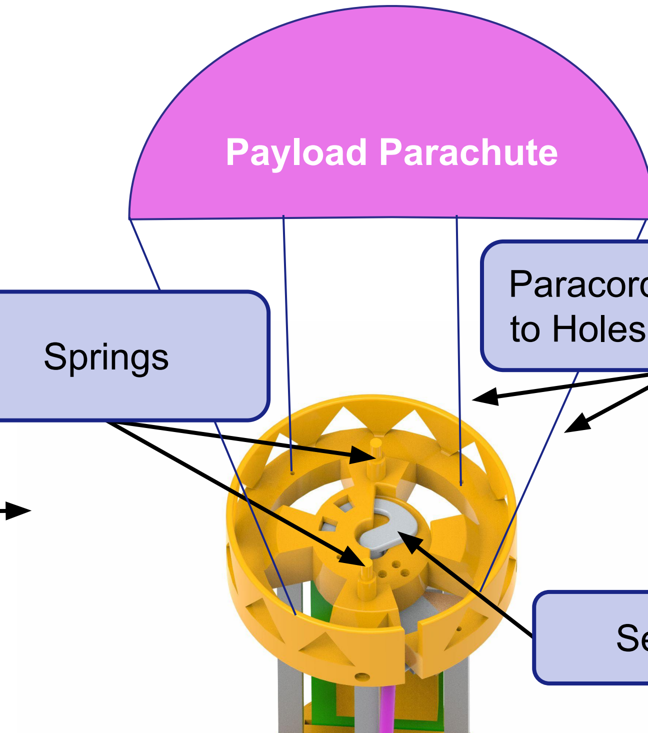
Payload Parachute Deployment Configuration (2/2)

Parachute Lid

Neon Pink Parachute Kept Under Blue Lid.



The parachute is store on the top plate and is constrained by the Parachute lid.



Springs

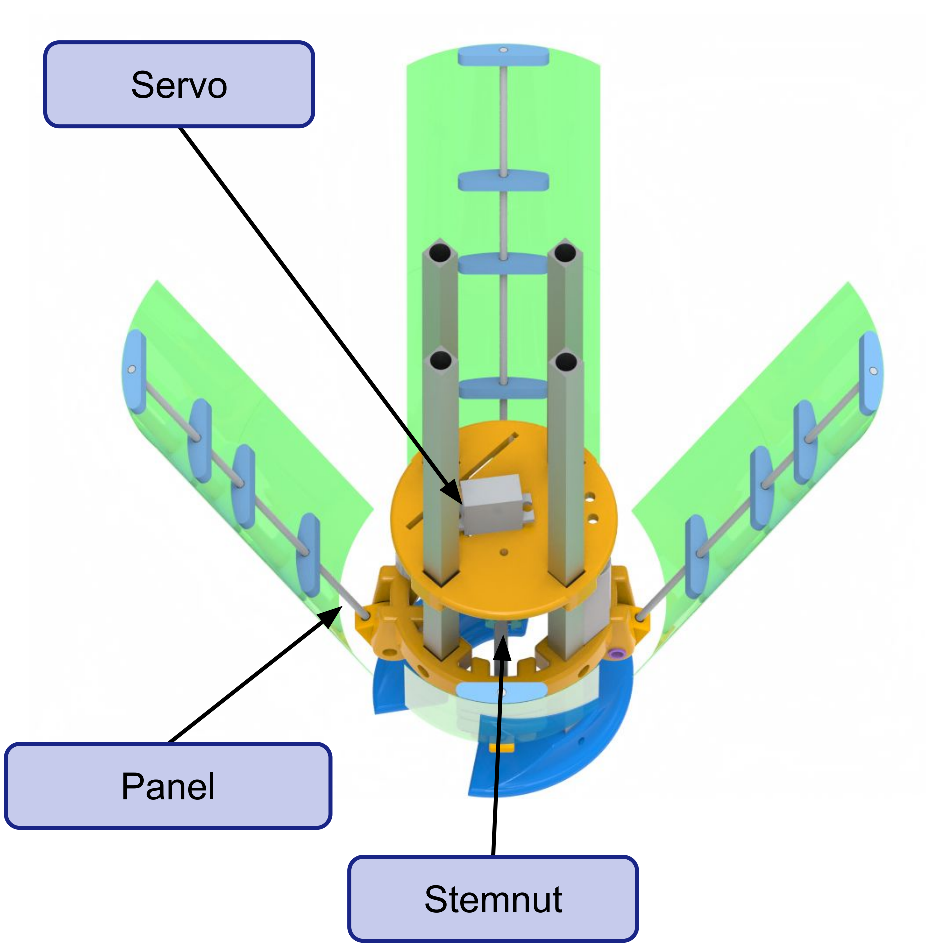
Paracord is Attached to Holes in Top Plate

Servo Head

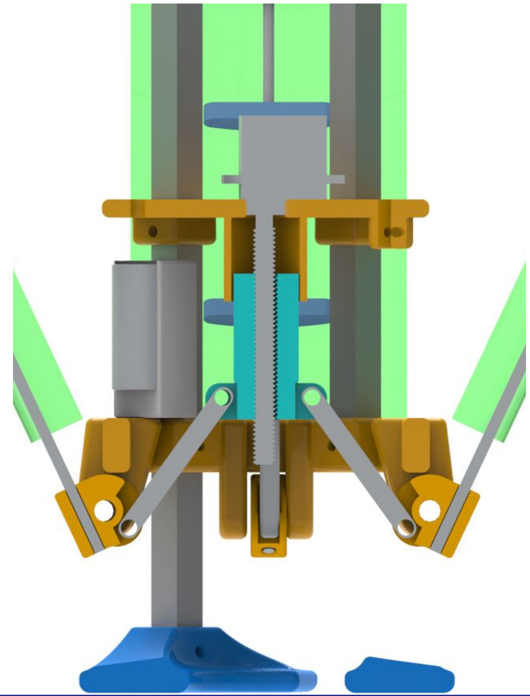
A servo will rotate and release a compressed spring, which will open the top plate and release the parachute

Payload Uprighting Description (1/2)

ISO VIEW



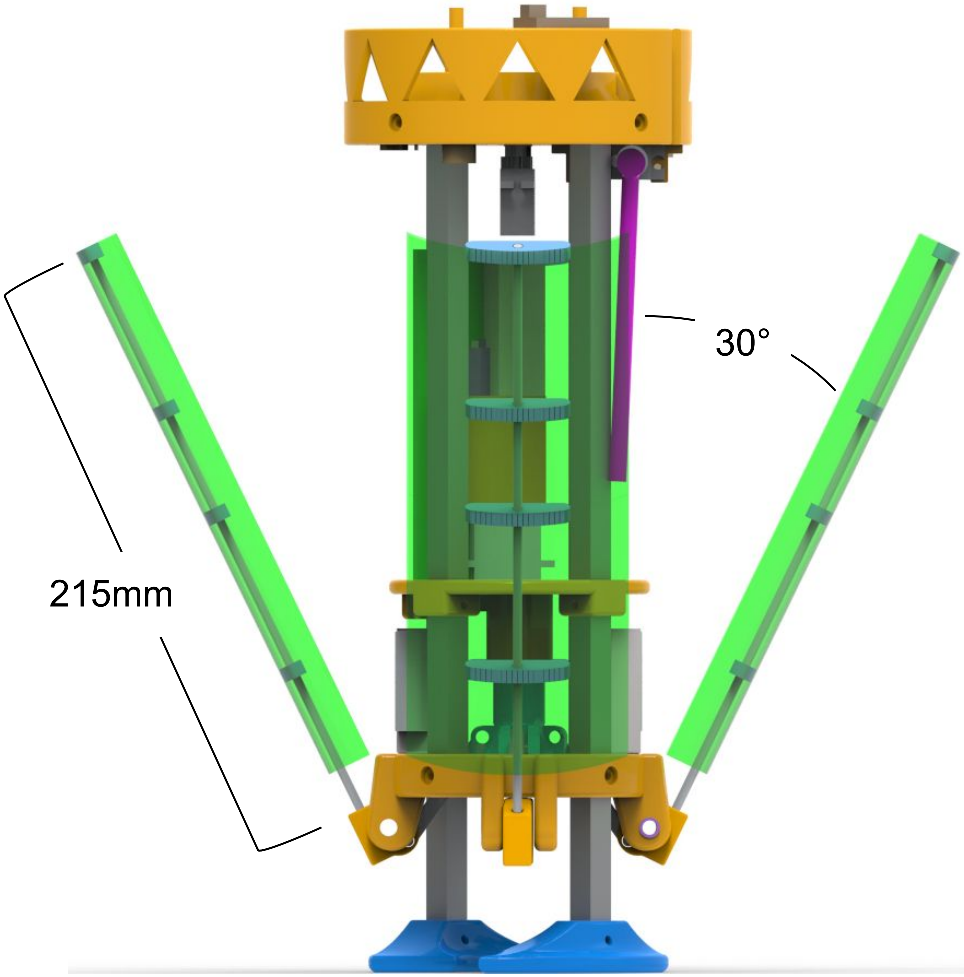
CROSS-SECTION VIEW



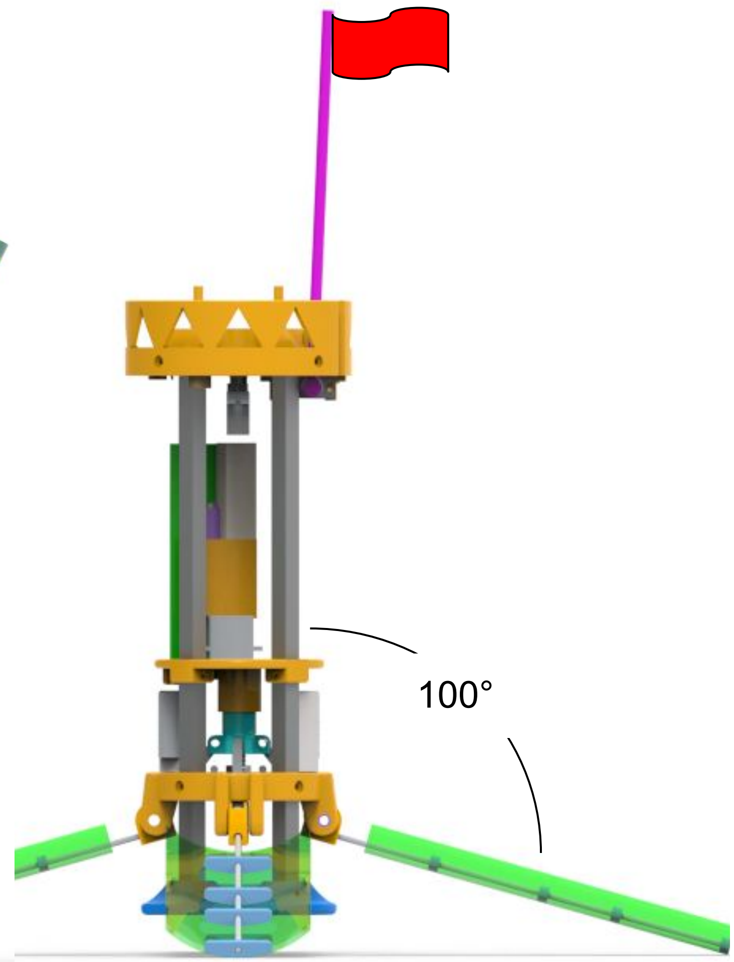
The servo rotates a threaded rod inside the Stemnut, pushing down/up on the panel protrusion, causing it to fold/deploy.

Payload Uprighting Description (2/2)

Deployed Configuration



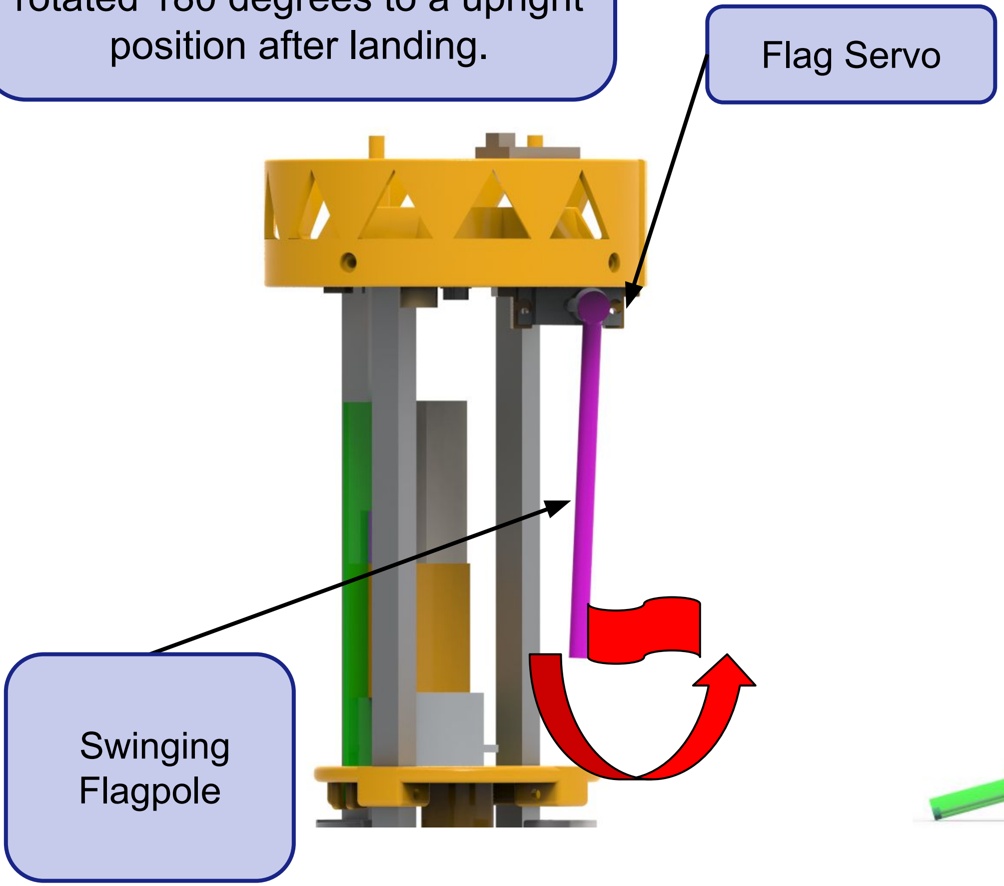
Landed Configuration

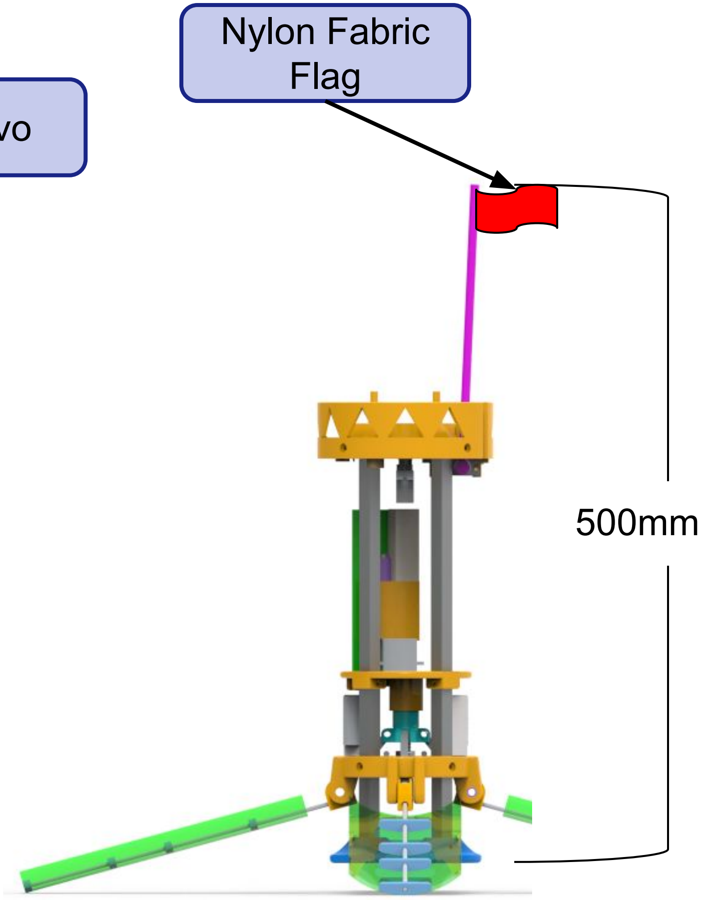


Payload Flag Deployment Configuration

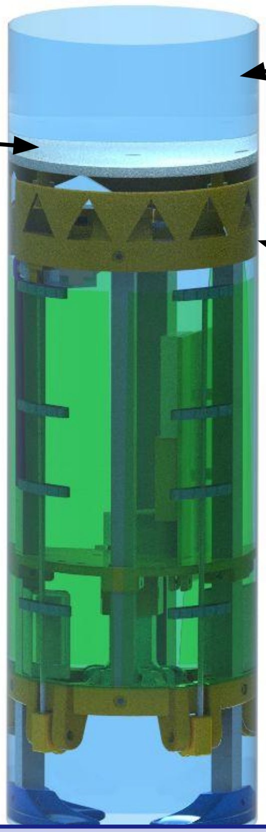
Flag Mechanism

The servo is directly connected to a 3D printed rod that is then rotated 180 degrees to a upright position after landing.





Container Payload Mount (1/2)



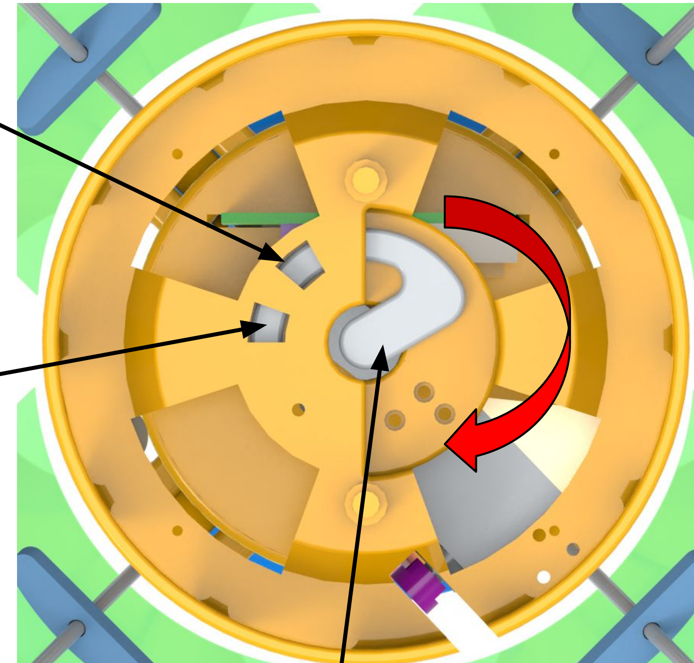
Before release, the top base plate will be attached to the Holding Plate by 50 lbs rated braided cord. The holding plate will be connected the the fiberglass shell by glue.

Container Payload Mount (2/2)

Release Latch

Parachute Release Hole

Payload Release Hole

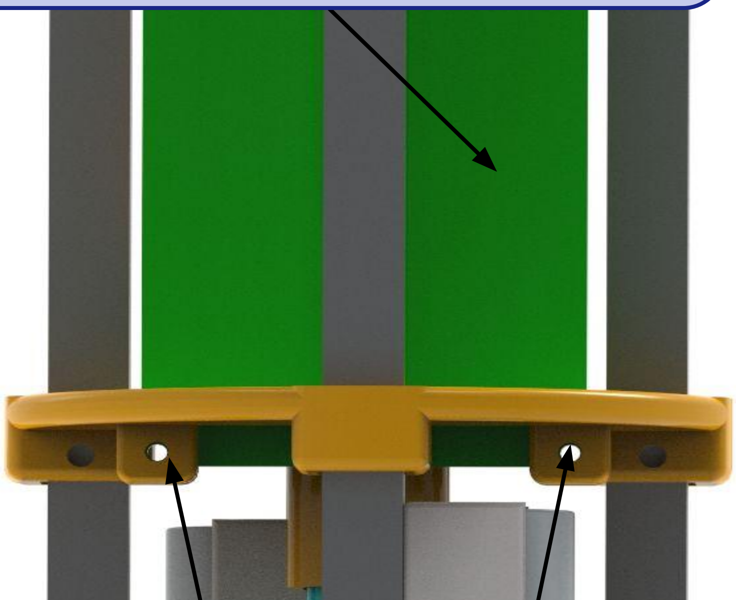


Release Latch

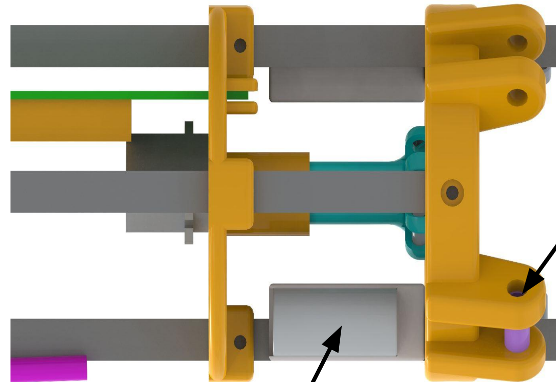
A servo will rotate which will pull braided cord rated for 50 lbs attached to the Holding Plate which releases the payload

Structure Survivability(1/2)

PCB. For electrical connections wires will be wrapped with electrical tape to secure connection, adhesives and braided cord for accessory objects like cameras and LED



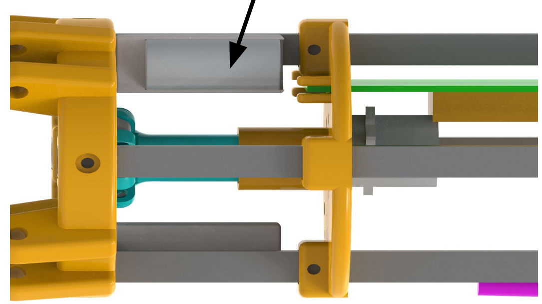
Bolt Holes for 3M bolts to Attach to the PCB.



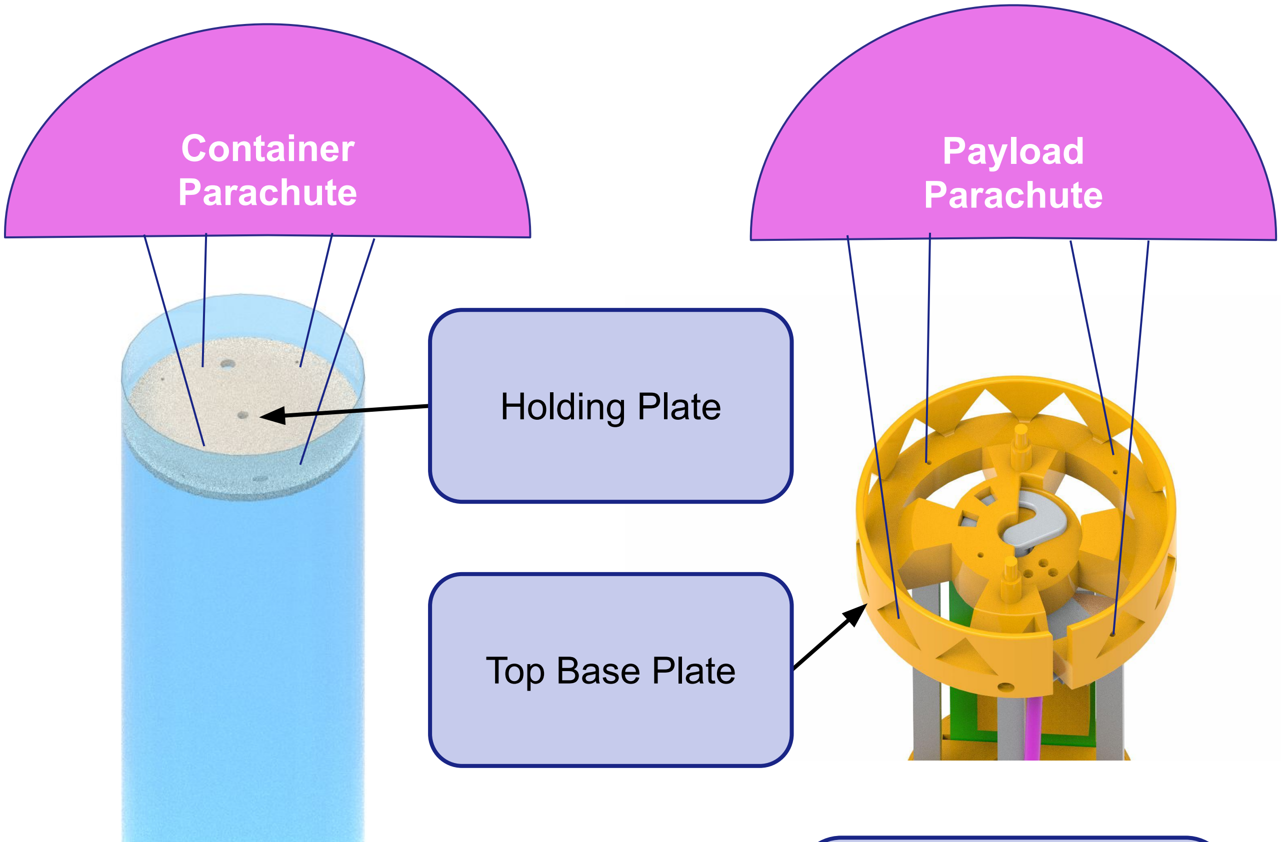
Heat Shield Panels Mounted with M4 Bolt as Axels.

Batteries Secured by Screws

The electronics will be stored inside of the Heat Shield



Structure Survivability(2/2)



The Container and payload will have to survive 15 Gs of acceleration and 30 Gs of shock. We will have tests that allow the payload to experience the acceleration and shock forces on the payload.

The container parachute will be attached to the holding plate paracord

The Payload parachute is attached to the Top Base Plate by paracord.

Mass Budget (1/3)

Payload					
Component	Source	Quantity	Mass/Unit (g)	Mass Summary (g)	Uncertainty (+/- g)
Adafruit BMP388	Measured	1	2.00	2.00	0.50
SAM-M8Q (GPS)	Measured	1	12.00	12.00	0.50
BNO055	Measured	1	2.00	2.00	0.50
XBP9B-DMST-002 (XBee)	Measured	1	13.00	13.00	0.50
Feather Huzzah 32 (Microcontroller)	Measured	1	8.00	8.00	0.50
LEDs	Measured	1	negligible	negligible	0.50
Buzzer	Measured	1	0.70	0.70	0.50
Mini Spy Camera	Measured	2	3.00	6.00	0.50
Payload Processor & Memory (SD+)	Measured	1	4.00	4.00	0.50
Onboard reader	Measured	1	negligible	negligible	0.50
Battery holder	Measured	2	4.00	8.00	0.50

Mass Budget (2/3)

Component	Source	Quantity	Mass/Unit (g)	Mass Summary (g)	Uncertainty (+/- g)
180 Degree Servo	Measured	2	13.00	26.00	0.50
Continuous Rotation Servo	Measured	1	45.00	45.00	0.50
Battery	Measured	2	16.00	32.00	0.50
PCB	Measured	1	20.00	20.00	0.50
Heat Shield Panel	Calculated	4	12.00	48.00	0.50
Top Plate	Calculated	1	72.00	72.00	0.50
Parachute (Payload)	Calculated	1	25.00	25.00	0.50
Leg	Calculated	2	25.00	50.00	0.50
Nylon Rod	Calculated	1	3.24	3.24	0.50
Panel Carbon Fiber Rod	Measured	4	7.00	24.00	0.50
Carbon Fiber Rod	Calculated	4	30.00	120.00	0.50
Lid	Measured	1	24.00	24.00	0.50
Plate	Measured	1	26.00	26.00	0.50

Mass Budget (3/3)

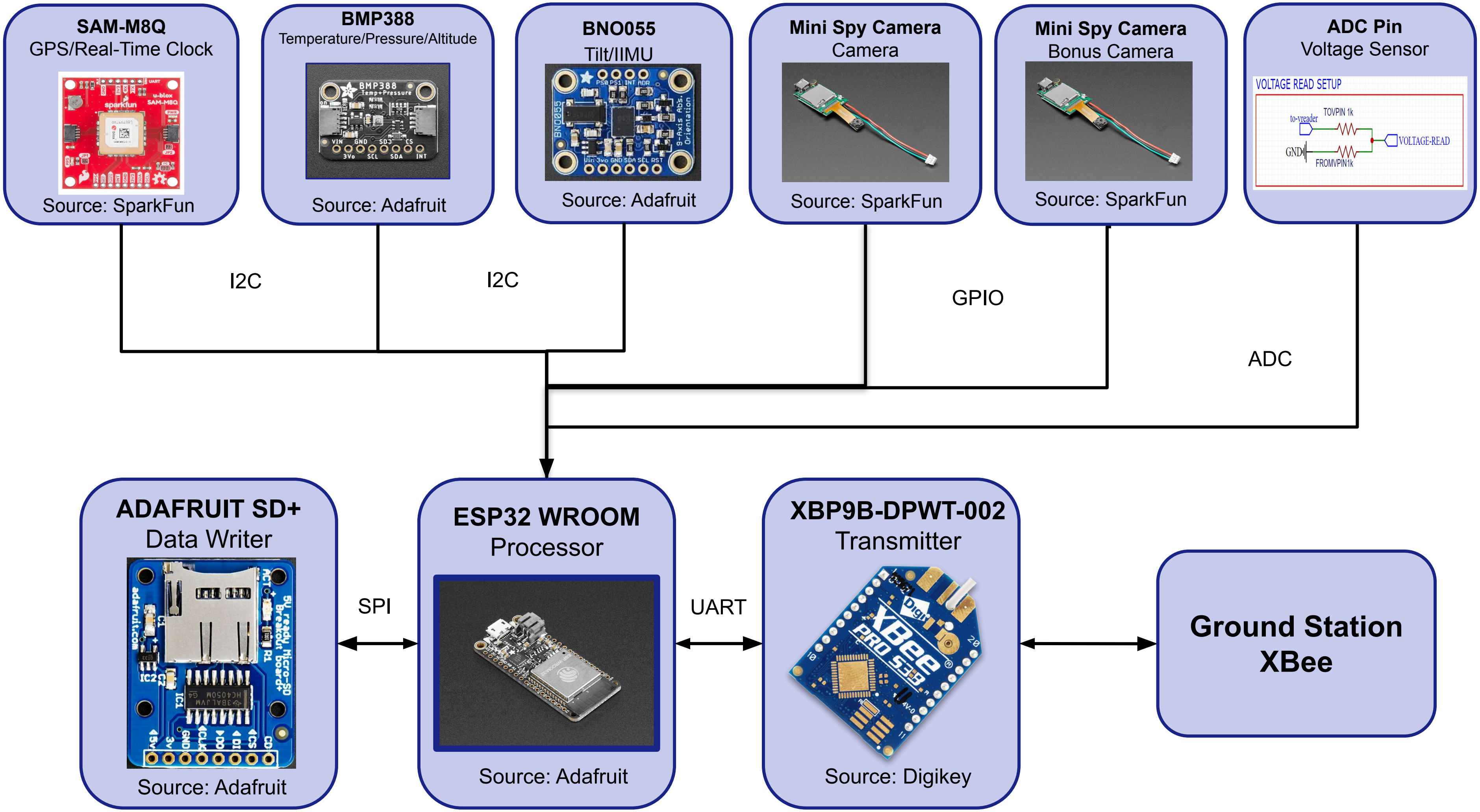
Component	Source	Quantity	Mass/Unit (g)	Mass Summary (g)	Uncertainty (+/- g)
Bottom Plate	Measured	1	41.00	41.00	0.50
Stemnut	Measured	1	10.00	10.00	0.50
Transfer Shaft	Measured	4	1.00	4.00	0.50
			Total Payload	592.44	±13.5
Container					
Fiberglass shell	Calculated	1	60.00	60.00	0.50
Parachute (Container)	Calculated	1	30.00	30.00	0.50
Holding Plate	Measured	10	1.00	10	0.50
			Total Container	100.00	±1.5
			TOTAL	692.44	±15.00
			MASS MARGIN	9.56	

In the event that our mass budget is under we plan to mitigate this by adding mass to the Cansat until it is the proper weight

Communication and Data Handling (CDH) Subsystem Design

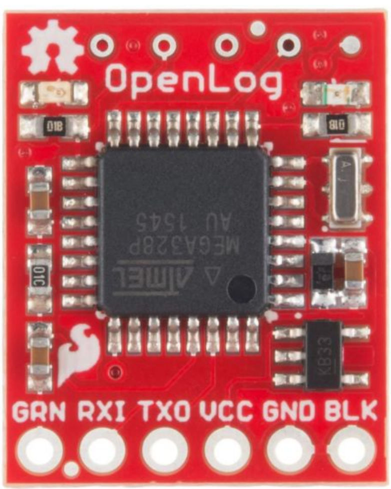
Emily Jolly and Jamie Roberson

CDH Overview

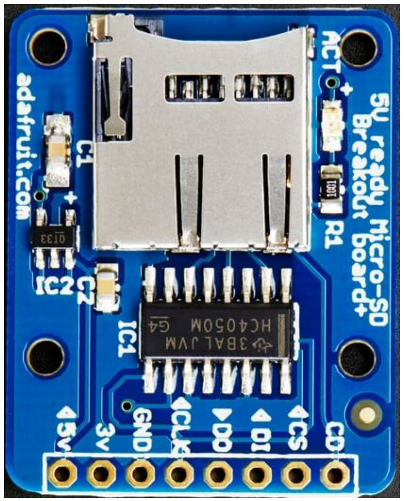


CDH Changes Since PDR

PDR	CDR	Rationale
OpenLog DEV-13712	Adafruit SD+	Adafruit SD+ adds the ability to read data on top of writing



Source: Sparkfun



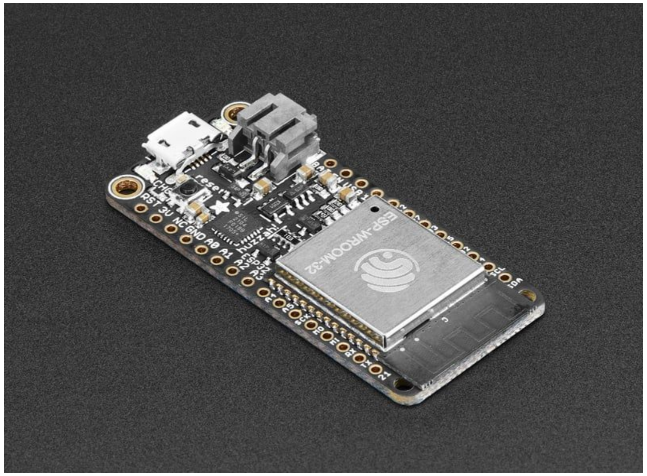
Source: Adafruit

Payload Processor & Memory Selection (1/2)

Processor

Model	Data Bus Width	Flash Memory	Boot Time	Processor Speed	UART Pin(s)	ADC Pin(s)	GPIO Pin(s)	Weight (g)	Cost
Feather HUZZAH	32-bit	4 MB	200-300 ms	240 MHz	2 pairs	13	20	6.8	$19.95

Selection: Feather ESP32 HUZZAH
- Speed - 240 MHz
- Expansive memory - 4 MB
- Best SRAM - 520 kB



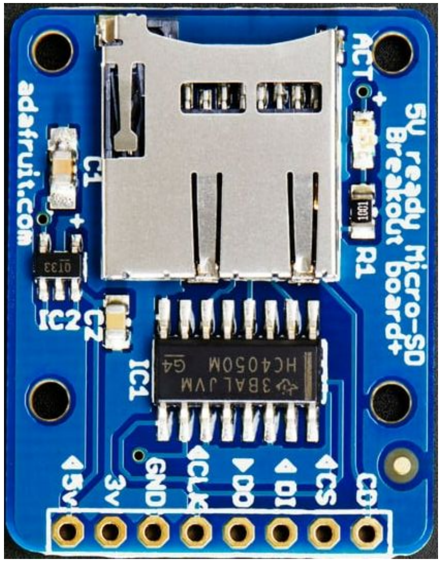
Source: Adafruit

Payload Processor & Memory Selection (2/2)

Memory

Model	Interface	Capacity (GB)	Size (in)	Weight (g)	Cost
Adafruit SD+	SPI	16	1.25 x 1.00 x 0.15	4.00	$7.50

Selection: Adafruit SD+
- Storage capacity
- Reading-ability

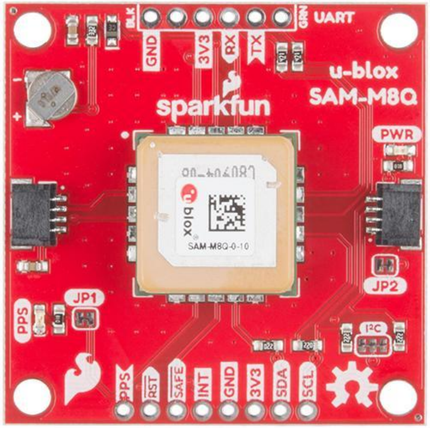


Source: Adafruit

Model	Interface	Battery Backup	Oscillator (kHz)	Input Voltage (V)	Weight (g)	Cost
SAM-M8Q	I²C	Coin Battery	32	3.3	13.00	$42.95

Selection: SAM-M8Q

- Plan to attach coin battery for independent power source
- For reset tolerance, will check for internal backup data storage and set internal variables



Source: Sparkfun

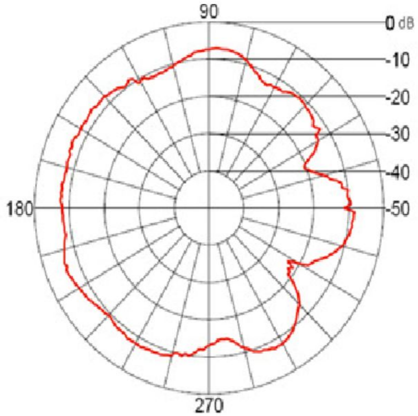
Payload Antenna Selection

Model	Range (km)	Transmit Power	Gain (dBi)	Voltage (V)	Pattern	Mounting Type	Cost
XBP9B-DPWT-002	9.6	24 dBm	2.1	2.1 - 3.6	Omnidirectional	Integrated	Negligible

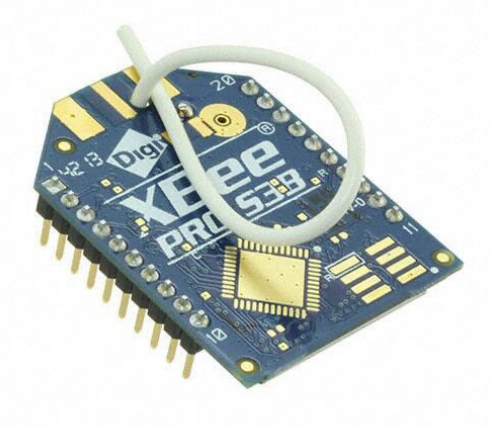
Selection: XB9B-DPWT-002

- 200 kbs radio frequency
- Appropriate range
- Lower mass implications

Radiation Pattern



Source: researchgate



Source: Digikey

Payload Radio Configuration

IDLE, READY:
- Only debug/simulation & telemetry commands on
- CXON

ASCENT, DESCENT, HEATSHIELD, PARACHUTE:
- Manual release (rocket, heat shield, parachute) commands active

LANDED:
- Locator & telemetry commands on

Testing via XCTU
- Short range (within a few meters), same computer testing
- Short range, different computer testing
- Medium (20 meters) range testing
- High range (100 meters) with antennae
- Practice launch testing

Source: Digikey

XBee Node Identifier	Location	Model	NET ID	Destination High	Destination Low	Baud Rate
Obsidian	CanSat	XBP9B-DPWT-002	1070	13A200	Serial Low of Decepticon	9600
Decepticon	GCS	XBP9B-DMST-002	1070	13A200	Serial Low of Obsidian	9600

Payload Telemetry Format (1/3)

Telemetry	
Format	TEAM_ID, MISSION_TIME, PACKET_COUNT, MODE, STATE, ALTITUDE, HS_DEPLOYED, PC_DEPLOYED, MAST_RAISED, TEMPERATURE, PRESSURE, VOLTAGE, GPS_TIME, GPS_ALTITUDE, GPS_LATITUDE, GPS_LONGITUDE, GPS_SATS, TILT_X, TILT_Y, CMD_ECHO
Example	1070,13:14:02.22,178,F,HEATSHIELD,398.2,P,N,N,24.9,5.2,13:14:02,401.8,34.7252,-86.6405,1,5.21,7.45,CXON

Payload Telemetry Format (2/3)

Telemetry	Description	Units
TEAM_ID	Assigned four digit team identification number (1070)	N/A
MISSION_TIME	Mission Time in UTC with 1 second or better resolution	hh:mm:ss.ss
PACKET_COUNT	Total count of transmitted packets	N/A
MODE	‘F’ for flight mode and ‘S’ for simulation mode	N/A
STATE	Operating state of the software	N/A
ALTITUDE	Altitude in units of meters and relative to ground level at the launch site. Resolution of 0.1 m	Meters (m)
HS_DEPLOYED	‘P’ indicates the Probe with heat shield is deployed, ‘N’ otherwise	N/A
PC_DEPLOYED	‘C’ indicates the Probe parachute is deployed (at 200 m), ‘N’ otherwise	N/A
MAST_RAISED	‘M’ indicates the flag mast has been raised after landing, ‘N’ otherwise	N/A
TEMPERATURE	Temperature in degrees Celsius. Resolution of 0.1 degrees	Celsius (°C)
PRESSURE	Air pressure of the sensor used. Value must be in kPa with a resolution of 0.1 kPa.	Kilopascals (kPa)
VOLTAGE	Voltage of the CanSat power bus. Resolution of 0.1 volts	Volts (V)

Payload Telemetry Format (3/3)

Telemetry	Description	Units
GPS_TIME	Time from the GPS receiver. The time must be reported in UTC. Resolution of 1 sec	Seconds (s)
GPS_ALTITUDE	Altitude from the GPS receiver in meters above mean sea level. Resolution of 0.1 meters	Meters (m)
GPS_LATITUDE	Latitude from the GPS receiver in decimal degrees. Resolution of 0.0001 degrees North	Degrees (°)
GPS_LONGITUDE	Longitude from the GPS receiver in decimal degrees. Resolution of 0.0001 degrees West	Degrees (°)
GPS_SATS	Number of GPS satellites being tracked by the GPS receiver	N/A
TILT_X	Angle of CanSat X axis in degrees. Resolution of 0.01 degrees	Degrees (°)
TILT_Y	Angle of CanSat Y axis in degrees. Resolution of 0.01 degrees	Degrees (°)
CMD_ECHO	Text of the last command received and processed by the CanSat	N/A

Payload Command Formats (1/2)

General Format - “CMD,1070,<COMMAND>,<ARGUMENT>”

Command	Argument	Argument Type	Description	Echo
CX	ON	String	Turns the telemetry on.	CXON
	OFF	String	Turns the telemetry off.	CXOFF
ST	GPS	String	Sets the internal time to the GPS’s internal time.	STGPS
	[Custom]	String (HH:MM:SS.ss)	Sets the internal time to the custom time	STCUS
PING	–	–	Pings the CanSat to ensure a stable connection.	PING
SIM	ENABLE	String	Enables but does not run the simulation mode.	SIME
	DISABLE	String	Disables and stops the simulation mode.	SIMD
	ACTIVATE	String	Runs the simulation mode.	SIMA

Payload Command Formats (2/2)

General Format - “CMD,1070,<COMMAND>,<ARGUMENT>”

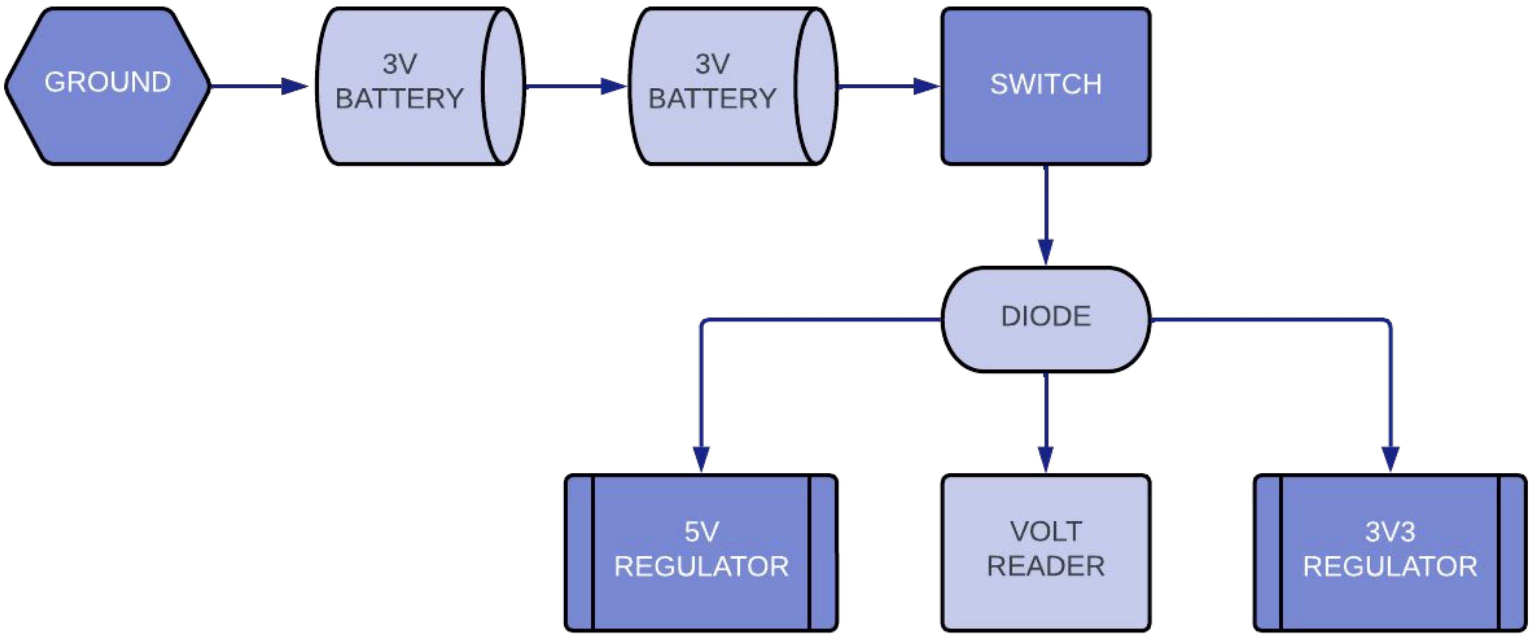
Command	Argument	Argument Type	Description	Echo
SIMP	[Custom]	Float	Sends a fake pressure value to the container.	SIMP
CAL	–	–	Calibrates the altitude of the container to 0 at its current height.	CAL
ACT	MR	String	Activates the release mechanism.	ACTMR
	HS	String	Activates the heat shield deployment.	ACTHS
	PC	String	Activates the parachute.	ACTPC
	AB	String	Toggles the audio beacon.	ACTAB
	LED	String	Toggles the LED.	ACTLED

Electrical Power Subsystem Design

Madison Kromer

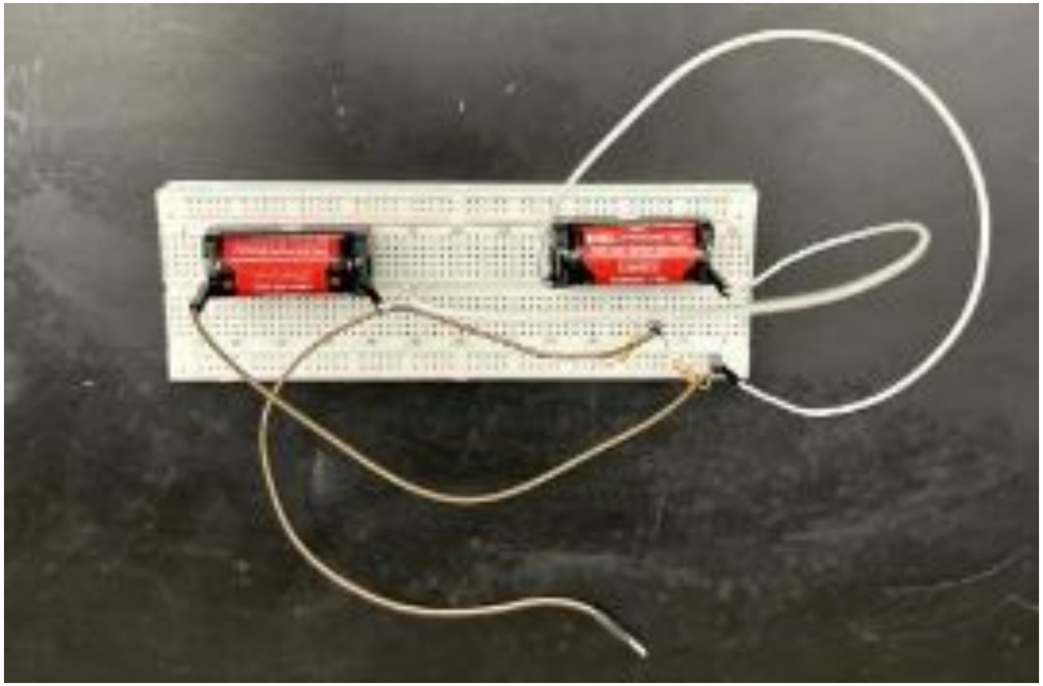
EPS Overview

Two Battery System at 6 Volts Feeding a 5 Volt and 3.3 Volt Regulator

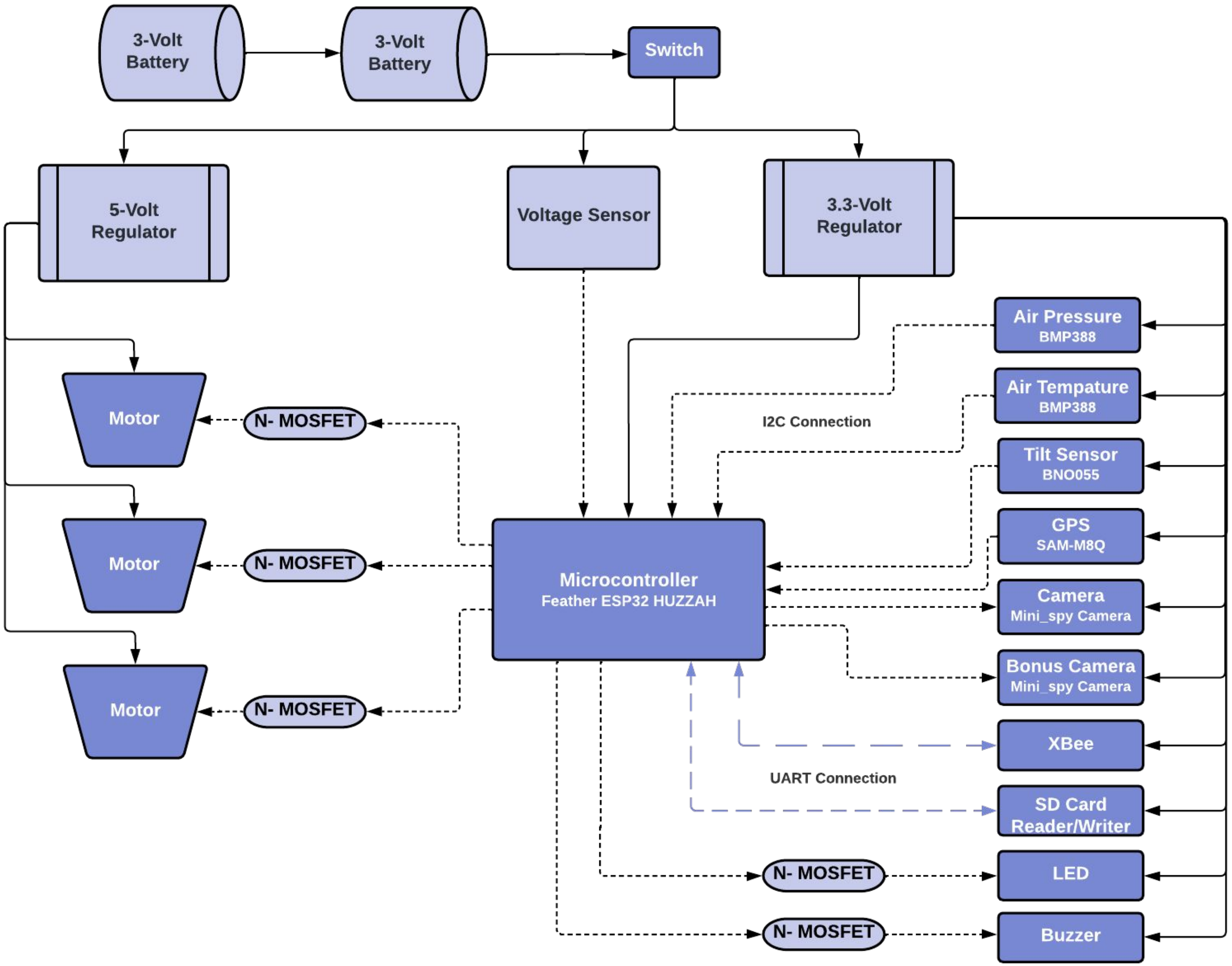


EPS Changes Since PDR

PDR	CDR	Rationale
SparkFun OpenLog	Adafruit SD+	Adafruit SD+ solves issues with the readability and the writing of the data because the data can be read without removing the SD card from the writer.



Payload Electrical Block Diagram



Key

(light purple box)	Power Subsystem
(dark purple box)	Sensor Subsystems
(solid line)	Power Connection
(dotted line)	I2C Connection
(dashed light line)	UART Connection

Payload Power Source

Model	Quantity	Nominal Voltage (V)	Nominal Capacity (mAh)	Nominal Energy (Wh)	Size (mm)	Weight (g)	Cost
SureFire-123A	2 in Series	6.0	1550	9.3	34.5 x 17	34	1.48

Selection: SureFire-123A

- Provides a longer life for high drain devices and can be up to ⅓ lighter than alkaline batteries.
- Provides a steady voltage curve, which is ideal.
- Energy Density (Wh/kg): 273.5

Source: theshorelinemarket

Mounting Device/ Battery Holder: CR123A

Source: Digikey

Payload Power Budget (1/2)

Component	Input Voltage (V)	Max Active Current (mA)	Idle Current (mA)	Active Power (W)	Idle Power (W)	Duty Cycle	Power Consumption (Wh)	Source
SAM-M8Q (GPS)	3.3	29	23	0.1044	0.0759	100%	0.2088	DS
BMP 388	3.3	0.7	0.1	0.0023	0.0003	100%	0.00462	DS
BNO055	3.3	12.3	0.4	0.0406	0.0013	100%	0.0812	DS
CanSat Camera	3.3	110	85	0.3630	0.2810	100%	0.726	DS
Probe Camera	3.3	110	85	0.3630	0.2810	100%	0.726	DS
LED	5	100	0	0.5000	0.0000	20%	0.200	DS
XBP9B-DMST-002	3.3	215	29	0.7100	0.145	50%	1.00	DS
Servo #1	5	550	100	2.7500	0.5000	0.50%	0.00275	DS
Servo #2	5	550	100	2.7500	0.5000	0.50%	0.00275	DS
Servo #3	5	550	100	2.7500	0.5000	0.50%	0.00275	DS
Feather HUZZAH	3.3	240	20	0.7920	0.0660	100%	1.58	DS
Adafruit SD+	5	15	2	0.1000	0.0150	50%	0.115	DS
				Total Power Consumption			**4.65Wh**	

Calculated using max current while components are active.

Payload Power Budget (2/2)

Calculated for a Two Hour Operation Time

Total Power Consumption: **4.65Wh**

Total Power Available: **9.30Wh**

Calculated Using Two 3V Surefire 123A Batteries

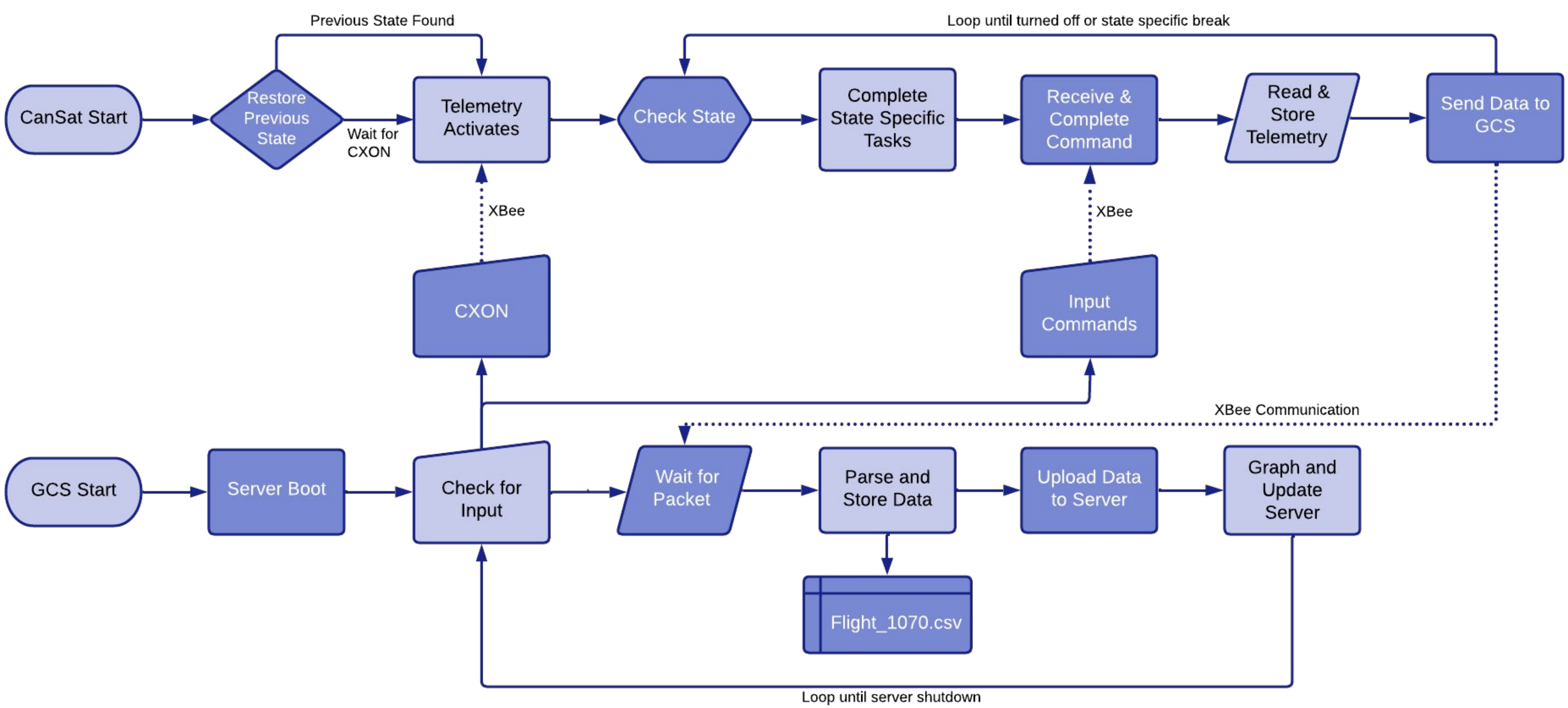
Margin: **4.65Wh**

At 80% Efficiency, total power consumption is **5.58Wh**
Margin will then be **3.72Wh**
Remaining battery percentage: **40%**

Flight Software (FSW) Design

Jamie Roberson

FSW Overview (1/2)



FSW Overview (2/2)

Embedded Software

- Written in C++
  - Adafruit_BNO055.h
  - utility/imumaths.h
  - Sparkfun_u-blox_GNSS_Arduino_Library.h
  - u-blox_config_keys.h
  - Wire.h
  - Adafruit_Sensor.h
  - Adafruit_BMP3XX.h
  - Servo.h
  - SoftwareSerial.h
- Arduino IDE

Ground Control Station

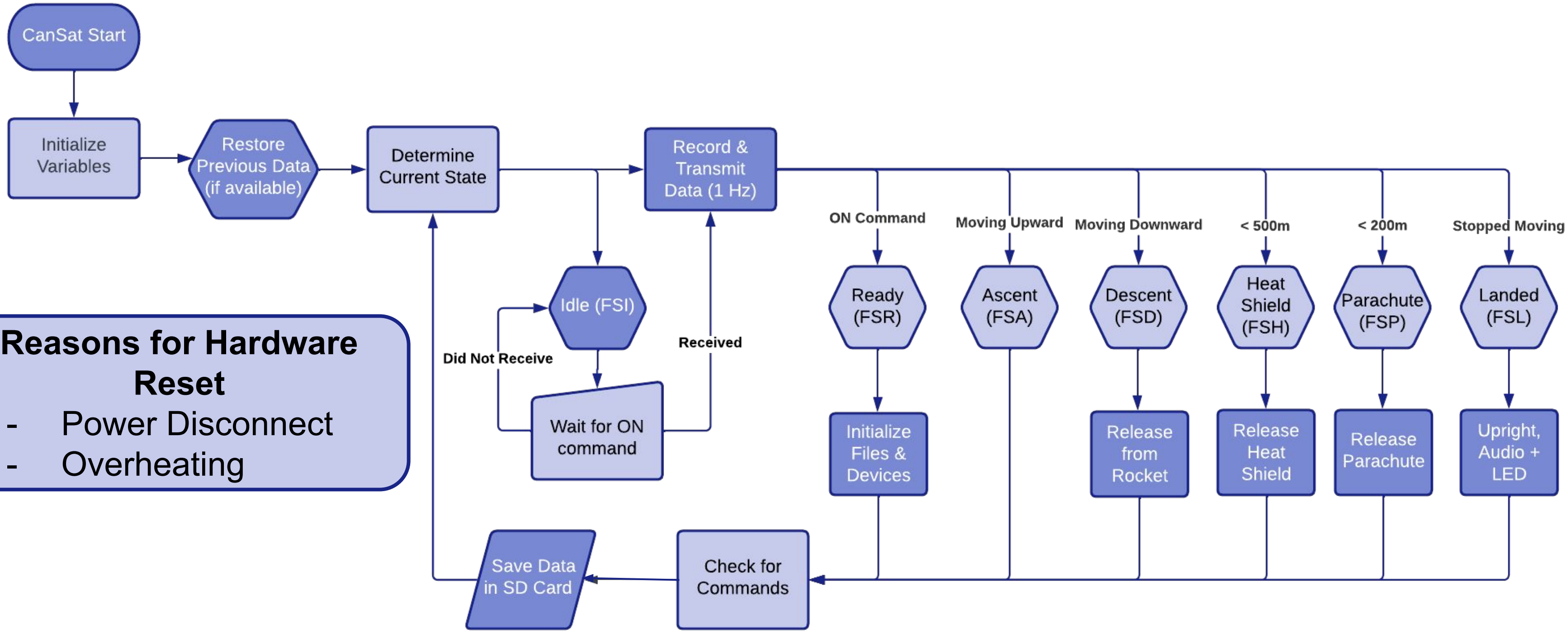
- Golang Backend
  - fmt
  - log
  - math
  - os
  - serial-master
  - time
- HTTP Server Front End
  - CanvasJS
  - Bootstrap
  - Designed in Figma
- Visual Studio Code

Embedded Software Tasks	Ground Control Station Tasks
Generate and store needed telemetry	Send and confirm commands
Receive and process commands	Receive and store needed telemetry
Communicate effectively with GCS	Create visualization of data for users

FSW Changes Since PDR

PDR	CDR	Rationale
When hardware resets, the microcontroller requests backup from the ground station.	When the hardware resets, the information is stored onboard for necessary variables.	In case of problems with the ground station, using onboard storage reduces the risk for error. It creates a point at which information can be restored.

Payload CanSat FSW State Diagram

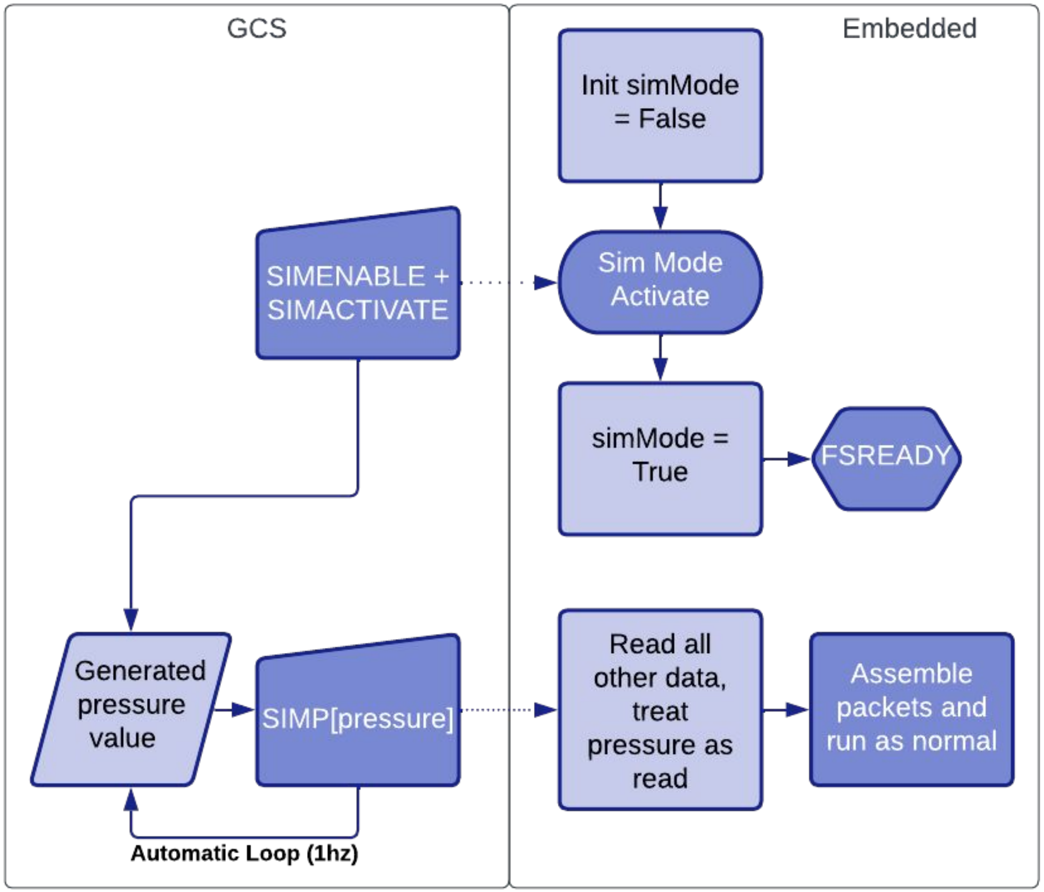


Reasons for Hardware Reset
- Power Disconnect
- Overheating

Method of Recovery
- SD Card Onboard w/ Storage
- Check before processes start if SD Card has previous data, meaning a hardware reset happened

Data Used for Restoration
- Time
- Packet Count
- Payload State
  - ex. FSA
- Mechanism Flags
  - ex. PC_DEPLOYED

Simulation Mode Software



Simulation Commands

SIM,E - Enables Simulation Mode
SIM,D - Disables and Stops Simulation Mode
SIM,A - Activates Simulation Mode
SIMP - Generated pressure value packet

- Internal variable simMode used to keep track of simulation
- Pressure data is made from a Go generator on GCS, used to determine the altitude of the container
- 1 Hz rate of transmission
- All other data is measured exactly the same, just with generated pressure data

Software Development Plan (1/2)

Team Member	Main Responsibilities
Jamie Roberson	GCS front-end development, embedded software development, server creation, website design, UI/UX, live server updating, command handler, inter-software integration, project management
Emily Jolly	Embedded software development, telemetry reader, packet creation, command receiver & executer, integration with electrical & mechanical
John Raburn	GCS back-end development, packet receiver, CSV generator, self-created data generator, data parser, performance

Test Methodology

- Data Generator to test GCS without needing embedded software
- XBEE Integration Testing via XCTU
- Embedded breadboard/PCB integration testing with Arduino IDE

Software Development Plan (2/2)

Embedded Development	Progress
Microcontroller Connection	Needs More Testing
Telemetry	Needs More Testing
Internal Storage	Complete
Command Parser	Complete
Staging	Complete
Servo Connection	Complete
XBEE Connection	Needs More Testing

GCS Development	Progress
Front End Design	Complete
Front End Graphs	Functionally Complete
Front End Labels	Functionally Complete
Data Generator	Complete
Packet Parser	Complete
CSV Writer	Complete
Front-Back End Connection	In Progress

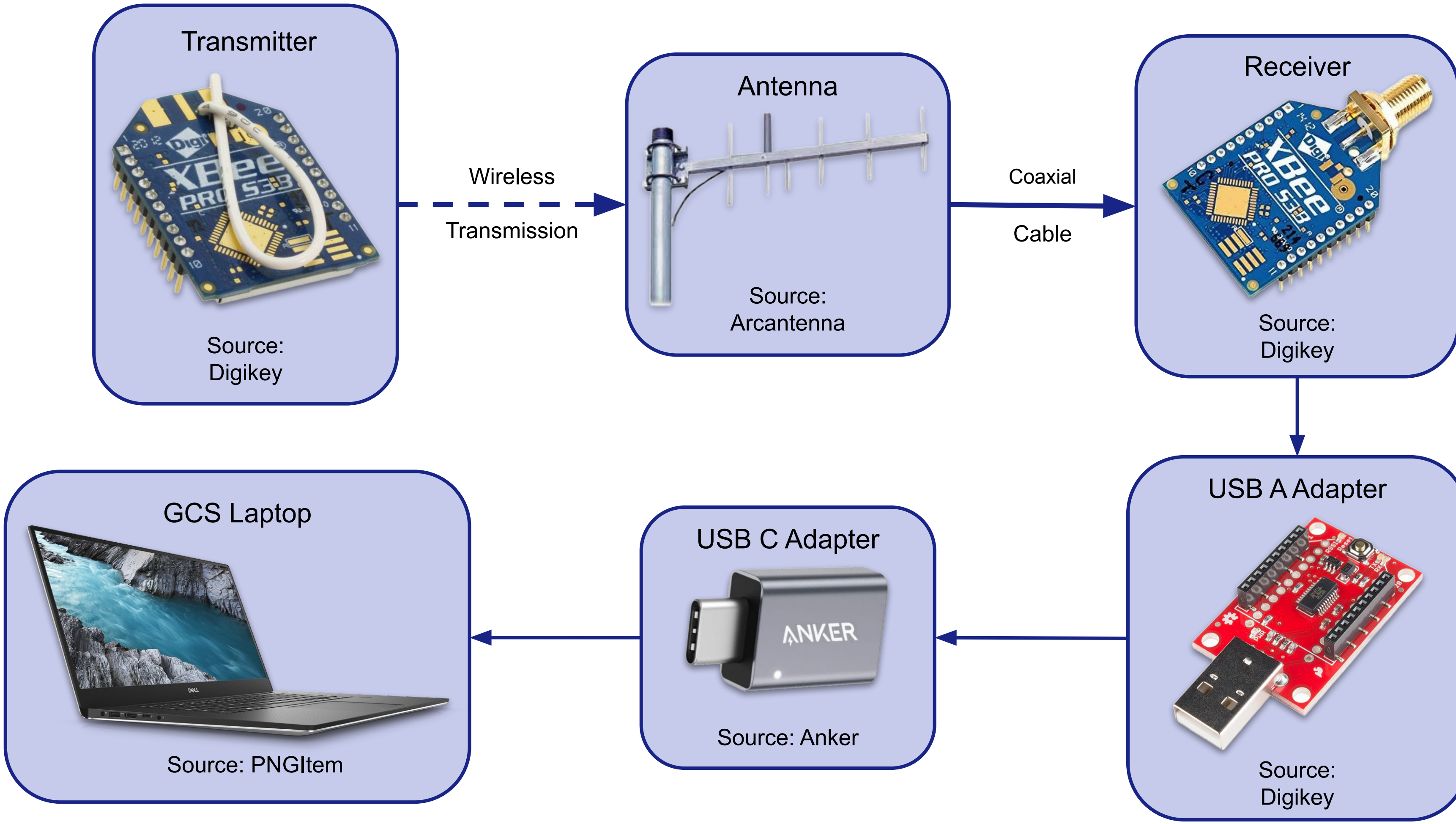
Prototyping and Prototyping Environments

- Develop Embedded Software in C++ in Arduino IDE
- Visual Studio Code for GCS Software
- Test the code for each sensor/component individually
  - Helps for singling out errors in code

Ground Control System (GCS) Design

John Raburn

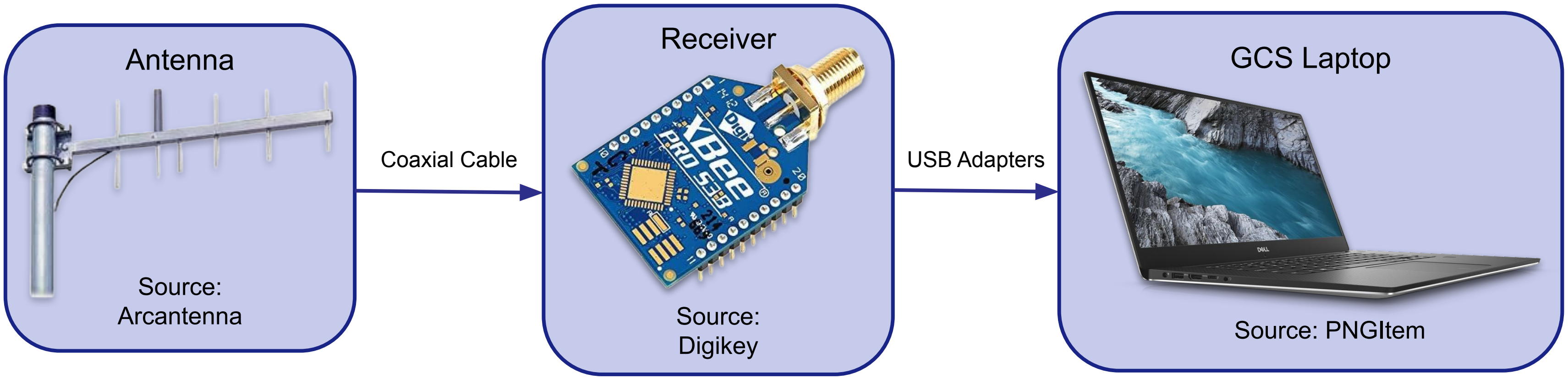
GCS Overview



GCS Changes Since PDR

PDR	CDR	Rationale
Using React.js for Front End Layout	Using Bootstrap for Front End Layout	Bootstrap is easier to understand and works better for our project.
Manually creating graphs in HTML	Using CanvasJS for graphs	CanvasJS has better live graphing and is much easier to embed as opposed to creating our own graphs.

GCS Design



Computer Specifications:

- Battery Life
    - 5 hrs w/o charger
- Overheating Mitigation
    - An umbrella will provide shade
    - Fans will be on performance
    - Any computer can be used
- Auto-update Mitigation
    - Auto-update will be off

Connections Used:

- USB
    - XBee to USB A
    - USB A to C (For computer ports)
- Coaxial
    - Antenna to XBee
      (Male to Male RP-SMA cord)
- Wireless
    - Container to Ground

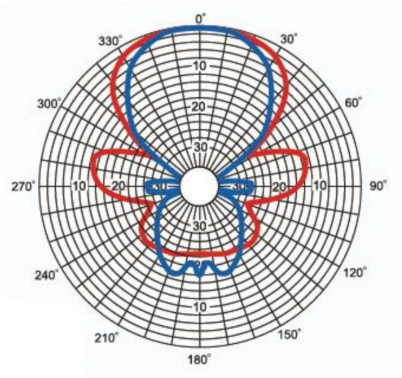
GCS Antenna (1/2)

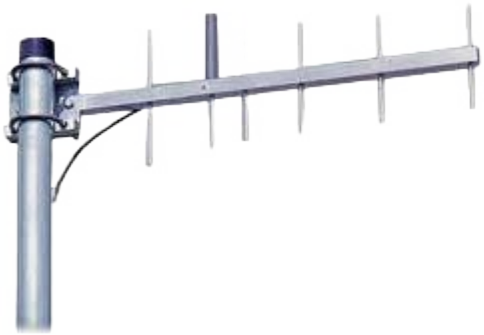
Model	Frequency Range	Gain	Pattern	Mounting Type	Cost
PC960N Yagi	896-940 MHz	11.1 dBi	Directional	Handheld (N-Female Connector)	$65.68

Selection: PC960N Yagi

- Reliability
- High gain
- Adequate frequency range
- Handheld; pointed in direction of CanSat for best signal

Radiation Pattern

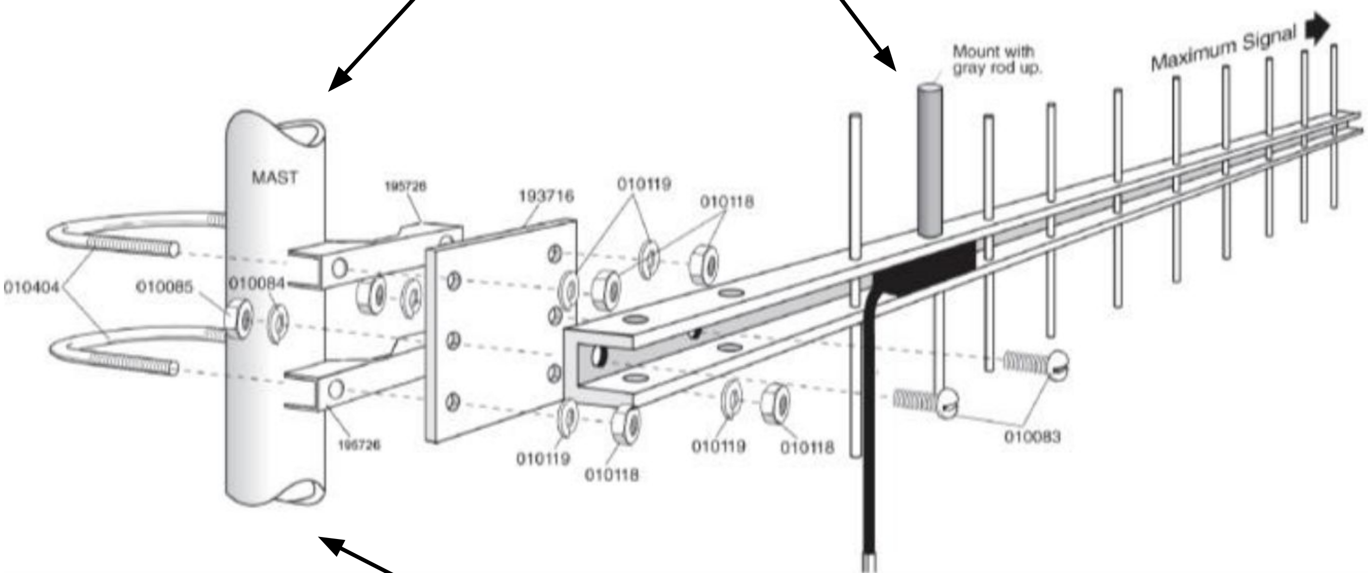




Source: Arcantenna

GCS Antenna (2/2)

Portability



Handheld

Source: Laird Connectivity

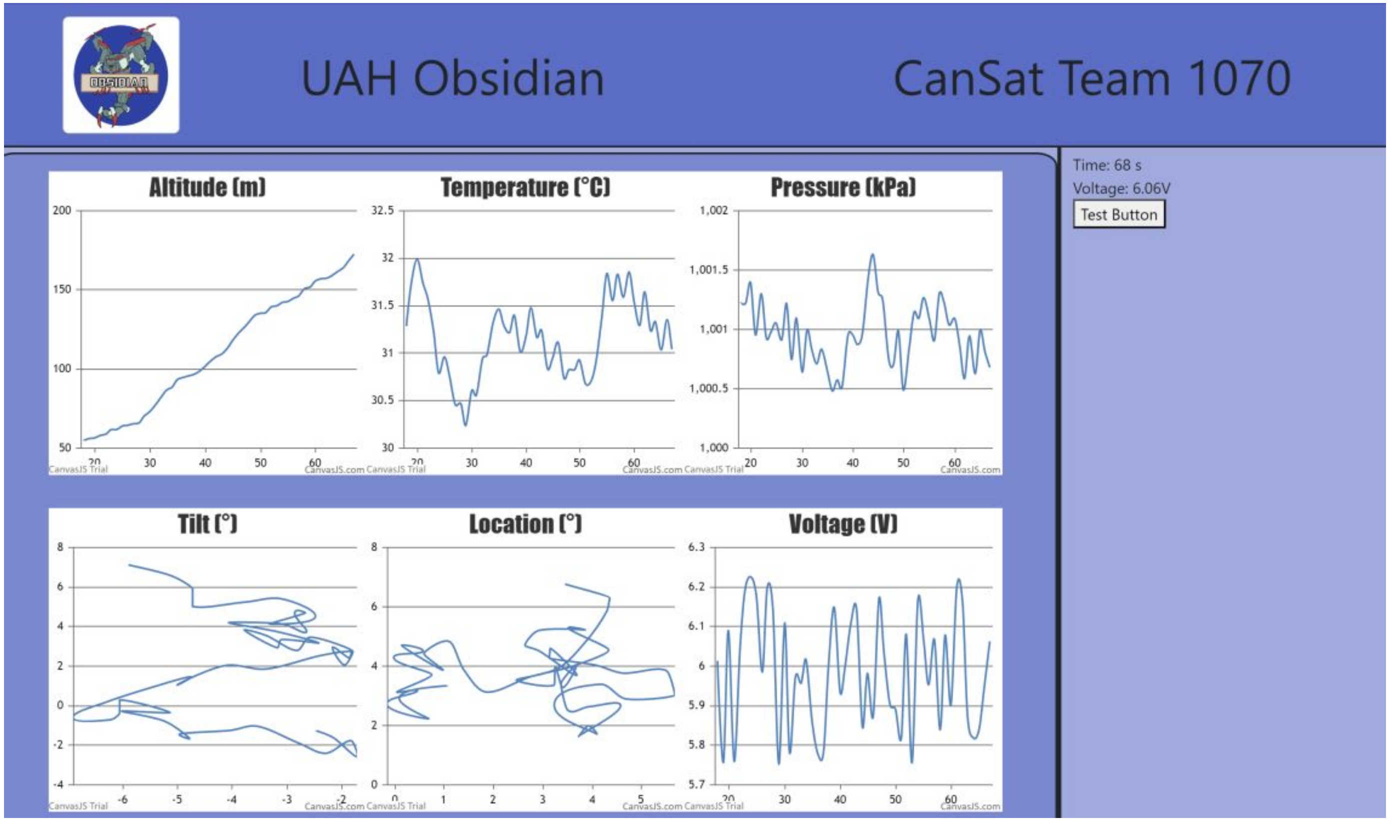
Construction:
- All parts come included
- A rough guide can be put together from the image

Portability:
- The antenna can be split into two parts: the antenna and the handle
- About 2 ft long (24¾ in)

Coverage:
- Link Margin: ~7.33dB
- Distance: ~8km

Link Margin Calculation Source: https://info.bannerengineering.com/

GCS Software (1/2)



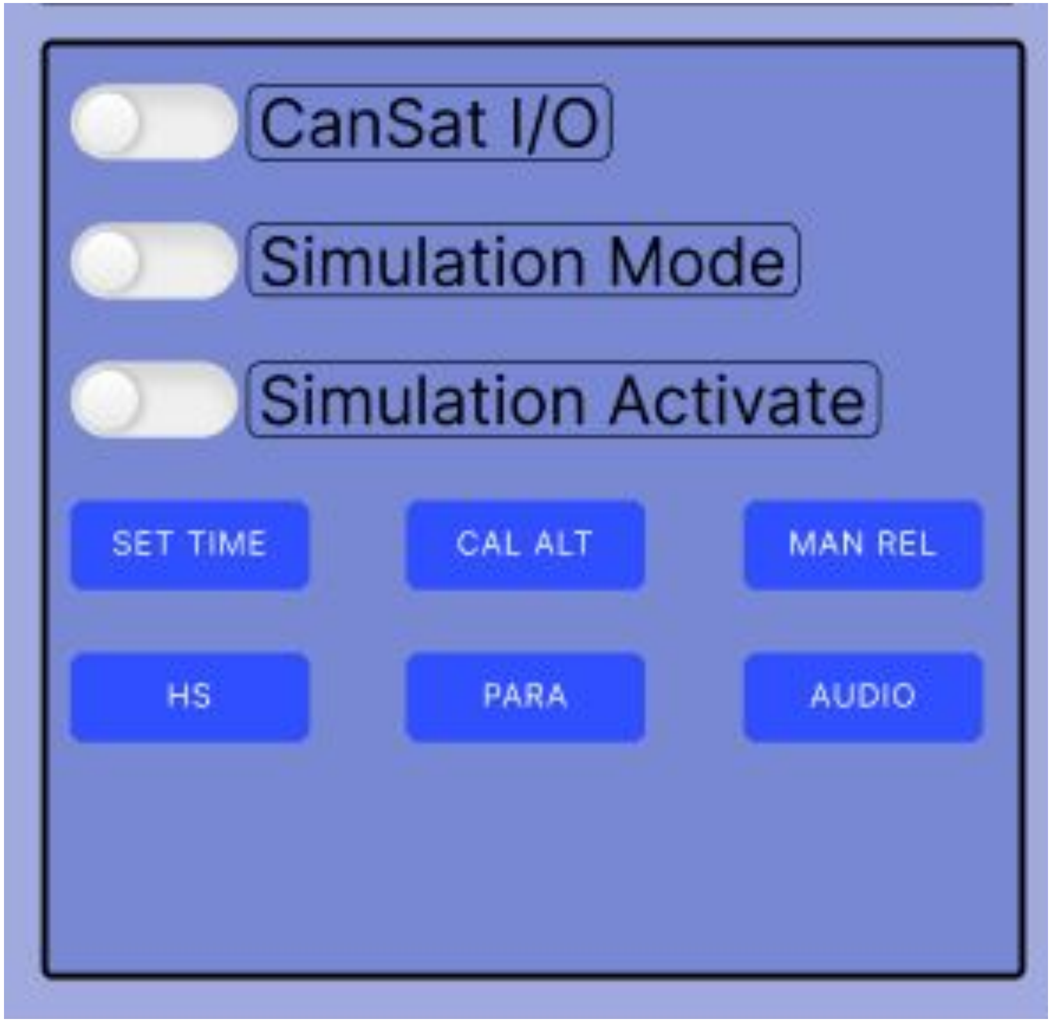
Current Progress for GCS

Software:
- Backend - Go
- Organized on GitHub

Telemetry Data:
- Formatted to CSV and then sorted by packet number.
- Parsed internally, then sent to frontend to be plotted.

COTS Software:
- Bootstrap for Front End Layout
- CanvasJS for graphs

GCS Software (2/2)



Command Interface:

- Includes toggled values
- Includes button commands

Simulation Mode:

- Can be loaded with different profiles.
- Profiles stored in CSV files and to be included with the github.
- Internal CSVRead and ProfileParser functions will handle the selected profile's routine.
- Will transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.

CanSat Integration and Test

Emily Jolly

CanSat Integration and Test Overview

Integration and Testing Stages		
Subsystem Level Test Plan	In this testing stage, each subteam will be responsible for testing individual components of the CanSat. This stage allows us to test our individual components to reduce the number of integration errors.	Sensors, CDH, EPS, Radio communications, FSW, Mechanical, Descent Control
Integrated Level Function Test Plan	In this testing stage, the subteams will integrate the individual components. We will use this stage to test and adjust components if needed.	Decent Testing, Communications, Mechanisms, Deployment
Environmental Test Plan	In this testing stage, the CanSat will be tested using the guidelines listed in the CanSat Competition Guide. This test is used to test our CanSat's durability for the mission.	Drop test, Thermal test, Vibration test, Fit Check, VACUUM test
Simulation Test Plan	In this testing stage, software subteam will make a code that will test our release mechanisms. The code will read in simulated data for pressure.	Simulated Pressure Data test

Subsystem Level Testing Plan (1/4)

#	Subsystem	Test	Component(s)	Test Description	Requirement to Pass
1	Sensors	Air Pressure	BMP388	We will place the sensor into our vacuum chamber where we compare the barometer pressure.	The recorded pressure and the barometer pressure are approximately the same.
2	Sensors	Air Temperature	BMP388	We will place the sensor in two places with known temperatures.	The recorded temperatures of both locations are approximately the same as known temperature.
3	Sensors	Tilt	BNO055	We will tilt the sensor next to a protractor.	The recorded angle and the protractor angle are approximately the same.
4	Sensors	GPS	SAM-M8Q	We will take our sensor to three locations along with google maps.	The recorded coordinates are approximately the same latitude and longitude as the phone coordinates.
5	Sensors	Camera(s)	Mini-Spy Camera	We will film with both cameras for an extended time.	The footage is clear and records for the entire time it is turned.
6	Sensors	Real Time Clock	SAM-M8Q	We will run the sensor along side a computer clock.	The recorded time and the computer time are the same.

Subsystem Level Testing Plan (2/4)

#	Subsystem	Test	Test Description	Requirement to Pass
7	CDH	Command Input	Send a command from the Ground Station to the container and Payload.	The CanSat and GCS will communicate effectively and be able to parse the sent packets.
8	EPS	Battery Voltage	We will test the battery voltage and the voltage output of both linear regulators with a voltmeter.	The record voltage from the voltmeter will be the same for batteries and linear regulators as the expected voltage.
9	EPS	Electrical Consistency	Turn on electronics then use a multimeter to test voltage input for all electrical components.	The multimeter measures the proper amount of voltage input as necessary.
10	Radio Communication	XBee Communication	The Ground Station sends commands to the payload at three different distances.	The payload will respond to the command at all three distances.
11	FSW	Reset Test	We perform a manual reset for the electronics.	The microcontroller will record data from the last sent packet.
12	FSW	Packet Test	We will collect data from the sensors and compile it into the required telemetry format.	The telemetry will display in the required format and display accurate values.

Subsystem Level Testing Plan (3/4)

#	Subsystem	Test	Test Description	Requirement to Pass
13	FSW	Server Test	We will generate data from the ground station and send it to the server.	The server will display the information that we generate correctly.
14	Mechanical	Payload Release	We will use our manual release command to allow our payload to release from the shell without obstacles.	When our manual release command release our payload from our shell without getting caught on the shell.
15	Mechanical	Uprighting Mechanism	We will have our place our CanSat at different angles on the ground and have the servos turn and upright the payload.	When the panels upright itself completely.
16	Mechanical	Flag Raising	We will turn on our servo and have the flag raise.	When the servo turns the flag will raise.
17	Descent Control	First Deployment	We will turn our threaded rod where the release mechanism and the first parachute are attached.	When the CanSat properly deploys from the container and the parachute deploys correctly.
18	Descent Control	Second Deployment	We will turn our servo until the aerobrake is open.	When our servos turn, our aerobrake deploys to the correct angle.

Subsystem Level Testing Plan (4/4)

#	Subsystem	Test	Test Description	Requirement to Pass
19	Descent Control	Third Deployment	We will test our lid containing our second parachute opens when the servo turns.	When our lid opens without external influences.
20	Mechanical	Stress Test	We will test the structure of our CanSat when mechanical is fully assembled by placing weights on the structure.	The structure will withstand having 1,400g of weight placed on-top of the mechanical structures and it will not change its shape.
21	Mechanical	Impact Test	We will drop our mechanical structures from the parking garage without our sensors to test when the structure impacts with the ground.	When dropped from a third story parking garage and the structure stays intact.
22	Mechanical	Flag Raising	We will turn on our servo and have the flag raise.	When the servo turns the flag will raise.

Integrated Level Functional Test Plan

#	Integrated Test	Test Description	Requirements to Pass
23	Decent Testing	We will take our completed CanSat and drop it off of multiple different heights. We will test the first parachute, the aerobrake, and the second parachute.	The CanSat will fall at 15m/s with the first parachute, 20m/s with the aerobrake, and then fall at 5m/s with the second parachute.
24	Communication	We will turn on our completed CanSat to begin recording data. All the sensors will record data to the SD card and send the data to the Ground Station.	Our telemetry will be properly transmitted and formatted in the server.
25	Mechanisms	We will take our mechanical components and integrate with electrical components.	Our electrical components are securely in the CanSat with the switch easily accessed.
26	Deployment	We will put our completed CanSat in our vacuum chamber to simulate different altitudes. As we change the altitude in the vacuum chamber, the releases mechanisms will deploy our parachutes and our aerobrake.	When our CanSat deploys our parachutes and aerobrake at the correct altitude given by the vacuum chamber.

Environmental Test Plan (1/2)

#	Test	Method	Test Description	Requirement to Pass
27	Drop Test	Fixed Point Drop	The parachute on the CanSat will be attached to a 61 cm cord that is attached to a fixed room with enough space and height that the CanSat does not hit anything. The CanSat will be dropped from the height of the fixed point.	The CanSat did not lose power, telemetry is still retrieved, and there are no detached parts or damage
28	Thermal Test	Thermal Chamber	A thermal chamber will be assembled using and insulating cooler, hair dryer, and thermometer. The hair dryer will circulate and heat the air inside the cooler to 60℃, which will be maintained for 2 hours.	The integrity of all mechanisms has not been compromised and the epoxy joints and composite materials maintain their strength
29	Vibration Test	Random Orbital Sander	The CanSat will be placed on a random orbital sander that exposes the CanSat to vibrations from 0 Hz to 233 Hz and generates around 20 to 29 Gs for one minute.	The CanSat has no structural damage, functions correctly, and accelerometer data is still received
30	Fit Check	Mock Rocket Test	The CanSat will be slid into a tube that has the same dimensions as the rocket used during the competition	The CanSat slides in and out of the tube easily with no impediments

Environmental Test Plan (2/2)

#	Test	Method	Test Description	Requirement to Pass
31	Vacuum Test	Vacuum Chamber	The fully configured and powered CanSat will be placed in a vacuum chamber in which the system will be pulled to a vacuum. Throughout the test the telemetry will be monitored, and when the maximum altitude is reached the vacuum will be stopped	The CanSat must transmit and record telemetry during the test, and the telemetry must be provided to judges

Test Procedures Descriptions (1/7)

Subsystem Level Test Procedures (1/4)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
1	We will place the sensor into our vacuum chamber where we compare the barometer pressure.	10,32,34,35,38,39	The recorded pressure and the barometer pressure are approximately the same.
2	We will place the sensor in two places with known temperatures.	38,39	The recorded temperatures of both locations are approximately the same as known temperature.
3	We will tilt the sensor next to a protractor.	36,38,39	The recorded angle and the protractor angle are approximately the same.
4	We will take our sensor to three locations along with google maps.	11,38,39	The recorded coordinates are approximately the same latitude and longitude as the phone coordinates.
5	We will film with both cameras for an extended time.	40,41,42	The footage is clear and records for the entire time it is turned.
6	We will run the sensor along side a computer clock.	46,52	The recorded time and the computer time are the same.

Subsystem Level Test Procedures (2/4)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
7	Send a command from the Ground Station to the container and Payload.	36,38,39, 48,55,60, 61	The CanSat and GCS will communicate effectively and be able to parse the sent packets.
8	We will test the battery voltage and the voltage output of both linear regulators with a voltmeter.	31	The record voltage from the voltmeter will be the same for batteries and linear regulators as the expected voltage.
9	Turn on electronics then use a multimeter to test voltage input for all electrical components.	31	The multimeter measures the proper amount of voltage input as necessary.
10	The Ground Station sends commands to the payload at three different distances.	36,38,39	The payload will respond to the command at all three distances.
11	We perform a manual reset for the electronics.	44	The microcontroller will record data from the last sent packet.
12	We will collect data from the sensors and compile it into the required telemetry format.	38,39	The telemetry will display in the required format and display accurate values.

Subsystem Level Test Procedures (3/4)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
13	We will generate data from the ground station and send it to the server.	47,49,51, 54,56,61	The server will display the information that we generate correctly.
14	We will use our manual release command to allow our payload to release from the shell without obstacles.	2,3,32,54	When our manual release command release our payload from our shell without getting caught on the shell.
15	We will have our place our CanSat at different angles on the ground and have the servos turn and upright the payload.	15,36	When the panels upright itself completely.
16	We will turn on our servo and have the flag raise.	3715,	When the servo turns the flag will raise.
17	We will turn our threaded rod where the release mechanism and the first parachute are attached.	15,35	When the CanSat properly deploys from the container and the parachute deploys correctly.
18	We will turn our servo until the aerobrake is open.	15,33,34, 36	When our servos turn, our aerobrake deploys to the correct angle.

Subsystem Level Test Procedures (4/4)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
19	We will test our lid containing our second parachute opens when the servo turns.	15,35	When our lid opens without external influences.
20	We will test the structure of our CanSat when mechanical is fully assembled by placing weights on the structure.	12,13,15	The structure will withstand having 1,400g of weight placed on-top of the mechanical structures and it will not change its shape.
21	We will drop our mechanical structures from the parking garage without our sensors to test when the structure impacts with the ground.	12,13,15	When dropped from a third story parking garage and the structure stays intact.

Test Procedures Descriptions (5/7)

Integrated Level Test Procedures

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
22	We will take our completed CanSat and drop it off of multiple different heights. We will test the first parachute, the aerobrake, and the second parachute.	12,13,15, 34,35	The CanSat will fall at 15m/s with the first parachute, 20m/s with the aerobrake, and then fall at 5m/s with the second parachute.
23	We will turn on our completed CanSat to begin recording data. All the sensors will record data to the SD card and send the data to the Ground Station.	38,39,44, 45	Our telemetry will be properly transmitted and formatted in the server.
24	We will take our mechanical components and integrate with electrical components.	3,5,8,14, 15,23,24, 25,27,28, 31	Our electrical components are securely in the CanSat with the switch easily accessed.
25	We will put our completed CanSat in our vacuum chamber to simulate different altitudes. As we change the altitude in the vacuum chamber, the releases mechanisms will deploy our parachutes and our aerobrake.	23,30,33, 35,36,38	When our CanSat deploys our parachutes and aerobrake at the correct altitude given by the vacuum chamber.

Environmental Level Test Procedures (1/2)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
26	The parachute on the CanSat will be attached to a 61 cm cord that is attached to a fixed room with enough space and height that the CanSat does not hit anything. The CanSat will be dropped from the height of the fixed point.	12,13,15, 29,38	The CanSat did not lose power, telemetry is still retrieved, and there are no detached parts or damage
27	A thermal chamber will be assembled using and insulating cooler, hair dryer, and thermometer. The hair dryer will circulate and heat the air inside the cooler to 60℃, which will be maintained for 2 hours.	12,13,15, 30,38	The integrity of all mechanisms has not been compromised and the epoxy joints and composite materials maintain their strength
28	The CanSat will be placed on a random orbital sander that exposes the CanSat to vibrations from 0 Hz to 233 Hz and generates around 20 to 29 Gs for one minute.	12,13,15, 30,38	The CanSat has no structural damage, functions correctly, and accelerometer data is still received
29	The CanSat will be slid into a tube that has the same dimensions as the rocket used during the competition	2,3,4,5,30	The CanSat slides in and out of the tube easily with no impediments

Test Procedures Descriptions (7/7)

Environmental Level Test Procedures (2/2)

Test Procedure	Test Description	Rqmnt Num(s)	Pass/ Fail Criteria
30	The fully configured and powered CanSat will be placed in a vacuum chamber in which the system will be pulled to a vacuum. Throughout the test the telemetry will be monitored, and when the maximum altitude is reached the vacuum will be stopped.	5,8,24,30, 33,35,36, 38	The CanSat must transmit and record telemetry during the test, and the telemetry must be provided to judges

Simulation Test Plan

Component	Description	Requirement
Ground	Send activate and enable simulation commands then send generated pressure data to the CanSat using the SIMP command.	The Ground Station should provide data to the CanSat with the simulated pressure data every second.
CanSat	When the activate and enable commands are received, calculate altitude from given pressure. Record all other data as normal.	CanSat enters the Simulation Mode commanded from the GCS. The CanSat should receive the simulated pressure data and respond to the corresponding altitude.

Mission Operations & Analysis

Emily Jolly

Overview of Mission Sequence of Events

Stage	Task	Team
Arrival	Arrive at Launch Site	Everyone
Pre-Launch	Ground Station Setup and Antenna Construction	Ground Station Crew
	CanSat Final Preparation (Assembly and Test)	CanSat Crew
	CanSat Check in	CanSat Crew
Launch	Turn CanSat on	CanSat Crew
	Integrate CanSat with Rocket	CanSat Crew
	Monitor Ground Station	Ground Station Crew
	Move to Launch Control Table and Execute Launch Procedures	MIssion Control Officer
Descent	Monitor Ground Station	Ground Station Crew
Recovery	Recover the CanSat	Recovery Crew
Data Analysis	Analyze Data and Turn in Thumb Drive to Field Judge	Ground Station Crew
	Post Flight Review (PFR)	Everyone
	Return to Check in	Recovery Crew

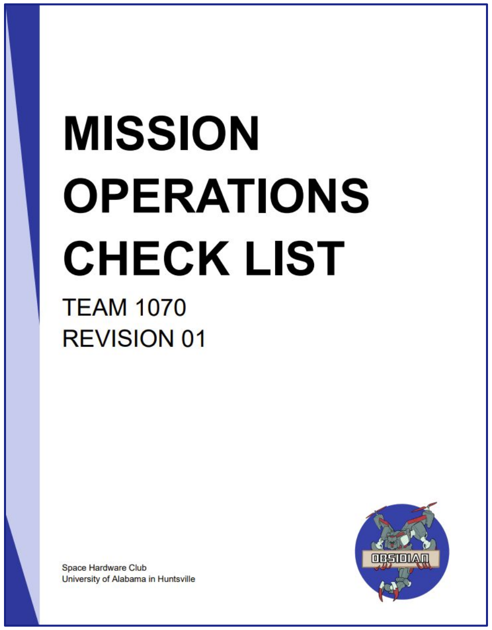
Team Assignments	
Mission Control Officer	Emily Jolly
Ground Station Crew	Jamie Roberson, John Raburn
Recovery Crew	Adam Burden, Preston Beesley
CanSat Cew	John Kelly, Adam Burden, Madison Kromer, Brooks Calhoun

Field Safety Rules Compliance (1/2)

Section	Content
Mission Sequence of Events	Includes an overview of the different mission stages and the processes and team required for each stage
Team Assignments	Will provide an overview of the roles assigned to team members and the responsibilities for each role
Ground Station Overview	Overview of the ground station and all of its components, including a checklist for the components
Ground Station Configuration	Procedures for setting up the ground station, including a list of all interactions possible with the ground station.
CanSat Preparation	Overall checklist of all components of the CanSat that need to be reviewed before launch.
CanSat Integration	Procedures and responsibilities for each team role during launch preparation. Includes steps to verify functionality of CanSat
Launch Preparation	Procedure for preparing for launch
Launch Procedure	Procedure for all team role responsibilities during launch
Appendix A	General maintenance instructions/operations for the CanSat

Field Safety Rules Compliance (2/2)

Section	Development Status
Mission Sequence of Events	Complete
Team Assignments	Complete
Ground Station Overview	In Progress
Ground Station Configuration	In Progress
CanSat Preparation	In Progress
CanSat Integration	In Progress
Launch Preparation	Complete
Launch Procedure	Complete


MISSION OPERATIONS CHECK LIST

TEAM 1070

REVISION 01

Space Hardware Club

University of Alabama in Huntsville

The Mission Operations Manual is in progress and will be completed by May. The manual will include the sections above, as well as an Appendix that includes maintenance.

CanSat Location and Recovery

CanSat Recovery Options

- GPS will provide an estimated location of the CanSat
- Buzzer will sound when CanSat lands
- Flashing LED
- Flag will raise after CanSat lands and uprights itself
- Container and Payload will have label with contact information and return address
- Coloring visible components
    - Container will be neon orange
    - Parachute will be neon pink

CanSat Team #1070
Obsidian

601 John Wright Drive
Huntsville, AL 35805

Team Lead: Emily Jolly
erj0009@uah.edu
256 - 572 - 6949

Address Label Example

Mission Rehearsal Activities (1/2)

Section	Procedures
Ground System Radio Link	• Turn on the CanSat and the Ground Station • Use the PING command to show that uplink and downlink are secure
Powering On/Off the CanSat	• Insert batteries into the CanSat • Turn on switch inside the CanSat • Confirm all components are on and working • Confirm communication with Ground Station
Launch Configuration Preparations	• Fold and attach parachutes • Put lid on top of payload • Connect payload to holding plate inside fiberglass shell • Insert and attach payload into fiberglass shell • Turn on CanSat

Mission Rehearsal Activities (2/2)

Section	Procedures
Loading CanSat into Launch Vehicle	● Simulate launch procedures and insert CanSat into rocket
Telemetry Processing	● Turn on CanSat and the Ground Station ● Ensure the uplink and downlink are secure ● Use the CXON command to turn on telemetry ● Ensure the Ground Station is receiving properly formatted telemetry
Recovery	● Recover CanSat after landing

Currently none of the rehearsal activities have been completed. All rehearsal activities are scheduled to be practiced on May 6th at a test launch, in which the CanSat will be launched from a rocket and simulate the actual mission

Requirements Compliance

Quinlyn Scully

Requirements Compliance Overview

We currently comply to 55 of the 61 requirements

Full Compliance	Rqmnt Num	Reasoning
Partial Compliance	12	We need to test all structures on an orbital sander to test that it will survive 15 Gs of launch acceleration.
	13	We need to test all structures to survive 30 Gs of shock.
	15	We are in progress of testing all mechanisms to see if they remain in their configuration during all forces.
	30	We need to complete our environmental tests to comply with this requirement.
	31	We need to test our battery for the whole duration of the mission before complying to this requirement.
No Compliance		We have full/partial compliance with all requirements
Omitted Requirements	43	We omit requirements number 43 due to being skipped on the mission guide.

Requirements Compliance (1/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (science probe and container) shall be 700 grams +/- 10 grams.	Comply	65	
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	22-23	
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Comply	23	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	123	
5	The container shall be solid and fully enclose the science probes. Small holes to allow access to turn on the science probes are allowed. The end of the container where the probe deploys may be open.	Comply	59	
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	23	
7	The rocket airframe shall not be used as part of the CanSat operations.	Comply	23	
8	The container's parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Comply	49	
9	The Parachute shall be fluorescent Pink or Orange	Comply	123	
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second +/- 5 m/s.	Comply	44	

Requirements Compliance (2/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
11	0 altitude reference shall be at the launch pad.	Comply	29	Under initialize variables
12	All structures shall be built to survive 15 Gs of launch acceleration.	**Partial**	**116**	Needs testing
13	All structures shall be built to survive 30 Gs of shock.	**Partial**	**116**	Needs testing
14	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	17	
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.	**Partial**	**116**	Needs testing
16	Mechanisms shall not use pyrotechnics or chemicals.	Comply	13-23	
17	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	13-23	
18	Both the container and probe shall be labeled with team contact information including email address.	Comply	123	
19	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years shall be included in this cost, based on current market value.	Comply	139-141	
20	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	72-73	

Requirements Compliance (3/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
21	XBEE radios shall have their NETID/PANID set to their team number.	Comply	72-73	
22	XBEE radios shall not use broadcast mode.	Comply	72-73	
23	The container and probe shall include an easily accessible power switch that can be accessed without disassembling the CanSat and science probes and in the stowed configuration.	Comply	16-17	
24	The probe shall include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the CanSat and in the stowed state.	Comply	15	
25	An audio beacon is required for the probe. It shall be powered after landing.	Comply	15	
26	The audio beacon shall have a minimum sound pressure level of 92 dB, unobstructed.	Comply	139	Budget
27	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	82	
28	An easily accessible battery compartment shall be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Comply	21	
29	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	82	

Requirements Compliance (4/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
30	The CanSat shall operate during the environmental tests laid out in Section 3.5.	**Partial**	**104-109**	Testing needed
31	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	**Partial**	**85-86,104-109**	Testing needed
32	The probe shall be released from the container when the CanSat reaches 500 meters.	**Comply**	**13**	
33	The probe shall deploy a heat shield after leaving the container.	**Comply**	**13**	
34	The heat shield shall be used as an aerobrake and limit the descent rate to 20 m/s or less.	**Comply**	**13, 44, 58**	
35	At 200 meters, the probe shall release a parachute to reduce the descent rate to 5 m/s +/- 1 m/sec.	**Comply**	**13, 44**	
36	Once landed, the probe shall upright itself.	**Comply**	**13, 59**	
37	After uprighting, the probe shall deploy a flag 500 mm above the base of the probe when the probe is in the upright position.	**Comply**	**13, 60**	
38	The probe shall transmit telemetry once per second.	**Comply**	**89**	
39	The probe telemetry shall include altitude, air pressure, temperature, battery voltage, probe tilt angles, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	**Comply**	**73-75**	
40	The probe shall include a video camera pointing down to the ground.	**Comply**	**17**	

Requirements Compliance (5/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
41	The video camera shall record the flight of the probe from release to landing.	Comply	17	
42	The video camera shall record video in color and with a minimum resolution of 640x480.	Comply	32-33	
44	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	73	
45	The probe shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	Comply	29, 73	
46	The probe shall have its time set to within one second UTC time prior to launch.	Comply	73-74	
47	The probe flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	Comply	89	
48	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude.	Comply	89-91	
49	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	76-77	
50	The ground station shall command the CanSat to start calibrating the altitude to zero when the CanSat is on the launch pad prior to launch.	Comply	76-77	

Requirements Compliance (6/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
51	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	73	
52	Telemetry shall include mission time with 1 second or better resolution.	Comply	73	
53	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	Comply	89	
54	Each team shall develop their own ground station.	Comply	99-100	
55	All telemetry shall be displayed in real time during descent on the ground station.	Comply	99	
56	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	73-75	
57	Teams shall plot each telemetry data field in real time during flight.	Comply	99	
58	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Comply	94, 96	
59	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	94, 96, 97	

Requirements Compliance (7/7)

Rqmnt Num	Requirement	Comply/ No Comply/ Partial	Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
60	The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Comply	100	
61	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	89	

Management

Quinlyn Scully

Status of Procurements (1/3)

First Ordering Process

Component	Order Date	Received Date
Feather HUZZAH32	01/31/2023	03/23/2023
BMP388	01/31/2023	03/23/2023
BNO055	01/31/2023	03/23/2023
SAM-M8Q	01/31/2023	03/23/2023
Adafruit SD+	01/31/2023	03/23/2023
Mini Spy Camera Adafruit ID: 3202	01/31/2023	03/23/2023
Buzzer: PS1240	01/31/2023	03/23/2023
Servo: FS90R	01/31/2023	03/23/2023
CanSat XBee	Reused	-
Ground Station Xbee	Reused	-
N-CHANNEL MOSFET	01/31/2023	Not Received
5V Regulator	01/31/2023	03/23/2023

Status of Procurements (2/3)

First Ordering Process

Component	Order Date	Received Date
3.3V Regulator	01/31/2023	03/23/2023
LED Sequins	01/31/2023	03/23/2023
SD/MicroSD Memory Card (8 GB SDHC)	01/31/2023	03/23/2023
Nylon Threaded Rod	01/31/2023	03/06/2023
Routing Eyebolt with Nut	01/31/2023	03/06/2023
Urethane Casting Compound	01/31/2023	03/06/2023
Carbon Fiber Rod	01/31/2023	03/06/2023
Carbon Fiber Square Tube	01/31/2023	Not Received
Batteries	01/31/2023	03/23/2023
Battery Holder	Reused	-
Nylon Parachute	01/31/2023	03/23/2023
PETG	01/31/2023	03/23/2023

Status of Procurements (1/2)

Second Ordering Process

Component	Order Date	Received Date
N-CHANNEL MOSFET	03/24/2023	In Progress
Carbon Fiber Square Tube	03/25/2023	03/29/2023

CanSat Budget – Hardware (1/3)

Component	Model	Quantity	Reusing	Unit Price	Total	Actual/Estimates /Budgeted	Source
Microcontroller	Feather HUZZAH32	1	No	$19.95	$19.95	Actual	Adafruit
Air Pressure and Temperature	BMP388	1	No	$9.95	$9.95	Actual	Adafruit
IMU	BNO-055	1	No	$29.95	$29.95	Actual	Adafruit
GPS and Real-Time Clock	SAM-M8Q	1	No	$42.95	$42.95	Actual	SparkFun
SD Card Writer	Adafruit SD+	1	No	$7.50	$7.50	Actual	SparkFun
Camera	Mini Spy Camera Adafruit ID: 3202	2	No	$12.50	$25.00	Actual	Adafruit
Buzzer	PS1240	1	No	$1.50	$1.50	Actual	Adafruit
Servo	FS90R	3	No	$7.50	$22.50	Actual	Adafruit
Subtotal				**$149.30**			

CanSat Budget – Hardware (2/3)

Component	Model	Quantity	Reusing	Unit Price	Total	Actual/Estimates /Budgeted	Source
CanSat XBee	XBP9B-DMWT-002	1	No	$62.08	$62.08	Actual	Digikey
Ground Station Xbee	XBP9B-DMST-002	1	No	$62.08	$62.08	Actual	Digikey
Mosfet	N-CHANNEL MOSFET	3	No	$2.25	$6.75	Actual	Adafruit
5V Regulator	5V 1.5A Linear Voltage Regulator	1	No	$0.75	$0.75	Actual	Adafruit
3.3V Regulator	3.3V 800mA Linear Voltage Regulator	1	No	$1.25	$1.25	Actual	Adafruit
LED	LED Sequins	1	No	$3.95	$3.95	Actual	Adafruit
SD Card	SD/MicroSD Memory Card (8 GB SDHC)	3	No	$9.95	$29.85	Actual	Adafruit
Nylon Threaded Rod	98831A360	1	No	$6.35	$6.35	Actual	McMaster-Carr
Subtotal				**$175.31**			

CanSat Budget – Hardware (3/3)

Component	Model	Quantity	Reusing	Unit Price	Total	Actual/Estimates /Budgeted	Source
Routing Eyebolt with Nut	9489T52	4	No	$7.88	$31.52	Actual	McMaster-Carr
Urethane Casting Compound	8644K53	1	No	$40.12	$40.12	Actual	McMaster-Carr
Carbon Fiber Rod	2153T15	6	No	$9.98	$59.88	Actual	McMaster-Carr
Carbon Fiber Square Tube	B09935SJZN	1	No	$13.99	$13.99	Actual	McMaster-Carr
Batteries	Surefire SF123A	24	No	$39.21	$39.21	Actual	Amazon
Battery Holder	BH123a	2	Yes	$1.23	$2.46	Actual	Digikey
Total				**$511.79**			

CanSat Budget – Other Costs

Component	Cost	Quantity	Actual/Estimates /Budgeted	Cost	Reuse
Travel (per person)	$116.69	9	Estimate	$1,050.21	
Lodging (per person)	$250.00	9	Estimate	$2,250.00	
Food (per person)	$166.69	9	Estimate	$1,500.21	
XBee Pro 900HP	$62.08	1	Estimate	$62.08	Yes
Prototyping Mechanical	$50.00	1	Estimate	$50.00	
Prototyping Electronics	$20.00	1	Estimate	$20.00	
Ground Station Laptop	$2,200.00	1	Estimate	$2,200.00	Yes
Yagi Antenna	$43.39	1	Actual	$43.39	Yes
CanSat Total Cost	$511.79	3	Actual	$1,535.37	
			Total	**$8,711.26**	

Program Schedule Overview

Obsidian Full Team Schedule

TASK	START	END
Obsidian		
Team Application	11/1/22	11/4/22
MCR	11/2/22	12/2/22
PDR Preparation	12/2/22	1/27/23
Finals	12/5/22	12/9/22
Winter Break	12/9/22	1/9/22
PDR Presentation	1/27/23	2/10/23
CDR Preperation	2/10/23	4/1/23
Spring Break	3/13/23	3/17/23
First Ordering Process (STATUS OF PROCUREMENTS)	1/31/23	3/23/23
Second Ordering Process (STATUS OF PROCUREMENTS)	3/24/23	4/7/23
CDR Presentation	4/1/23	4/14/23
Test Launch Phase	4/14/23	5/7/23
Environmental Test Review	4/15/23	5/19/23
Finals	4/24/23	4/28/23
Test Launch	5/1/23	5/7/23
Environmental Test Submission	5/19/23	5/26/23
FRR (Competition)	6/9/23	6/10/23
Post Flight Review (PFR)	6/11/23	6/11/23

Currently we are at an estimated 60% completion of the CanSat

Electrical Subteam Schedule

TASK	START	END	November					December				January					Feburary				March				April				May					June	
			01	08	15	22	29	06	13	20	27	03	10	17	24	31	07	14	21	28	07	14	21	28	04	11	18	25	02	09	16	23	30	06	13
Obsidian																																			
Electrical Subteam Tasks																																			
Trade Studies	11/1/22	11/14/22																																	
Surfacemounting and Mech. int.	11/1/22	11/24/22																																	
Block Diagram	11/14/22	11/24/22																																	
Schematic	11/20/22	12/2/22																																	
Design and Order Prototype PCB Board	11/20/22	2/1/23																																	
Parts Order	1/10/23	2/10/23																																	
Design and Order Second Prototype PCB Board	2/1/23	2/15/23																																	
Breadboarding (Section Components)	2/5/23	2/15/23																																	
Official PCB Order	2/15/23	3/1/23																																	
Protoboarding	3/5/23	4/14/23																																	
Complete Integration	4/14/23	4/23/23																																	

Detailed Program Schedule (2/3)

Software Subteam Schedule

TASK	START	END
Obsidian		
Software Subteam Tasks		
Research Sensor Libraries	11/21/22	12/2/22
BMP Altitude Code	11/21/22	12/2/22
BMP Temperature Code	11/21/22	12/2/22
Microcontroller Voltage Code	11/28/22	12/2/22
GPS Code	11/28/22	12/2/22
Gyroscope Tilt Code	11/28/22	12/2/22
Internal Telemetry Code	11/21/22	12/2/22
Packet Constructor Code	11/21/22	12/2/22
Packet Transmission Code	11/21/22	12/2/22
Breadboard Code Integration	2/5/23	2/15/23
Final Integration	4/14/23	4/23/23
Research Ground Station Language	11/1/22	11/11/22
Research How to Approach Front End	11/1/22	11/11/22
Research How to Approach Back End	11/1/22	11/11/22
Design Basic Front End Layout	11/12/22	11/19/22
Create Web Server	11/20/22	11/30/22
Create Labels for Static Vars	12/10/22	1/3/23
Create Graphs for Plotted Vars	12/10/22	1/3/23
Create Buttons for Commands	12/10/22	1/3/23
Implement GUI Elements onto Front End	1/4/23	1/15/23
Create Data Collector w/ Parser	1/16/23	1/24/23
Create Internal Data Storage for Back End	2/1/23	2/15/23
Create Generator for Testing Data Collector	11/12/22	12/5/22
Create CSV writer	11/12/22	11/16/22
Create Telemetry Communicator	1/27/23	2/15/23
Connect Front End w/ Back End	1/24/23	2/14/23
Set up Command Functions	2/15/23	2/28/23
Add general quality of life changes to UI	3/1/23	3/15/23

Mechanical Subteam Schedule

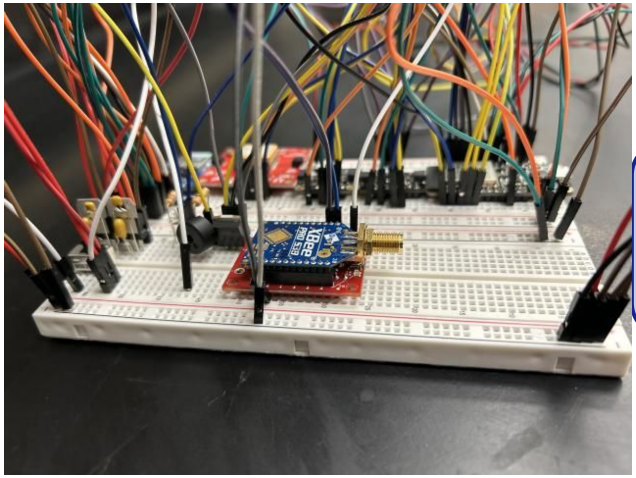
TASK	START	END
Obsidian		
Mechanical Subteam Tasks		
CAD Design First Design	11/1/22	11/21/22
Release Mechanism Final Decision	11/1/22	11/25/22
Flag Pole Design	11/1/22	11/15/22
Mass Budget	11/1/22	11/18/22
Servos decision	11/1/22	11/14/22
Heat Shield Design	11/4/22	11/21/22
Material Decision	11/12/22	12/2/22
Decent Calculations	11/14/22	11/26/22
MCR Presentation	11/14/22	11/28/22
Cansat Frame Building and Testing	11/21/22	1/31/23
Mechanical Ordering	11/21/22	2/15/23
Righting Mechanism building and testing	1/10/23	2/1/23
Parachute prototypes	1/10/23	2/1/23
Parts Order	1/10/23	2/10/23
Release Mechanism building and testing	1/24/23	2/15/23
1st Cansat Build Testing	2/15/23	4/3/23
Test Heat Sheild with Software	3/5/23	3/15/23
Test Flag with Software	3/6/23	3/16/23
Test releasing mechanism with Software	3/15/23	3/27/23
Second Cansat Build	4/3/23	4/14/23
HAR Presentation Work	4/6/23	4/14/23
Preperation for FRR	4/29/23	6/9/23

Shipping and Transportation

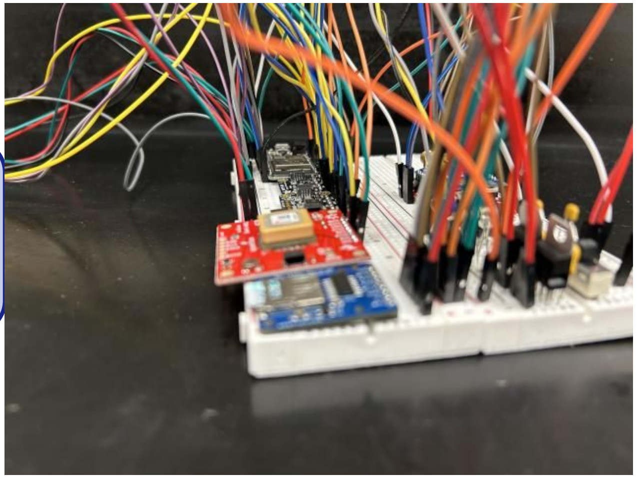
Transportation Plan
We are planning to drive to the competition from Huntsville, AL. All CanSat hardware will be stored in containers. We will place cushioning in the containers to prevent damage to any parts.
Checklist
Hardware includes the CanSat, Ground Station components, extra parts, tools and equipment, and launch day material. A checklist will be created and used to ensure all components are accounted for and in the vehicle.
After Arrival
Once we arrive, we will go over the ground station setup and CanSat preparation to ensure all systems work. In the case that they don’t, enough material will be brought make repairs or create a second CanSat.

Conclusions (1/4)

Electrical Subteam	
Major Accomplishments:	Designed and tested three different protoboard. We are currently ordering the fourth version to test with our sensors. We have also began breadboarding all of our sensors
Major Unfinished Work:	We do not have a final protoboard with fully functioning data lines.
Testing to Complete:	Electrical is testing their breadboards and prototype protoboards by using a multimeter. We are currently in the process of testing our datalines and power lines.



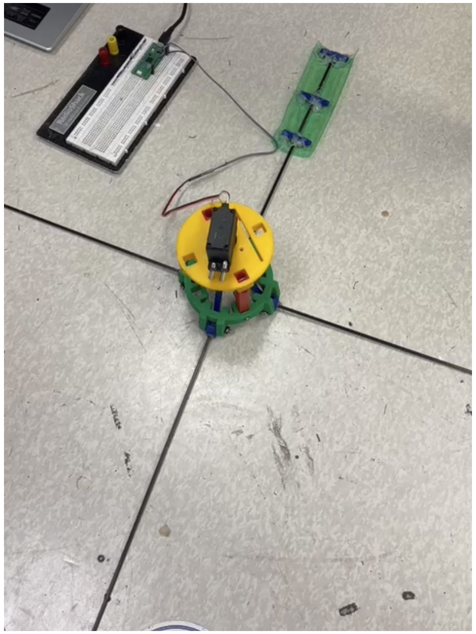
We have two pictures of our breadboarded sensors



Conclusions (2/4)

Mechanical Subteam	
Major Accomplishments:	We have functional release mechanism, the flag mechanism, and the uprighting mechanism. We prototyped multiple designs for the final version of the CanSat.
Major Unfinished Work:	We still have to create a parachute, finish the final construction of the CanSat, and create functioning shock absorbers.
Testing to Complete:	We need to test our CanSat's structural integrity of our frame. We also need to test our decent rates without parachute.

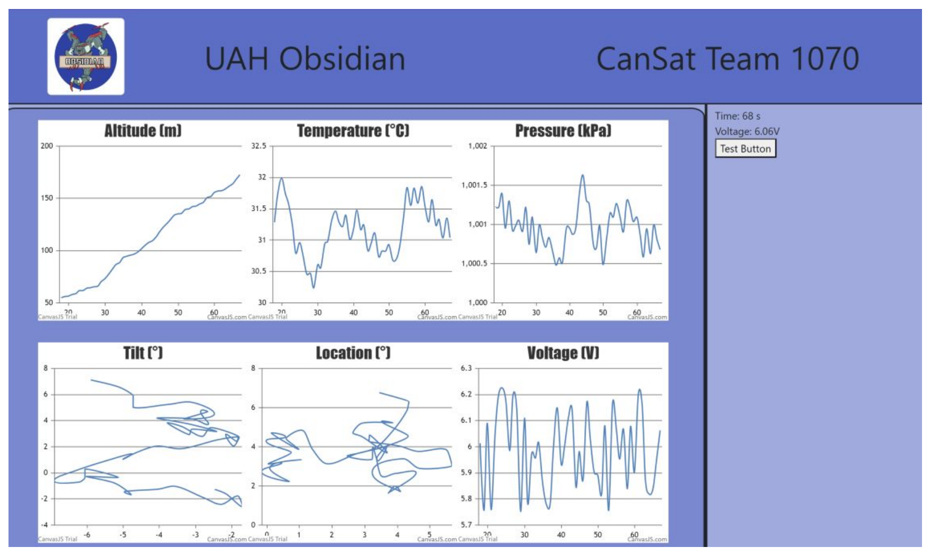
On the left, we have our CanSat in the stowed position. On the right we have our CanSat after it uprighted itself.



Conclusions (3/4)

Software Subteam	
Major Accomplishments:	We have a lot of the logic code done for the embedded software, the test generator and the data parser is complete, and we have a working ground station display and interface.
Major Unfinished Work:	We need to test our embedded software with the electrical subteam. We also need to integrate the backend code and the front end code.
Testing to Complete:	We need to test our code on the breadboard the electrical subteam is making.
Flight Software Status:	We are making good progress with the embedded code despite having delayed parts arrival. Ground station is almost done.

On the right, we have a picture of our prototype ground station display with randomly generated data.



Conclusions (4/4)

Full Team	
Major Accomplishments:	We have made good progress with our tasks and have been able to begin integrating between software, electrical, and mechanical. We have a working uprighting mechanism and working breadboards.
Major Unfinished Work:	We are still working on our final CanSat. We have to finish our code, finalize our breadboard, and finish the actual CanSat
Testing to Complete:	The biggest testing we have as a team will be on May 6th we will be having a practice launch to simulate the entire mission from the prelaunch to post launch. We will be launching our completed CanSat in a rocket to have a final test for our CanSat.
Flight Software Status:	We are making good progress with the embedded code despite having delayed parts arrival. Ground station is almost done.
Next Steps:	We are ready to continue with the next steps for the project because each subteam has made major progress individually and we are ready to continue with integration testing.

Does Anyone Have Any Questions?