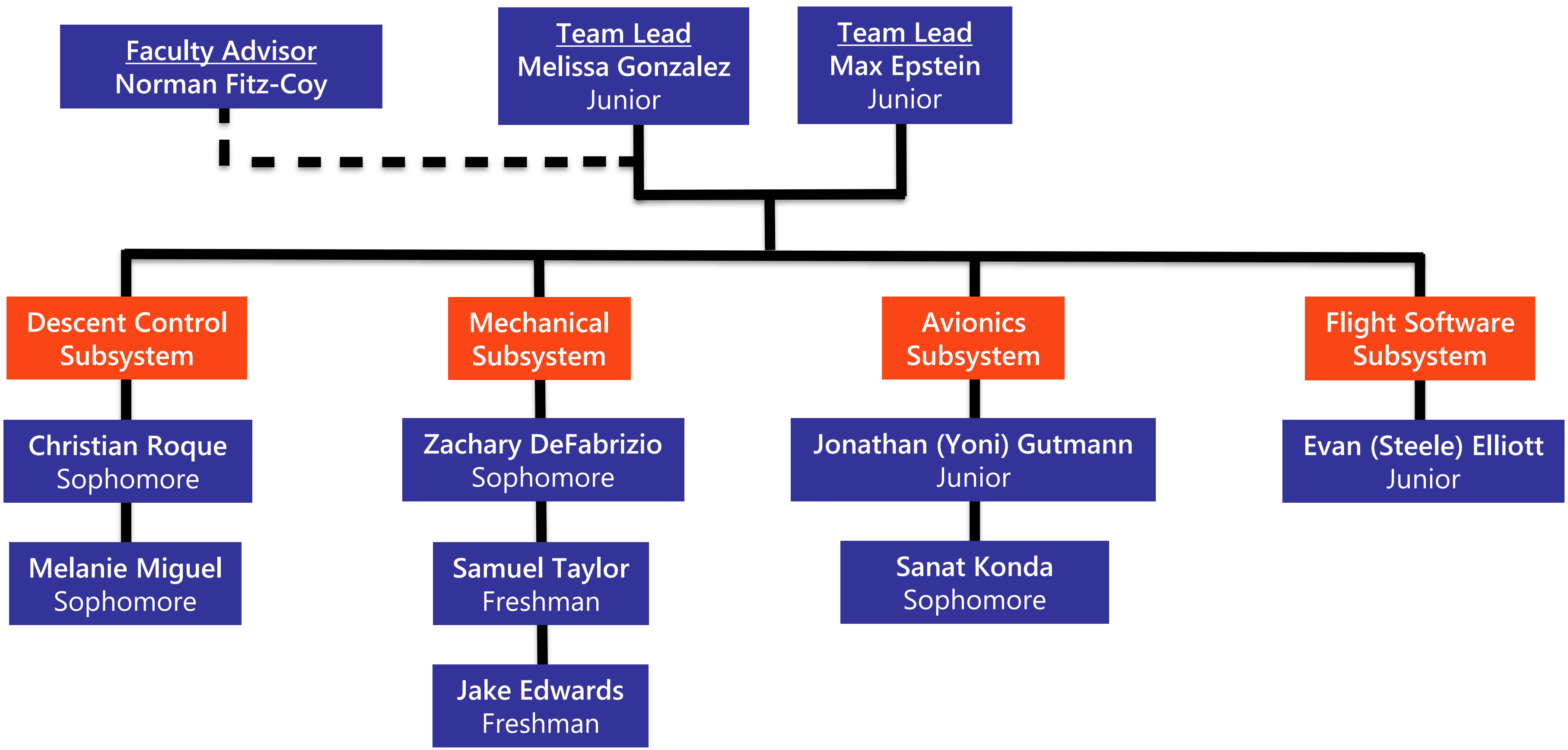
CanSat 2024
Critical Design Review (CDR)
Outline
Version 1.2

Team 2031

Eggsplorer 1

Presentation Outline

Team Organization



Acronyms

Acronym	Meaning
ABS	Acrylonitrile Butadiene Styrene
CD	Drag Coefficient
CDH	Communication and Data Handling
CSV	Comma-Separated Values
DAC	Digital-to-Analog Converter
EPS	Electrical Power Subsystem
FSW	Flight Software
GCS	Ground Control System
GPS	Global Positioning System
IDE	Integrated Development Environment
LED	Light-Emitting Diode

Acronym	Meaning
MAE	Mechanical & Aerospace Engineering
OTS	Off-the-shelf
PDR	Preliminary Design Review
PID	Proportional-Integral-Derivative
PWM	Pulse-Width Modulation
RPM	Revolutions per Minute
SMA	Subminiature Version A
SPI	Serial Peripheral Interface
SSDC	Space Systems Design Club
STEM	Science, Technology, Engineering, and Mathematics
UF	University of Florida

System Overview

Zachary DeFabrizio, Jake Edwards,
Max Epstein, Melissa Gonzalez

Main Objectives:

Design a CanSat that shall simulate a space probe entering a planetary atmosphere while carrying a delicate instrument.

- The CanSat shall act and operate as the nosecone during ascent
- The CanSat must survive the forces at launch and deployment
- The CanSat shall be launched to a maximum altitude of 725 meters above the launch site and deployed near apogee (peak altitude)
- The CanSat shall measure the speed of the rocket during both ascent and descent with a pitot tube
- The CanSat shall open an aerobraking heatshield which should have a descent rate of between 10 to 30 meters per second and not tumble
- At 100 meters, the CanSat shall detach the aerobraking heatshield and simultaneously release a parachute, reducing the descent to 5 meters per second or less
- The CanSat shall land with the egg intact
- The camera shall point in one direction and maintain that direction through the descent

Mission Summary (2/2)

Bonus Objective:

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

- We will not be attempting the bonus objective

External Objectives:

- To promote STEM engagement at the university level
- To provide team members with valuable hands-on engineering project experience that includes designing, manufacturing and testing of an aerospace system
- To challenge students with unique projects that require critical thinking
- To inspire underclassmen to continue participating in the annual CanSat competition at UF

Summary of Changes Since PDR

Changes	Reasoning
Decent Control – rotation control during descent	• Wanted to combat spinning during descent with parachute • Increased surface area of aerobraking heatshield to aid in descent control
Mechanical Subsystem – structural integrity	• Ran into various mechanical problems when constructing a prototype of the CanSat • During testing, various parts failed and lacked structural integrity

System Requirement Summary (1/7)

Requirement Number	Description
C1	The CanSat will act as the nose cone during the rocket's ascent portion of the flight.
C2	The CanSat shall be deployed when the ejection charge fires.
C3	After deployment, the CanSat shall deploy its heat shield/aerobraking mechanism.
C4	A silver or gold mylar streamer of 50 mm width and 1.5 meters in length shall be connected to the CanSat and released at deployment, used to locate and identify the CanSat.
C5	At 100 meters, the CanSat shall deploy a parachute and release the heat shield.
C6	Upon landing, the CanSat shall stop transmitting data.
C7	Upon landing, the CanSat shall activate and audio beacon.
C8	The CanSat shall carry a provided large hen's egg with a weight between 51 and 65 grams.
C9	0 altitude reference shall be at the launch pad
C10	During descent with the heat shield deployed, the descent rate shall be between 10 and 30 m/s.
C11	At 100 meters, the CanSat shall have a descent rate of less than 5 m/s.
C12	Total cost of the CanSat shall be below $1000. Ground support and analysis equipment are not included in this cost. Equipment from previous years shall be included at current market price.

System Requirement Summary (2/7)

Requirement Number	Description
S1	The CanSat mass shall be 900 grams +/- 10 grams without the egg.
S2	The nose cone shall be symmetrical along the thrust axis.
S3	The nose cone radius shall be exactly 71 mm.
S4	The nose cone shoulder radius shall be exactly 68 mm.
S5	The nose cone shoulder length shall be a minimum of 50 mm.
S6	CanSat structure must be able to survive 15 Gs vibration.
S7	CanSat shall must survive 30 Gs shock.
S8	The CanSat shall perform the function of the nose cone during rocket ascent.
S9	The rocket airframe can be used to restrain any deployable parts of the CanSat, but shall allow the CanSat to slide out of the payload section freely.
S10	The rocket airframe can be used as part of the CanSat operations.
S11	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.

System Requirement Summary (3/7)

Requirement Number	Description
M1	No pyrotechnical or chemical actuators are allowed.
M2	Mechanisms that use heat shall not be exposed to the outside environment to reduce risk of setting the vegetation on fire.
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.
M4	Spring contacts shall not be used for making electrical connections to batteries as shock forces can case momentary disconnects.
M5	The CanSat shall deploy a heat shield after deploying from the rocket.
M6	The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.
M7	At 100 meters, the CanSat shall release a parachute to reduce the descent rate to less than 5 m/s.
M8	The CanSat shall protect a hen's egg from damage during all portions of the flight.
M9	If the nose cone is to be considered part of the heat shield, the documentation shall identify the configuration.
M10	After the CanSat has separated from the rocket, and if the nose cone portion of the CanSat is to be separated from the rest of the CanSat, the nose cone portion shall descent at less than 10 m/s using any type of descent control device.

System Requirement Summary (4/7)

Requirement Number	Description
E1	Lithium polymer batteries are not allowed.
E2	Battery source may be alkaline, Ni-Cad, NiMH or Lithium. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.
E3	The power switch must be easily accessible.
E4	There must be a power indicator.
E5	The CanSat shall operate for a minimum of two hours when integrated into the rocket.
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series in addition to 900 MHz Series are allowed.
X2	XBEE radios shall have their NETID/PANID set to their team number.
X3	XBEE radios shall not use broadcast mode.
X4	The CanSat shall transmit telemetry once per second.
X5	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, tilt angles, air speed, command echo, and GPS coordinates which include latitude, longitude, altitude, and number of satellites.

System Requirement Summary (5/7)

Requirement Number	Description
SN1	CanSat shall measure its speed with a pitot tube during both ascent and descent.
SN1	CanSat shall measure its altitude using air pressure.
SN3	CanSat shall measure its internal temperature.
SN4	CanSat shall measure its angle stability with the aerobraking mechanism deployed.
SN5	CanSat shall measure its rotation rate during descent.
SN6	CanSat shall measure its battery voltage.
SN7	The CanSat shall include a video camera pointing horizontally.
SN8	The video camera shall record the flight of the CanSat from launch to landing.
SN9	The video camera shall record video in color and with a minimum resolution of 640x480.

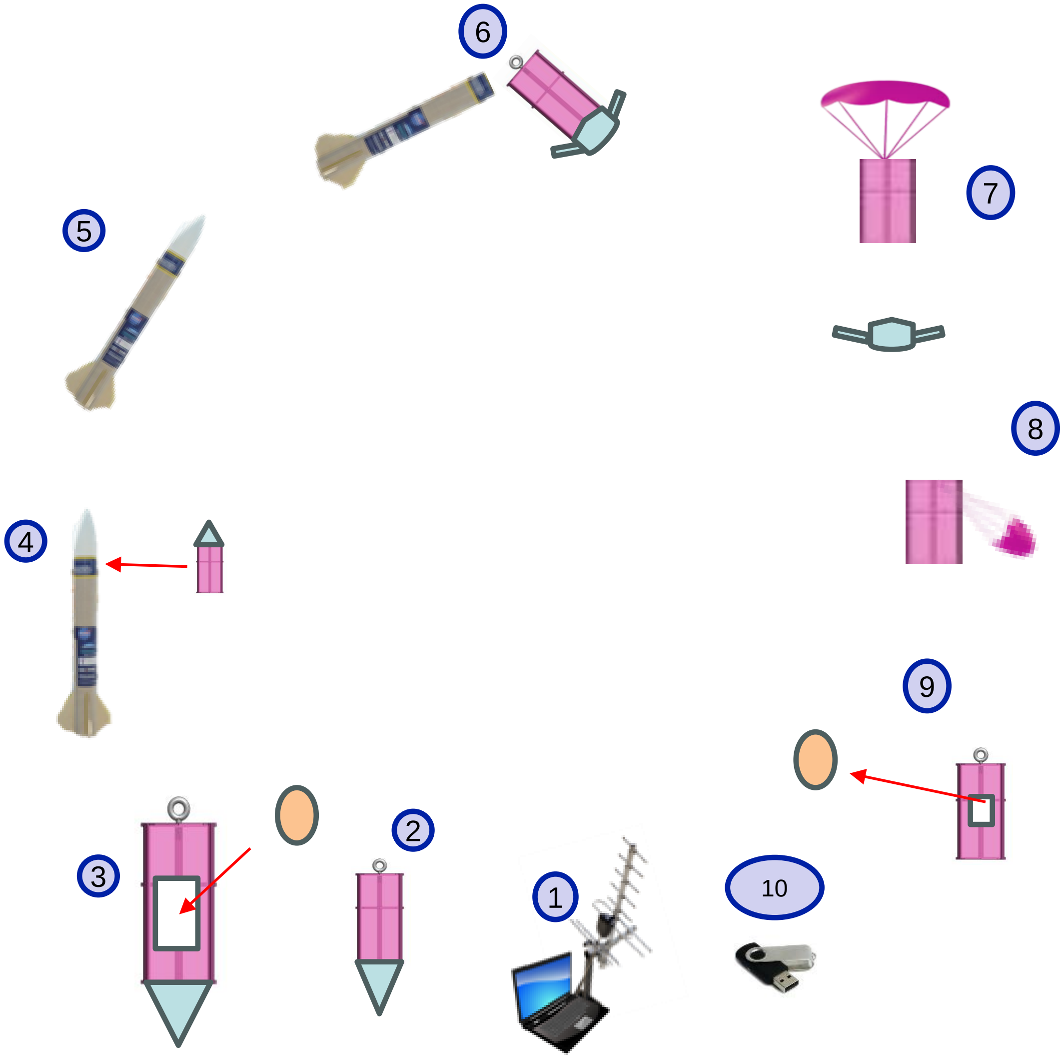
System Requirement Summary (6/7)

Requirement Number	Description
G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.
G3	Telemetry shall include mission time with 1 second or better resolution.
G4	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.
G5	Each team shall develop their own ground station.
G6	All telemetry shall be displayed in real time during descent on the ground station.
G7	All telemetry shall be displayed in engineering units and the units shall be indicated on the displays.
G8	Teams shall plot each telemetry data field in real time.
G9	The ground station shall include one laptop computer with a minimum of two hours battery operation, XBEE radio, and an antenna.
G10	The ground station must be portable so that the team can be positioned at the ground station operation site along the flight line. AC power will be not available.
G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.

System Requirement Summary (7/7)

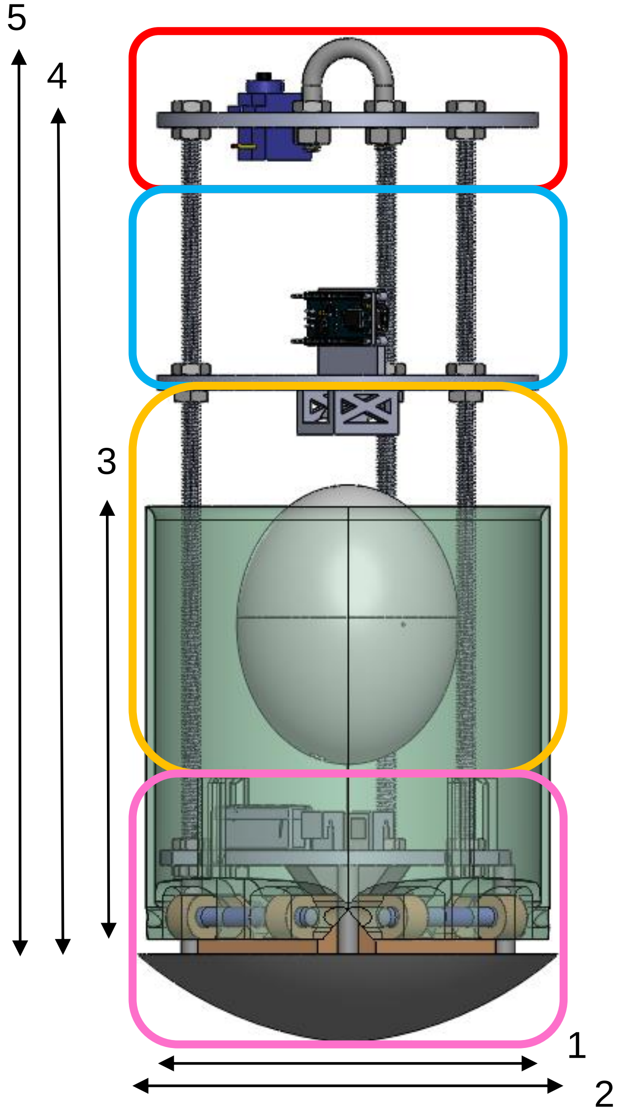
Requirement Number	Description
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at 1 Hz interval to the CanSat.
G13	The ground station shall use a table top or handheld antenna.
G14	The displays on the ground station shall be designed with larger fonts (14pt minimum), bold plot traces and axes, and dark text on a light background since the ground station will be viewed in bright sundlight.
G15	The ground system shall count the number of received packets. This is not the number of transmitted packets but the number of packets successfully received at the ground station.
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission through the mission. This value shall be maintained through processor resets.
F2	The CanSat shall maintain mission time throughout the whole mission regardless of processor resets or power loss.
F3	The CanSat shall have its time set to within one second UTC time prior to launch.
F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.
F5	In simulation mode, the flight software shall use the radio uplink pressure values I place of the pressure sensor for determining the payload altitude.
F6	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVE commands.

System Concept of Operations (CONOPS)



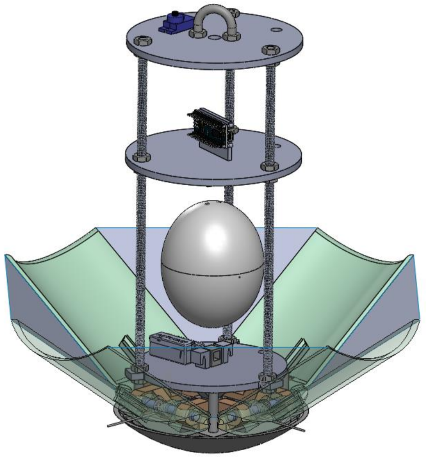
1. Set up ground station.
2. Power on CanSat.
3. Egg is placed inside compartment and loaded into CanSat.
4. Place CanSat into rocket.
5. Rocket is launched.
6. At maximum altitude of 725 m, CanSat is ejected from the rocket the heat shield is immediately deployed and aerobraking starts. Descent is slowed to 10-30 m/s.
7. At 100 m heat shield/aerobrake is detached and the parachute is deployed decreasing the descent to <5 m/s.
8. CanSat will land upright.
9. Recovery crew tracks and collects CanSat and intact egg.
10. FSW obtains and saves flight data & video recording thumb drive.

CanSat Physical Layout



Red: Parachute Deployment
Blue: Avionics Bay
Yellow: Egg Protection Bay
Pink: Heat Shield and Deployment

Basic Dimensions
1: Shoulder Width - 136 mm
2: Nose Cone Diameter - 142 mm
3: Shoulder Length - 146 mm
4: 283.78 mm
5: 308.78 mm

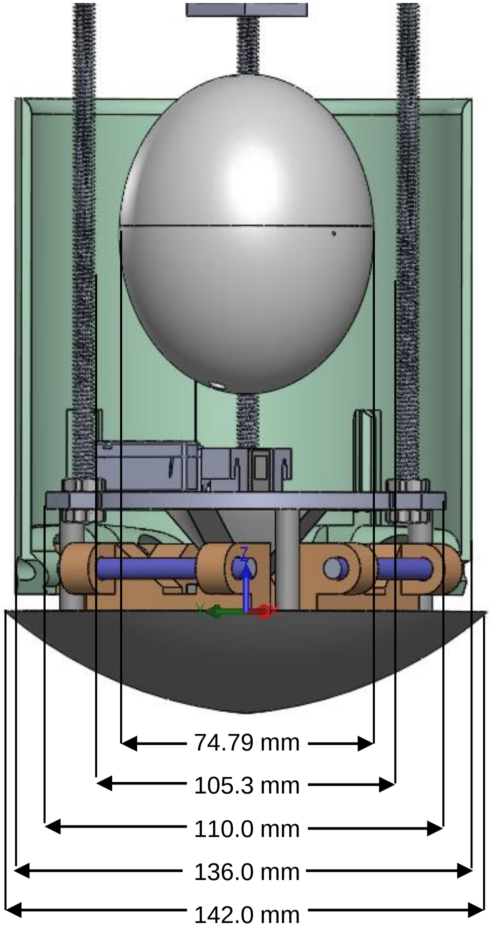


Deployment configuration. Grey panels are mylar fabric

Total Mass 903.67 g

Launch Vehicle Compatibility

Sharp protrusions and corners will be sanded down.



Sensor Subsystem Design

Jonathan (Yoni) Gutmann

Sensor Subsystem Overview

Sensor Type	Model	Purpose	CanSat Location
GPS module	Adafruit Ultimate	Determine location coordinates (X,Y,Z) & exact time	Payload
Pressure Sensor	Adafruit BMP280	Measure altitude of Container & Payload	Payload
Rotational Sensor	BNO055	Measure gyro readings in degrees per second, angular acceleration, and magnetometer readings in gauss	Payload
Temperature Sensor	Adafruit BMP280	Measure temperature readings	Payload
Camera	ESP-32	View and record Earth's terrain during descendent	Payload
Wind Speed Sensor	PX4	Measure air speed differential	Payload

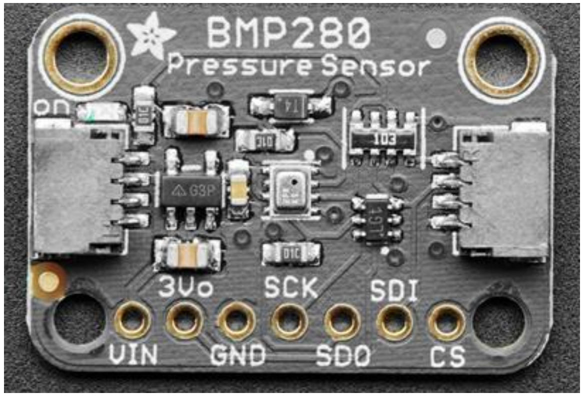
Sensor Changes Since PDR

- **No changes have been made since the PDR**

Payload Air Pressure Sensor Summary

Sensors	Current (at 1Hz) (µA)	Temperature Range (°C)	Interfaces	Resolution (hPa)	Voltage Usage (V)	Size (mm) L x W x H	Weight (g)	Price ($)
Adafruit MPRLS	3.6	-40 to 85	I2C, SPI	.30	1.65 ~ 3.6	17.8 x 16.7 x 7.5	1.1	14.95
Adafruit BMP280	2.7	-40 to 85	I2C, SPI	.0016	1.71 ~ 3.6	19.2 x 17.9 x 2.9	1.3	9.95
MPL3115A2	8.5	-40 to 85	I2C	.015	1.95~ 3.6	18 x 19 x 2	1.2	9.95

Selection	Reasoning for the selection
Adafruit BMP280	- Lower current draw in comparison to other inspected sensors - Greater resolution in comparison to other inspected sensors - Previous familiarity with the sensor - Also satisfies as our temperature sensor



Payload Air Temperature Sensor Summary

Sensors	Current (at 1Hz) (µA)	Temperature Range (°C)	Interfaces	Resolution (hPa)	Voltage Usage (V)	Size (mm) L x W x H	Weight (g)	Price ($)
Adafruit MPRLS	3.6	-40 to 85	I2C, SPI	.30	1.65 ~ 3.6	17.8 x 16.7 x 7.5	1.1	14.95
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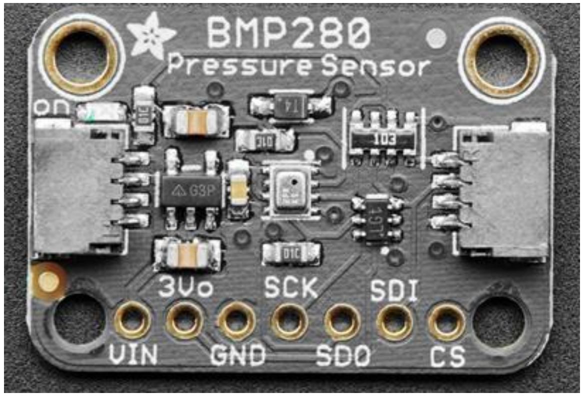
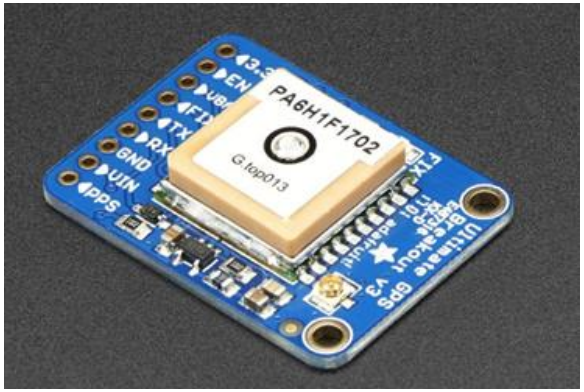


Payload GPS Sensor Summary

Sensors	Update Rate (Hz)	Operating Voltage (V)	Current (Tracking) (mA)	Interfaces	Size (mm) L x W x H	Weight (g)	Price ($)
Adafruit Ultimate Breakout v3	10	3.0 – 5.0	20	I2C, SPI, UART	25.5 x 35 x 6.5	8.5	29.95
uBlox NEO M8N	10	2.7 – 3.6	23	I2C, SPI, UART	27.6 x 26.6 x 2.4	9.8	11.59
Titan X1	10	3.0 – 4.3	25	I2C, SPI, UART	12.5 x 12.5 6.5	4	69.84

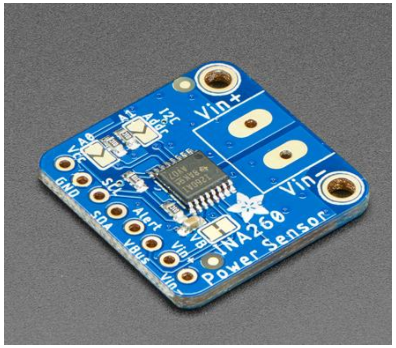
Selection	Reasoning for the selection
Adafruit Ultimate	- Lower current draw during tracking in comparison to other inspected sensors - Previous experience with sensor and familiarity with Arduino - Availability



Payload Voltage Sensor Summary

Sensors	Resolution	Interfaces	Size (mm) L x W x H	Weight (g)	Price ($)
Adafruit INA219	12 bit	I2C	25.6 x 20.4 x 4.7	4.6	9.95
Adafruit INA260	16 bit	I2C	22.9 x 22.8 x 2.7	2	9.95
Precision LM4040	12 bit	I2C	16 x 12.5 x 2.5	0.7	7.50

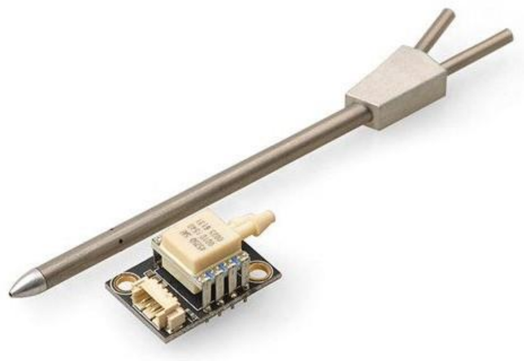
Selection	Reasoning for the selection
Adafruit INA260	- Greater resolution bit compared to other sensors - Previous experience and familiarity with sensor - Availability



Speed Sensor Summary

Sensors	Resolution	Interfaces	Size (mm) L x W x H	Weight (g)	Price ($)
PX4 Differential Air Speed	12 bit	I2C	100x15	16	55.88
PT60	12 bit	I2C	110 x 9.8	14.1	48.99

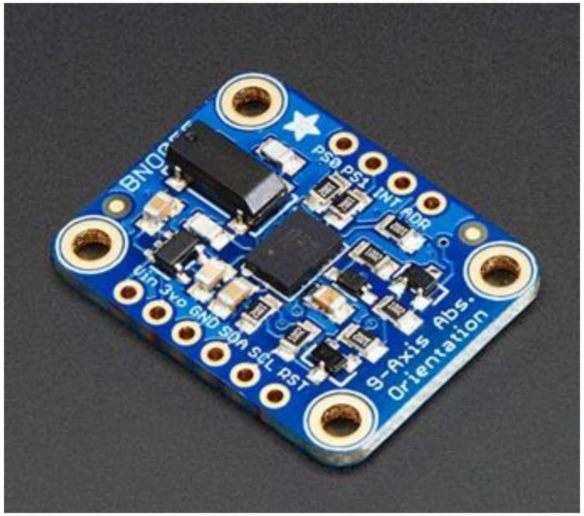
Selection	Reasoning for the selection
PX4 Differential Air Speed	- More advantageous regarding budget - Microcontroller friendly - Speedy shipping



Payload Tilt Sensor Summary

Sensors	Temperature Range (°C)	Interfaces	Voltage Usage (V)	Size (mm) L x W x H	Weight (g)	Price ($)
HTU31 Temperature & Humidity Sensor	-40 to 125	I2C	3.3 – 5.5	25.5 x 17.7 x 4.6	1.6	6.95
BNO055	-40 to 85	I2C or UART	1.7 – 3.6	20 x 27 x 4	3	34.95
Sensirion SHT31-D	-40 to 125	I2C	2.4 – 5.5	12.7 x 18 x 2.6	0.8	13.95

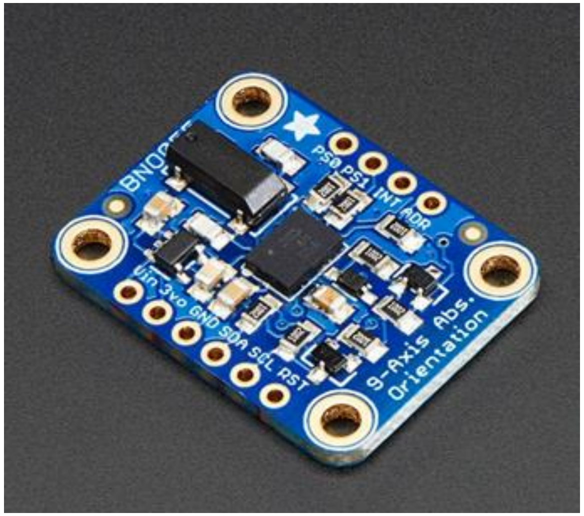
Selection	Reasoning for the selection
BNO 055	- Familiarity with sensor - Compatibility with microcontroller - Availability



Payload Rotation Sensor Summary

Sensors	Temperature Range (°C)	Interfaces	Voltage Usage (V)	Size (mm) L x W x H	Weight (g)	Price ($)
HTU31 Temperature & Humidity Sensor	-40 to 125	I2C	3.3 – 5.5	25.5 x 17.7 x 4.6	1.6	6.95
BNO055	-40 to 85	I2C or UART	1.7 – 3.6	20 x 27 x 4	3	34.95
Sensirion SHT31-D	-40 to 125	I2C	2.4 – 5.5	12.7 x 18 x 2.6	0.8	13.95

Selection	Reasoning for the selection
BNO 055	- Familiarity with sensor - Compatibility with microcontroller - Availability - Also used as tilt sensor



Camera Summary

Name	Price ($)	Weight (g)	Size (mm)	Operating Voltage (V)	Current Draw (mA)	Framerate (fps)
Miniature TTL Serial JPEG Camera	34.95	3	20 x 28	3.3 - 5.0	75	30
Arducam Mini 2MP Plus	25.99	20	24 x 34	3.3 - 5.0	20	15
ESP-32	18.49	28	90 x 55 x 37	4.75V-5.25V	310	30

Selection	Reasoning for the selection
ESP-32	- Records at a resolution of 480p at 30fps (meets requirements) - Readily available - SD card slot is built-in and video storage is easily configurable

Bonus Camera Summary

- **The bonus is not being attempted**

Descent Control Design

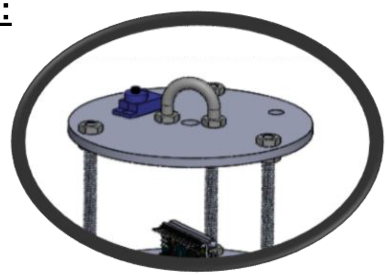
Zachary DeFabrizio, Melanie Miguel,
Christian Roque, Samuel Taylor

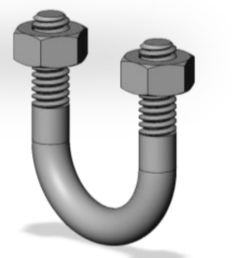
<u>Container Descent Control System:</u>

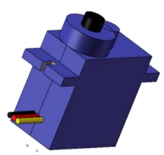
System: Aerobraking Heat Shield
+ Parachute

System Components:

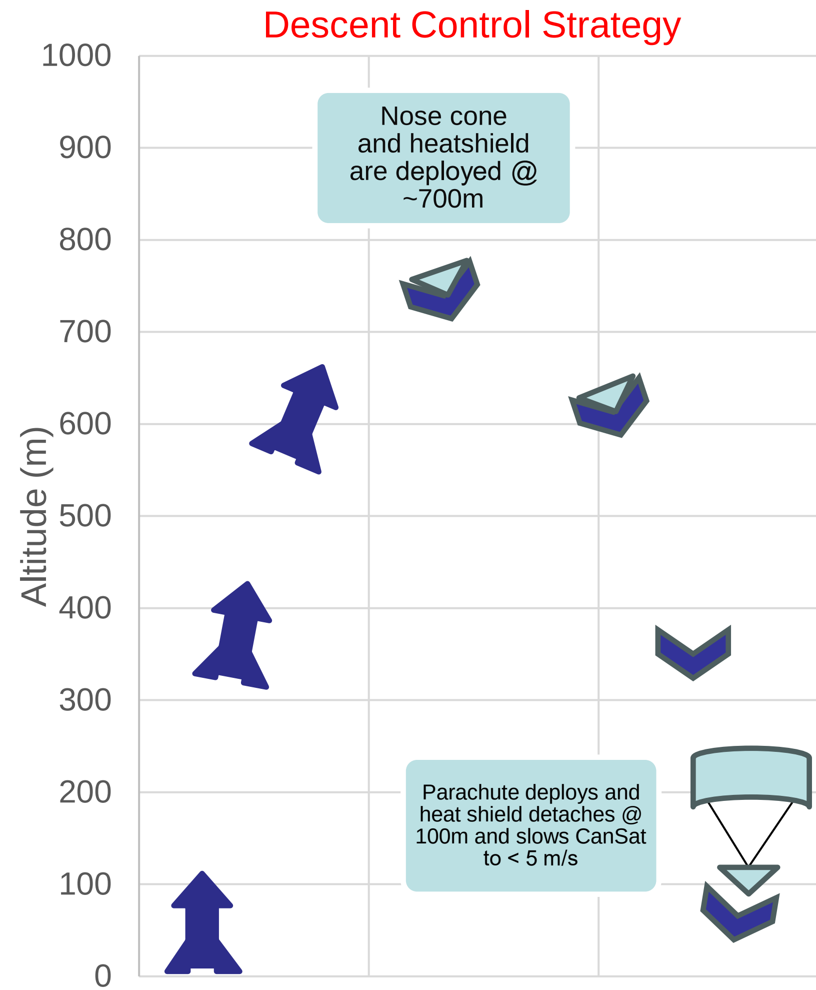
- U-bolt and swivel hook
- TARC Hexagonal Parachute with Spill Hole
- Nylon Parachute Chords
- Servo Motor
- Rubber Band







System Overview: A U-bolt is attached to the base of the nose cone on a section separating the parachute system from the other nosecone components. A swivel hook is then attached to allow the parachute to move separate from the CanSat. The parachute will stay on top of the plate tied tightly to the eyebolt. A rubber band holds the parachute together, against the plate and is looped off the side to the end of the servo motor. The servo is attached to the opposite side of the plate. When the desired altitude is achieved, the servo will retract forcing the rubber band to release quickly along with the parachute.



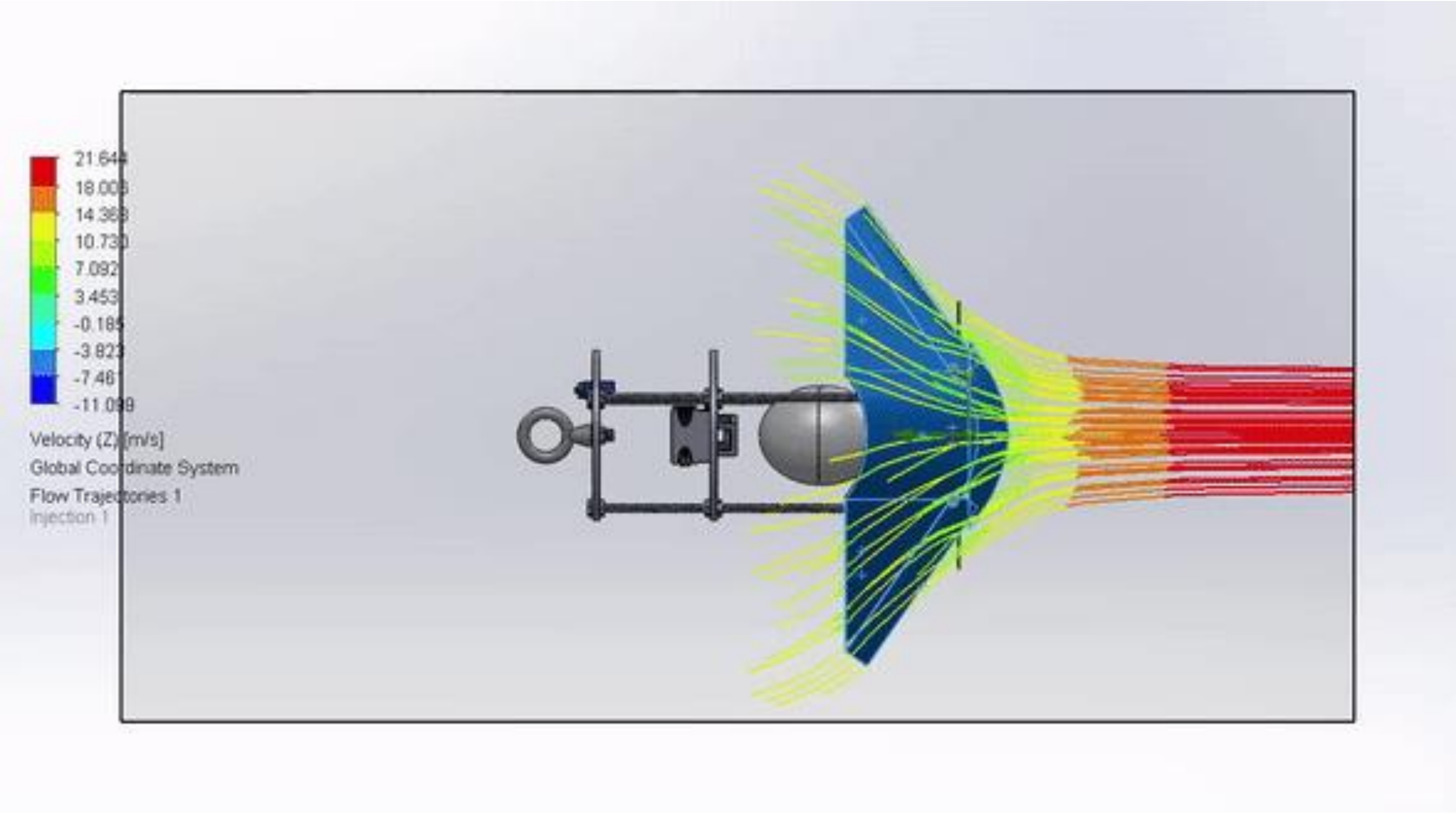
Descent Control Changes Since PDR

Changes	Reasoning
Remodeling of the hinged heatshield, increased size/thickness	• During testing the old heatshield hinges broke during deployment • During deployment, the heatshield would interfere with the nose cone
Reworked the nose cone to increase the stability of the CanSat, added additional support structures	• Old nose cone lacked sufficient contact points to provide stability throughout the CanSat
Changed parachute attachment mechanism to swivel hook	• Decided to switch the parachute attachment to combat spinning during decent • Old model was static and had no ability to prevent spinning

Payload Aerobraking Descent Control Hardware Summary (1/2)

Aerobraking	
System	Torsion hinge shield
System Components	Torsion hinges
	Nose cone
	Spring system which releases the hinges into place
	Shield flaps
	Mylar fabric for the heatshield
System overview	We chose the rounded top cone shape in order to get the maximum surface area while also allowing for a controlled decent
	The 45° angle was chosen because it allows for the necessary surface area to slow the CANSAT down to optimal speed, but also allows for there to still be enough downward velocity to stop tumbling
	The spring system compresses shield flaps during payload storage. Upon deployment, the shield fold outward to enlarge the nose cone, forming a truncated circular cone at 45-degree angle using the mylar fabric that increases drag
Key design considerations	Stability control and reliability
Testing	Heat shield deployment testing

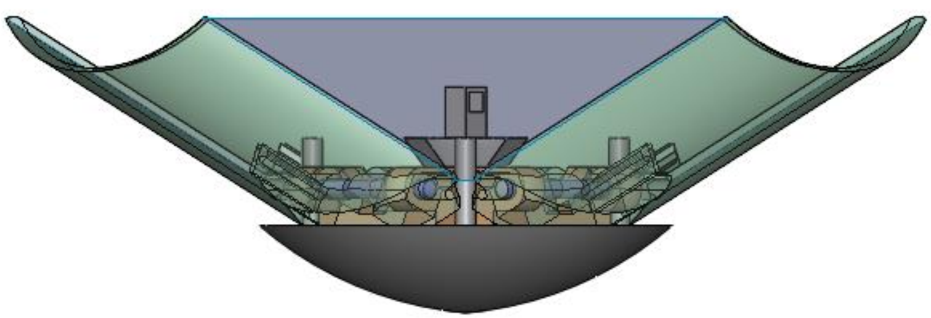
Payload Aerobraking Descent Control Hardware Summary (2/2)



Simulation of airflow on the CanSat done using SolidWorks.

Payload Descent Stability Control Design

Mechanisms Used	Staying Nadir	Stability Control Method
Variable Angle Heatshield Bottom-Heavy CanSat Design Swiveling parachute	Our CanSat will be kept Nadir through its bottom-heavy design and variable angle heat shield. Once deployed, the heatshield will passively ensure the CanSat's stability. This mechanism, along with the bottom-heavy design, will provide a well-balanced decent while nadir	Passive, bottom heavy design

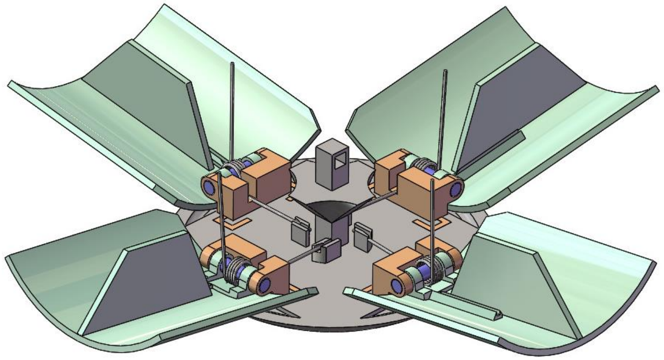


Payload Rotation Control Strategy

Utilizing fins on the interior of the shields to help stop rotation around the Z axis by restricting the flow of air as it falls

The fins located on the interior of the heat shield stop air from rotating the CanSat as it falls towards the ground.

By putting the fins farther away from the center of mass we can generate a greater torque.



Payload Parachute Descent Control Hardware Summary (1/2)

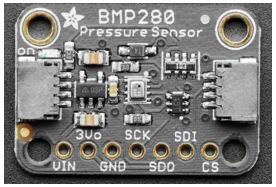
Payload Descent Control – Parachute	Description
System	Parachute
System components	TARC hexagonal parachute with spill hole
	4 nylon parachute cords
	Aluminum U-bolt and swivel hooks
	Servo Motor (and arm)
	Rubber bands
	BMP280 Sensor
Parachute sizing	30” diameter (0.762 m)
	7 ¼” x 1”= 5.69”^3 packing
	3” Spill hole
Parachute color	Black and orange
U-bolt sizing	1 ¼ “ height and 1” width
	¼” – 20 threads
Key design characteristics	Components are secured to the CanSat and release is kept relatively simple with low chance of error. Components can fit in the payload and allows for separate dynamic movement from payload.
Parachute Color	Black and orange

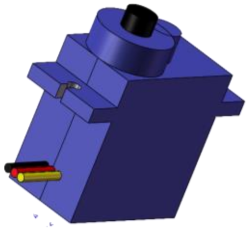
Payload Parachute Descent Control Hardware Summary (2/2)

Active Components	Description
BMP280 Sensor	Measures the altitude/distance from the ground of the Earth and will allow for the servo motor to release the parachute
Servo Motor	Provides rotational motion with arm to unhook the rubber band that ties the parachute to the rest of the payload
Overview	Parachute is secured to the payload with both a U-bolt connected to the payload and swivel hooks connected to the parachute cords and the U-bolt. When the desired altitude of ~100m is achieves, the servo motor will allow the arm to rotate to unhook the rubber band and release the parachute.

<GPS_ALTITUDE>	GPS altitude coordinate in decimal degrees (+/- 0.1 m from sea level)

BMP280 Sensor





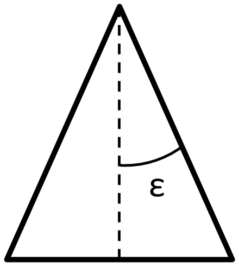
Arduino Servo Motor

Descent Rate Estimates (1/2)

Discussion

- Drag coefficient of parachute based on information provided by the vendor and heatshield drag coefficient determined through research
- According to calculations, once the heatshield is at terminal velocity, it's arms should form no less than a 45˚ half-vertex angle
- Weight of the nosecone may vary if further drop testing shows that a lower center of mass is required.
- All parameters used are to simulate maximum and harshest conditions

ε = half-vertex angle



Formulas Used:

$$v_t = \sqrt{\frac{2mg}{\rho A C_d}}$$

$$\Delta x = v_0 t + \frac{1}{2} a t^2$$

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

$$T = 518.67 - 0.003567h\,^\circ\mathrm{R}$$

$$\rho = \rho_0 \left(\frac{T}{T_0}\right)^{-\frac{g}{a_0 R} - 1}$$

Descent Rate Estimates (2/2)

Decent Rate Estimates for the following Configurations

Configuration	Device	Desired Rate	Decent Rate Estimate	Method of Calculation
Payload with heatshield	Aerobraking	10 m/s - 30 m/s	< 17.432 m/s	Terminal velocity calculations
Payload without heatshield	Parachute	Less than 5 m/s	< 4.129 m/s	Parachute calculations
Heatshield only	Aerobraking	Less than 10 m/s	< 9.760 m/s	Terminal velocity calculations

Assumptions

- **Heatshield weight is 377.2 grams**
- **Total weight is 975 grams or less**
- **Cd ≈ 0.75 of a 3D cone with 45° half vertex**
- **Standard atmospheric model used**
- **Estimated altitude range: 634m – 1359m**
- **Estimated air density range: 1.03588kg/m^3 - 1.11308 kg/m^3**
- **Estimated air density @ 100m above ground = 1.10219 kg/m^3**

Mechanical Subsystem Design

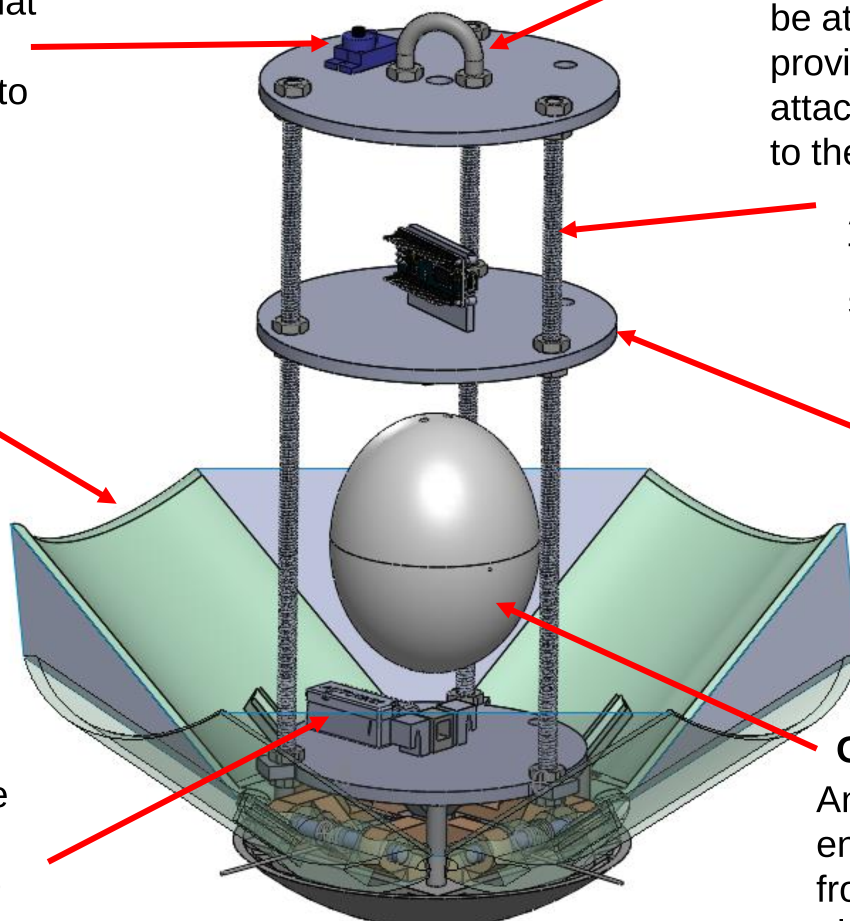
Zachary DeFabrizio, Jake Edwards, Melissa Gonzalez, Jonathan (Yoni) Gutmann, Melanie Miguel, Christian Roque, Samuel Taylor

Mechanical Subsystem Overview

Servo Motor:
Attached to a nylon cord that holds the parachute to the CanSat. Can be activated to release the parachute.

Parachute Attachment:
An aluminum U-bolt that will be attached to a swivel that provides a physical attachment from the CanSat to the parachute.

Aluminum threaded rod:
Threaded rods that provide structural integrity along with layer adjustments.



Torsion Hinged Heatshield:
Four ABS shields rest inside the shoulder of the rocket before separation. After separation, torsion springs open rotating the shields outward increasing the drag force on the CanSat.

ABS platforms:
Circular ABS platforms that allow for the placement of electronics and the mounting of the egg capsule.

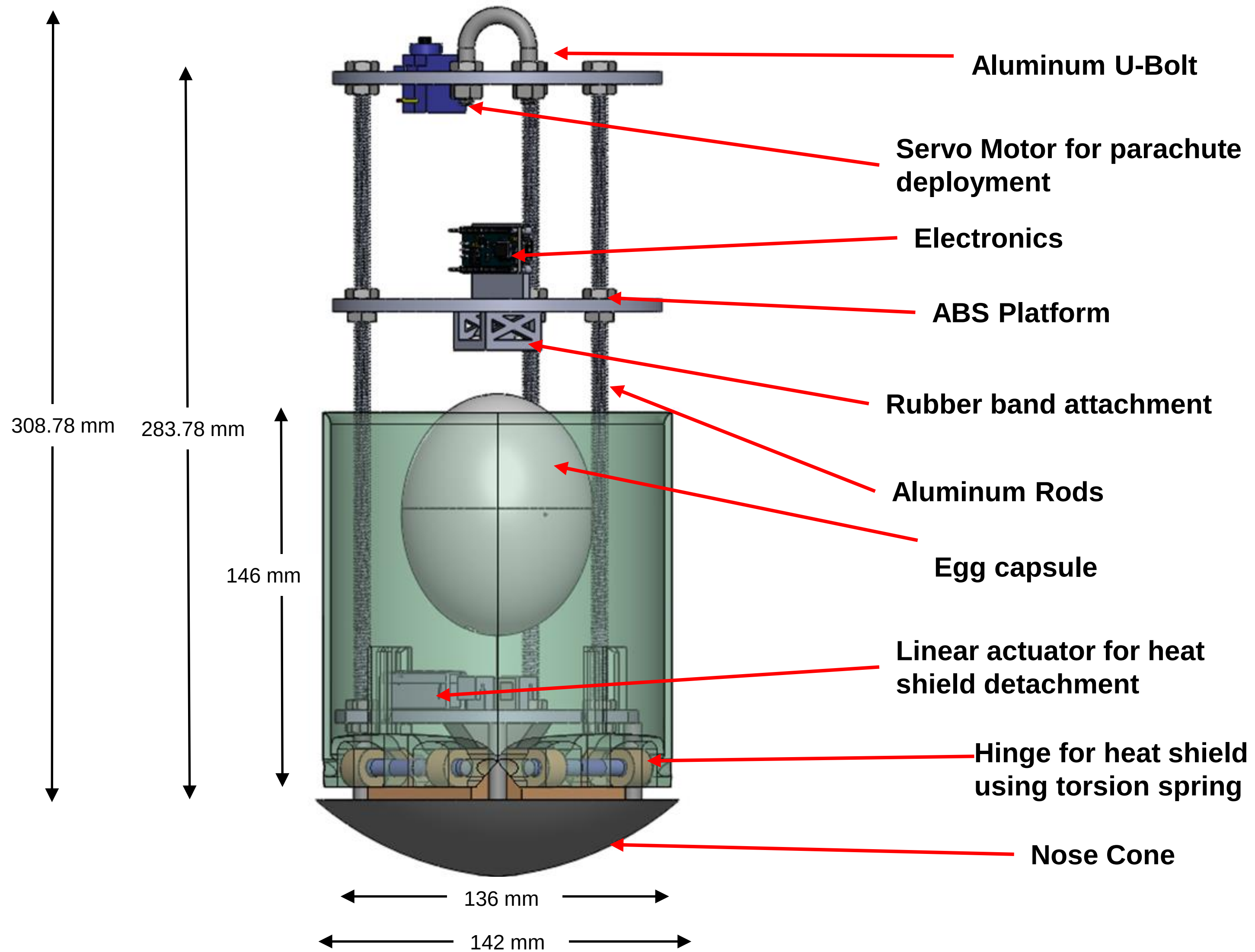
Linear Actuator:
Attaches the Heatshield to the rest of the CanSat when deployed. Can be retracted to release heatshield at desired altitude.

Oval shaped egg capsule:
An ABS container that encapsulates the egg. Suspended from the bottom and middle platform with elastic bands as shock resistance.

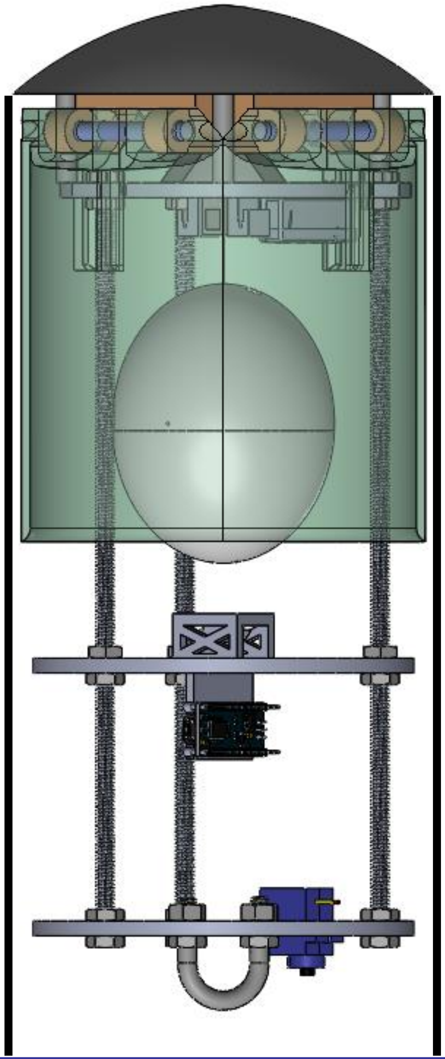
Mechanical Subsystem Changes Since PDR

- Nosecone hinges redesigned to be more structurally sound
- Heatshield plates redesigned to be more structurally sound and have larger surface area.
- Hinge rods made longer and thicker
- Nose cone has extra support beams for stabilization
- Bottom plate remodeled to not collide with hinge mechanism
- Parachute attachment redesigned to prevent spinning

Payload Mechanical Layout of Components



Payload Aerobraking Pre Deployment Configuration



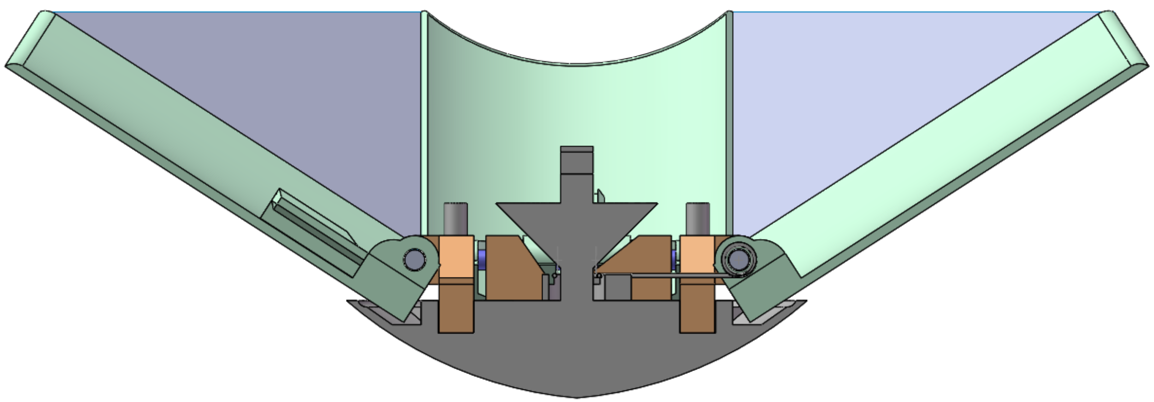
Heat shield panels exert force on inside of rocket keeping it in place. All parts are secured to the payload.

Heat shield panels are compressed by inside of rocket and deploy by spring force after ejection.

Payload Aerobraking Deployment Configuration

The springs are leveraged against the walls of the rocket. Once the payload launches out of the CanSat, the springs will force the shields to push outward at a 45° angle along with Mylar between each shield.

No changes have been made to the Aerobraking Deployment Configuration

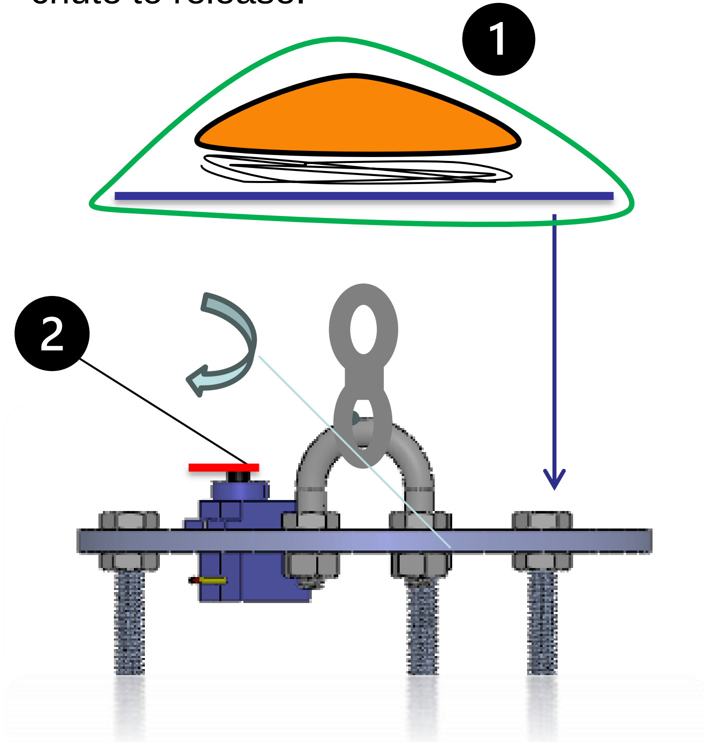


Camera Pointing Control

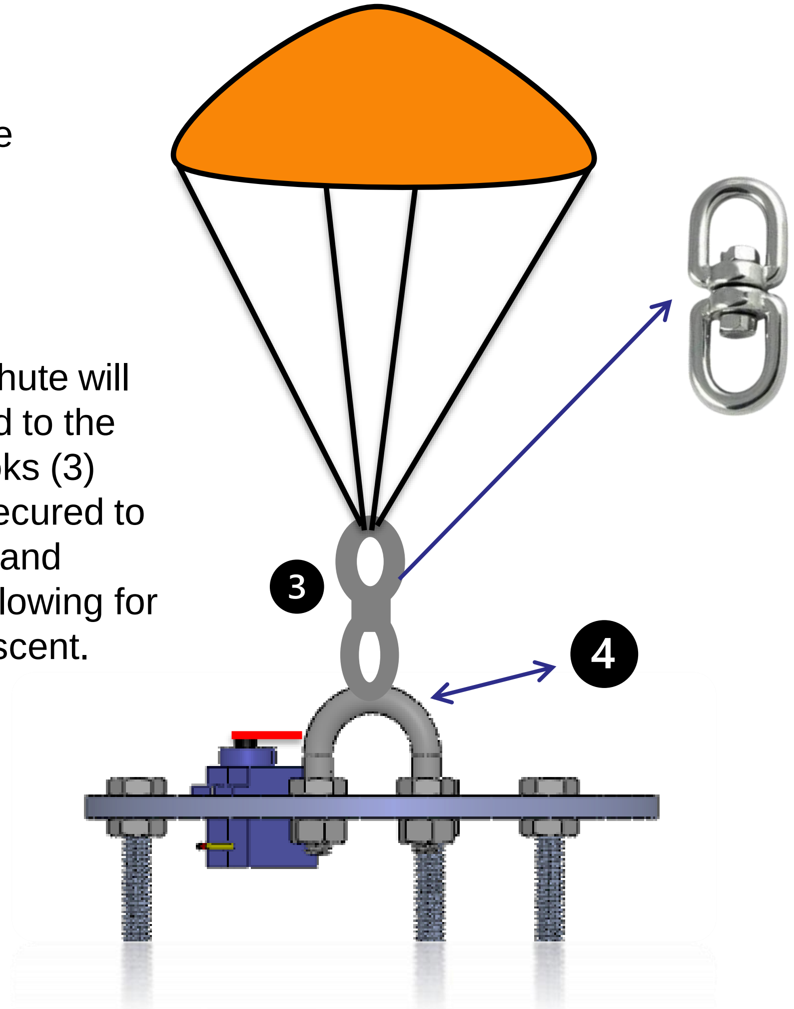
- **During descent, the horizontal camera will control and maintain its pointing via:**
  - Rigid and secure mounting of the camera to the avionics bay with high performance adhesives and screws to prevent the camera from moving
  - Rotation control due to a swivel connection between the parachute and CanSat to prevent any parachute rotation from causing rotation of the camera pointing direction

Payload Parachute Deployment Configuration

The parachute (1) is set on the top of the payload secured by rubber bands that ties around the servo (2) and hooks around the arm. When ~100m is reached, the arm will rotate which unhooks the bands and allows the chute to release.

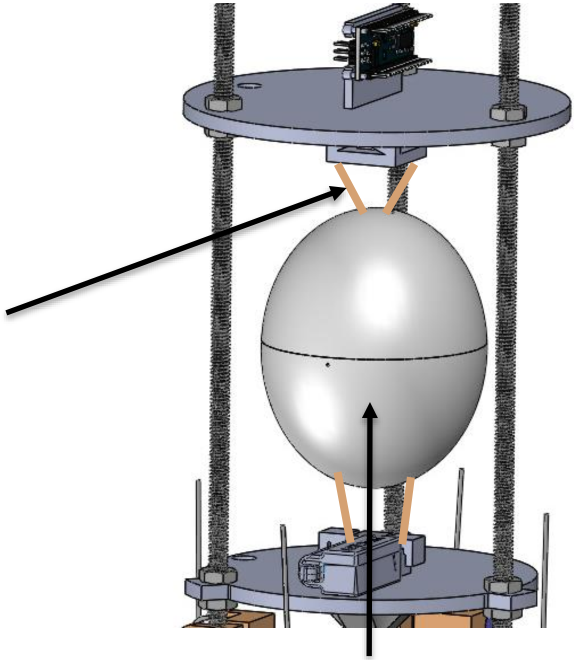


The parachute will be secured to the swivel hooks (3) which is secured to the U-bolt and payload allowing for steady descent.



Payload Egg Containment Configuration

- Egg is placed inside of larger capsule stuffed with foam
- The capsule is then suspended omnidirectionality with rubber bands to hooks on nearby platforms
- Rubber bands keep the egg stable in varying decent paths, providing reliability in unexpected scenarios.



Capsule attached to frame with elastic bands

Structure Survivability

- The PCBs for the container and the payload are mounted to the plates using standoffs which are screwed into the plastic
- The various electrical connections/components will be soldered to the PCB, securing them in place
- The eyebolt (container) and the tie down ring (payload) are used for parachute attachment deployed during descent
- The canister and payload were designed with adequate thickness and strength to survive 15 G's of acceleration without buckling or yielding.
- The canister and payload will both be tested for shock force resistance according to the environmental test plan.

Mass Budget (1/3)

Component	Quantity	Mass (g)	Source	Uncertainty (±g)
Adafruit BMP280	1	1.3 g	Actual from Datasheet	-
Arduino Nano	1	7 g	Actual from Datasheet	-
BNO-055	1	3 g	Actual from Datasheet	-
Adafruit Ultimate	1	8.5 g	Actual from Datasheet	-
ANT-900-RP-2-A	1	5 g	Estimate	± 1.8 g
XBEE Pro 900 Mhz Radio	1	5 g	Actual from Datasheet	-
9 Volt Battery	1	45 g	Actual from Datasheet	-
PX4 Pitot Tube	1	16 g	Estimate	± 1.1g
ESP-32	1	18 g	Actual from Datasheet	-
INA260	1	2 g	Actual from Datasheet	-
Servo Motor	1	9 g	Actual from Datasheet	-
Linear Actuator	1	15 g	Actual from Datasheet	-

Mass Budget (2/3)

Component	Quantity	Mass (g)	Source	Uncertainty (±g)
U-Bolt	1	3.26	Actual from Datasheet	-
Swivel Attachment	1	31 g	Actual from Datasheet	-
Nut	20	1 g (20 g total)	Estimate	± 1.5 g
Aluminum Rod	3	16.78 g (50.34 g total)	Actual from Datasheet	-
Egg Container	1	42.5 g	Actual from Datasheet	-
ABS Platforms	3	185.09 g total	Estimate	± 1.2 g
Hinge	4	16 g (64 g total)	Estimate	± 1.3 g
Hinge Pin	4	1 g (4 g total)	Actual from Datasheet	-
Torsion Spring	4	4 g (16 g total)	Actual from Datasheet	-
Nose Cone	1	120 g	Estimate	± 1.4 g
Heat Shield Plate	4	46.27 g (185.08 g total)	Actual from Datasheet	-
Parachute	1	34 g	Actual from Datasheet	-

Mass Budget (3/3)

Component	Quantity	Mass (g)	Source	Uncertainty (±g)
Standoffs	4	0.5 g (2 g total)	Actual from Datasheet	-
High Performance Adhesive	1	1 g	Estimate	± 0.5 g
Mylar	1	2 g	Estimate	± 0.5 g
PCB Screws	6	0.1 g (0.6 g total)	Actual from Datasheet	-
Elastic Bands	2	1.5 g (3 g total)	Actual from Datasheet	-
Memory Foam	1	5 g	Actual from Datasheet	-

Mass Totals		
Mass (g)	Margin [+, -] (g)	Requirement Total (g)
903.67	± 9.3	900 ± 10

- If final CanSat is overweight, measures will be taken to reduce the weight to fit the mass requirement.
- If final CanSat is underweight, any 3D printed parts will be reprinted with a higher infill, adding additional weight to fit the mass requirement.

Communication and Data Handling (CDH) Subsystem Design

Sanat Konda, Evan (Steele) Elliott

CDH Overview

Device Type	Model	Purpose
Processor & Memory	Arduino Nano	Facilitate data storage, sensing, communication
Real-Time Clock	Adafruit Ultimate Breakout v3 GPS Module	Keep track of times for data & calculation purposes
Antenna	ANT-900-RP-2-A	Transmit/receive data from radio/processor configuration
Radio	XBEE-PRO 900HP	Communicate between antennae & processors

CDH Changes Since PDR

- **No changes have been made since the PDR**

Payload Processor & Memory Selection

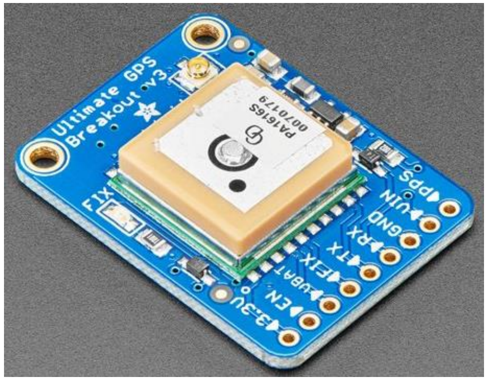
Processor	Boot time (s)	Speed (Mhz)	Memory (KB)	Weight (g)	Dimension (mm)	Voltage Input (V)	Ports
Arduino Nano	8 - 10	16	32	7	18 x 45	7 - 12	Analog Input - 8 PWM Output - 6 I2C I/O - 1 SPI - 1 DAC Output - 0
Raspberry pi Pico	0.5	125	264	3	21 x 51.3	1.8 – 5.5	Analog Input - 4 PWM Output - 8 I2C I/O – 1 SPI – 1 DAC Output - 1
Teensy 3.2	5	16	256	4.8	18 x 36	5	Analog Input - 25 PWM Output - 22 I2C I/O - 4 SPI - 3 DAC Output - 2

Selection	Reasoning for selection
Arduino Nano	- Compact size - Ease of use and familiarity - Availability

Payload Real-Time Clock

Real-Time Clock Keeper	Tolerance Reset	Interface	Cost ($)
Microchip MCP7940M-I/P	Real-Time clock continues keeping time in the event of a reset	I2C	0.75
Arduino Ultimate Breakout v3	Real-Time clock continues keeping time in the event of a reset	Internal to GPS	0.00

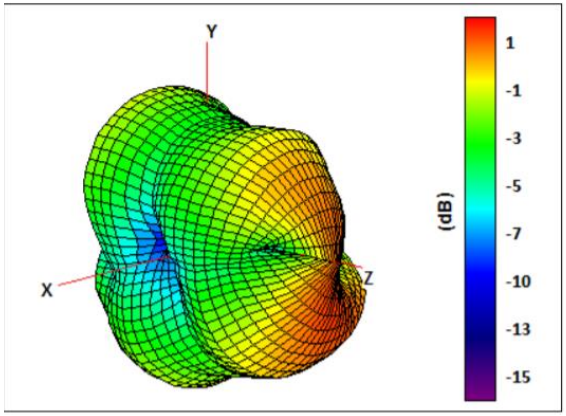
Selection	Reasoning for selection
Adafruit Ultimate GPS Breakout	- Already part of the telemetry communications - Has an independent, onboard battery - No additional weight, size, or circuitry required

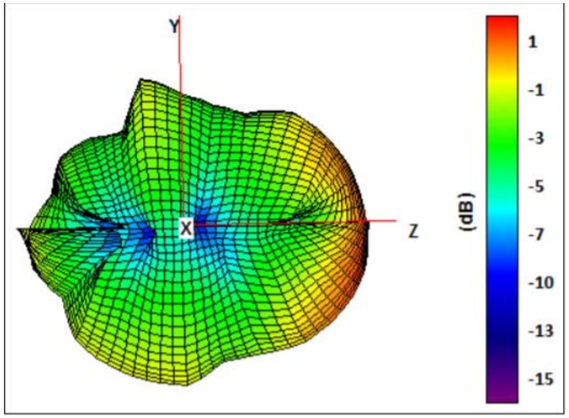


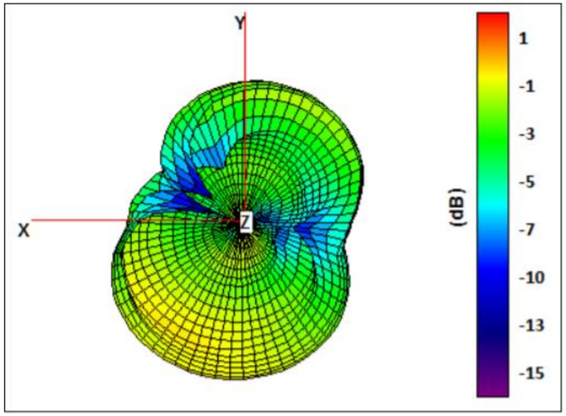
Payload Antenna Selection

Name	Frequency Range (GHz)	Length of Antenna (mm)	Gain (dBi)	Polarization	Connection Type	Weight (g)
ANT-900-RP-2-A	.880-.960	115	2.1	(Linear) Vertical	SMA	11
Taoglas FXP290 915 MHz	.902-.928	100	1.5	Linear	U.FL	1.5

Selection	Reasoning for selection
ANT-900-RP-2-A	- In accepted frequency range - Compatible with selected radio - Compact size







Payload Radio Configuration

Name	Frequency Range (GHz)	Outside Range (km)	Antenna Type	Weight (g)	Cost ($)
XBEE-PRO 900HP	.902 - .928	6.5	RPSMSA	6.9	68
XBee S2C 802.15.4	2.4	1.2	Wire	5	30

Selection	Reasoning for selection
XBEE-PRO 900HP	- Operates on accepted frequency - Excellent outside range - Previous familiarity and availability

Transmission Control
- Data will be continuously sent at 1 Hz during all stages of flight - Transmission will be handled by FSW, starting on power on and ending once the container and payload have landed

NETID/PANID – 2031

Payload Telemetry Format (1/3)

- **Transmitted Data will be saved to a .csv file on ground station.**
- **Data Transmitted:**
- To GCS at 1 Hz packet transmission rate:
- Payload sensor readings (Air pressure/temperature, mission time, GPS time, coordinates, power supply voltage, tilt, altitude, and various states)
- **How is data formatted?**
  - -Payload-to-GCS:

    TEAM_ID, MISSION_TIME, PACKET_COUNT, MODE, STATE, ALTITUDE, AIR_SPEED, HS_DEPLOYED, PC_DEPLOYED, TEMPERATURE, VOLTAGE, PRESSURE, GPS_TIME, GPS_ALTITUDE, GPS_LATITUDE, GPS_LONGITUDE, GPS_SATS, TILT_X, TILT_Y, ROT_Z, CMD_ECHO
- **Example:**

2031, 23:35:59, 25, F, LAUNCH_WAIT, 150.2, 15.76, N, N, 25.3, 8.3,230, 13:35:35, 25, 150.0258, 168.6765, 58, 5.02, 3.05, 2.63, CXON

Payload Telemetry Format (2/3)

Telemetry Field	Purpose	Relayed From:
<TEAM_ID>	Team ID number (2031)	Payload
<MISSION_TIME>	UTC time from RST=0 in 1st software state (hh:mm:ss)	
<PACKET_COUNT>	# of packets transmitted across all devices	
<MODE>	'F' = Flight (default) mode, 'S' = Simulation mode	
<STATE>	Software State (STARTUP, DESCENT, etc.)	
<ALTITUDE>	Altitude in meters relative to ground level (+/- 0.1 m)	
<HS_DEPLOYED>	‘P’ if the heat shield has been deployed, ‘N’ if not	
<PC_DEPLOYED>	‘C’ if the probe parachute has been deployed, ‘N’ if not	
<AIR_SPEED>	Airspeed in meters per second measured with the pitot tube during both ascent and descent.	
<TEMP>	The temperature in degrees Celsius (+/- 0.1C)	

Payload Telemetry Format (3/3)

Telemetry Field	Purpose	Relayed From:
<PRESSURE>	The air pressure in kPa (+/- 0.1 kPa)	Payload
<VOLTAGE>	Voltage reading of Container power bus (+/- 0.1 V)	
<GPS_TIME>	UTC time generated from GPS (hh:mm:ss) (+/- 1 sec)	
<GPS_LATITUDE>	GPS latitude coordinate in decimal degrees (+/- 0.0001 degrees North)	
<GPS_LONGITUDE>	GPS longitude coordinate in decimal degrees (+/- 0.0001 degrees West)	
<GPS_ALTITUDE>	GPS altitude coordinate in decimal degrees (+/- 0.1 m from sea level)	
<GPS_SATS>	# of satellites being tracked by GPS	
<TILT_X>	The angle of the payload in the x direction in degrees (+/- 0.01)	
<TILT_Y>	The angle of the payload in the y direction in degrees (+/- 0.01)	
<CMD_ECHO>	The last command received and processed by the payload	
<ROT_Z>	The rotation rate of the CanSat in degrees per second (+/- 0.1)	

Payload Command Formats (1/2)

CX - Container Telemetry On/Off Command	
CMD,<TEAM_ID>, CX, <ON_OFF>	
CMD & CX	Static Text
<TEAM_ID>	Assigned Team Identification
<ON_OFF>	ON-activates Container transmissions OFF- turns off transmissions
Example: CMD,2031,CX,ON	

SIM - Simulation Mode Control Command	
CMD,<TEAM_ID>, SIM, <MODE>	
CMD & SIM	Static Text
<TEAM_ID>	Assigned Team Identification
<MODE>	'ENABLE' to enable - 'ACTIVATE' to activate- 'DISABLE' both disables and deactivates -> simulation mode.
Example: CMD,2031,SIM,ACTIVATE	

ST - Set Time	
CMD,<TEAM_ID>, ST, <UTC_TIME>	
CMD & ST	Static Text
<TEAM_ID>	Assigned Team Identification
<UTC_TIME>	UTC time in the format hh:mm:ss
Example: CMD,2031,ST,13:35:59	

SIMP - Simulated Pressure Data	
CMD,<TEAM_ID>, SIMP, <PRESSURE>	
CMD & SIMP	Static Text
<TEAM_ID>	Assigned Team Identification
<PRESSURE>	simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.
Example: CMD,2031,SIMP,101325	

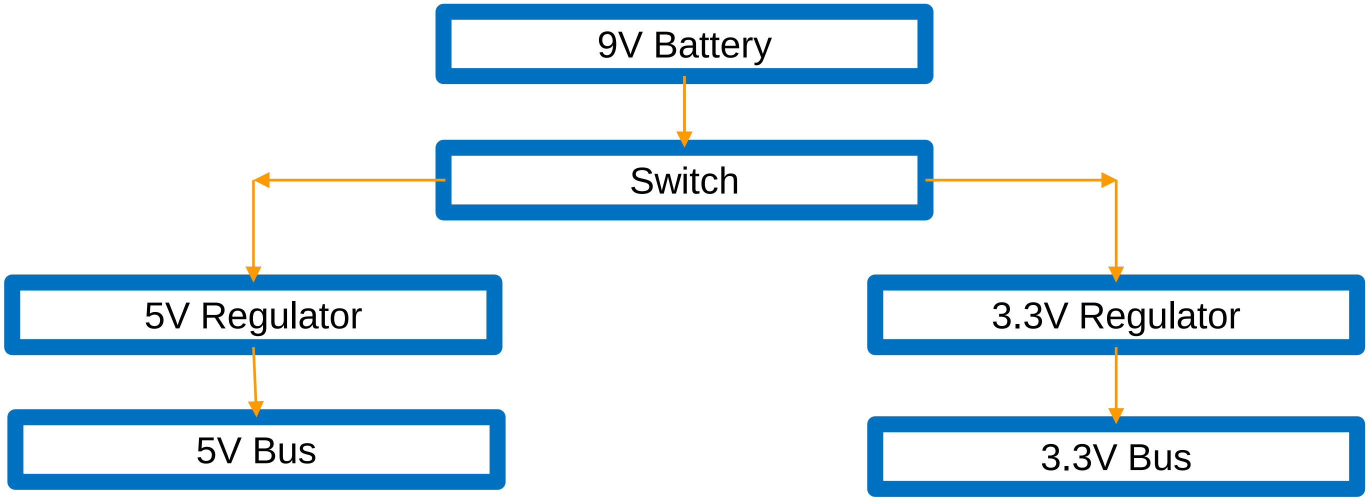
Payload Command Formats (2/2)

CAL – Calibrate Altitude to Zero	
CMD,<TEAM_ID>, CAL	
CMD & CAL	Static Text
<TEAM_ID>	Assigned Team Identification
Example: CMD,2031,CAL	

BCN – Control Audio Beacon	
CMD,<TEAM_ID>,BCN,ON|OFF	
CMD & BCN	Static Text
<TEAM_ID>	Assigned Team Identification
ON|OFF	ON- turns on audio beacon OFF- turns off audio beacon
Example: CMD,2031,BCN,ON	

Electrical Power Subsystem Design

Evan (Steele) Elliott, Jonathan (Yoni) Gutmann

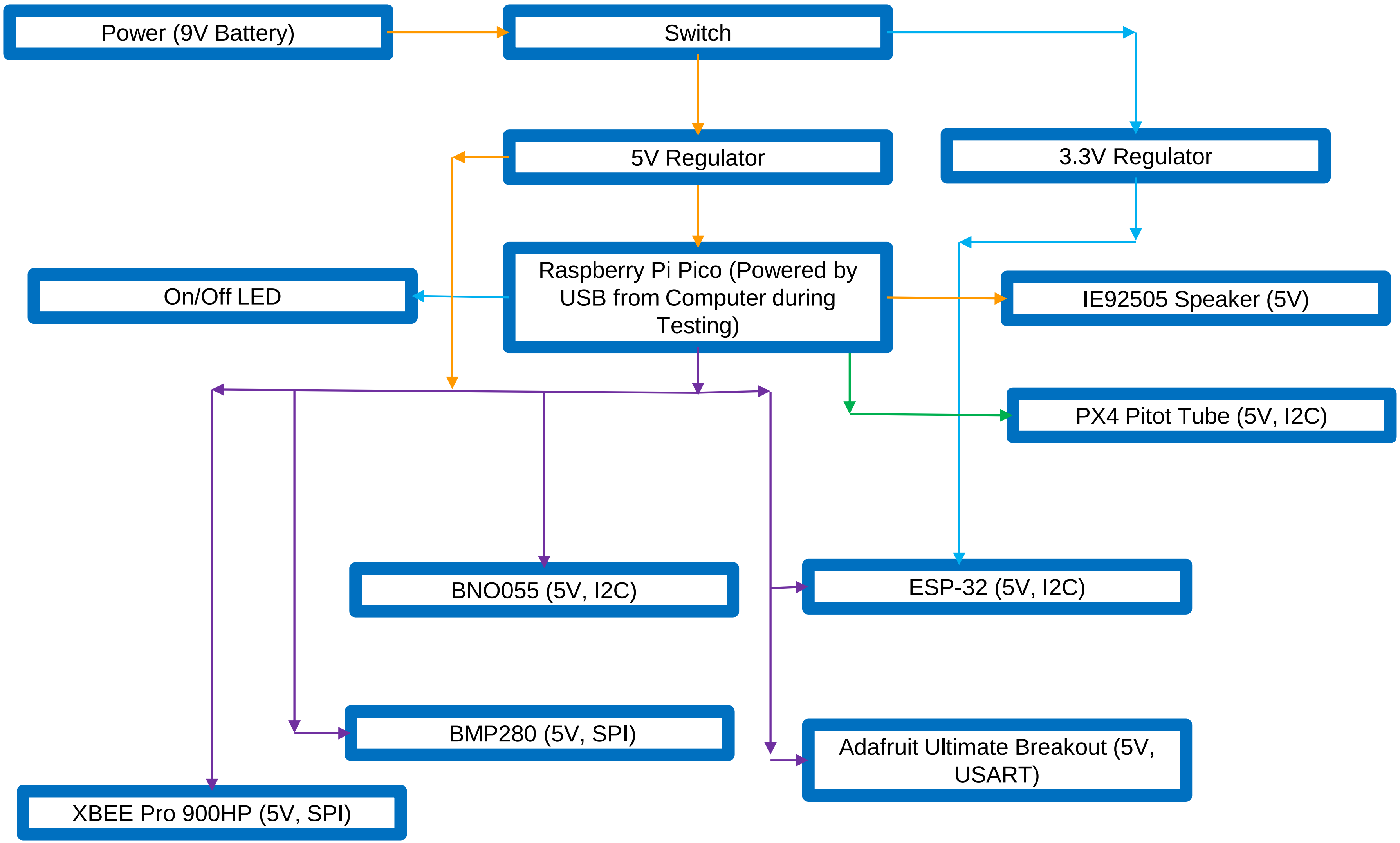


9V Battery
Switch
5V Regulator
3.3V Regulator
5V Bus
3.3V Bus

EPS Changes Since PDR

- **No Changes have been made since the PDR**

Payload Electrical Block Diagram

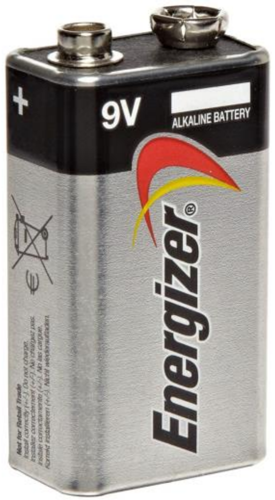


Payload Power Source

Type	Battery	Voltage	Capacity	Weight	Qty. Needed	Total Voltage	Total Weight
Lithium LiCB	CR2032	3.3V	236mAh	3.1g	2	6.6V	6.2g
Alkaline Industrial Battery	9V	9V	3.6mAh	46g	1	9V	46g

Selection	Reason for Selection
Alkaline Industrial Battery	- Provides enough current to power the entire system.

Battery Configuration
Single 9V Battery



Payload Power Budget

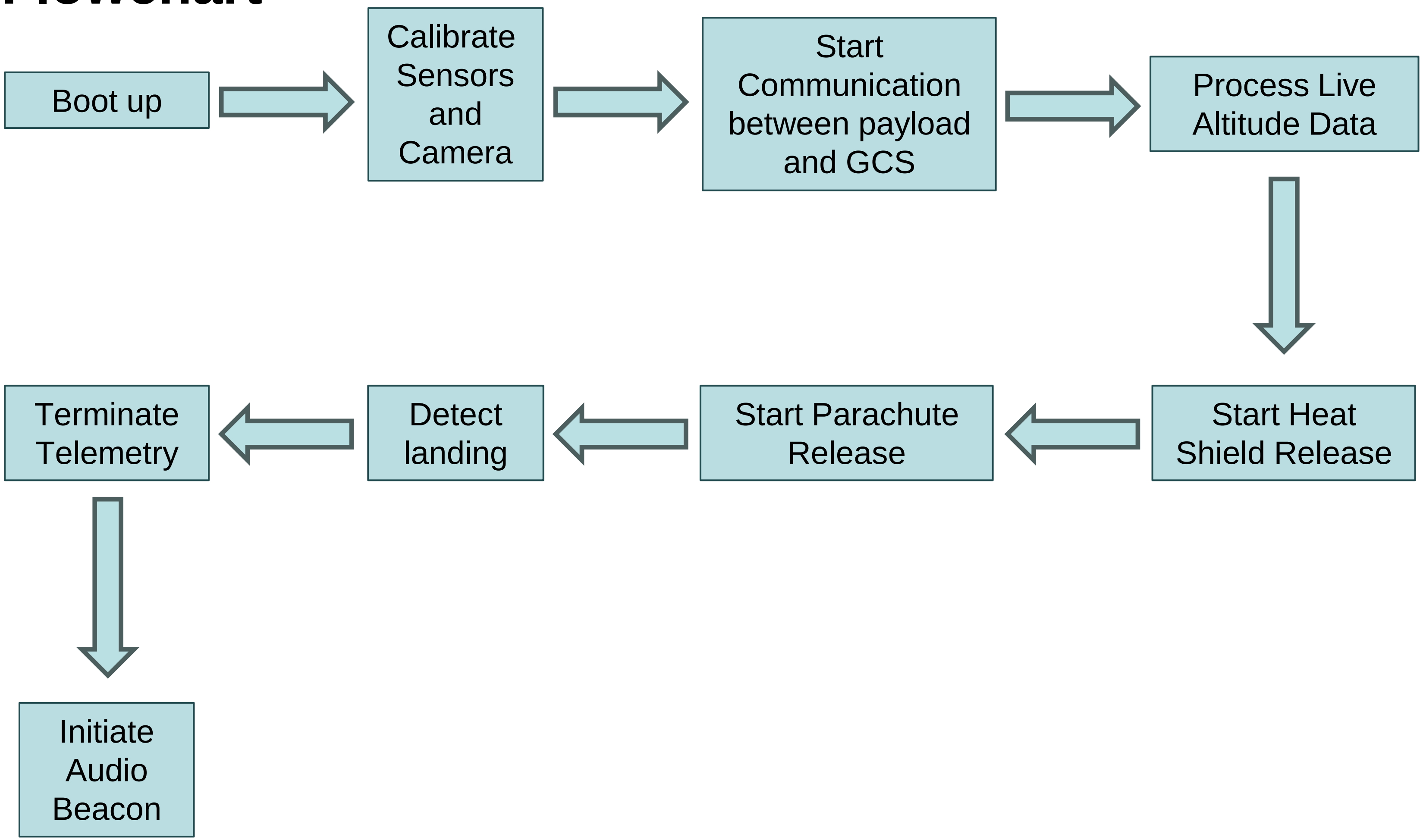
Component	Voltage (V)	Power per Unit (W)	Duty Cycle (%)	Power Consumption (Wh)	Source
Raspberry Pi Pico (Microcontroller)	9V	.1406	100	0.1406	Datasheet
Adafruit Ultimate Breakout (GPS)	5V	.1	100	.1	Datasheet
BMP280 (Air Temperature/Pressure)	5V	0.00025	100	0.000025	Datasheet
PX4 Differential Air Speed	5V	3.6	100	3.6	Datasheet
Xbee Pro 900 HP (Radio Module)	5V	.0.95	100	.95	Datasheet
ESP32	3.3V	1.65	100	1.65	Datasheet
BNO 055 (Temp/Rotational Sensor)	1.7-3.6V	0.0123	100	0.00155	Datasheet

Flight Software (FSW) Design

Evan (Steele) Elliott, Max Epstein

FSW Overview (1/2)

Flowchart



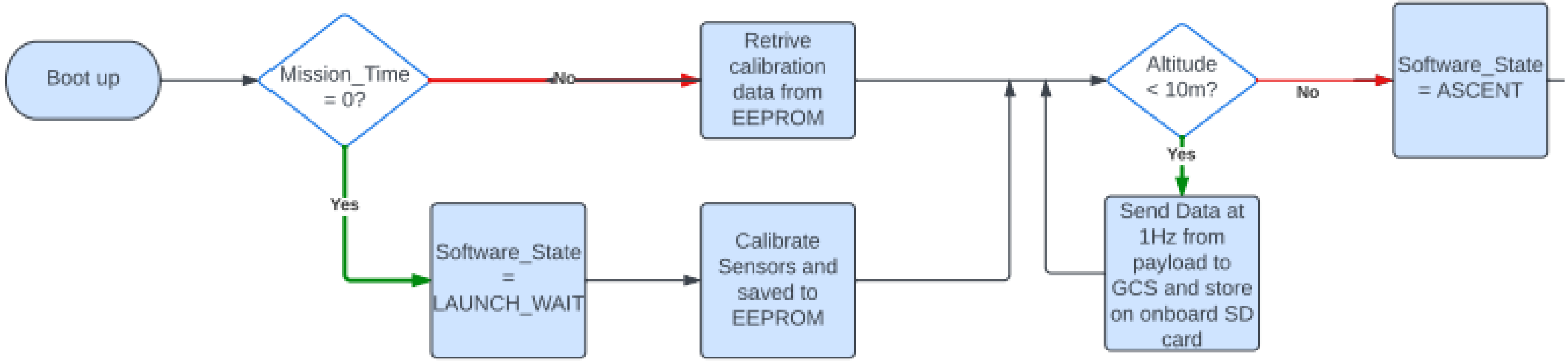
FSW Overview (2/2)

Programming Languages	Python / C
Development Environments	Visual Studio Code & Arduino IDE
FSW Tasks	- Boot up and collect sensor data in the correct units required by CanSat. - Communicate telemetry from the payload to the GCS to store data. - Keep track of altitude and release the heat shield and parachute when needed. - Trigger audio beacon after landing.
Payload FSW	- Payload communication - In charge of collecting data with sensors - Contains temperature sensor, pressure sensor, rotational sensor, camera

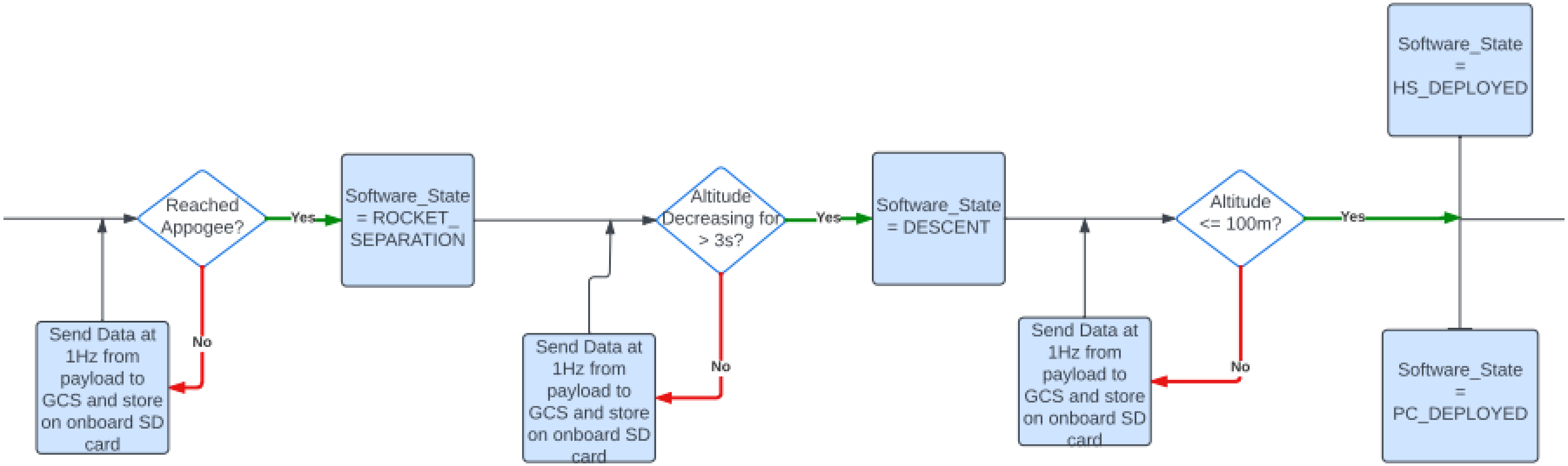
FSW Changes Since PDR

- **No Changes have been made since the PDR**

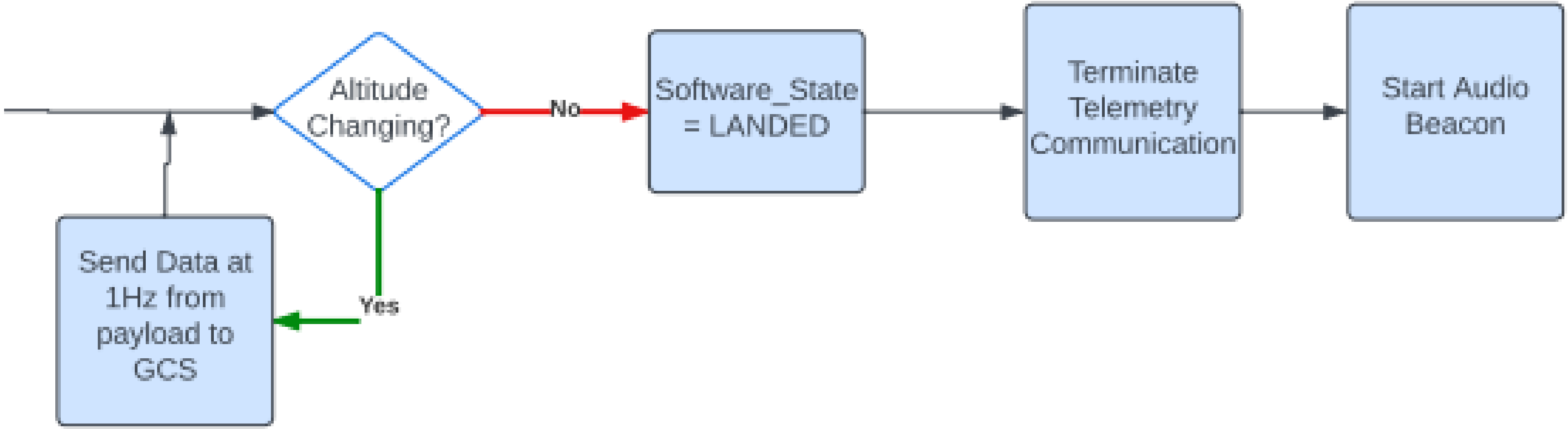
Payload FSW State Diagram (1/4)



Payload FSW State Diagram (2/4)



Payload FSW State Diagram (3/4)



FSW Recovery from Reset

What is used to recover:

- Mission Time
- GPS Time
- Software State
- Altitude

Causes that call for reset:

- Power loss (power supply)
- Physical damage
- Processor failure

Simulation Mode Software

- **Sensor changes**
  - All air pressure sensors disabled

- **Simulation mode commands**
  - <MODE> switches from 'F' (Flight) to 'S' (Simulation)

- **How is simulated sensor data substituted with real data?**
  - External data from text file fed into certain fields instead of air pressure sensor readings
    - <ALTITUDE>, <PRESSURE>
  - All other sensor readings & telemetry remain the same

Software Development Plan (1/2)

Prototyping and Prototyping Environments

- Environment in Visual Studio Code and Arduino IDE
- Modular code parts

Development Team

- Steele Elliott
- Max Epstein
- Jonathan (Yoni) Gutmann
- Sanat Konda

Test Methodology

- Simulation mode with varying datasets
- Freefall sensor testing

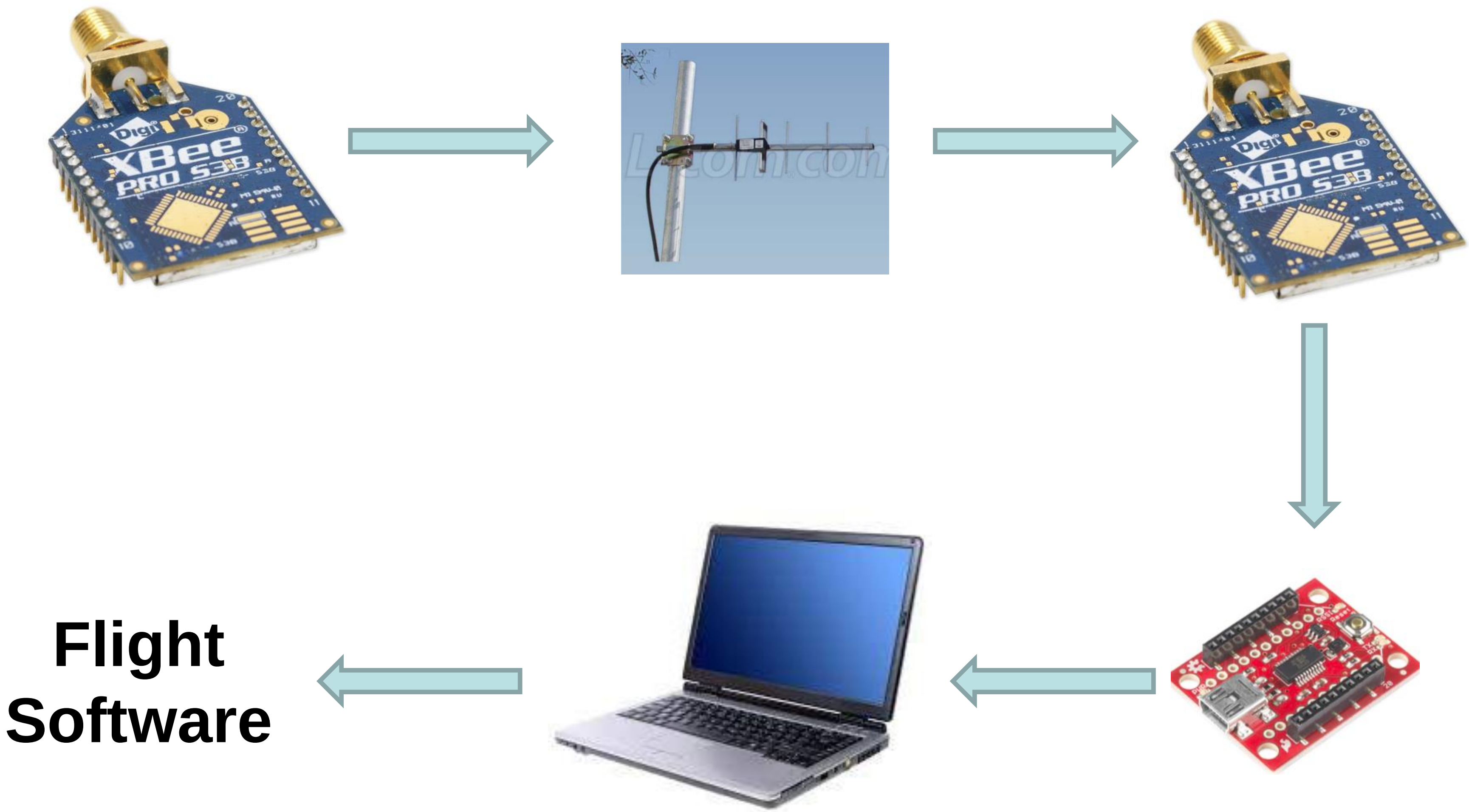
Software Development Plan (2/2)

Subsystem	Development Sequence
Sensors	1. Sensor trade and selection compare and select the best 2. Program each individual sensor in Arduino 3. Integrate and conglomerate all programs, make sure it still functions
Xbee Radio	1. Configure and test point to point communication for the radio (controller and GCS port) 2. Integrate sensors with Xbee for data transmission
Flight Control	1. Program feedback system with servos connected to flight mechanisms
Release Mechanisms	1. Program release mechanisms such as linear actuators and servos
Software State	1. Use the data from sensors to change the states
Audio Beacon	1. Program locator audio beacon
Integration	1. Integrate all software subsystem and ensure 1Hz data transmission from payload. Also, to make sure the software states match up with what is occurring.

Ground Control System (GCS) Design

Evan (Steele) Elliott, Sanat Konda

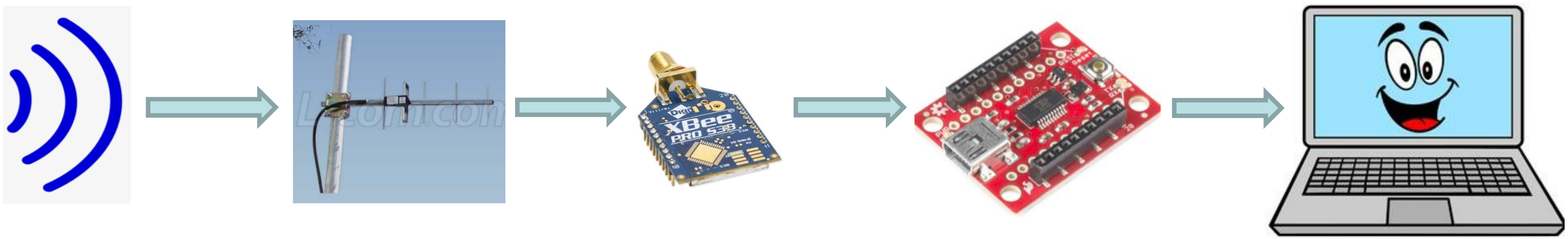
GCS Overview



GCS Changes Since PDR

- **No changes have been made since the PDR**

GCS Design

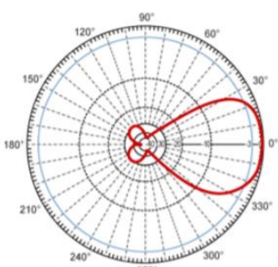


Specifications	
Laptop Battery	4 Hours
Overheating Mitigation	Umbrella, Laptop Cooler, and Jacket
Auto update Mitigation	Disable Auto-Update

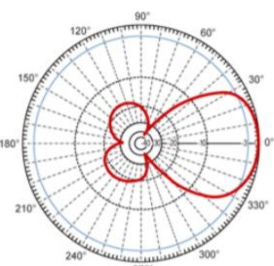
GCS Antenna

Name	Frequency Range (GHz)	Length of Antenna (mm)	Gain (dBi)	Polarization	Connection Type	Weight (g)	Cost ($)
Right-Angle Mini GSM	.85-2.1	57	2	(Linear) Vertical	Right Angle SMA	8	4.95
TL-Dipole Swivel Antenna	2.4	200	5	(Linear) Vertical	RP-SMA	30	8.95
900 MHz 14 dBi Al Yagi Antenna	.90-.928	1422	14	Linear	N-Female	680	72.32

Selection	Reasoning for selection
Yagi Antenna	- Gain strength immensely stronger than the other antennas - Larger antenna - Ideal frequency range - Handheld, easy to maneuver - Previous use and accessibility



Vertical



Horizontal

GCS Software (1/4)

Software Packages:

- Python 3.11.5 - Computational environment of choice
- XCTU – XBee Program Software
- XBEE Python Library – real time access to XBEE via USB interface
- Matplotlib Python Library – real time plotting and data manipulation
- PySimpleGUI Python Library – visual design layout and manipulation
- Pandas Python Library – real time data collection and .csv file status

Command Software and Interface:

- Commands can be sent from the Ground Control Station to the CanSat via command.
- The GCS uses the XBEE Python Library to access the XBEE receiver through the USB interface.

GCS Software (2/4)

Telemetry Data Recording:

- Telemetry will be saved in a .csv file without manipulation after being read via USB interface.
- .csv data will be analyzed in python and presented via GUI and saved in file.

CSV File Generation:

- .csv file will be generated in GCS Python software for payload and data will be continuously added to the created file as it arrives in packets to GCS.

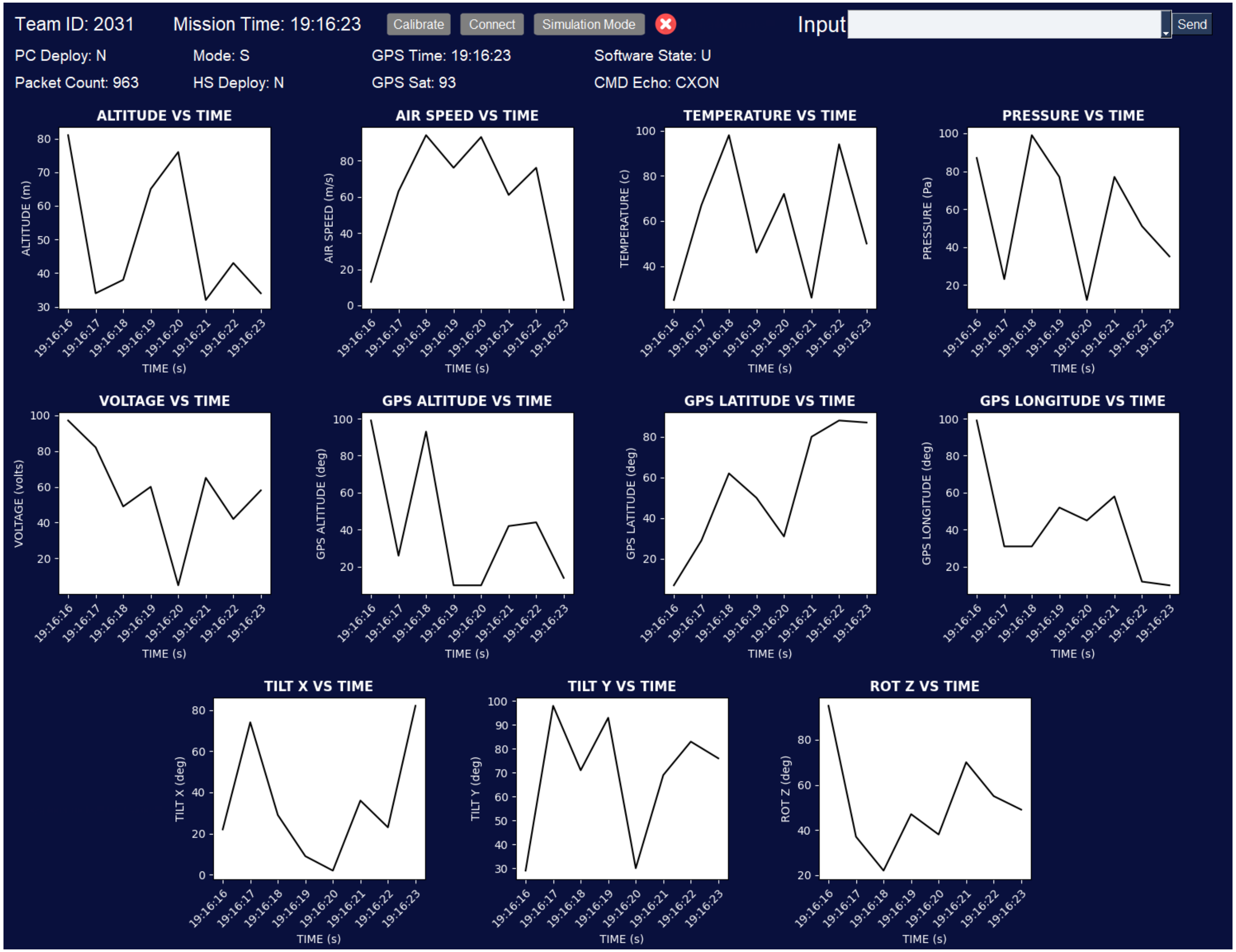
Simulation Mode:

- Opens simulation data .csv file and simulates reading commands at frequency of 1 Hz

Progress since PDR

- Fixed frequency at which commands are read in simulation mode
- Implemented ability to read in simulated pressure command file
- Sending input commands to the payload through radio signal communications

GCS Software (3/4)



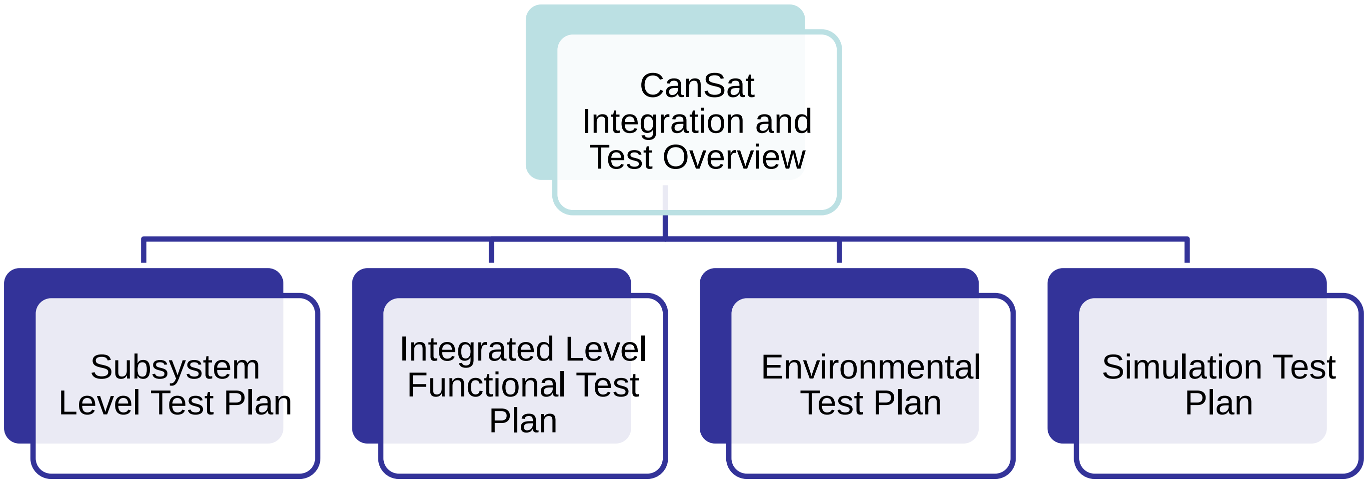
GCS Software (4/4)

TEAM_ID	MISSION_	PACKET_C	MODE	STATE	ALTITUDE	AIR_SPEED	HS_DEPLO	PC_DEPLO	TEMPERAT	PRESSURE	VOLTAGE	GPS_TIME	GPS_ALTIT	GPS_LATIT	GPS_LONG	GPS_SATS	TILT_X	TILT_Y	TILT_Z	ROT_Z	CMD_ECHO
2031	10:13:00	1	S	LAUNCH_	39	79	N	N	N	59	45	10:13:00	24	12	19	35	40	100	37	67	CXON
2031	10:13:01	2	S	LAUNCH_	12	92	N	N	N	95	92	10:13:01	71	48	20	91	20	53	36	100	CXON
2031	10:13:02	3	S	LAUNCH_	78	53	N	N	N	4	24	10:13:02	46	90	64	87	45	22	74	19	CXON
2031	10:13:03	4	S	LAUNCH_	89	39	N	N	N	79	5	10:13:03	8	12	38	6	62	23	80	84	CXON
2031	10:13:04	5	S	LAUNCH_	50	24	N	N	N	2	22	10:13:04	33	80	9	88	1	23	46	10	CXON
2031	10:13:05	6	S	LAUNCH_	83	10	N	N	N	74	35	10:13:05	12	42	83	50	86	60	27	18	CXON
2031	10:13:06	7	S	LAUNCH_	24	89	N	N	N	56	27	10:13:06	8	55	60	99	74	39	56	80	CXON
2031	10:13:07	8	S	LAUNCH_	95	8	N	N	N	75	27	10:13:07	13	56	42	71	8	24	24	63	CXON
2031	10:13:08	9	S	LAUNCH_	55	30	N	N	N	37	4	10:13:08	85	80	6	57	77	47	22	53	CXON
2031	10:13:09	10	S	LAUNCH_	63	5	N	N	N	25	11	10:13:09	5	59	32	88	49	30	37	33	CXON
2031	10:13:10	11	S	LAUNCH_	99	7	N	N	N	78	22	10:13:10	5	16	48	93	71	24	68	87	CXON
2031	10:13:11	12	S	LAUNCH_	12	17	N	N	N	1	15	10:13:11	98	64	20	90	53	10	26	61	CXON
2031	10:13:12	13	S	LAUNCH_	32	83	N	N	N	37	48	10:13:12	32	48	58	14	35	9	86	57	CXON
2031	10:13:13	14	S	LAUNCH_	52	26	N	N	N	49	2	10:13:13	52	25	76	1	6	49	74	59	CXON
2031	10:13:14	15	S	LAUNCH_	26	39	N	N	N	53	13	10:13:14	13	100	13	98	15	35	3	7	CXON
2031	10:13:15	16	S	LAUNCH_	93	33	N	N	N	62	30	10:13:15	99	84	30	72	15	8	28	25	CXON
2031	10:13:16	17	S	LAUNCH_	33	93	N	N	N	81	37	10:13:16	19	33	78	12	86	65	21	2	CXON
2031	10:13:17	18	S	LAUNCH_	48	55	N	N	N	43	44	10:13:17	27	2	18	43	70	18	25	95	CXON
2031	10:13:18	19	S	LAUNCH_	70	31	N	N	N	9	16	10:13:18	95	37	95	38	58	32	81	57	CXON
2031	10:13:19	20	S	LAUNCH_	30	80	N	N	N	72	69	10:13:19	53	93	58	6	72	4	4	75	CXON
2031	10:13:20	21	S	LAUNCH_	25	24	N	N	N	55	58	10:13:20	59	35	25	1	28	91	47	83	CXON
2031	10:13:21	22	S	LAUNCH_	30	9	N	N	N	31	90	10:13:21	4	82	19	3	65	70	2	11	CXON
2031	10:13:22	23	S	LAUNCH_	14	87	N	N	N	79	3	10:13:22	90	17	57	24	34	95	93	23	CXON
2031	10:13:23	24	S	LAUNCH_	70	17	N	N	N	48	76	10:13:23	78	95	79	55	77	25	89	46	CXON
2031	10:13:24	25	S	LAUNCH_	80	49	N	N	N	49	71	10:13:24	96	49	87	76	21	69	27	16	CXON
2031	10:13:25	26	S	LAUNCH_	33	40	N	N	N	21	48	10:13:25	84	44	85	15	35	55	24	22	CXON

CanSat Integration and Test

Evan (Steele) Elliott, Max Epstein, Melissa Gonzalez

CanSat Integration and Test Overview



Subsystem Level Testing Plan (1/2)

Subsystem Level Testing	
Sensors	• Pressure sensor tests • Temperature sensor tests • GPS location & time tests • Rotational Sensors tests • Camera recording and saving video tests
CDH	• Processor clock speed tests • EEPROM storage size tests • EEPROM read/write speed tests
EPS	• Battery voltage readings • Impedance tests on each component • Battery power output & tolerance tests
Radio Communications	• XBEE radio receiver/sender tests • Antenna signal quality tests • Packet receival and transmission tests

Subsystem Level Testing Plan (2/2)

Subsystem Level Testing	
FSW	• Data live graph generation tests • Simulation mode tests • CSV data saving & handling • Software states testing
Mechanical	• CanSat structural tests • Aerobrake deployment tests • Avionics bay structural integrity tests • Parachute deployment release tests • CanSat stability control tests
Descent Control	• Parachute Drogue tests • Parachute reefing tests • Parachute deployment tests • Aerobraking device testing

Integrated Level Functional Test Plan

Testing Plan	
Decent Testing	• PID Controller payload descent rate tests
Communications	• Telemetry transmission and retrieval tests • Communication between GCS and Payload
Mechanisms	• Payload release mechanism tests • Payload stability control tests • Aerobrake release mechanism tests • Flag deployment mechanism tests • Payload parachute release mechanism tests
Deployment	• Payload deployment tests are various altitudes • Payload parachute deployments tests at various altitudes • Aerobrake deployments tests are various altitudes • Linear actuator integration with altitude sensor readings

Drop Test
- Verify that all structures can survive 15 Gs of launch acceleration and 30 Gs of shock
- Verify that the container can survive deployment from rocket
- Verify that payload remains in stowed state
- Verify that component and battery mounts can withstand applied forces

Thermal Test
- Verify the CanSat can operate in a hot environment without materials and/or components becoming functionally compromised

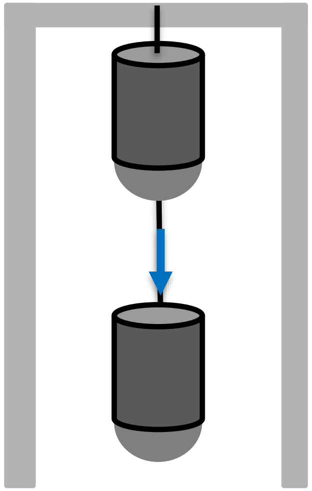
Vibration Test
- Verify the structural integrity of all mounts and connections within the CanSat
- Verify that payload remains in stowed state

Vacuum Test
- Verify deployment operations of the payload

Environmental Test Plan (2/3)

Drop Test

- Secure the CanSat to testing rig with non-stretch cord
- Release the CanSat from 61 cm and allow it to freefall
- Inspect CanSat for damage
- If there was no damage, then run a functional test



Thermal Test

- Turn on the CanSat
- Place the CanSat in an insulating cooler with a hair dryer
- Use a remote thermometer to monitor temperature
- Turn off the heat source once internal temperatures reach 60°C and turn on heat source when temperature reaches 55°C
- Maintain this for 2 hours
- With heat source off, visually inspect and run functional test on CanSat to verify operational intergrity

Environmental Test Plan (3/3)

Vibration Test

- Attach the CanSat to an orbital sander and power it up to full speed
- Wait 5 seconds after the sander is at full speed then power it off
- Repeat the process 5 more times
- Remove CanSat from fixture and visually inspect
- Run functionality test to verify operational integrity
- Verify accelerometer data is still being collected

Vacuum Test

- Construct a vacuum chamber using a bucket and vacuum cleaner
- Suspend fully configured and powered CanSat within the vacuum chamber
- Turn on vacuum
- Monitor telemetry and stop vacuum once peak altitude has been reached
- Let air enter the vacuum chamber slowly and monitor operation of CanSat
- Collect and save telemetry data

Test Procedures Descriptions (1/4)

Drop Test			
Test Proc	**Test Description**	**Requirements**	**Pass Fail Criteria**
1	Power on the CanSat	E2-E5	Pass if CanSat powers on. Otherwise fail.
2	Verify telemetry is being received.	X4-X5, G1-G15, F1-F6	Pass if data is received. Otherwise fail.
3	Raise CanSat by the attached cord, so that the two attachment points of the cord are at the same height.	N/A	N/A
4	Release the CanSat.	N/A	N/A
5	Verify the CanSat did not lose power.	S7, E2-E5	Pass if CanSat doesn't lose power. Otherwise fail.
6	Inspect for any damage, or detached parts.	S7, M3	Pass if there is no damage. Otherwise fail.
7	Verify telemetry is still being received.	X4-X5, G1-G15, F1-F6	Pass if data is still receiving. Otherwise fail.
8	Power down CanSat.	E2-E5	Pass if CanSat turns off. Otherwise fail.

Test Procedures Descriptions (2/4)

Thermal Test			
Test Proc	**Test Description**	**Requirements**	**Pass Fail Criteria**
1	Place CanSat into a thermal chamber.	N/A	N/A
2	Power on the CanSat.	E2-E5	Pass if CanSat powers on. Otherwise fail.
3	Close and seal the thermal chamber and turn on the heat source.	N/A	N/A
4	Monitor the temperature and turn off the heat source when the internal temperature reaches 60°C and turn on the heat source when the temperature drops to 55°C, while maintaining the test conditions for two hours.	SN3, E5	N/A
5	Turn off the heat source and perform visual inspection and any functional tests to verify the CanSat survived the thermal exposure and can operate as expected.	M3	Pass if CanSat operates as expected. Otherwise fail.
6	With the CanSat still hot, test any mechanisms and structures to make sure the integrity has not been compromised. Take precautions to avoid injury. Verify epoxy joints and composite materials still maintain their strengths.	M3	Pass if everything is intact. Otherwise fail.
7	Verify that CanSat is still sending data to GCS	X4-X5, G1-G15, F1-F6	Pass if data is being sent. Otherwise fail.
8	Power down CanSat.	E2-E5	Pass if CanSat can turn off. Otherwise fail.

Test Procedures Descriptions (3/4)

Vibration Test			
Test Proc	**Test Description**	**Requirements**	**Pass Fail Criteria**
1	Power on the CanSat.	E2-E5	Pass if CanSat powers on. Otherwise fail.
2	Verify accelerometer data is being collected.	X4-X5, G1-G15, F1-F6	Pass if accelerometer data is received on the Ground Control Station. Otherwise fail.
3	Power up the sander.	N/A	N/A
4	Once the sander is up to full speed, wait 5 seconds.	N/A	N/A
5	Power down the sander to a full stop.	N/A	N/A
6	Repeat steps 3 to 5 four more times.	N/A	N/A
7	Inspect the CanSat for damage and functionality.	S6, S11, M3	Pass if CanSat maintains function and structural integrity with no damage to mounting or connections. Otherwise fail.
8	Verify accelerometer data is still being collected.	X4-X5, G1-G15, F1-F6	Pass if accelerometer data is received on the Ground Control Station. Otherwise fail.
9	Power down CanSat.	E2-E5	Pass if CanSat can turn off. Otherwise fail.

Test Procedures Descriptions (4/4)

Vacuum Test			
Test Proc	**Test Description**	**Requirements**	**Pass Fail Criteria**
1	Suspend the fully configured and powered CanSat in the vacuum chamber.	E2-E5	Pass if CanSat powers on. Otherwise fail.
2	Turn on the vacuum to start pulling a vacuum.	N/A	N/A
3	Monitor the telemetry and stop the vacuum when the peak altitude has been reached.	X4-X5, G1-G15, F1-F6	N/A
4	Let the air enter the vacuum chamber slowly and monitor the operation of the CanSat.	S8, M3	Pass if CanSat operates as expected. Otherwise fail.
5	Collect and save telemetry.	X4-X5, G1-G15, F1-F6	Pass if data is received. Otherwise fail.
6	Make the saved telemetry available for the judges to review.	X4-X5, G1-G15, F1-F6	Pass if data is saved. Otherwise fail.
7	Power down CanSat.	E2-E5	Pass if CanSat can turn off. Otherwise fail.

Simulation Test Plan

How simulation works

- After configuration, once the SIM ENABLE and SIM ACTIVATE commands are ran, simulation mode will run.
- The ground station will transmit pressure data from a csv file at 1Hz intervals to the payload.
- The flight software will determine altitude using radio linked values instead of live sensor data.
- The flight software will detect the launch and release payload and parachute at respective altitudes.
- Lastly, the audio beacon will begin and telemetry will terminate once landing is detected

What parts are tested

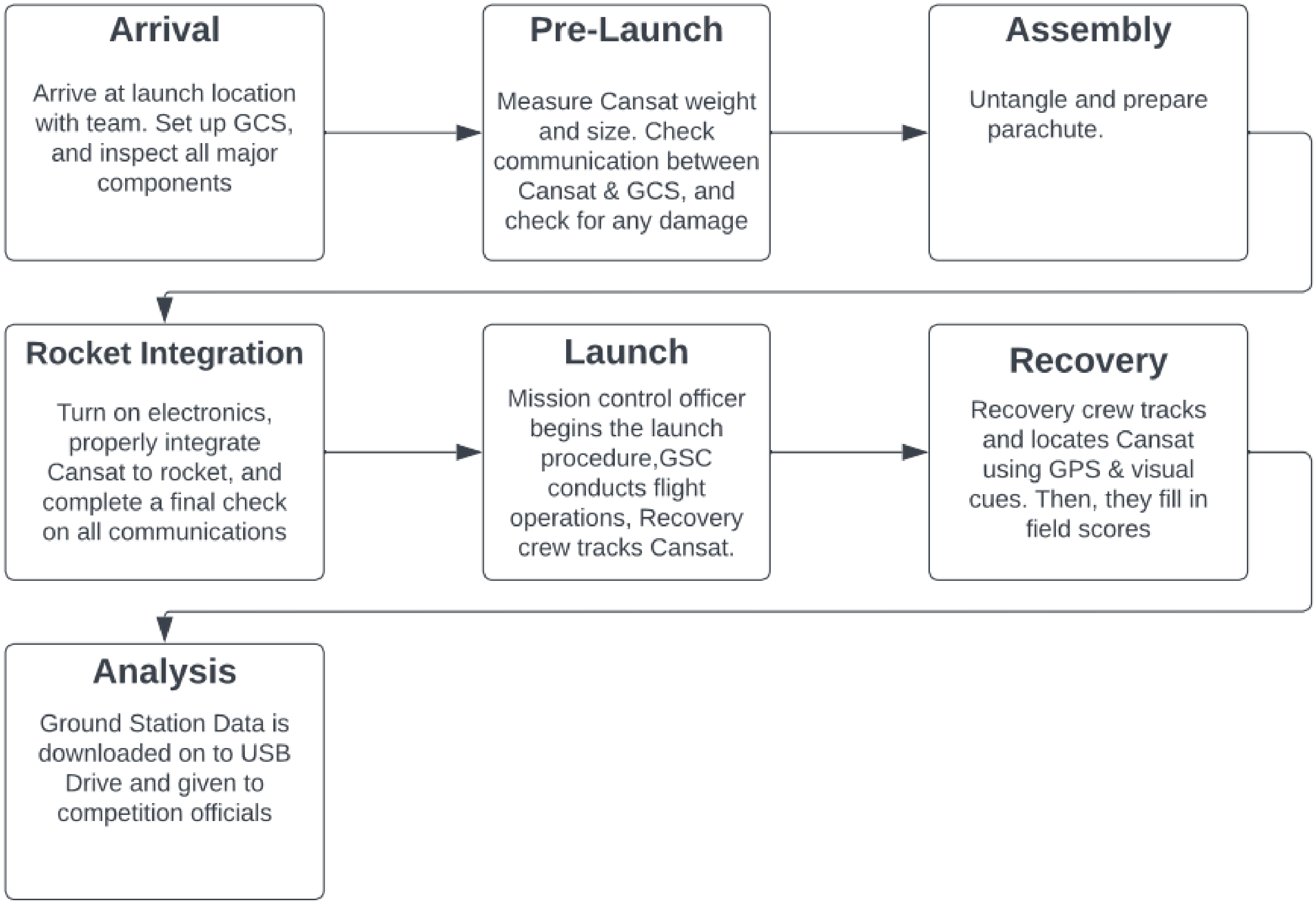
- The configuration and echoing of commands.
- The calculation of altitude with fed data from the CSV.
- The deployment of payload parachute and trigger of audio beacon.
- Payload video is saved and pointing in the correct direction.

Mission Operations & Analysis

Max Epstein, Melissa Gonzalez

Overview of Mission Sequence of Events (1/2)

Flowchart



Overview of Mission Sequence of Events (2/2)

Roles & Responsibilities

- **Mission Control Officer – Melissa Gonzalez**
  - Manages the team and launches the rocket
- **Ground Station Crew – Evan (Steele) Elliott, Max Epstein, Jonathan (Yoni) Gutmann**
  - Monitors the telemetry and issues commands to the CanSat
- **Recovery Crew – Sanat Konda, Christian Roque**
  - Recovers the CanSat post launch
- **CanSat Crew – Zachary DeFabrizio, Jake Edwards, Samuel Taylor, Melanie Miguel**
  - Prepares and integrates the CanSat into the rocket

Antenna Construction & Ground System Setup

- **Handheld ground station antenna will be mounted to a wood plank to be easily handled and aimed before competition date**
- **Ground system will be setup by Ground Station Crew, this includes the adapters necessary for the ground station antenna and XBEE radio**

Field Safety Rules Compliance

<u>Mission Operations Manual Outline:</u>

GCS Configuration:

- Indicates the status of the GCS, antennas, and flight software for final pre-flight checks.

CanSat Preparation and Assembly:

- Indicates the assembly of the CanSat, damage inspection, and assembly of components

CanSat-Rocket Integration:

- Indicates a final checklist and procedure for rocket clearances and assembly inspections.

Launch Preparation:

- Provided by CanSat competition.

Launch Procedure:

- Provided by CanSat competition.

Removal Procedure:

- Provided by CanSat competition.

CanSat Location and Recovery

Recovery Crew will be responsible for container and payload recovery.

- Parachute will be a bright orange color making the CanSat easier to identify and locate.
- A 1.5 m long silver Mylar streamer will be attached to the CanSat to aid in identification and locating.
- Most recently logged position on GPS will be used to more accurately locate the payload.
- Contact information and return address labels will be on both the container and the payload.

Mission Rehearsal Activities

Activities	Rehearsal	Description
Ground System Radio Link Procedures	No	• XBee settings check • Antenna and XBee communication check • Data transmission check
Powering on/off the CanSat	No	• Switch is flicked to turn on CanSat and flicked to turn off
Launch Configuration Preparations	No	• Fit check • Payload is integrated into container • Parachute folding procedure
Loading the CanSat in Launch Vehicle	No	• CanSat to rocket integration
Telemetry processing, archiving, and analysis	No	• Ground station receives all telemetry data • Data is transferred onto CSV file • Data is processed and displayed in real time • Data transfer is ended once container lands
Recovery	No	• Fluorescent container will be tracked during flight • Container buzzer will be listened to and followed • Video data from payload and container transferred to thumb drive
Written Procedures	No	• Mission Operations Guide has been written

Requirements Compliance

Max Epstein

Requirements Compliance Overview

- *Eggsplorer 1* complies with the requirements of the CanSat 2024 mission
- The requirement compliance was measure using three conditions which are detailed below: Full Compliance, Partial Compliance, and No Compliance.

Full Compliance	The CanSat project complies 71/73 mission requirements
Partial Compliance	There are 2 requirements partially satisfied by our CanSat. This means that the requirement is technically met but will require further analysis and testing for finalization.
No Compliance	There are 0 requirements our current build does not comply to.

Requirements Compliance (1/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
C1	The CanSat will act as the nose cone during the rocket's ascent portion of the flight.	Comply	16, 17, 46	
C2	The CanSat shall be deployed when the ejection charge fires.	Comply	16	
C3	After deployment, the CanSat shall deploy its heat shield/aerobraking mechanism.	Comply	16, 17, 34	
C4	A silver or gold mylar streamer of 50mm and 1.5 meters in length shall be connected to the CanSat and released at deployment, used to locate and identify the CanSat.	Comply	110	
C5	At 100 meters, the CanSat shall deploy a parachute and release the heat shield.	Comply	16, 32	
C6	Upon landing, the CanSat shall stop transmitting data.	Comply	16	
C7	Upon landing, the CanSat shall activate and audio beacon.	Comply	66, 74, 75, 83, 105	
C8	The CanSat shall carry a provided large hen's egg with a weight between 51 and 65 grams.	Comply	50	
C9	0 altitude reference shall be at the launch pad.	Comply	16	
C10	During descent with the heat shield deployed, the descent rate shall be between 10 and 30 m/s.	Comply	16, 41	
C11	At 100 meters, the CanSat shall have a descent rate of less than 5 m/s.	Comply	16, 41	
C12	Total cost of the CanSat shall be below $1000. Ground support and analysis equipment are not included in this cost. Equipment from previous years shall be included at current market price.	Comply	126	

Requirements Compliance (2/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
S1	The CanSat mass shall be 900 grams +/- 10 grams without the egg.	Comply	17, 52-54	
S2	The nose cone shall be symmetrical along the thrust axis.	Comply	17	
S3	The nose cone radius shall be exactly 71 mm.	Comply	17, 45	
S4	The nose cone shoulder radius shall be exactly 68 mm.	Comply	17, 45	
S5	The nose cone shoulder length shall be a minimum of 50 mm.	Comply	17, 45	
S6	CanSat structure must be able to survive 15 Gs vibration.	Partial	51	Testing has taken place with prototype of CanSat, further testing will take place with completed CanSat
S7	CanSat shall must survive 30 Gs shock.	Partial	51	Testing has taken place with prototype of CanSat, further testing will take place with completed CanSat
S8	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	16, 46	
S9	The rocket airframe can be used to restrain any deployable parts of the CanSat but shall allow the CanSat to slide out of the payload section freely.	Comply	17, 46	
S10	The rocket airframe can be used as part of the CanSat operations.	Comply	16, 17, 46	
S11	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Comply	43, 46	

Requirements Compliance (3/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
M1	No pyrotechnical or chemical actuators are allowed.	Comply	43	
M2	Mechanisms that use heat shall not be exposed to the outside environment to reduce risk of setting the vegetation on fire.	Comply	43	
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	43, 46	
M4	Spring contacts shall not be used for making electrical connections to batteries as shock forces can case momentary disconnects.	Comply	43	
M5	The CanSat shall deploy a heat shield after deploying from the rocket.	Comply	16	
M6	The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.	Comply	41	
M7	At 100 meters, the CanSat shall release a parachute to reduce the descent rate to less than 5 m/s.	Comply	16, 32	
M8	The CanSat shall protect a hen's egg from damage during all portions of the flight.	Comply	16, 50	
M9	If the nose cone is to be considered part of the heat shield, the documentation shall identify the configuration.	Comply	34, 36	
M10	After the CanSat has separated from the rocket, and if the nose cone portion of the CanSat is to be separated from the rest of the CanSat, the nose cone portion shall descent at less than 10 m/s using any type of descent control device.	Comply	16, 32	

Requirements Compliance (4/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
E1	Lithium polymer batteries are not allowed.	Comply	70	
E2	Battery source may be alkaline, Ni-Cad, NiMH or Lithium. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Comply	70	
E3	The power switch must be easily accessible.	Comply	67, 69	
E4	There must be a power indicator.	Comply	67, 69	
E5	The CanSat shall operate for a minimum of two hours when integrated into the rocket	Comply	71	
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series in addition to 900 MHz Series are allowed.	Comply	55, 60	
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	60	
X3	XBEE radios shall not use broadcast mode.	Comply	60	
X4	The CanSat shall transmit telemetry once per second.	Comply	60, 89	
X5	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, tilt angles, air speed, command echo, and GPS coordinates which include latitude, longitude, altitude, and number of satellites.	Comply	20	

Requirements Compliance (5/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
SN1	CanSat shall measure its speed with a pitot tube during both ascent and descent.	Comply	26	
SN1	CanSat shall measure its altitude using air pressure.	Comply	22	
SN3	CanSat shall measure its internal temperature.	Comply	23	
SN4	CanSat shall measure its angle stability with the aerobraking mechanism deployed.	Comply	27	
SN5	CanSat shall measure its rotation rate during descent.	Comply	27	
SN6	CanSat shall measure its battery voltage.	Comply	25	
SN7	The CanSat shall include a video camera pointing horizontally.	Comply	29	
SN8	The video camera shall record the flight of the CanSat from launch to landing.	Comply	29	
SN9	The video camera shall record video in color and with a minimum resolution of 640x480.	Comply	29	

Requirements Compliance (6/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Comply	76-78	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	89	
G3	Telemetry shall include mission time with 1 second or better resolution.	Comply	88, 89	
G4	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	Comply	76-78	
G5	Each team shall develop their own ground station.	Comply	84	
G6	All telemetry shall be displayed in real time during descent on the ground station.	Comply	89	
G7	All telemetry shall be displayed in engineering units and the units shall be indicated on the displays.	Comply	90	
G8	Teams shall plot each telemetry data field in real time.	Comply	88	
G9	The ground station shall include one laptop computer with a minimum of two hours battery operation, XBEE radio, and an antenna.	Comply	86	
G10	The ground station must be portable so that the team can be positioned at the ground station operation site along the flight line. AC power will be not available.	Comply	86	
G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Comply	64, 65	

Requirements Compliance (7/7)

Req #	Description	Comply / No Comply/ Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or notes
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at 1 Hz interval to the CanSat.	Comply	89	
G13	The ground station shall use a tabletop or handheld antenna.	Comply	87	
G14	The displays on the ground station shall be designed with larger fonts (14pt minimum), bold plot traces and axes, and dark text on a light background since the ground station will be viewed in bright sunlight.	Comply	90	
G15	The ground system shall count the number of received packets. This is not the number of transmitted packets, but the number of packets successfully received at the ground station.	Comply	91	
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission through the mission. This value shall be maintained through processor resets.	Comply	91	
F2	The CanSat shall maintain mission time throughout the whole mission regardless of processor resets or power loss.	Comply	91	
F3	The CanSat shall have its time set to within one second UTC time prior to launch.	Comply	76-78	
F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	Comply	104	
F5	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Comply	104	
F6	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVE commands.	Comply	104	

Management

Max Epstein, Melissa Gonzalez

Status of Procurements

- **All components and electronics to be used in the final design of the CanSat and the Ground Control Station have been purchased prior to the submission of the CDR.**

- **In terms of electronics, several backup units were purchased in order to account for damage during testing and travel, and all components have been received.**

- **All CanSat structural components also have several backup units currently in production to account for damage during testing and travel.**

- **Procurement of our CanSat's components is mostly completed**

CanSat Budget – Hardware

Component	Quantity	Unit Price ($)	Total Price ($)	Value Type
Adafruit BMP280	1	9.95	9.95	Actual
BNO-055	1	34.95	34.95	Actual
Adafruit Ultimate	1	29.95	29.95	Actual
Arduino Nano	1	25.00	25.00	Actual
ANT-900-RP-2-A	1	3.99	3.99	Actual
ESP 32	1	9.99	9.99	Actual
Mirco SD cards	1	4.20	4.20	Actual
PX4 Pitot Tube	1	55.88	55.88	Actual
XBEE Pro 900 Mhz Radio	1	68.25	68.25	Actual
9 Volt Battery	1	1.62	1.62	Actual
INA 260	1	6.38	6.38	Actual
Linear Actuator	1	65.00	65.00	Actual
Servo Motor	1	8.84	8.84	Actual

CanSat Budget – Hardware

Component	Quantity	Unit Price ($)	Total Price ($)	Value Type
Threaded Aluminum Rod	3	3.67	11.01	Actual
Nut	18	2.09	37.58	Actual
Fiberglass Eyebolt	1	8.12	8.12	Actual
Torsion Spring	4	1.63	6.51	Actual
Parachute	1	36.50	36.50	Actual
Mylar Fabric	1	26.00	26.00	Actual
Elastic Bands	2	0.85	1.70	Actual
High Performance Adhesive	1	3.88	3.88	Actual
Memory Foam	1	10.00	10.00	Actual

CanSat Budget – Other Costs (1/2)

Component	Quantity	Unit Price ($)	Total Price ($)	Value Type
Ground Station	-	-	-	-
Xbee USB Shield	1	26.00	26.00	Actual
900 MHz 14 dBi Al Yagi Antenna - reuse	1	72.32	72.32	Actual
900 MHz XBEE Radio - reuse	1	68.25	68.25	Actual
Laptop	1	1	0	Provided by Team Member
Prototyping	1	1	150.00	Estimate
Test Supplies	1	1	150.00	Estimate
Test Facilities/ Manufacturing Equipment	1	1	0	Covered by University

CanSat Budget – Other Costs (2/2)

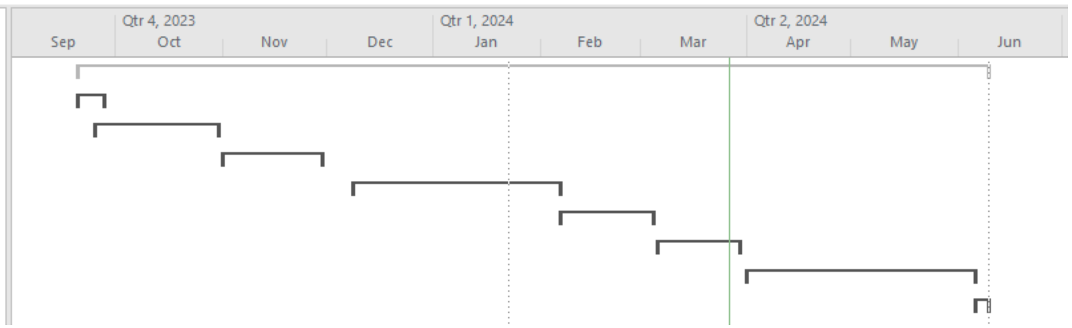
Source of Income:	Funds Provided ($):
UF MAE Department	$2,700

Hardware Costs:	$465.30
Other Costs:	$466.57
Competition Fees:	$200
Total Costs:	**$1,131.87**

A total cost of $1131.87 for the testing and building of our CanSat as well as CanSat related fees leaves us with a total of **$1568.13** for travel, housing, and food expense. This is expected to be more than sufficient for our 10 members. We also have various travel related sponsorships from the university.

An overview of the competition schedule is shown below, along with a key defining the symbols used in the following detailed schedule.

Task Name	Duration	Start	Finish	Subteam
2024 CANSAT Plan	188 days?	Wed 9/20/23	Sun 6/9/24	All
Preliminary Design Phase	6 days?	Wed 9/20/23	Wed 9/27/23	Management
Research	26 days	Mon 9/25/23	Mon 10/30/23	All
Trade Studies	21 days	Wed 11/1/23	Wed 11/29/23	All
PDR Completion	42 days	Sat 12/9/23	Tue 2/6/24	All
Critical Design Phase	19 days	Wed 2/7/24	Mon 3/4/24	All
CDR Completion	18 days	Wed 3/6/24	Fri 3/29/24	All
Testing	48 days	Mon 4/1/24	Wed 6/5/24	All
Competition	2 days	Thu 6/6/24	Sun 6/9/24	All

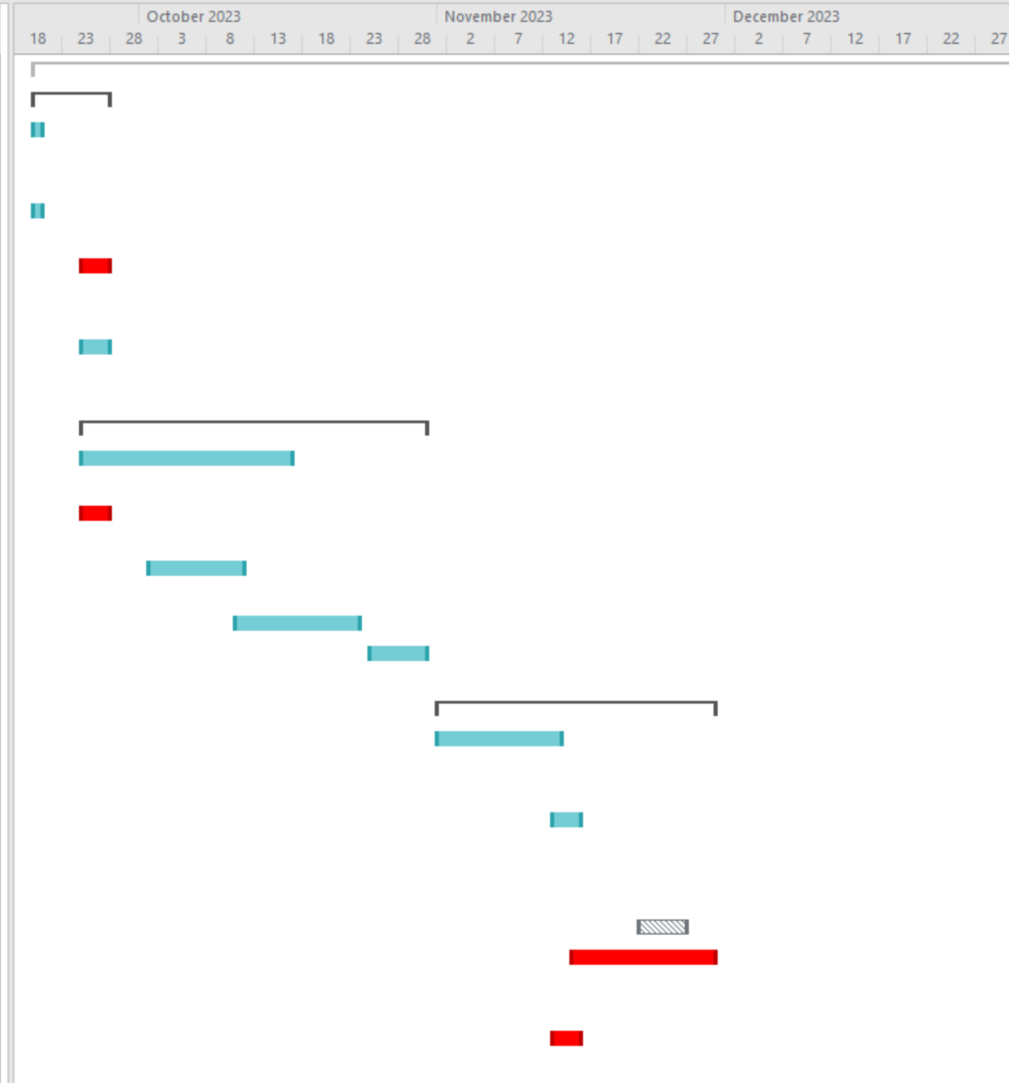


Key

Design Phase Overview	Task
Important Action	Holiday/Vacation

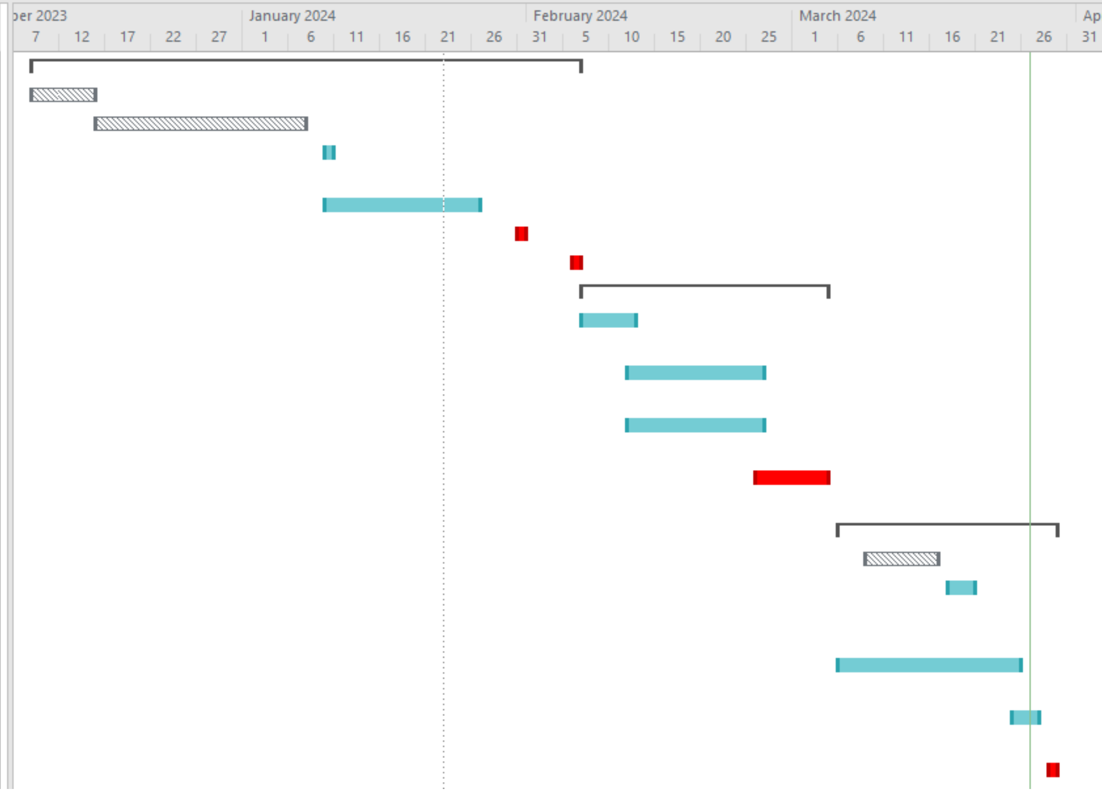
Detailed Program Schedule (1/3)

Task Name	Duration	Start	Finish	Subteam
2024 CANSAT Plan	**188 days?**	**Wed 9/20/23**	**Sun 6/9/24**	**All**
Preliminary Design Phase	**6 days?**	**Wed 9/20/23**	**Wed 9/27/23**	**Management**
Present Mission Guide and Competition Objectives	1 day	Wed 9/20/23	Wed 9/20/23	Management
Finalize Meeting Schedule	1 day	Wed 9/20/23	Wed 9/20/23	Management
Organize and Divide Team and Responsibilities	3 days	Mon 9/25/23	Wed 9/27/23	Management
Document and Organize Competition Requirements	3 days	Mon 9/25/23	Wed 9/27/23	Management
Research	**26 days**	**Mon 9/25/23**	**Mon 10/30/23**	**All**
Sensors/Electronics Research	16 days	Mon 9/25/23	Mon 10/16/23	Electrical Team
Design Conceptualization	3 days	Mon 9/25/23	Wed 9/27/23	Mechanical Team
Subsystem Design Discussions	8 days	Mon 10/2/23	Wed 10/11/23	All
Prototyping Designs	9 days	Wed 10/11/23	Mon 10/23/23	Mechanical Team
Document Pros and Cons of Each Design Proposal	4 days	Wed 10/25/23	Mon 10/30/23	Mechanical Team
Trade Studies	**21 days**	**Wed 11/1/23**	**Wed 11/29/23**	**All**
Prototype Testing and Quantative Data Collection	9 days	Wed 11/1/23	Mon 11/13/23	Mechanical Team
Verify Requirements are Met by Each Subsystem and Make According Edits	3 days	Mon 11/13/23	Wed 11/15/23	All
Thanksgiving Break	4 days	Wed 11/22/23	Sun 11/26/23	All
Conduct Trade Studies on Various Designs for each Subsystem	11 days	Wed 11/15/23	Wed 11/29/23	All
Order Electronics and Parts	3 days	Mon 11/13/23	Wed 11/15/23	Electrical Team



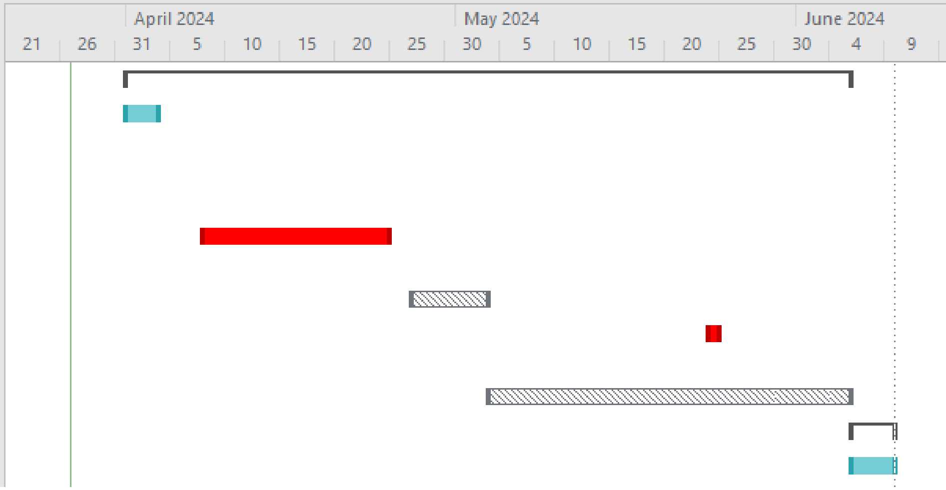
Detailed Program Schedule (2/3)

Task Name	Duration	Start	Finish	Subteam
PDR Completion	**42 days**	**Sat 12/9/23**	**Tue 2/6/24**	**All**
Fall Final Exams	6 days	Sat 12/9/23	Fri 12/15/23	All
Winter Break	17 days	Sat 12/16/23	Sun 1/7/24	All
Assign Slides and Start Formatting	1 day	Wed 1/10/24	Wed 1/10/24	Management
Fill Out Slides	13 days	Wed 1/10/24	Fri 1/26/24	All
PDR Due	1 day	Wed 1/31/24	Wed 1/31/24	All
Present PDR	1 day	Tue 2/6/24	Tue 2/6/24	All
Critical Design Phase	**19 days**	**Wed 2/7/24**	**Mon 3/4/24**	**All**
Review Requirements for CDR	4 days	Wed 2/7/24	Mon 2/12/24	All
Manufacture Finalized Subsystems	11 days	Mon 2/12/24	Mon 2/26/24	Mechanical Team
Test Flight Software and Electronics	11 days	Mon 2/12/24	Mon 2/26/24	Electrical Team
Conduct the Integration of Subsystems	6 days	Mon 2/26/24	Mon 3/4/24	All
CDR Completion	**18 days**	**Wed 3/6/24**	**Fri 3/29/24**	**All**
Spring Break	7 days	Sat 3/9/24	Sat 3/16/24	All
Document Final Design and Analysis for all Subsystems	3 days	Mon 3/18/24	Wed 3/20/24	All
Fill Out Slides and Verify Completion	14 days	Wed 3/6/24	Mon 3/25/24	All
Format and Make Final Adjustments	3 days	Mon 3/25/24	Wed 3/27/24	All
CDR Due	1 day	Fri 3/29/24	Fri 3/29/24	All



Detailed Program Schedule (3/3)

Task Name	Duration	Start	Finish	Subteam
Testing	**48 days**	**Mon 4/1/24**	**Wed 6/5/24**	**All**
Verify System Intergration Meets Competition Requirements	3 days	Mon 4/1/24	Wed 4/3/24	All
Conduct Tests on Full System	13 days	Mon 4/8/24	Wed 4/24/24	All
Spring Final Exams	6 days	Sat 4/27/24	Fri 5/3/24	All
Environmental Test Document Due	1 day	Fri 5/24/24	Fri 5/24/24	All
Summer Break	24 days	Sat 5/4/24	Wed 6/5/24	All
Competition	**2 days**	**Thu 6/6/24**	**Sun 6/9/24**	**All**
Competition Weekend	3 days	Thu 6/6/24	Sun 6/9/24	All



Shipping and Transportation

- Entire completed CanSat will be packaged carefully in a padded box.
- Any additional hardware, spare parts, supplies etc. will be packaged in separate boxes.
- These boxes will be transported by car from Gainesville, FL to Blacksburg, VA by team members driving to the competition.

Conclusions

Major Unfinished Work

- Telemetry communication tests between CanSat and Ground Station
- Full manufactured prototype of CanSat
- Egg container has been prototyped but has not been tested

Testing To Be Done

- Drop Test
- Thermal Test
- Vibration Test
- Vacuum Test

Flight Software Status

- Ground Station is Complete
- Radio Testing has Started
- CanSat Software is almost complete

Major Accomplishments

- All electronics have been purchased and ordered
- Majority of telemetry components programmed
- Avionics communication and data handling in progress
- Significant funding secured
- Started prototyping CanSat components