CanSat 2023
Preliminary Design Review (PDR)
Outline
Version 1.0

Team 1032

Yes we CANSAT

Presentation Outline

Team Organization

- **Faculty Advisor** — Ting Dong
- **Team Lead** — Savari Datta, Junior
  - **Container Subsystem**
    - **Container** — Christian Roque, Freshman
  - **Payload & Aerodynamics**
    - **Payload Lead** — Jordi Rey, Junior
      - Daniel Horton, Junior
        - Melissa Gonzalez Grospe, Sophomore
  - **Payload Deployment**
    - **Aerodynamics Lead** — Jovana Markovic, Junior
  - **Avionics Subsystem**
    - **Avionics Lead** — Dylan Falzone, Junior
      - Yashas Shivaram, Junior
        - Paolo D'Alessandro, Junior
  - **Flight Software**
    - **Flight Software** — Max Epstein, Sophomore

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
MAE	Mechanical & Aerospace Engineering

Acronym	Meaning
MQTT	MQ Telemetry Transport
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

Systems Overview

Savari Datta, Jordi Rey, Daniel Horton

Mission Summary (1/2)

Main Objectives:

Design a CanSat that shall consist of a container and a payload. The probe shall simulate the sequence of a planetary probe

- 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).
- The CanSat must survive the forces incurred at launch and deployment.
- Once the CanSat is deployed from the rocket, the CanSat shall descend using a parachute at a rate of 15 m/s.
- At 500 meters, the CanSat shall deploy a probe that shall open a heat shield.
- The heat shield will be used as an aerobraking device with a descent rate of 20 meters/second or less.
- When the probe reaches 200 meters, the probe shall deploy a parachute and slow the descent rate to 5 meters/second.
- Once the probe has landed, it shall attempt to upright itself and raise a flag 500 mm above the base of the probe.
- The video camera shall be pointed towards the ground during descent.

Mission Summary (2/2)

Bonus Objectives:

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.

- Will not be attempting 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

System Requirement Summary (1/6)

Requirement Number	Description
1	Total mass of the CanSat (science payloads and container) shall be 700 grams +/- 10 grams.
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.
4	The container shall be a fluorescent color; pink, red or orange.
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.
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.
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.
9	The Parachutes shall be fluorescent Pink or Orange
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second +/- 5m/s.
11	0 altitude reference shall be at the launch pad.

System Requirement Summary (2/6)

Requirement Number	Description
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.
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.
16	Mechanisms shall not use pyrotechnics or chemicals.
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.
18	Both the container and payload shall be labeled with team contact information including email address.
19	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years should be included in this cost, based on current market value.
20	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.
21	XBEE radios shall have their NETID/PANID set to their team number.
22	XBEE radios shall not use broadcast mode.
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.

System Requirement Summary (3/6)

Requirement Number	Description
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.
25	An audio beacon is required for the probe. It shall be powered after landing.
26	The audio beacon shall have a minimum sound pressure level of 92 dB, unobstructed.
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.
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.
29	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.
30	The CanSat shall operate during the environmental tests laid out in Section 3.5.
31	The CanSat shall operate for a minimum of two hours when integrated into the rocket.
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 +/- 1m/sec.

System Requirement Summary (4/6)

Requirement Number	Description
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.
38	The probe shall transmit telemetry once per second.
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.
40	The probe shall include a video camera pointing down to the ground.
41	The video camera shall record the flight of the probe from release to landing.
42	The video camera shall record video in color and with a minimum resolution of 640x480.
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
45	The probe shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.
46	The probe shall have its time set to within one second UTC time prior to launch.
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.
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.

System Requirement Summary (5/6)

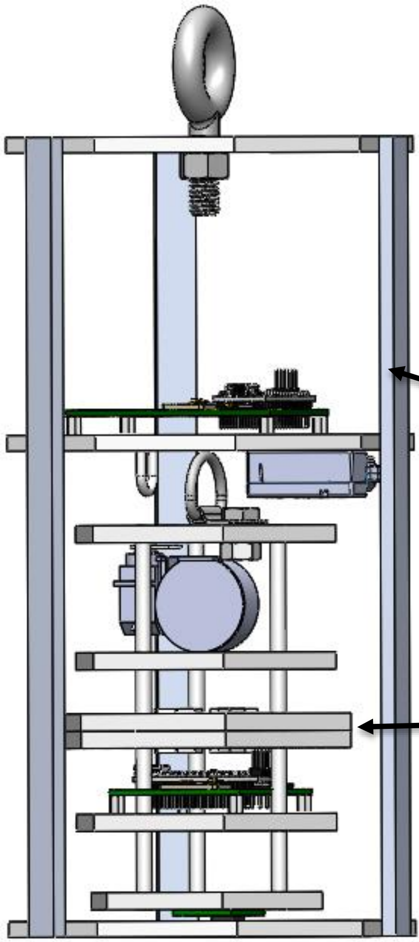
Requirement Number	Description
49	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.
50	The ground station shall command the CanSat to start calibrating the altitude to zero when the CanSat is on the launch pad prior to launch.
51	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.
52	Telemetry shall include mission time with 0.01 second or better resolution.
53	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.
54	Each team shall develop their own ground station.
55	All telemetry shall be displayed in real time during descent on the ground station.
56	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
57	Teams shall plot each telemetry data field in real time during flight.
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.
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
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.

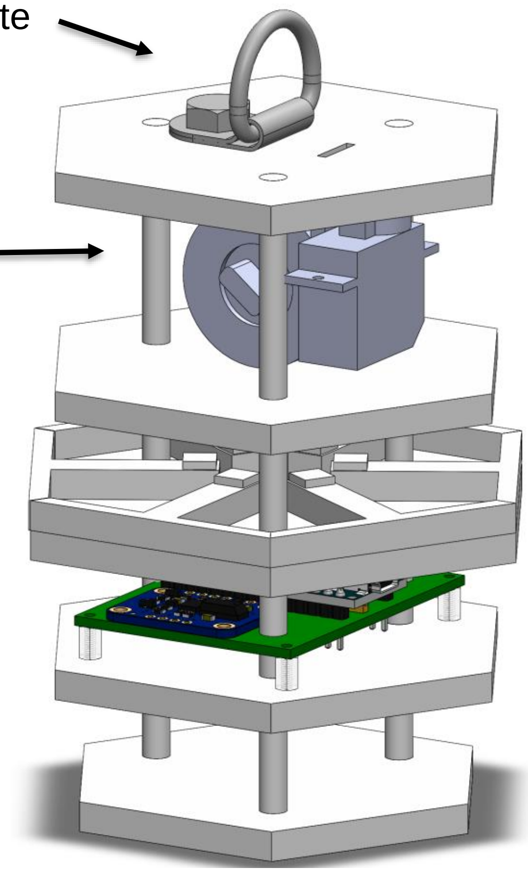
System Requirement Summary (6/6)

Requirement Number	Description
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.

System Level CanSat Configuration Trade & Selection

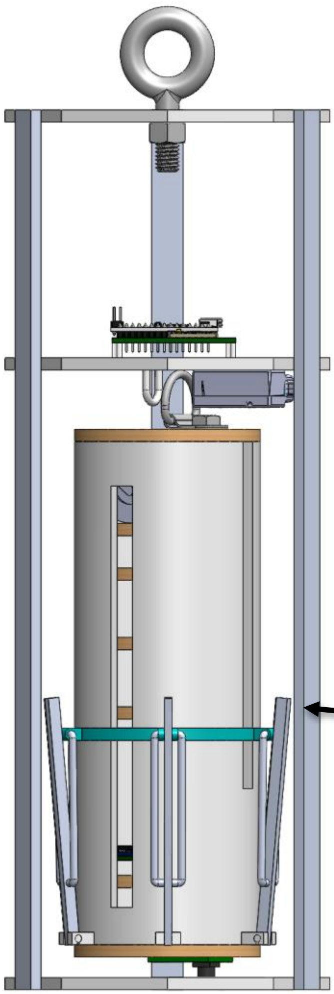
System Design 1

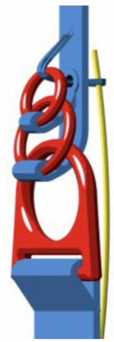




System Level CanSat Configuration Trade & Selection

System Design 2



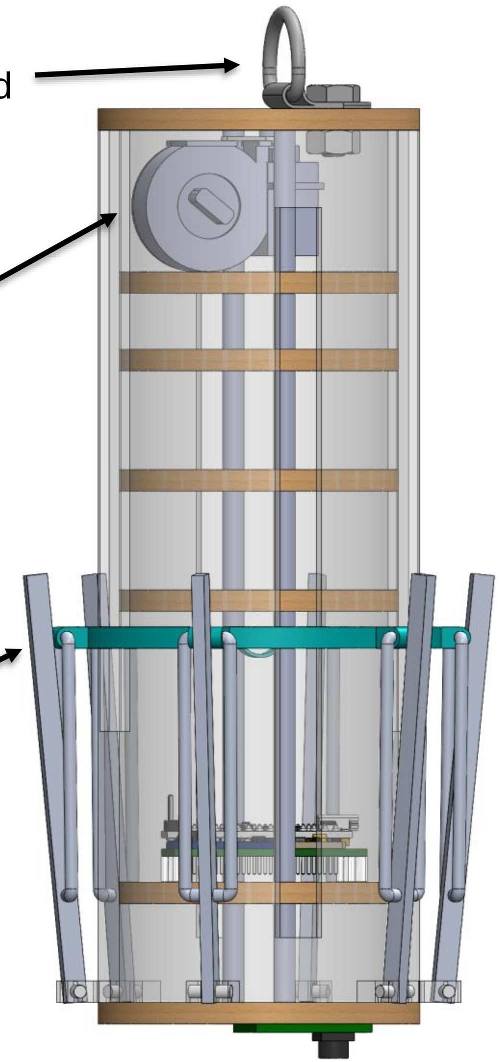


Tie-down ring for parachute – attached to three-ring release system

Flag deployment mechanism

Canister avionics bay

ABS-enclosed cylindrical payload with deployable heatshield mechanism

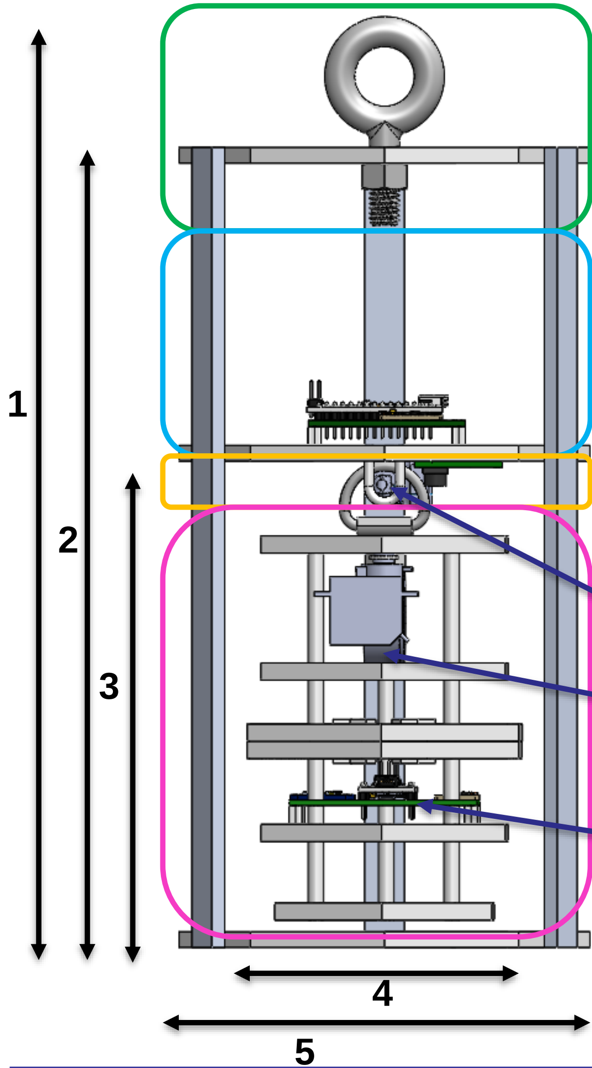


System Level Configuration Selection

Chosen Design: System 1	
Configuration	**Reasoning**
9-sided polygon Canister	Simple to manufacture, light-weight design, composed only of ABS plastic plates, fiberglass eyebolt and aluminum supports fixed together using epoxy.
Hexagonal payload configuration	ABS plates with 6 spring-deployed arms for the aerobraking-heatshield, and aluminum rods supporting the plates. More compact design with fewer unique parts required, making it easier to manufacture.
Altimeter Chute Release	Electronic chute release; does not require any other mechanical components on the payload to deploy the parachute when the desired altitude is reached.

Physical Layout

Launch Configuration



Green- Parachute bay
Blue- Cannister Avionics bay
Yellow- Payload Deployment Assembly
Pink- Payload subassembly

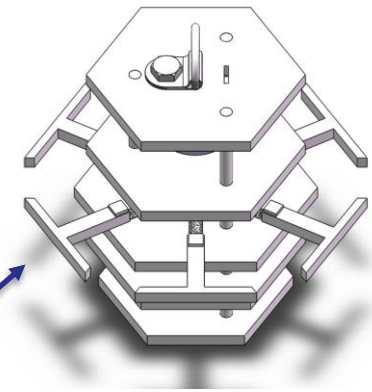
Basic Dimensions

1- 296.45 mm
2- 255.0 mm
3- 154.14 mm
4- 80.0 mm
5- 124.0 mm

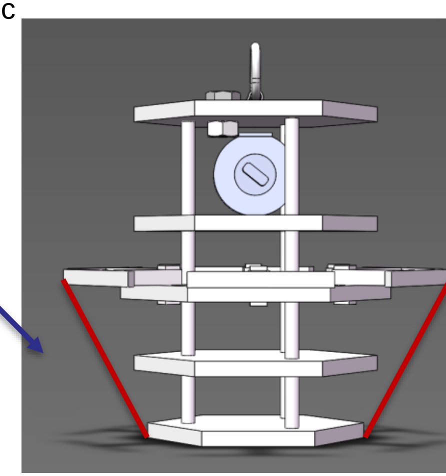
Linear Actuator payload deployment system

Flag deployment system

Payload Avionics Bay

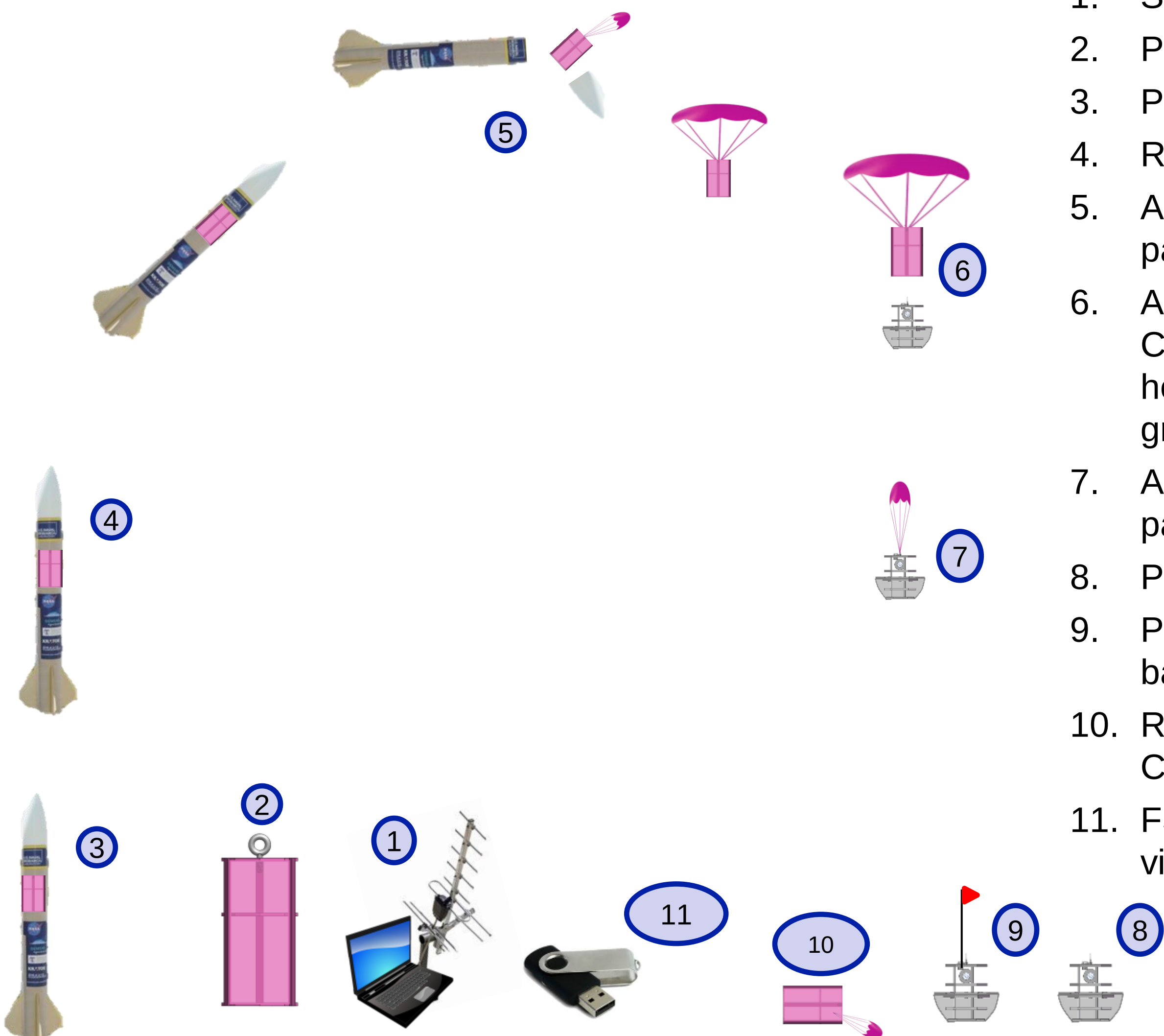


Payload deployment configuration, Red lines outline the mylar fabric that will act as the aerobraking heatshield



Total mass is 681.2 g

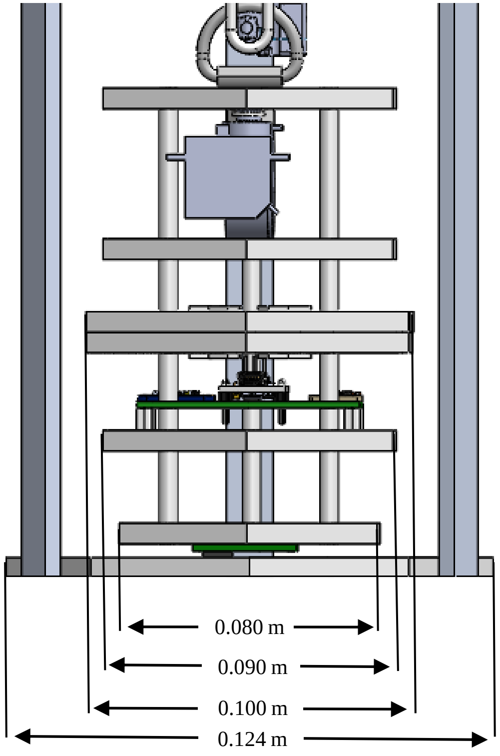
System Concept of Operations



1. Set up ground station
2. Power on CanSat
3. Place CanSat into rocket
4. Rocket is launched
5. At 670-725m the CanSat separates and parachute opens
6. At 400m a probe will be released from the CanSat, which will deploy an aerobraking heat shield, with a camera facing the ground at all times
7. At 200m the probe will deploy a parachute too reduce descent rate
8. Probe will land upright
9. Probe will deploy a flag 500mm above the base of the probe
10. Recovery crew tracks and collects CanSat
11. FSW obtains and saves flight data & video recording to thumb drive

Payload Clearance

Sharp edges in this section will be sanded down



NOTE: The first two plates are the same size as the third plate (0.090 m)

Sensor Subsystem Design

Dylan Falzone

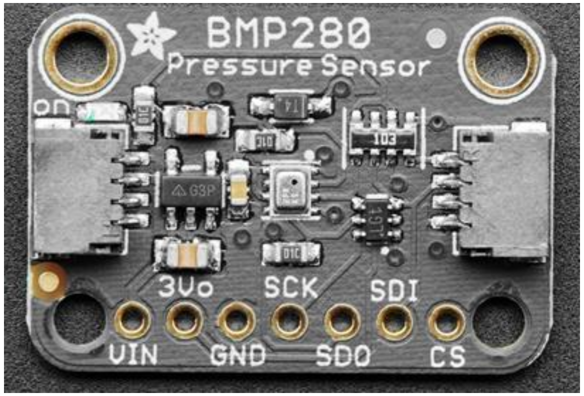
Sensor Subsystem Overview

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	Container, Payload
Rotational Sensor	BNO055	Measure gyro readings in degrees per second, angular acceleration, and magnetometer readings in gauss	Payload
Temperature Sensor	BNO055	Measure temperature readings	Payload
Camera	Arducam Mini 2MP Plus	View and record Earth's terrain during descendent	Payload

Payload Air Pressure Sensor Trade & Selection

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

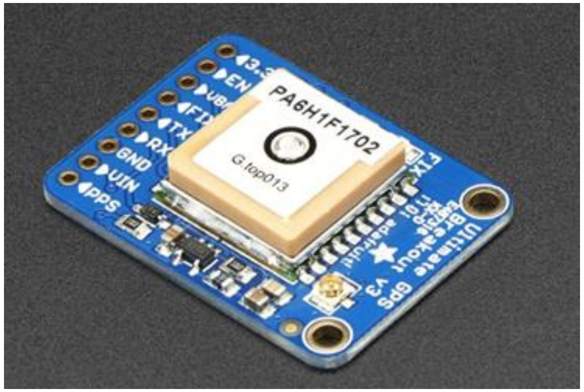
Selection	Reasoning for the selection
Adafruit BMP280	- Lower current draw in comparison to other inspected sensors - Greater resolution in comparison to other inspected sensors



Payload GPS Sensor Trade & Selection

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

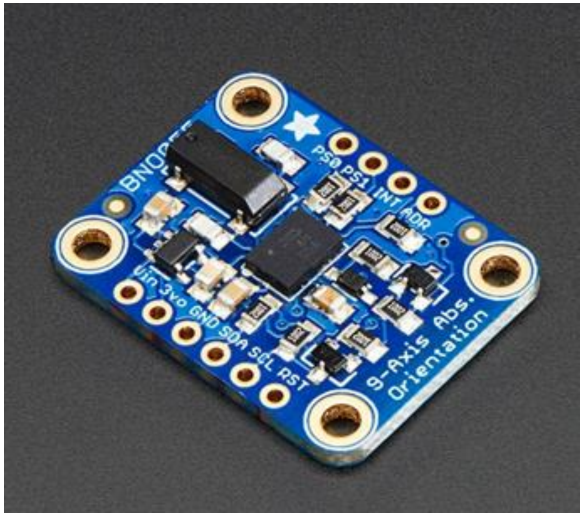
Selection	Reasoning for the selection
Adafruit Ultimate	- Lower current draw during tracking in comparison to other inspected sensors - Previous experience with sensor and familiarity with Arduino - Availability



Payload Air Temperature Sensor Trade & Selection

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	5.95
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

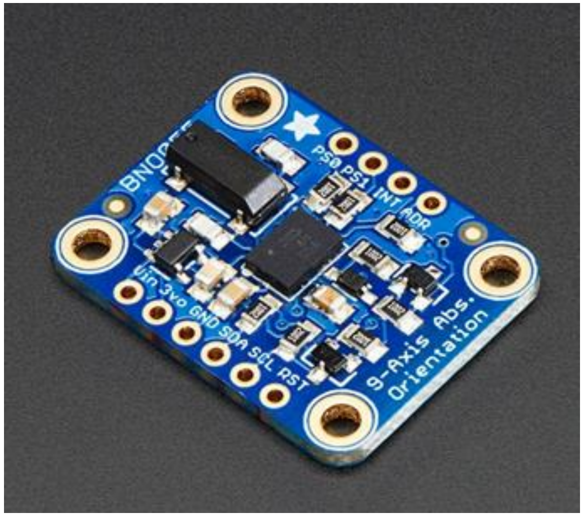
Selection	Reasoning for the selection
BNO 055	- Familiarity with sensor - Also meets our requirements for the payload's temperature sensor - Availability



Payload Tilt Sensor Trade & Selection

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	5.95
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

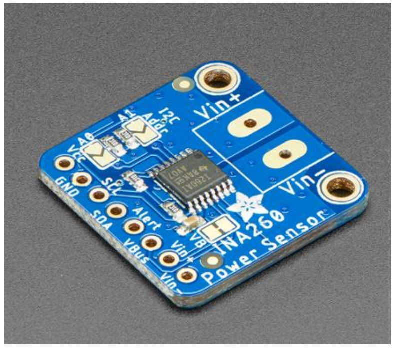
Selection	Reasoning for the selection
BNO 055	- Familiarity with sensor - Also meets our requirements for the payload's temperature sensor - Availability



Payload Battery Voltage Sensor Trade & Selection

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



Payload Camera Trade & Selection

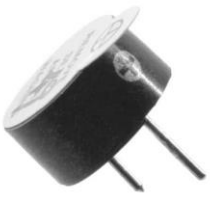
Name	Price ($)	Weight (g)	Size (mm)	Operating Voltage (V)	Current Draw (mA)	Framerate (fps)
Miniature TTL Serial JPEG Camera	34.95	3	20 x 28	3.3 - 5.0	75	30
Arducam Mini 2MP Plus	25.99	20	24 x 34	3.3 - 5.0	20	30

Selection	Reasoning for the selection
Arducam Mini 2MP Plus	- Compatibility with microprocessor - Lower current draw in comparison to other inspected sensors

Audio Beacon Trade & Selection

Name	Min Sound Pressure (dB)	Weight (g)	Operating Voltage (V)	Mini Current Draw (mA)
PS1240P02BT	60	1	3	40
IE092505-1	80	1	5	30

Selection	Reasoning for the selection
IE092505-1	- Compatibility with microprocessor - Meet sound level requirement



Bonus Camera Trade and Selection

- **N/A**

Descent Control Design

Jovana Markovic, Melissa Gonzalez Grospe

Descent Control Overview (1/3)

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

System: Parachute

System Components: Hexagonal Parachute
Parachute Chords
Eyebolt

System Overview: The eyebolt is screwed into the can. The parachute is attached to the eyebolt using chords. The parachute sits atop the can prior to the can's ejection from the rocket after which the parachute will deploy naturally

Payload Descent Control System:

System: Parachute

System Components: Hexagonal Parachute
Parachute Chords
Altimeter Chute Release

System Overview: The parachute is attached to a tie down ring which is screwed into the payload. The parachute will sit atop the payload held together by the device until the desired altitude is reached, after which the device will release, and the parachute will be allowed to deploy naturally

Descent Control Overview (3/3)

<u>Aerobraking:</u>

System: Hexagonal Prism Payload Shape

System Components: Hexagonal Plates

Extendable arms which serve to enlarge one of the plates

Spring system which releases the arms into place

Poles for vertical alignment

System Overview: The spring system will allow for the arm attachments to remain compressed while the payload is within the can. Following deployment from the can, the arms will extend and enlarge the surface area of the central hexagonal plate. The enlarged plate will create a truncated hexagonal pyramid which will increase drag.

Container Descent Control Strategy Selection and Trade

Decent Control			Eyebolt Design			Tie Down Ring Design		
Objective	Weighting Factor	Parameter	Mag.	Score	Value	Mag.	Score	Value
Mass	0.30	grams	10.1	9.4	2.8	15.6	6.0	1.8
Durability	0.10	discussion	good	8.0	0.8	okay	6.0	0.6
Stability	0.30	discussion	great	10.0	3.0	good	8.0	2.4
Size (Vertical Height)	0.20	mm	66.5	3.6	0.7	23.8	10.0	2.0
Simplicity	0.10	# of parts	2.0	10.0	1.0	4.0	5.0	0.5
Overall value					8.3			7.3

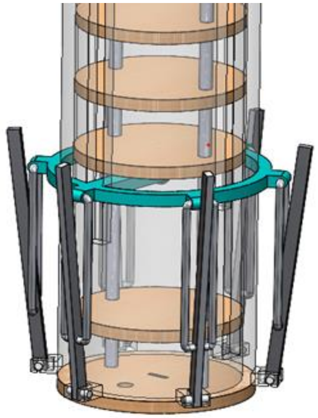
Justification: The Eye Bolt design was selected to attach the parachute to the can as it weighs less and requires fewer parts to be installed in comparison to the Tie Down Ring

Configuration A: Eyebolt

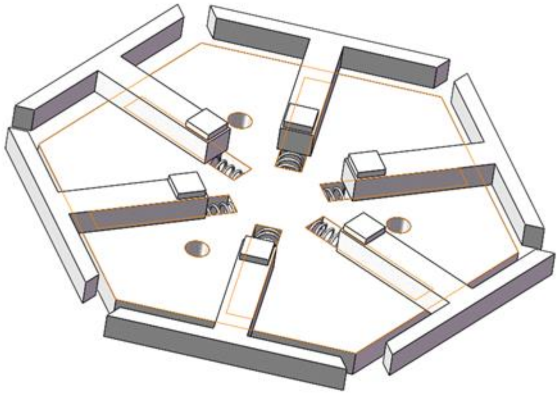
Configuration B: Tie Down Ring

Payload Aerobraking Descent Control Strategy Selection and Trade

Design	Description	Identified Issues	Evaluation
Umbrella Mechanism	Following deployment from the can, six rods will release naturally and extend at an angle in order to create an aerodynamic parabolic shape.	Manufacturing the rods to allow for easy movement proved to be difficult. Lack of storage space for electronics.	Discarded
Spring Loaded Hexagon	Following deployment from the can, a spring system will allow for rods to extend on the top plate of the payload. The top plate will now be larger, which will create a cone shaped payload.	Design is heavier than preferred. The bottom of the payload is a hexagonal plate which may disturb the aerodynamics.	Selected, allows for necessary deceleration while being cheaper and easier to manufacture



Configuration A: Umbrella Mechanism



Configuration B: Spring Loaded Hexagon

Payload Aerobraking Descent Stability Control Strategy Selection and Trade

Method	Description	Identified Issues	Evaluation
Bottom Heavy Payload Design	Designing the payload in a manner in which most of the mechanisms are located towards the center bottom of the payload and distributing the contents of the payload such as the electronics toward the bottom would ensure that the payload lands upright.	Requires extensive testing. Adequate space for the configuration may be an issue. The payload contents may be more susceptible to damage from the shock of deployment in this configuration.	Selected, simple design and preliminary testing has already been completed.
Spinning Payload	The spinning serves the gyroscopically stabilize the payload.	Difficult to implement. The spinning could have a significant effect on the speed at which the payload is descending.	Discarded, impractical

Payload Parachute Descent Control Strategy Selection and Trade

Method	Description	Identified Issues	Evaluation
Eyebolt	Consists of a 6.6675 cm long shank which anchors the eye bolt to the payload and a ring at the top which allows for attaching the parachute. Would require an additional nut to hold the eye bolt in place.	Vertical height exceeds allowable value. Would add considerable height to the payload design, possibly requiring modifications to the can design in order to accommodate the height.	Discarded
Tie Down Ring	The tie down ring consists of a D shaped ring which is securely nestled within a base plate. The base plate is folded over and through the ring to secure it. The tie down ring is secured to the payload using an additional nut and screw.	Heavier than preferable. More complex manufacturing compared to eyebolt design. Requires more parts.	Selected, shorter possible shank length saves space, shorter overall height.

Configuration A: Eyebolt

Configuration B: Tie Down Ring

Decent Rate Estimates for the following Configurations

Configuration	Device	Desired Rate	Decent Rate Estimate	Method of Calculation
CanSat with payload	Parachute	15 ± 5 m/s	15.3 m/s	Parachute calculations
Payload aerobraking	Umbrella Device	less than 20 m/s	11.3 ± 3.1 m/s	Drop Testing
Payload parachute released	Parachute	5 ± 1 m/s	5.89 ± 1.1 m/s	Drop Testing

Assumptions

- **~2.7 m/s winds**
- **Total weight is 700 grams**
- **Payload weight is 300 grams**
- **0.53m Hexagon Parachute for Payload**

Descent Rate Estimates (2/2)

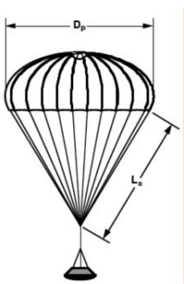
Testing Information

- **3D Printed Model of Container and Aerobraking device**
- **Brass weights were used to simulate the weight of the interior components (700 grams & 300 grams)**
- **Parachutes used were those selected from the Trade Study**
- **Prototype was abruptly thrown in an attempt to mimic shock forces incurred at apogee**
- **Each protype was tested 10 times and outliers were removed from each data set**

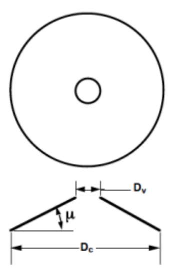
Formulas Used

$$\bar{v} = \frac{\Delta x}{\Delta t} \qquad \Delta x = v_0 t + \frac{1}{2} a t^2 \qquad \sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

$$V_{\text{terminal}}^2 = \frac{2 M_{vehicle} \cdot g / \rho}{\left(C_D \cdot S\right)_0^{parachute} + \left(C_D \cdot S\right)_{ref}^{vehicle}}$$



$$D_P = \sqrt{\frac{4 S_P}{\pi}}$$



$$S_0 = \lambda \frac{D_c^2}{4} \sqrt{1 + \tan^2 \mu}$$

$$D_0 = \sqrt{\frac{4 S_0}{\lambda}}$$

$$S_v = \lambda \frac{D_v^2}{4} \sqrt{1 + \tan^2 \mu}$$

$$\lambda_g = \frac{S_v}{S_0}$$

Formulas Retrieved from:
Section 3.5 Recovery Systems: Parachutes 101 - Utah State University. http://mae-nas.eng.usu.edu/MAE_6530_Web/New_Course/launch_design/Section7.5.pdf.

Mechanical Subsystem Design

Daniel Horton, Christian Roque, Savari Datta, Melissa Gonzalez Grospe

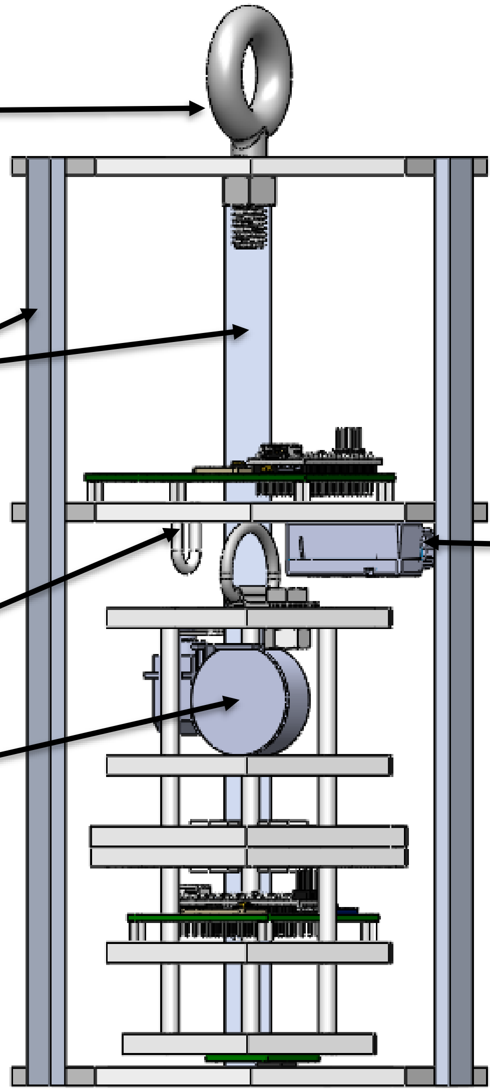
Mechanical Subsystem Overview

Parachute Attachment - Lightweight fiberglass eyebolt providing mechanical connection between parachute and can.

Aluminum Supports - Aluminum bar stock fixed to the ABS platforms provides rigid support for the can shape.

Payload Securement Ring - Used to stop payload from sliding off linear actuator arm.

Flag Deployment – a container will house a clock spring that will be used in reverse to simulate a tape measure that pushes outwards rather than inwards, raising the flag



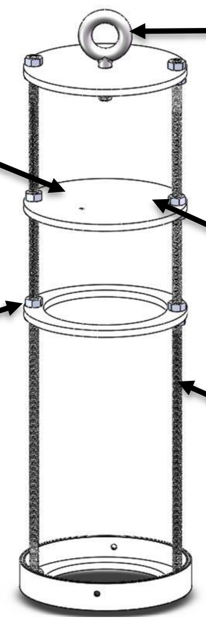
ABS Platforms - Nine sided levels add structural support for mounting aluminum rods/supports on the sides, parachute attachment, and electronics.

Linear Actuator - Holds the payload inside the container when deployed. Can be retracted to release payload at desired altitude.

ABS Nonagon Ring - Bottom platform is an open nine-sided ring, providing structural support while still allowing the payload to drop through.

Container Mechanical Layout of Components Trade & Selection (1/2)

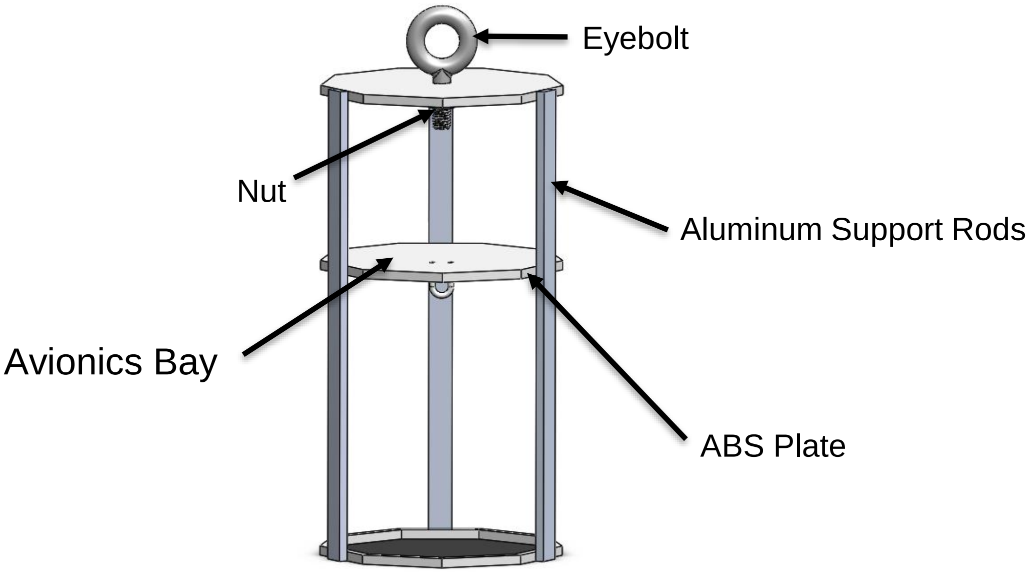
Configuration A: Circular Container



Design	Description	Materials	Evaluation
Circular Container	Circular shaped container with four levels held together by 2 aluminum rods and 16 corresponding nuts.	Eyebolt (1) – Fiberglass Rod (2) - Aluminum Nut (17) - Aluminum Plates (4) - ABS Plastic	Discarded, not enough space for electrical components and payload to fit

Container Mechanical Layout of Components Trade & Selection (2/2)

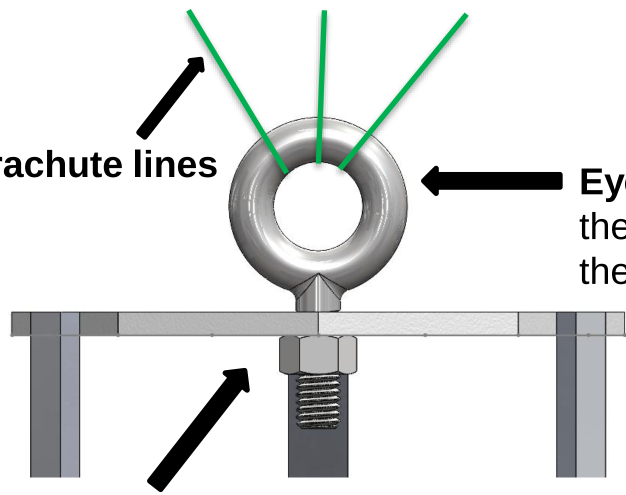
Configuration B: Nonagon Container

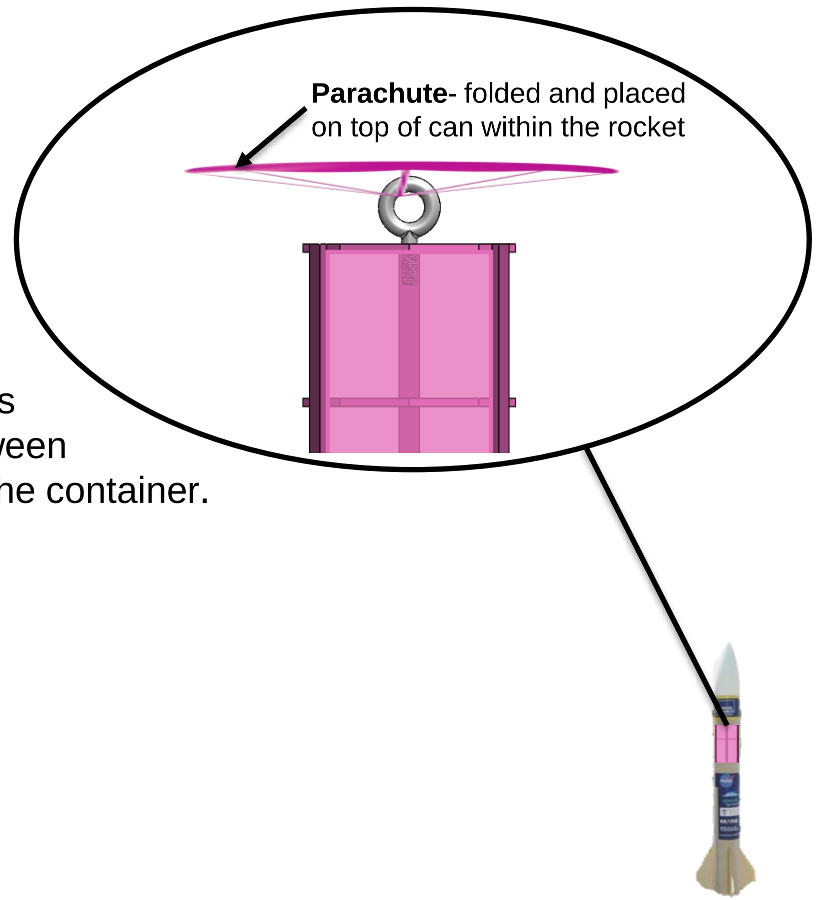


Design	Description	Materials	Evaluation
Nonagon Container	Nonagon shaped container with three levels held together by 3 aluminum supports using epoxy.	Eyebolt (1) – Fiberglass Supports (3) – Aluminum Plates (3) - ABS Plastic Nut (1) - Aluminum	Selected, more space on each plate, 3 supports make it structurally intact, less components makes it simpler and much lighter in weight.

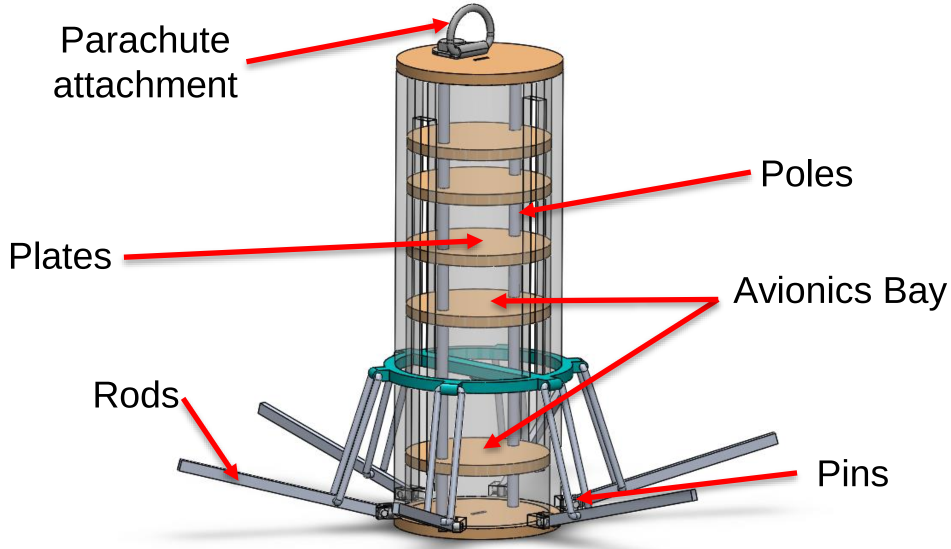
Container Parachute Attachment Mechanism

The parachute for the container will be connected via a fiberglass routing eyebolt that is attached to the top of the container using a nut.





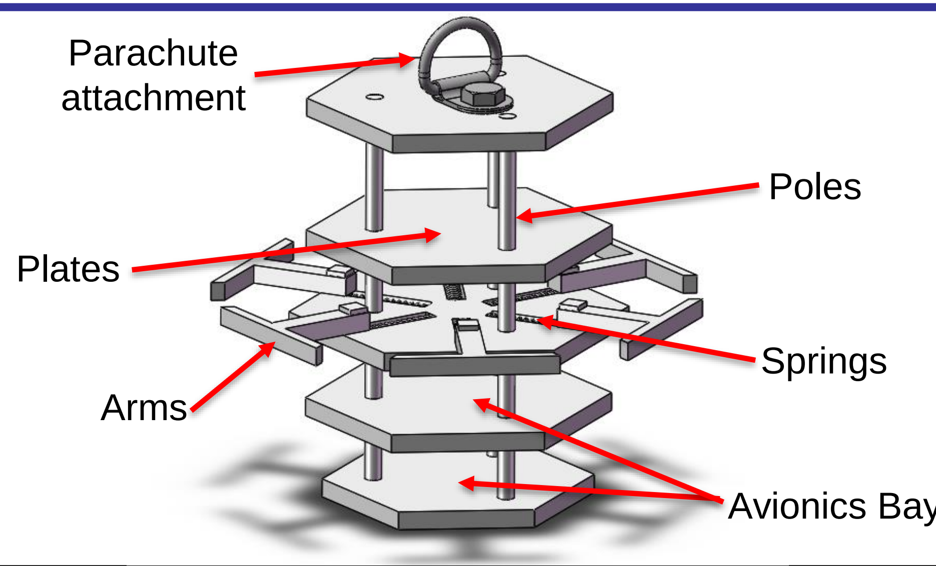
Payload Mechanical Layout of Components Trade & Selection (1/2)



NOTE: Payload will be released at 500 meters

Design	Description	Materials	Evaluation
Umbrella Mechanism	Overall cylindrical shape when compacted (in can). When released from can, rods fully extend to create a widened parabolic shape for the bottom half of the payload. All plates are circular. Top 2 plates are used for the parachute attachment and flag deployment device. The rest of the plates that make up the structure of the payload are reserved for electronics.	Plates – Wood Poles – ABS Plastic Rods – Aluminum Pins – ABS Plastic Parachute Attachment – Steel	Discarded

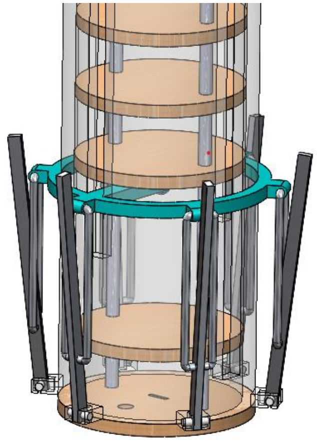
Payload Mechanical Layout of Components Trade & Selection (2/2)



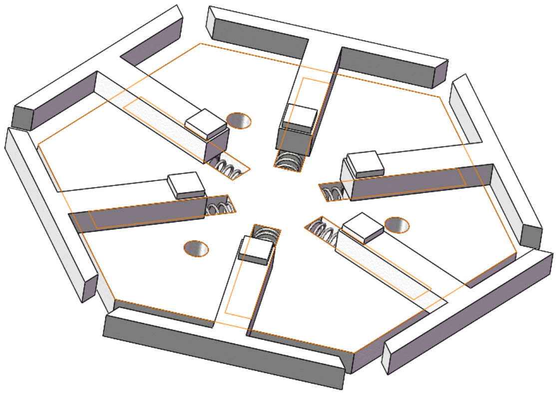
Design	Description	Materials	Evaluation
Spring Loaded Hexagon	Overall hexagonal prism shape when compacted (in can). When released from can, arms expand to create an upside down truncated hexagonal pyramid for the bottom half of the payload. All plates are hexagonal. Bottom 2 plates are reserved for electrical components. Top 2 plates are used for the parachute attachment and flag deployment device.	Plates – ABS Plastic Poles – Aluminum Arms – ABS Plastic Springs – Zinc Plated Steel Parachute Attachment – Steel	Selected, easier to manufacture, lighter in weight, structurally practical

Payload Aerobraking Pre Deployment Configuration Trade & Selection

Configuration A: Umbrella Mechanism



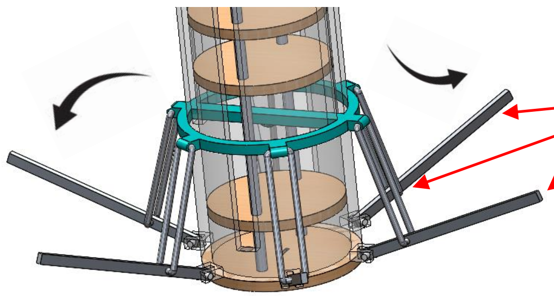
Configuration B: Spring Loaded Mechanism



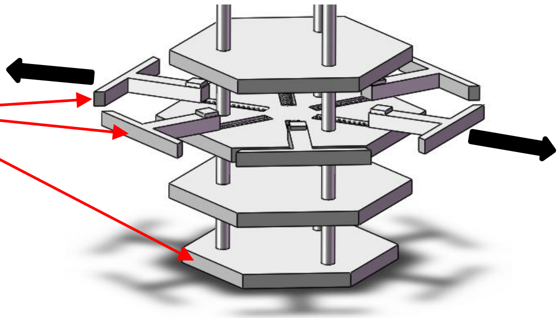
NOTE: Both designs will be compressed by the interior wall of the container during pre-deployment

Configuration	Advantages	Disadvantages	Evaluation
Umbrella Mechanism	Only uses one spring More secure	Significantly heavier than configuration B Takes up large amount of space Difficult to manufacture	Discarded
Spring Loaded Hexagon	Lightweight Occupies small section of the CanSat Uniform expansion	Large number of components required to hold it in place More friction along the walls of the CanSat	Selected, easier to keep in place

Payload Aerobraking Deployment Configuration Trade & Selection



Attach Heat Shield material (Mylar) here

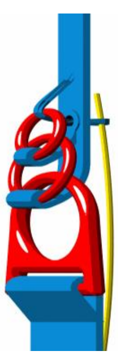


Configuration	Method	Identified Issues	Evaluation
Umbrella Mechanism	Upon release from can, the rods will extend fully, causing the implementation of the heat shield which acts as the aerobraking device. This creates an aerodynamic parabolic shape.	Entirely dependent on gravity, difficulty manufacturing the rods	Discarded
Spring Loaded Hexagon	Upon release from can, the spring loaded arms will be expanded, causing the implementation of the heat shield which acts as the aerobraking device. This creates an upside down truncated hexagonal pyramid shape.	Springs could go off inside the can, difficulty assembling the payload and inserting into can	Selected, smaller size makes it easier to deploy. Also, lightweight and easy to manufacture

Payload Parachute Deployment Configuration Trade & Selection

Method	Description	Identified Issues	Evaluation
Three Ring Release System	A cable is passed through this series of loops. Once the payload reaches the desired altitude, the chord will be released in a linear motion using a linear actuator. Releasing the chord will allow the parachute to naturally deploy	Requires a complex mechanical system. Additional linear actuator will add weight to the system. Linear actuator must be able to resist the shock of deployment. Requires extensive testing.	Discarded
Altimeter Chute Release	The parachute will sit atop the payload and be held together by the device using a chord and hook which are attached to the device. Once the desired altitude is reached, the device will release, and the parachute will be allowed to deploy naturally.	Device would add considerable weight to the system. Device would need to be purchased from a third-party and thus add to the expenses.	Selected, easier to secure and implement

Configuration A: Three Ring Release System



Configuration B: Altimeter Chute release

Payload Uprighting Configuration Trade & Selection

Method	Benefits	Identified Issues	Evaluation
Active Uprighting System	Much better chance of payload being upright,	Additional subsystem to implement, which would add weight, complexity, and issues with room for all components	Discarded
Passive Uprighting system	Would not require an additional subsystem	Not a guarantee for the payload to land upright, requires extensive testing	Selected, easier to manufacture, less weight added to the system

Container Mass Budget

Sensor	Quantity	Weight (g)	Source
Adafruit BMP280	1	1.3	Actual from Datasheet
Arduino Nano	1	7	Actual from Datasheet
2032 Cell Batteries	2	6.2 (3.1 each)	Actual from Datasheet
Aluminum Supports	3	124.9	Actual from Datasheet
Aluminum Nut	1	0.5	Actual from Datasheet
Eyebolt	1	2.4	Actual from Datasheet
Can Platforms	3	140.3	Estimate
JB Weld Plastic Bonder	1	2	Estimate
Linear Actuator	1	15	Actual from Datasheet
Linear Actuator Ring	1	0.2	Actual from Datasheet
Plastic Coupling Nuts	4	0.4	Actual from Datasheet
PCB Screws	4	0.1	Actual from Datasheet

Total Mass: 300.3g

Payload Mass Budget (1/3)

Sensor	Quantity	Weight (g)	Source
Adafruit BMP280	1	1.3	Actual from Datasheet
BNO-055	1	3	Actual from Datasheet
Adafruit Ultimate	1	8.5	Actual from Datasheet
Raspberry Pi Pico	1	3	Actual from Datasheet
ANT-900-RP-2-A	1	5	Estimate
Arducam Mini	1	20	Actual from Datasheet
Mirco SD cards	1	1	Actual from Datasheet
Micro SD Readers	1	3.4	Actual from Datasheet
XBEE Pro 900 Mhz Radio	1	5	Actual from Datasheet
2032 Cell Batteries	2	6.2 (3.1 each)	Actual from Datasheet

Payload Mass Budget (2/3)

Sensor	Quantity	Weight (g)	Source
Springs	6	0.3	Actual from Datasheet
Heatshield Arms	6	14.1	Estimate
Payload Rods	3	19.5	Estimate
Platforms	5	138.3	Estimate
Flag Release	1	6.84	Estimate
Steel Tape	1	1	Estimate
Super Lube	1	1	Estimate
Clock Spring	1	7.8	Actual from Datasheet
Screw	1	0.7	Actual from Datasheet
Nut	1	0.5	Actual from Datasheet
Servo Motor	1	9	Actual from Datasheet

Payload Mass Budget (3/3)

Sensor	Quantity	Weight (g)	Source
Servo Motor	1	9	Actual from Datasheet
Mylar Fabric	1	112.1	Estimate
Parachute	1	28	Estimate

Total Mass: 380.9 g

Communication and Data Handling (CDH) Subsystem Design

Max Epstein, Yashas Shivaram

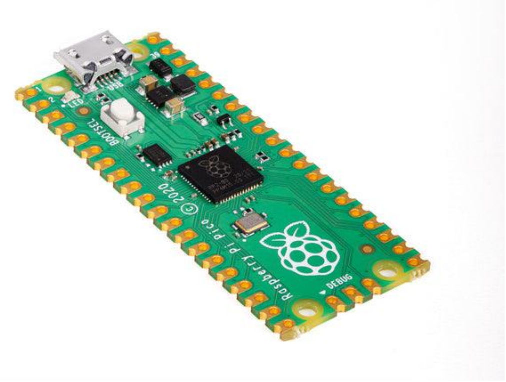
Payload Command Data Handler (CDH) Overview

Device Type	Model	Purpose
Processor & Memory	Raspberry Pi Pico	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

Payload Processor & Memory Trade & 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	51.3x21	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

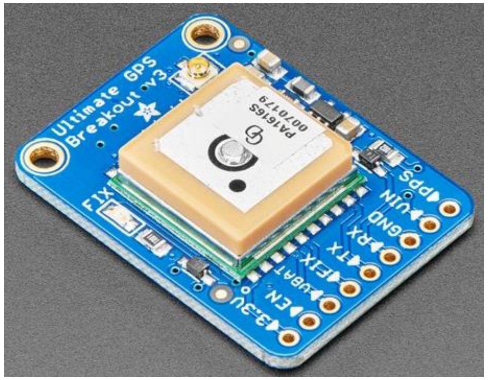
Selection	Reasoning for selection
Raspberry Pi Pico	- Compact size - Compatibility with camera/Familiarity - Availability



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

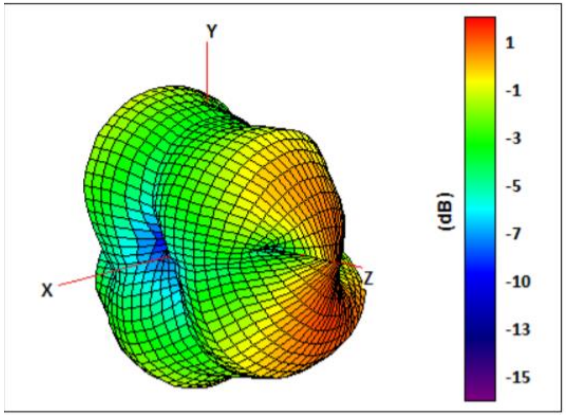
Selection	Reasoning for selection
Adafruit Ultimate GPS Breakout	- Already part of the board - GPS Module will have an independent battery backup - No additional weight, size, or circuitry required

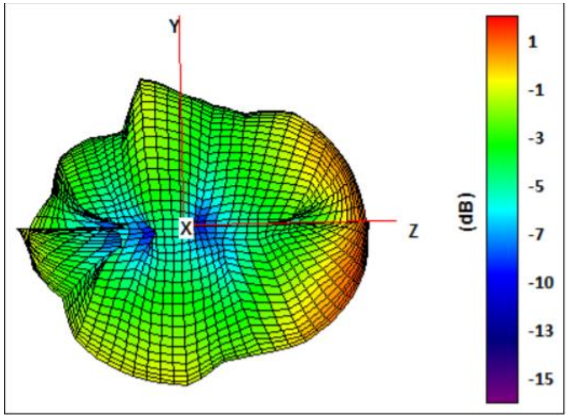


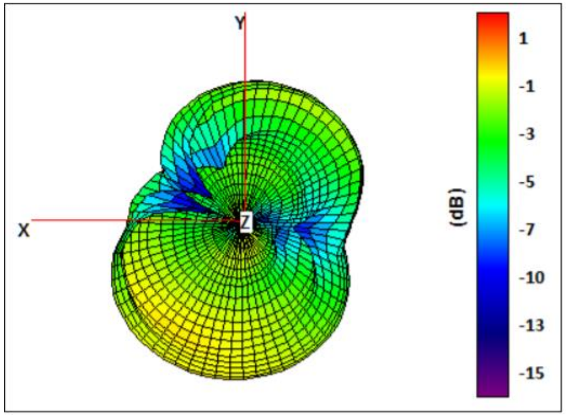
Payload Antenna Trade & Selection

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 - Relatively small 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

NETID/PANID – 1032

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

Payload Telemetry Format

- **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 the data formatted?

-Payload-to-GCS:

-<TEAM_ID>,< MISSION_TIME>, <PACKET_COUNT>, <MODE>, <STATE>, <ALTITUDE>,<HS_DEPLOYED>,<PC_DEPLOYED>,<MAST_RASIED> <TEMP>, <VOLTAGE>, <PRESSURE>,< GPS_TIME>, <GPS_ALTITUDE>, <GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_SATS>, <TILT_X>,<TILT_Y>, <CMD_ECHO>

- **Example:**
- <1063>, <13:35:59>, <25>, <F>, <LAUNCH_WAIT>,<N>,<N>,<N>,<25.3>,<8.3>,<230>, <13:35:35>,<25>,<150.0258>,<168.6765>,<58>,<5.02>,<3.05><CXON>

Payload Telemetry Format

Telemetry Field	Purpose	Relayed From:
<TEAM_ID>	Team ID number (1063)	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_DEPLOAYED>	‘P’ if the probe has been deployed, ‘N’ if not	
<PC_DEPLOAYED>	‘C’ if the probe parachute has been deployed, ‘N’ if not	
<MAST_RAISED>	‘M’ if the flag has been raised, ‘N’ if not	
<TEMP>	The temperature in degrees Celsius (+/- 0.1C)	

Payload Telemetry Format

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	

Payload Command Formats

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,1032,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,1032,SIM,ACTIVATE	

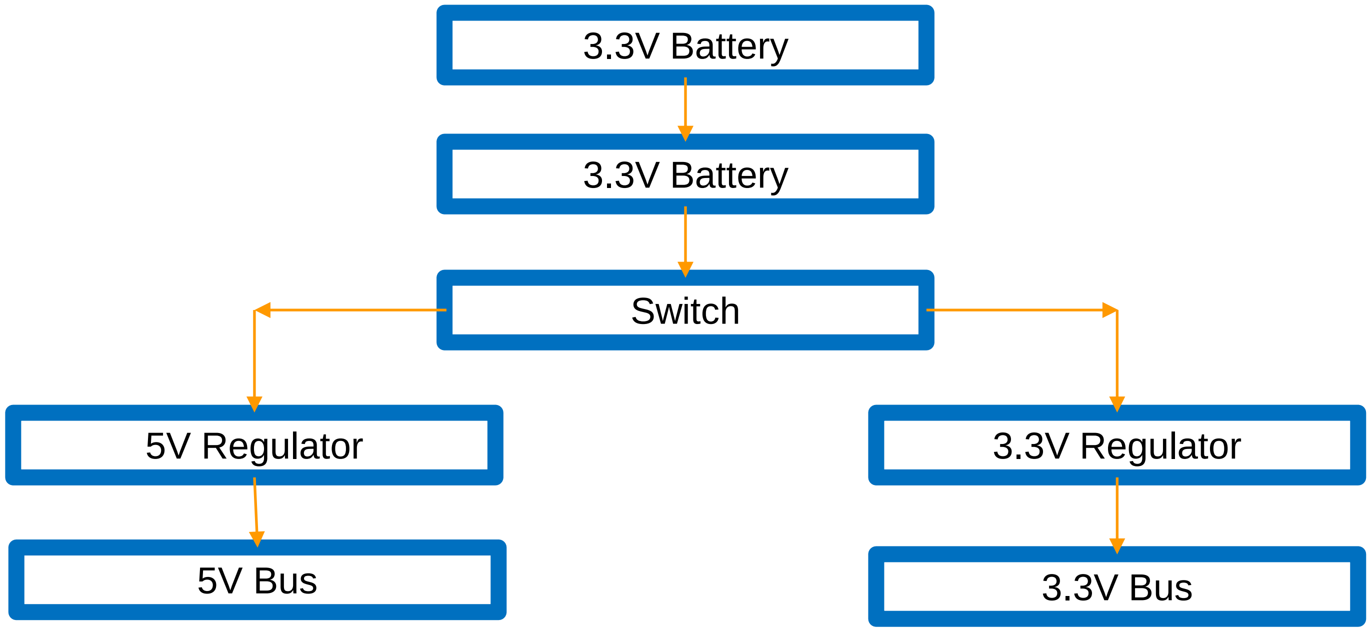
ST - Set Time	
CMD,<TEAM_ID>, ST, <UTC_TIME>	
CMD & ST	Static Text
<TEAM_ID>	Assigned Team Identification
<UTC_TIME>	UTC time in the format hh:mm:ss
Example: CMD,1032,ST,13:35:59	

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,1032,SIMP,101325	

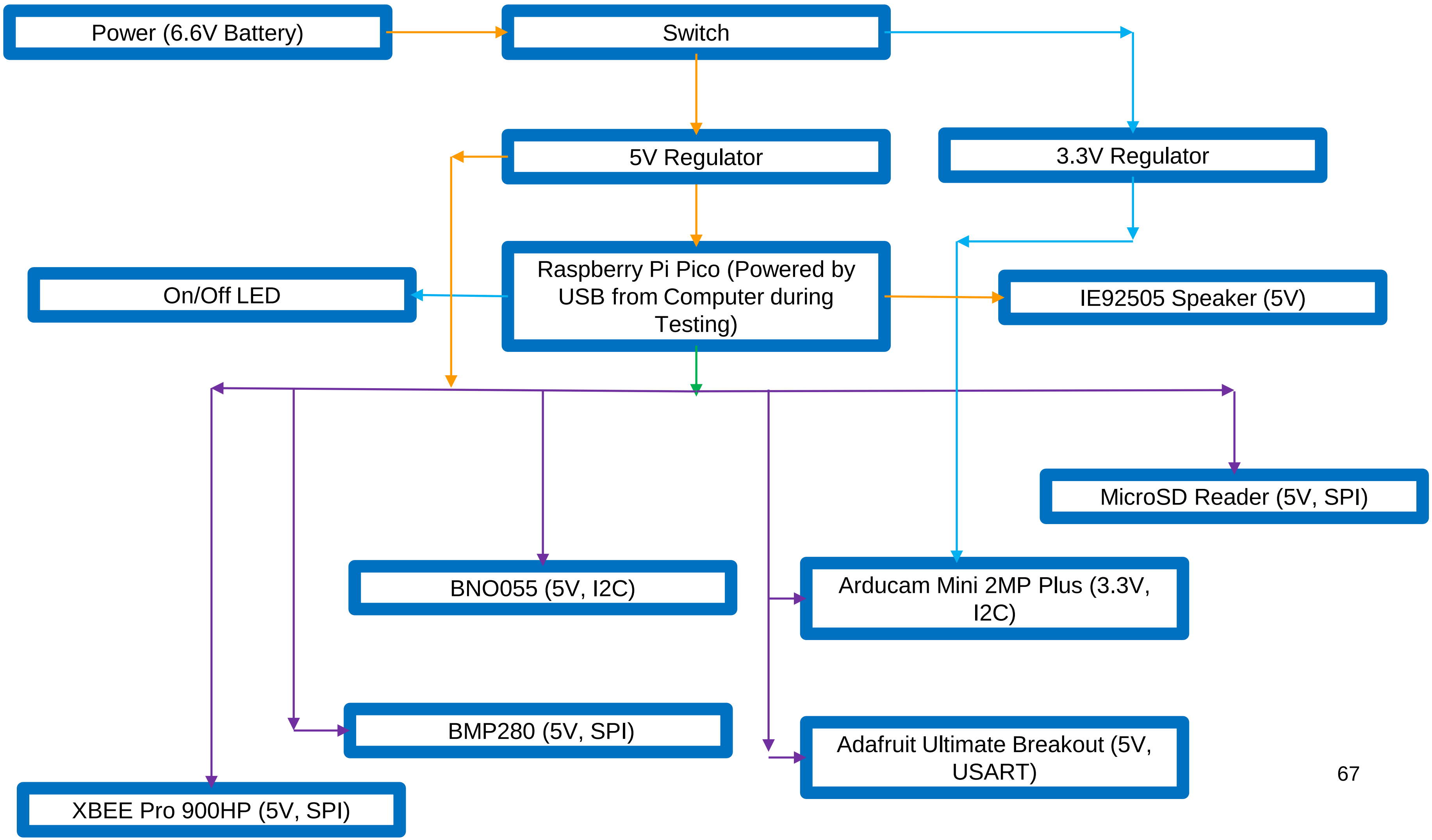
Electrical Power Subsystem (EPS) Design

Paolo D’Alessandro

EPS Overview



Payload Electrical Block Diagram



Payload Power Trade & Selection

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

Selection	Reason for Selection
Lithium LiCB CR2032	- Smaller weight and easily scalable for more power

Battery Configuration
Two CR2032 in series to provide ~6V

Payload Power Budget

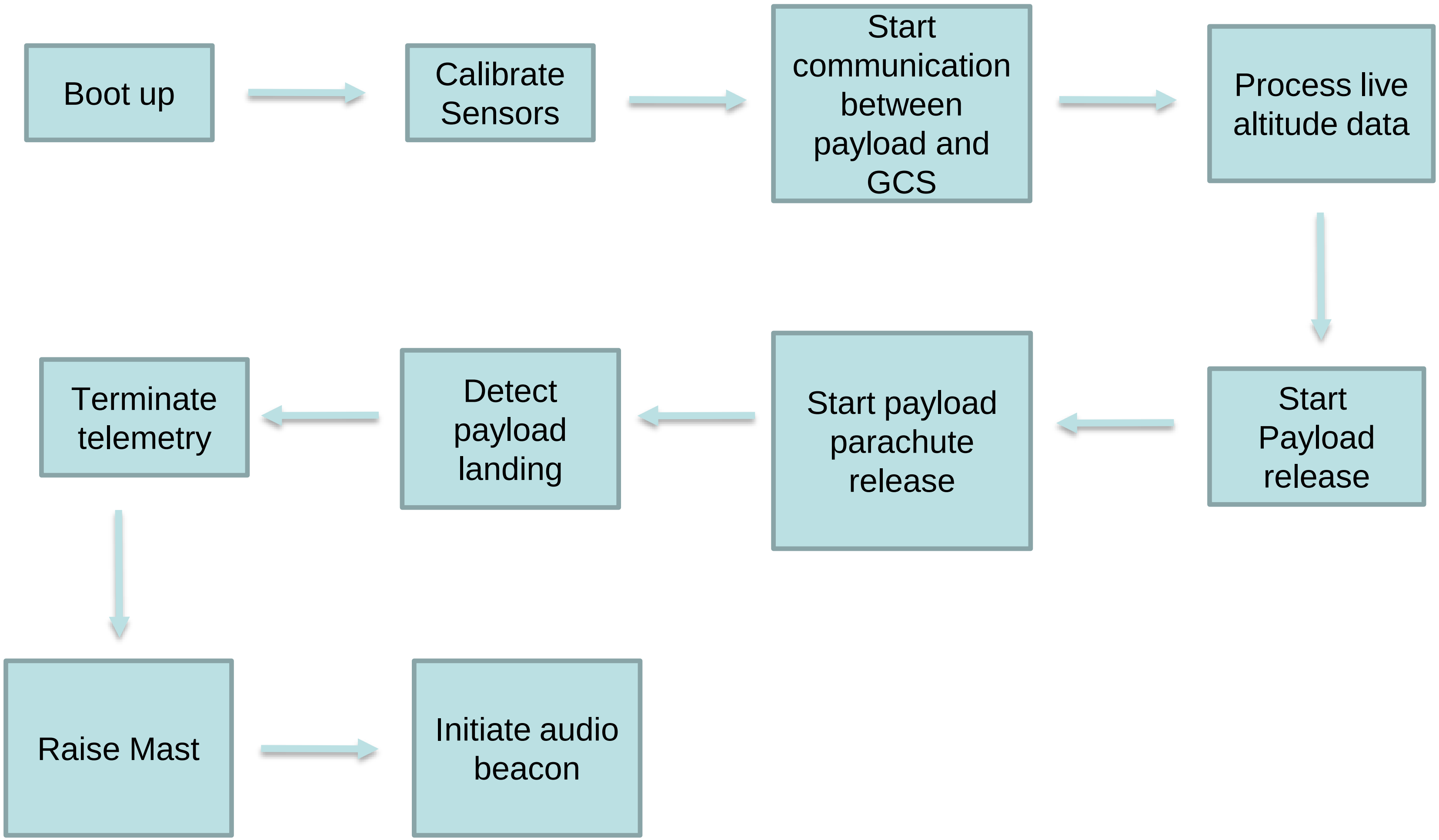
Component	Voltage (V)	Power per Unit (W)	Duty Cycle (%)	Power Consumption (Wh)	Source
Raspberry Pi Pico (Microcontroller)	9V	.1406	100	0.1406	Datasheet
Adafruit Ultimate Breakout (GPS)	5V	.1	100	.1	Datasheet
BMP280 (Air Temperature/Pressure)	5V	0.00025	100	0.000025	Datasheet
IE092505-1 (Sound Alert)	5V	.03	100	50m	Datasheet
Xbee Pro 900 HP (Radio Module)	5V	.0.95	100	.95	Datasheet
LED Light (Lighting Alert)	2.2V	0.044	100	0.044	Datasheet
BNO 055 (Temp/Rotational Sensor)	1.7-3.6V	0.0123	100	0.00155	Datasheet

Flight Software (FSW) Design

Max Epstein

FSW Overview (1/2)

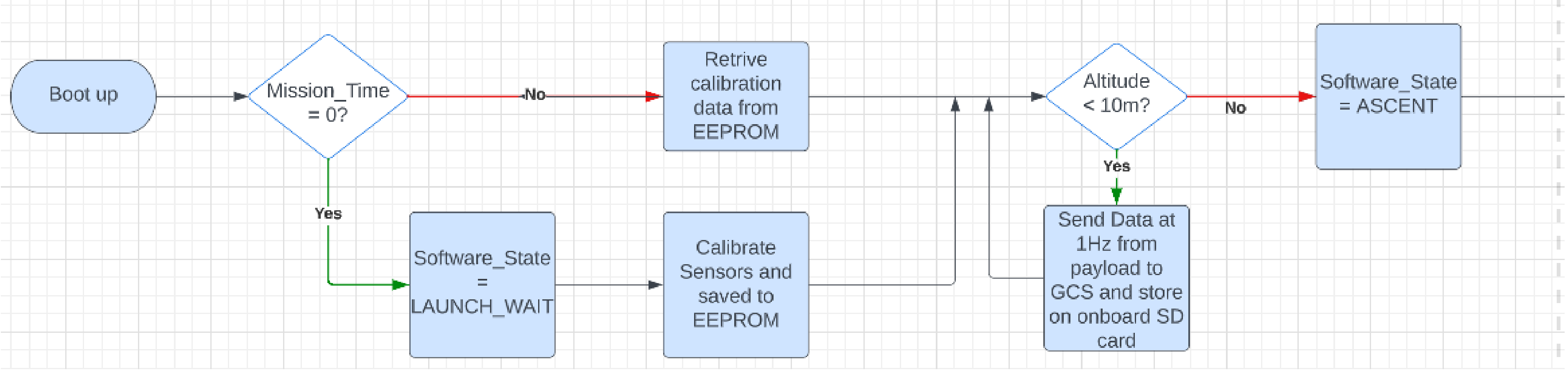
Flowchart



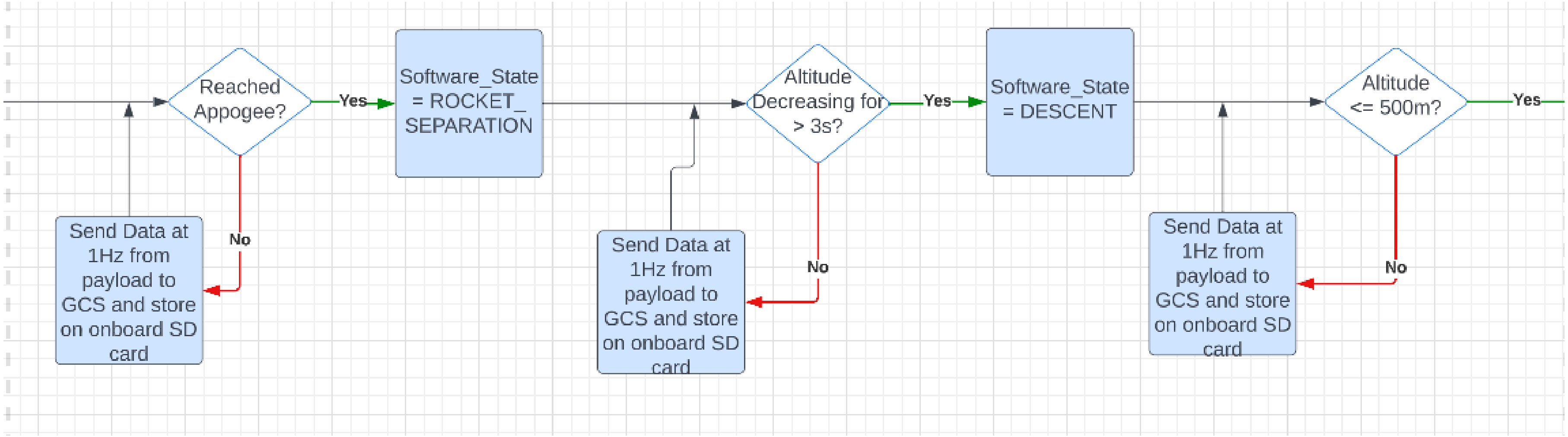
FSW Overview (2/2)

Programming Languages	Python
Development Environments	Visual Studio Code
FSW Tasks	- Boot up and collect sensor data in the correct units required by CanSat. - Communicate telemetry from the payload and container to the GCS to store data. - Keep track of altitude and release the payload 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

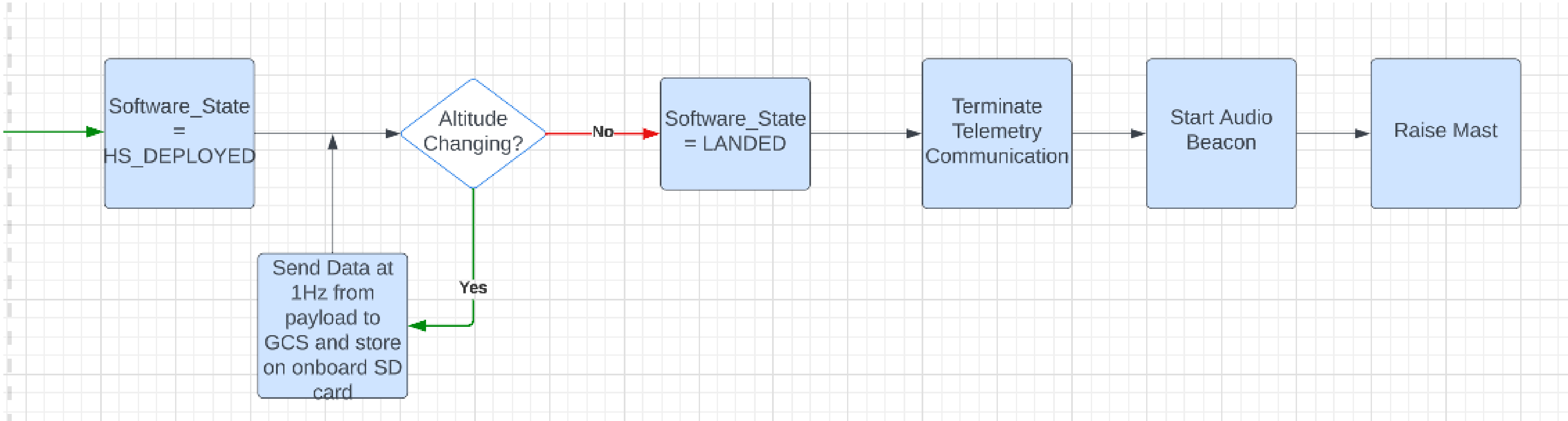
Payload FSW State Diagram (1/3)



Payload FSW State Diagram (2/3)



Payload FSW State Diagram (3/3)



Payload FSW State Diagram

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

- Max Epstein
- Dylan Falzone
- Yashas Shivaram
- Paolo D’Alessandro

Test Methodology

- Simulation mode with varying datasets.
- Freefall sensor testing

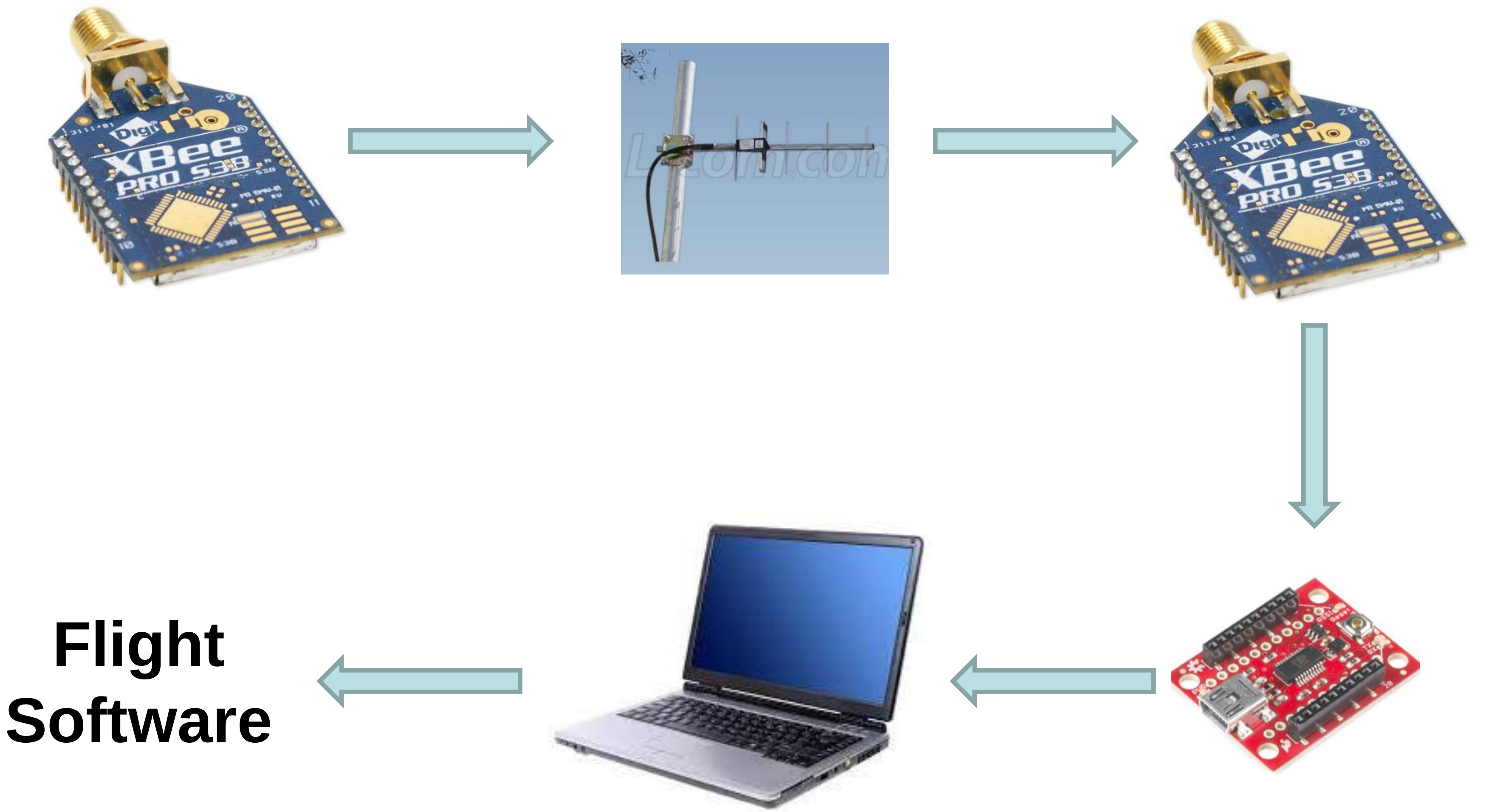
Software Development Plan (2/2)

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

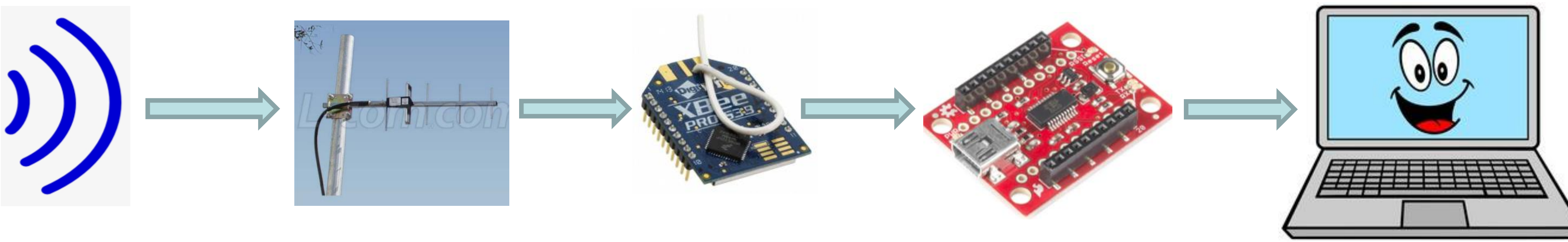
Ground Control System (GCS) Design

Dylan Falzone, Max Epstein

GCS Overview



GCS Design

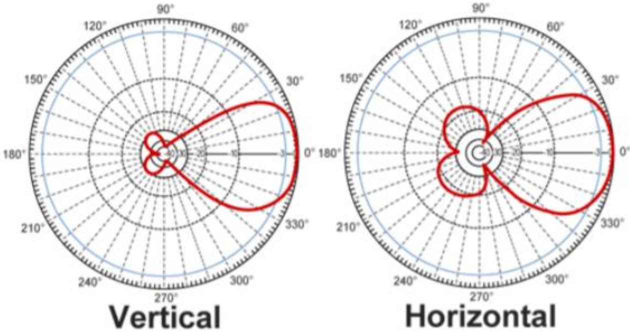


Specifications	
Laptop Battery	4 Hours
Overheating Mitigation	Umbrella & Laptop Cooler
Auto update Mitigation	Disable Auto-Update

GCS Antenna Trade & Selection

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



GCS Software (1/3)

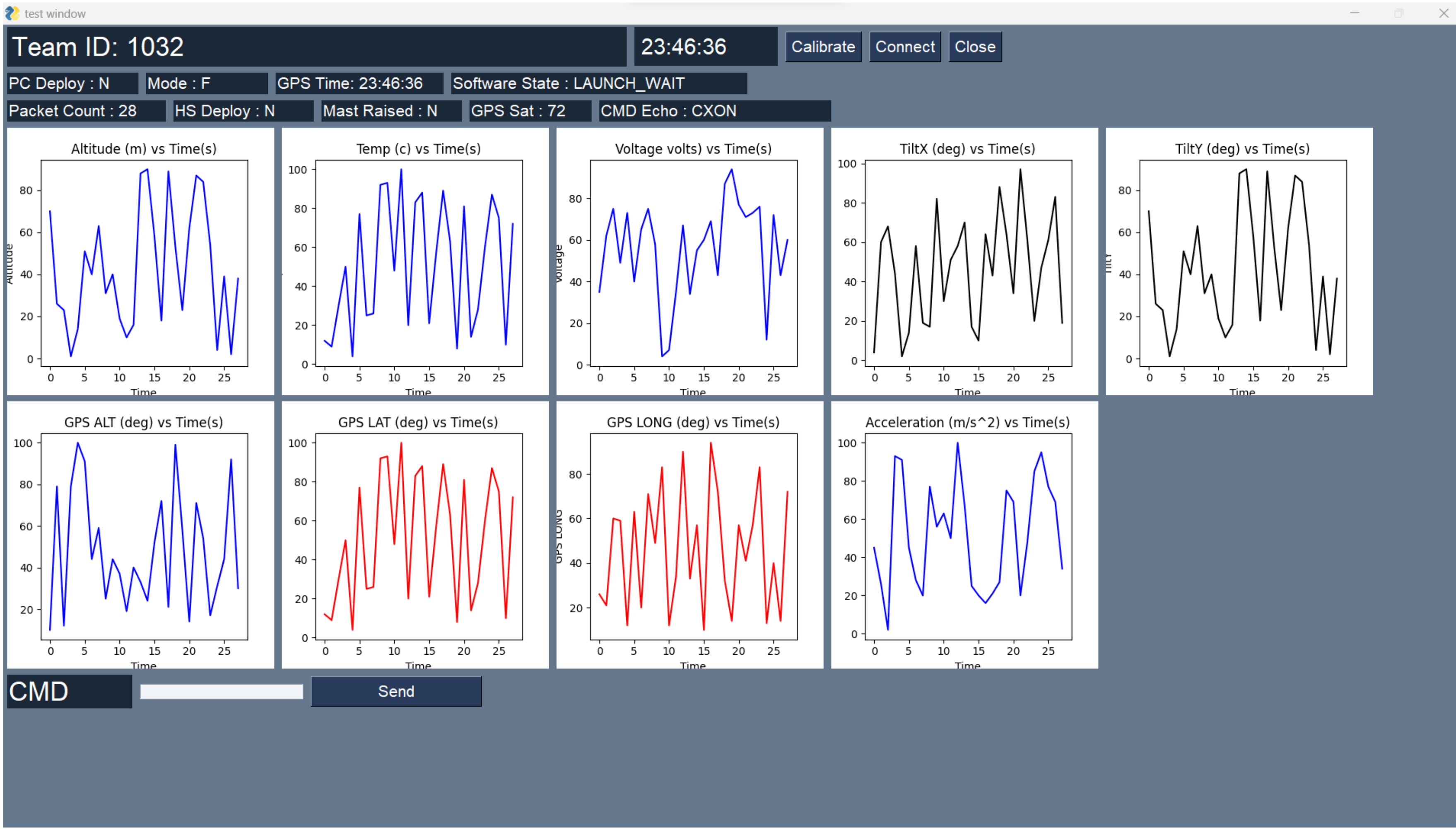
Software Packages:
- Python 3.9.7 - Computational environment of choice
- XCTU – XBee Program Software
- XBEE Python Library – real time access to XBEE via USB interface
- Matplotlib Python Library – real time plotting and data manipulation
- PySimpleGUI Python Library – visual design layout and manipulation
- 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.

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.

GCS Software (2/3)



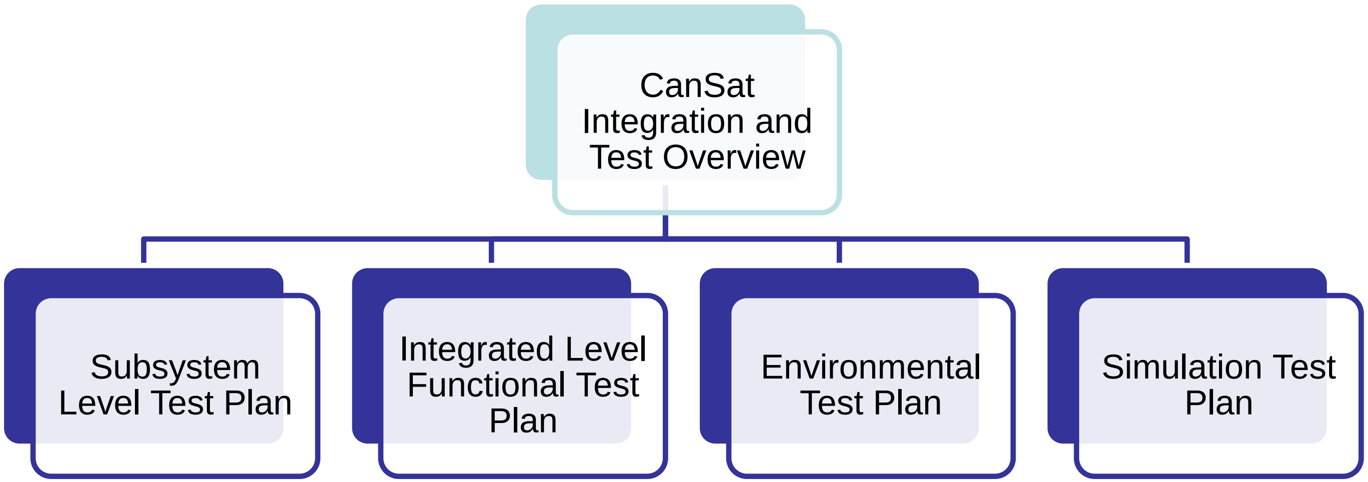
GCS Software (3/3)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	TEAM_ID	MISSION_	PACKET_C	MODE	STATE	ALTITUDE	HS_DEPLO	PC_DEPLO	MAST_RAI	TEMPERAT	VOLTAGE	GPS_TIME	GPS_ALTIT	GPS_LATIT	GPS_LONG	GPS_SATS	TILT_X	TILT_Y	CMD_ECH	T+ Time	Accelerati
2	1032	13:18:34	1	F	LAUNCH_\	70	N	N	N	12	35	13:18:34	10	12	26	12	4	70	CXON	0	45
3	1032	13:18:35	2	F	LAUNCH_\	26	N	N	N	9	62	13:18:35	79	9	21	9	60	26	CXON	1	26
4	1032	13:18:36	3	F	LAUNCH_\	23	N	N	N	30	75	13:18:36	12	30	60	30	68	23	CXON	2	2
5	1032	13:18:37	4	F	LAUNCH_\	1	N	N	N	50	49	13:18:37	79	50	59	50	44	1	CXON	3	93
6	1032	13:18:38	5	F	LAUNCH_\	14	N	N	N	4	73	13:18:38	100	4	12	4	2	14	CXON	4	91
7	1032	13:18:39	6	F	LAUNCH_\	51	N	N	N	77	40	13:18:39	91	77	63	77	14	51	CXON	5	45
8	1032	13:18:40	7	F	LAUNCH_\	40	N	N	N	25	65	13:18:40	44	25	20	25	58	40	CXON	6	28
9	1032	13:18:41	8	F	LAUNCH_\	63	N	N	N	26	75	13:18:41	59	26	71	26	19	63	CXON	7	20
10	1032	13:18:42	9	F	LAUNCH_\	31	N	N	N	92	58	13:18:42	25	92	49	92	17	31	CXON	8	77
11	1032	13:18:43	10	F	LAUNCH_\	40	N	N	N	93	4	13:18:43	44	93	83	93	82	40	CXON	9	56
12	1032	13:18:44	11	F	LAUNCH_\	19	N	N	N	48	7	13:18:44	37	48	12	48	30	19	CXON	10	63
13	1032	13:18:45	12	F	LAUNCH_\	10	N	N	N	100	35	13:18:45	19	100	34	100	51	10	CXON	11	50
14	1032	13:18:46	13	F	LAUNCH_\	16	N	N	N	20	67	13:18:46	40	20	90	20	58	16	CXON	12	100
15	1032	13:18:47	14	F	LAUNCH_\	88	N	N	N	83	34	13:18:47	33	83	33	83	70	88	CXON	13	67
16	1032	13:18:48	15	F	LAUNCH_\	90	N	N	N	88	55	13:18:48	24	88	57	88	17	90	CXON	14	25
17	1032	13:18:49	16	F	LAUNCH_\	58	N	N	N	21	60	13:18:49	52	21	10	21	10	58	CXON	15	20
18	1032	13:18:50	17	F	LAUNCH_\	18	N	N	N	57	69	13:18:50	72	57	94	57	64	18	CXON	16	16
19	1032	13:18:51	18	F	LAUNCH_\	89	N	N	N	89	43	13:18:51	21	89	72	89	43	89	CXON	17	21
20	1032	13:18:52	19	F	LAUNCH_\	53	N	N	N	63	87	13:18:52	99	63	32	63	88	53	CXON	18	27
21	1032	13:18:53	20	F	LAUNCH_\	23	N	N	N	8	94	13:18:53	58	8	14	8	64	23	CXON	19	75
22	1032	13:18:54	21	F	LAUNCH_\	62	N	N	N	81	77	13:18:54	14	81	57	81	34	62	CXON	20	69
23	1032	13:18:55	22	F	LAUNCH_\	87	N	N	N	14	71	13:18:55	71	14	41	14	97	87	CXON	21	20
24	1032	13:18:56	23	F	LAUNCH_\	84	N	N	N	28	73	13:18:56	54	28	57	28	61	84	CXON	22	48
25	1032	13:18:57	24	F	LAUNCH_\	54	N	N	N	60	76	13:18:57	17	60	83	60	20	54	CXON	23	85
26	1032	13:18:58	25	F	LAUNCH_\	4	N	N	N	87	12	13:18:58	31	87	13	87	47	4	CXON	24	95
27	1032	13:18:59	26	F	LAUNCH_\	39	N	N	N	75	72	13:18:59	44	75	40	75	61	39	CXON	25	77
28	1032	13:19:00	27	F	LAUNCH_\	2	N	N	N	10	43	13:19:00	92	10	14	10	83	2	CXON	26	69

CanSat Integration and Test

Jordi Rey, Yashas Shivaram

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	- Container & probe structural tests - Probe deployment tests - Probe upright testing - Avionics bay structural integrity tests - Parachute deployment release tests - Probe stability control tests - Flag raising test
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

Environmental Test Plan (1/2)

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

Fit Check
- Verify that the CanSat and container fits within rocket to minimize deployment failure

Vacuum Test
- Verify deployment operations of the payload

Environmental Test Plan (2/2)

Drop Test

- Plan: Secure the CanSat to testing rig with non-stretch cord, release the CanSat from 61 cm and allow it to freefall, inspect CanSat and payloads for damage, if there was no damage then run a functional test.

Thermal Test

- Plan: Place the CanSat in an insulating cooler with a hair dryer, use a remote thermometer to monitor temperature, turn on the CanSat, turn off the heat source once internal temperatures reach 60C and turn on heat sources when temperature reaches 55C. Main this for 2 hours. With heat source off, visually inspect and functionally test CanSat to verify operational integrity survived thermal exposure.

Vibration Test

- Plan: Attach the CanSat to a random 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 and functionally test CanSat to verify operation integrity. Verify accelerometer data is still being collected.

Fit Check

- Plan: Construct a prototype of the rocket cylinder wall, place the container with the payloads properly stowed inside of the prototype and check for proper fit as well as the ability to securely deploy.

Vacuum Test

- Plan: Construct a vacuum chamber using a bucket and a vacuum cleaner. Suspend fully configured and powered CanSat within the vacuum chamber and turn on the vacuum. Monitor telemetry and stop the vacuum once peak altitude has been reached. Let air enter vacuum chamber slowly and monitor operation of CanSat. Collect and save telemetry. Save telemetry for judge reviewal.

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 mast will be raised and the audio beacon will begin once landing is detected

What parts are tested

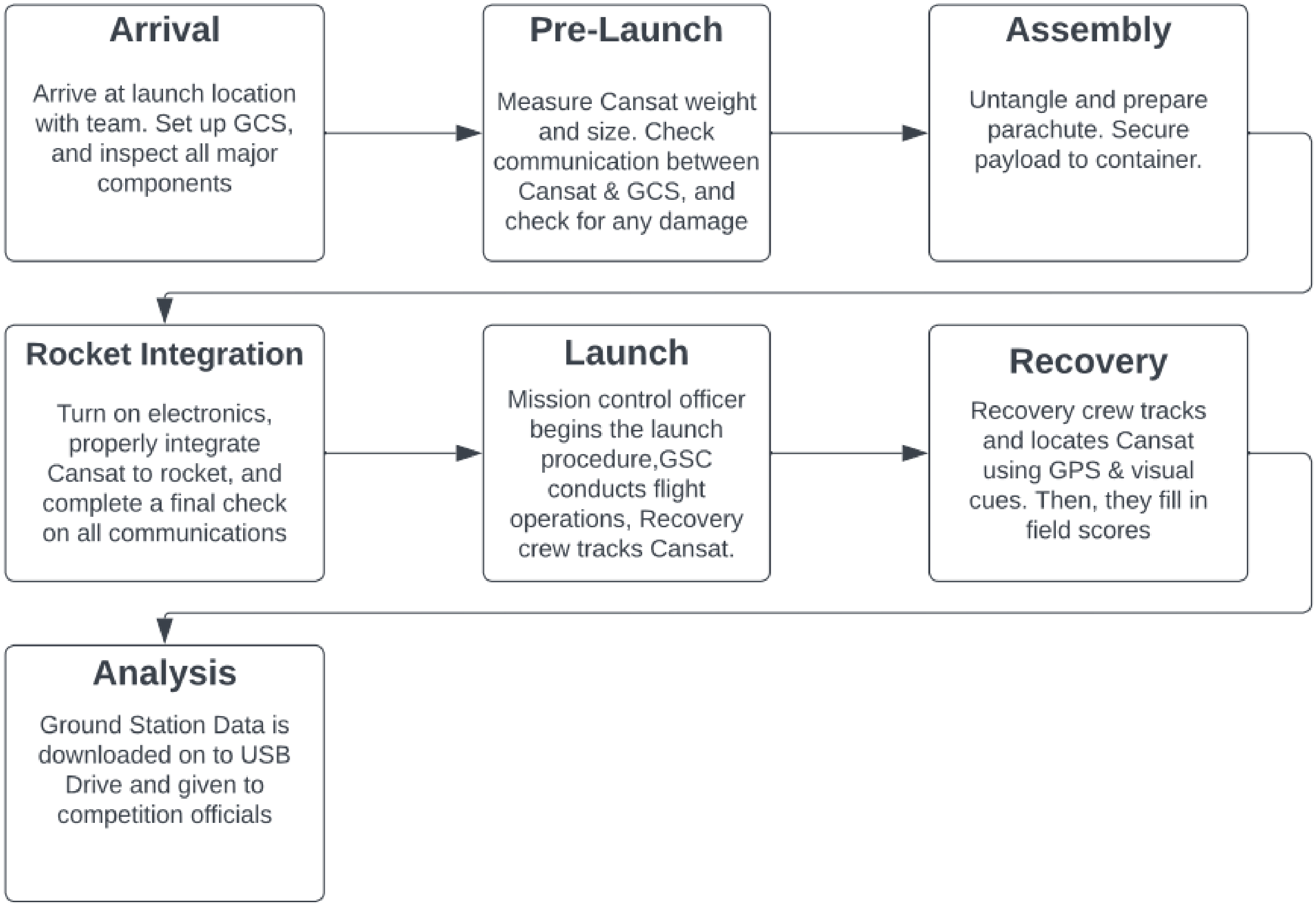
- The configuration and echoing of commands.
- The calculation of altitude with fed data from the CSV.
- The deployment of payload parachute, mast raise, and trigger of audio beacon.
- Payload video is saved and pointing in the correct direction.

Mission Operations & Analysis

Jordi Rey

Overview of Mission Sequence of Events (1/2)

Flowchart



Overview of Mission Sequence of Events (2/2)

Roles & Responsibilities

- Mission Control Officer – Savari Datta
- Ground Station Crew – Christian Roque, Max Epstein, and Yashas Shivaram
- Recovery Crew – Jordi Rey and Daniel Horton
- CanSat Crew – Paolo D'Alessandro, Jovana Markovic, Melissa Gonzalez Grospe, Dylan Falzone, Savari Datta, Jordi Rey

Antenna Construction & Ground System Setup

- Handheld ground station antenna will be mounted to wood 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

Mission Operations Manual Development Plan

Mission Operations Manual Outline:

CGS 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.

Recovery Crew will be responsible for container and payload recovery

- Container & Parachute will be a bright pink color making them easier to identify and locate.
- 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

Requirements Compliance

Savari Datta

Requirements Compliance Overview

- *Yes we CANSAT*'s project complies with the requirements of the CanSat 2023 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 50/61 mission requirements
Partial Compliance	There are 8 requirements partially satisfied by our CanSat. This means that the requirement is technically met but will require further analysis and testing for finalization. The mass will meet requirements after the addition of the “No Compliance” components
No Compliance	There are 3 requirements our current build does not comply to. Modifications are currently being planned out to add access to the switch and wrap everything so it is secure

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
1	Total mass of the CanSat (science payloads and container) shall be 700 grams +/- 10 grams.	Partial	17	Additional Components to be added
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	17	
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	19	Sides will be sanded
4	The container shall be a fluorescent color; pink, red or orange.	Comply	44, 99	
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.	No comply		To be added
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	41	
7	The rocket airframe shall not be used as part of the CanSat operations.	Comply	41	
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	44	
9	The Parachutes shall be fluorescent Pink or Orange	Comply	99	
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second +/- 5m/s.	Comply	38	

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
11	0 altitude reference shall be at the launch pad.	Comply	85	
12	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	39	Needs Testing
13	All structures shall be built to survive 30 Gs of shock	Comply	39	Needs Testing
14	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Comply	41-46	
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.	No Comply	39	Needs Testing
16	Mechanisms shall not use pyrotechnics or chemicals.	Comply	41	
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	41	
18	Both the container and payload shall be labeled with team contact information including email address.	Comply	99	
19	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years should be included in this cost, based on current market value.	Comply	51-55	
20	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	60	
21	XBEE radios shall have their NETID/PANID set to their team number.	Comply	60	

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
22	XBEE radios shall not use broadcast mode.	Comply	60	
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.	Partial	67,68	
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	67	
25	An audio beacon is required for the probe. It shall be powered after landing.	Comply	67, 75	
26	The audio beacon shall have a minimum sound pressure level of 92 dB, unobstructed.	Partial	28	Mid-implementation
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	68	
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.	Partial	17	Mid-implementation
29	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	81-89	
30	The Cansat shall operate during the environmental tests laid out in Section 3.5.	Comply	93	
31	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	58	
32	The probe shall be released from the container when the CanSat reaches 500 meters.	Comply	45	

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
33	The probe shall deploy a heat shield after leaving the container.	Comply	47-48	
34	The heat shield shall be used as an aerobrake and limit the descent rate to 20 m/s or less.	Comply	31, 35-34	
35	At 200 meters, the probe shall release a parachute to reduce the descent rate to 5 m/s +/- 1m/sec.	Comply	49, 38	
36	Once landed, the probe shall upright itself.	Partial	50	No active uprighting
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	41	
38	The probe shall transmit telemetry once per second.	Comply	60, 75, 92	
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	61	
40	The probe shall include a video camera pointing down to the ground.	Comply	28	
41	The video camera shall record the flight of the probe from release to landing.	Comply	28	
42	The video camera shall record video in color and with a minimum resolution of 640x480.	Comply	28	
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	61	
45	The probe shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	Comply	61	

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
46	The probe shall have its time set to within one second UTC time prior to launch.	Comply	64	
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.	No Comply		To be added
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.	No Comply		To be added
49	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	63, 65, 94	
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	64	
51	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	86	
52	Telemetry shall include mission time with 0.01 second or better resolution.	Comply	61	
53	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	Comply	73	
54	Each team shall develop their own ground station.	Comply	81	
55	All telemetry shall be displayed in real time during descent on the ground station.	Comply	85	
56	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	85	

Requirements Compliance

Req #	Description	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments or notes
57	Teams shall plot each telemetry data field in real time during flight.	Comply	85	
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	81	
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	81	
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	84, 94	
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	84, 94	

Management

Savari Datta

CanSat Budget – Hardware (1/2)

Component	Quantity	Unit Price ($)	Total Price ($)	Value Type
Adafruit BMP280	2	9.95	19.90	Actual
BNO-055	1	34.95	34.95	Actual
Adafruit Ultimate	1	29.95	29.95	Actual
Raspberry Pi Pico	1	4.50	4.50	Actual
ANT-900-RP-2-A	1	3.99	3.99	Actual
Arducam Mini	1	25.99	25.99	Actual
Mirco SD cards	1	4.20	4.20	Actual
Micro SD Readers	1	8.00	8.00	Actual
XBEE Pro 900 Mhz Radio	1	68.25	68.25	Actual
2032 Cell Batteries	4	1.20	4.80	Actual
Arduino Nano	1	20.70	20.70	Actual
ABS Filament 1.75mm ABS, 1 kg	1	22.99	22.99	Actual
Springs	6	2.32	13.92	Actual
Tie Down Ring	1	1.24	1.24	Actual

CanSat Budget – Hardware (2/2)

Component	Quantity	Unit Price ($)	Total Price ($)	Value Type
Linear Actuator	1	65.00	65.00	Actual
Servo Motor	1	8.84	8.84	Actual
¼-20 Hex Nut	2	9.81	9.81	Actual
Steel Tape	1	14.99	14.99	Actual
Super Lube	1	7.39	7.39	Actual
Clock Spring	1	8.38	8.38	Actual
JB Weld Plastic Bonder	1	15.74	15.74	Actual
Fiberglass Eyebolt	1	5.66	5.66	Actual
Aluminum Poles	1	5.00	5.00	Estimate
¼ -20 Screw	1	13.84	13.84	Actual
Mylar Reflective Material	1	26.00	26.00	Actual
Aluminum Strip	1	6.93	6.93	Actual
Parachutes	2	17.95	35.90	Actual
Plastic Coupling Nuts	4	5.55	22.20	Actual
PCB Screws	4	1.25	5.00	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	1	72.32	72.32	Actual
900 MHz XBEE Radio	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)

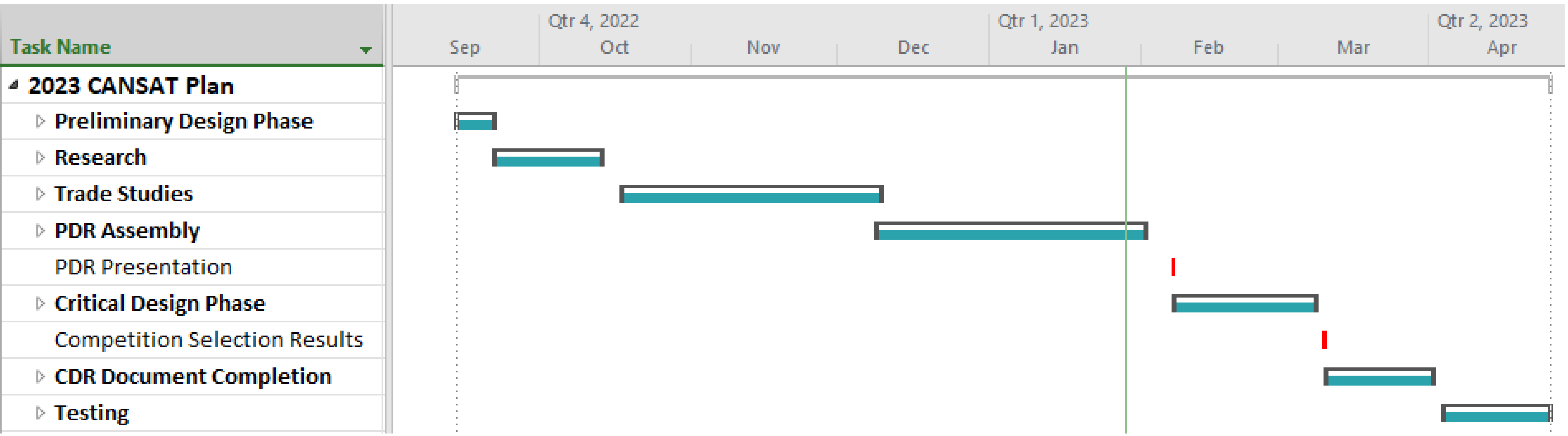
Source of Income:	Funds Provided ($):
UF MAE Department	4000.00

Hardware Costs:	$514.06
Other Costs:	$466.57
Competition Fees:	$200.00
Total Costs:	**$1180.63**

A total cost of $1057.09 for the testing and building of our CanSat as well as CanSat related fees leaves us with a total of **$2819.37** for travel, housing, and food expense. This is expected to be more than sufficient for our 10 members.

Program Schedule Overview

- The schedule below is a broad overlook of the 2022-2023 completion schedule for our team
- The key below defines symbols for the more detailed schedule

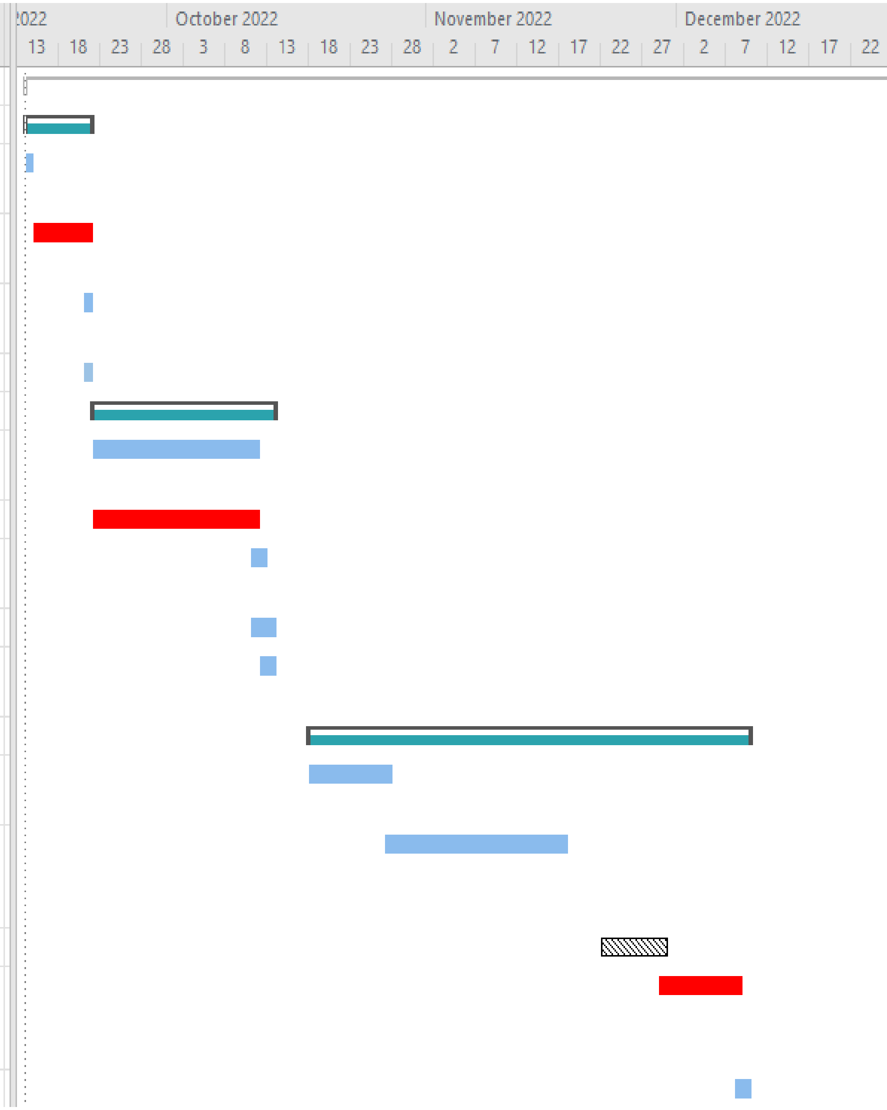


KEY

Design Phase Overview		Important Action	
Task		Holiday/Vacation	

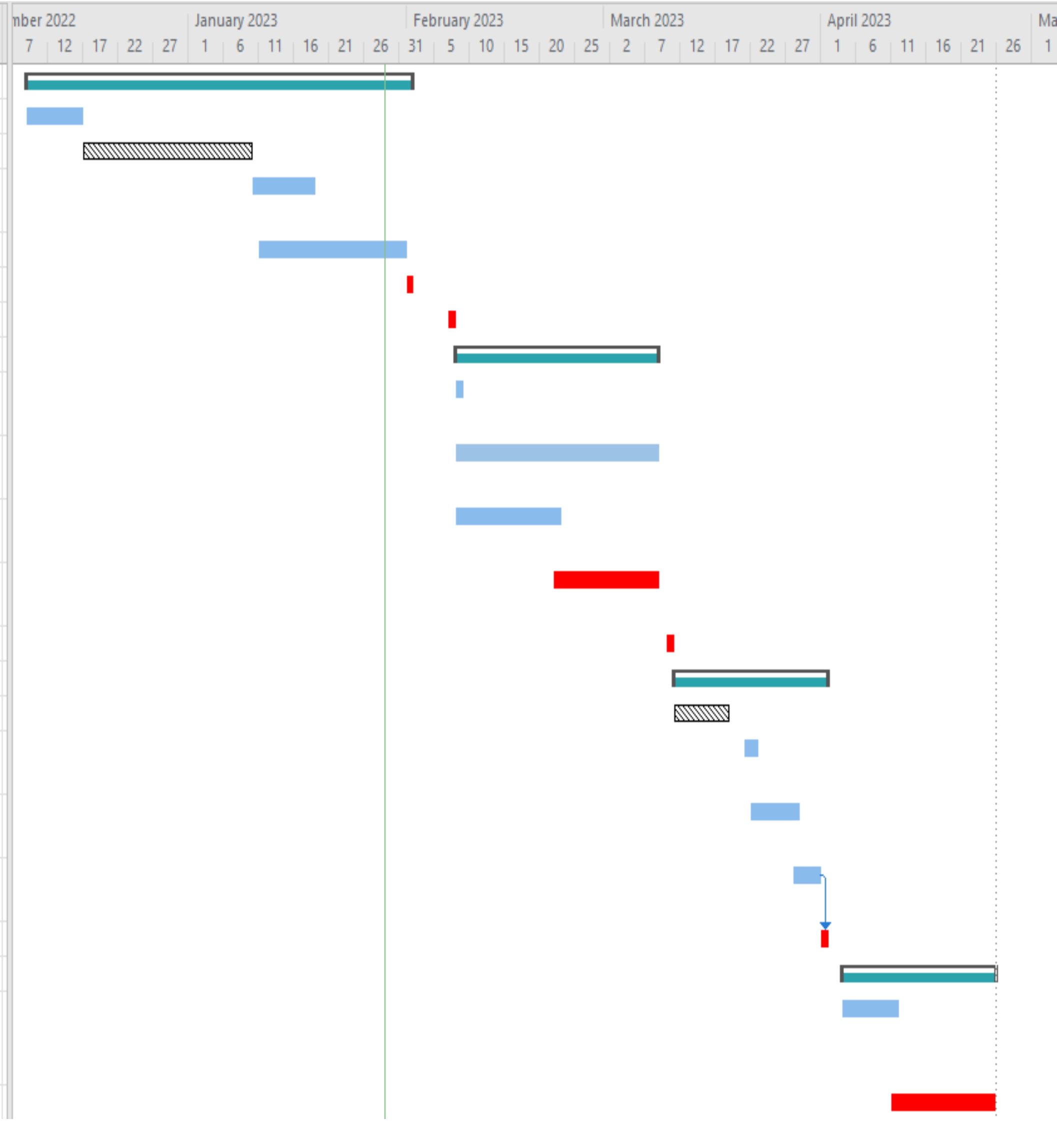
Detailed Program Schedule (1/2)

	Task Name	Duration	Start	Finish	Subteam
0	**2023 CANSAT Plan**	**164 days?**	**Wed 9/14/22**	**Tue 4/25/23**	
1	**Preliminary Design Phase**	**6 days?**	**Wed 9/14/22**	**Wed 9/21/22**	**All**
2	Present Mission Guide and Objective of competition	1 day	Wed 9/14/22	Wed 9/14/22	Management
3	Organize and divide team and responsibilities	5 days	Thu 9/15/22	Wed 9/21/22	Management
4	Document and organize competition requirements	1 day	Wed 9/21/22	Wed 9/21/22	Management
5	Finalize meeting schedule	1 day	Wed 9/21/22	Wed 9/21/22	Management
6	**Research**	**16 days**	**Thu 9/22/22**	**Thu 10/13/22**	**All**
7	Sensors and Electronic research	14 days	Thu 9/22/22	Tue 10/11/22	Avionics and FSW
8	Design Conceptualization	14 days	Thu 9/22/22	Tue 10/11/22	Payload and Container
9	Subsystem design discussions	2 days	Tue 10/11/22	Wed 10/12/22	All
10	Prototyping Designs	3 days	Tue 10/11/22	Thu 10/13/22	Payload and Container
11	Document pros and cons of each design proposal	2 days	Wed 10/12/22	Thu 10/13/22	Payload and Container
12	**Trade Studies**	**39 days**	**Tue 10/18/22**	**Fri 12/9/22**	**All**
13	Prototype testing and quantitative data collection	8 days	Tue 10/18/22	Thu 10/27/22	Payload and Container
14	Verify requirements are met by each subsystem and make according edits	16 days	Thu 10/27/22	Thu 11/17/22	All
15	Thanksgiving Break	6 days	Tue 11/22/22	Tue 11/29/22	All
16	Conduct trade study on various designs for each subsytem	8 days	Tue 11/29/22	Thu 12/8/22	Payload and Container
17	Order materials	2 days	Thu 12/8/22	Fri 12/9/22	Management



Detailed Program Schedule (2/2)

	Task Name	Duration	Start	Finish	Subteam
18	**PDR Assembly**	**40 days**	**Fri 12/9/22**	**Wed 2/1/23**	**All**
19	Finals Prep	6 days	Fri 12/9/22	Fri 12/16/22	All
20	Winter Break	17 days	Sat 12/17/22	Mon 1/9/23	All
21	Assign slides and start formatting	7 days	Tue 1/10/23	Wed 1/18/23	All
22	Fill in Tables and Slides	15 days	Wed 1/11/23	Tue 1/31/23	All
23	PDR Due	1 day	Wed 2/1/23	Wed 2/1/23	All
24	PDR Presentation	1 day	Tue 2/7/23	Tue 2/7/23	All
25	**Critical Design Phase**	**21 days**	**Wed 2/8/23**	**Wed 3/8/23**	**All**
26	Review Requirements for CDR and mission	1 day	Wed 2/8/23	Wed 2/8/23	All
27	Begin Manufacturing of Finalized Subsystems	21 days	Wed 2/8/23	Wed 3/8/23	Payload and Container
28	Test Flight Software and Avionics	11 days	Wed 2/8/23	Wed 2/22/23	Avionics and Flight Software
29	Conduct the integration of subsystems	11 days	Wed 2/22/23	Wed 3/8/23	All
30	Competition Selection Results	1 day?	Fri 3/10/23	Fri 3/10/23	All
31	**CDR Document Completion**	**18 days?**	**Sat 3/11/23**	**Sat 4/1/23**	**All**
32	Spring Break	7 days?	Sat 3/11/23	Sat 3/18/23	All
33	Document Final Design and Analysis for all Subteams	2 days	Tue 3/21/23	Wed 3/22/23	All
34	Fill in Slides and Verify Completion	5 days	Wed 3/22/23	Tue 3/28/23	All
35	Format and Make final Adjustments	4 days	Tue 3/28/23	Fri 3/31/23	All
36	CDR due	1 day	Sat 4/1/23	Sat 4/1/23	Management
37	**Testing**	**16 days?**	**Tue 4/4/23**	**Tue 4/25/23**	**All**
38	Verify Sytem Integration meets Competition Requirements	6 days?	Tue 4/4/23	Tue 4/11/23	All
39	Conduct Tests on full system	11 days	Tue 4/11/23	Tue 4/25/23	All



Conclusions

Major Accomplishments

- All electronics have been purchased and ordered
- Parachute testing has been conducted
- Payload subsystem has run preliminary testing
- Majority of telemetry components programmed
- Avionics communication and data handling in progress
- Significant funding secured

Major Unfinished Work

- Prototype of CanSat
- Telemetry communication tests between payload, container, and Ground Station
- Manufactured container and payload
- Definitive plan to enclose container and payload

Justification for Next Stage

- Major goals for each subsystem outlined and in progress
- Testing on descent has started
- Full team engaged and dedicated to success