CanSat 2020
Preliminary Design Review (PDR)
Outline
Version 1.0

Team ID 1360

UHMC Onipa`a

Presentation Outline

Section	Presenter
Systems Overview	Jhaymar Mendez
Sensor Subsystem Design	Guillermo Martin
Descent Control Design	Arthur S Agdeppa Jr
Mechanical Subsystem Design	Jhaymar Mendez
Communication and Data Handling (CDH) Subsystem Design	Tim Marcello
Electrical Power Subsystem (EPS) Design	Guillermo Martin
Flight Software (FSW) Design	Arthur S Agdeppa Jr
Ground Control System (GCS) Design	Arthur S Agdeppa Jr
CanSat Integration and Test	Jhaymar Mendez
Mission Operations and Analysis	Guillermo Martin
Requirements Compliance	Tim Marcello
Management	Arthur S Agdeppa Jr

Team Organization

Arthur S Agdeppa
Team Leader
Senior
BAS Engineering Technology

Dr. Jung Park
Faculty Advisor

Jhaymar Mendez
Mechanical Subsystem
Alternate Team Leader
Senior
BAS Engineering Technology

Guillermo Martin
Electrical / Computer Subsystem
Junior
BAS Engineering Technology

Tim Marcello
Aeronautical Subsystem
Sophomore
BAS Engineering Technology

Acronyms (1/2)

B.A.S	Bachelor of Applied Science
CS	Computer Science
CONOPS	Concept of Operation
dB	Decibel
DCS	Distributed Control System
DAC	Digital to Analog Converter
EE	Electrical Engineer
g	Grams
Gs	Gravitational Force
GPS	Global Positioning System

GCS	Ground Control Station
hPa	HectoPascal
Hz	Hertz
I2C	Inter-Integrated Circuit
m	Meters
mA	MilliAmps
m/s	Meters per second
mm	Millimeters
PCB	Printed Circuit Board
PETG	Polyethylene Terephthalate

Acronyms (2/2)

RTC	Real Time Clock
SPI	Serial Peripheral Interface
STEM	Science, Technology, Engineering and Mathematics
V	Volts
Vin	Voltage Input
W	Watts
Wh	Watt Hour
Y	Yes
N	No
GUI	Graphical User Interface

AC	Alternating Current
OS	Operating System
EEPROM	Electrically Erasable Programmable Read-Only Memory
CDH	Communication and Data Handling
EPS	Electrical Power Subsystem
FSW	Flight Software
C	Celcius
GHz	Gigahertz
LED	Light Emitting Diode
GB	GigaBytes

Systems Overview

Jhaymar Mendez

Mission Summary (1/2)

Design a CanSat that will include a container and a science payload.

- The CanSat will be launched to an altitude of 670m to 725m and will be deployed near apogee.
- The CanSat container shall protect the payload from damage during launch and deployment.
- The CanSat shall descend at a rate of 20m/s once released.
- The payload which is a glider shall be released at an altitude of 450m.
- The glider, once released, shall glide in a circular pattern with a radius of 250m for one minute and stay above 100m while collecting sensor data.
- At 100m, the payload shall deploy a parachute so it can descend at 10m/s
- The payload shall monitor altitude, air speed, and particulate concentration in the air while gliding

Mission Summary (2/2)

Bonus Objective

- A minimum of 640x480 resolution 30 Hertz color camera will be integrated to the payload.
- The video will be retrieved when the payload is retrieved.
- The video shall maintain pointing at the provided coordinates for 30 seconds.

External Objective

- To promote STEM to our community and to gain the confidence of young aspiring engineers.
- To increase enrollment to STEM classes by presenting our project to various presentation opportunity.
- To gain experience in working on Engineering project, adapting to a teamwork environment, implementing project and time management.

System Requirement Summary

Requirements	Description
1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerance 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 payload. Small holes to allow access to turn on thes science payload is allowed. The end of the container where the payload 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 operation
8	The container 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 descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.

System Requirement Summary

Requirements	Description
10	The container shall release the payload at 450 meters +/- 10 meters.
11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.
12	The science payload shall be a delta wing glider.
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5m/s
14	All descent control device attachment components shall survive 30 Gs of shock.
15	All electronics components shall be enclosed and shielded from the environment with the exception of sensors.
16	All structures shall be built to survive 15 Gs of launch acceleration.
17	All structures shall be built to survive 30 Gs of shock.
18	All Electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
19	All mechanism shall be capable of maintaining their configuration or states under all forces.

System Requirement Summary

Requirements	Description
20	Mechanism shall not use pyrotechnics or chemicals.
21	Mechanism that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.
22	The science payload shall measure altitude using an air pressure sensor.
23	The science payload shall provide position using GPS.
24	The science payload shall measure its battery voltage.
25	The science payload shall measure outside temperature.
26	The science payload shall measure particulates in the air as it glides.
27	The science payload shall measure airspeed.
28	The science payload shall transmit all sensors data in the telemetry.
29	Telemetry shall be updated once per second.
30	The parachutes shall be fluorescent Pink or Orange
31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.

System Requirement Summary

Requirements	Description
32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.
33	Telemetry shall include mission time with one second or better solution. Mission time shall be maintained in the event of processor reset during the launch and mission.
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.
35	XBEE radios shall be used for telemetry. 2.5 GHz Series radios are allowed. 900 MHz XBEE Pro radios also allowed.
36	XBEE radios shall have their NETIP/PANID set to their team number.
37	XBEE radios shall not use broadcast mode.
38	Cost of CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
39	Each team shall develop their own ground station.
40	All telemetry shall be displayed in real time during descent.
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)

System Requirement Summary

Requirements	Description
42	Team shall plot each telemetry data field in real time during flight.
43	
44	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.
45	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.
46	Both the container and probe shall be labeled with team contact information including email addresses.
47	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 process resets.
48	No lasers allowed.
49	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.
50	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.

System Requirement Summary

Requirements	Description
51	Audio beacon is required for the probe. It may be powered after landing or operate continuously.
52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.
53	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.
54	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.
55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.
56	The CANSAT must operate during the environmental tests laid out in Section 3.5.
57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.

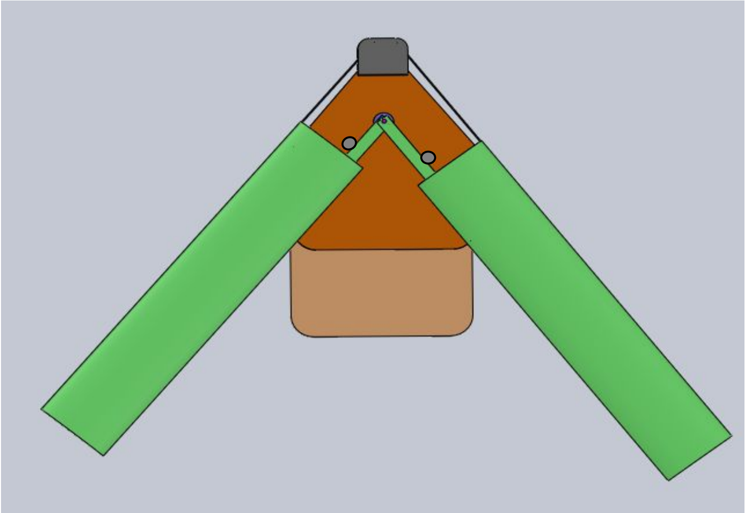
System Level CanSat Configuration Trade & Selection (1 / 2)

Configuration 1

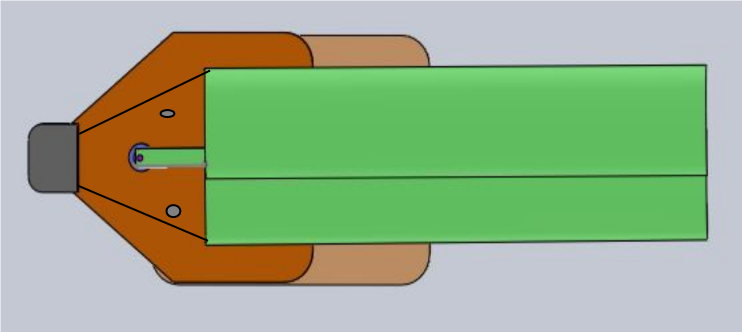
General Description:
- Wings are folded together horizontally, with a retractable mechanism.
- Base frame are 3D printed materials, where electronics are mounted in PCB board attached to the base frame with standoffs, bolts, screws. Consist of multiple layers of frames prior to electronics integration, weight reduction, easier to find center of gravity.
- Fishing line will hold the payload connected with nichrome wire and fishing line will hold the payload to the container as well as a release mechanism. Wings expanded will have stopper for functionality.

Pros:
- High Aspect ratio for gliders.
- Produce more lift.
- Easy to Integrate Electronics.

Cons:
- Folding mechanism is inefficient.
- Wings are handcrafted and base frame too small.
- Requires more materials.



Wings Expanded



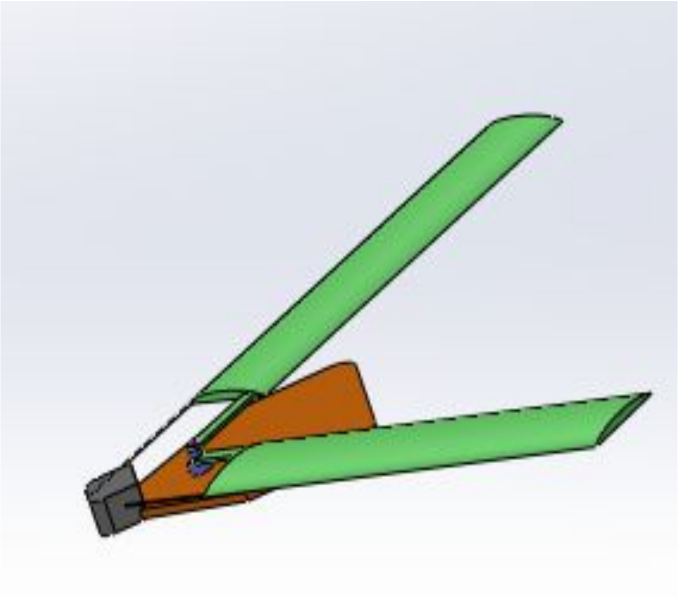
Wings Folded

System Level CanSat Configuration Trade & Selection (1 / 2)

Configuration 1 Descent Method

General Description:

- The wings unfolds using a spring loaded hinge.
- There are no room for active control on the wings so it will have to be a passive control system.



Descent Method

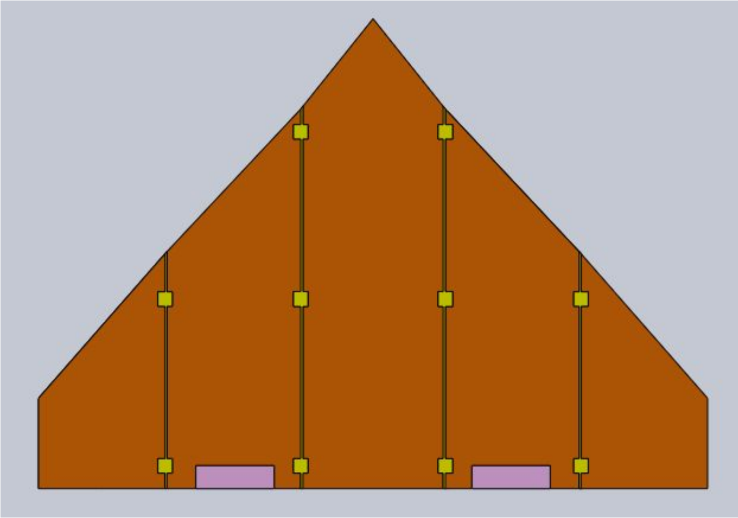
System Level CanSat Configuration Trade & Selection (2 / 2)

Configuration 2

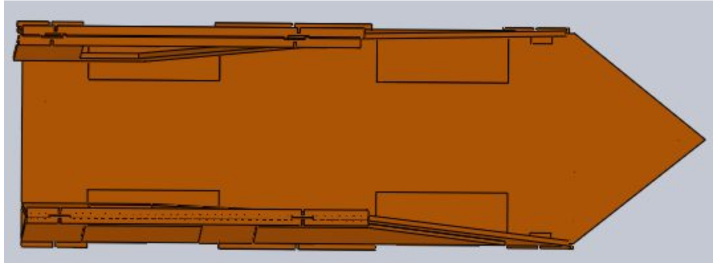
General Description:
- Consist of two vertically folded wings, main frame is 3D printed material, and fuselages at the center attached with printed PCB board and electronics components.
- Center will be the fuselages, separate compartments for electronics integration, weight distribution / reductions.
- Servos are mounted on both wings to control the ailerons.
- Hinges and rubbers bands to ensure folding mechanism
- Nichrome wire and fishing will hold the payload and container and as release mechanism

Pros:
- Less weight
- Efficient in Electronic Integration
- More room for adjustments and assembly

Cons:
- More folded wings (more parts required)
- Placing of components for a quality descend



Wings Expanded



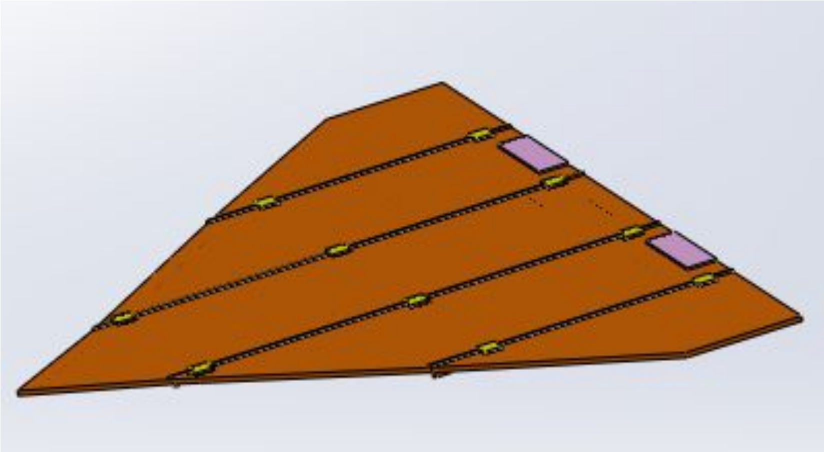
Wings Folded

Configuration 2 is selected due to simple structure, adhere the Competition requirements, and sufficient in electronics/ parts modification.

System Level CanSat Configuration Trade & Selection (2 / 2)

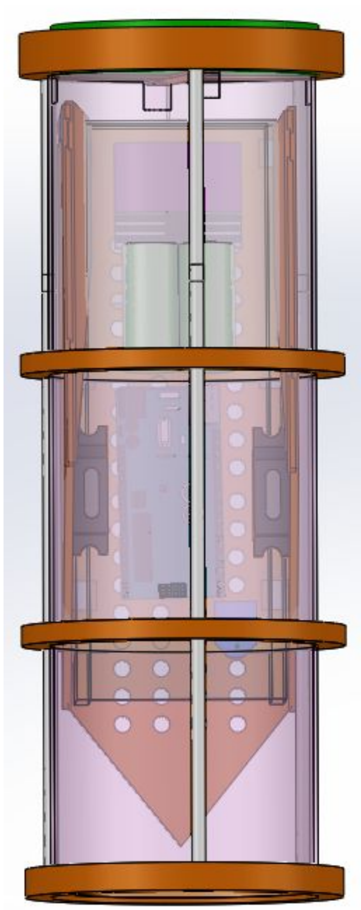
Configuration 2 Descent Method

- Semi rigid wing.
- Electronics is located on the bottom of the glider.
- Active control system because there is room on the wings to install servos and elevens.

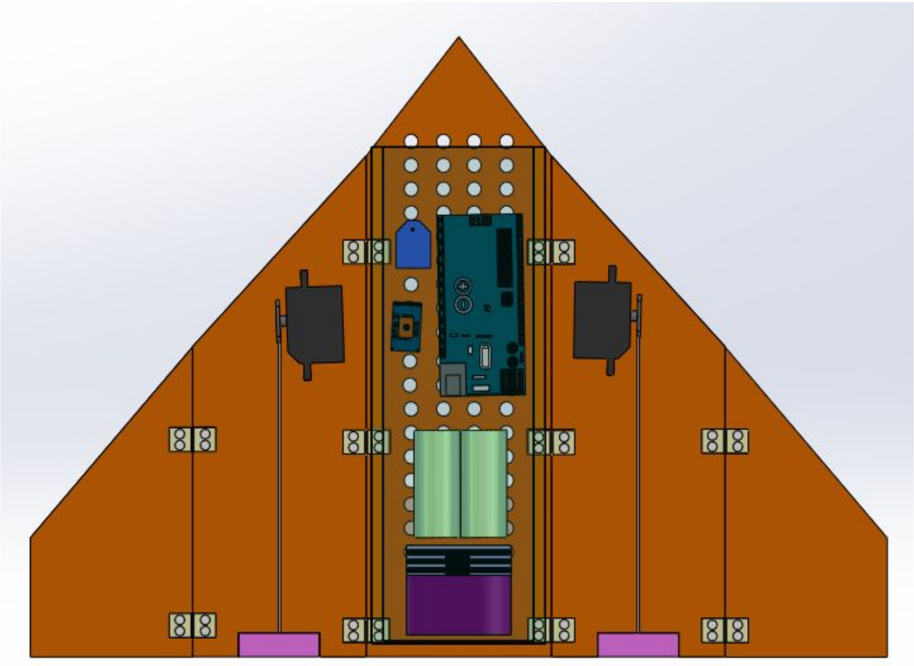


Descent Method

Physical Layout (1/4)

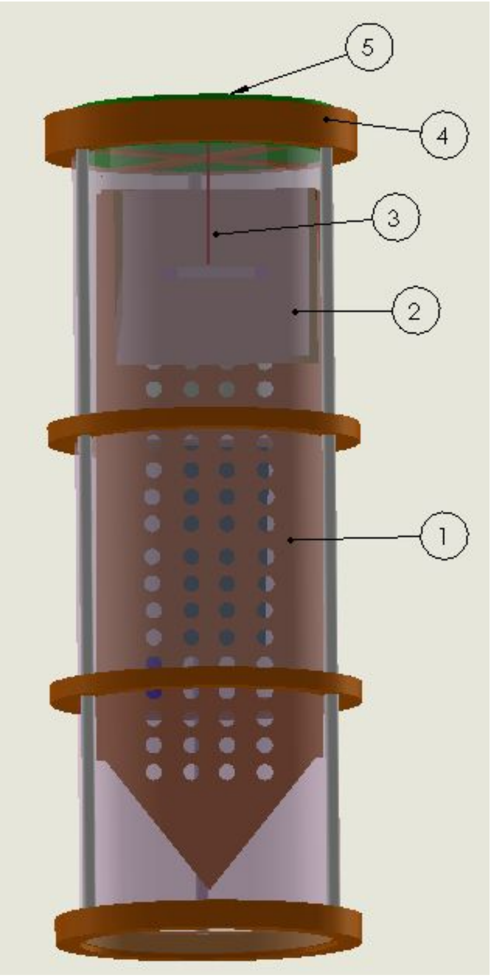


Launch Configuration



Configuration Deployment

Physical Layout (2/4)

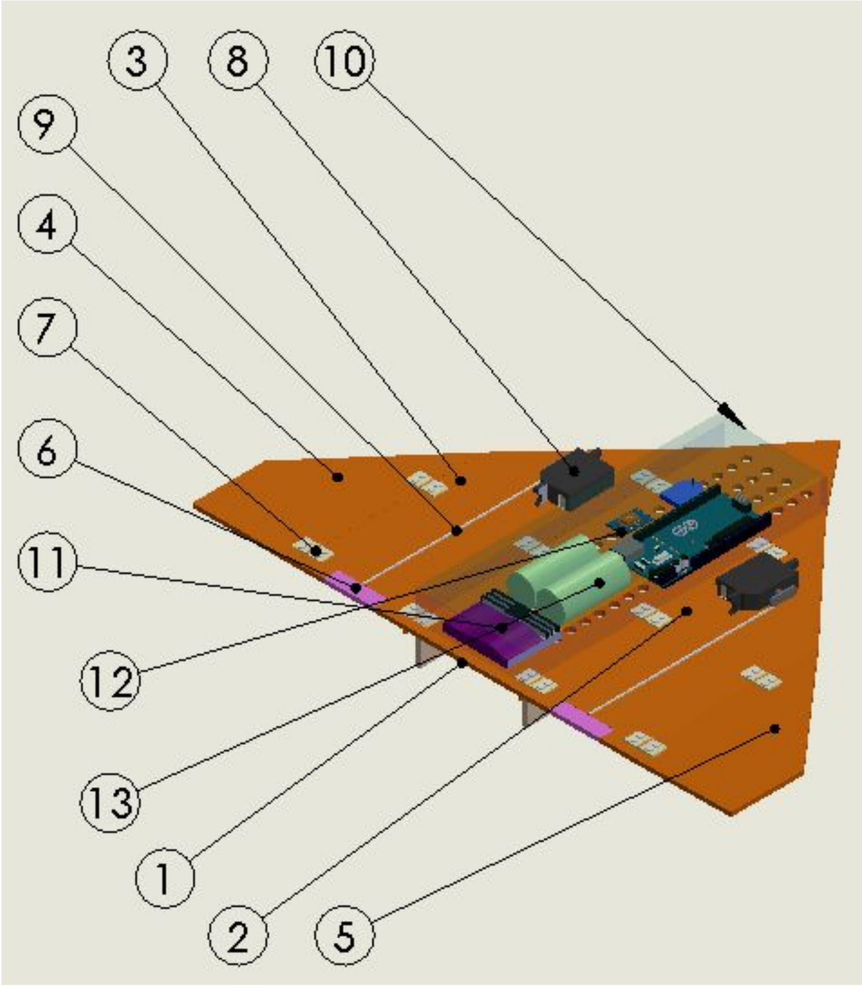


Part Number	Description
1	Payload
2	Release Mechanism/nichrome wire
3	Fishing line
4	Container
5	Parachute

Container Mechanics

Physical Layout (3/4)

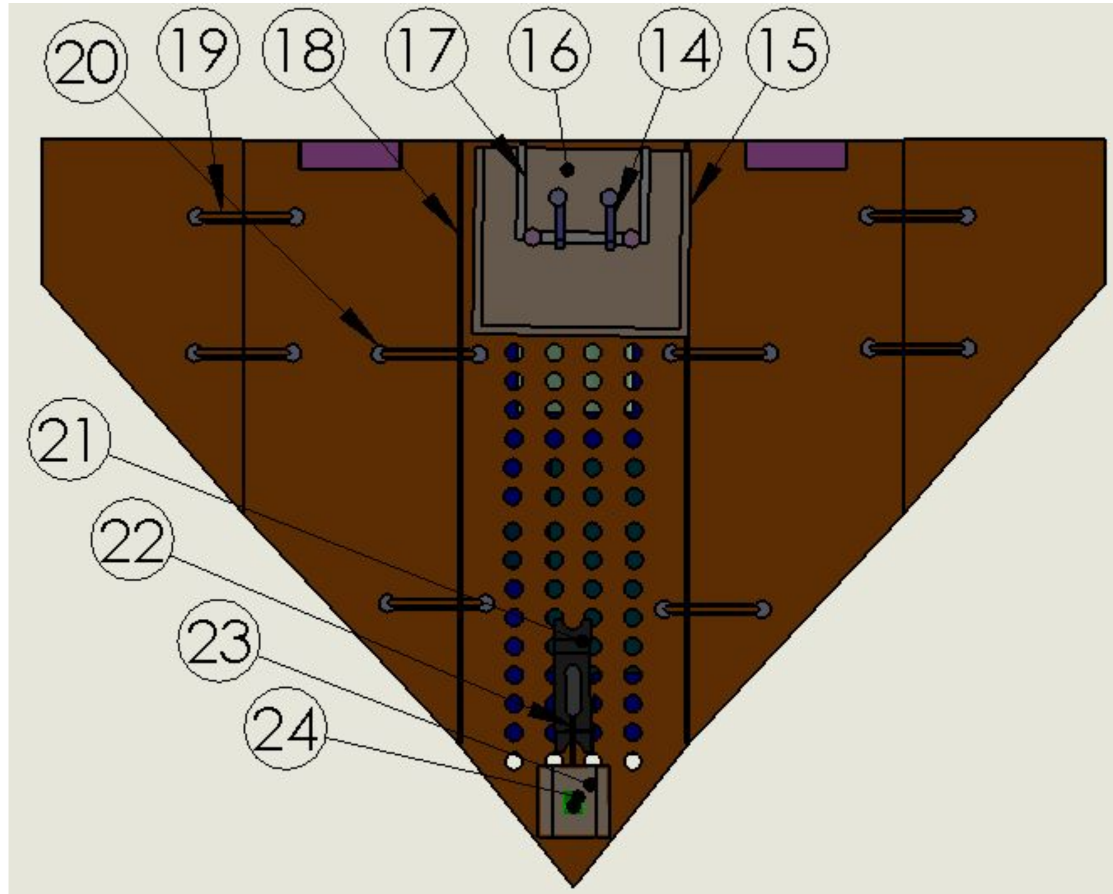
Part Number	Description
1	Main Frame
2	Right Wing Frame
3	Left Wing Frame
4	Left Winglet
5	Right Winglet
6	Ailerons
7	Hinges
8	Servos
9	String
10	Component Cover
11	Parachute
12	Electronics
13	Batteries



Payload Mechanics

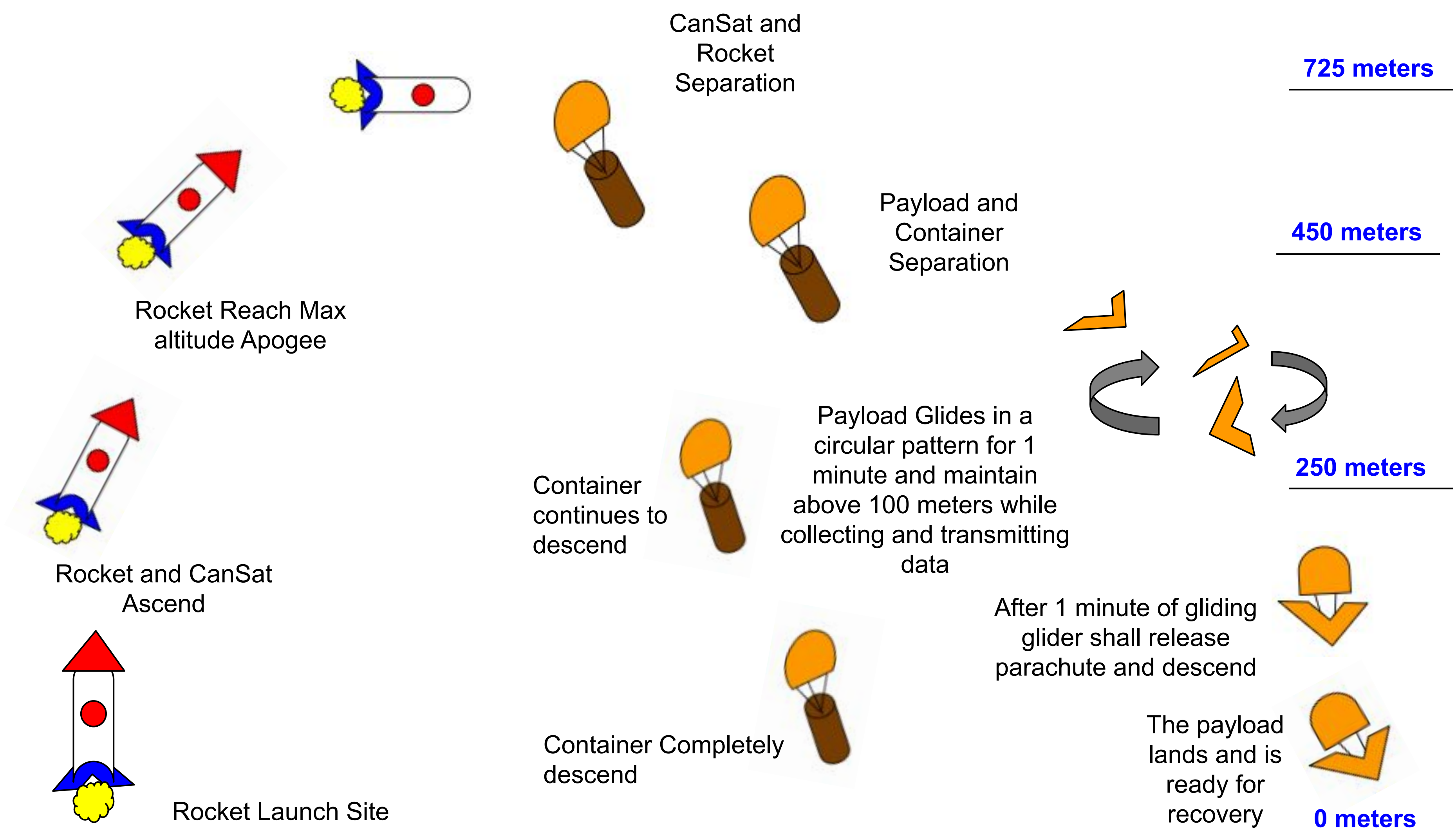
Physical Layout(4/4)

Part Number	Descriptions
14	Nichrome Wire
15	Release Mechanism Cover
16	Release Mechanism Frame
17	Fishing Line
18	Stopper
19	Rubber Band
20	Hooks for Rubber Bands
21	Servo
22	Directional String
23	Flexiglass Cover
24	Camera



Payload Mechanics

System Concept of Operations (1 / 2)



System Concept of Operations(2 / 2)

- Arrive at launch site
- Team Discussion
- Make final Adjustments on CanSat
- Set up Ground Station
- Make final Check on telemetry / configuration
- Turn in CanSat for launch

Pre-Launch

- CanSat Ascend with the rocket
- Separation of Rocket and CanSat
- Container and Payload Separation
- Gather Data telemetry save to .cvs file

Launch

- Recover Payload and Container
- Analyze the condition of Payload and Container
- Analyze Data
- Prepare for PFR
- Presentation of PFR

Post - Launch

Launch Vehicle Compatibility (1 / 2)

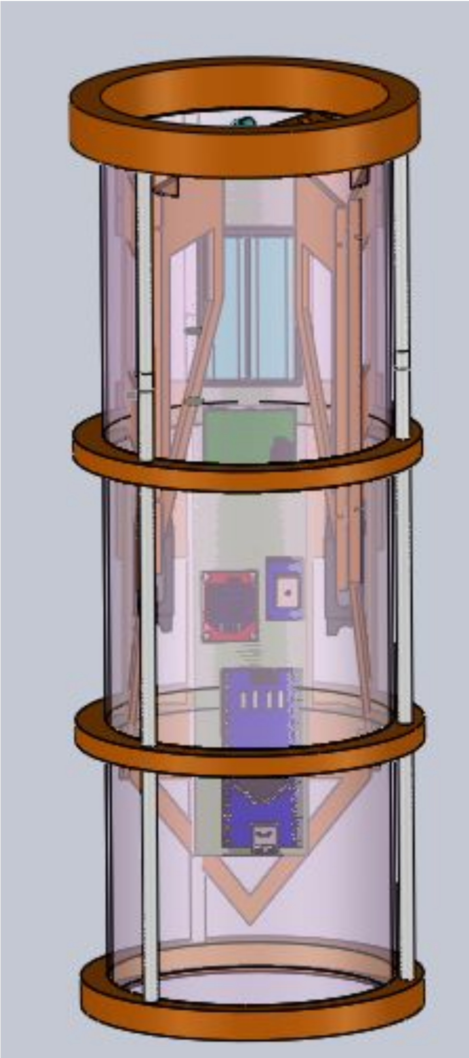
Mission Guide Rocket Payload dimensions:
- Height : 310 mm
- Diameter : 125 mm

CanSat Dimensions:
- Height : 300 mm
- Diameter : 116 mm

Payload Dimensions after deployment:
- Wing Span : 370 mm
- Tail to Nose : 260 mm

Parachute Dimensions:
- Diameter: 228.6 mm
- Spill Hole Diameter:

**Selection of CanSat based on Container dimension for payload to fit with sufficient margin*
** Reduce weight also to prevent possible failure on deployment and no sharp protrusions*



Launch Vehicle Compatibility (2 / 2)

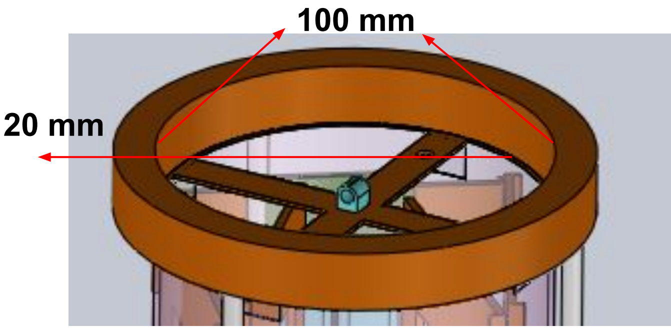
Rocket (Purple color) and Payload Dimensions:

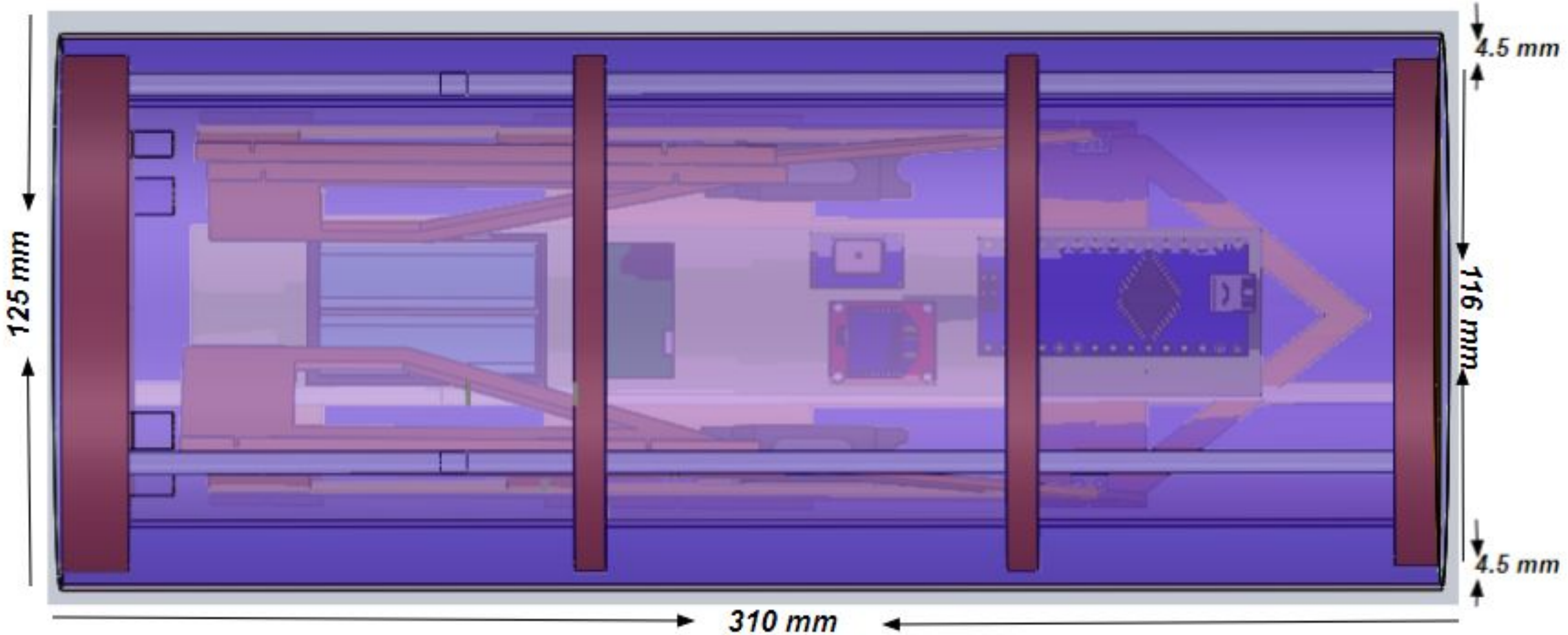
- Margin : 4.5 mm

CanSat Parachute Shell

- Height : 20 mm
- Diameter : 100 mm

**Dimensions and margins comply to the safety during deployment from the rocket and reduce the risk of failure*





Sensor Subsystem Design

Guillermo Martin

Sensor Subsystem Overview

Sensor Type	Model	Purpose	CanSat Location
Outside Thermometer	LM35DT	Detect outside temperature	Payload
Air Speed Sensor	MPXV7002DP	Detect True Air Speed	Payload
GPS	Adafruit Ultimate GPS	Detect longitude and latitude	Payload
Altitude	BME280	Detect altitude	Payload
Voltage	Series 10K resistor	Detect battery voltage	Payload
Particulate Sensor	SPS30	Measure air particulates	Payload
Pitch and Roll	MPU6050	Detect glider's pitch and roll	Payload

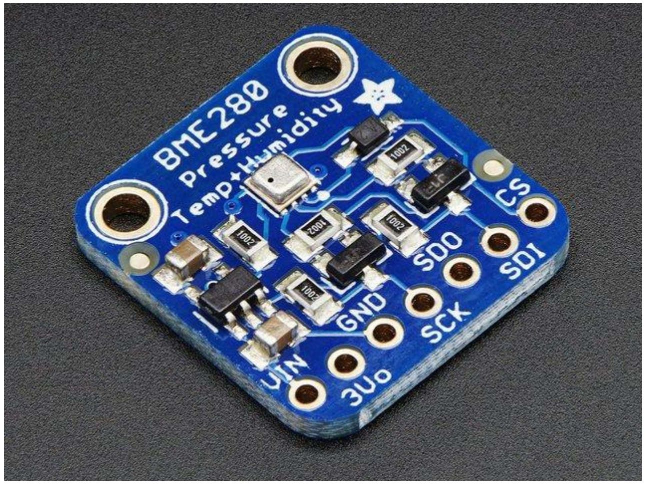
System Requirement Summary

Requirements	Description
15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
22	The science payload shall measure altitude using an air pressure sensor.
23	The science payload shall provide position using GPS.
24	The science payload shall measure its battery voltage.
25	The science payload shall measure outside temperature.
26	The science payload shall measure particulates in the air as it glides.
27	The science payload shall measure air speed.

Payload Air Pressure Sensor Trade & Selection

Sensor	Current @1Hz	Temperature range	Port	Resolution (hPa)	Voltage Usage	Size	Weight	Price
BME280	3.6 uA	-40 to +85 °C	I2C or SPI	.03	1.65V ~ 3.6V	19mm x 18mm x 3.0mm	1.2g	$19.95
MPL115A2	6 uA	-40 to +85 °C	I2C	1.5	2.4V ~ 5.5V	19.2mm x 17.9mm x 2.9mm	.61g	$7.95

Selected	Rationale
BME280	• Availability of parts (in stock) • We have experience in programming it • Higher resolution than MPL115A2 • Tested to be stable in our application



Payload Air Temperature Sensor Trade & Selection

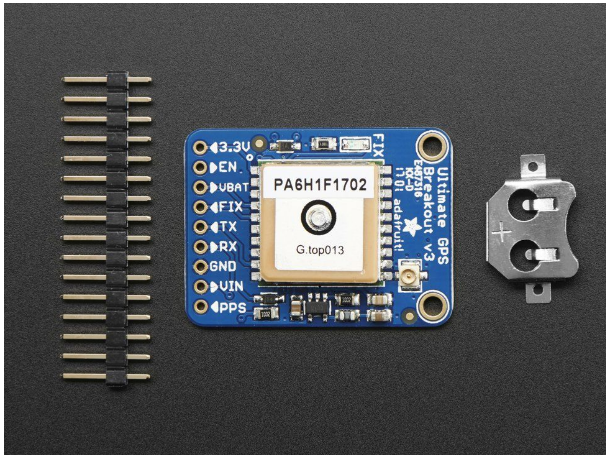
Sensor	Vin	Temperature Range	Margin of Error	Cost
LM35DT	4V-30V	-55℃ to 150℃	±0.75℃	$3.49
BME280	1.71V-3.6V	-40℃ to 85℃	±.005℃	$19.95

Selected	Rationale
LM35DT	• Easier to place outside of glider to measure temperature • Margin of error is acceptable • Low cost • Our power is 5V regulated so it is easier to provide power

GPS Sensor
Trade & Selection

Name	Price (USD)	Weight (g)	Size (mm)	Operating Voltage (V)	Current Usage (mA)	Update Rate (Hz)
Adafruit Ultimate GPS breakout	$39.95 Adafruit	8.5	15 x 15 x 4	3.0 - 5.5	20	1 - 10
MakerFocus GPS NEO-6M	$12.99 Amazon	9.07	27.6 x 26.6	3.6 - 5.0	40 - 45	1 - 5

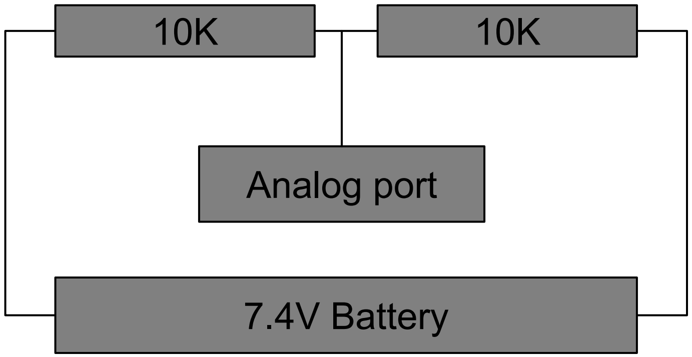
Selected	Rationale
Adafruit Ultimate GPS Breakout	• Smaller in size • Low power consumption • Real Time Clock for reset mitigation • The GPS is very stable when tested



Payload Power Voltage Sensor Trade & Selection

Name	Price (USD)	Weight (g)	Size (mm)	Operating Voltage (V)	Current Usage (mA)
INA260	$9.95	2	22.9 x 22.9 x 2.7	2.7 - 5.5	.310
Series Resistor	$0	< 1	5 x 1	.1 - 10	.740

Selected	Rationale
Series Resistor	• Availability of component • Easier and smaller to mount • No extra load on i2c interface • Available analog port on controller



Air Speed Sensor Trade & Selection

Name	Weight / Size	Cost	Power	Operational Environment Ambient Temperature/ Storage Temperature	Interface	Resolution/Accuracy
MS4525D0/kit	3 / 12.4 x 17.4 x 8.2	$43 ebay	3mA/ <1µA standby	-25 to 105 Celsius	I2C	0.84 Pa
MPXV7002/kit	16.76 x 7.62 x 13.21	$28 ebay	10mA	10 to 60 Celsius	Analogue	1.0V/kPa

Selected	Rationale
MPXV7002	• Availability of part • Calibration of sensor is doable • Less traffic on the I2C interface • Easier to program on Arduino

Particulate/Dust Sensor Trade & Selection

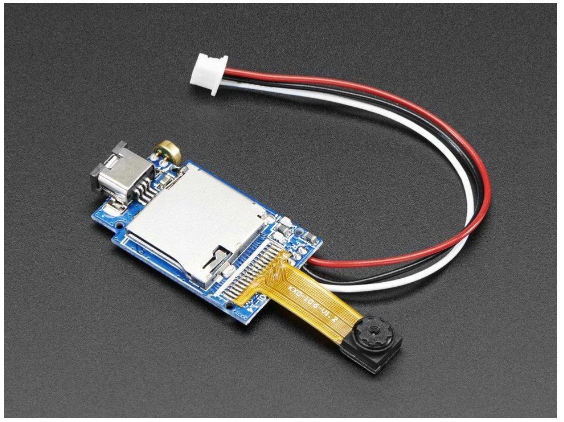
<table>
<tr><th>Name</th><th>Weight (g)/ Size (mm)</th><th>Cost (USD)</th><th>Power</th><th>Operational Environment Ambient Temperature/ Storage Temperature</th><th>Detectable particle size(min)(µm)</th><th>Relative Humidity (non-condensing)</th><th>Interface</th></tr>
<tr><td rowspan="2">Sensirion SPS30</td><td>26</td><td rowspan="2">$46.95</td><td rowspan="2">80 mA x 5V</td><td>-10 - 60 Celcius</td><td rowspan="2">1
2.5
4
10</td><td rowspan="2">10 - 95%</td><td rowspan="2">I2C</td></tr>
<tr><td>21.0 x 18.0 x3.0mm</td><td>-40 - 70 Celcius</td></tr>
<tr><td rowspan="2">Grove PPD42NS</td><td>59 x 45 x 22 mm</td><td rowspan="2">11,50 USD</td><td rowspan="2">90 mA x 5 V</td><td>0 - 45 Celcius</td><td rowspan="2">1</td><td rowspan="2">0 - 95%</td><td rowspan="2">Digital I/O</td></tr>
<tr><td>24 g</td><td>-30 - 60 Celcius</td></tr>
</table>

Selected	Rationale
Sensirion SPS30	• Available library for arduino makes it easier to program • Detects particle concentration which complies with CanSat guideline • Smaller in size, easier to mount.

Bonus Camera Trade & Selection

Name	Weight (g)/ Size (mm)	Cost (USD)	Power mA(5V)	Resolution	SD Card	Interface
Arducam Mini Module Camera	20 34.1 x 24.4 x 36	$25.99	20	1600 x 1200	No	SPI
Adafruit Mini Spy Camera	2.8 28 x 17 x 4.2	$12.50	110	640 x 480	Yes	Digital I/O

Selected	Rationale
Adafruit Mini Spy Camera	• Onboard SD card will relieve controller of processing power • Resolution complies with CanSat guideline • Digital I/O control spares SPI



Container Air Pressure Sensor Trade & Selection

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Descent Control Design

Arthur S. Agdeppa

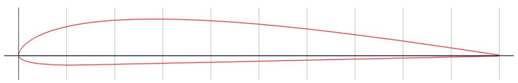
Descent Control Overview (1/3)

Airfoil (Flat bottom AG03)

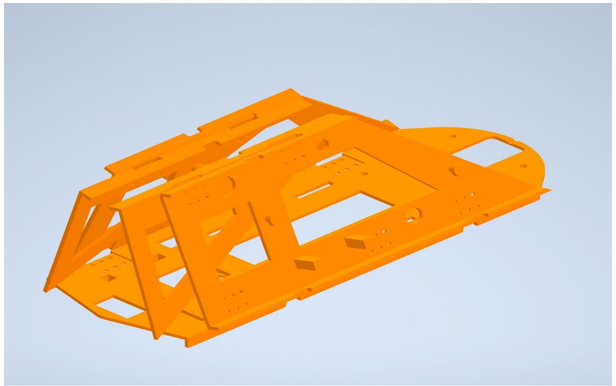
We chose flat bottom airfoil because it makes it easier for us to design our payload. Our configuration, the wing fold and the placement of the hinges will cause the flat part of the folded wing to touch each other. Making it fit in our container.

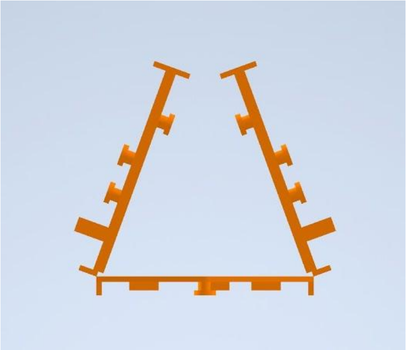
Parachute

Our parachute is hexagon shape with 22.86 centimeter diameter. It will hold our container with the payload to approximately 16.86 m/s descent rate. Our payload will have the same size and it will hold it to approximately 12.8 m/s descent rate.

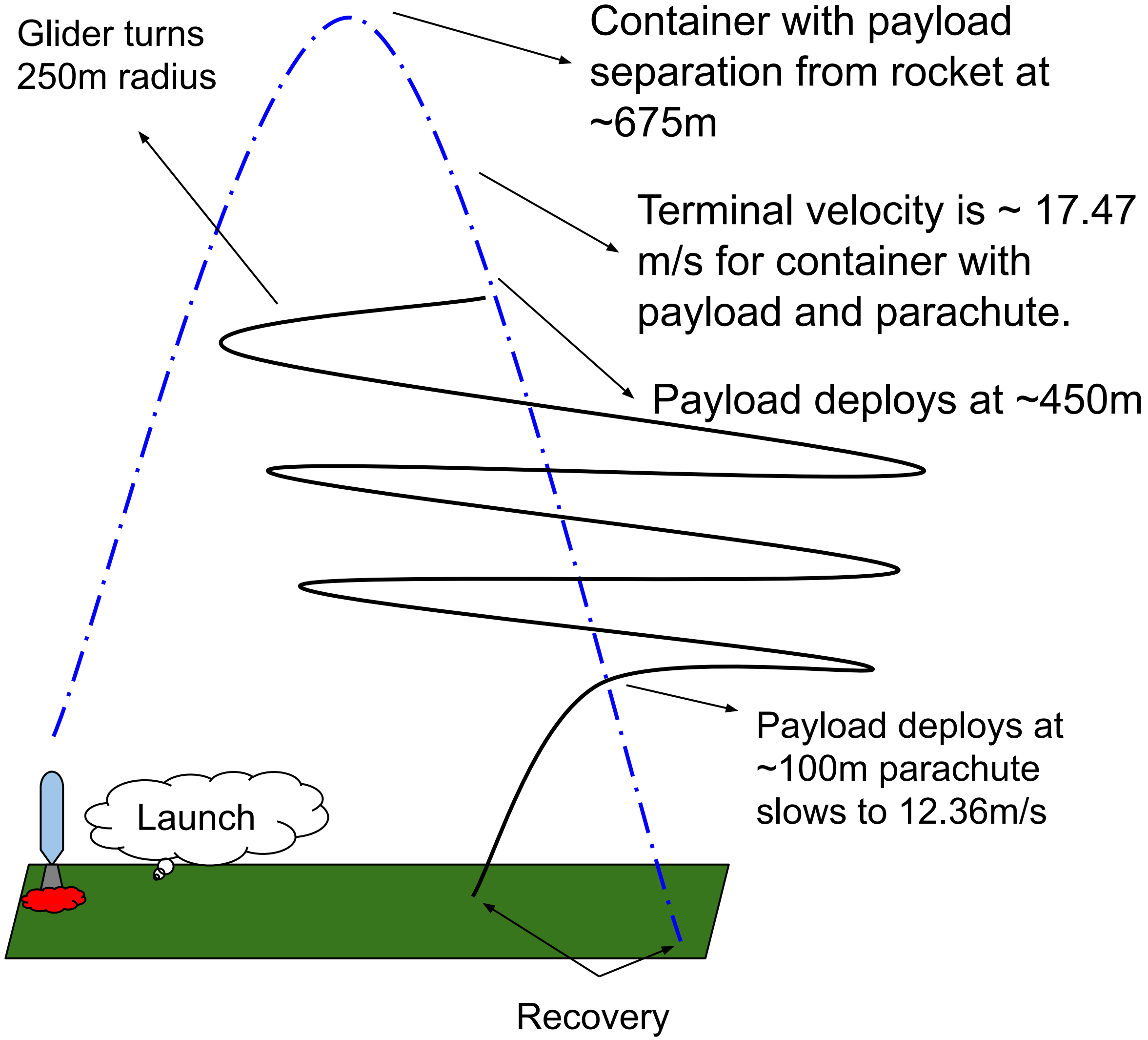


AG03





Descent Control Overview (2/3)



Event 1
Pre-flight Operations.
Communications check.

Event 2
Rocket Launched

Event 3
Apogee has been reached deploying container with payload.

Event 4
Payload separates from container. Glider engages autopilot.

Event 5
Payload deploys parachute

Event 6
Landing and recovery

Descent Control Overview (3/3)

Configuration Selected: Cropped Delta wing glider with 50mm tip chord, 260mm root chord and a wing span of 370mm.

Components:

Component	Material Used
Glider wing support structure	PETG 3D printed
Hinges	Nylon hinges
Wing body	Foamboard
Parachute	Ripstop nylon
Parachute cord	Nylon Shroud

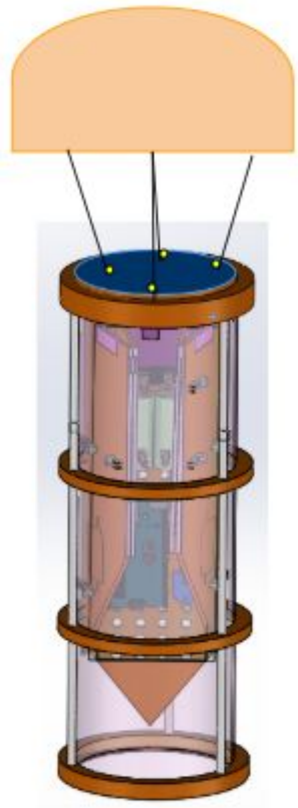
Descent Control Requirements

Requirements	Description
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.
8	The container 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 descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.
10	The container shall release the payload at 450 meters +/- 10 meters.
11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s

Payload Descent Control Strategy Selection and Trade (Pre-deployment)(1/2)

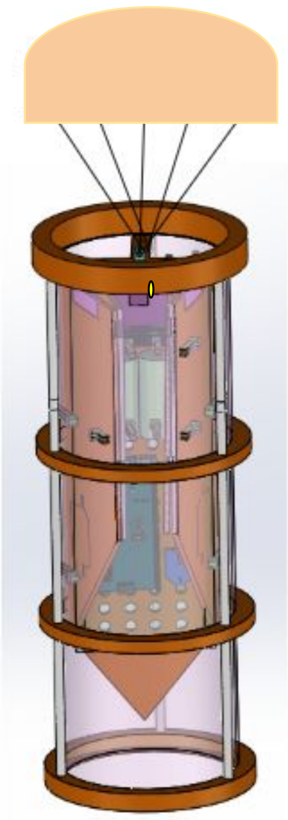
Configuration 1

- Parachute is attached to the container by attaching each of the cord to their dedicated holes
- Parachute sits on top of the container for passive deployment



Configuration 2

- Parachute is attached to the container by tying the cords to a central eye bolt.
- Central eye bolt on the container will have bushings to prevent the container from twisting with the parachute.



Selected Configuration 2
Rationale:

- **Less likely for our container to twist during its descent which could prevent payload deployment**

Payload Descent Control Strategy Selection and Trade (Pre-deployment)(2/2)

Configuration 1:
Dome parachute with spill hole
- Stable with spill hole
- Difficult to manufacture
- High drag coefficient

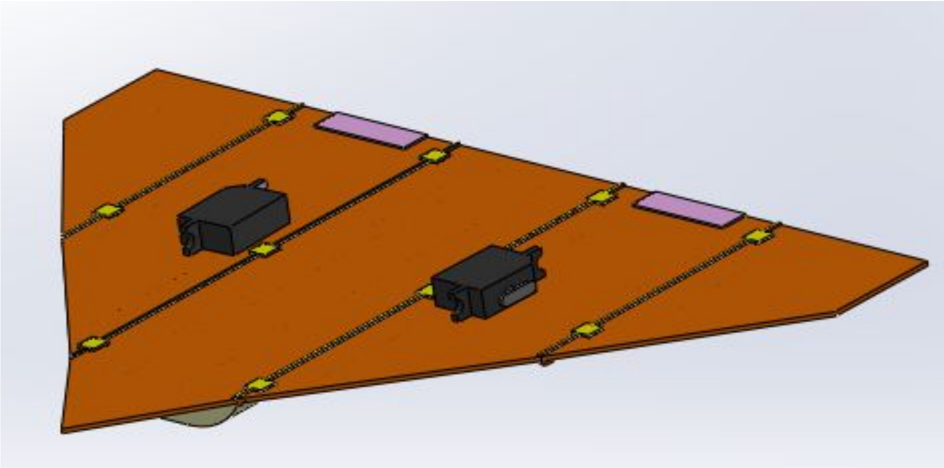
Configuration 2:
Flat hexagon parachute
- Lightweight
- Low drag coefficient
- Easy to manufacture
- Premade parachute is available

Selected: Configuration 2
Rationale:
- **Easier to manufacture or acquire**
- **Spill hole not required**

Payload Descent Control Strategy Selection and Trade (Post-Deployment)(1/2)

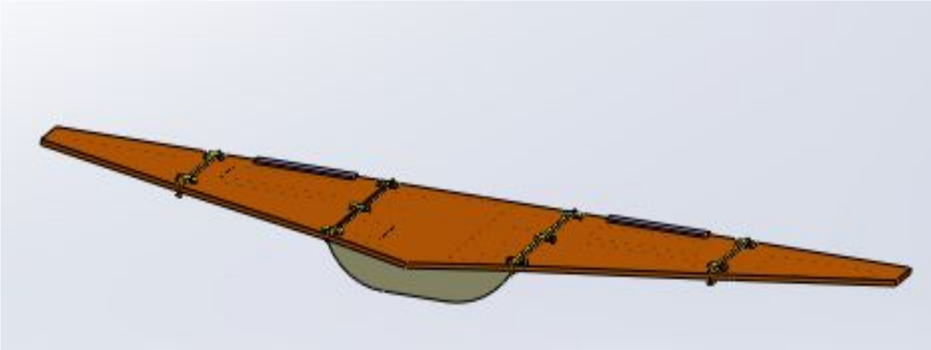
Active

- Closed loop control system that controls left and right servo connected to an elevon
- **Nadir** direction will be determined by the accelerometer
- Tumbling will be prevented by tuning the control system to fastest possible response



Passive

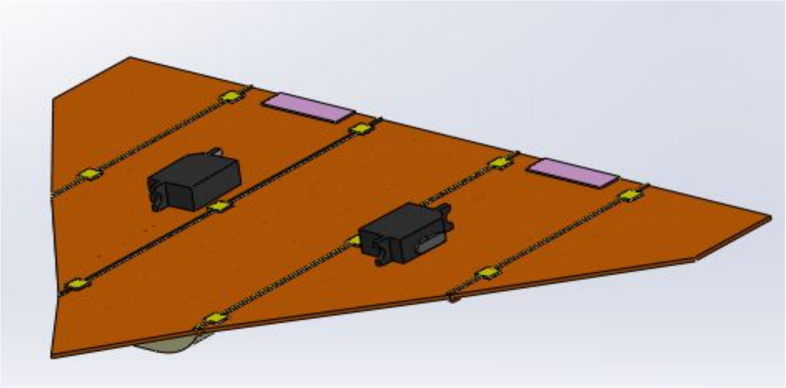
- Shifting the center of mass to the side to bank the glider in the direction of the turn
- **Nadir** direction will be maintained by placing all components including the battery on the bottom of the glider
- Tumbling is prevented by making sure Center of Gravity is on point



Payload Descent Control Strategy Selection and Trade (Post-deployment)(2/2)

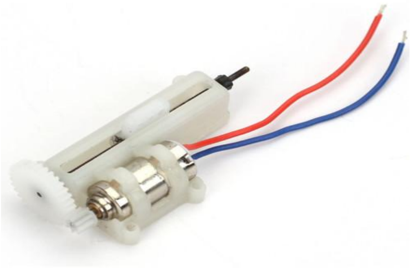
Configuration 1:
Micro regular servo to elevon active control

- Closed feedback
- MPU6050 sensor
- PID controller
- Will activate after deployment from container



Configuration 2:
Linear servo to elevon active control

- Closed feedback
- MPU6050 sensor
- PID controller
- Will activate after deployment from container
- Lower profile than micro servo



Selected: Configuration 2
Rationale:

- **Lower possibility of getting stuck inside container during deployment because of its lower profile height**

Container and payload with parachute descent velocity:

$$v = \sqrt{\frac{2(m)(g)}{\rho(S)(C_d))}} = \sqrt{\frac{2(.6kg)(9.8m/s^2)}{1.225kg/m^3(.866(.22^2m))(.75)}} = 17.47m/s$$

- ***v*** is terminal velocity
- m is mass of container and payload (~.6kg)
- g is gravity
- ρ is air density
- S is area of parachute (.866 * (Diameter)^{2} for hexagon)
- D is diameter of parachute estimated to be 22cm
- Cd is drag coefficient (.75 for hexagon ripstop)

Descent Rate Estimates

Container after payload release:

$$v = \sqrt{\frac{2(m)(g)}{\rho(S)(C_d))}} = \sqrt{\frac{2(.32kg)(9.8m/s^2)}{1.225kg/m^3(.866(.22^2m))(.75)}} = 12.76m/s$$

- ***v*** is terminal velocity
- m is mass of container (~.32kg)
- g is gravity
- ρ is air density
- S is area of parachute {.866*(Diameter)$^{\mathbf{2}}$ for hexagon}
- D is estimated to be 22cm
- Cd is drag coefficient (.75 for hexagon ripstop)

Descent Rate Estimates

Payload Descent terminal velocity:

$$v = \sqrt{\frac{2(m)(g)}{\rho(S)\sqrt{C_L^2 + C_d^2}}} = \sqrt{\frac{2(.28kg)(9.8m/s^2)}{1.225kg/m^3(.057m^2)(\sqrt{.32^2 + .024^2})}} = 15.65m/s$$

- Wingspan = .370m
- Root chord = .260m
- Tip chord = .05m
- *S* is Wing area = .057m^2
- *Cl* is Lift coefficient = .32
- *Cd is* Drag coefficient = .024
- *m* is mass = .3kg
- *g* is gravity = 9.8m/s^2

Descent Rate Estimates

Payload Control System Setpoint:

- Pitch = 0 degrees
- Yaw = 0 degrees

$$roll(\theta) = tan^{-1}\left(\frac{TAS/r}{g}\right)$$

Air Speed (m/s)	Radius of turn (m)	Roll Angle (degrees)
16.19	250	.4
16.19	150	.6
16.19	50	1.8
16.19	15	6.3

- **TAS** is True Air Speed
- ***r*** is radius of turn (250m)
- ***g*** is gravity

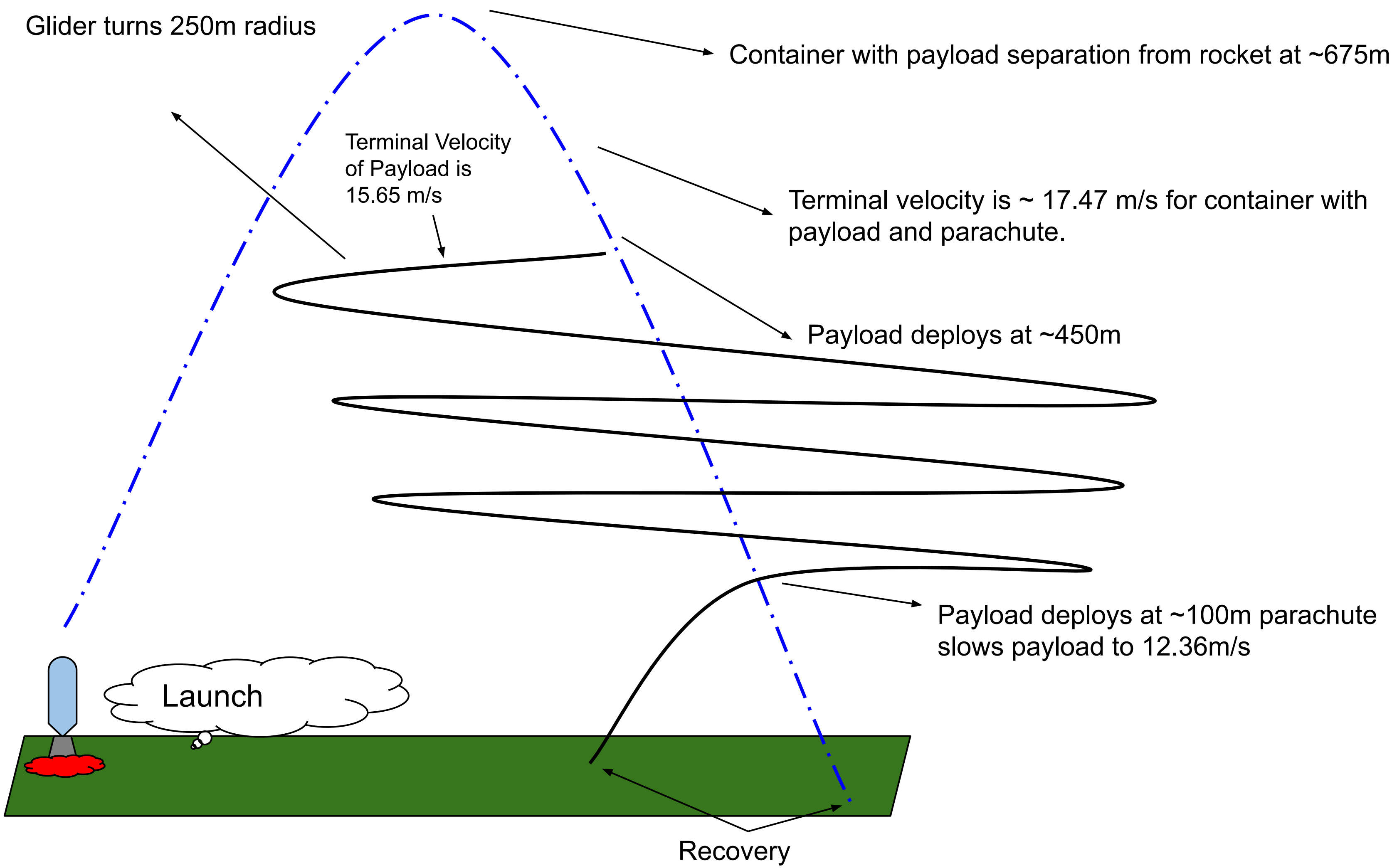
Descent Rate Estimates

Payload with parachute deployed descent velocity:

$$v = \sqrt{\frac{2(m)(g)))}{\rho(S)(C_d))}} = \sqrt{\frac{2(.3kg)(9.8m/s^2)}{1.225kg/m^3(.866(.22^2m))(.75)}} = 12.36m/s$$

- ***v*** is terminal velocity
- m is mass of container and payload (~.3kg)
- g is gravity
- ρ is air density
- S is area of parachute {.866 * (Diameter)$^{\mathbf{2}}$ for hexagon}
- D is diameter of parachute estimated to be 22cm
- Cd is drag coefficient (.75 for hexagon ripstop)

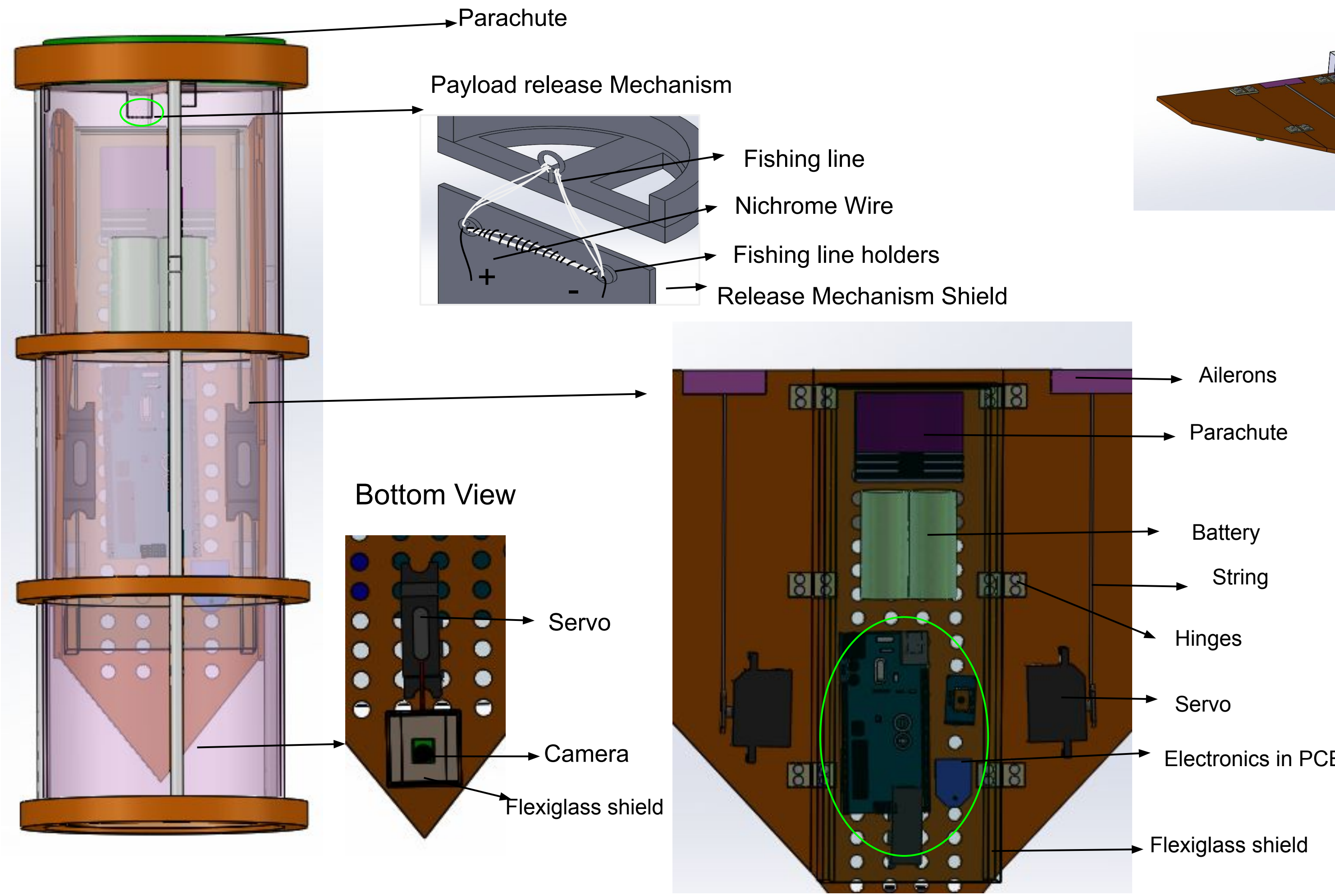
Descent Rate Estimates



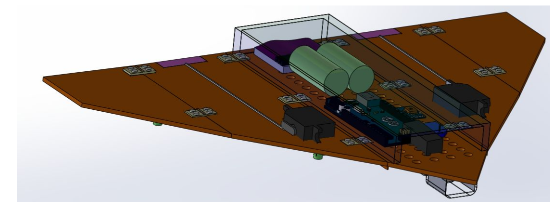
Mechanical Subsystem Design

Jhaymar Mendez

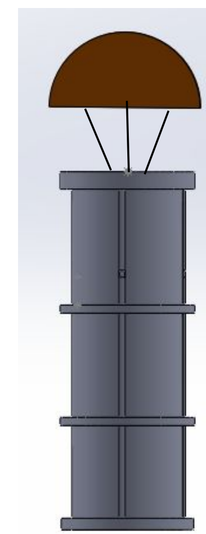
Mechanical Subsystem Overview



Top View



Payload



Container

Mechanical Sub-System Requirements

Requirements	Description
1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerance 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 payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload 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 operation
8	The container 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

Mechanical Sub-System Requirements

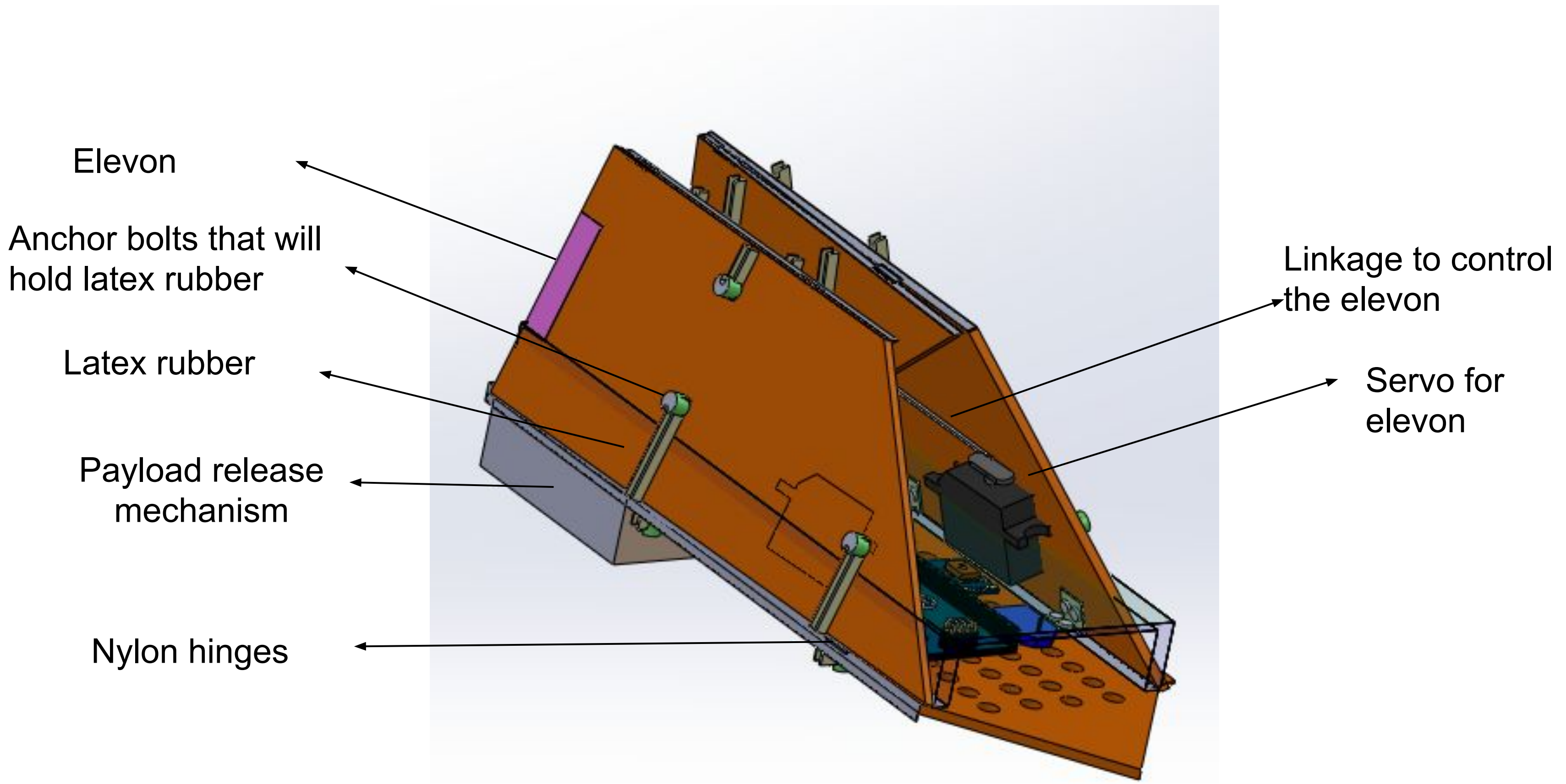
Requirements	Description
12	The science payload shall be a delta wing glider.
14	The science payload shall be a delta wing glider.
15	All electronics components shall be enclosed and shielded from the environment with the exception of sensors.
16	All structures shall be built to survive 15 Gs of launch acceleration.
17	All structures shall be built to survive 30 Gs of shock.
18	All Electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
19	All mechanism shall be capable of maintaining their configuration or states under all forces.
20	Mechanism shall not use pyrotechnics or chemicals.
21	Mechanism that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.

Mechanical Sub-System Requirements

Requirements	Description
30	The parachutes shall be fluorescent Pink or Orange
38	Cost of CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
46	Both the container and probe shall be labeled with team contact information including email addresses.
49	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.
50	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.

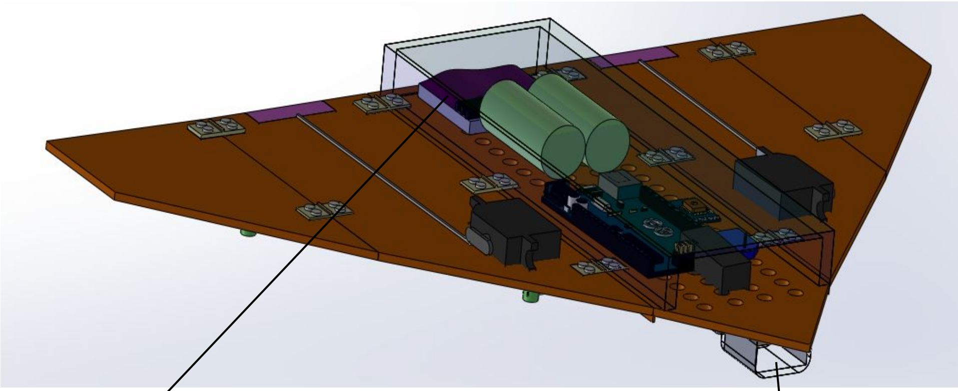
Payload Mechanical Layout of Components Trade & Selection (1/3)

Configuration 1



Payload Mechanical Layout of Components Trade & Selection (2/3)

Configuration 1

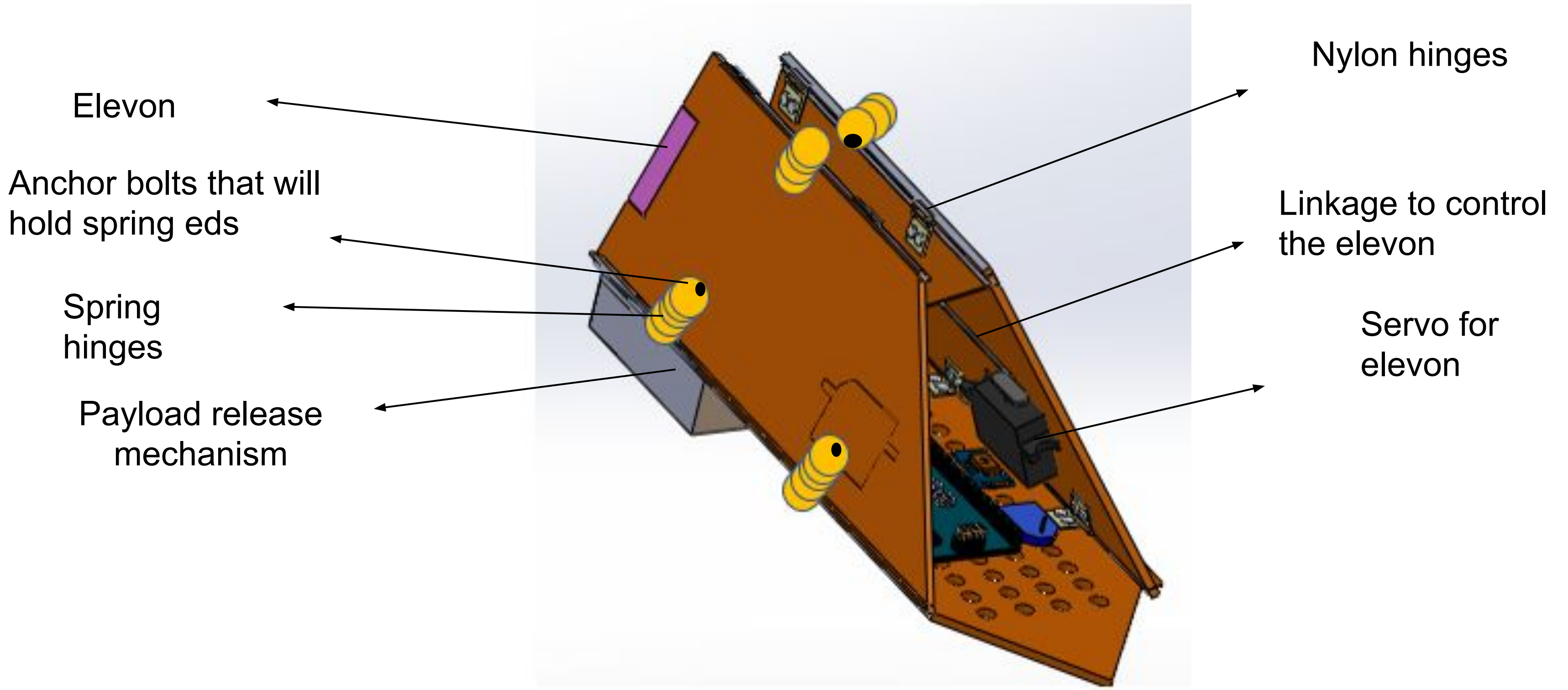


Parachute release mechanism

Camera Gimbal

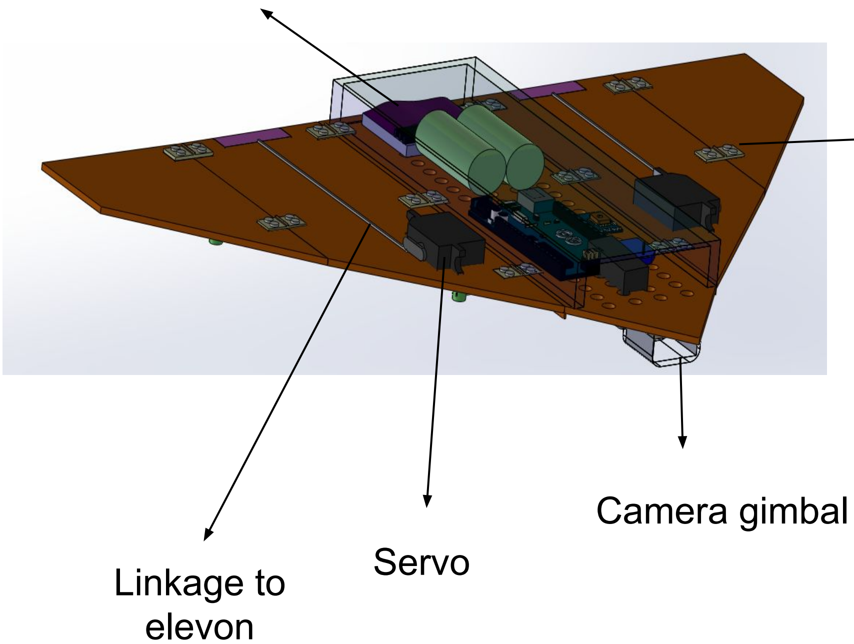
Payload Mechanical Layout of Components Trade & Selection (1/3)

Configuration 2



Payload Mechanical Layout of Components Trade & Selection (3/3)

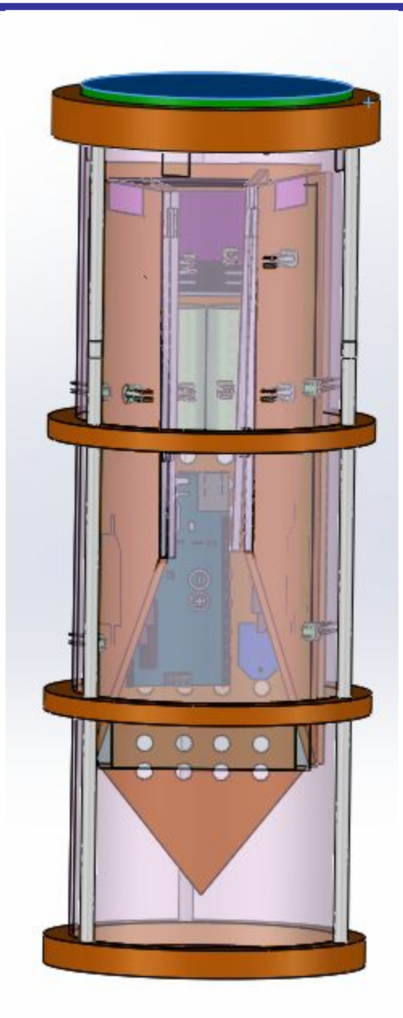
Configuration 2



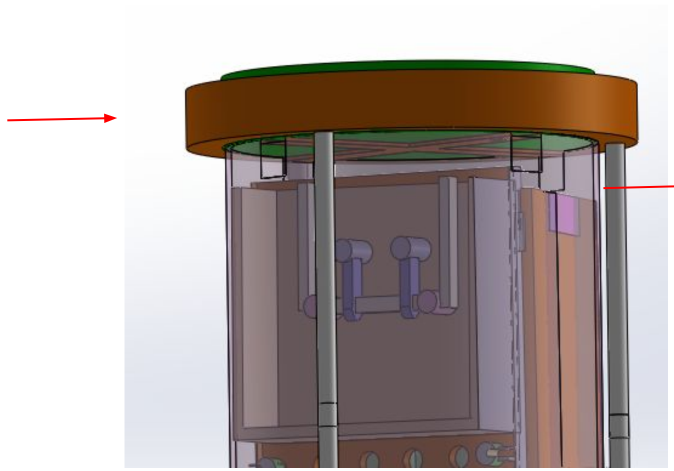
Selected Configuration 1

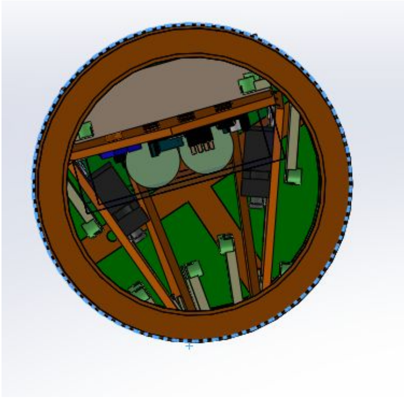
Rationale:
- Easier to manufacture
- Latex rubber is more lightweight than spring loaded hinges

Payload Pre Deployment Configuration Trade & Selection (Stowed Configuration) (1/2)



Stowed



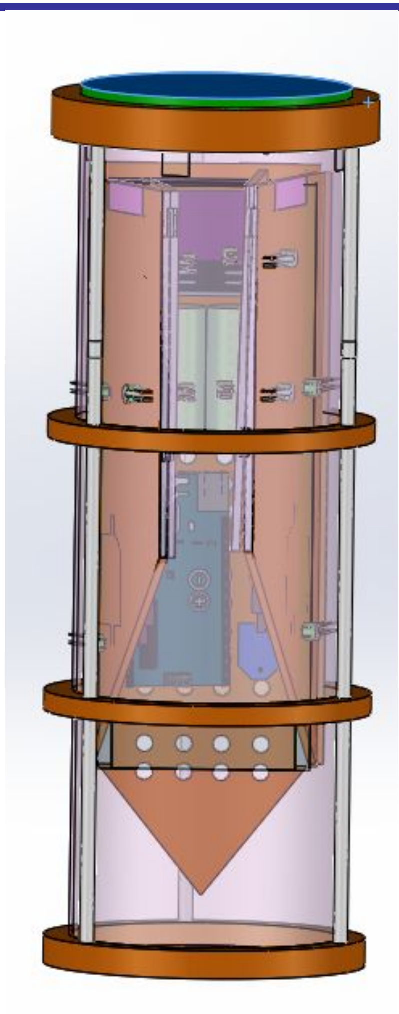


Bottom View

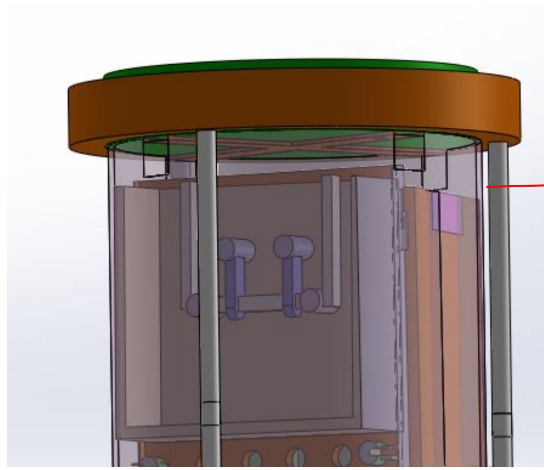
Configuration 1

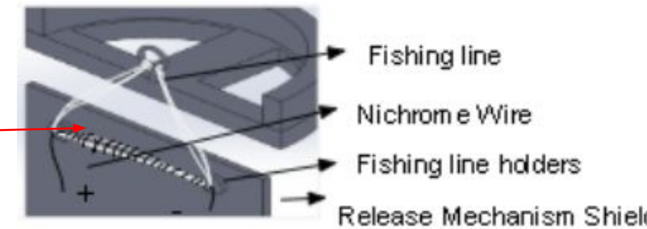
- Folded payload sits inside the container.
- The pressure of the payload folded wings will push the walls of the container
- There will be no sharp edges or sticky parts from the folded wings that will prevent it from deployment

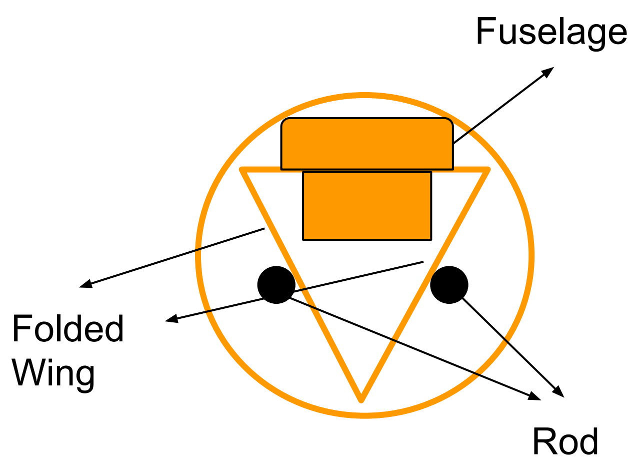
Payload Pre Deployment Configuration Trade & Selection (Stowed Configuration) (2/2)



Stowed







Bottom View

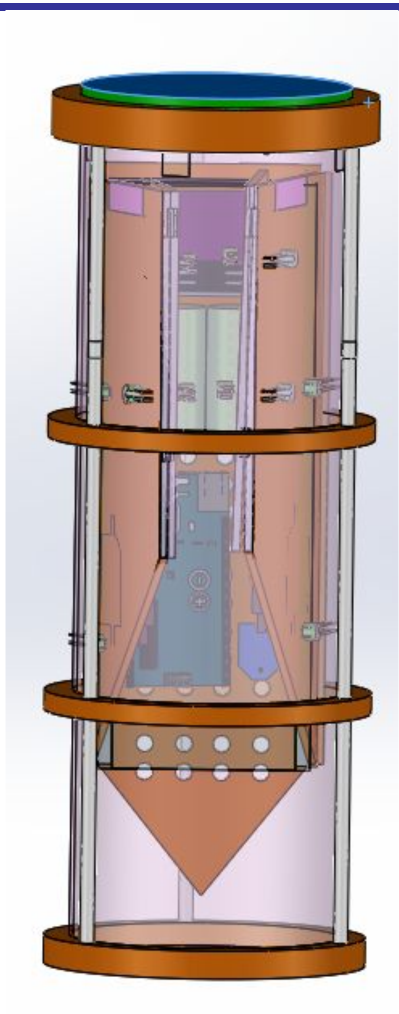
Configuration 2

- A vertical rod holds the folded wings together to decrease the pressure to the container wall
- The rod will be a smooth surface to ensure deployment of the payload

Selected (Configuration 1)

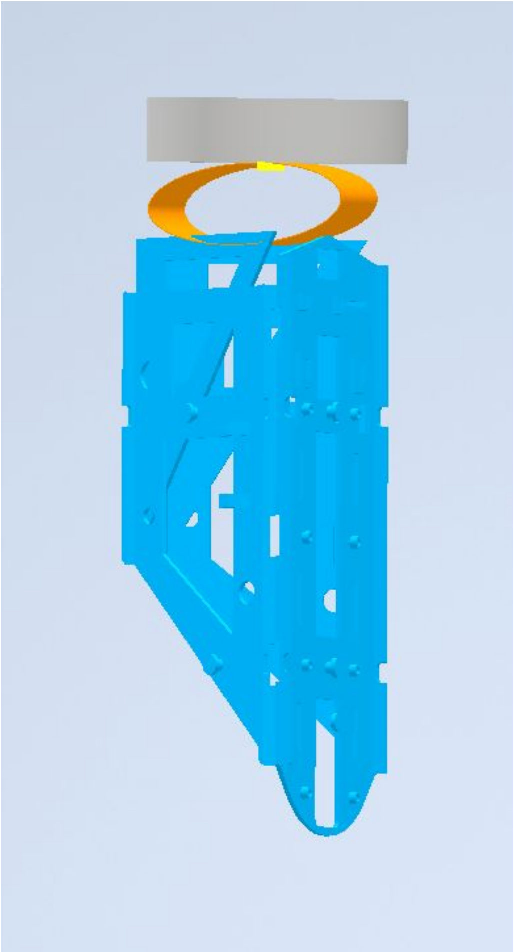
- Easier to implement
- Because of configuration 2s vertical rods. Solid container top and warp testing must be done which takes a lot of time

Payload Pre Deployment Configuration Trade & Selection (Payload Deployment)(1/2)

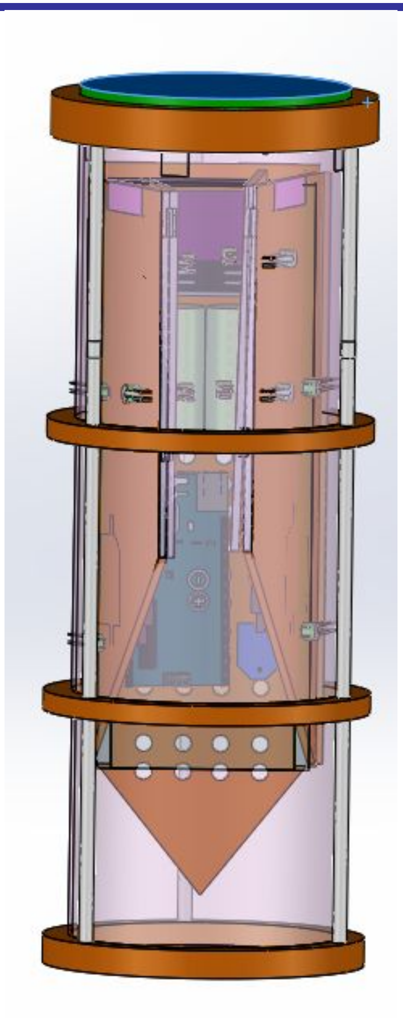


Configuration 1

- Plastic leaf spring is attached on the bottom of the container top.
- When the payload release mechanism is activated, the leaf spring pushes the payload downward.



Payload Pre Deployment Configuration Trade & Selection (Payload Deployment)(2/2)



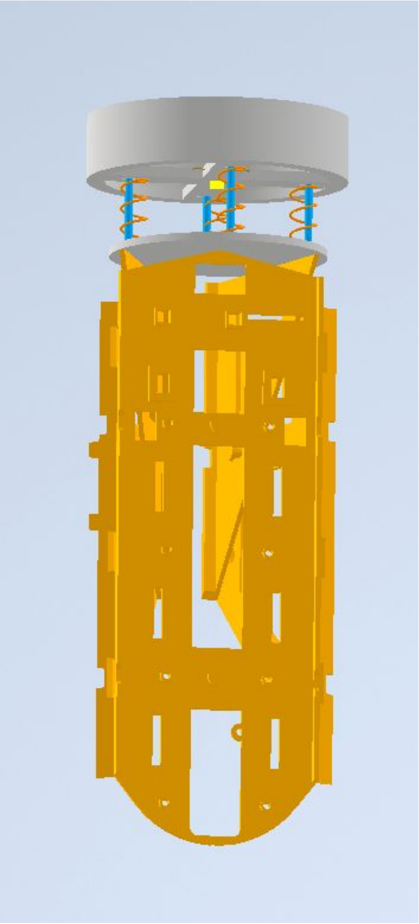
Configuration 2

- A 3D printed plate with four rods guided by holes of the container top
- The rods are spring loaded and secured with bolts
- When the release mechanism is activated, the plate is pushed by the springs which pushes the payload downward

Selected Configuration2

Rationale:

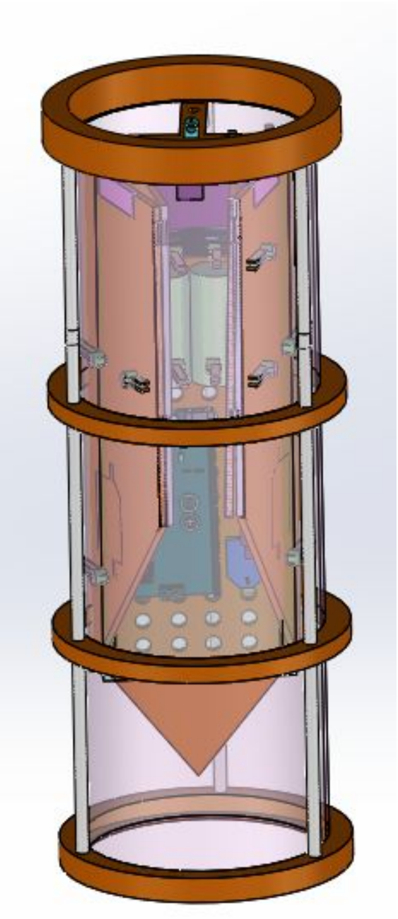
- Better distribution of pressure
- Configuration 1 is unpredictable especially in an environment where vibration is high



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

Configuration 1

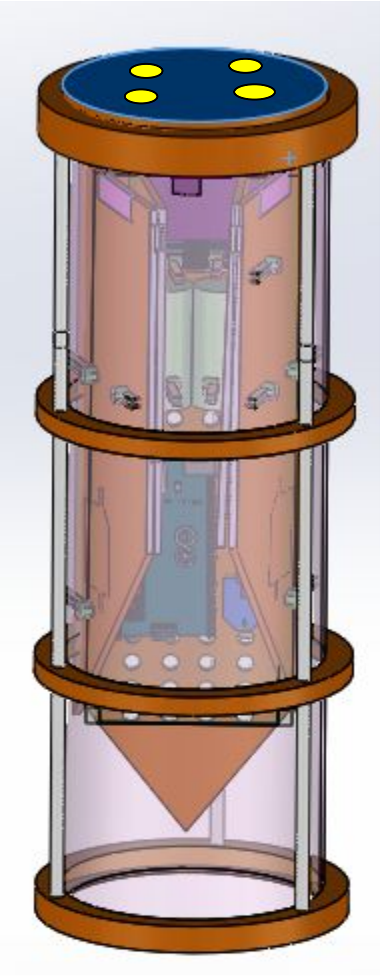
- Wall is a thin but durable double laminated pink paper
- The wall is reinforced with four 3D printed rings
- The rings are attached to four vertical rods
- It won’t use rocket for CanSat operation



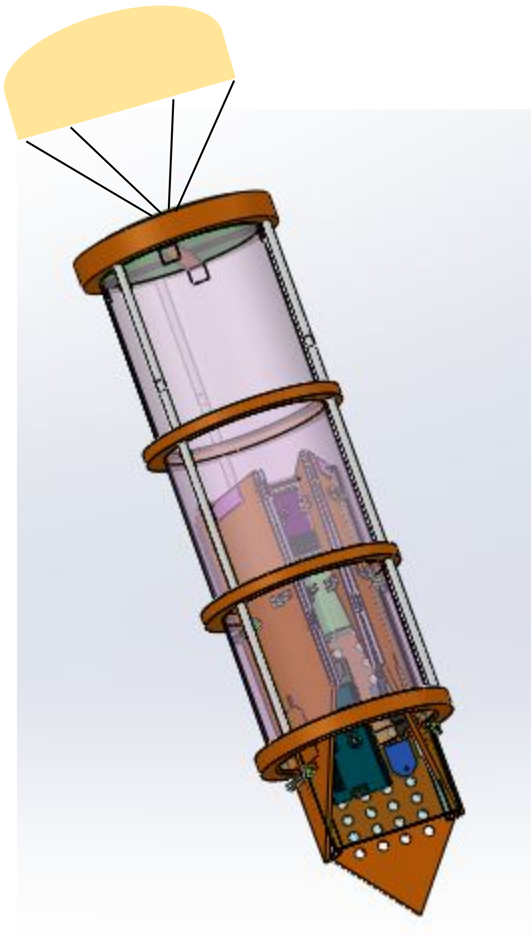
Selected Configuration 1
Rationale
- 3D printed container is difficult to manufacture and takes a lot of time

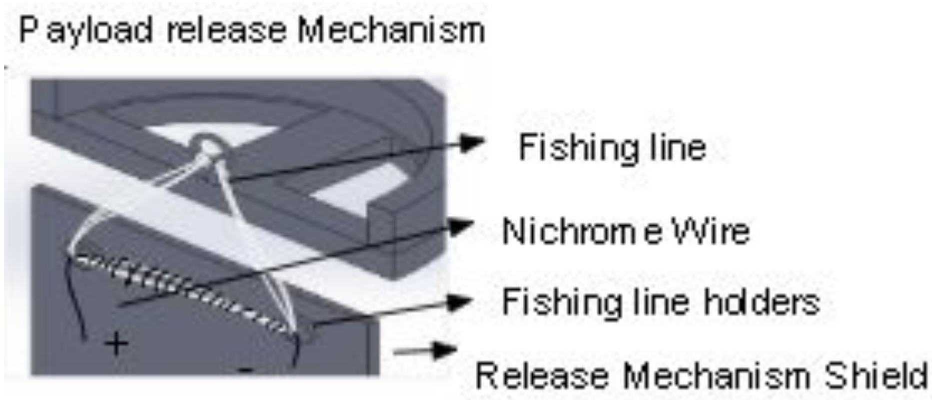
Configuration 2

- Solid 3D printed container
- PETG material is used
- Orange will be the color
- It won’t use rocket for CanSat operation



Payload Deployment Configuration Trade & Selection (Payload Release Mechanism)



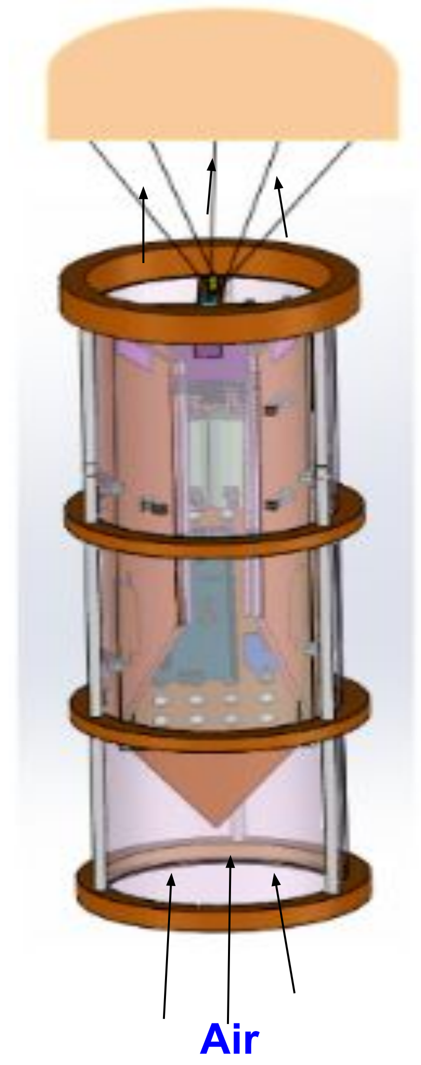


Description:

- Payload is attached to the container using fishing line
- Release mechanism will be housed inside a fireproof box to avoid fire or parts meltdown
- When CanSat descends at ~450 meters the nichrome wire will be activated by the controller using MOSFET transistor with 7.4V
- When the fishing line is melted the difference of terminal velocity of the container (~12.76 m/s) and the payload (~16 m/s) will separate the two.

Container Parachute Attachment Mechanism

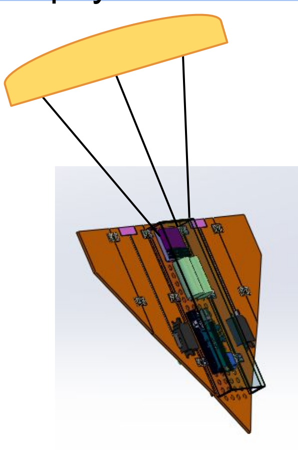
- Parachute will passively sit on top of container while inside the rocket
- During descent, top of container will provide air flow to ensure parachute deployment.

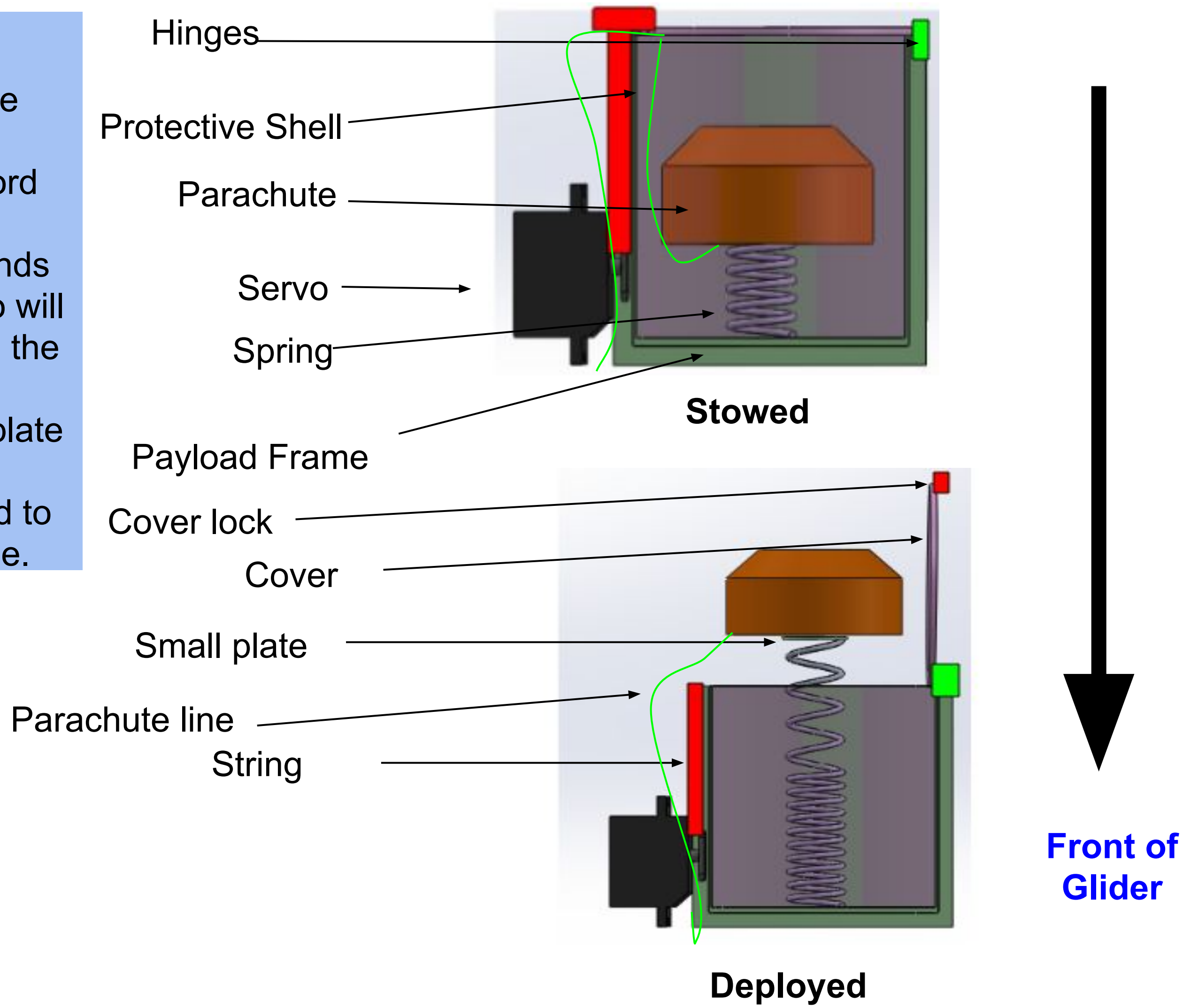


Payload Parachute Release Mechanism

Description:

- The spring and small plate will be held inside the cylinder using a Kevlar cord to avoid littering
- When the payload descends to ~100 meters, the servo will be activated which opens the lid. The parachute will be pushed out by the small plate and spring.
- The parachute is attached to the payload with a tail hole.





Electronics Structural Integrity

Electronic Component Mounting Methods ● Electronic components is organized and soldered into a PCB. The PCB will be mounted using double sided foam tape and zip ties ● The PCBs will have breakouts to other subsystems. The breakouts will be headers with Molex connectors hot glued together to avoid disconnect ● Sensors that cannot be mounted on a PCB board such as outside temp sensor, air speed sensor and particulate sensor will be mounted using double sided foam tape, zip ties or pre-designed 3d printed mounting
Electronic Component Enclosures ● The fuselage will be 3d printed using PETG material. All the electronics and sensors will be enclosed inside the fuselage ● The release mechanism enclosure will be 3D printed on the outside with fireproof fiberglass on the on the inside.

Electronics Structural Integrity

Securing Electrical Connections

- Each battery will have a screw terminal block on the PCB to allow battery charging and easy swap.
- Electrical connections to breakout subsystems will have a header and Molex connector hot glued together to avoid disconnect

Descent Control Attachments

- The elevon will be attached using nylon horns, steel push rods and linkage stopper to the servo
- The servo will be screwed on and hot glued to the wing
- The container parachute is connected by nylon shroud line to an eyebolt on the CanSat.
- The payload parachute is connected by a nylon shroud line to a reinforced tail hole on the payload
- The wings is connected together using nylon hinges hot glued and bolted on.
- The wing openers are anchored with micro bolts and washers
- All materials will be tested to ensure that it will survive 30Gs of shock

Mass Budget

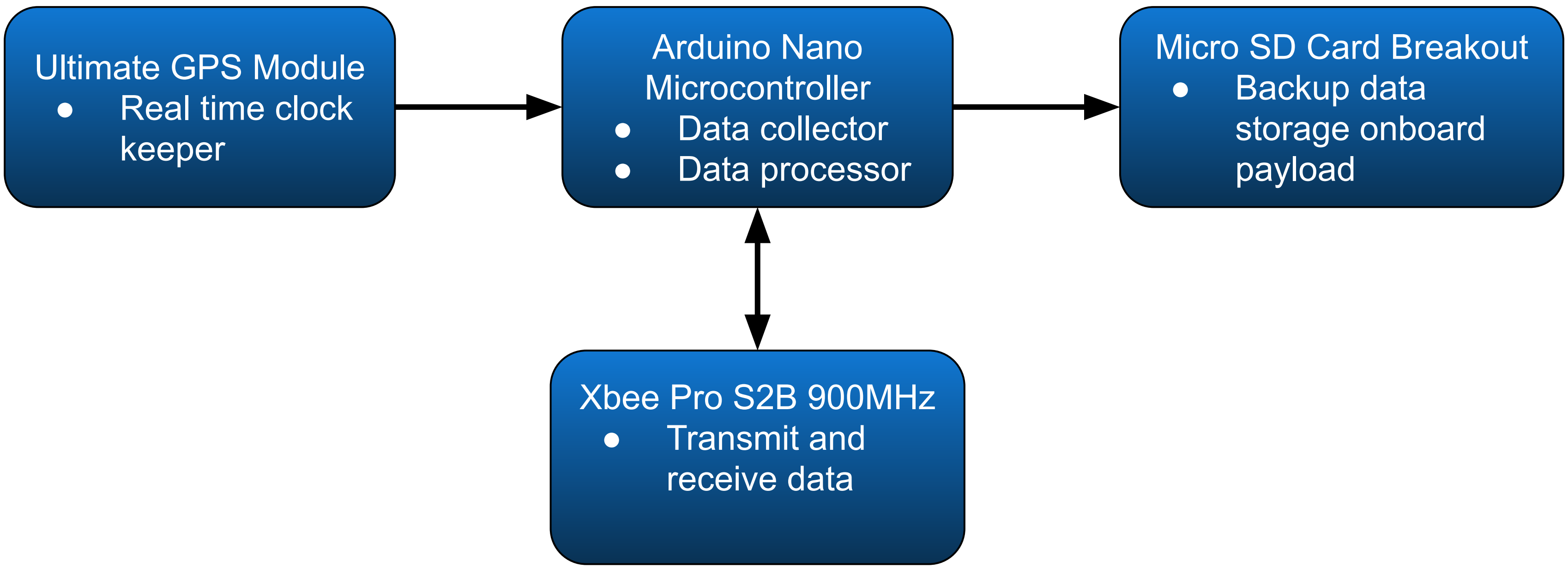
Payload Components	Weight (g)	Source
Microcontrollers	14	Datesheet
Payload Structure	140	Estimate
Temp Sensor	1	Datasheet
Air Speed Sensor	8.5	Datasheet
GPS	8.5	Datasheet
BME280	1.3	Datasheet
Payload release	.5	Datasheet
MOSFET	1	Estimated
Camera	2.8	Estimated
Batteries	50	Estimate
Audio Beacon	1	Estimate
Xbee	4	Datasheet
Particle Sensor	26	Datasheet
Parachute	9	Measured

Total Weight of Payload		
281.8 grams		
Container Components	**Weight (g)**	**Source**
Container	175	Measured
Payload Deployment Parts	131	Estimated
Parachute	9	Measured
Total Mass of CanSat (g)		
598.8		
Mass Margin		
600g - 596.8g **= 3.2 grams**		
Mass Margin is within 600g +/- 10g		

Communication and Data Handling (CDH) Subsystem Design

Tim Marcello

Payload CDH Overview



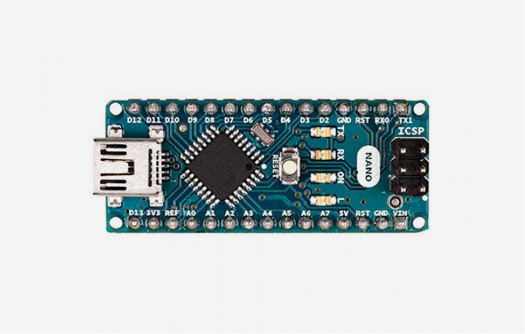
Payload CDH Requirements

Requirements	Description
29	Telemetry shall be updated once per second.
33	Telemetry shall include mission time with one second or better solution. Mission time shall be maintained in the event of processor reset during the launch and mission.
35	XBEE radios shall be used for telemetry. 2.5 GHz Series radios are allowed. 900 MHz XBEE Pro radios also allowed.
36	XBEE radios shall have their NETIP/PANID set to their team number.
37	XBEE radios shall not use broadcast mode.
38	Cost of CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)

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
Teensy 3.6	15	180	1000	4.9	62 x 13 x 4.2	5	Analog Input - 25 PWM Output - 22 I2C I/O - 4 SPI - 3 DAC Output - 2

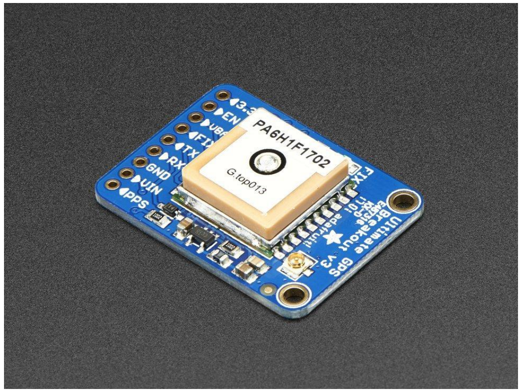
Selection	Reason for Selection
Arduino Nano	• Availability • Familiarity of programming • Smaller in size



Payload Real-Time Clock

Real-Time Clock Keeper	Type	Reset Method
Arduino Nano Function	Software	Save to file and retrieve it during reset recovery
Ultimate GPS Board	Hardware	Battery backup RTC

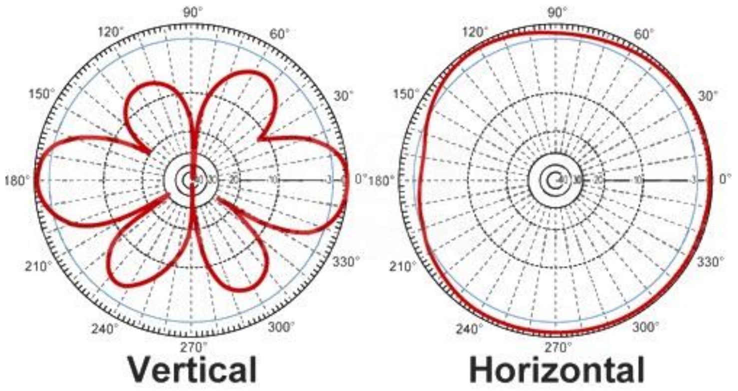
Selection	Reason for Selection
Ultimate GPS Board	Faster retrieval of real time clock



Payload Antenna Trade & Selection

Name	Frequency Range	Length	Gain	Connection Type	Calculated Range
Noyito Antenna	900 MHz - 915 MHz	195 mm (unbended)	5 dBi	SMA	9 miles
Onboard Wire antenna	900 MHz	50mm	2.1 dBi	Soldered	4 miles

Selection	Reason for Selection
Noyito Antenna	Range is better



Payload Radio Configuration

Radio	Frequency	Transmit Power
Xbee 900HP Pro	900 Mhz	250mW 24dBm Software Selectable

Radio Configuration
• NET ID - 1360 (Team ID) • Configuration Mode - Point to Point Unicast • Transmission Control -- Data will be sent continuously at 1Hz during all phases • Will stop data transmission after landing. Altitude sensor will be used to detect landing

Payload Telemetry Format

Data Format	Sample Data	Description
<TEAM ID>	1360	The assigned team identification number
<MISSION TIME>	1615	Time since initial power up in seconds
<PACKET COUNT>	1571	The count of transmitted packets
<ALTITUDE>	73.1	The altitude in meters relative to ground level. The resolution is 0.1 meters
<PRESSURE>	100674	The measurement of atmospheric pressure in unit of pascals. The resolution is 1 pascal.
<TEMP>	27.0	The sensed temperature in degrees C with 0.1 of a degree resolution
<VOLTAGE>	7.93	The voltage of the CanSat power bus. Resolution must be 0.01 volts
<GPS TIME>	04:38:34	The time generated by the GPS receiver. Time must report in UTC and have a resolution of a second
<GPS LATITUDE>	20.9079	The latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees
<GPS LONGITUDE>	-156.4987	The longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001
<GPS ALTITUDE>	51.2	The altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters

Payload Telemetry Format

Data Format	Sample Data	Description
<GPS SATS>	7	The number of GPS satellites being tracked by the GPS receiver. This must be in an integer number.
<AIR SPEED>	17.00	The air speed relative to the payload in meters/second
<SOFTWARE STATE>	1	The operating state of the software
<PARTICLE COUNT>	73.1	Decimal value representing the measured particle count in mg/m^3

- Data from payload shall transmit continuously at 1Hz sample rate
- Data format:
  <TEAM ID>,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>, <PRESSURE>, <TEMP>,<VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>,<AIR SPEED>,<SOFTWARE STATE>, <PARTICLE COUNT> \newline
- Telemetry data file name: Flight_1360.csv

Payload Telemetry Format

- **What data is included?**
  - **Check the competition guide for telemetry requirements**
  - Include fields for bonus objectives
- **Data rate of packets?**
  - Continuous or burst
- **How is data formatted?**
  - <u>Include example frames</u> with sample data and complete descriptions
  - *Does the presented format match the Competition Guide requirements?*

Container CDH Overview

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Container CDH Requirements

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Container Processor & Memory Trade & Selection

This slide does not pertain to our team's design.

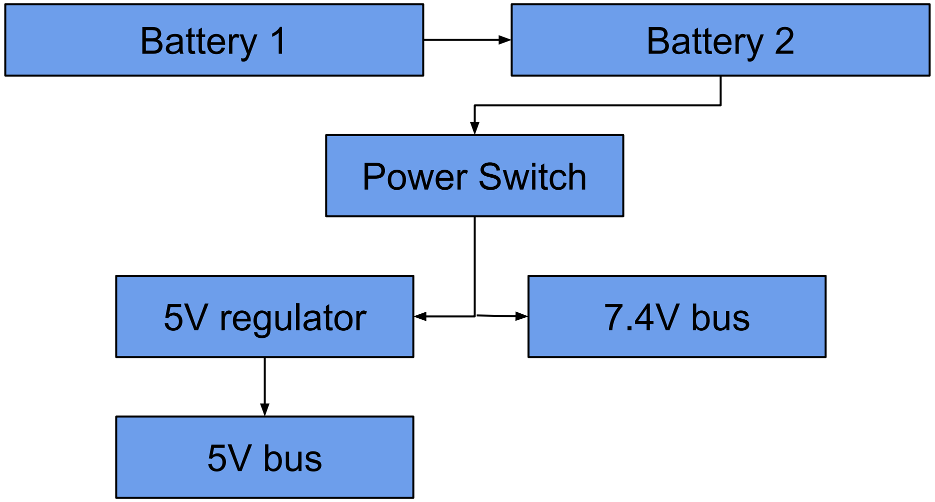
Our team's container does not have components relating to this slide.

Electrical Power Subsystem (EPS) Design

Guillermo Martin

EPS Overview

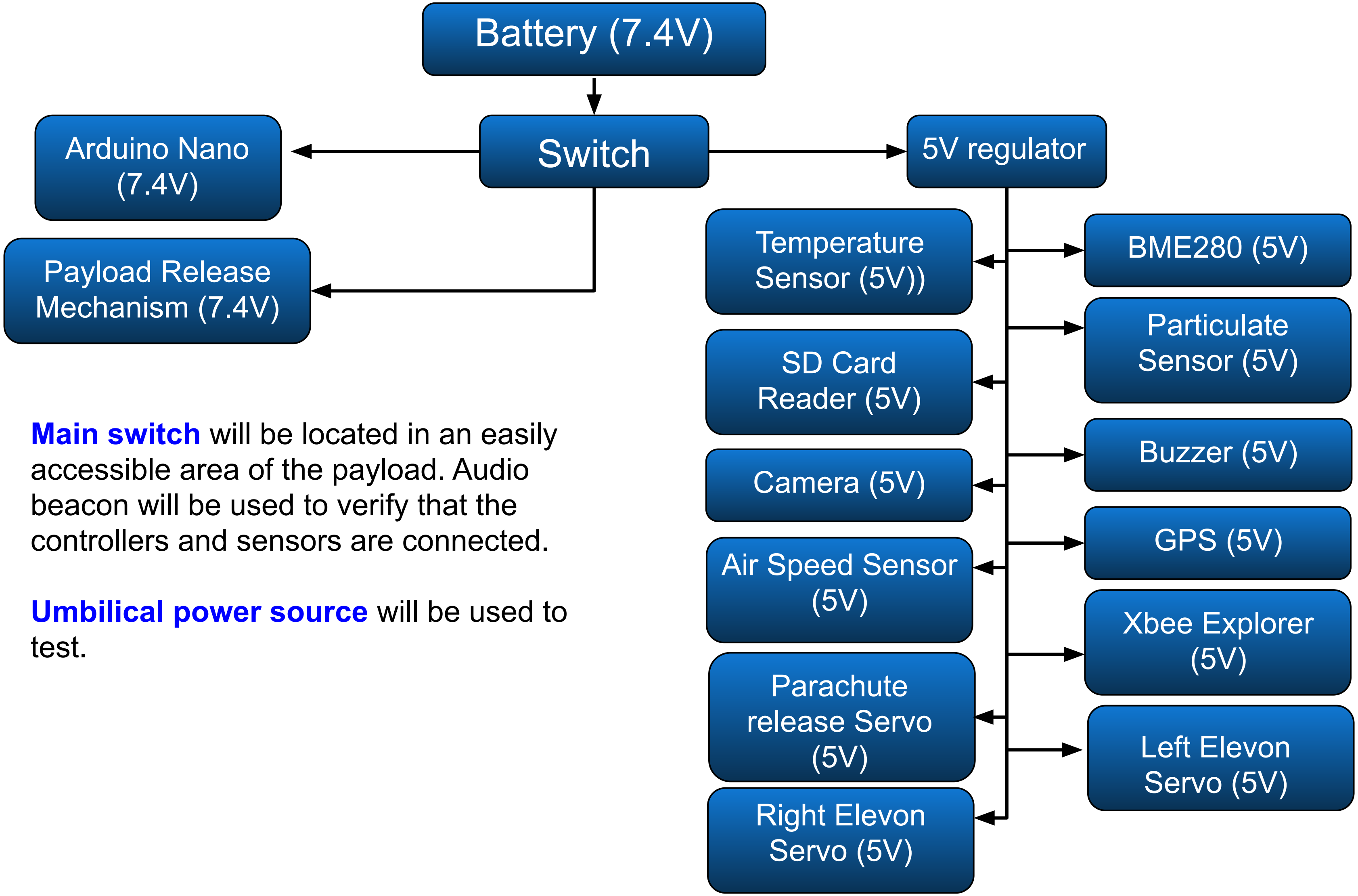
Component	Purpose
3.7V 18650 Batteries	Power source
5V step down regulator	Provides clean 5 volts supply to sensors
Power switch	Mechanism that cuts out main power to the payload
5V bus	Power bus for sensors
7.4V bus	Power bus for controller and nichrome wire



EPS Requirements

Requirements	Description
15	All electronics components shall be enclosed and shielded from the environment with the exception of sensors.
49	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.
50	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.
53	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.
54	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.
55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.
57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.

Payload Electrical Block Diagram



Main switch will be located in an easily accessible area of the payload. Audio beacon will be used to verify that the controllers and sensors are connected.

Umbilical power source will be used to test.

Payload Power Trade & Selection

Type	Battery	Voltage	Capacity	Weight	Qty. Needed	Total Voltage	Total Weight
Alkaline	9V	9V	310mAh	45g	1	9V	45g
Lithium-Ion	18650	3.7V	3000mAh	18.5g	2	7.4V	50g

Selection	Reason for Selection
Lithium-Ion 18650	Greater capacity and lower total weight

Battery Configuration
Two 18650 batteries in series to provide ~8.2V

Payload Power Budget

Component	Voltage (V)	Power(W)	Duty Cycle(%)	Power Consumption(Wh)	Source
Arduino Nano	7.4V	.1406	100	.1406	Datasheet
Adafruit Ultimate GPS	5V	.1	100	.1	Datasheet
Tem Sensor	5V	.0003	100	.0003	Datasheet
BME280	5V	0.000025	100	0.000025	Datasheet
SD Card Reader	5V	.75	100	.75	Estimate
Xbee Explorer	5V	1	100	1	Estimate
Particulate Sensor	5V	.3	100	.3	Datasheet
Camera	5V	.55	100	.55	Datasheet
Buzzer	5V	.4	1	.4	Estimate

Payload Power Budget

Component	Voltage (V)	Power (W)	Duty Cycle(%)	Power Consumption(Wh)	Source
Airspeed Sensor	5V	.05	100	.05	Datasheet
Servo x2	5V	2*2.5	20	2*2.5	Estimate

Total Power (W)	Total Power Consumption(Wh) (2 hrs)
8.3	**16.6**

Available total power (Wh) (2 hrs)	Power consumption margin (Wh) (2 hrs)
22.2	**5.6**

Container Electrical Block Diagram

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Container Power Trade & Selection

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Container Power Budget

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Flight Software (FSW) Design

Arthur S Agdeppa Jr

FSW Overview (1/2)

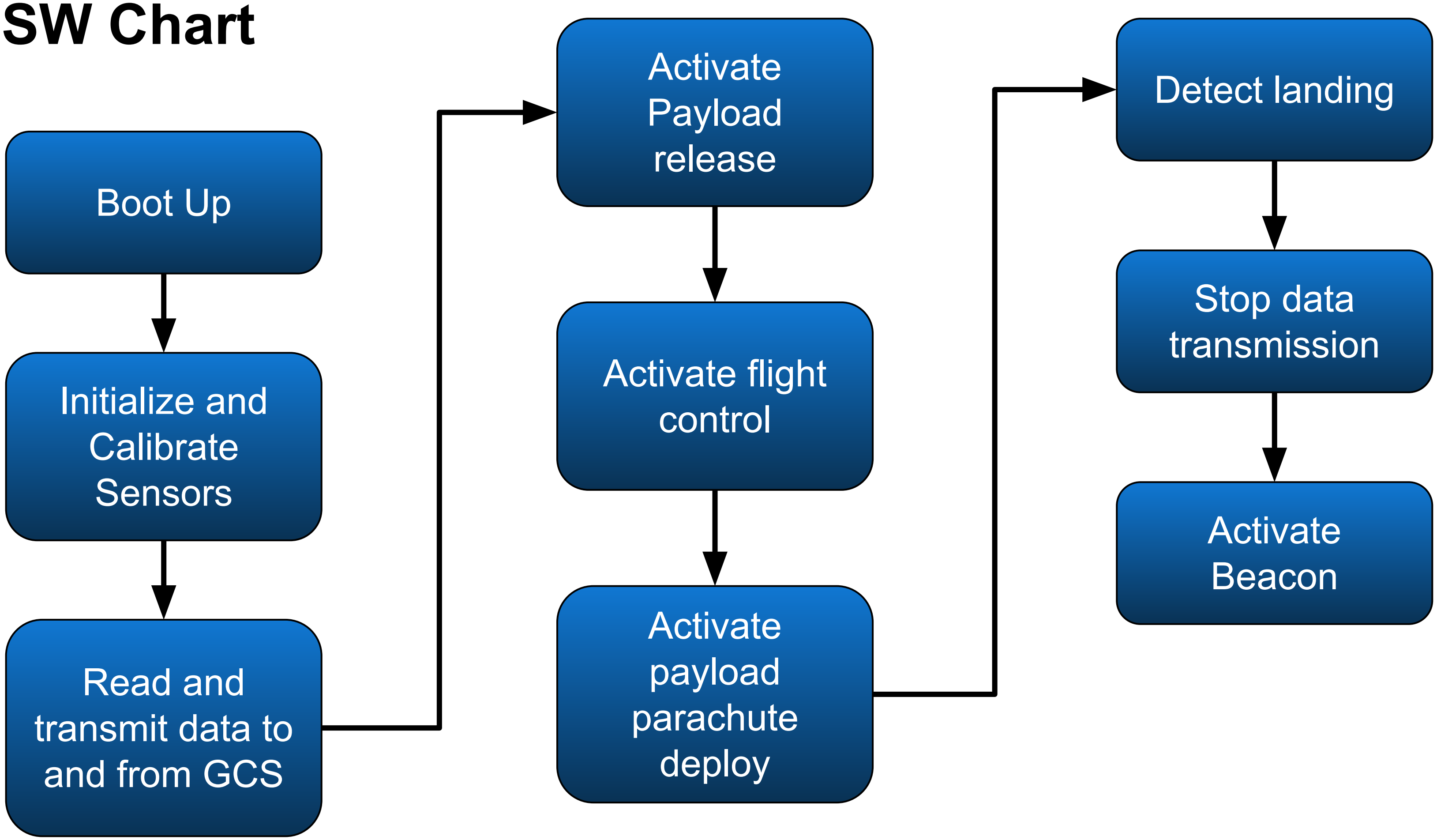
Programming Languages:
- C/C++

Development environments:
- Arduino IDE

Summary of FSW tasks:
- To collect sensors data and convert it to a value that complies with CanSat requirements
- To format sensors data in correct sequence according to CanSat requirements. Send it to Ground control station and store it to an onboard backup SD card.
- Monitor altitude changes to trigger payload release
- Engage flight control system
- Monitor altitude during gliding flight to trigger payload parachute release
- Activate audio beacon after landing

FSW Overview (2/2)

FSW Chart



FSW Requirements

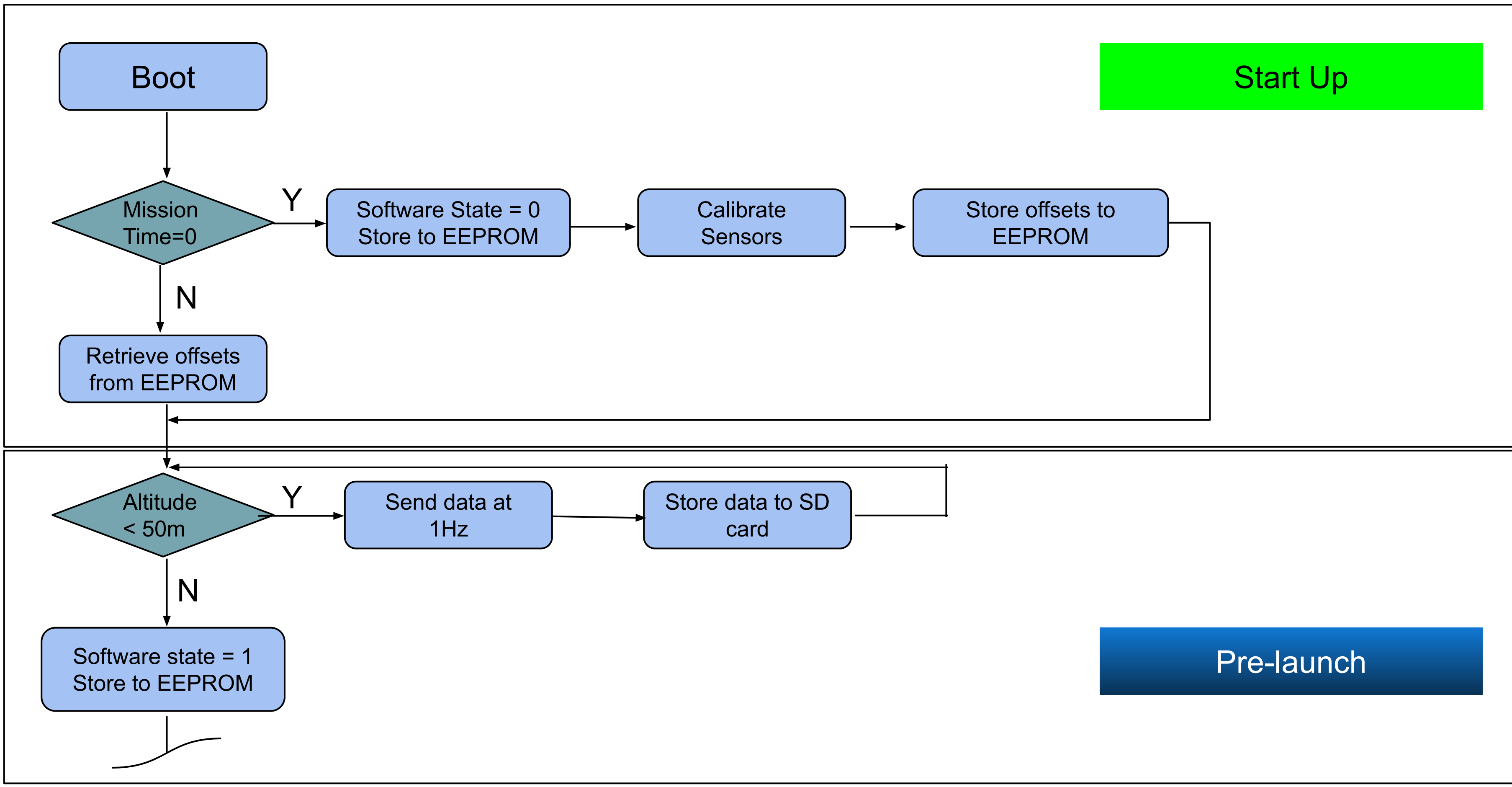
Requirements	Description
10	The container shall release the payload at 450 meters +/- 10 meters.
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5m/s
22	The science payload shall measure altitude using an air pressure sensor.
23	The science payload shall provide position using GPS.
24	The science payload shall measure its battery voltage.
25	The science payload shall measure outside temperature.
26	The science payload shall measure particulates in the air as it glides.
27	The science payload shall measure airspeed.

FSW Requirements

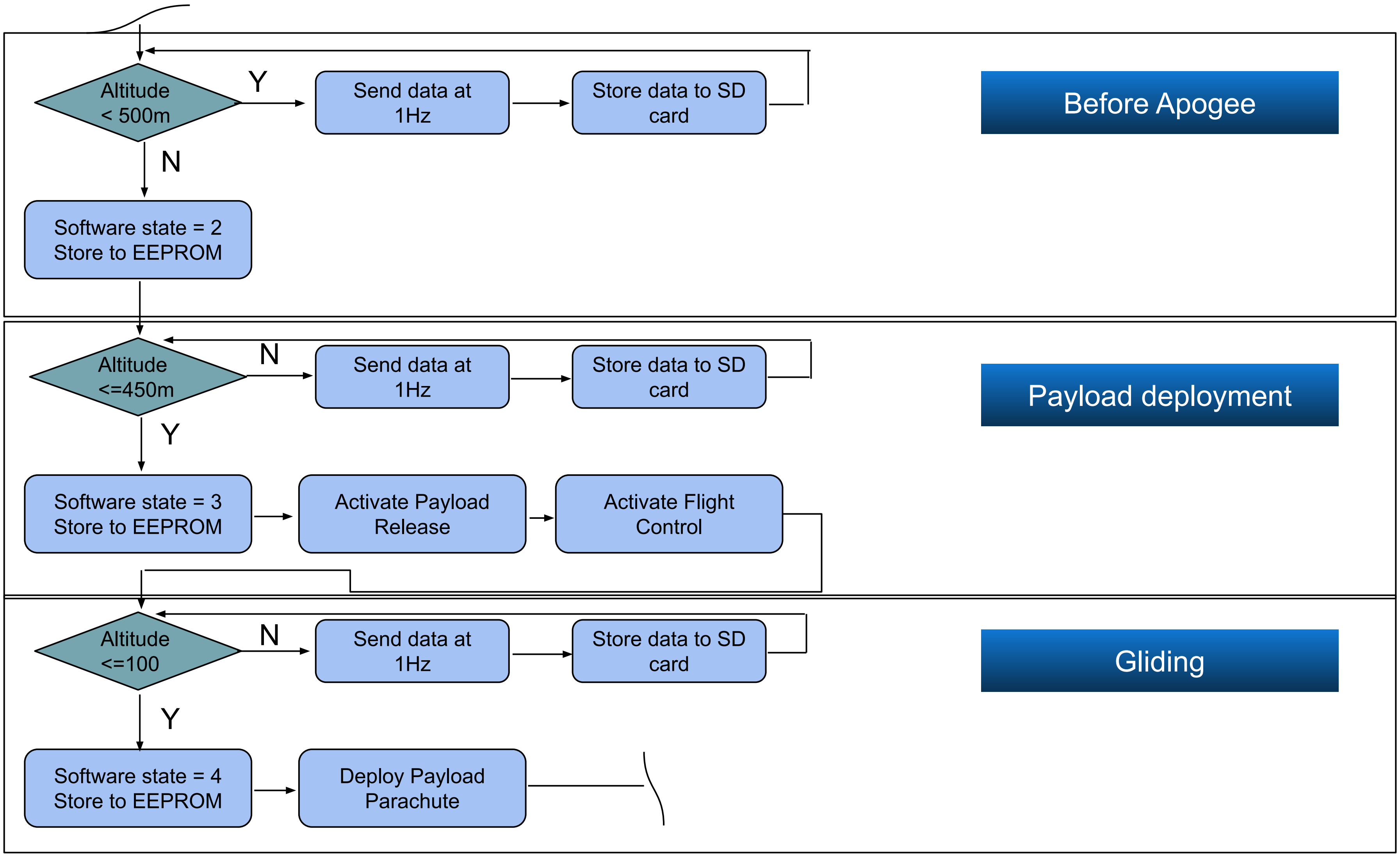
Requirements	Description
28	The science payload shall transmit all sensors data in the telemetry.
29	Telemetry shall be updated once per second.
33	Telemetry shall include mission time with one second or better solution. Mission time shall be maintained in the event of processor reset during the launch and mission.
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.
47	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 process resets.

Payload FSW State Diagram

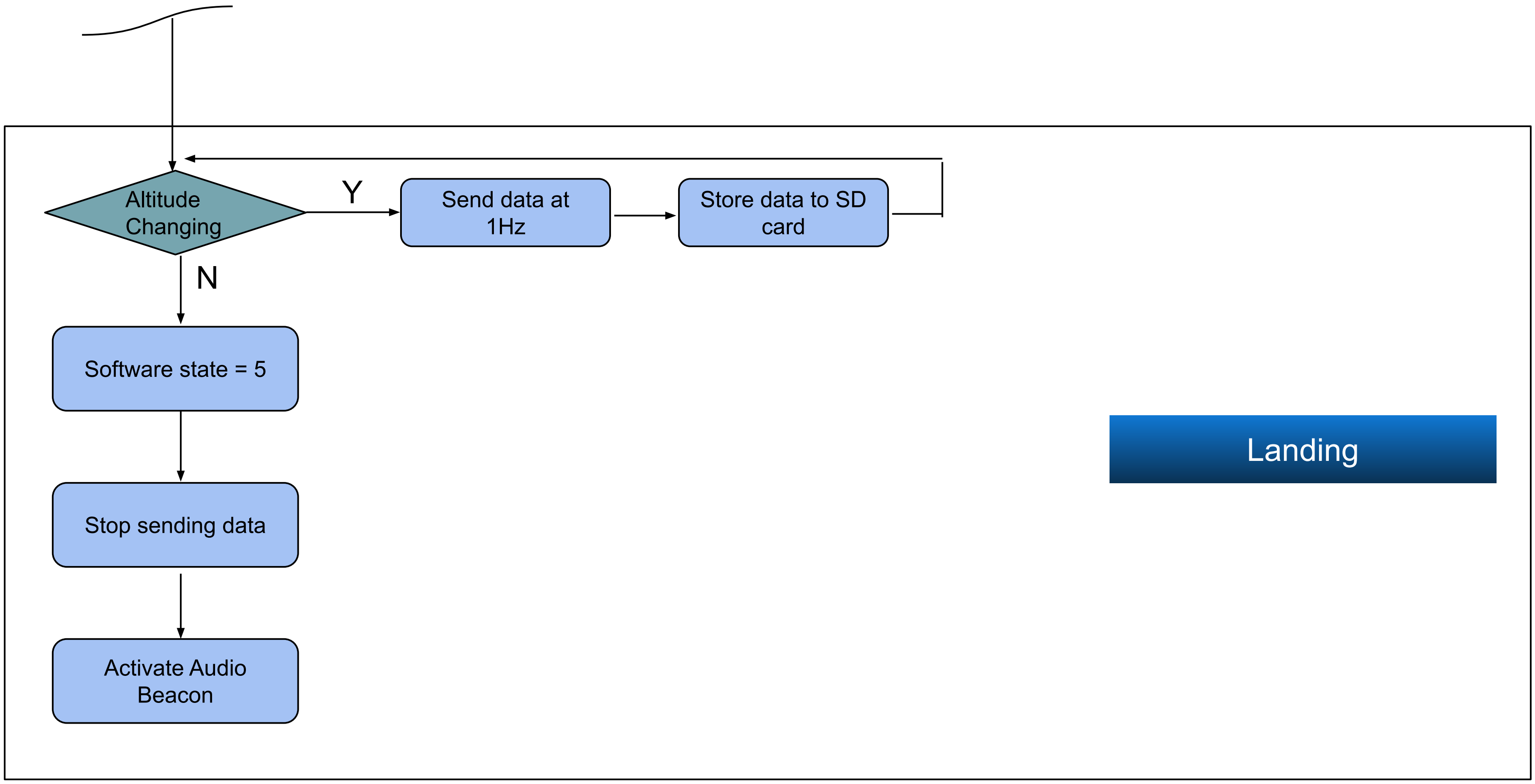
FSW Chart



Payload FSW State Diagram



Payload FSW State Diagram



Payload FSW State Diagram

FSW Reset Recovery:

Date used to recover (will store in EEPROM at a rate of 1Hz):

1. Mission Time
2. Packet Count
3. Software State
4. Previous Altitude
5. GPS Time

Reasons for reset:

1. Payload loss of power supply reset. Method of recovery will be data retrieval from EEPROM.
2. Software hang reset. Method of recovery will be data retrieval from EEPROM.

Container FSW State Diagram

This slide does not pertain to our team's design.

Our team's container does not have components relating to this slide.

Software Development Plan (1 of 2)

Prototyping and prototyping environments

- Breadboard components
- Prototype board components

Development Team

- Arthur Agdeppa
- Tim Marcello
- Guillermo Martin

Test Methodology

- Classroom lab test
- Outdoor free fall test
- Drone flight test sensors

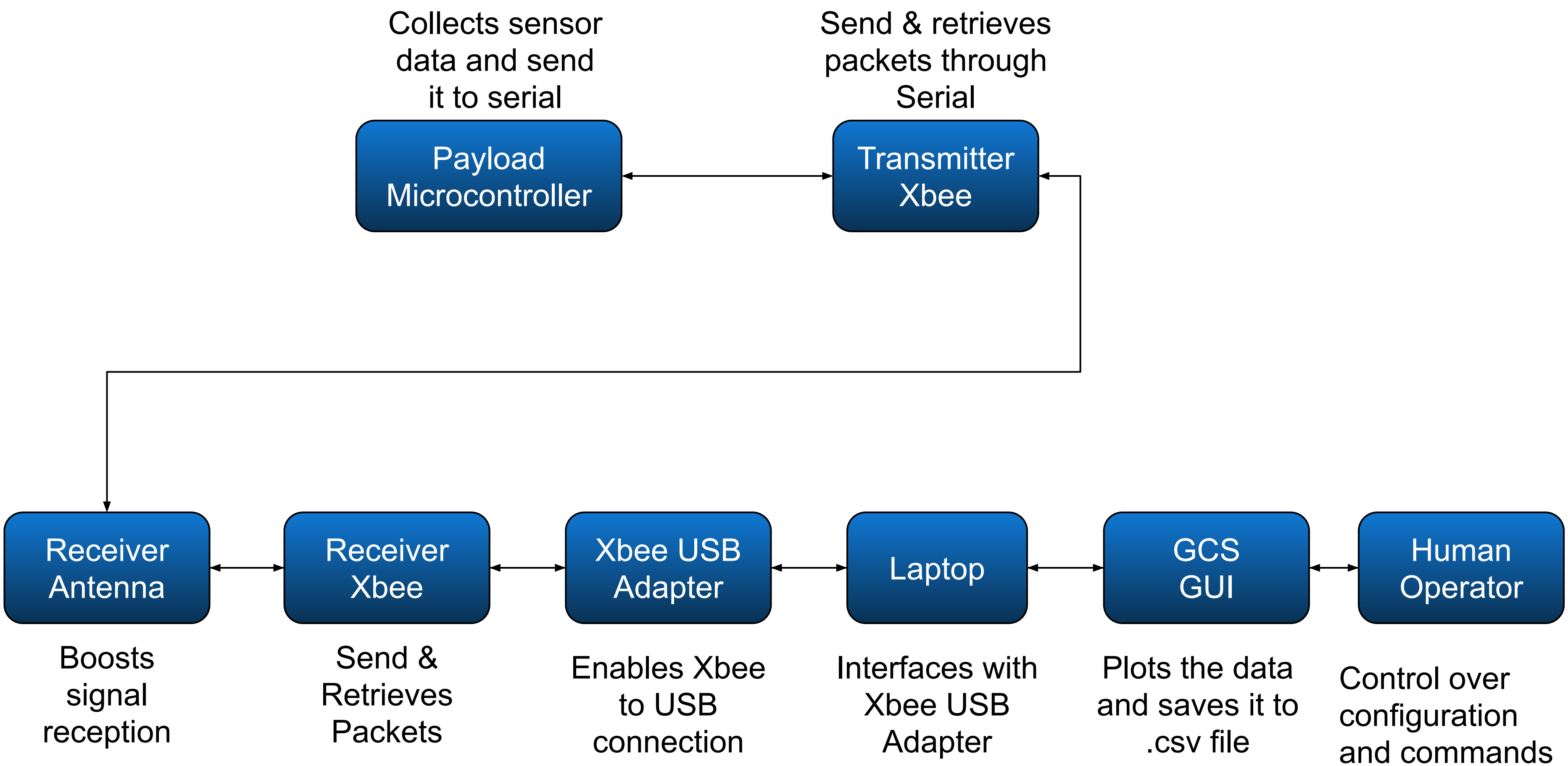
Software Development Plan (2 of 2)

Subsystem	Development Sequence
Sensors	1. Sensor trade and selection - select the best sensors for our application 2. Individual sensor programming - program each sensor with arduino to avoid confusion 3. Integrate all sensor programming into one program and test all sensors are working
Xbee Radio	1. Configure and test point to point communication fo the radio using controller and GCS serial port 2. Integrate sensors with Xbee to ensure data transmission at 1Hz
Flight Control	1. Program closed feedback control system with servos connected to elevon
Release mechanisms	1. Program release mechanisms such as nichrome wire and servos
Software state	1. Program software state logic using altitude sensor as data
Audio Beacon	1. Program locator audio beacon
Integrate all	Integrate all software subsystem and ensure that data transmits at 1Hz and all events at the software state is executed.

Ground Control System (GCS) Design

Arthur S Agdeppa Jr

GCS Overview



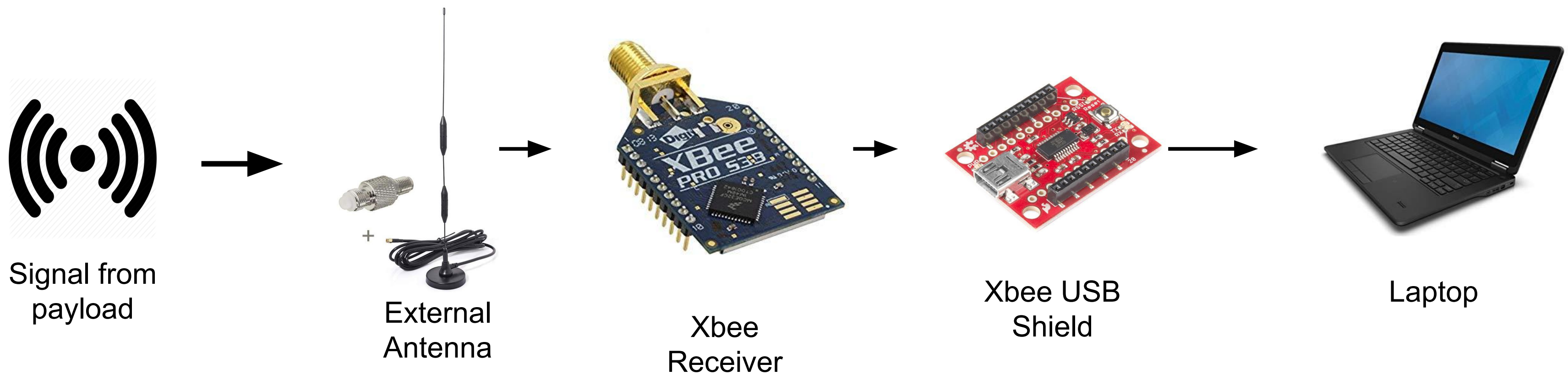
GCS Requirements

Requirements	Description
29	Telemetry shall be updated once per second.
31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.
32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.
33	Telemetry shall include mission time with one second or better solution. Mission time shall be maintained in the event of processor reset during the launch and mission.
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.
35	XBEE radios shall be used for telemetry. 2.5 GHz Series radios are allowed. 900 MHz XBEE Pro radios also allowed.
36	XBEE radios shall have their NETIP/PANID set to their team number.
37	XBEE radios shall not use broadcast mode.
38	Cost of CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
39	Each team shall develop their own ground station.

GCS Requirements

Requirements	Description
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
42	Team shall plot each telemetry data field in real time during flight.
44	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.
45	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.

GCS Design

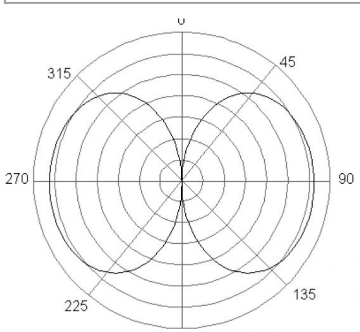


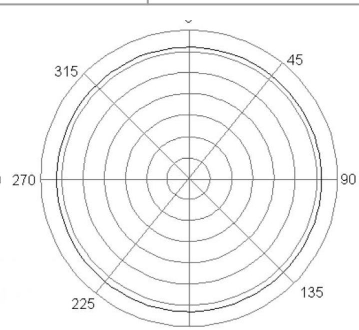
Specification	Description
Laptop battery life	4 hours
Auto-Update mitigation	Windows 10 OS update will be disabled
Overheating mitigation	Umbrella will be used to block off sunlight
	Laptop fan with own battery
Contingency Plan	External portable battery pack will be used in case laptop power is not enough

GCS Antenna Trade & Selection

Name	Connection Type	Frequency	Range	Direction	Price
Xbee-PRO 900HP Wire antenna	Wired	900 - 928 MHz	140 m (Indoor) 3.8 km (Outdoor)	Omni-directional	$22.95 - $32.00 (Wire comes in kit)
WLANIOT	RP - SMA	900 - 1900 MHz	14km	Omni-directional	$19.90

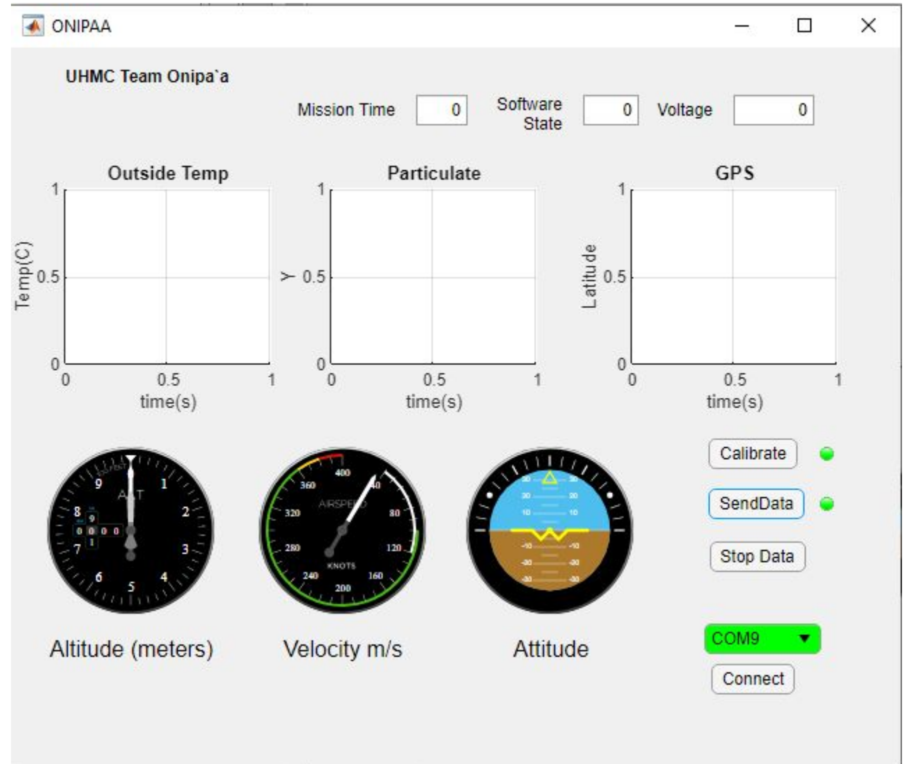
Selected	WLANIOT
Rationale	• Better range • Portability • Desktop stand will hold antenna on top of the desk





GCS Software

Software Used	**MATLAB Student Version** **Rationale:** 1. Availability 2. Student’s familiarity with the software
Software Design	1. Parse data when serial data available 2. Save data to CSV file 3. Plot data to GUI 4. Back to step 1
Calibration command	1. Payload will start calibration upon receiving specific data from GCS 2. Payload will send calibration OK to GCS when done 3. Start sending data
CSV file creation	1. File will be comma delimited and formatted according to CANSAT requirements



Onipa`a plotter prototype

CanSat Integration and Test

Jhaymar Mendez

CanSat Integration and Test Overview

Sensor Subsystem Tests
- Operational test
- Controller integration test

Communication Data Handling Test
- SD Card storage test
- GPS Real time clock test
- Xbee radio communication test
- Antenna range test
- Sensors and controller interfaces test

EPS Subsystem Test
- All electronics current draw test
- Battery power capacity test

FSW Subsystem Test
- Payload release mechanism test
- Reset recovery test
- Software phases test
- Camera test
- Audio beacon test

Descent strategy tests
- Parachute descent speed test
- Payload release test
- Glider center of gravity test

Mechanical Subsystem Tests
- Servo and elevon tests
- Control System tests
- Payload parachute release test
- Folding wing deployment test
- Camera gimbal test
- Vibration test
- Heat test
- Drop test

Test Plan	
Subsystem Level	Every test listed in this page will be performed
Integrated Level	Integrated subsystems will be tested immediately and any errors or flaws will be swiftly corrected
Environmental Level	Heat test will be performed on the structure materials. Vibration and drop test will be done to integrated payload and container.

Subsystem Level Testing Plan

Sensors

- Sensors is connected to Arduino using a breadboard to test the interface.
- Sensor output value will be checked and calibrated.

CDH

- When all sensors are integrated to Arduino using a breadboard, all sensor values are outputted to serial console. Ensure the format is according to CANSAT guideline.
- The SD Card storage will be tested with the Arduino.
- CSV file write test to SD card will be performed.

EPS

- Current draw is measured when all electronics are integrated to ensure power source is enough to support it.
- Battery Watt hour capacity is measured to calculate margin.

Radio Communication

- Xbee is configured for point to point communication. Broadcast communication will be tested using a spare Xbee.
- Range test will be performed.

Subsystem Level Testing Plan

Mechanical

- Unfolded wings is weight tested to ensure it is rigid for gliding.
- Folded payload will be fitted inside container then test payload release to ensure flawless separation
- Payload parachute deployment will be tested.
- Elevon will be visually inspected to ensure freedom of operation.
- Servo will be visually inspected to ensure freedom of operation.

Descent Control

- Parachute drop will be tested to calculate drag.
- Glider prototype will be launched to calculate lift and drag.
- Control system will be tested to fine tune PID controller.
- Air speed sensor will be calibrated with Drone.

Integrated Level Functional Test Plan

Descent Testing	Communications Test
Parachute ● Descent rate - Will drop it from top of buildings to calculate drag ● Payload parachute deployment test **Glider** ● Glider will be launched on top of buildings to fine tune Center of Gravity and aerodynamics ● Glider will be subjected to abrupt changes to pitch and roll to test control system ● Air Speed sensor will be tested and calibrated using a known good drone air speed sensor **Prototypes** ● A prototype of the container and payload with similar weight to the real one will be dropped from top of buildings or from a drone to observe the drop rate and aerodynamics	**Xbee** ● Transmitter will be tested by placing it on top of building while receiver is 800 meters away line of sight to simulate range. ● Transmitter will be placed inside a cardboard to simulate the rocket cylinder wall

Integrated Level Functional Test Plan

Mechanism Test	Deployment Test
Payload release ● Payload release will be tested by turning it on for 5 to 10 seconds to ensure the enclosure can withstand the heat ● Communications will be tested while payload release is turned on to ensure sufficient power is available **Folding wings** ● Folding wings will be tested thoroughly to ensure the latex and anchors are able to pull the wings open **Glider support structure** ● The payload with its mechanical parts -- hinges, elevon linkages, servo -- will be subjected to calculated force to ensure operational integrity when airborne	**Payload release** ● The payload-container separation will be tested by stowing the payload into the container with all latex springs operational. ● Visually inspecting the inside of the container to ensure there are no sharp edges or obstructions that will prevent it from deployment **Payload parachute deployment** ● It will be tested by having the parachute in stowed position and deploying it. ● The BME280 altitude sensor will be tested for accuracy using a drone

Environmental Test Plan

Drop Test	Thermal Test
• A 61 cm non-stretching cord is attached to a rigid fixed point. The other end will be tied to the parachute. A harness will be placed on the bottom just in case the test fails. • The cansat is turned on and telemetry is working before being dropped. After being dropped, verify the CanSat did not lose power and telemetry is still being received.	• A hair dryer is placed inside an insulating cooler. A remote thermometer will allow reading the temperature inside. • The hair dryer won't be blowing directly to CanSat • Turn on Cansat • Temperature will be from 55C to 60C for two hours • Visually inspect CanSat for operational integrity

Environmental Test Plan

Vibration Test	Fit Check
1. Power on CanSat. 2. Verify accelerometer data is being collected 3. Power up sander. 4. Wait 5 seconds after sander is up full speed 5. Power down sander. 6. Repeat steps 3 to 5 four more times. 7. Inspect the CanSat for Damage and functionality. 8. Verify accelerometer data is still being collected. 9. Power down CanSat.	• Prototype of the rocket cylinder wall will be built. • The container with stowed payload will be fitted inside and check for deployability.

Mission Operations & Analysis

Guillermo Martin

Overview of Mission Sequence of Events

Launch Operations Crew Assignment	Team Member Assigned
Mission Control Officer	Tim Marcell
Ground Control Station Crew	Arthur S Agdeppa
Recovery Crew	Guillermo Martin
CanSat Crew	Jhaymar Mendez

Antenna Construction and Ground System Setup:

- The setup will be easy because the Xbee shield is USB plug and play
- The external antenna is desktop and will have the necessary adaptor to connect to the Xbee
- The laptop will be pre-loaded with the monitoring software

CanSat Assembly and Test:

- The payload and container are to be pre-assembled prior to arriving onsite
- Testing procedure will be turning on the master switch and wait for the audio beacon that indicates everything is OK.
- Container and payload will be labeled with team contact information including email addresses

Overview of Mission Sequence of Events

Event	Duties and Responsibilities
1. Arrival	● Ground Control Station will be assembled and checked ● Payload and Container will be inspected and checked for full operation of system ● Check Xbee communications ● Integrate payload and container
2. Before Launch	● Turn in CanSat for weight and fit check
3. Rocket Integration	● GCS and crew will man assigned launch pad ● Collect CanSat, turn it on, integrate to rocket and ensure communication with GCS
4. Launch	● Team Mission Control Officer (Tim Marcell) will go to launch control table to execute launch procedure ● Ground station crew will perform all required flight operations
5. Recovery	● Recovery crew will head out to attempt recovery of payload and container ● GCS crew will clear out of the ground station area to allow the next batch of teams to set up.
6. Data Analysis	● Ground crew must turn in thumb drive with ground station data to the ground station judge

Mission Operations Manual Development Plan

Ground Station Configuration Manual

- Checklist that will include building the GCS, antenna and monitoring software and ensuring they are operational

CanSat Preparation

- Checklist that will include all points to inspect payload and container are free of damage and fully operational

CanSat to Rocket integration

- Checklist to ensure all are in place before integrating CanSat to rocket

Launch Preparation and Procedure

- Document is provided by CanSat competition

Removal Procedure

- Document is provided by CanSat competition

CanSat Location and Recovery

Container:

- Recovery crew will maintain visual contact with the container to ease recovery
- Pink color of the container will aid the recovery crew
- Parachute will be orange
- Team information will be written on the container

Payload:

- Recovery crew will maintain visual contact with the payload to ease recovery
- Payload frame will be orange in color
- Last GPS data and activated audio beacon will aid the recovery
- Team information will be written on the frame

The purpose of this section is to summarize and cross reference the compliance to the CanSat Competition Mission Guide requirements.

Requirements Compliance

Tim Marcello

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Comply	71	
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerance are to be included to facilitate container deployment from the rocket fairing.	Comply	25	
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	65	
4	The Container shall be a fluorescent color ; pink, red, or orange	Comply	65	
5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Comply	65	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Comply	65	
7	The rocket airframe shall not be used as part of the CanSat operation	Comply	65	
8	The container 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	67	
9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Partial	47	~17.47m/s Calculated
10	The container shall release the payload at 450 meters +/- 10 meters.	Comply	40	
11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	Comply	50	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
12	The science payload shall be a delta wing glider.	Comply	17	
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5m/s	Partial	51	~12.36m/s calculated
14	All descent control device attachment components shall survive 30 Gs of shock.	Comply	70	
15	All electronics components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	69	
16	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	69	
17	All structures shall be built to survive 30 Gs of shock.	Comply	70	
18	All Electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	69	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
19	All mechanism shall be capable of maintaining their configuration or states under all forces.	Comply	69,70	
20	Mechanism shall not use pyrotechnics or chemicals.	Comply	58-67	
21	Mechanism 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	66	
22	The science payload shall measure altitude using an air pressure sensor.	Comply	30	
23	The science payload shall provide position using GPS.	Comply	32	
24	The science payload shall measure its battery voltage.	Comply	33	
25	The science payload shall measure outside temperature.	Comply	31	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
26	The science payload shall measure particulates in the air as it glides.	Comply	35	
27	The science payload shall measure airspeed.	Comply	34	
28	The science payload shall transmit all sensors data in the telemetry.	Comply	80	
29	Telemetry shall be updated once per second.	Comply	80	
30	The parachutes shall be fluorescent Pink or Orange	Comply	44	
31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Comply	113	
32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Comply	113	
33	Telemetry shall include mission time with one second or better solution. Mission time shall be maintained in the event of processor reset during the launch and mission.	Comply	80	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Comply	103	
35	XBEE radios shall be used for telemetry. 2.5 GHz Series radios are allowed. 900 MHz XBEE Pro radios also allowed.	Comply	78	
36	XBEE radios shall have their NETIP/PANID set to their team number.	Comply	78	
37	XBEE radios shall not use broadcast mode.	Comply	78	
38	Cost of CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	139	
39	Each team shall develop their own ground station.	Comply	113	
40	All telemetry shall be displayed in real time during descent.	Comply	113	
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	79-80	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
42	Team shall plot each telemetry data field in real time during flight.	Comply	113	
44	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	111	
45	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	111	
46	Both the container and probe shall be labeled with team contact information including email addresses.	Comply	123	
47	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 process resets.	Comply	103	
48	No lasers allowed.	Comply	58-68	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
49	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Comply	88	
50	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Comply	88	
51	Audio beacon is required for the probe. It may be powered after landing or operate continuously.	Comply	88	
52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	88	
53	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.	Comply	89	
54	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Comply	54	

System Requirement Summary

Rqmt Num	Description	Comply/ No Comply / Partial	X-ref Slide(s) Demonstrating Compliance	Team Comments or Notes
55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	70	
56	The CANSAT must operate during the environmental tests laid out in Section 3.5.	Partial	116,117	We are yet to integrate our payload
57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	91	

Management

Arthur S Agdeppa Jr.

CanSat Budget – Hardware

Part	Status	Price	Quantity	Total Price	Type
Arduino Nano	New	$22.00	2	$44.00	Actual
Xbee 900 MHz	New	$40.00	2	$80.00	Actual
Xbee USB Adapter	New	$29.95	1	$29.95	Actual
18650 Battery	New	$5.00	2	$10.00	Actual
LM35DT	New	$4.00	1	$4.00	Actual
MPXV7002DP	New	$30.00	1	$30.00	Actual
Adafruit Ultimate GPS	New	$39.95	1	$39.95	Actual
BME280	New	$9.95	1	$9.95	Actual
Mini Spy Camera	New	$12.50	1	$12.50	Actual
92dB Buzzer	New	$1.73	1	$1.73	Actual
SD Card Breakout	New	$7.50	1	$7.50	Actual
Micro SD Card (16GB)	New	$4.50	2	$9.00	Actual

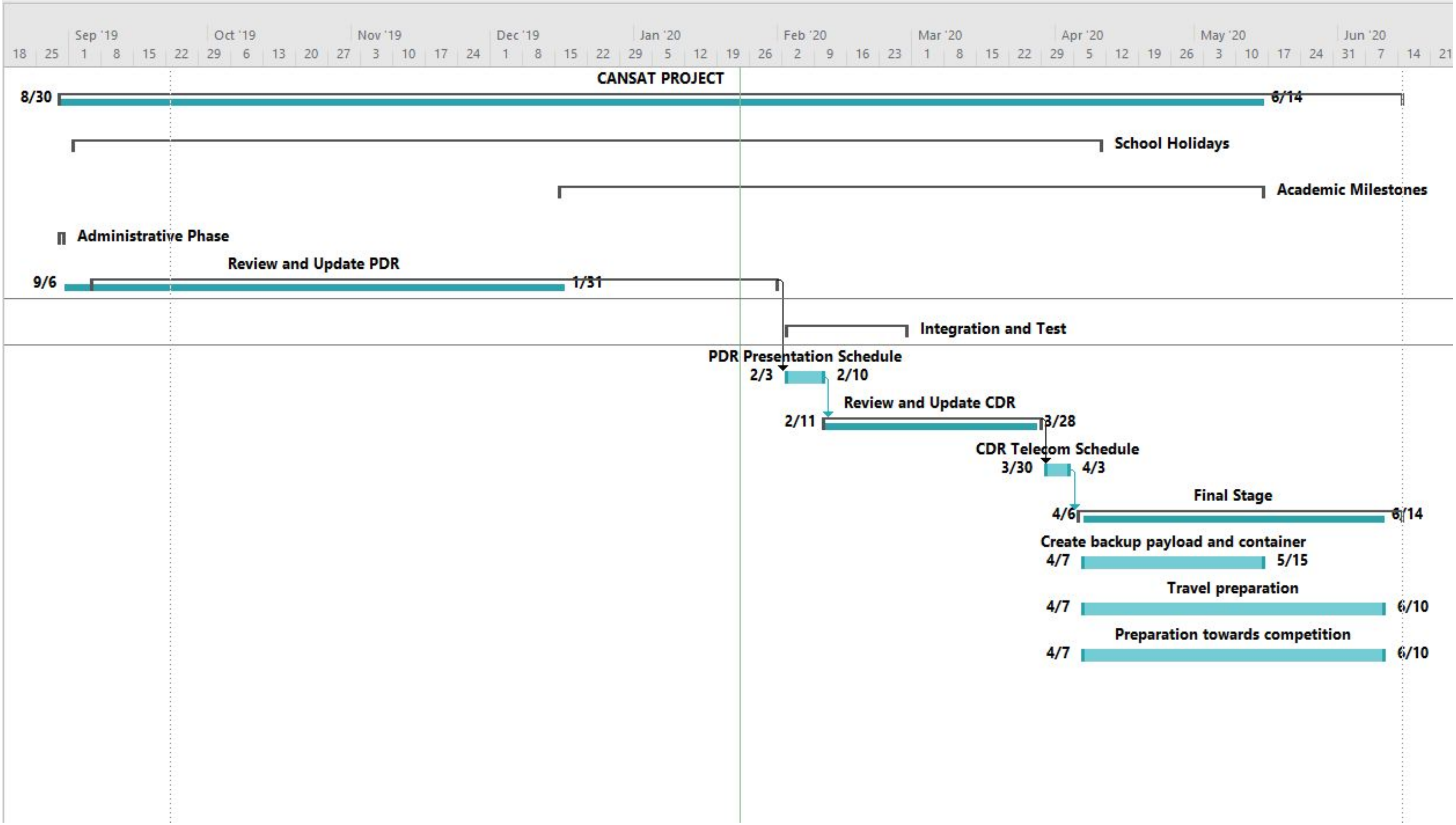
CanSat Budget – Hardware

Part	Status	Price	Quantity	Total Price	Type
Micro Servo	New	$5.95	3	$17.85	Actual
SPS30 (Particulate/Dust)	New	$46.95	1	$46.95	Actual
5V regulator D24V50F5	New	$14.95	1	$14.95	Actual
Xbee regulator adapter	New	$11.95	1	$11.95	Actual
Total Price				**$370.28**	

CanSat Budget – Other Costs

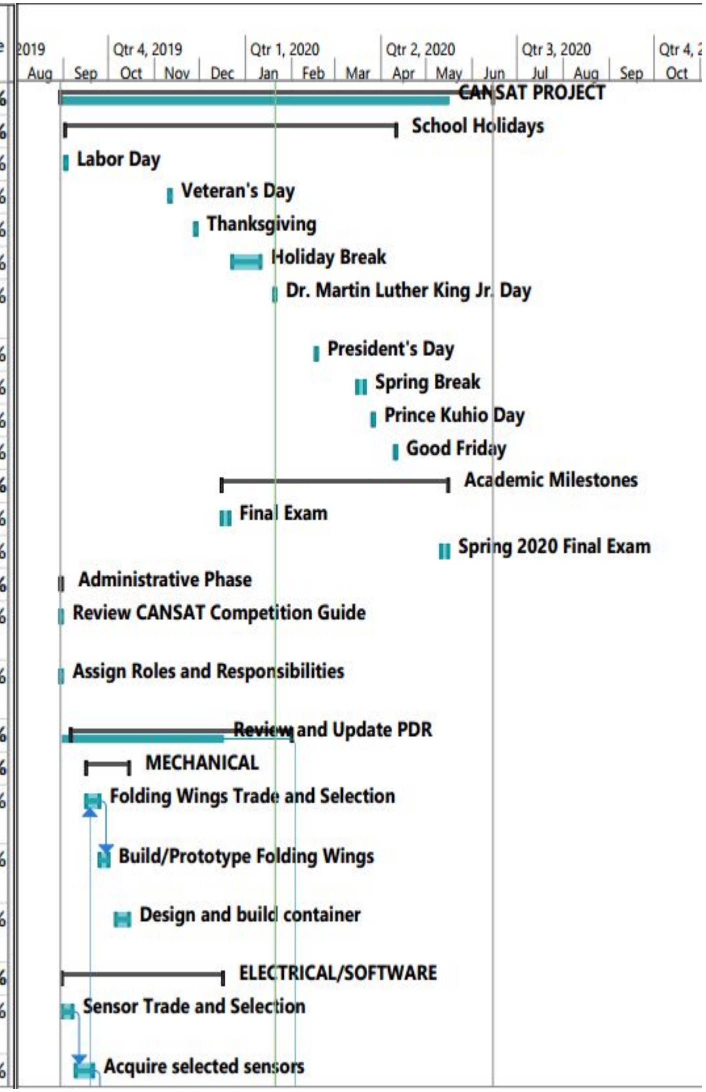
Part	Status	Price	Quantity	Total Price	Type
Prototype and testing	N/A	$100.00	1	$100.00	Estimate
Competition Fee	N/A	$200.00	1	$200.00	Actual
Airfare	N/A	$845.79/person	5	$4,228.95	Estimate
Hotel	N/A	$95/day	5	$475.00	Estimate
Food	N/A	$60/day/person	25	$1,500.00	Estimate
Car	N/A	$64/day	5	$320.00	Estimate
Gasoline	N/A	$200.00	1	$200.00	Estimate
Team uniform	New	$50.00/person	5	$250.00	Estimate
			Total Price	**$7,273.95**	

Program Schedule Overview



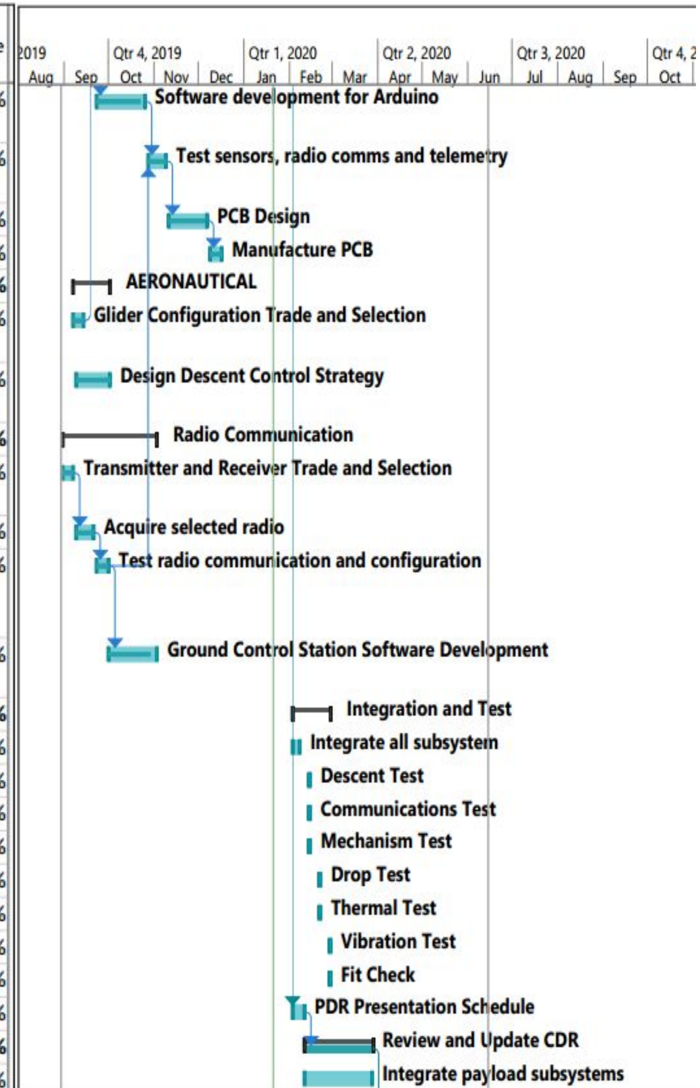
Detailed Program Schedule

ID	Task Name	Duration	Start	Finish	Pred	Resource Names	% Complete
1	**CANSAT PROJECT**	**207 days?**	**Fri 8/30/19**	**Sun 6/14/20**			**81%**
2	**School Holidays**	**160 days**	**Mon 9/2/19**	**Fri 4/10/20**			**70%**
3	Labor Day	1 day	Mon 9/2/19	Mon 9/2/19			100%
4	Veteran's Day	1 day	Mon 11/11/19	Mon 11/11/19			100%
5	Thanksgiving	1 day	Thu 11/28/19	Thu 11/28/19			100%
6	Holiday Break	15 days	Mon 12/23/19	Fri 1/10/20			100%
7	Dr. Martin Luther King Jr. Day	1 day	Mon 1/20/20	Mon 1/20/20			100%
8	President's Day	1 day	Mon 2/17/20	Mon 2/17/20			0%
9	Spring Break	5 days	Mon 3/16/20	Fri 3/20/20			0%
10	Prince Kuhio Day	1 day	Thu 3/26/20	Thu 3/26/20			0%
11	Good Friday	1 day	Fri 4/10/20	Fri 4/10/20			0%
12	**Academic Milestones**	**110 days**	**Mon 12/16/19**	**Fri 5/15/20**			**0%**
13	Final Exam	5 days	Mon 12/16/19	Fri 12/20/19			0%
14	Spring 2020 Final Exam	5 days	Mon 5/11/20	Fri 5/15/20			0%
15	**Administrative Phase**	**1 day**	**Fri 8/30/19**	**Fri 8/30/19**		**ALL**	**100%**
16	Review CANSAT Competition Guide	1 day	Fri 8/30/19	Fri 8/30/19		ALL	100%
17	Assign Roles and Responsibilities	1 day	Fri 8/30/19	Fri 8/30/19		Arthur S	100%
18	**Review and Update PDR**	**106 days?**	**Fri 9/6/19**	**Fri 1/31/20**		**ALL**	**93%**
19	**MECHANICAL**	**21 days**	**Mon 9/16/19**	**Mon 10/14/19**			**100%**
20	Folding Wings Trade and Selection	7 days	Mon 9/16/19	Tue 9/24/19	31	Jhaymar M,Reece G	100%
21	Build/Prototype Folding Wings	4 days	Wed 9/25/19	Mon 9/30/19	20	Jhaymar M,Reece G	100%
22	Design and build container	7 days	Sun 10/6/19	Mon 10/14/19		Arthur S,Jhaymar M	100%
23	**ELECTRICAL/SOFTWARE**	**76 days**	**Sat 8/31/19**	**Mon 12/16/19**			**92%**
24	Sensor Trade and Selection	6 days	Sat 8/31/19	Fri 9/6/19		ALL	100%
25	Acquire selected sensors	10 days	Mon 9/9/19	Fri 9/20/19	24	Arthur S	100%



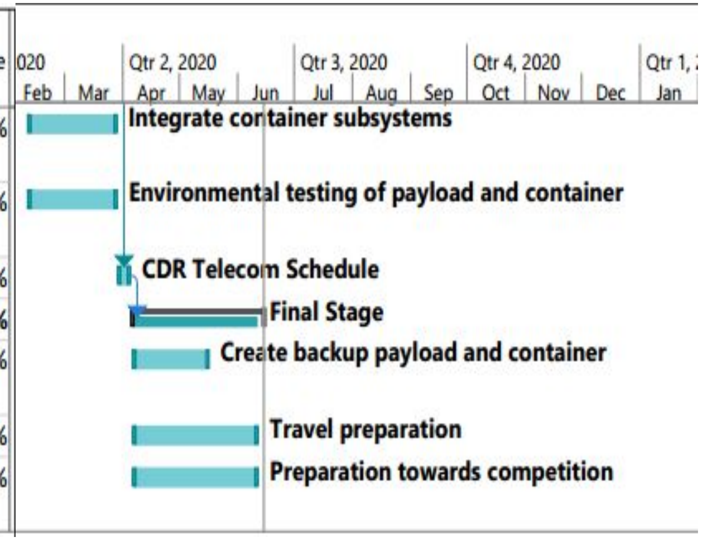
Detailed Program Schedule

ID	Task Name	Duration	Start	Finish	Prec	Resource Names	% Complete
26	Software development for Arduino	25 days	Mon 9/23/19	Fri 10/25/19	25	Arthur S,Guillermo M	85%
27	Test sensors, radio comms and telemetry	10 days	Mon 10/28/19	Fri 11/8/19	26,:	Arthur S,Reece G	100%
28	PCB Design	20 days	Mon 11/11/19	Fri 12/6/19	27	Guillermo M	90%
29	Manufacture PCB	6 days	Mon 12/9/19	Mon 12/16/19	28	Arthur S,Guiller	90%
30	**AERONAUTICAL**	**17 days**	**Sat 9/7/19**	**Tue 10/1/19**			**100%**
31	Glider Configuration Trade and Selection	6 days	Sat 9/7/19	Fri 9/13/19		Tim M,Jeff C	100%
32	Design Descent Control Strategy	17 days	Mon 9/9/19	Tue 10/1/19		Jeff C,Tim M	100%
33	**Radio Communication**	**45 days**	**Sat 8/31/19**	**Sat 11/2/19**			**89%**
34	Transmitter and Receiver Trade and Selection	6 days	Sat 8/31/19	Fri 9/6/19		John C,Reece G	100%
35	Acquire selected radio	10 days	Mon 9/9/19	Fri 9/20/19	34	Arthur S	100%
36	Test radio communication and configuration	6 days	Mon 9/23/19	Mon 9/30/19	35	Arthur S,John C	100%
37	Ground Control Station Software Development	25 days	Tue 10/1/19	Sat 11/2/19	36	Arthur S,John C	80%
38	**Integration and Test**	**20 days**	**Mon 2/3/20**	**Fri 2/28/20**			**0%**
39	Integrate all subsystem	5 days	Mon 2/3/20	Fri 2/7/20			0%
40	Descent Test	1 day	Fri 2/14/20	Fri 2/14/20			0%
41	Communications Test	1 day	Fri 2/14/20	Fri 2/14/20			0%
42	Mechanism Test	1 day	Fri 2/14/20	Fri 2/14/20			0%
43	Drop Test	1 day	Fri 2/21/20	Fri 2/21/20			0%
44	Thermal Test	1 day	Fri 2/21/20	Fri 2/21/20			0%
45	Vibration Test	1 day	Fri 2/28/20	Fri 2/28/20			0%
46	Fit Check	1 day	Fri 2/28/20	Fri 2/28/20			0%
47	PDR Presentation Schedule	6 days	Mon 2/3/20	Mon 2/10/20	18		0%
48	**Review and Update CDR**	**35 days?**	**Tue 2/11/20**	**Sat 3/28/20**	**47**		**0%**
49	Integrate payload subsystems	34 days	Tue 2/11/20	Fri 3/27/20			0%



Detailed Program Schedule

ID	Task Name	Duration	Start	Finish	Pred	Resource Names	% Complete
50	Integrate container subsystems	34 days	Tue 2/11/20	Fri 3/27/20			0%
51	Environmental testing of payload and container	34 days	Tue 2/11/20	Fri 3/27/20			0%
52	CDR Telecom Schedule	5 days	Mon 3/30/20	Fri 4/3/20	48		0%
53	**Final Stage**	**51 days?**	**Mon 4/6/20**	**Sun 6/14/20**	**52**		**0%**
54	Create backup payload and container	29 days	Tue 4/7/20	Fri 5/15/20			0%
55	Travel preparation	47 days	Tue 4/7/20	Wed 6/10/20			0%
56	Preparation towards competition	47 days	Tue 4/7/20	Wed 6/10/20			0%



Conclusions

Major accomplishments

- Testing of electronic components and telemetry is transmitting and receiving at 1Hz with Xbee. It is also storing to SD card at 1Hz.
- Prototypes have been built and tested.
- Container is finished and is being used to fit the actual payload

Major unfinished work

- 3D printing of glider support structure. We printed out many prototypes and we are currently deciding which design is best.
- Integration of sensors, batteries, mechanical, and servos to payload is done, but it needs to be cleaned up
- Environmental testing of payload and container

Why are you ready to proceed to next state of development

- All electronic components including batteries, sensors, servos and mechanical are available to us to integrate.
- Software has been written for all sensors and Ground Control
- Our design meets requirements according to CanSat guideline
- Radio transmission and reception is complete