



CanSat 2022

Preliminary Design Review (PDR)

Outline

Version 1.1

**1064
UCASAL**



Presentation Outline (1 of 2)



Contents	Presenter	Slides
Team Organization	Jorge Royon	
Acronyms	Jorge Royon	
Systems Overviews	Jorge Royon	
Sensor Subsystem Design	Enzo Juarez Juan Esteban Yurquina	
Descent Control Design	Jorge Royon	
Mechanical Subsystem Design	Jorge Royon	
Communication and Data Handling (CDH) Subsystem Design	Jorge Royon Enzo Juarez Juan Esteban Yurquina	



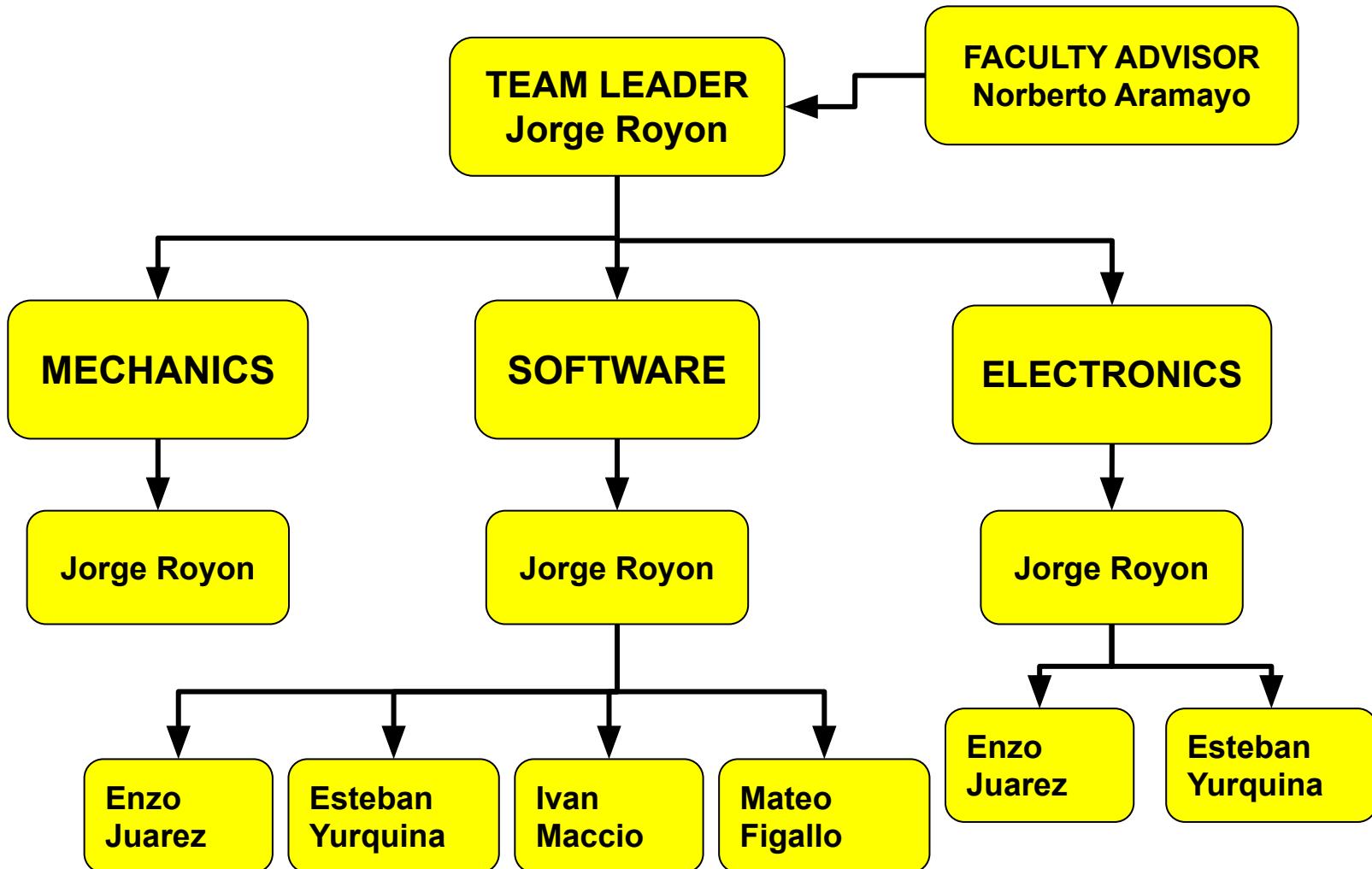
Presentation Outline (2 of 2)



Contents	Presenter	Slides
Electrical Power Subsystem (EPS) Design	Enzo Juarez Juan Esteban Yurquina	
Flight Software (FSW) Design	Jorge Royon Enzo Juarez Juan Esteban Yurquina	
Ground Control System (GCS) Design	Ivan Maccio Mateo Figallo	
Cansat Integration and Test	Ivan Maccio Mateo Figallo	



Team Organization





Acronyms



Acronyms	Analysis
CDR	Critical design review
Hz	Frequency
DCS	Descent Control System
FRR	Flight Readiness Review
GCS	Ground Control Station
CG	Center of gravity
LCO	Launch Control Officer
RPM	Revolution per minute



Systems Overview

Jorge Royon



Mission Summary



MAIN OBJECTIVES

Design a Cansat that shall consist of a container and a payload. 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.
- The Cansat shall descend using a parachute at a rate of 15 m/s.
- At 400 meters, the Cansat shall deploy a larger parachute to reduce the descent rate to 5 m/s.
- At 300 meters, the Cansat shall release a tethered payload to a distance of 10 meters in 20 seconds.
- During that time, the payload shall maintain the orientation of a video camera pointing in the south direction.
- The video camera shall be pointed 45 degrees downward to assure terrain is in the video.



Mission Summary

BONUS OBJECTIVES

As the container is releasing the payload, the container shall contain a video camera and start recording to show the descent of the payload. All videos are to be recorded and recovered when the Cansat is recovered from the field.



System Requirement Summary



REQ	DESCRIPTION
1	Total mass of the CanSat (science payloads and container) shall be 600 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 payloads. Small holes to allow access to turn on the science payloads are 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 operations.
8	The container's first 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



System Requirement Summary



REQ	DESCRIPTION
10	The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s after deployment while above 400 meters.
11	The descent rate of the CanSat shall be reduced to 5 meters/second +/-2 m/s when the CanSat descends below 400 meters.
12	0 altitude reference shall be at the launch pad.
13	All structures shall be built to survive 15 Gs of launch acceleration.
14	All structures shall be built to survive 30 Gs of shock.
15	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
16	All mechanisms shall be capable of maintaining their configuration or states under all forces.
17	Mechanisms shall not use pyrotechnics or chemicals.
18	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.



System Requirement Summary



REQ	DESCRIPTION
19	Both the container and payload shall be labeled with team contact information including email address.
20	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.
21	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.
22	XBEE radios shall have their NETID/PANID set to their team number.
23	XBEE radios shall not use broadcast mode.
24	The container shall include electronics to receive sensor payload telemetry.
25	The container shall include electronics and mechanisms to release the science payload on a tether.
26	The container shall include a GPS sensor to track its position.
27	The container shall include a pressure sensor to measure altitude.
28	The container shall measure its battery voltage.



System Requirement Summary



REQ	DESCRIPTION
29	The container shall transmit its telemetry once per second (1 Hz) in the formats described in the Telemetry Requirements section.
30	The container shall poll the payload for telemetry and relay that data four times per second (4 Hz) in the formats described in the Telemetry Requirements section.
31	The container shall stop polling and transmitting telemetry when it lands.
32	The container and science payload must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration.
33	The container and payload must 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.
34	An audio beacon is required for the container. It shall be powered after landing.
35	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.
36	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.



System Requirement Summary



REQ	DESCRIPTION
37	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.
38	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.
39	The Cansat must operate during the environmental tests laid out in Section 3.5.
40	The Cansat shall operate for a minimum of two hours when integrated into the rocket.
41	The science payload shall have their NETID/PANID set to their team number plus 5000. If the team number is 1000, sensor payload NETID is 6000.
42	The science payload shall transmit sensor telemetry to the container when polled.
43	Missing in mission guide
44	The science payload shall include a pressure sensor, temperature sensor and rotation sensor.
45	The science payload shall include a video camera pointing 45 degrees up from the payload NADIR direction.



System Requirement Summary



REQ	DESCRIPTION
46	The science payload shall maintain orientation so the camera always faces south within +/- 20 degrees.
47	The payload shall be connected to the container with a 10 meter tether.
48	At 300 meters, the payload shall be released from the container at a rate of .5 meters per second.
49	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.
50	The container shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.
51	The container shall have its time set to UTC time to within one second before launch.
52	The container 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.
53	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



REQ	DESCRIPTION
54	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.
55	The ground station shall command the Cansat to start transmitting telemetry prior to launch.
56	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.
57	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.
58	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.
59	Each team shall develop their own ground station.
60	All telemetry shall be displayed in real time during descent on the ground station.
61	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
62	Teams shall plot each telemetry data field in real time during flight.



System Requirement Summary



REQ	DESCRIPTION
63	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.
64	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.
65	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.
66	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 container.
67	The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container.
68	All video cameras shall be in color, have a resolution of at least 640x480 and record at a minimum of 30 frames a second.



System Level CanSat Configuration Trade & Selection



CONFIGURATION 1

General description:

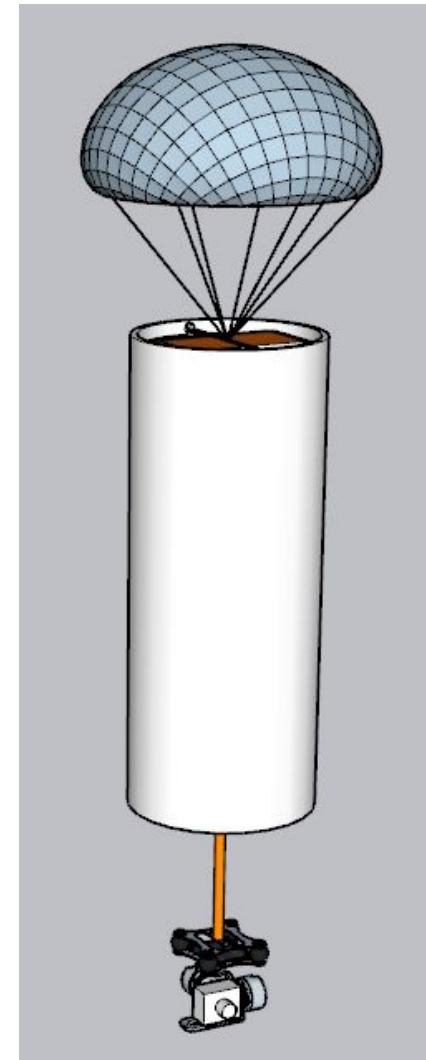
- Payload consist on a 3 axis gimbal for smooth and precise stabilization
- Second parachute is retained by a rubber band and a servo, the first parachute is tethered with cotton strings to the second one
- Electronics in container and payload for easy manipulation and to use all the space available
- 3D printed container for thin walls to maximize useful space and lightweight

PROS:

- Container is 3d printed and saves precious building time
- Gimbal are a proven method to stabilize cameras even in rough conditions
- Easy to build

CONS:

- Container is fragile
- Expensive





System Level CanSat Configuration Trade & Selection



CONFIGURATION 2

General description:

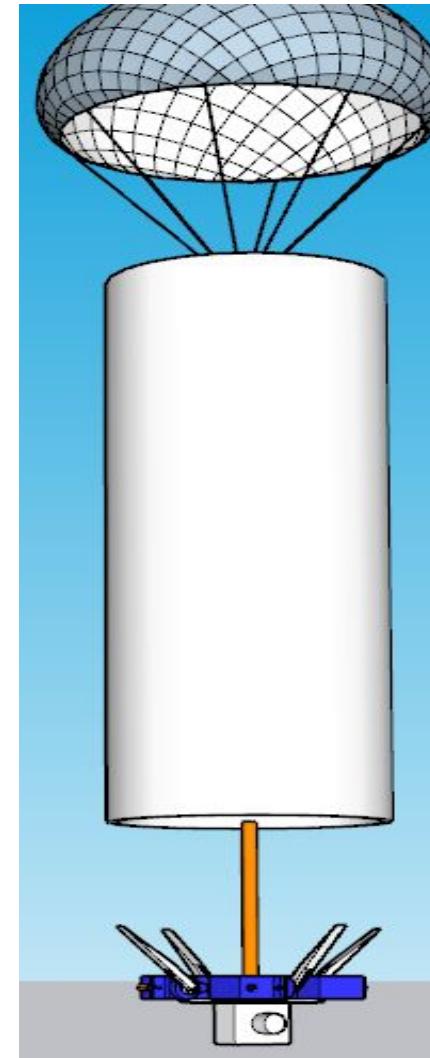
- Payload consist on a platform that had 4 servos with movable fins to stabilize camera
- Second parachute is retained by a rubber band and a servo, the first parachute is tethered with cotton strings to the second one
- Electronics in container and payload for easy manipulation and to use all the space available
- 3D printed container for thin walls to maximize useful space and lightweight

PROS:

- Container is 3d printed and saves precious building time
- Easy to build

CONS:

- Container is fragile
- Too many servos
- Can be hard to program
- Stabilization depends on wind speed that are unpredictable





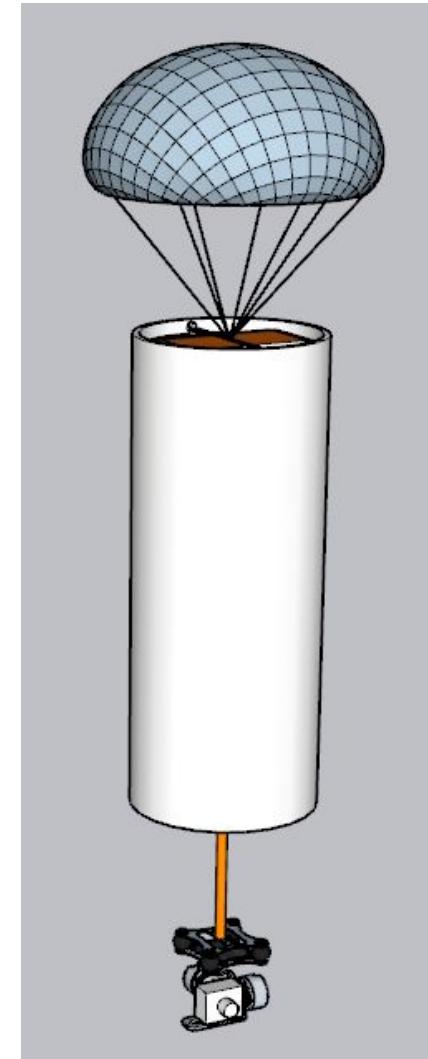
System Level Configuration Selection



CONFIGURATION 1 SELECTED

Rationale:

- We choose configuration 1 because uses proven and reliable methods and is easy to build

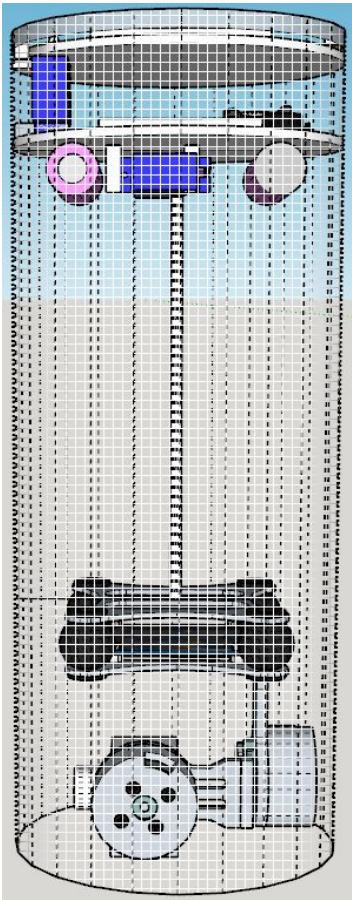




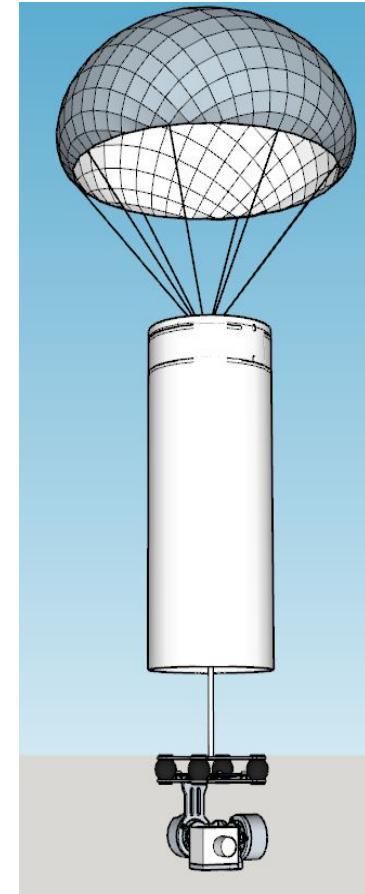
Physical Layout



STOWED STATE



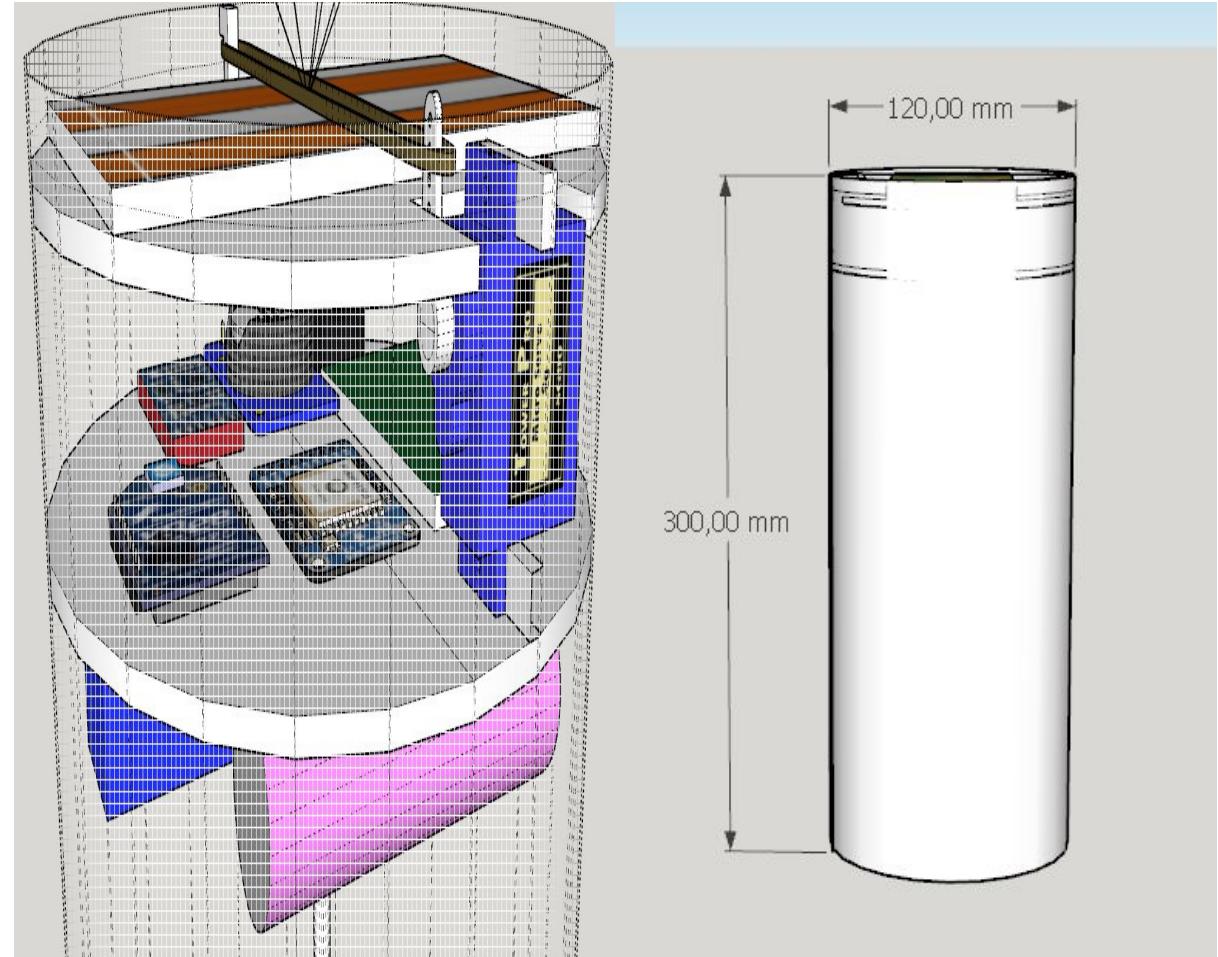
DEPLOYED STATE



Physical Layout

CONTAINER

The container consist on two bays, one to hold the parachutes and the other one to hold the electronics, both are hold to the container with wood screw



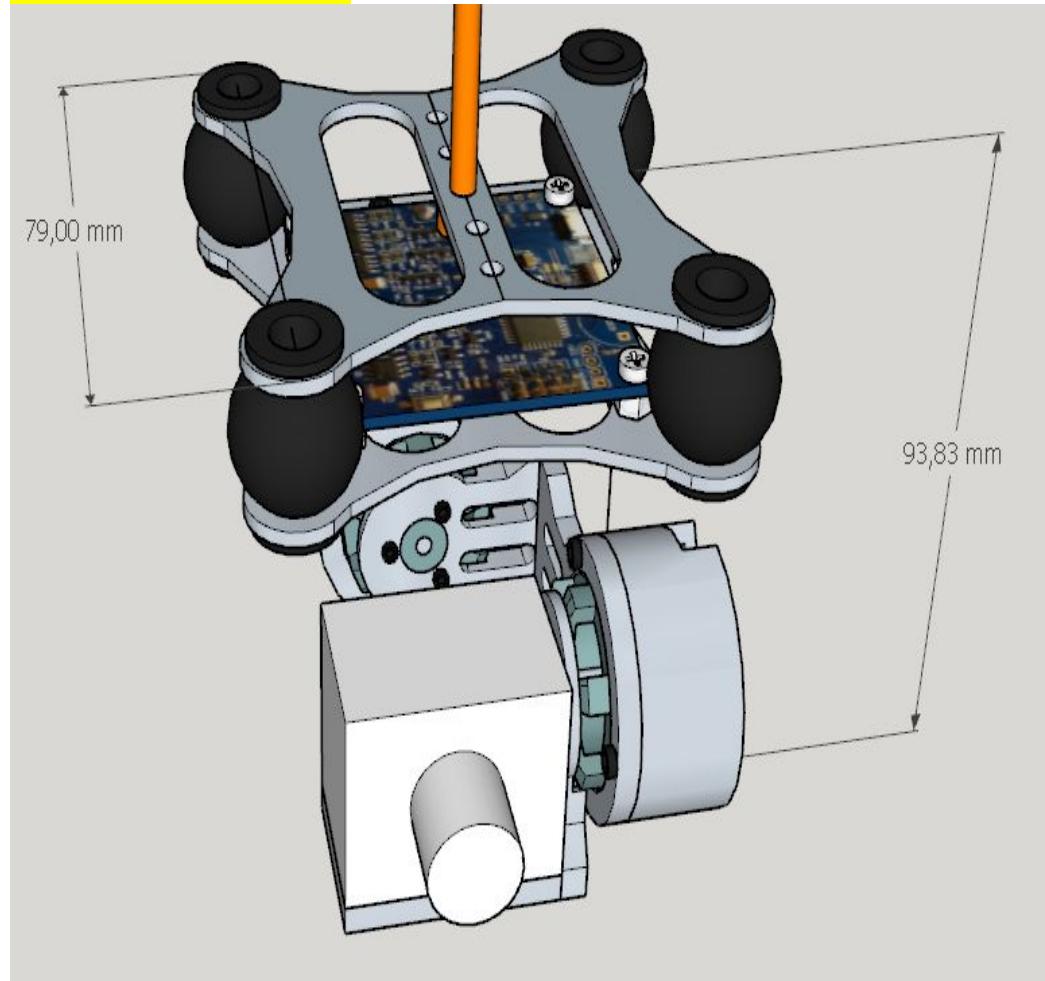


Physical Layout



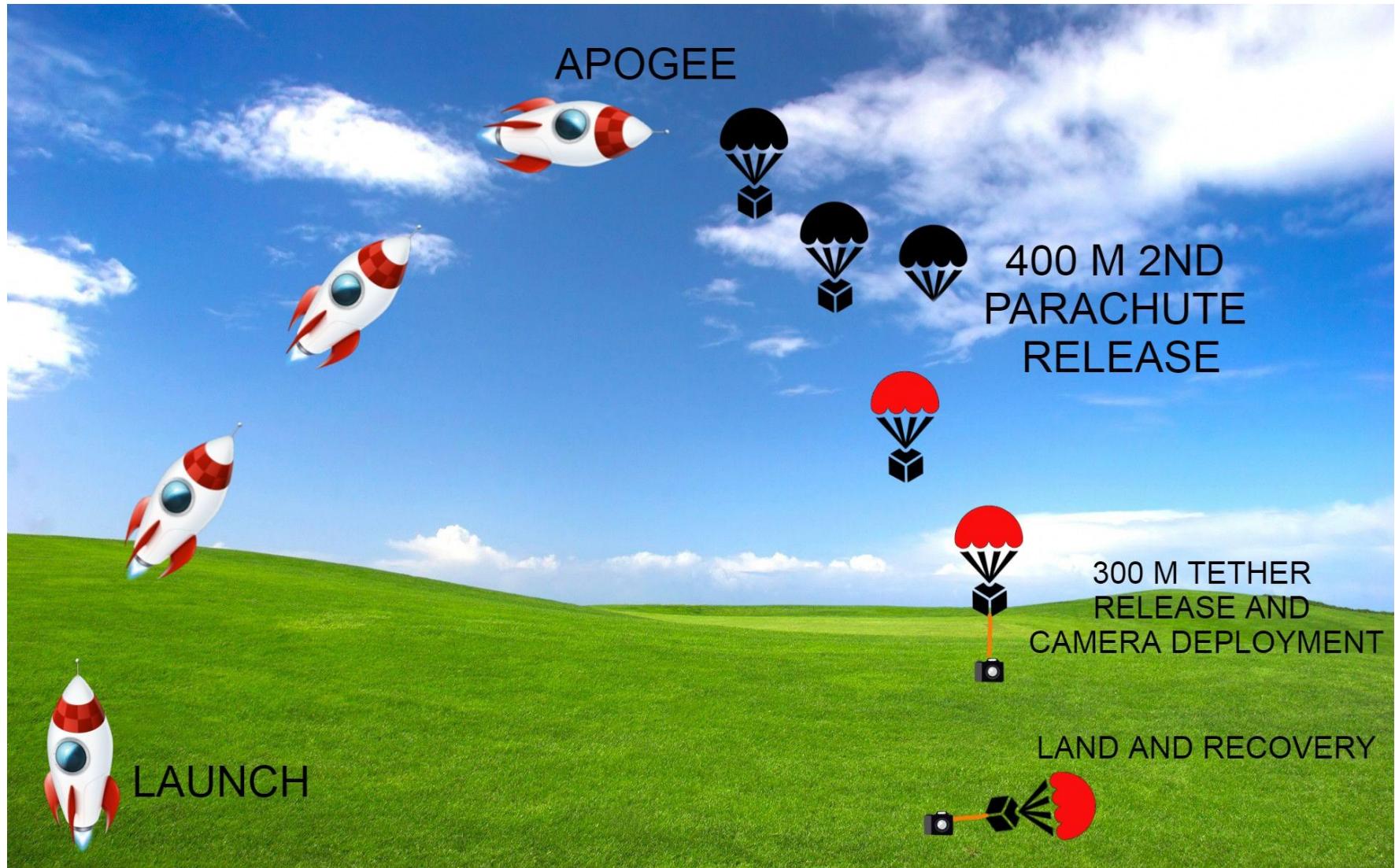
The payload consist in a 3 axis stabilization gimbal that keeps the camera at the required angle and has a bay for all the electronics

PAYLOAD





System Concept of Operations





System Concept of Operations



- Competition area arrival
- Team briefing
- Checklist of materials
- Deploy Ground Control Station
- Last check of fully integrated CanSat
- Placement of CanSat into the rocket payload section

- Launch CanSat.
- Container deploy.
- Payload deploy.
- Record telemetry.

- Recovery of Payload and Container
- Analysis of sampled data
- Preparation of the PFR
- PFR presentation and delivery



Launch Vehicle Compatibility



★Rocket payload section dimensions based on Mission Guide:

- Height: 310 mm
- Diameter: 125 mm

★CanSat dimensions:

- Height: 300 mm
- Diameter: 120 mm

★Payload dimensions:

- Diameter: 100mm
- Height: 90 mm

★First Parachute dimensions:

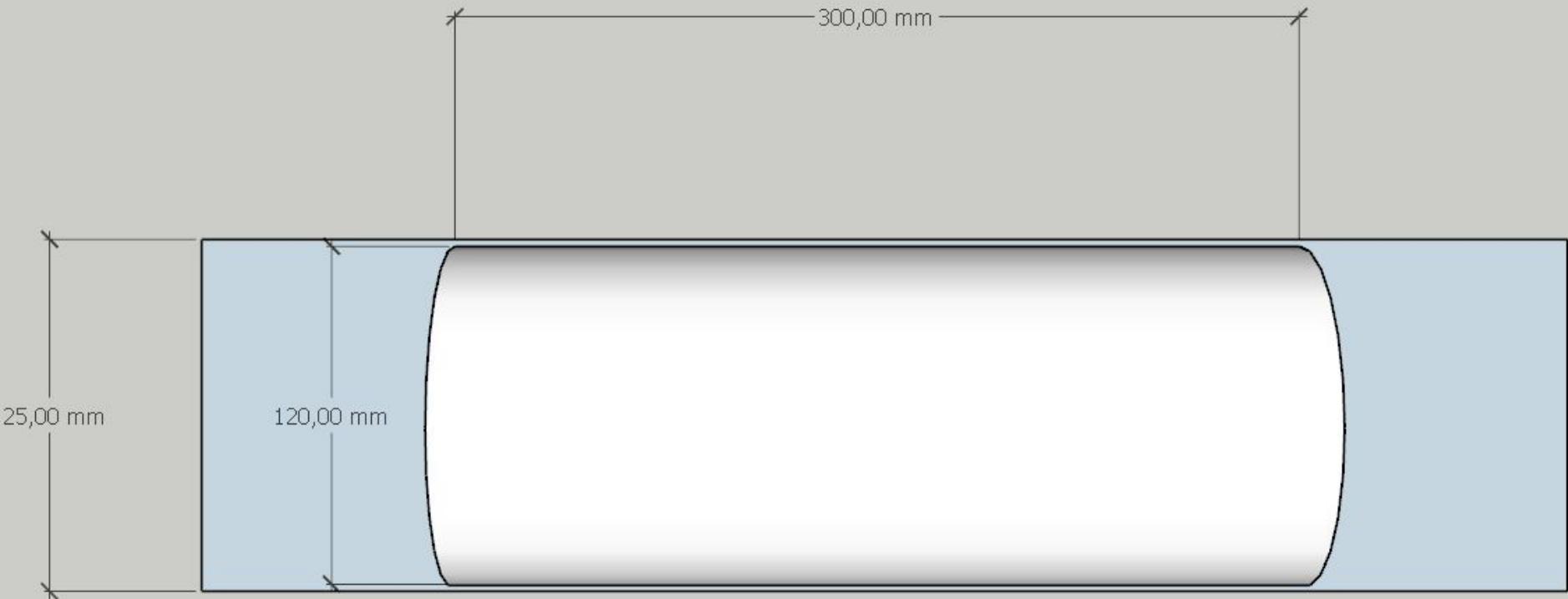
- Diameter: 190 mm
- Spill Hole Diameter: 42.56 mm

★Second Parachute dimensions:

- Diameter: 571 mm
- Spill Hole Diameter: 63.86 mm



Launch Vehicle Compatibility



There's enough space for the Container freely slide in the rocket frame



Sensor Subsystem Design

**Enzo Juarez
Juan Esteban Yurquina**



Sensor Subsystem Overview



Container Section

Sensor	Model	Purpose
Air Pressure	BMP280	Measure air pressure
GPS Sensor	Adafruit Ultimate GPS Sensor	Get GPS position
Voltage Sensor	Arduino ADC pin	Measure voltage
Altitude	BMP280	Detect altitude
Air Temperature	BMP280	Measure air, temperature & pressure



Sensor Subsystem Overview



Payload Section

Sensor	Model	Purpose
Air Pressure	BMP280	Measure air, temperature & pressure
Air Temperature	BMP280	Measure air, temperature & pressure
Rotation Sensor	MPU9250	Measure rotation
Voltage Sensor	Arduino ADC pin	Measure voltage
Gyroscope	MPU9255	Calculate the orientation.
Magnetometer	MPU9255	Measure magnetic fields in order to orientate the camera.

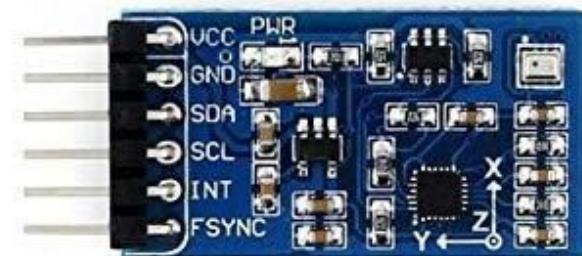


Container Air Pressure Sensor Trade & Selection



MODEL	INTERFACE	RANGE	ACCURACY	SIZE	MASS	COST
BME280	I2c	300 hPa / 1100 hPa	\pm 1 hPa	14 mm x 12 mm x 2 mm	0.9gr	\$8.99
Waveshare 10 DOF IMU	I2c	300 hPa / 1100 hPa	\pm 1 hPa	31.2 mm x 17 mm x 3 mm	2gr	\$17.99

- Selected Air Pressure Sensor: Waveshare 10DOF IMU with bmp280.
- Considering 1 hPa, high measurement accuracy .
- Wide range for healthy measurement.
- Easy to access and useful library.
- One small board that save cost for the price of three sensors.
- Small size.





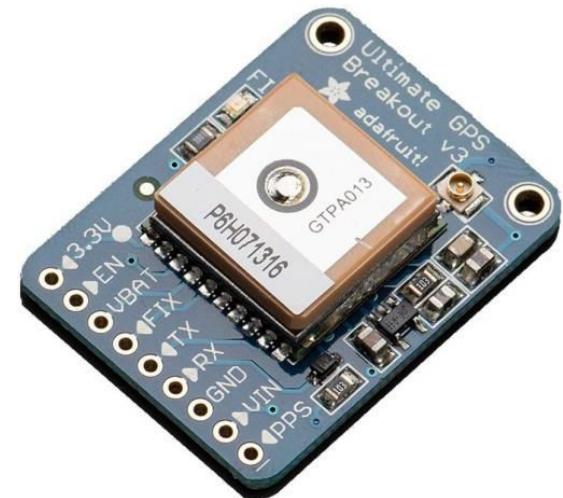
Container GPS Sensor Trade & Selection



MODEL	INTERFACE	ACCURACY	SIZE	MASS	COST
GPS NEO-6M	UART/USB/SPI	± 2m	27.6 mm x 26.6 mm x 6.5 mm	9g	\$12.99
Adafruit Ultimate GPS	UART	± 1.8 m	25 mm x 35 mm x 6.5 mm	8.5g	\$39.95

Selected GPS Sensor: Adafruit Ultimate GPS

- Considering its affordable cost, satisfies high position accuracy as 1.8 meter.
- Antenna of Adafruit Ultimate GPS is onboard, so it is useful in terms of volume.
- According to other projects experiences , Adafruit Ultimate GPS works stable.





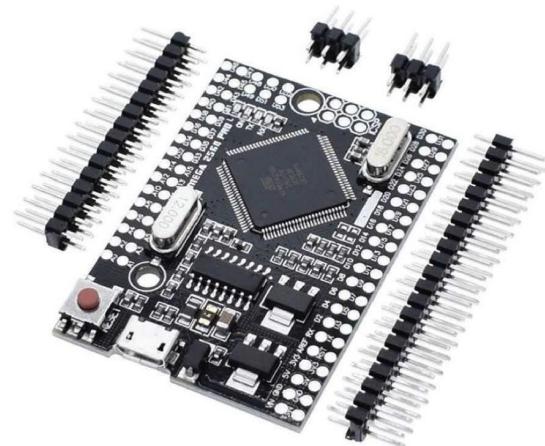
Container Battery Voltage Sensor Trade & Selection



MODEL	ACCURACY	SIZE	MASS	COST
Hitelgo Voltage sensor	$\pm 0.0049\text{C}$	27.6 mm x 26.6 mm	0.8gr	\$ 5.39
Arduino analog pin	$\pm 0.0049\text{v}$	108 mm x 54 mm	34,9g	\$ 0

Selected Voltage Sensor: Arduino analog pin

- Considering it comes with the controlling electronics and high precision there's no need to invest in other sensor





Payload Air Pressure Sensor Trade & Selection



MODEL	INTERFACE	RANGE	ACCURACY	SIZE	MASS	COST
BME280	I2c	300 hPa / 1100 hPa	\pm 1 hPa	14 mm x 12 mm x 2 mm	0.9gr	\$8.99
Waveshare 10 DOF IMU with bmp280	I2c	300 hPa / 1100 hPa	\pm 1 hPa	31.2 mm x 17 mm x 3 mm	2gr	\$17.99

- Selected Air Pressure Sensor: Waveshare 10DOF IMU with bmp280.
- Considering 1 hPa, high measurement accuracy .
- Wide range for healthy measurement.
- Easy to access and useful library.
- One small board that save cost for the price of three sensors.
- Small size.





Payload Air Temperature Sensor Trade & Selection



MODEL	INTERFACE	RANGE	ACCURACY	SIZE	MASS	COST
BME280	I2c	-40 °C/85 °C	± 1°C	14 mm x 12 mm x 2 mm	0.9gr	\$8.99
Waveshare 10 DOF IMU with bmp280	I2c	-40 °C/85 °C	± 1°C	31.2 mm x 17 mm x 3 mm	2gr	\$17.99

- Selected Air Temperature Sensor: Waveshare 10DOF IMU with bmp280.
- Considering 1°C, high measurement accuracy .
- Wide range for healthy measurement.
- Easy to access and useful library.
- One small board that save cost for the price of three sensors.
- Small size.





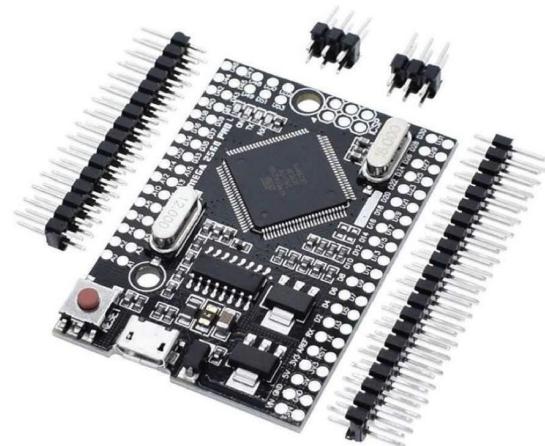
Payload Battery Voltage Sensor Trade & Selection



MODEL	ACCURACY	SIZE	MASS	COST
Hitelgo Voltage sensor	$\pm 0.0049\text{C}$	27.6 mm x 26.6 mm	0.8gr	\$ 5.39
Arduino analog pin	$\pm 0.0049\text{v}$	108 mm x 54 mm	34.9g	\$ 0

Selected Voltage Sensor: Arduino analog pin

- Considering its come with the controlling electronics and high precision there's no need to invest in other sensor





Payload Rotation Control Sensor Trade & Selection



MODEL	INTERFACE	RANGE	ACCURACY	SIZE	MASS	COST
Adafruit 9-DOFBNO0 55	I2c	2000 °/s	±3%	14 mm x 12 mm x 2 mm	3gr	\$34.95
Waveshare 10 DOF IMU with bmp280	I2c	2000 °/s	±3%	31.2 mm x 17 mm x 3 mm	2gr	\$17.99

- Selected Rotation Control Sensor: Waveshare 10DOF IMU with bmp280.
- Considering ±3% , high measurement accuracy.
- Wide range for healthy measurement.
- Easy to access and useful library.
- One small board that save cost for the price of three sensors.
- Small size.





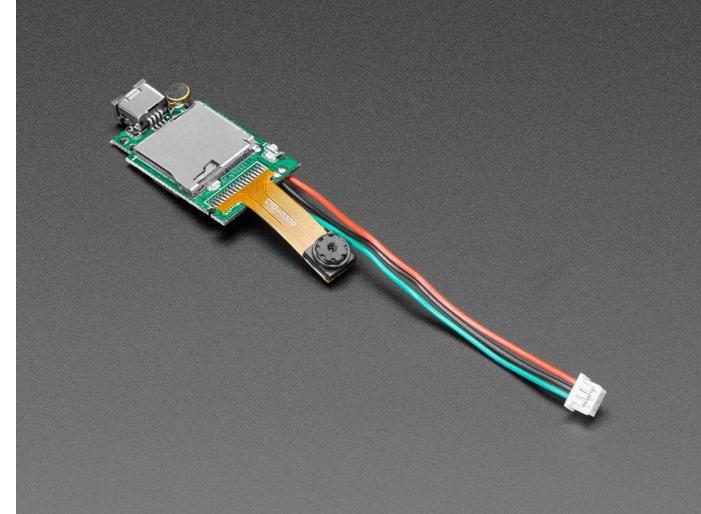
Payload Camera Trade & Selection



MODEL	INTERFACE	RESOLUTION	SIZE	MASS	COST
GENERIC SPY PEN CAMERA	USB	1280×960	85 mm × 12.5 mm × 12.5 mm	2g	\$ 5.00
Adafruit MINI SPY CAMERA	USB/ANALOG	640x480	28.5 mm x 17mm x 4.2mm	2.8g	\$ 12.50

Selected Camera: Adafruit camera

- Considering its size that is easy to fit in a slip tray to ease rotation.
- Easy interface with arduino, only one signal wire to start and stop recording.





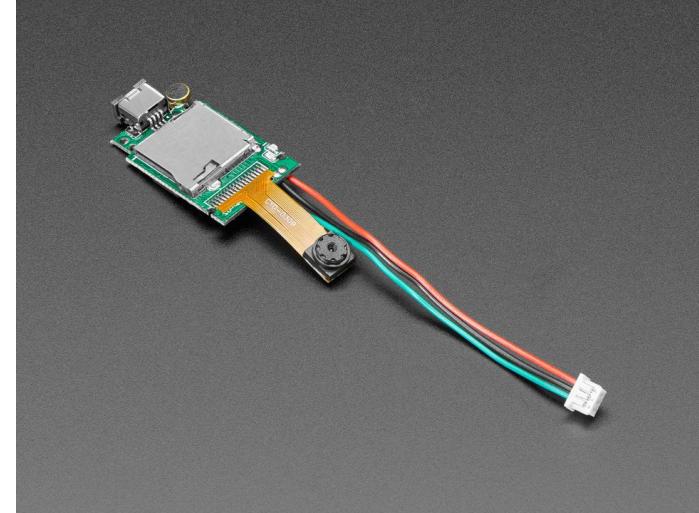
Bonus Camera Trade and Selection



MODEL	INTERFACE	RESOLUTION	SIZE	MASS	COST
GENERIC SPY PEN CAMERA	USB	1280×960	85 mm × 12.5 mm × 12.5 mm	2g	\$ 5.00
Adafruit MINI SPY CAMERA	USB/ANALOG	640x480	28.5 mm x 17mm x 4.2mm	2.8g	\$ 12.50

Selected Camera: Adafruit camera

- Considering its size that is easy to fit in a slip tray to ease rotation.
- Easy interface with arduino, only one signal wire to start and stop recording.





Descent Control Design

Jorge Royon



Descent Control Overview

Container Descent Control System

The parachute has 19 cm diameter to reach 15 m/s. It has been made from plastic and It has 2.28 cm radius spill hole to stabilize container during descent





Container Descent Control Strategy Selection and Trade



DOME PARACHUTE



X TYPE PARACHUTE



Container Descent Control Strategy Selection and Trade



DOME PARACHUTE	X TYPE PARACHUTE
Stability is easily ensured by a spill hole.	Easy to stack.
High drag coefficient.	Low drag coefficient.
Easy to make.	Easy to manufacture.
Requires less space when stacked.	Lightweight.
Horizontal displacement is low.	

We selected the Parachute Dome due the following reasons:

- Apogee model 29126 is cheap
- Apogee model 29126 accomplish all requirement
- Apogee model 29126 Will be painted orange to meet requirements



Container Descent Control Strategy Selection and Trade



DOME PARACHUTE	X TYPE PARACHUTE
Stability is easily ensured by a spill hole.	Easy to stack.
High drag coefficient.	Low drag coefficient.
Easy to make.	Easy to manufacture.
Requires less space when stacked.	Lightweight.
Horizontal displacement is low.	

For the second parachute we also choose dome parachute:

- Apogee model 29118 is cheap
- Apogee model 29118 accomplish all requirement
- Apogee model 29118 Will be painted orange to meet requirements



Container and Payload Descent Stability Control Strategy Selection and Trade



DESCRIPTION:

- We consider the use of a 3d printed flexible passive aileron to improve stability

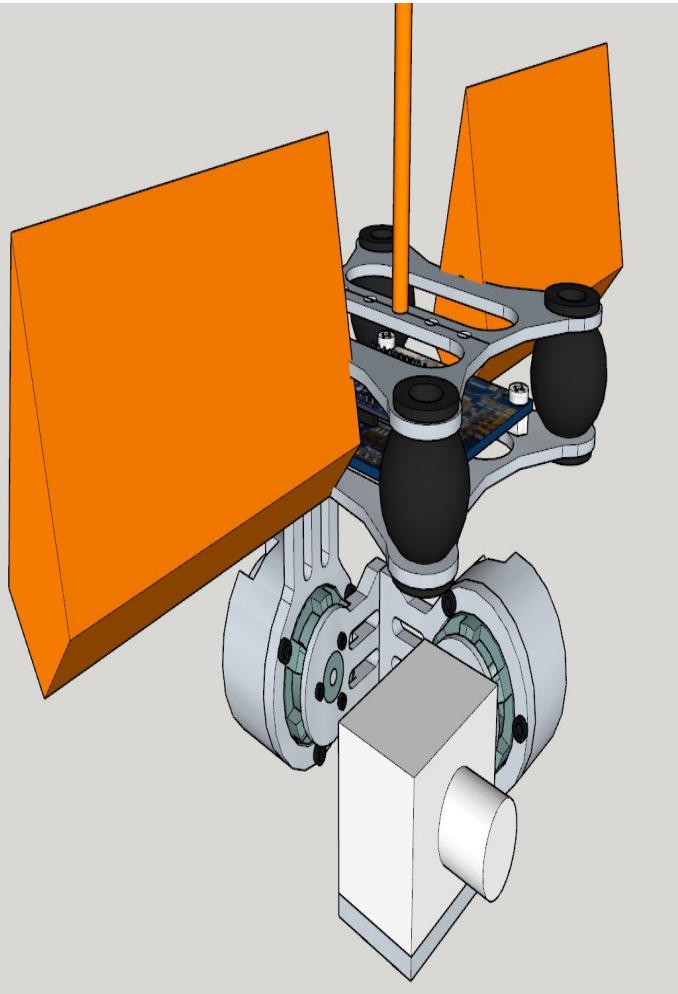
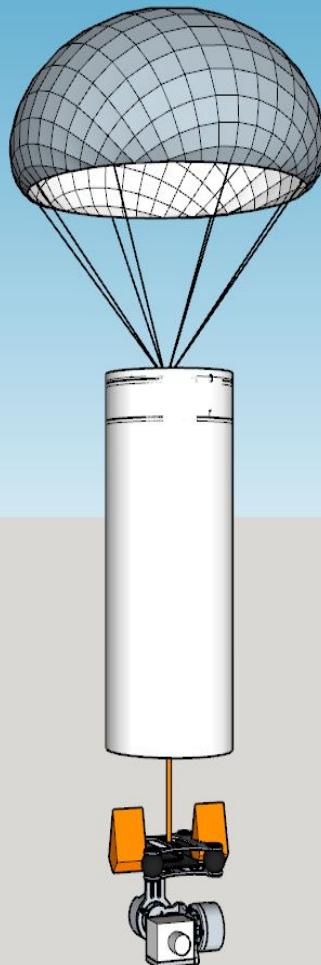
PROS:

- Improve stability
- Mitigate bounces inside the container when stowed

CONS:

- Stability is slightly improved
- More weight

OPTION A





Container and Payload Descent Stability Control Strategy Selection and Trade



DESCRIPTION

- We consider that the weight of the payload in the bottom on the container and when deployed it will be 10M away will be enough to stabilize it.

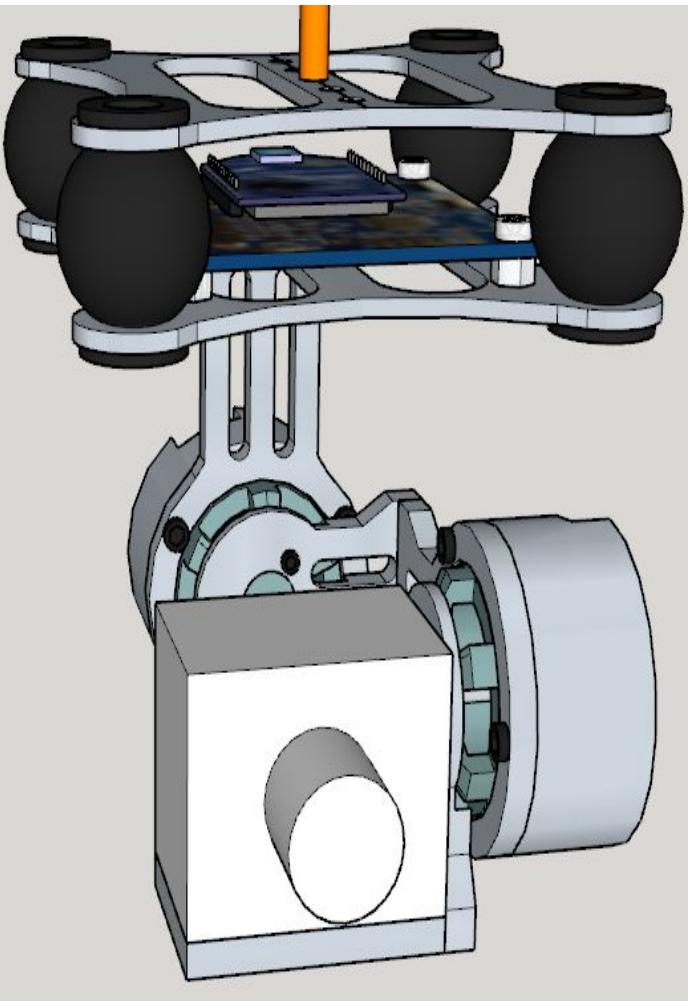
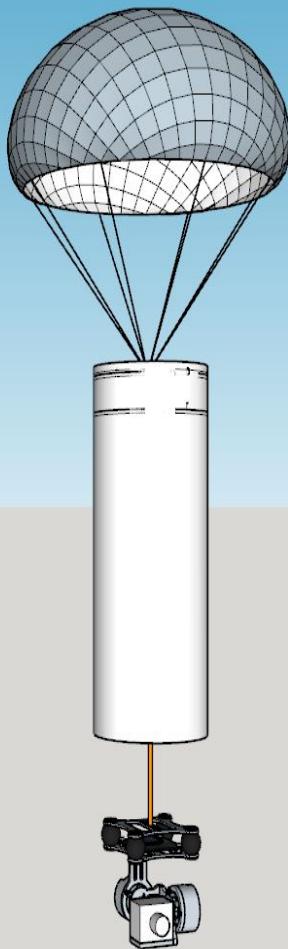
PROS:

- Easy to build
- Lightweight

CONS:

- Stability is achieved in a passive way and high speed winds can be a problem

OPTION B





Container and Payload Descent Stability Control Strategy Selection and Trade



OPTION A	OPTION B
Stability is slightly improved.	Easy to stack.
Mitigate bounces inside the container	Easy to manufacture. Lightweight.

We choose the option B because the option A is not worth the effort to build



Descent Rate Estimates



Container Descent Rate Estimate

The area formula of the first parachute with spill hole is

$$S_p = \frac{2 \times m \times g}{\rho \times V^2 \times C_D}$$

where

S_p = Area of the parachute with a spill hole (m^2)

D = The diameter of the parachute mm

V = Descent speed m/s

CD = 1.5 Drift coefficient of parachute

ρ = 1.225 kg/m³(Air density at +15 C from sea level)

m =0.600kg Container+Payload

$g=9.81m/s^2$

$S_{(s_H)}$ =Spill hole area

$s_{_Hr}$ =Spill hole radius



Descent Rate Estimates

Container Descent Rate Estimate

Replacing the data gives the following results

$$S_p = \frac{2 \times (0,6\text{kg}) \times (9,81 \frac{\text{m}}{\text{s}^2})}{(1,225 \text{kg/m}^3) \times (15 \frac{\text{m}}{\text{s}})^2 \times 1,5}$$

$$\textcolor{red}{Sp=0.02847\text{m}^2}$$

The diameter can be calculated from the formula

$$S_p = \frac{1}{4} \pi D^2$$



Descent Rate Estimates



Container Descent Rate Estimate

Clearing terms and replacing the data give us

$$D = \sqrt{\frac{4 \times S_p}{\pi}} = \sqrt{\frac{4 \times 0,02847m^2}{\pi}} = 0,1904036m = 190mm$$

The spill house area is chosen to be 5% of the total parachute area

$$S_{sh} = S_p \times 5\% = 0.02847m^2 * 0.05 = 0.0014235m^2$$



Descent Rate Estimates

Container Descent Rate Estimate

The spill house radius can be determined by

$$S_{SH} = \frac{\pi r^2}{4} \Rightarrow r = \sqrt{\frac{4S_{SH}}{\pi}} = \sqrt{\frac{0,0014235\text{m}^2}{\pi}} = 0,0212864\text{m} = 21,28\text{mm}$$

This give us a parachute of a 190 mm in diameter with a spill house radius of 21,28 mm for the first parachute



Descent Rate Estimates



Container Descent Rate Estimate

Now we can estimate the descent speed of the container with the payload

$$V = \sqrt{\frac{2 \times F_{Drag}}{\rho \times S_P \times C_D}}$$

$$V = \sqrt{\frac{2 \times (0.6\text{kg}) \times (9.81\text{m/s}^2)}{1.225\text{kg/m}^3 \times (0.02847\text{m}^2) \times (1.5)}} = 15\text{m/s}$$

With these result we accomplish the mission requirements for the first stage



Descent Rate Estimates

Container Descent Rate Estimate

The area formula of the second parachute with spill hole is

$$S_p = \frac{2 \times m \times g}{\rho \times V^2 \times C_D}$$

where

S_p = Area of the parachute with a spill hole (m^2)

D = The diameter of the parachute mm

V = Descent speed m/s

CD = 1.5 Drift coefficient of parachute

ρ = 1.225 kg/m³(Air density at +15 C from sea level)

m =0.600kg Container+Payload

$g=9.81m/s^2$

$S_{(s_H)}$ =Spill hole area

$s_{_Hr}$ =Spill hole radius



Descent Rate Estimates



Container Descent Rate Estimate

Replacing the data gives the following results

$$S_p = \frac{2 \times (0,6\text{kg}) \times \left(9,81 \frac{\text{m}}{\text{s}^2}\right)}{(1,225 \text{kg/m}^3) \times \left(5 \frac{\text{m}}{\text{s}}\right)^2 \times 1,5}$$

$$\textcolor{red}{Sp=0.25626\text{m}^2}$$

The diameter can be calculated from the formula

$$S_p = \frac{1}{4} \pi D^2$$



Descent Rate Estimates

Container Descent Rate Estimate

Clearing terms and replacing the data give us

$$D = \sqrt{\frac{4 \times S_p}{\pi}} = \sqrt{\frac{4 \times 0.25626m^2}{\pi}} = 0,5712109m = 571mm$$

The spill house area is chosen to be 5% of the total parachute area

$$S_{SH} = S_p \times 5\% = 0.25626m^2 * 0,05 = 0,0128m^2$$



Descent Rate Estimates

Container Descent Rate Estimate

The spill house radius can be determined by

$$S_{Hr} = \sqrt{\frac{S_{SH}}{\pi}} = \sqrt{\frac{0,012813\text{m}^2}{\pi}} = 0,06386332\text{m} = \mathbf{63,86\text{mm}}$$

This give us a parachute of a 571 mm in diameter with a spill house radius of 63,86 mm for the second parachute



Descent Rate Estimates



Container Descent Rate Estimate

Now we can estimate the descent speed of the container with the payload

$$V = \sqrt{\frac{2 \times F_{Drag}}{\rho \times S_P \times C_D}}$$

$$V = \sqrt{\frac{2 \times (0.6\text{kg}) \times (9.81\text{m/s}^2)}{1.225\text{kg/m}^3 \times (0.25626\text{m}^2) \times (1.5)}} = 5\text{m/s}$$

With these result we accomplish the mission requirements for the second stage



Mechanical Subsystem Design

Jorge Royon



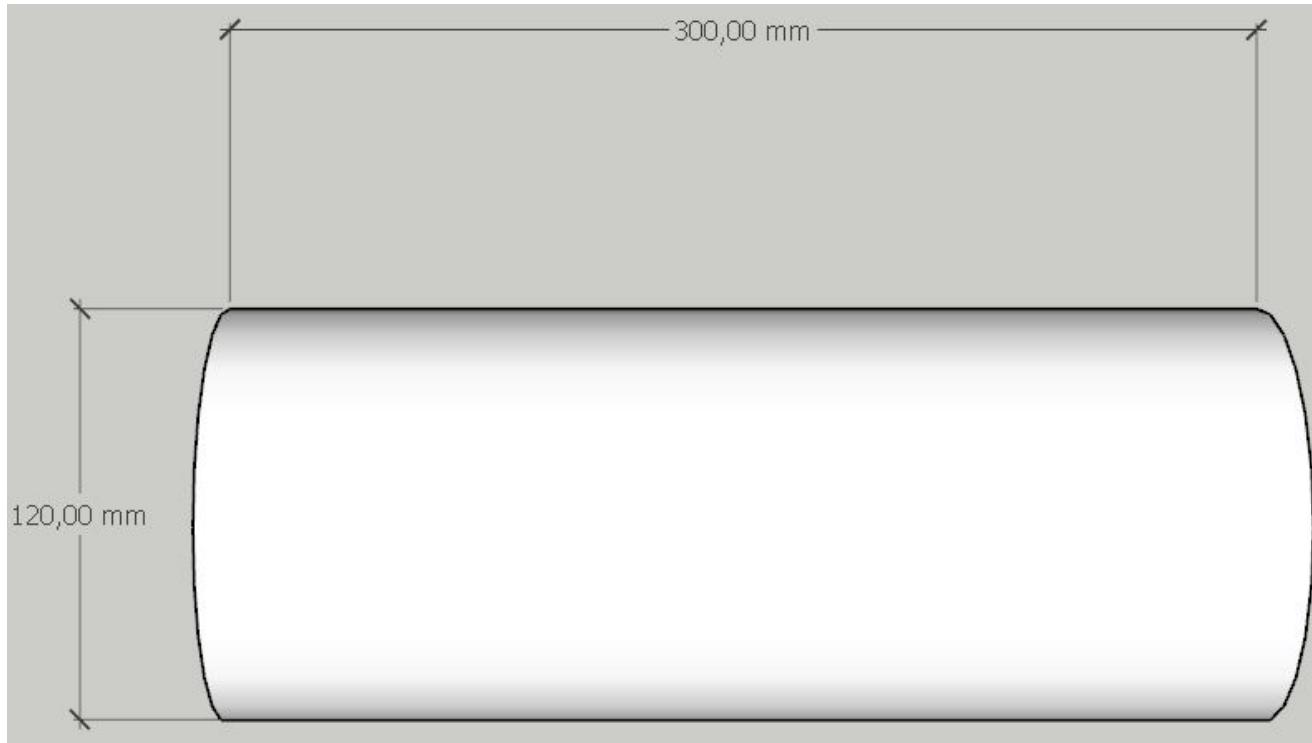
Mechanical Subsystem Overview



CONTAINER

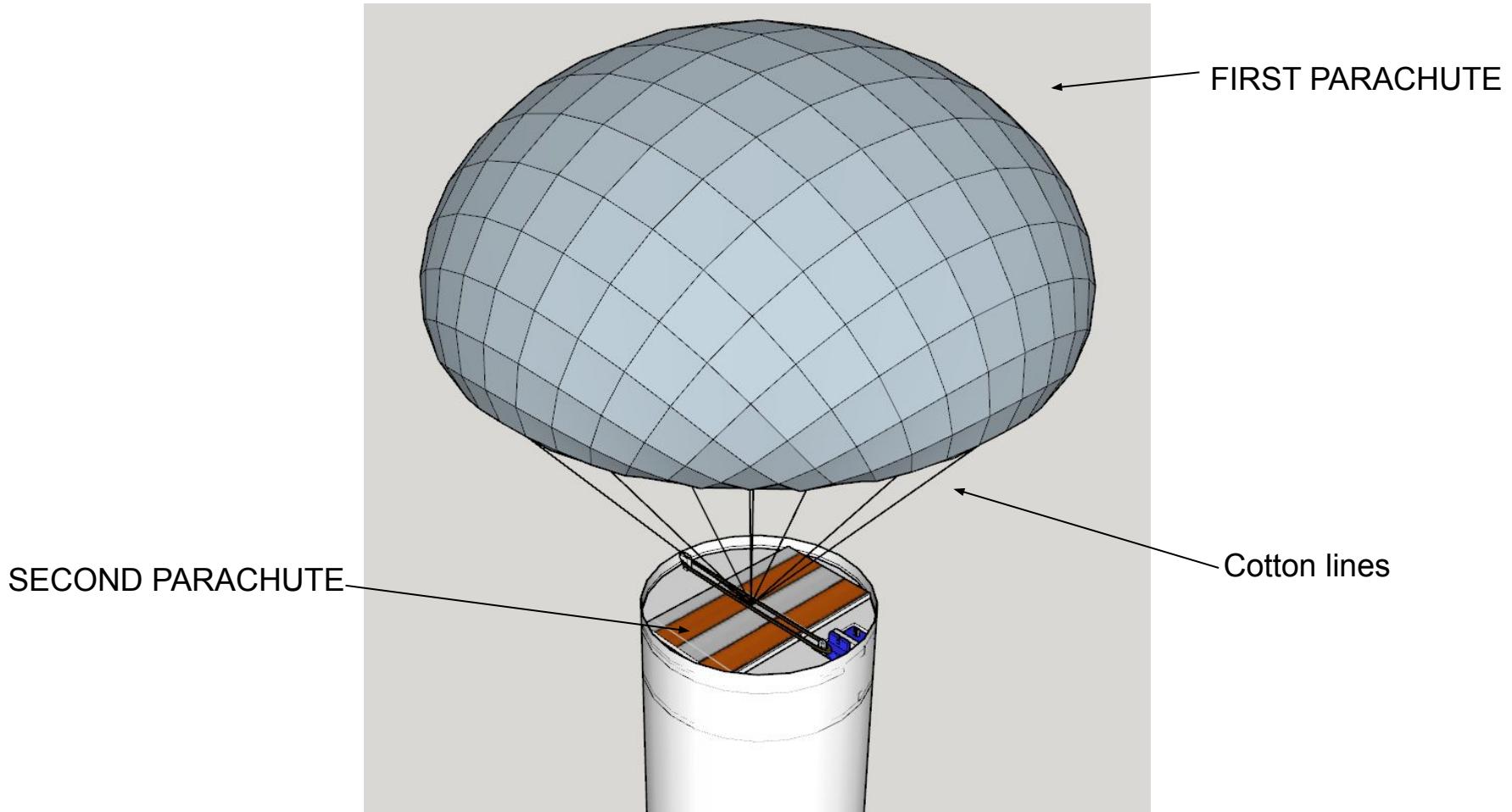
DESCRIPTION:

- 12 cm diameter by 30 cm length
- 3D printed in pla in thin walls of 0,8mm
- Estimate weight of 207,5gr



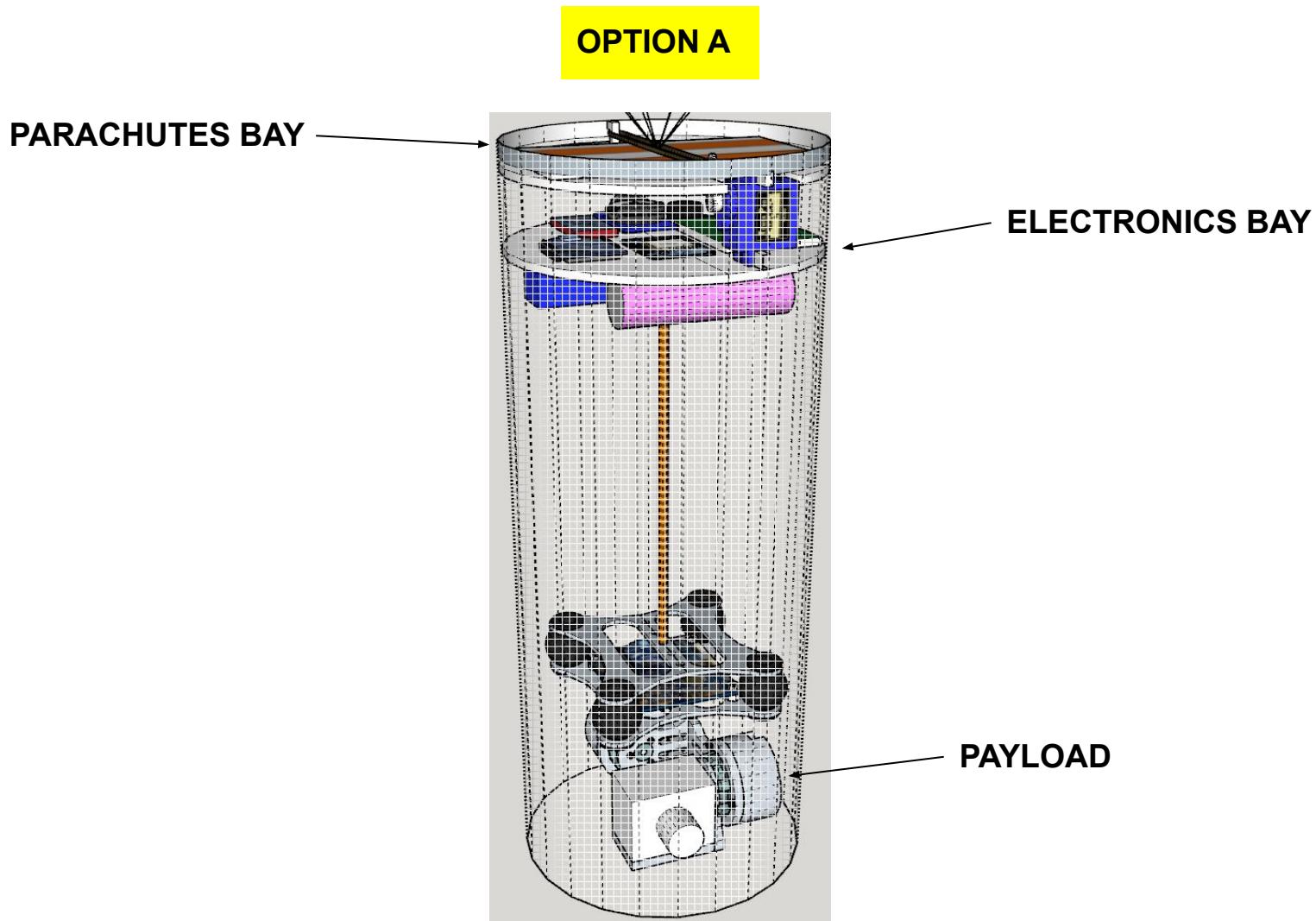
Mechanical Subsystem Overview

CONTAINER



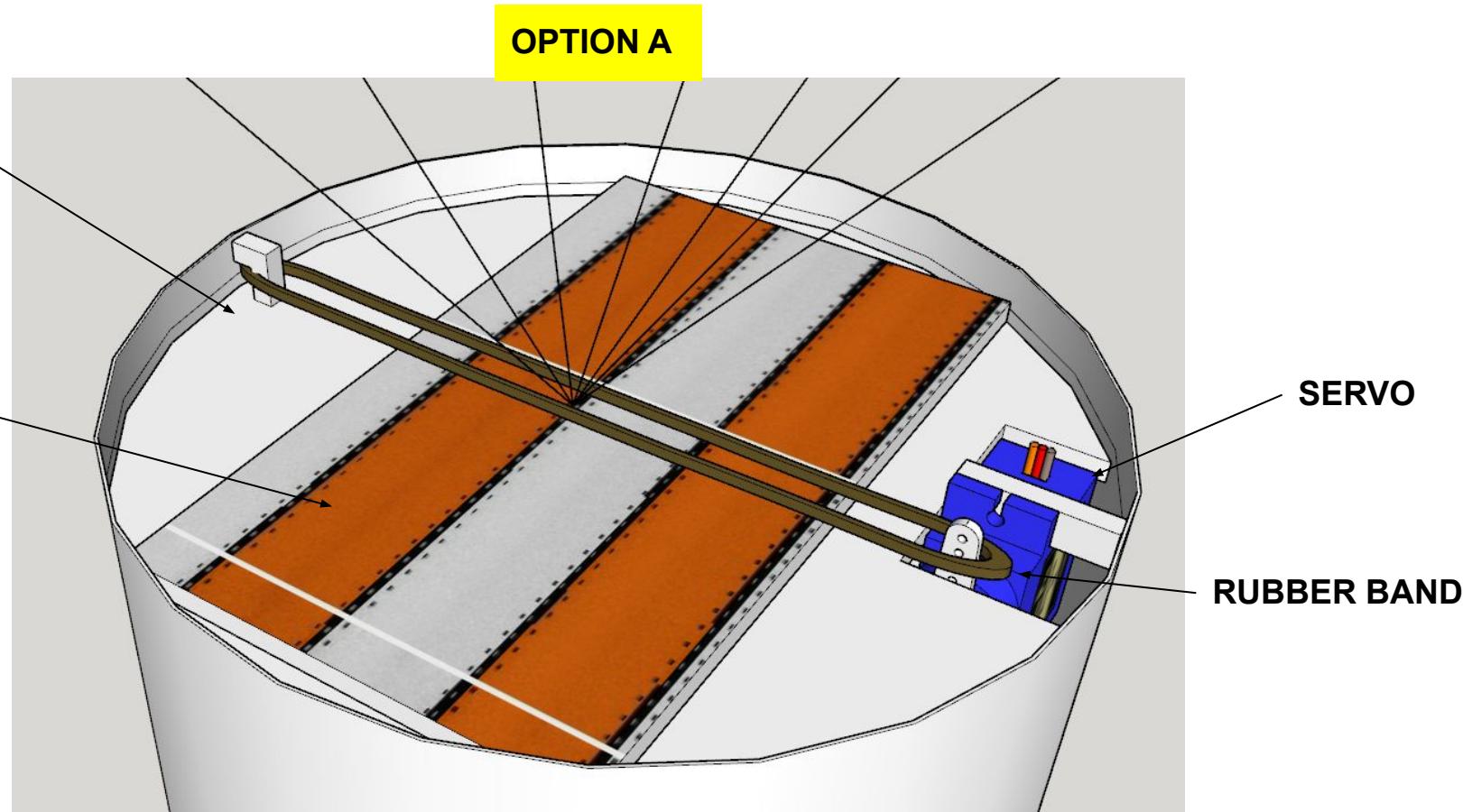


Container Mechanical Layout of Components Trade & Selection



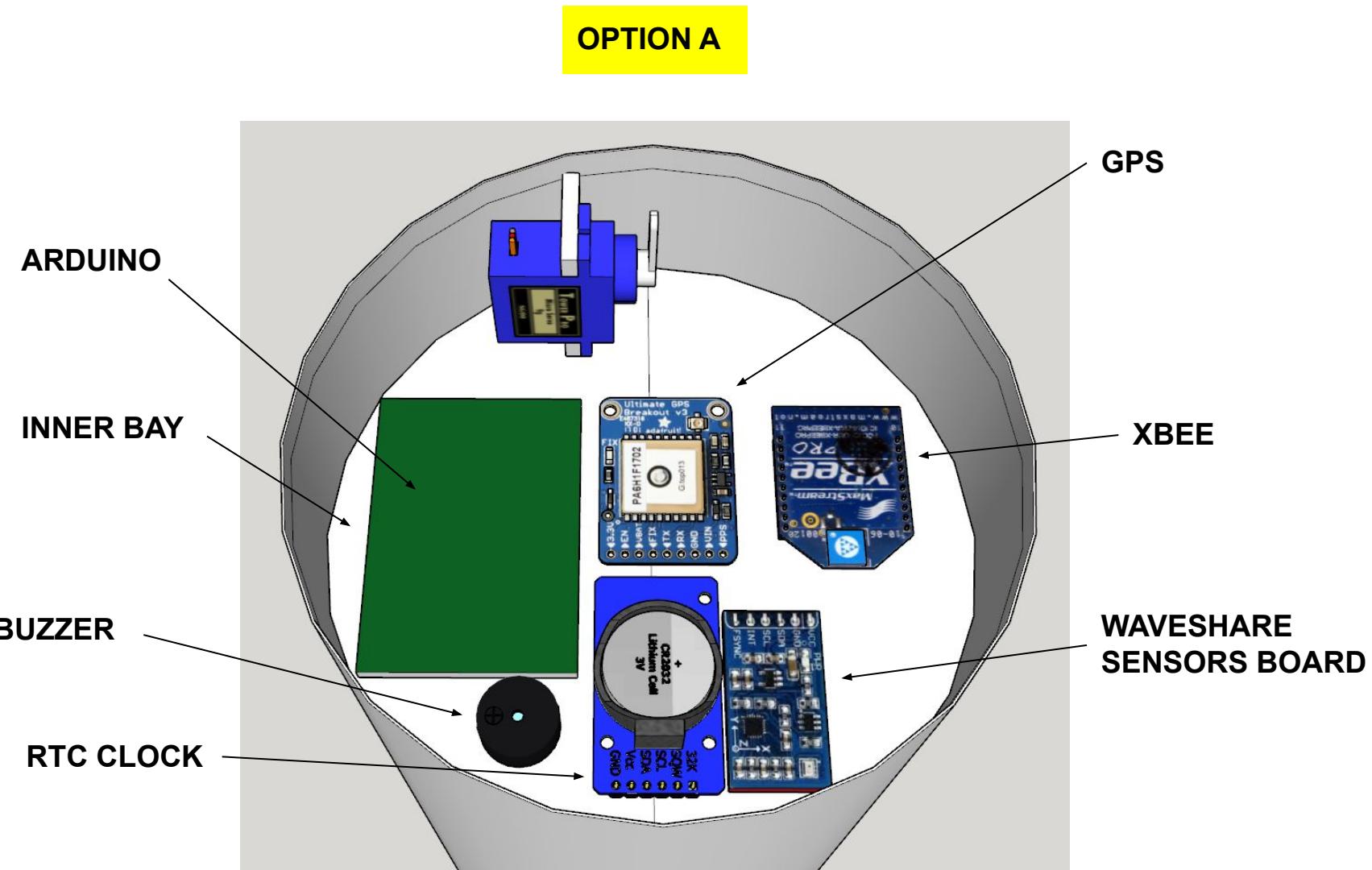


Container Mechanical Layout of Components Trade & Selection





Container Mechanical Layout of Components Trade & Selection

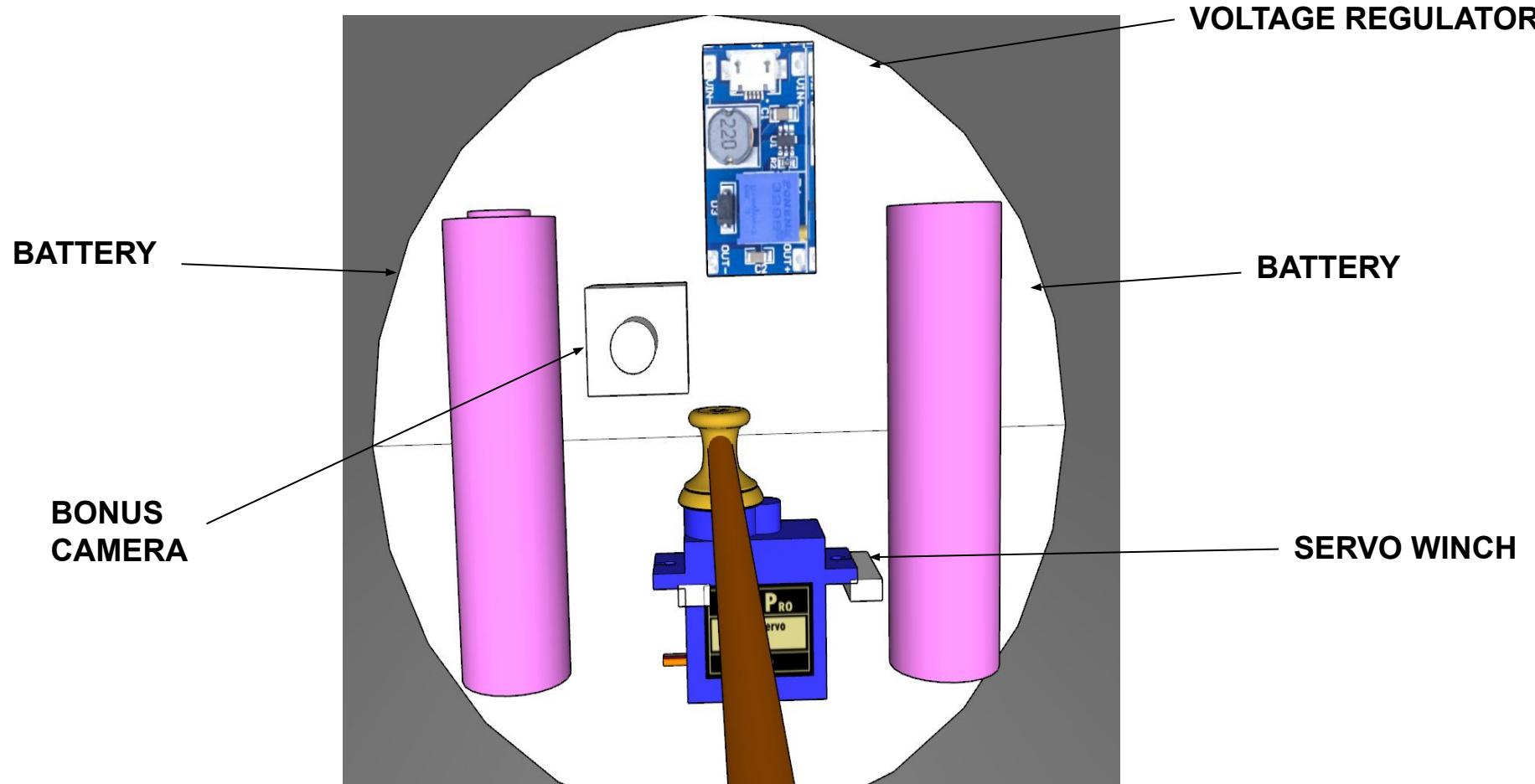




Container Mechanical Layout of Components Trade & Selection



OPTION A



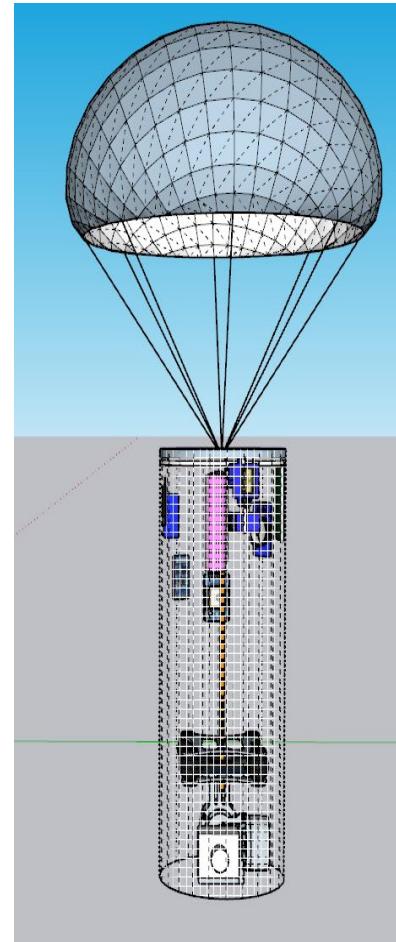


Container Mechanical Layout of Components Trade & Selection



OPTION B

SAME COMPONENTS OF
OPTION A

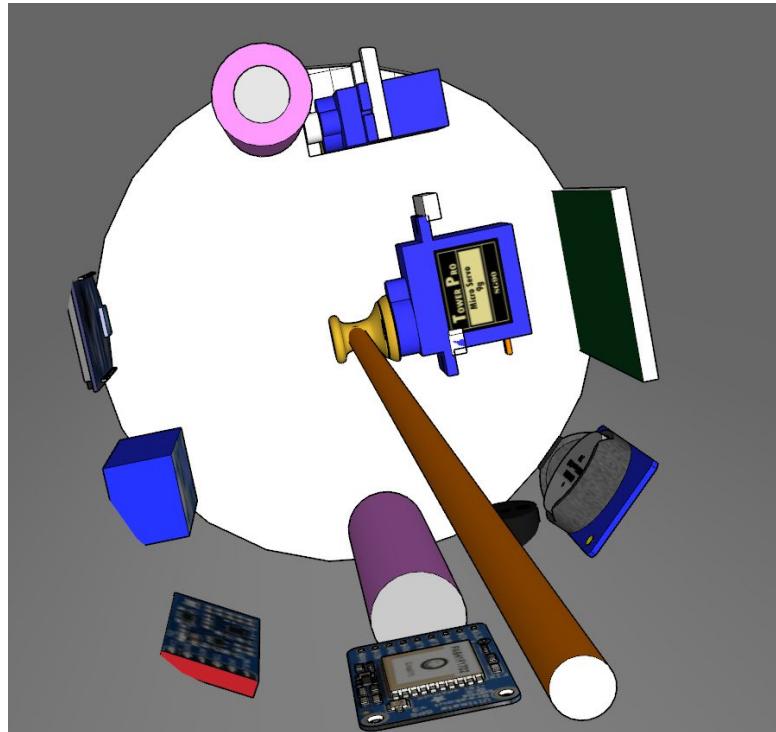




Container Mechanical Layout of Components Trade & Selection



OPTION B



INSTEAD OF USING AN ELECTRONIC BAY WE CONSIDER TO GLUE THE COMPONENTS TO THE CONTAINER WALLS



Container Mechanical Layout of Components Trade & Selection



Container Design

OPTION	Pros	Cons
A	Simple design Easy to manipulate electronics	Heavier
		Takes more time
		Need to design a second bay
B	One bay for the parachutes	Need extra glue
		Electronics are hard to manipulate

We choose design A because electronics are agrupated and easy to manipulate



Container Mechanical Layout of Components Trade & Selection



CONTAINER MATERIALS

MATERIAL	PROS	CONS
PLA	Easy to print	Heavy
	3D printed, tight tolerances is easy to achieve	Relative weak
ABS	Hard to print	Must be printed in parts due vertical warping in printing process
	3D printed, tight tolerances is easy to achieve	Acceptable strength
Carbon fiber	Extreme lightweight	expensive
	Strong	Hard to work it

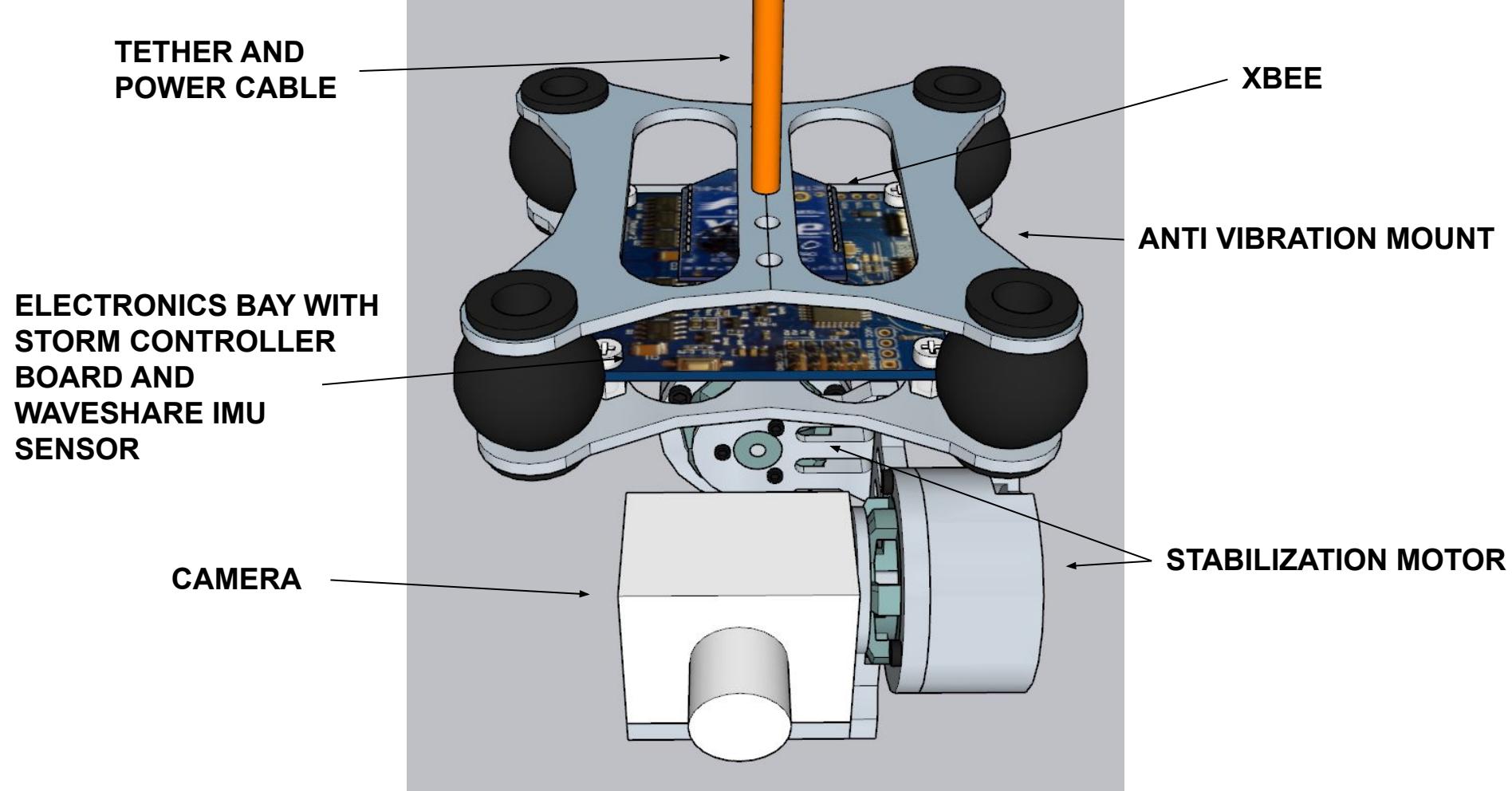
We choose pla for the advantages of manufacturing and the ability to achieve tight tolerances



Payload Mechanical Layout of Components Trade & Selection



OPTION A

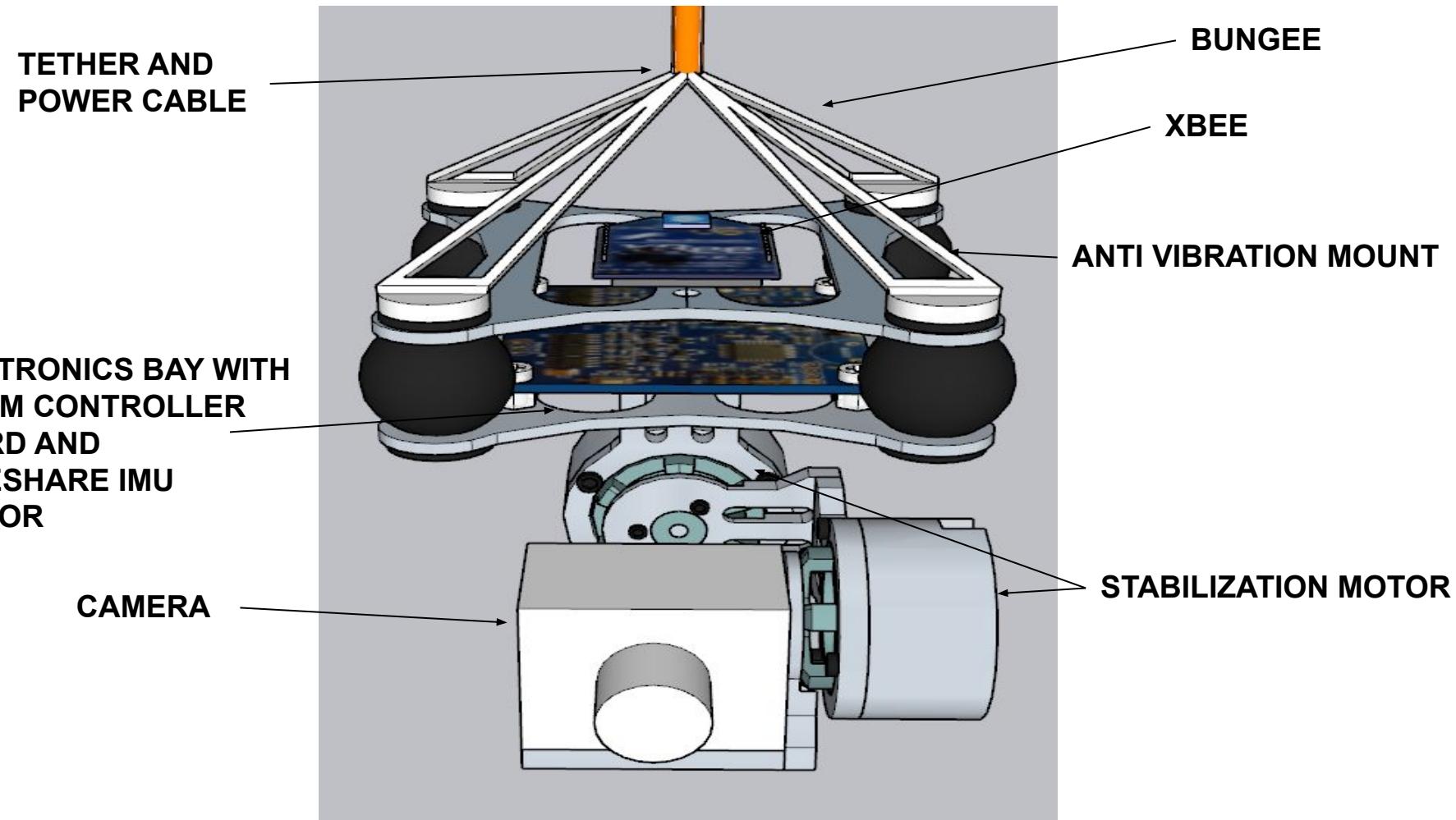




Payload Mechanical Layout of Components Trade & Selection



OPTION B





Payload Mechanical Layout of Components Trade & Selection



Payload Design

OPTION	Pros	Cons
A	Simple design	more unstable
B	Two bays for the electronics	Need a 3d printed bungee for attach the tether
	Electronics are hard to manipulate	Chance to get stuck inside the container

We choose design A because option B has more risk to the payload get stuck inside the container



Payload Mechanical Layout of Components Trade & Selection



Payload Materials

OPTION	Pros	Cons
ALUMINIUM	STRONG	Expensive machining process
	LIGHTWEIGHT	
3D PRINTED	Cheap	Weak, can break in a violent move

We option A because is stronger and lightweight



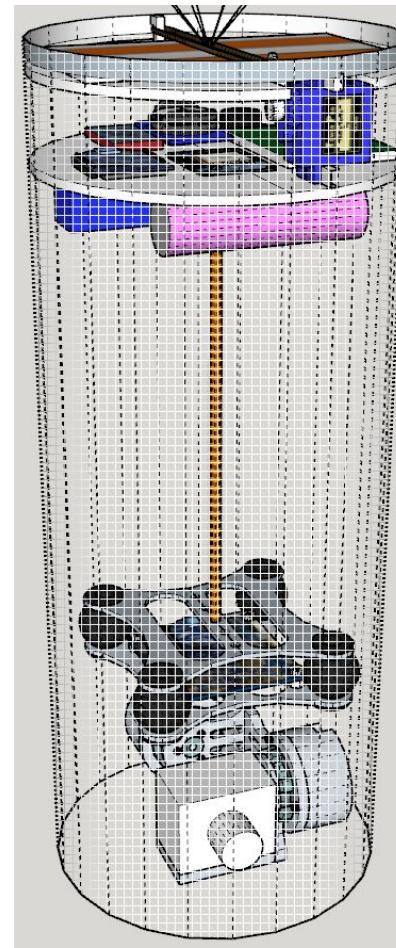
Payload Pre Deployment Configuration Trade & Selection



OPTION A

DESCRIPTION:

- Payload is stowed via a tether that is attach to a winch in a servo that spin in 360°





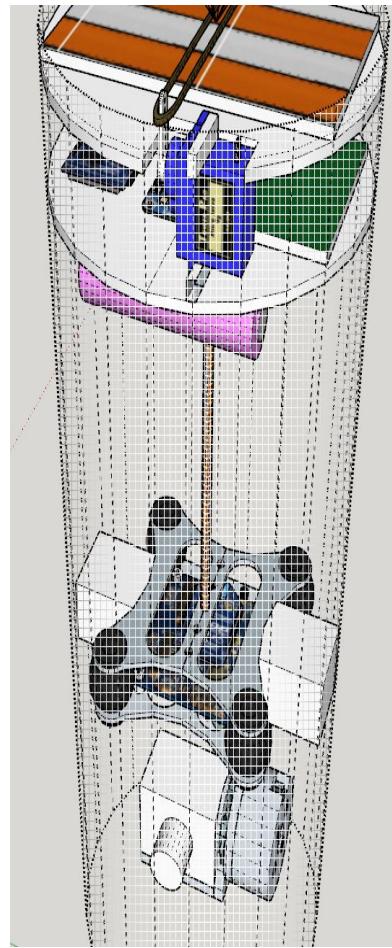
Payload Pre Deployment Configuration Trade & Selection



OPTION B

DESCRIPTION:

- Payload is stowed via a tether that is attach to a winch in a servo that spin in 360° and with balsa block to guide it and prevent it from bouncing





Payload Pre Deployment Configuration Trade & Selection



Payload Materials

OPTION	Pros	Cons
A	Easy to stow and deploy	Payload can bounce inside the container
	LIGHTWEIGHT	
B	Prevent bouncing inside the container	Can stuck in deployment

We option A because exist risk of stuck in option B

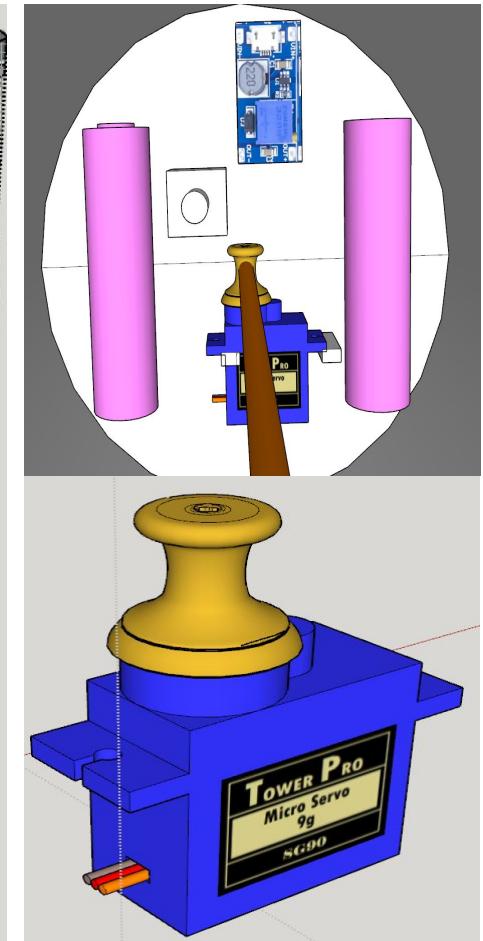
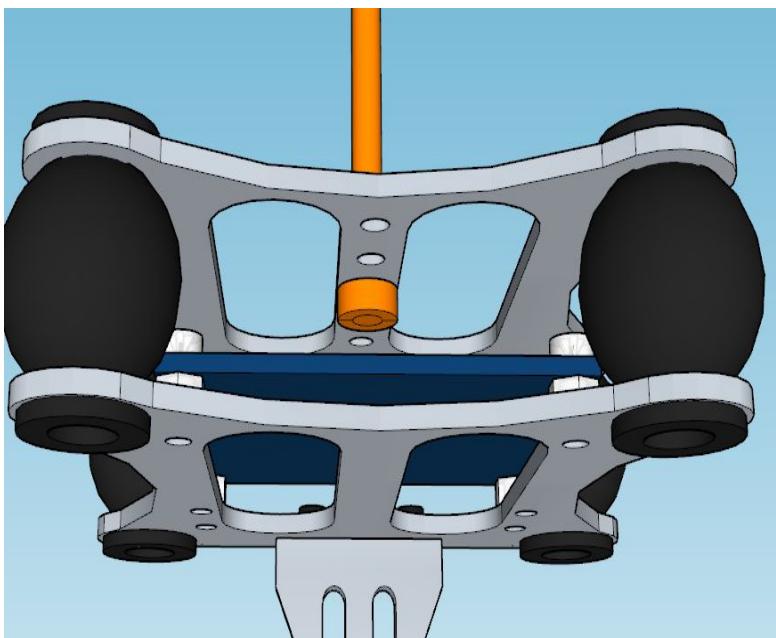


Payload Deployment Configuration Trade & Selection



DESCRIPTION:

- The payload is attached to one end of the tether with a 3D printed bulb of TPU, the same material of the tether and locked with glue and a servo with a spool rolls to tangle or untangle the tether so the payload be deployed or retracted as wish



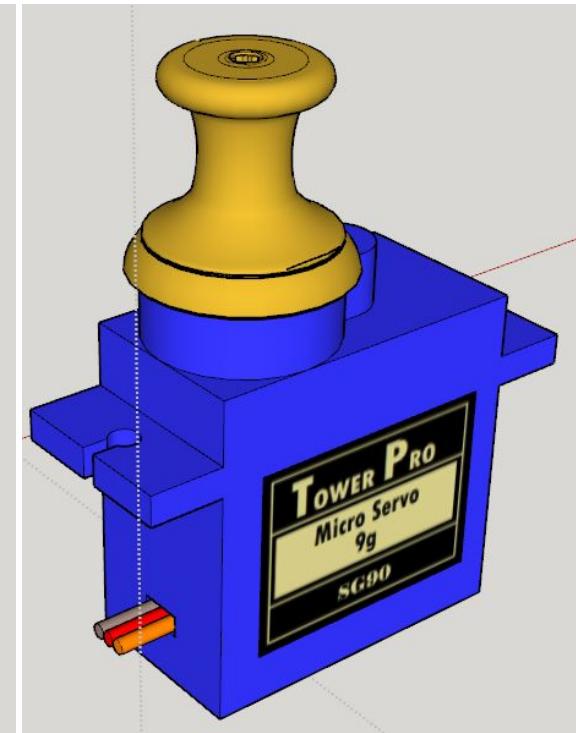
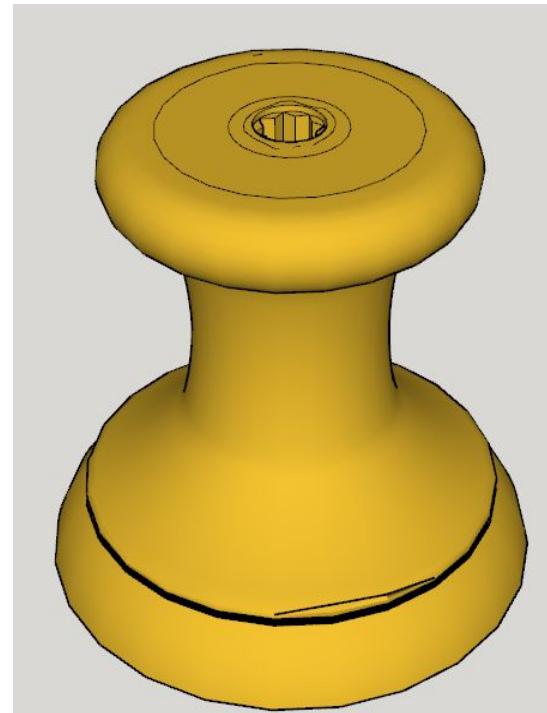


Tether Design Trade & Selection



Description:

- A special designed spool is used as servo arm on a modified servo that spins in continuous rotation in both directions that allows the tether to be tangled or untangled. A tiny and very flexible awg 35 cable with shrink tube will be used to give power to the payload, and for the tether material will choose TPU printing filament because is very flexible and can withstand high forces before fail



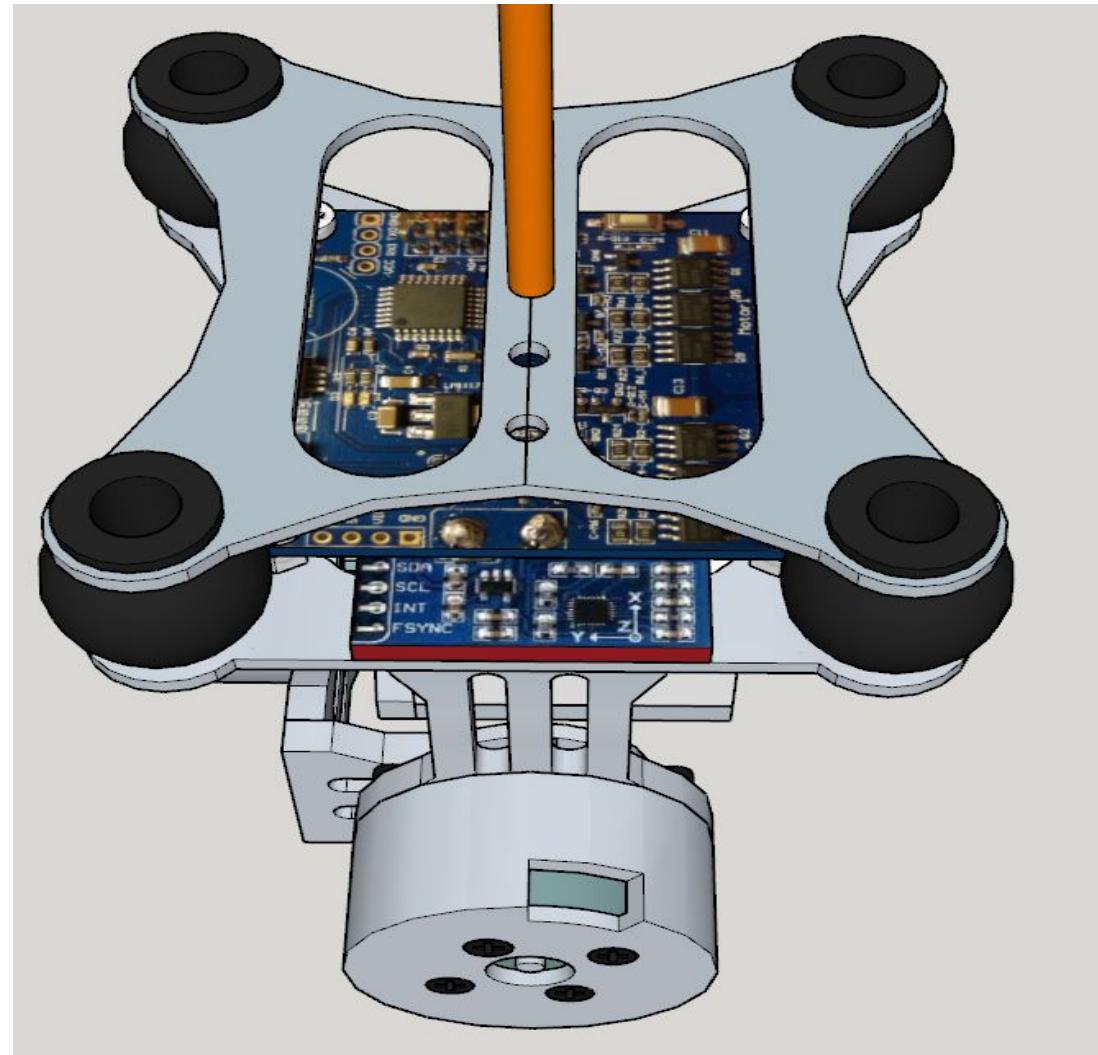


Tether Design Trade & Selection



Description:

- For keeping the descent speed of the payload to the mission requirement in the camera gimbal is a Waveshare IMU sensor board which can measure the altitude very precisely and with a PID algorithm in the arduino we can achieve precise speed under all circumstances accelerating or decelerating the servo rotation





Tether Material Trade & Selection



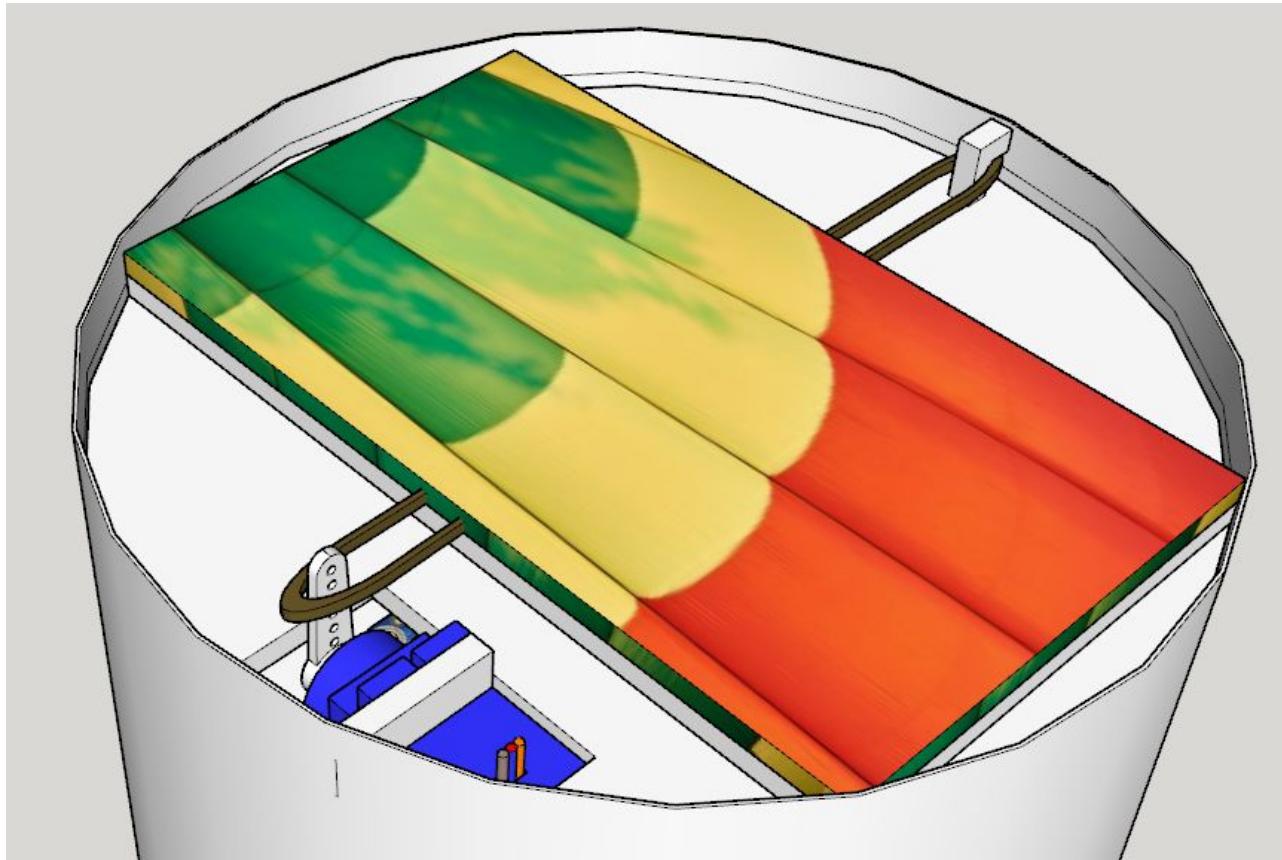
Tether Materials

OPTION	Pros	Cons
3D Printer TPU filament	Easy to stow and deploy due his flexibility	Expensive
	Strong	
Carbon Fiber	Extremely strong	Expensive
	lightweight	
Cotton	Cheap	Weak
	Easy to tangle and untangle	

We choose the 3D printer tpu filament because its flexibility that absorb shock and can be easy to tangle



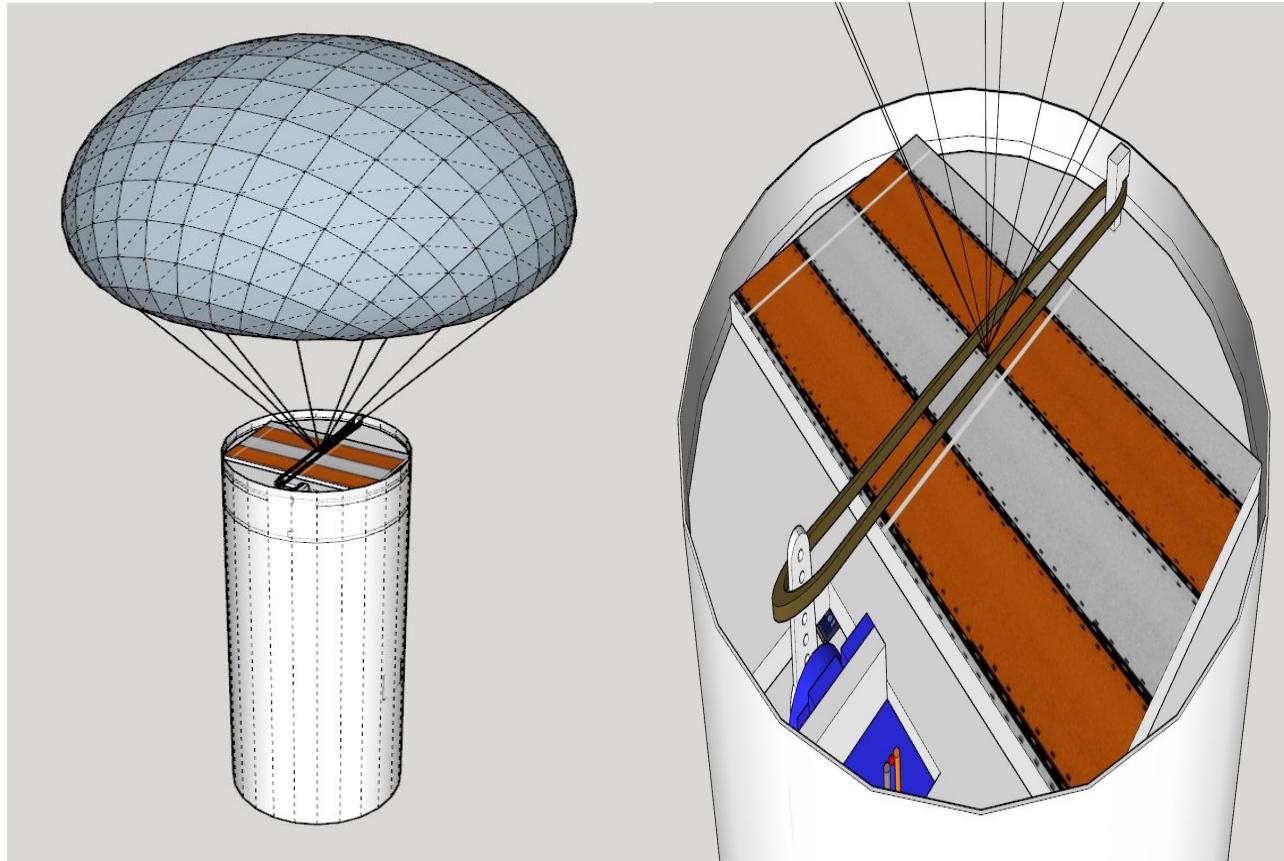
Container First Parachute Attachment Mechanism



The first parachute is tangled to the second parachute, that leaves the first parachute free to open when rocket releases the container



Container First Parachute Attachment Mechanism



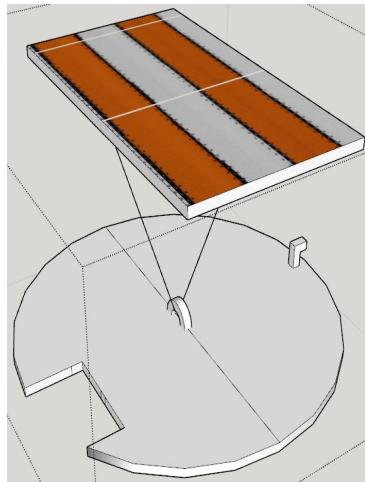
When the container is released the parachute deploy and keeps it place due the rubber band that is locked with a hook a rubber band and a servo



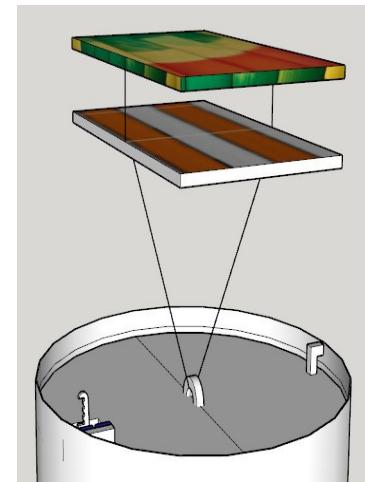
Container Second Parachute Deployment Mechanism Trade and Selection



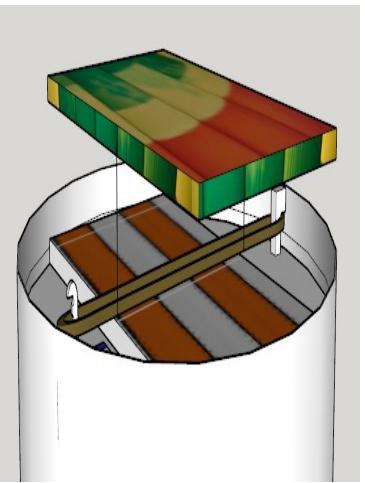
1)The second Parachute is folded and tied to the hook of the parachute bay



2)The parachute bay is secured with screw to the container, the first parachute is folded and tied to the second one



3)The second parachute is locked with a rubber band

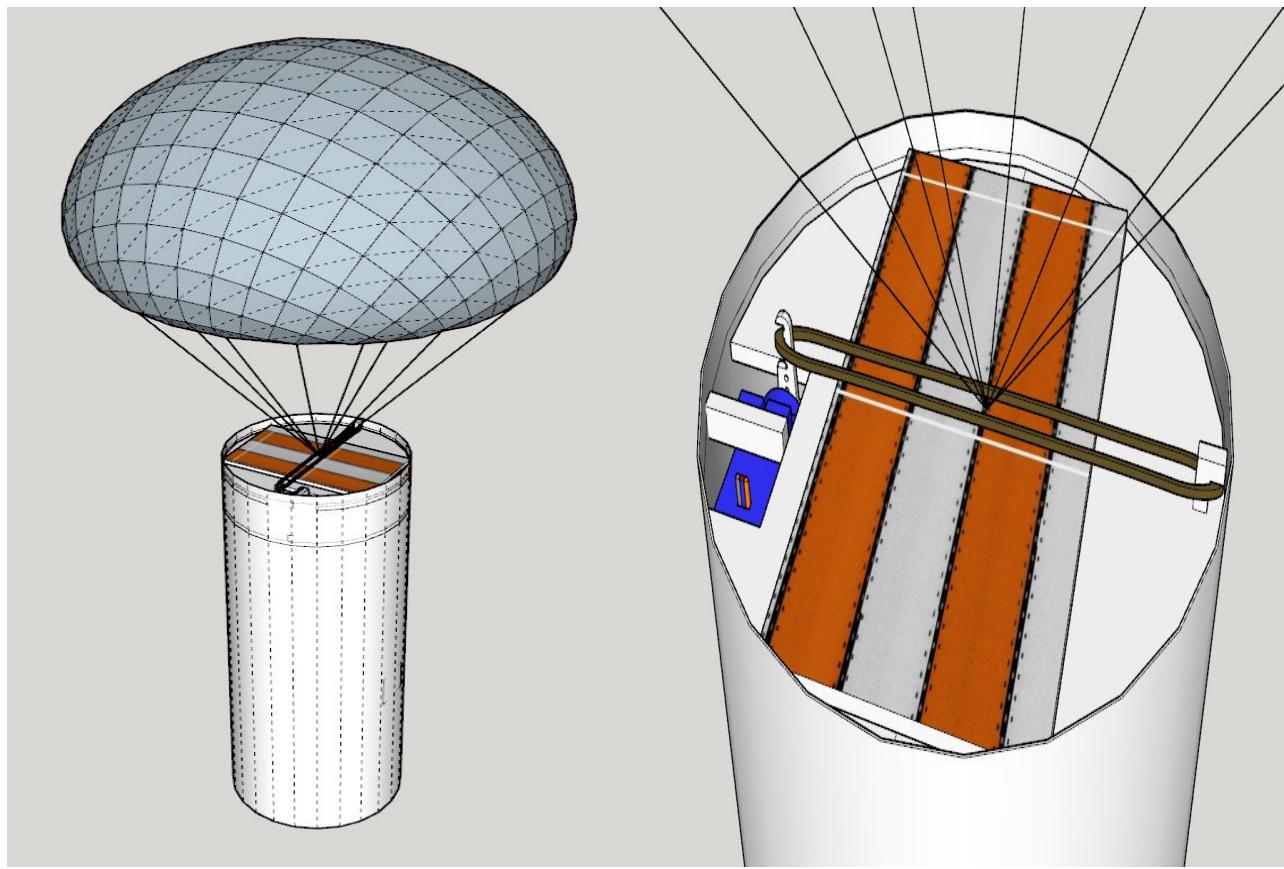


4)The first Parachute is folded and placed upside the second parachute on the top container





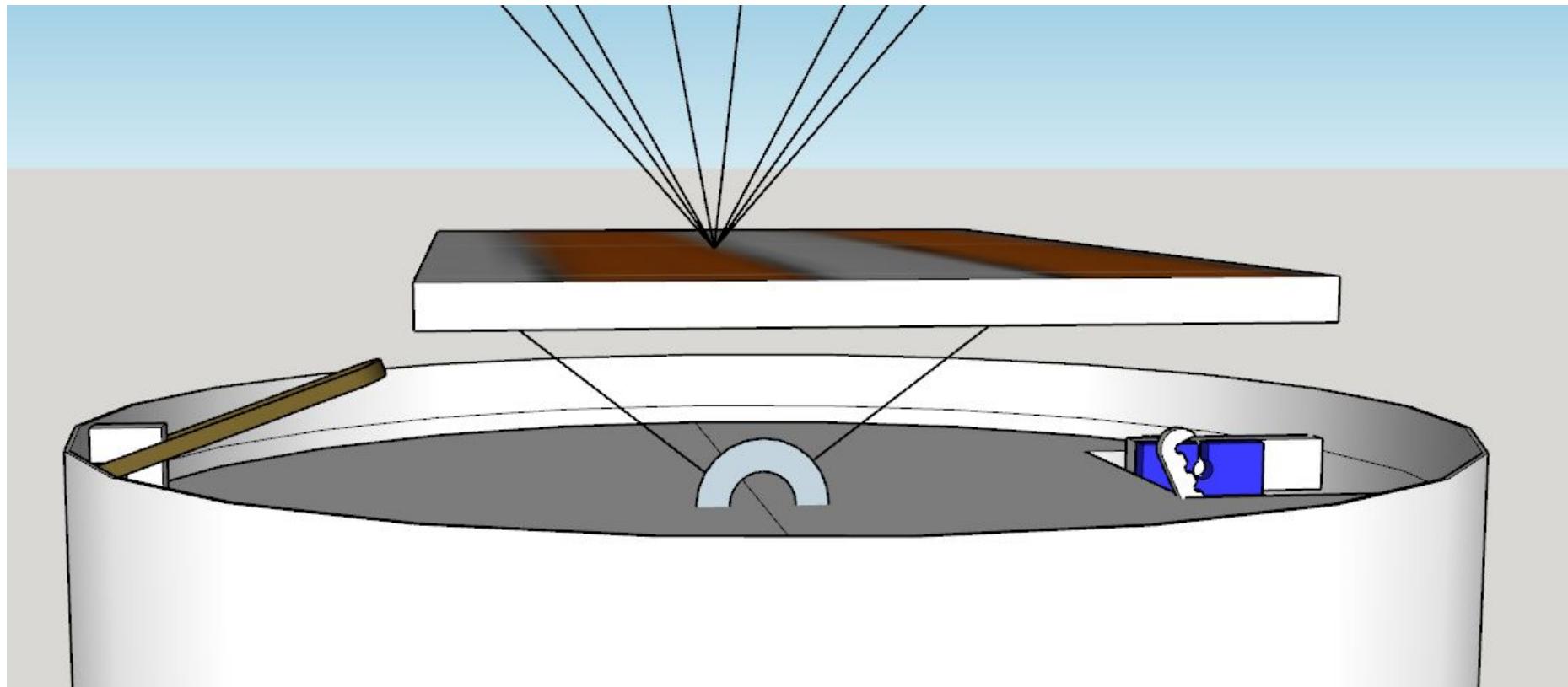
Container Second Parachute Deployment Mechanism Trade and Selection



When launched the first parachute is deployed and put tension on the second parachute that is locked with the rubber band



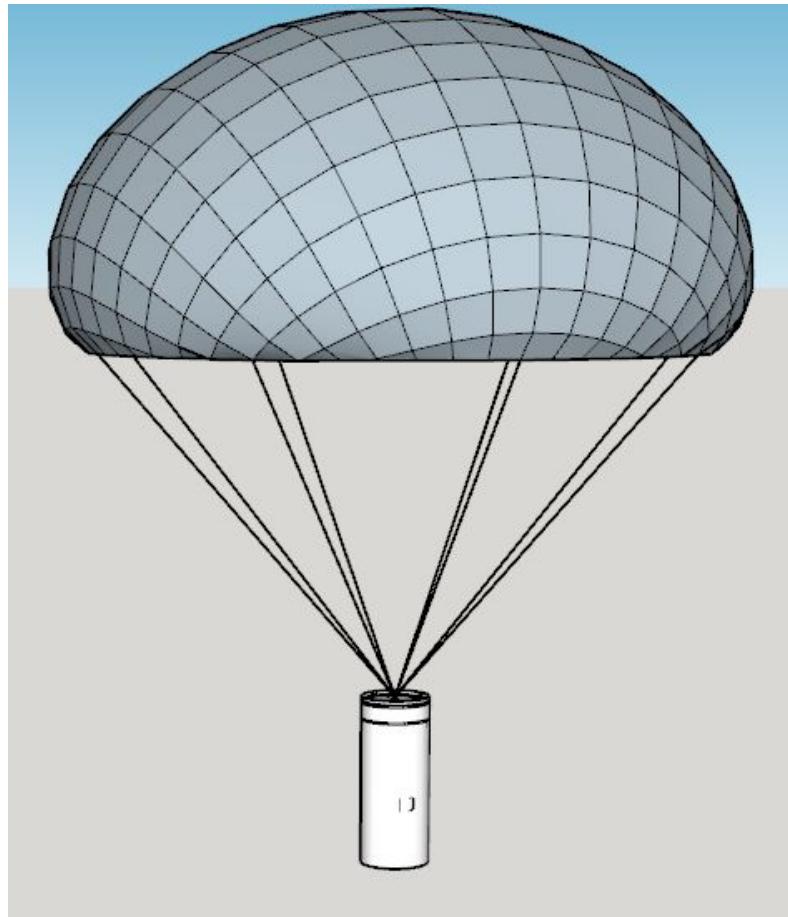
Container Second Parachute Deployment Mechanism Trade and Selection



Then the servo releases the rubber band and the first parachute pulls out the second one and because is only tangled in horizontal way to the second the cottom lines releases the first parachute



Container Second Parachute Deployment Mechanism Trade and Selection



Then the second larger parachute fully deploy and the container descend



Electronics Structural Integrity



Securing Electrical Connections

- Depending on the connection components, proper methods for securing will be used.

Electrical connection methods are:

- Soldering
- Cyanoacrylate
- Electric tape
- Heat shrink tube
- hot glue



Mass Budget



PAYOUT MASS

PART	mass gr	Data type
XBee	40	D
10 DOF IMU Sensor	4	D
Storm32 Controller	2	D
Brushless motor (x3)	93	D
Air frame	80	E
Camera	13	D
TOTAL PAYLOAD MASS	232 gr	

D:Datasheet
E:Estimated



Mass Budget



CONTAINER MASS

PART	mass gr	Data type
XBee	40	D
10 DOF IMU Sensor	1	D
Arduino mega 2560 mini	5	D
18650 battery (x2)	96	D
Frame	139,5	E
Container first parachute	2	E
Adafruit Ultimate GPS	8,5	D
Servo (x2)	18	D
Tether	2	E
Buzzer	15	D



Mass Budget



CONTAINER MASS

PART	mass gr	Data type
3D printed parts	3	E
Container first parachute	4	E
misc, (cotton wires, screw)	8	E
Real time clock	8	d
Camera	13	D
TOTAL CONTAINER MASS	363 gr	



Mass Budget



CANSAT MASS

PART	Mass gr
PAYOUT	232
CONTAINER	363
TOTAL	595

Total mass of the cansat is estimated in 595 gr, to reach the 600 gr mark we can add little plumbs in the container, and if its too heavy we can make holes in the lateral walls of the container and cover them with MONOKOTE to reduce weight

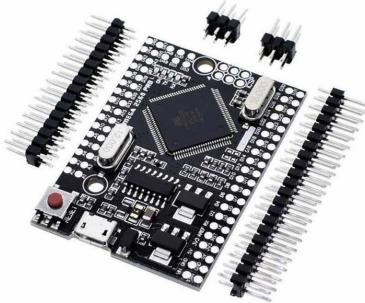


Communication and Data Handling (CDH) Subsystem Design

**Jorge Royon
Enzo Juarez
Juan Esteban Yurquina**



Container Command Data Handler (CDH) Overview



Arduino Mega 2560 Mini



XBee PRO S2C

Arduino 2560 mega mini: An Arduino mega, is used to get data from sensors, transmit it to the XBee PRO S2C and control the container.

A XBee PRO S2C module is a transceiver. It is used to transmit and receive data between the payload and the ground station.

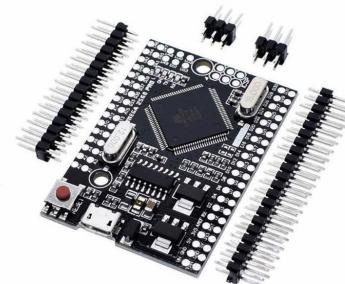


Container Processor & Memory Trade & Selection



MODEL	BOOT TIME	PROCESSOR SPEED	I/O PINS	INTERFACES	MEMORY STORAGE REQUIRED	SUPPLY VOLTAGE	COST
Arduino Nano	4.84 s	16 MHz	Analog In[8] PWM [6] Digital[62]	I2C [1] SPI [1] UART [1]	Flash-32 KB SRAM-2 KB EEPROM-1 KB	5V-9V	\$ 22,00
Arduino Mega 2560 mini	3.50 s	16 MHz	Analog In[16] PWM [14] Digital[70]	I2C [1] SPI [5] UART [4]	Flash-256 KB SRAM-8 KB EEPROM-4 KB	5V-12V	\$ 24,93

We choose Arduino Mega 2560 mini due to availability and performance

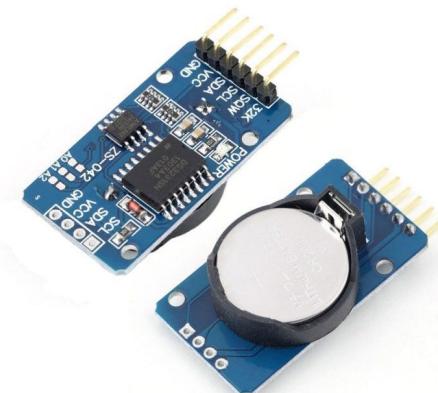




Container Real-Time Clock

MODEL	TYPE	VOLTAGE	CURRENT	ACCURACY	RESET TOLERANCE	COST
Raspberry DS1307	Hardware	5V	300 µA	±2 ppm	In reset condition external clock continues keeping time	\$ 2,20
Arduino RTC DS 3231	Hardware	3,3V	200 µA	±2 ppm	In reset condition external clock continues keeping time	\$ 2,00

We chose the Arduino DS 3231 because it is cheaper, consumes less energy, and is enough for what we need



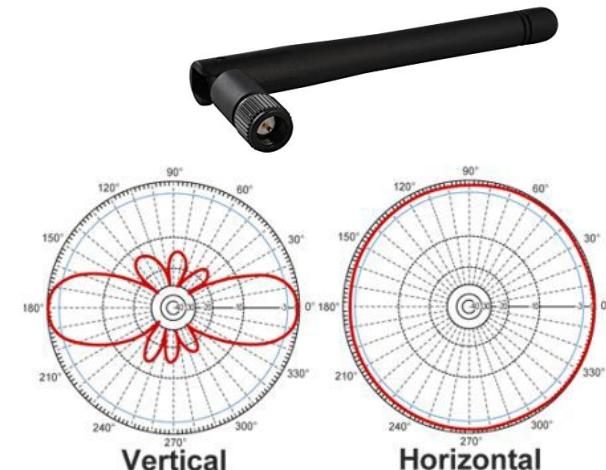


Container Antenna Trade & Selection



MODEL	CONNECTION TYPE	FREQUENCY	DIRECTION	GAIN	BEAM WIDTH HORIZONTAL/VERTICAL	COST
LGTERK WiFi Antenna	RP - SMA	2.4 GHz	Omnidirectional	5dBi	360°/32°	\$9.59
Generic 2.4GHz	RP - SMA	2.4 GHz	Omnidirectional	2dBi	360°/32°	\$2.00

We chose the generic antenna because we can peel off the plastic cover of the antenna to fit inside the container, plus the xbee's range exceeds the operational limit easily, so not as much gain is needed. Transmit power of XBee S2C is 250 mW 24dBm software selectable





Container Radio Configuration



- **XBEE radio selection:** XBee PRO S2C
- **NETID:** 1064 Container and 6064 for Payload
- **TRANSMISSION CONTROL:** The XBee in the container is set as Coordinator and the XBee in the ground station is set at Endpoint In all of the mission phases the Coordinator transmits the telemetry data to the Endpoint. In addition, the coordinator in the container receives the data from the modules in the payload while they are in flight and sends it to the ground station.
- **Data rate:** The xbee in the container is set to transmit de data to the ground station at 1 Hz transmission rate and 4 Hz when payload deployed
- Both xbees communicate in unicast mode



Container Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<TEAM_ID>	1064	Is the assigned team identification.
<MISSION_TIME>	08:12:55	Is UTC time in format hh:mm:ss, where hh is hours, mm is minutes, and ss is seconds.
<PACKET_COUNT>	1485	Is the count of transmitted packets, which is to be maintained through processor reset. One count is used for transmission of all packets, regardless of type.
<PACKET_TYPE>	C	Is the ASCII character 'C' for Container telemetry, character 'T' for tethered Payload (deployed first) relayed telemetry at 4 Hz.
<MODE>	F	= 'F' for flight (the default mode upon system start) and 'S' for simulation
TP_RELEASED	R	= 'N' for not released and 'R' for released



Container Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<ALTITUDE>	84.2	is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.
<TEMP>	24.3	is the temperature in degrees Celsius with a resolution of 0.1 degrees C.
<VOLTAGE>	4.45	is the voltage of the CanSat power bus. The resolution must be 0.01 volts.
<GPS_TIME>	08:12:55	is the time generated by the GPS receiver. The time must be reported in UTC and have a resolution of a second.
<GPS_LATITUDE>	25.0458	is the latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.
<GPS_LONGITUDE>	-160.5804	is the longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.



Container Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<GPS_ALTITUDE>	84.2	is the altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters.
<GPS_SATS>	6	is the number of GPS satellites being tracked by the GPS receiver. This must be an integer number.
<SOFTWARE STATE>	LAUNCH_WAIT	is the operating state of the software. (e.g., LAUNCH_WAIT, ASCENT, ROCKET_SEPARATION, DESCENT, TP_RELEASE, LANDED, etc.). Teams may define their own states.
<CMD_ECHO>	CMD1000SIMP1 0 1325	is the fixed text command id and argument of the last received command with no commas.



Container Telemetry Format



- **Data format**

<TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>,
<PACKET_TYPE>, <MODE>, <TP_RELEASED>, <ALTITUDE>,
<TEMP>, <VOLTAGE>, <GPS_TIME>, <GPS_LATITUDE>,
<GPS_LONGITUDE>, <GPS_ALTITUDE>, <GPS_SATS>,
<SOFTWARE_STATE>, <CMD_ECHO>

- **Telemetry data file name for the Container:**

- for Container: Fligth_1064_C.csv

- Data from payload shall transmit continuously at 4Hz sample rate



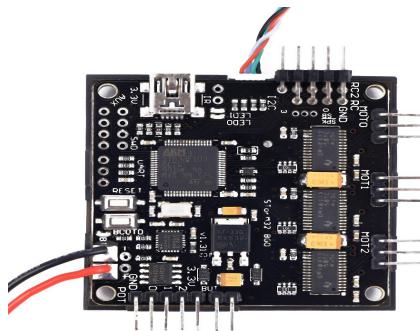
Container Command Formats



COMMAND	DESCRIPTION	DATA INCLUDED	DATA SAMPLE
CX	Container Telemetry On/Off Command	<ON_OFF> is the string ‘ON’ to activate the Container telemetry transmissions and ‘OFF’ to turn off the transmissions.	CMD,1064,CX,ON
ST	Set Time	<UTC_TIME> is UTC time in the format hh:mm:ss where hh is hours, mm is the minutes and ss is the seconds.	CMD,1064,ST,13:35:59
SIM	Simulation Mode Control Command	<MODE> is the string ‘ENABLE’ to enable the simulation mode, ‘ACTIVATE’ to activate the simulation mode, or ‘DISABLE’ which both disables and deactivates the simulation mode.	CMD,1064,SIM,ENABLE
SIMP	Simulated Pressure Data	<PRESSURE> is the simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.	CMD,1064,SIMP,101325



Payload CDH Overview



Storm32 Control Board



XBee³

A Storm32 Control Board, is used to get data from sensors and transmit it from the XBee³ to the container.

An XBee³ module is used to transmit data to the payload and to the ground station.

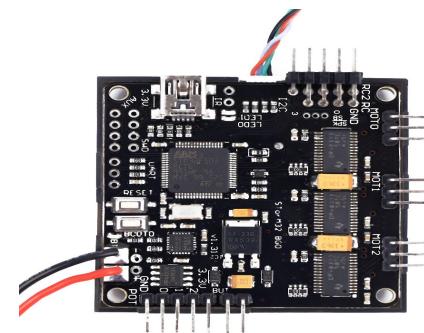


Payload Processor & Memory Trade & Selection



MODEL	BOOT TIME	PROCESSOR SPEED	I/O PINS	INTERFACES	MEMORY STORAGE REQUIRED	SUPPLY VOLTAGE	COST
Arduino Mega 2560 mini	3.50 s	16 MHz	Analog In[16] PWM [14] Digital [70]	I2C [1] SPI [5] UART [4]]	Flash- 256KB SRAM- 8KB EEPROM- 4KB	SV-12V	\$ 24,93
Storm32	4.84 s	16 MHz	Analog In[8] PWM [6] Digital[62]	I2C [1] SPI [1] UART [1]	Flash-32 KB SRAM-2 KB EEPROM-1 KB	5V-9V	\$ 22,00

We chose the Arduino Storm32 it is more compact and cheaper. It is not as complete as the Arduino Mega mini, but for what we need in the payload it is enough.



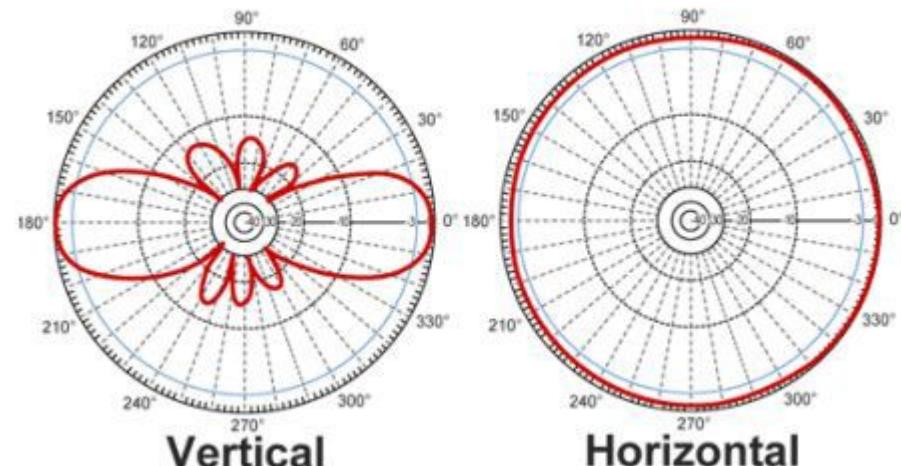


Payload Antenna Trade & Selection



MODEL	CONNECTION TYPE	FREQUENCY	DIRECTION	GAIN	BEAM WIDTH HORIZONTAL/VERTICAL	COST
Generic 2.4GHz	RP - SMA	2.4 GHz	Omnidirectional	2dBi	360°/32°	\$2.00
Antenna of XBee ³ module	-	2.4 GHz	Omnidirectional	2dBi	360°/32°	\$0.00

We chose to use the antenna that is included in the XBee module because in this way we reduce costs and and it is enough to cover our needs.





Payload Radio Configuration



- **XBEE radio selection:** XBee³
- **NETID:** 6064
- **TRANSMISSION CONTROL:** The XBEEs in the Payload are set as Endpoint and the XBee in the container is set at Coordinator. In all of the mission phases the Endpoints transmit the telemetry data only to the Coordinator, while they are in flight and then, the Coordinator sends it to the ground station.
- **Data rate:** The XBEEs in the Payload are set to transmit data to the container at 4 Hz transmission rate
- All the XBEE communicate in unicast mode



Payload Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<TEAM_ID>	1064	Is the assigned team identification.
<MISSION_TIME>	13:15:55	Is UTC time in format hh:mm:ss, where hh is hours, mm is minutes, and ss is seconds.
<PACKET_COUNT>	4237	Is the count of transmitted packets, which is to be maintained through processor reset. One count is used for transmission of all packets, regardless of type.
<PACKET_TYPE>	T	is the ASCII character 'C' for Container telemetry, character 'T' for Tethered Payload relay telemetry, and character 'X' for optional custom packets.
<TP_ALTITUDE>	84.1	Is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.
<TP_TEMP>	28.5	Is the measured temperature in degrees Celsius with a resolution of 0.1 degrees C.



Payload Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<TP_VOLTAGE>	4.45	is the voltage of the CanSat power bus. The resolution must be 0.01 volts.
<GYRO_R>	1	are the gyro readings in degrees per second for the roll, pitch, and yaw axes
<GYRO_P>	1	are the gyro readings in degrees per second for the roll, pitch, and yaw axes
<GYRO_Y>	1	are the gyro readings in degrees per second for the roll, pitch, and yaw axes
<ACCEL_R>	2	are the accelerometer readings for the roll, pitch and yaw axes.
<ACCEL_P>	2	are the accelerometer readings for the roll, pitch and yaw axes.



Payload Telemetry Format



DATA FORMAT	SAMPLE DATA	DESCRIPTION
<ACCEL_Y>	2	are the accelerometer readings for the roll, pitch and yaw axes.
<MAG_R>	1	are magnetometer readings in the roll, pitch and yaw axes in gauss.
<MAG_P>	1	are magnetometer readings in the roll, pitch and yaw axes in gauss.
<MAG_Y>	1	are magnetometer readings in the roll, pitch and yaw axes in gauss.
<POINTING_ERROR>	1	is the yaw pointing error in degrees. Zero degrees is due South.
<TP_SOFTWARE_STATE>	STANDBY	is the operating state of the Tethered Probe software. (e.g., STANDBY, RELEASED, ACQUIRING_TARGET, TARGET_POINTING, etc.). Teams may define their own states.



Payload Telemetry Format



- **Data format**

TEAM_ID, MISSION_TIME, PACKET_COUNT, PACKET_TYPE,
TP_ALTITUDE, TP_TEMP, TP_VOLTAGE, GYRO_R, GYRO_P,
GYRO_Y, ACCEL_P, ACCEL_P, ACCEL_Y, MAG_R, MAG_P, MAG_Y,
POINTING_ERROR, TP_SOFTWARE_STATE

- **Telemetry data file name:**

- for the Container Telemetry: Flight_1064_C.csv
- for the Tethered Payload: Flight_1064_T.csv



Electrical Power Subsystem (EPS) Design

Enzo Juarez



EPS Overview (1 of 4)



Component	Purpose
Battery Samsung 30Q 18650	Power Source
XBee	Radio Communicator Container
XBee	Radio Communicator Ground Station
Adafruit Ultimate GPS	GPS Sensor
Micro Servo SG90 1.5 Kg	Deploy 1st container parachute
Micro Servo SG90 1.5 Kg	Deploy 2nd container parachute
Mini Spy Camera (x2)	Record the descent and bonus camera
Switch	ON/OFF the Cansat
Buzzer	Audio Beacon



EPS Overview (2 of 4)



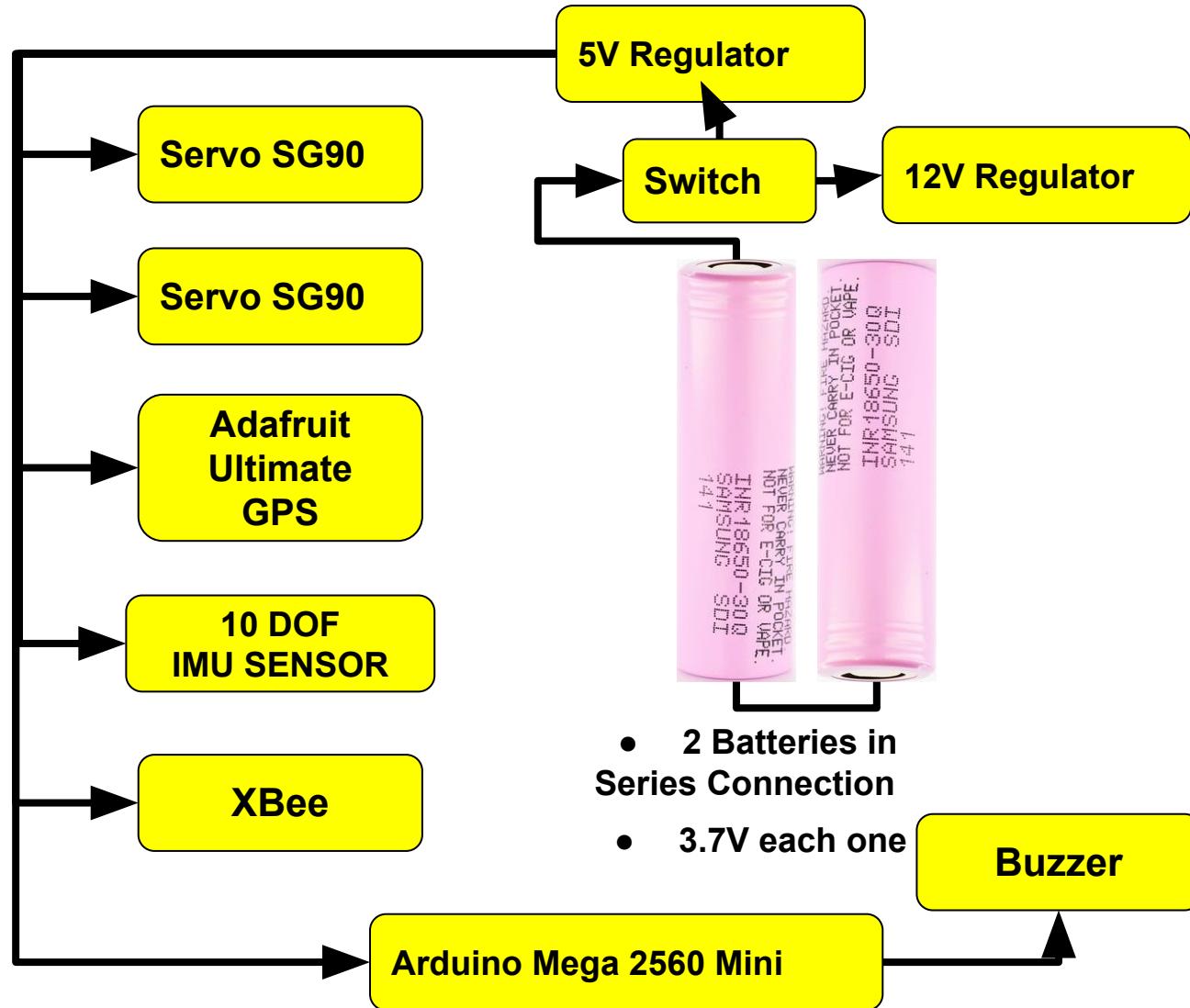
Component	Purpose
STorm32 Controller	Gimbal Camera and Motor Controller
Motor 2208 80T	Move and stabilize Camera
Motor 2208 80T	Move and stabilize Camera
Motor 2804 100T	Move and stabilize Camera
10 DOF IMU Sensor	Stabilization, Navigation, temperature and pressure sensor
Module Step UP 2A DC-DC XY-016	Gimbal Controller Power Supply Stabilizer
AMS1117 5.0 HT242E	Provides clean 5V Supply
Arduino Mega 2560 Mini	Microcontroller Based Control Board



EPS Overview (3 of 4)



Container EPS Overview

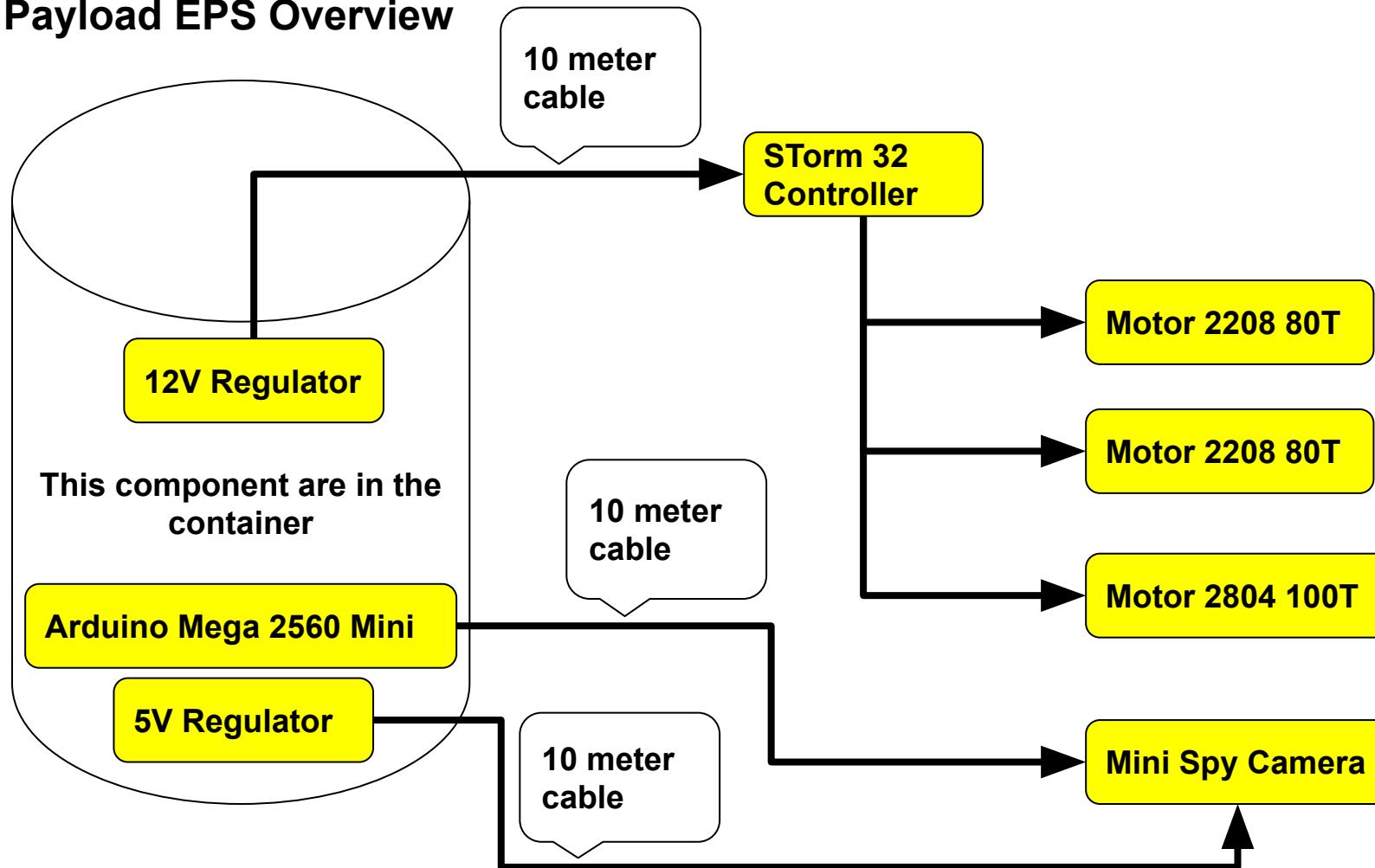




EPS Overview (4 of 4)



Payload EPS Overview

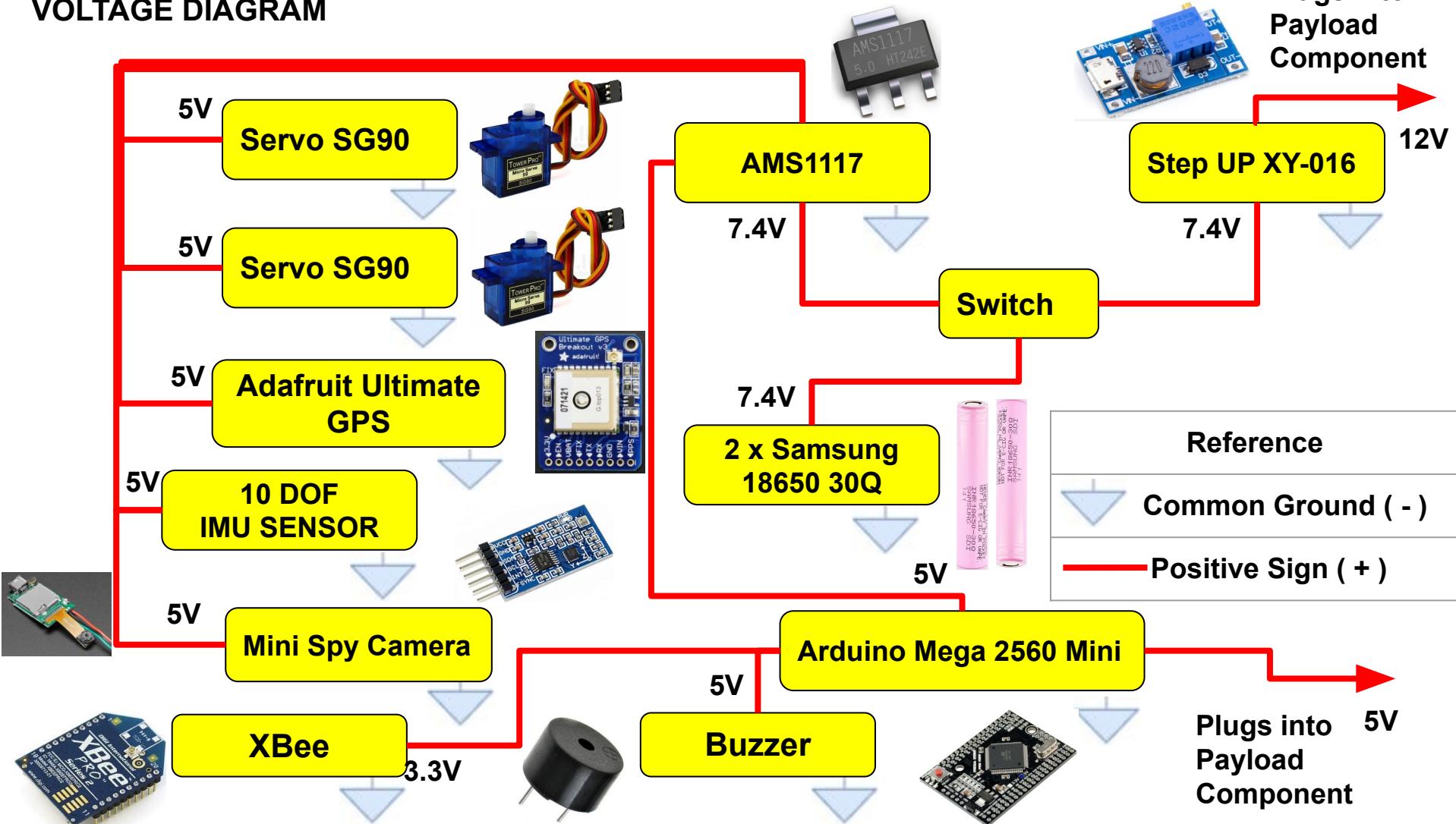




Container Electrical Block Diagram (1 of 2)



VOLTAGE DIAGRAM

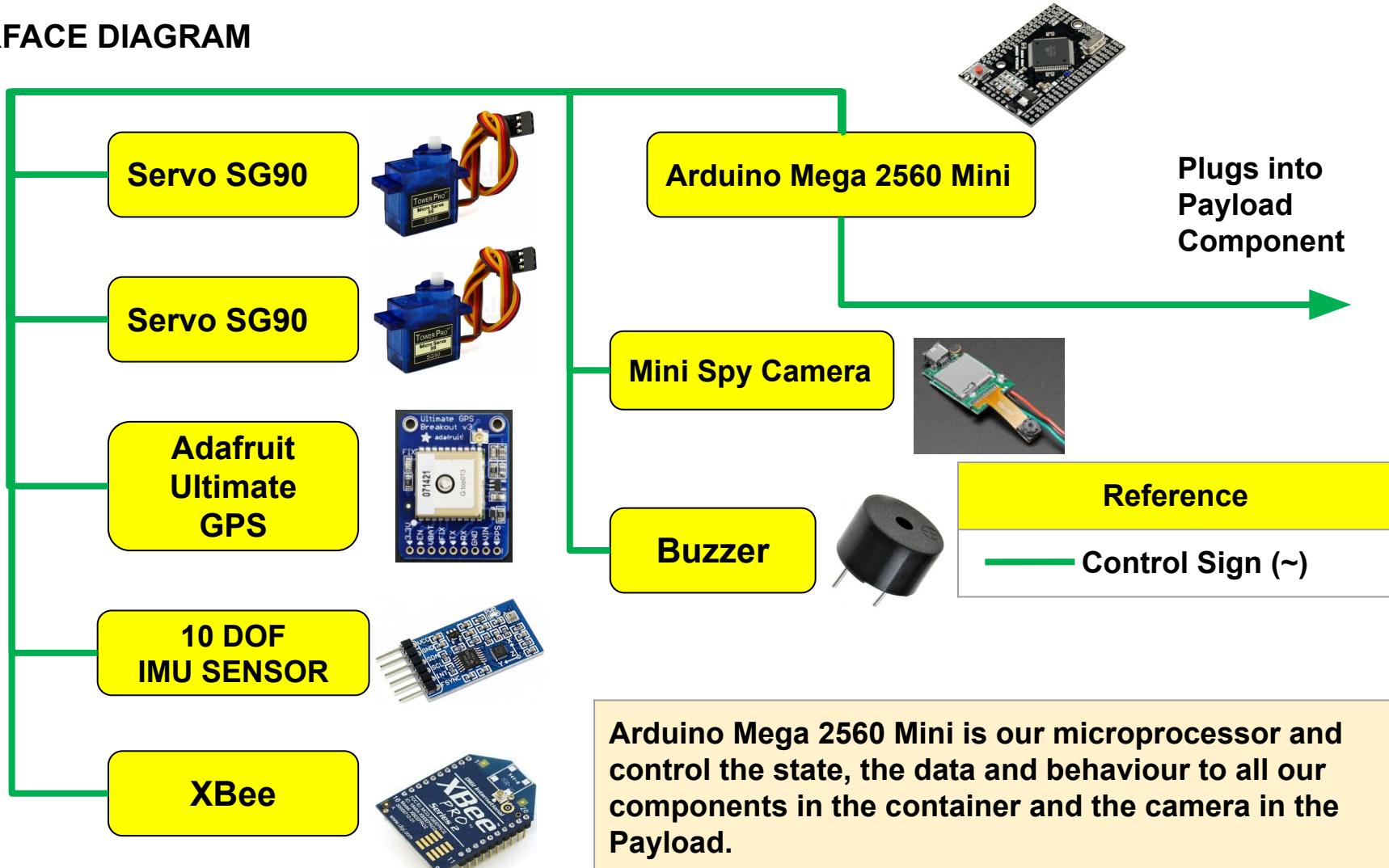




Container Electrical Block Diagram (2 of 2)



INTERFACE DIAGRAM





Container Power Trade & Selection (1 of 2)



NO	NAME / MODEL	TYPE	Nominal Voltage (V)	Capacity (mAh)	Weight (g)	Max Continuous Discharging Rate (A)	Price (\$)	Source
1	Olight 14500	Lithium Ion	3.7	3000	46.6	30	5.99	Datasheet
2	Samsung 20S 18650 Battery	Lithium Ion	3.6	2000	46	30	5.99	Datasheet
3	Samsung 30Q 18650 Battery	Lithium Ion	3.6	3000	48	30	7.99	Datasheet
4	9V	Alkaline	9	310	45	0.7	3.5	Datasheet

1



2



3



4





Container Power Trade & Selection (2 of 2)



Power Source Selection

Selected Battery:

Samsung 30Q 18650 Battery



Reasons
• Available in our Country
• Rechargeable
• High discharge rate
• It has capability to deliver enough current and power for the container
• Relatively Light

- We will use 2 x Samsung 30Q 18650 Battery will be used in SERIE configuration, where we will obtain 7.2V of Nominal Voltage and 3000mAh of Nominal Current.
- Both Samsung 30Q 18650 will mounted on container using battery socket



Container Power Budget (1 of 2)



NO	COMPONENT	Voltage (V)	Current (mA)	Duty Cycles (Hr)	Power Consumption (Wh)	Source
1	Servo SG90 N°1	5	650	0.016	0.052	Datasheet
2	Servo SG90 N°2	5	650	0.016	0.052	Datasheet
3	Arduino Mega 2560 Mini	5	0.51	2	0.0051	Datasheet
4	Modulo Xbee	3.3	23	2	0.1518	Datasheet
5	Adafruit Ultimate GPS	5	20	2	0.2	Datasheet
6	10 DOF IMU Sensor	5	42	2	0.42	Datasheet
7	Step Up XY-016	7.4	26	2	0.385	Estimate
8	AMS1117	5	0.2	2	0.12	Datasheet
9	Buzzer	5	500	0.016	0.04	Datasheet
10	Adafruit Mini Spy Camera	5	110	2	1.1	Datasheet



Container Power Budget (2 of 2)

Total Power Consumed in Container
(for Two Hours)

2.5259 Wh

Available Total Current Capacity
(for Two Hours)

3000mAh

Available Total Power Capacity
(for Two Hours)

21.6Wh

Margin of Power Consumption (for Two Hours)

$21.6 \text{ Wh} - 2.5259 \text{ Wh} = 19.0741 \text{ Wh}$ (Margin 88.3%)

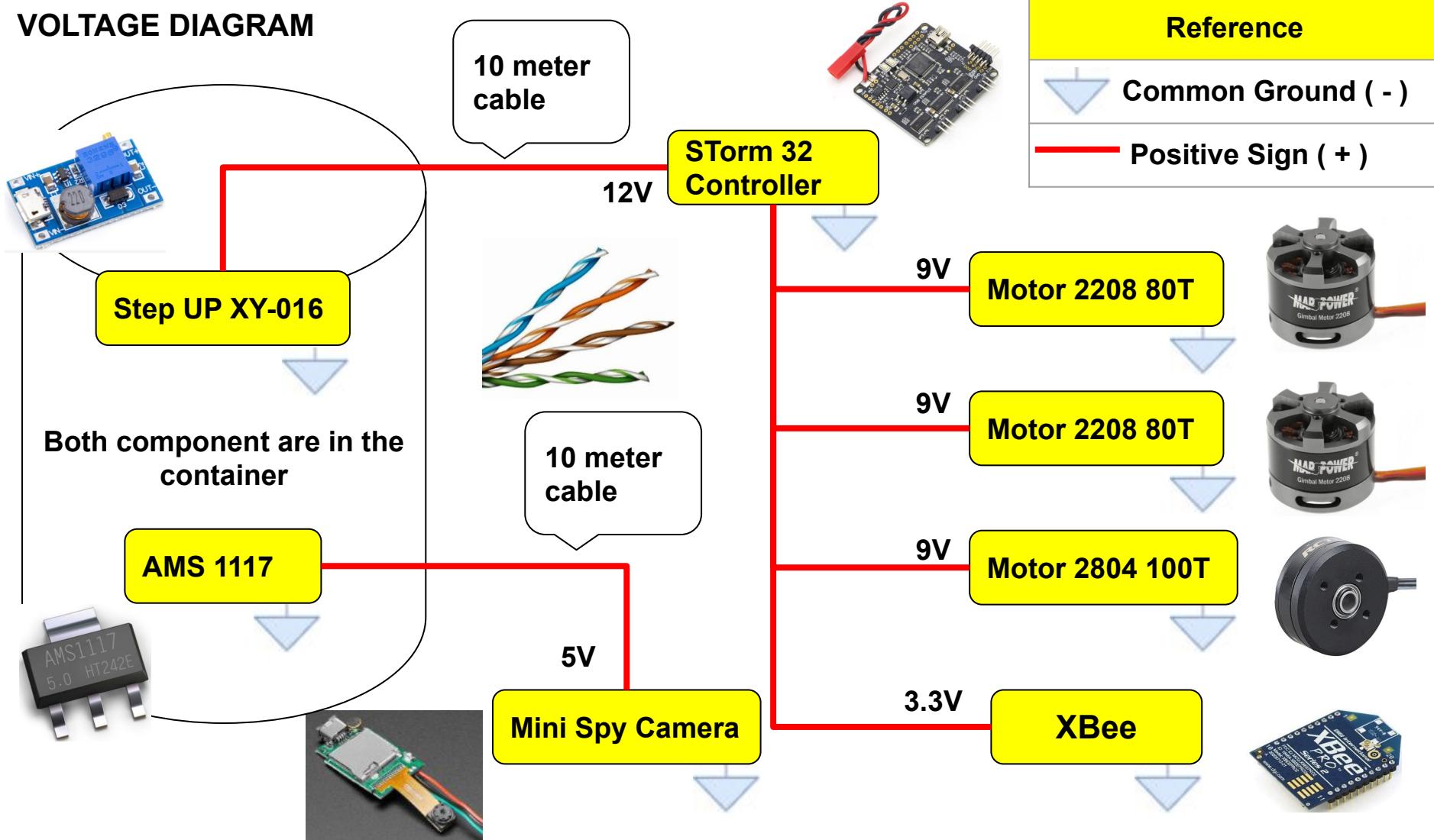
Conclusion: Our Battery is sufficient to power all component through the flight

We will add a final slide adding the consumption calculations of the container and the Payload, since they use the same battery as a source and the final calculation will be better represented there.



Payload Electrical Block Diagram (1 of 2)

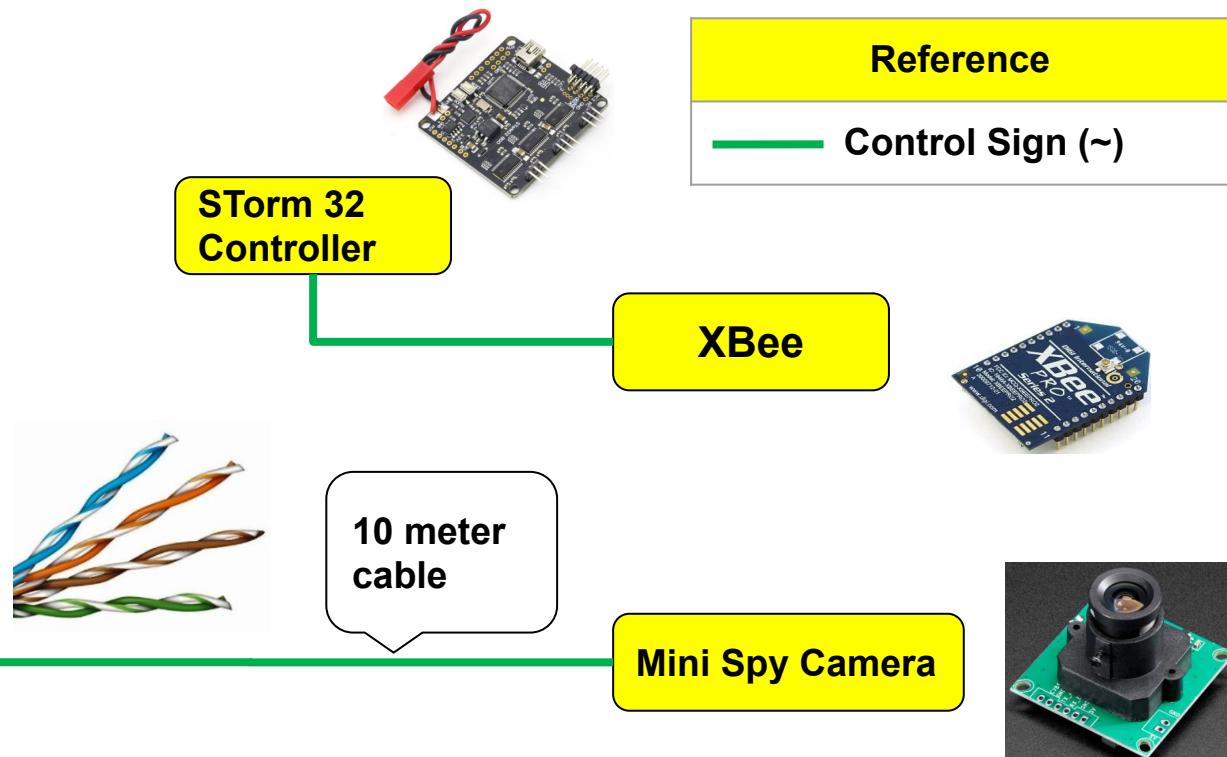
VOLTAGE DIAGRAM





Payload Electrical Block Diagram (1 of 2)

INTERFACE DIAGRAM



The Arduino Mega 2560 Mini tells the camera when to start recording and when to end



Payload Power Trade & Selection (1 of 2)



NO	NAME / MODEL	TYPE	Nominal Voltage (V)	Capacity (mAh)	Weight (g)	Max Continuous Discharging Rate (A)	Price (\$)	Source
1	LIR3048	Lithium Ion	3.6	230	12	0.001	3.45	Datasheet
2	CR123A / 16340	Lithium Ion	3.7	1800	24		5.87	Estimate
3	Samsung 30Q 18650 Battery	Lithium Ion	3.6	3000	48	30	7.99	Datasheet
4	9V	Alkaline	9	310	45	0.7	3.5	Datasheet

1



2



3



4





Payload Power Trade & Selection (2 of 2)



Power Source Selection

Selected Battery:

Samsung 30Q 18650 Battery



Reasons
• Available in our Country
• Rechargeable
• High discharge rate
• It has capability to deliver enough current and power for the payload
• Relatively Light

- We will use 2 x Samsung 30Q 18650 Battery will be used in SERIE configuration, where we will obtain 7.2V of Nominal Voltage and 3000mAh of Nominal Current.
- Both Samsung 30Q 18650 will mounted on container using battery socket and connect with payload components with cable



Payload Power Budget (1 of 2)



NO	COMPONENT	Voltage (V)	Current (mA)	Duty Cycles (Hr)	Power Consumption (Wh)	Source
1	STorm32 Controller	12	15	2	0.36	Estimate
2	Motor 2208 80T	7.4	30	2	0.44	Datasheet
3	Motor 2208 80T	7.4	30	2	0.44	Datasheet
4	Motor 2804 100T	7.4	7.4	2	0.44	Datasheet
5	Adafruit Mini Spy Camera	5	110	2	1.1	Datasheet
6	Module XBee	3.3	23	2	0.1518	Datasheet



Payload Power Budget (2 of 2)



Total Power Consumed in Payload
(for Two Hours)

2.932 Wh

Available Total Current Capacity
(for Two Hours)

3000mAh

Available Total Power Capacity
(for Two Hours)

21.6Wh

Margin of Power Consumption (for Two Hours)

$21.6 \text{ Wh} - 2.932 \text{ Wh} = 18.668 \text{ Wh}$ (Margin 86.42%)

Conclusion: Our Battery is sufficient to power all component through the flight

We will add a final slide adding the consumption calculations of the container and the Payload, since they use the same battery as a source and the final calculation will be better represented there.



Container and Payload Power Budget



Total Power Consumed in Container (for Two Hours)	Total Power Consumed in Payload (for Two Hours)
2.5259 Wh	2.932 Wh

Available Total Current Capacity (for Two Hours)	Available Total Power Capacity (for Two Hours)
3000mAh	21.6Wh

Margin of Power Consumption (for Two Hours)
$21.6 \text{ Wh} - 2.526\text{Wh} - 2.932 \text{ Wh} = 16.142 \text{ Wh}$ (Margin 74.73%)

Final Conclusion

Our Battery is sufficient to power all component through the flight and can operate Two Hours without problems.



Flight Software (FSW) Design

**Jorge Royon
Enzo Juarez
Juan Esteban Yurquina**



FSW Overview



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.
- Send data to the Ground control station and store it to an onboard backup EEPROM.
- Monitor altitude changes to trigger payload releases.
- Activate audio beacon after landing.
- Activate mechanisms in the correct time
- Ensure telemetry frequency is 1Hz and 4 Hz when payload is released
- Design a software architecture such that the processor can fully recover from a sudden power loss that might occur in any time during the mission and for arbitrary duration



FSW Overview

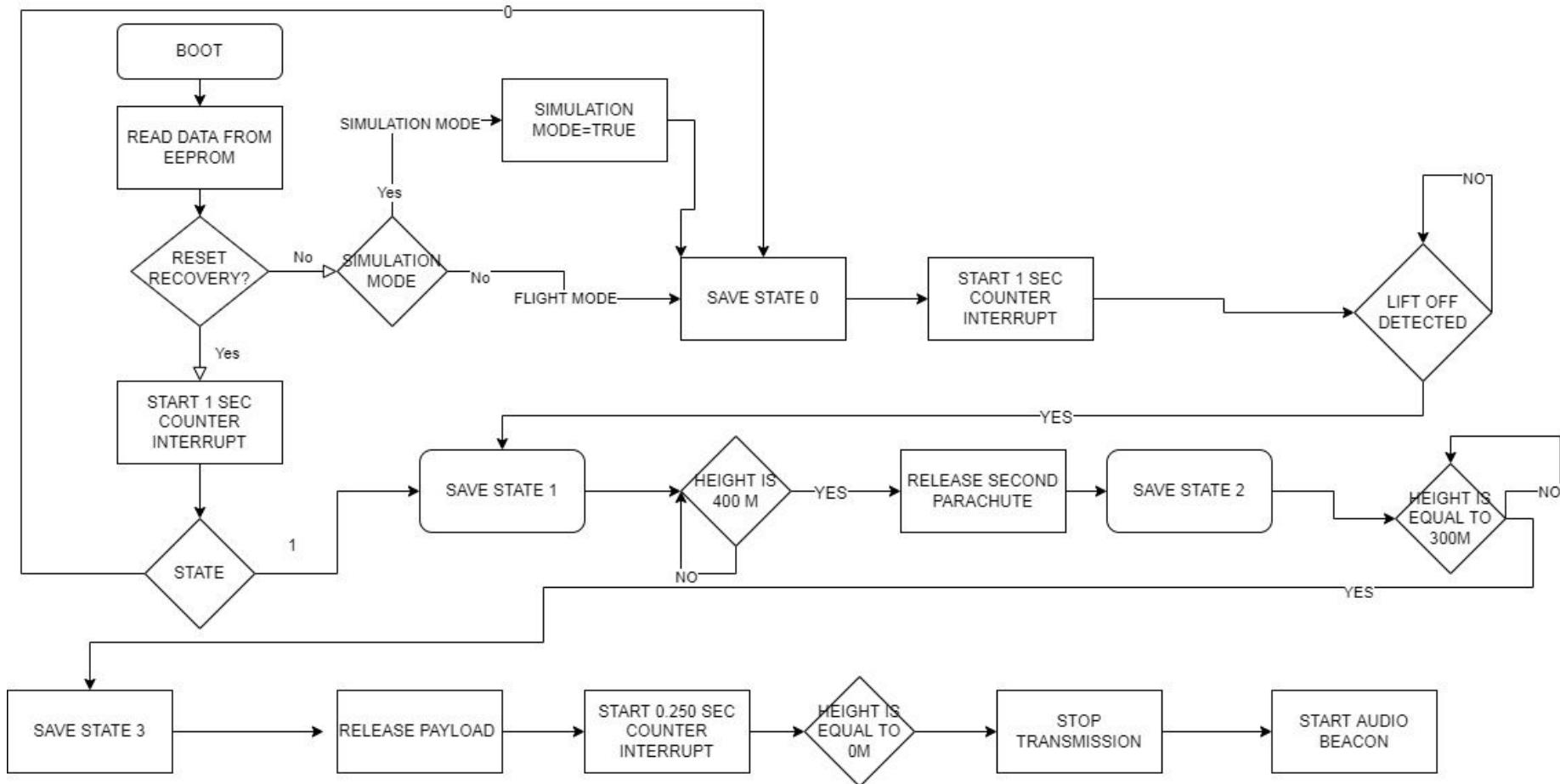


FSW Task:

Container	Payload
To collect sensors data and convert it to a value that complies with CanSat requirements.	To collect sensors data and convert it to a value that complies with CanSat requirements.
Send data to the Ground control station and store it to an onboard backup EEPROM.	Send data to the container and store it to an onboard backup EEPROM.
Monitor altitude changes to trigger payload releases	Ensure telemetry frequency is 4Hz
Activate audio beacon after landing	Recover from a sudden power loss that might occur in any time during the mission and for arbitrary duration
Activate mechanisms in the correct time	
Ensure telemetry frequency is 1Hz	

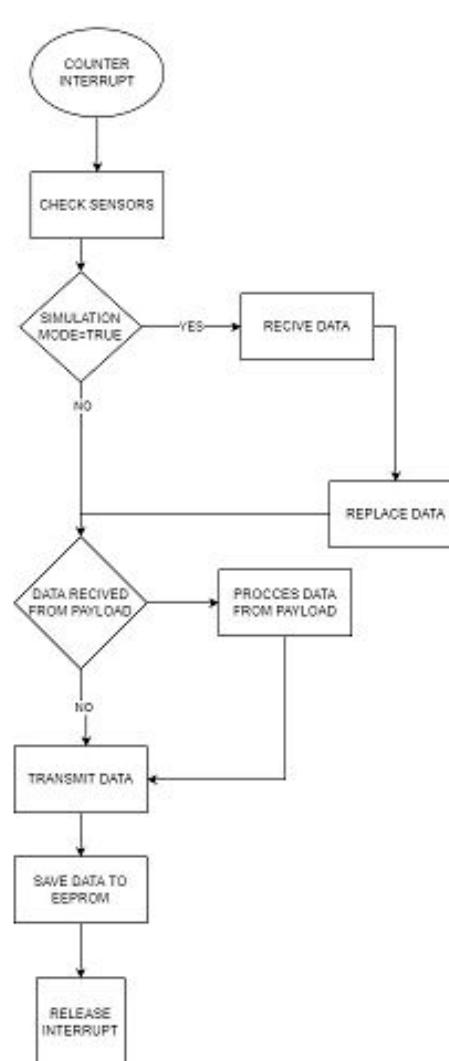


Container FSW State Diagram



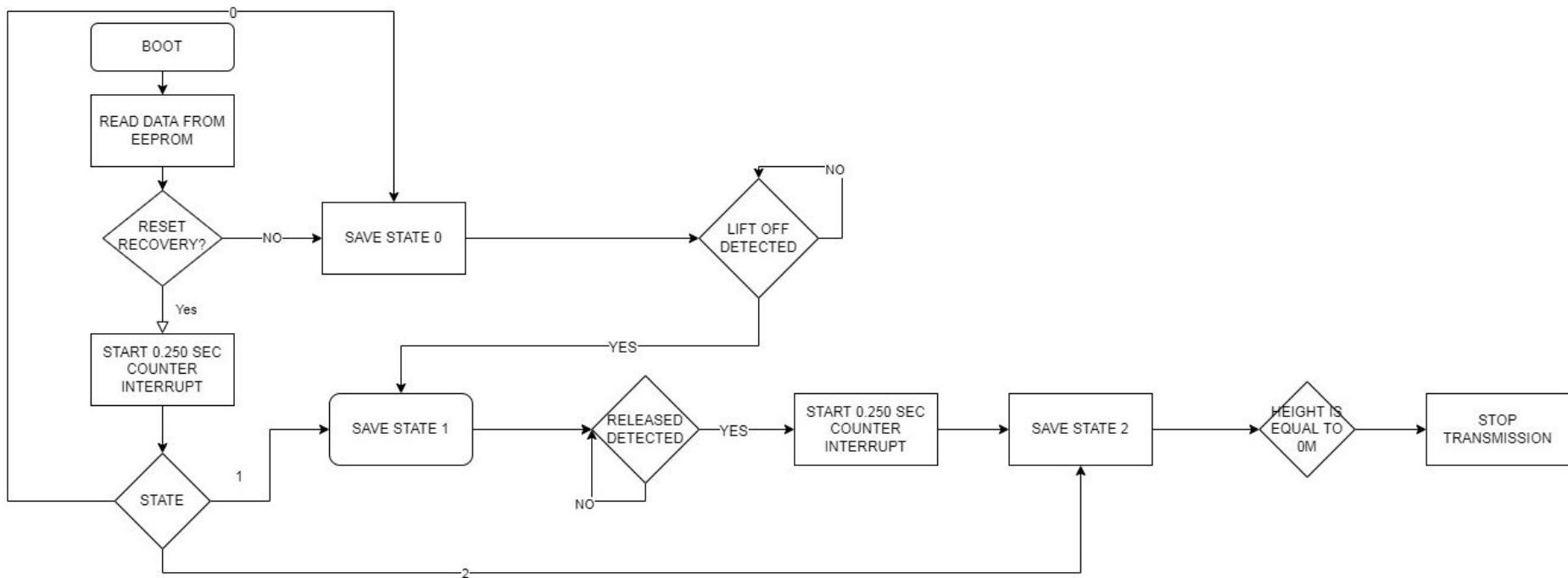


Container FSW State Diagram



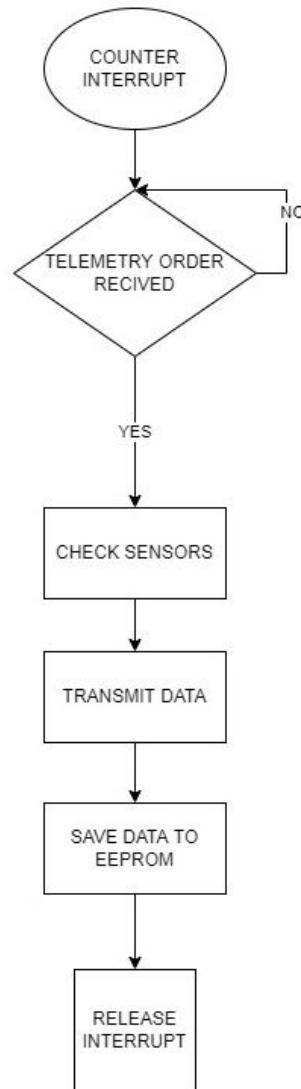


Payload FSW State Diagram





Payload FSW State Diagram





Simulation Mode Software



Simulation mode

The ground station will receive a file with the simulated data, then the data is transmitted to the container where the container firmware would calculate the altitude with the supplied data, then it will be formatted to complain requirements and transmitted to the ground station

Simulation commands

The simulation commands are:

- CMD,<TEAM_ID>,SIM,<MODE>

Where:

1. CMD and SIM are static text.
- 2.<TEAM_ID> is the assigned team identification.
- 3.<MODE> is the string ‘ENABLE’ to enable the simulation mode, ‘ACTIVATE’ to activate the simulation mode, or ‘DISABLE’ which both disables and deactivates the simulation mode.

Example: Both the CMD,1000,SIM,ENABLE and CMD,1000,SIM,ACTIVATE commands are required to begin simulation mode.

SIMP - Simulated Pressure Data (to be used in Simulation Mode only)

- CMD,<TEAM ID>,SIMP,<PRESSURE>

Where:

1. CMD and SIMP are static text.
- 2.<TEAM_ID> is the assigned team identification.
- 3.<PRESSURE> is the simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.

Example: CMD,1000,SIMP,101325 provides a simulated pressure reading to the Container (101325 Pascals = approximately sea level).



Software Development Plan



Component	Description
Ground station	Program interface
	Program Xbee
Container	Program arduino for each sensor
	Servo module
	Simulation module
Payload	Program Xbee
	Program sensors
Final integration	Full test of all function

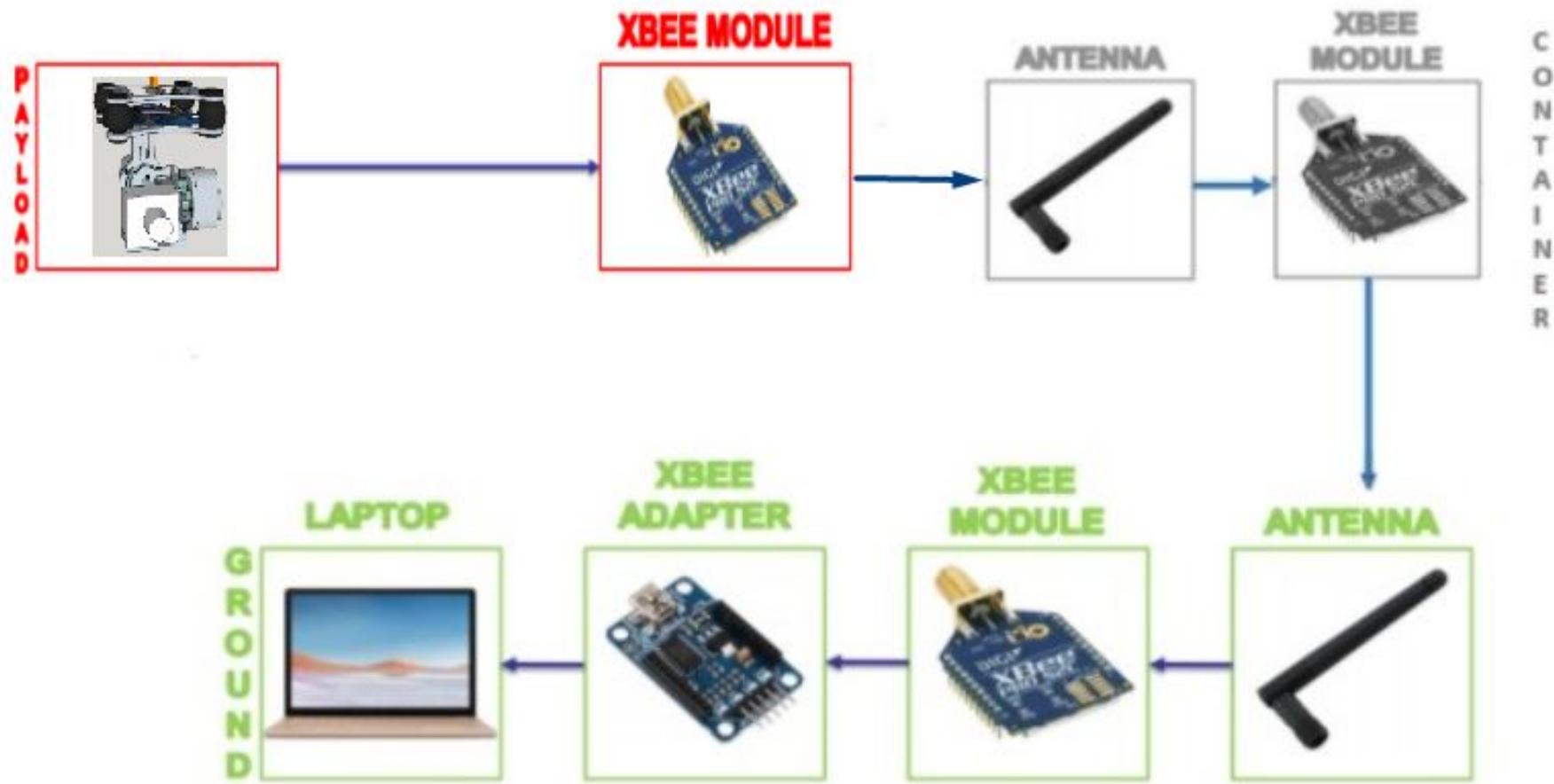


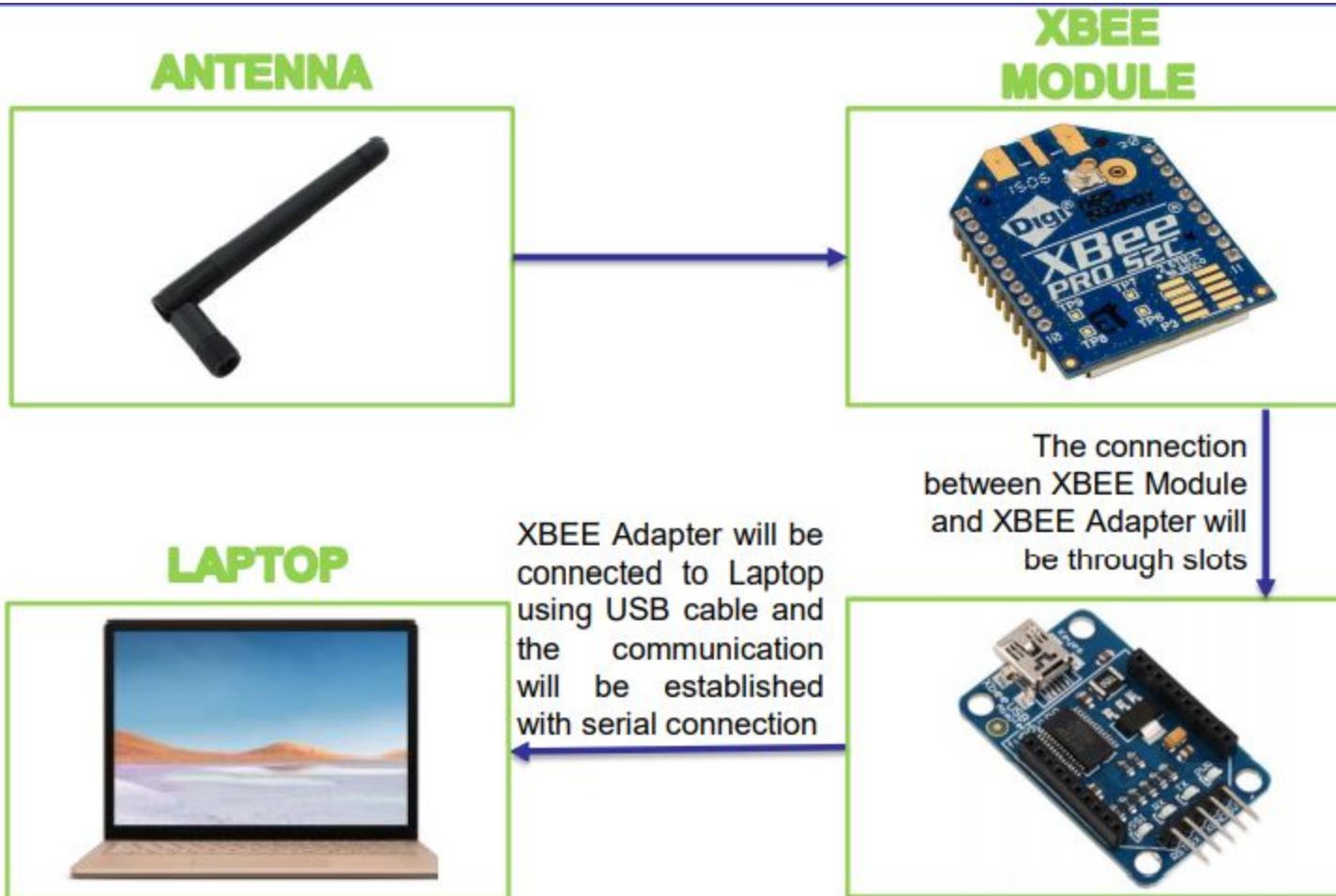
Ground Control System (GCS) Design

**Ivan Maccio
Mateo Figallo**



GCS Overview







GCS Design



• Specifications

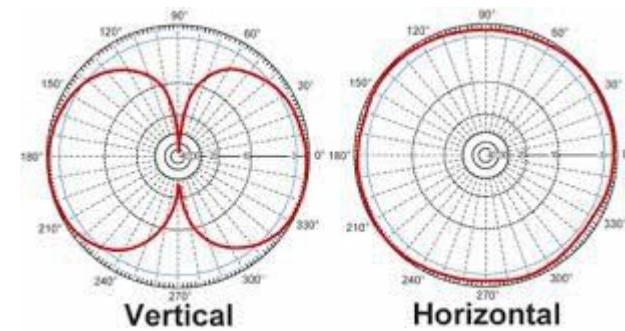
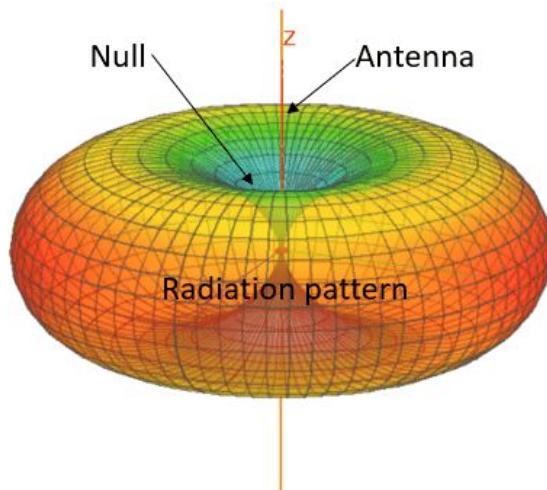
- Battery: The Ground Control Station Laptop can operate 3 hours with battery.
- Overheating Mitigation: There will be an umbrella to avoid direct sun exposure
- Auto update mitigation: The option of auto update will be disabled before the launch



GCS Antenna Trade & Selection



Model	Connection Type	Frequency	Direction	Gain	Beam Width Horizontal / Vertical	Price
Bingfu Dual Band WiFi 2.4GHz	RP-SMA	2,4 ghz	Omnidirectional	9dBi	360°/ 32°	\$ 7,99





GCS Software



- **Telemetry display prototypes**
 - <TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>, <PACKET_TYPE>, <MODE>, <TP_RELEASED>, <ALTITUDE>, <TEMP>, <VOLTAGE>, <GPS_TIME>, <GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_ALTITUDE>, <GPS_SATS>, <SOFTWARE_STATE>, <CMD_ECHO>
- **Commercial off the shelf (COTS) software packages used**
 - MATLAB GUI Package for Visual Studio 2015



GCS Software



- **Real-time plotting software design**
 - GCS Software will be designed with MATLAB GUI Package for Visual Studio 2015
 - The software will receive data from XBEE Module through USB cable
 - The received data will be displayed on the real time plots
- **Command software and interface**
 - The Ground Station will send the following commands from the container:
 - CX - Container Telemetry On/Off Command
 - Generic one: CMD,<TEAM_ID>,CX,<ON_OFF>
 - Example of command to be sent: CMD,1064,CX,ON, where:
 - CMD and CX are static text
 - ON is set to activate the Container telemetry transmissions. OFF would be used to turn off the transmissions
 - ST - Set Time
 - Generic one: CMD,<TEAM_ID>,ST,<UTC_TIME>
 - Example of command to be sent: CMD,1064,ST,13:35:59, where:
 - CMD and ST are static text
 - 13:35:59 is the parameter -in UTC format- which sets the mission time to the value given



GCS Software



- **Command software and interface**
- The Ground Station will send the following commands from the Ground Station:
 - SIM - Simulation Mode Control Command
 - Generic one: CMD,<TEAM_ID>,SIM,<MODE>
 - Example of command to be sent: CMD,1064,SIM,ENABLE, where:
 - CMD and SIM are static text
 - ENABLE enables the simulation mode. 'ACTIVATE' activates the simulation mode, and 'DISABLE' both disables and deactivates the simulation mode.
 - PX - Science Payload Transmission On/Off
 - Generic one: CMD,<TEAM_ID>,SP1X/SP1X,<ON_OFF>
 - Example of command to be sent: CMD,1064,SP1X,ON. This will trigger the Container to relay a command to the Science Payload 1 to begin telemetry transmissions.
 - SIMP - Simulated Pressure Data (to be used in Simulation Mode only)
 - Generic one: CMD,<TEAM ID>,SIMP,<PRESSURE>
 - Example of command to be sent: CMD,1064,SIMP,101325, which provides a simulated pressure reading to the Container (101325 Pascals = approximately sea level)



GCS Software



- **Telemetry data recording and media presentation to judges for inspection**
 - All telemetry data will be displayed on real time plots.
 - When software will obtain telemetry data, these shall be recorded in a commas separated value (.csv) file.
 - This .csv file will be presented to judges on an SD Card



GCS Software



- **Describe .csv telemetry file creation for judges**
 - .csv telemetry file will be created during the setup of ground station
 - Telemetry data will be appended to this .csv file meanwhile software be on
 - The name of the .csv file will be “Flight_1064.csv”



MQTT Integration



Once the ground station is turned on, we will proceed to connect it with the MQTT server:

```
Client.connect("mqtt://username:password@cansat.info");
```

When the ground station software saves a data line to a file, that line will be sent to the broker (1 line per second):

```
mqttc.publish("teams/1064", "<TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>,<PACKET_TYPE>, <MODE>, <TP_RELEASED>, <ALTITUDE>, <TEMP>, <VOLTAGE>, <GPS_TIME>,<GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_ALTITUDE>, <GPS_SATS>,<SOFTWARE_STATE>,<CMD_ECHO>");
```

At the end of sending all the lines, the client will be disconnected from the server:

```
Client.disconnect();
```

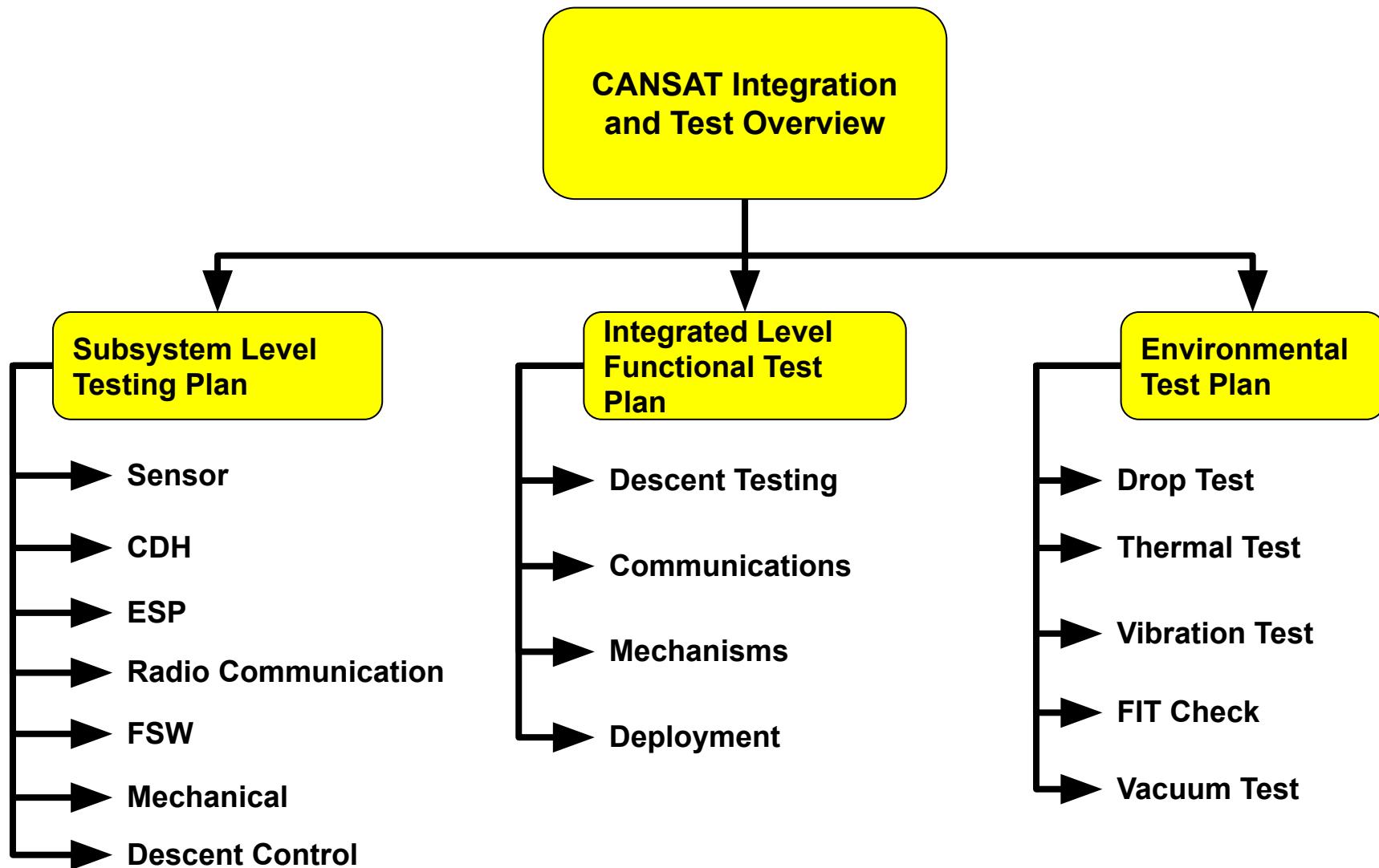


CanSat Integration and Test

**Mateo Figallo
Ivan Maccio**



CanSat Integration and Test Overview





Simulation Test Plan

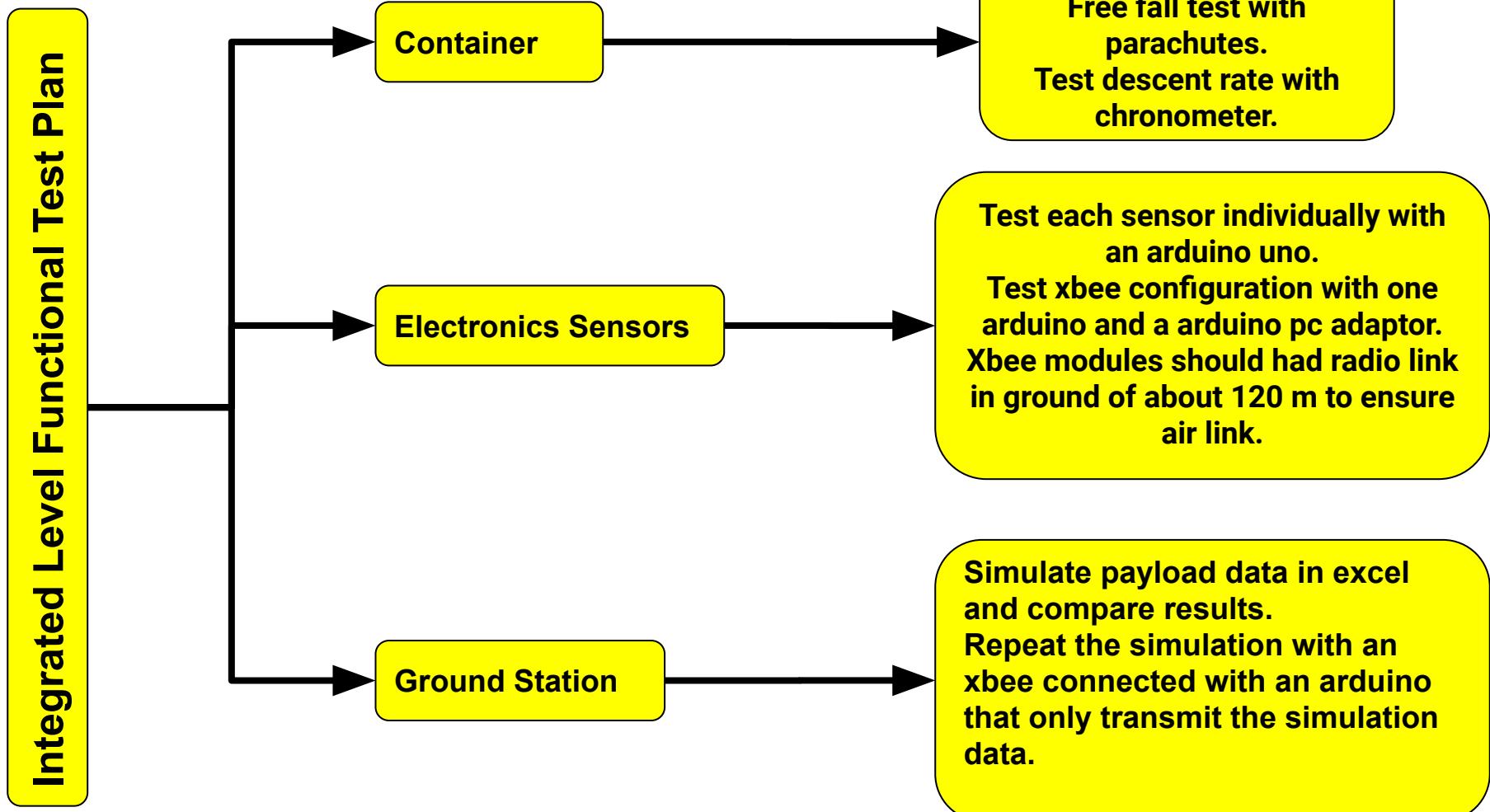


In order to make sure everything works as designed, a series of tests will be conducted:

- We are planning to test every sensor alone with an Arduino mega.
- Then, we are going to test the sensor in additive way, meaning that when we finish testing all sensors individually, we are start to test two sensors at once, then three sensors at once, then four, etc., until full integration is completed.
- In parallel we are going to make mechanical tests to the tethered payload.
- We are going to drop it from a drone
- There will be a Flight Software test as well, which consists in simulating all possible processor shut down -in any period of time- and check if the software works correctly in the facing of mentioned situation.
- The sending of data in the correct order will be tested
- We will check the accuracy of the received data from sensors

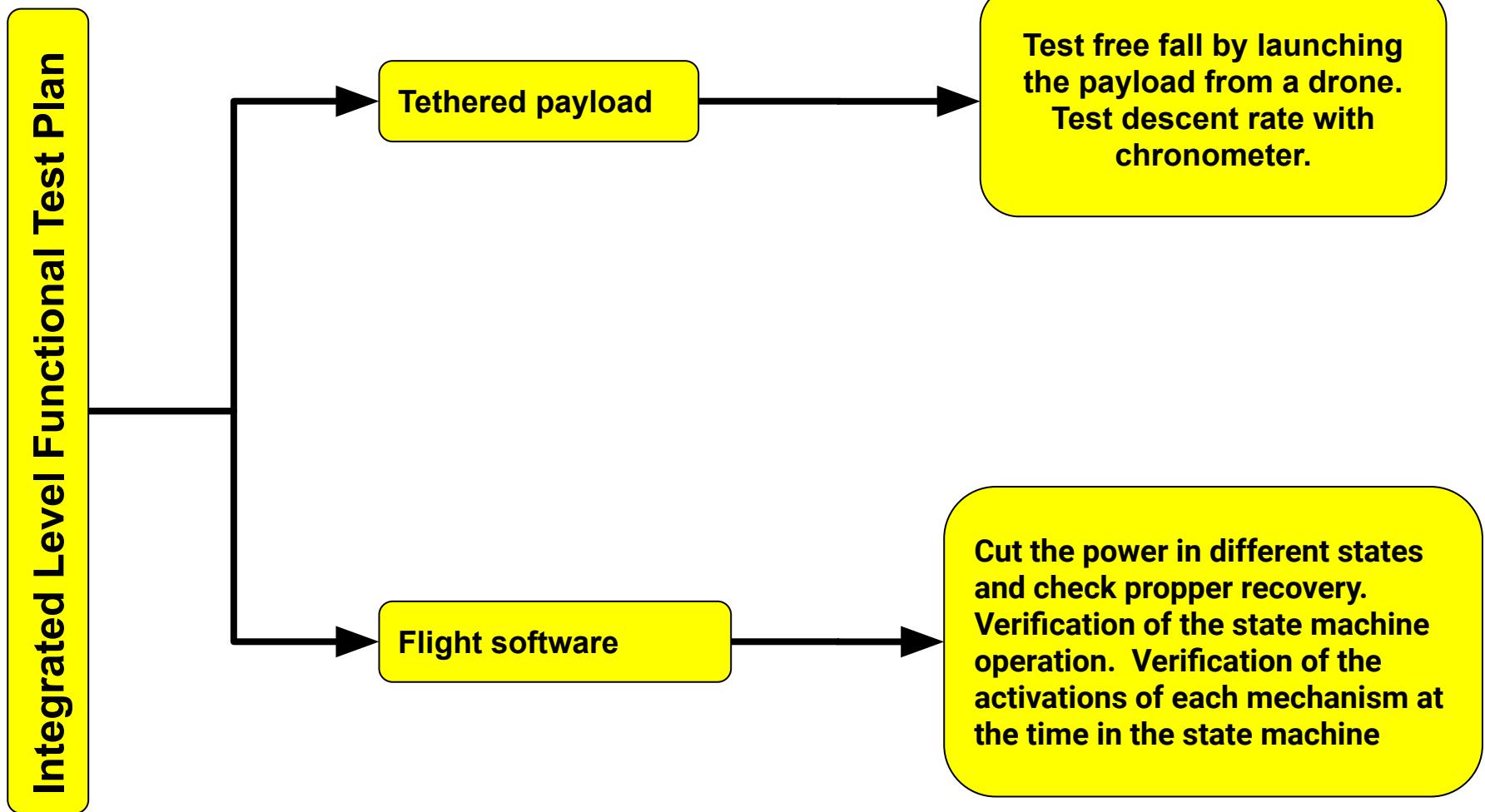


Integrated Level Functional Test Plan





Integrated Level Functional Test Plan





Environmental Test Plan



The tests are going to be executed as suggested in the mission guide, for the drop test we are going to use a non flexible string of the spec detailed in mission guide ,for the thermal test we are going to build a isolated foam box and use a hair dryer or a heat gun with temperature regulation for rise the temperature.

For the vibration test we had an orbital sander, we are going to 3D print a locking mechanism to hold the CanSat to the sander.



Simulation Test Plan



The tests are going to be executed as suggested in the mission guide.

We are going to use dummy data to test that the ground station correctly sends the data to the MQTT server. Corroborating them from cansat.info/plot.html.



Mission Operations & Analysis

Mateo Figallo



Overview of Mission Sequence of Events



Event	Duties and Responsibilities
Arrival at the simulation site	<ul style="list-style-type: none">• All team members will have to put their own facemasks• Ground Control Station, Container and Payload will be assembled and checked.
Setting up	<ul style="list-style-type: none">• Antenna will be checked.• Xbee communications will be checked as well.<ul style="list-style-type: none">• Fit check and mass measurement.• Container release mechanism check.<ul style="list-style-type: none">• Inspection of electronics.• Battery charge check.• Radio links check.
Pre launch	<ul style="list-style-type: none">• Review of the checklist.• Team leader approval in order to proceed.
CanSat preparation	<ul style="list-style-type: none">• Integrate payload and container.
Final checks preparation	<ul style="list-style-type: none">• Team approval.
Rocket integration	<ul style="list-style-type: none">• Integrate CanSat with the rocket.



Overview of Mission Sequence of Events



Event	Duties and Responsibilities
Launch	<ul style="list-style-type: none">• Take photos• Record
Recovery	<ul style="list-style-type: none">• Recover CanSat
Data presentation	<ul style="list-style-type: none">• Prepare data• Print / graph results• Deliver results• Save the equipment



Mission Operations Manual

Development Plan



- Ground Station

Checklist that will include building the antenna and monitoring software

- Cansat Preparation

Check that the payload and container are free of damage

- Cansat Rocket Integration

Check that everything is correct before integrating CanSat to rocket



CanSat Location and Recovery



- We will use a drone with a camera to an easier detection of CANSAT
- Container color will be chosen from red, Pink or orange.
- Team Leader's phone number and email address and team's number will be labeling on both container and payload



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

Requirements Compliance

Jorge Royon



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
1	Total mass of the CanSat (science payloads and container) shall be 600 grams +/- 10 grams	Y
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	Y
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	Y
4	The container shall be a fluorescent color; pink, red or orange	Y
5	The container shall be solid and fully enclose the science payloads. Small holes to allow access to turn on the science payloads are allowed. The end of the container where the payload deploys may be open	Y
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Y
7	The rocket airframe shall not be used as part of the CanSat operations	Y
8	The container's first 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	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
9	The Parachutes shall be fluorescent Pink or Orange	Y
10	The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s after deployment while above 400 meters	Y
11	The descent rate of the CanSat shall be reduced to 5 meters/second +/- 2 m/s when the CanSat descends below 400 meters	Y
12	0 altitude reference shall be at the launch pad	Y
13	All structures shall be built to survive 15 Gs of launch acceleration	Y
14	All structures shall be built to survive 30 Gs of shock	Y
15	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives	Y
16	All mechanisms shall be capable of maintaining their configuration or states under all forces	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
17	Mechanisms shall not use pyrotechnics or chemicals	Y
18	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	Y
19	Both the container and payload shall be labeled with team contact information including email address	Y
20	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	Y
21	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed	Y
22	XBEE radios shall have their NETID/PANID set to their team number	Y
23	XBEE radios shall not use broadcast mode	Y
24	The container shall include electronics to receive sensor payload telemetry	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
25	The container shall include electronics and mechanisms to release the science payload on a tether	Y
26	The container shall include a GPS sensor to track its position	Y
27	The container shall include a pressure sensor to measure altitude	Y
28	The container shall measure its battery voltage	Y
29	The container shall transmit its telemetry once per second (1 Hz) in the formats described in the Telemetry Requirements section	Y
30	The container shall poll the payload for telemetry and relay that data four times per second (4 Hz) in the formats described in the Telemetry Requirements section	Y
31	The container shall stop polling and transmitting telemetry when it lands	Y
32	The container and science payload must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
33	The container and payload must 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	Y
34	An audio beacon is required for the container. It shall be powered after landing	Y
35	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed	Y
36	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	Y
37	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	Y
38	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects	Y
39	The Cansat must operate during the environmental tests laid out in Section 3.5	Y
40	The Cansat shall operate for a minimum of two hours when integrated into the rocket	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
41	The science payload shall have their NETID/PANID set to their team number plus 5000. If the team number is 1000, sensor payload NETID is 6000	Y
42	The science payload shall transmit sensor telemetry to the container when polled	Y
43	Missing in mission guide (have fun and make new friends maybe?)	?
44	The science payload shall include a pressure sensor, temperature sensor and rotation sensor	Y
45	The science payload shall include a video camera pointing 45 degrees up from the payload NADIR direction	Y
46	The science payload shall maintain orientation so the camera always faces south within +/- 20 degrees	Y
47	The payload shall be connected to the container with a 10 meter tether	Y
48	At 300 meters, the payload shall be released from the container at a rate of .5 meters per second	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
49	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	Y
50	The container shall maintain mission time throughout the whole mission even with processor resets or momentary power loss	Y
51	The container shall have its time set to UTC time to within one second before launch	Y
52	The container 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	Y
53	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude	Y
54	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands	Y
55	The ground station shall command the Cansat to start transmitting telemetry prior to launch	Y
56	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
57	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission	Y
58	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission	Y
59	Each team shall develop their own ground station	Y
60	All telemetry shall be displayed in real time during descent on the ground station	Y
61	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Y
62	Teams shall plot each telemetry data field in real time during flight	Y
63	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna	Y
64	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	Y



Requirements Compliance (multiple slides, as needed)



RQ	Description	Comply
65	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	Y
66	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 container	Y
67	The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container	Y
68	All video cameras shall be in color, have a resolution of at least 640x480 and record at a minimum of 30 frames a second	Y



Management

Mateo Figallo



CanSat Budget – Hardware



Component	Quantity	Unit Price (\$)	Total (\$)	Status
Waveshare 10 DOF IMU C	1	17.99	17.99	NEW
Adafruit Ultimate GPS	1	12.99	12.99	NEW
Arduino mega 2560 mini	1	8.84	8.84	NEW
TowerPro sg90 servo	2	2.42	4.84	NEW
Adafruit spy camera	1	12.5	12.5	NEW
Xbee Pro S2C	2	32.56	65.12	NEW
Xbee Pro 3	1	32.56	32.56	NEW
Parachute Apogee 29126	1	3.74	3.74	NEW
Parachute Apogee 29118	1	7.38	7.38	NEW
2.4 ghz antenna	3	2.7	8.1	NEW
Buzzer	1	5	5	NEW
3D printed parts	6	7	42	NEW



CanSat Budget – Hardware



Component	Quantity	Unit Price (\$)	Total (\$)	Status
Gimbal	1	55.99	55.99	NEW
TPU 3D Printing Filament	1	33.99	33.99	NEW
Samsung 30Q 18650 Battery	2	7.99	15.98	NEW
Real clock module	1	2.1	2.1	NEW
Total			329.12\$	



CanSat Budget – Other Costs

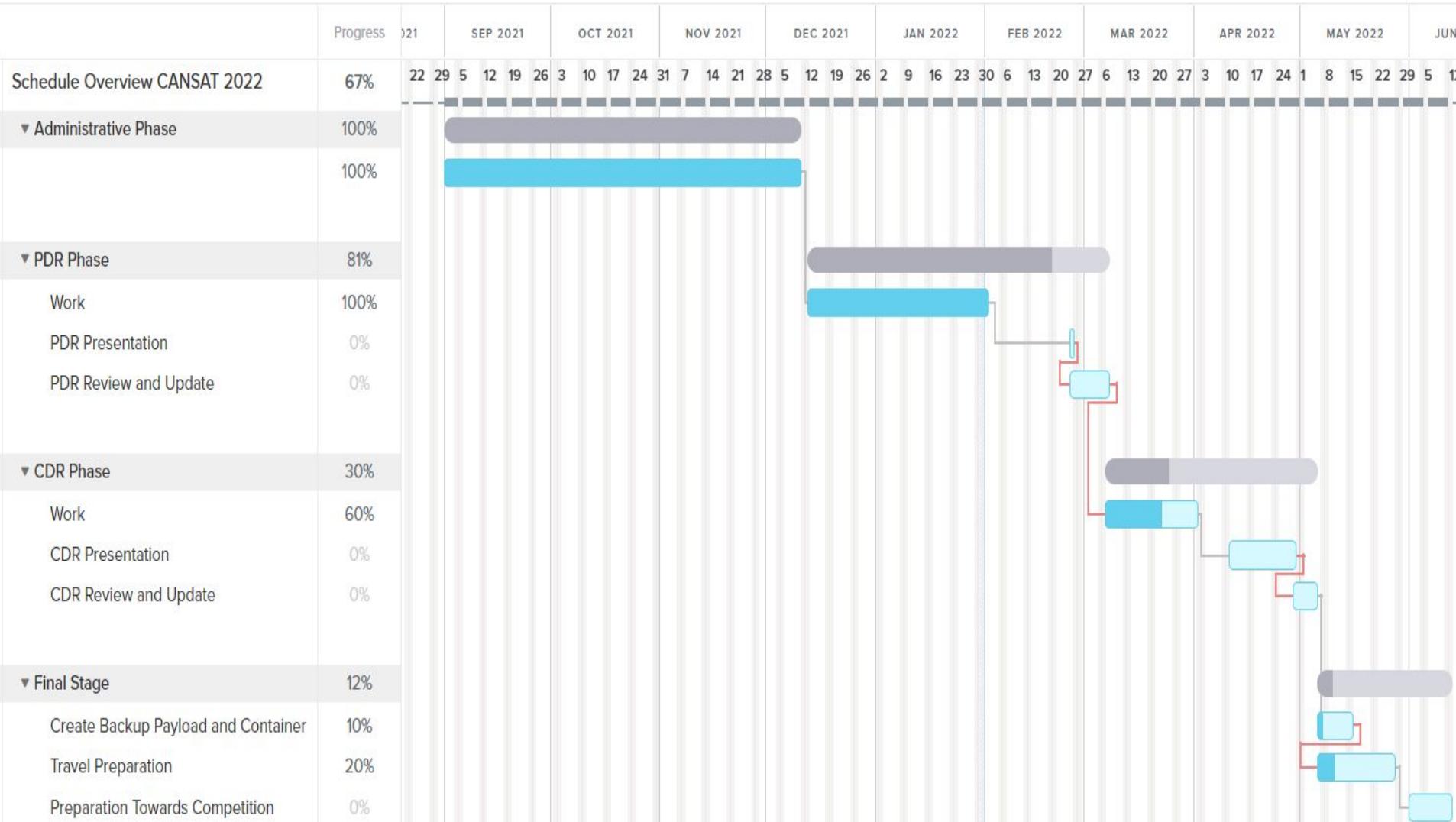


Other Cost	Quantity	Unit Price (\$)	Total (\$)
Air Ticket	5	-	-
Visa	5	-	-
Stay to Five People	1	-	-
Total		-	

The trip and stay is sponsored by the university

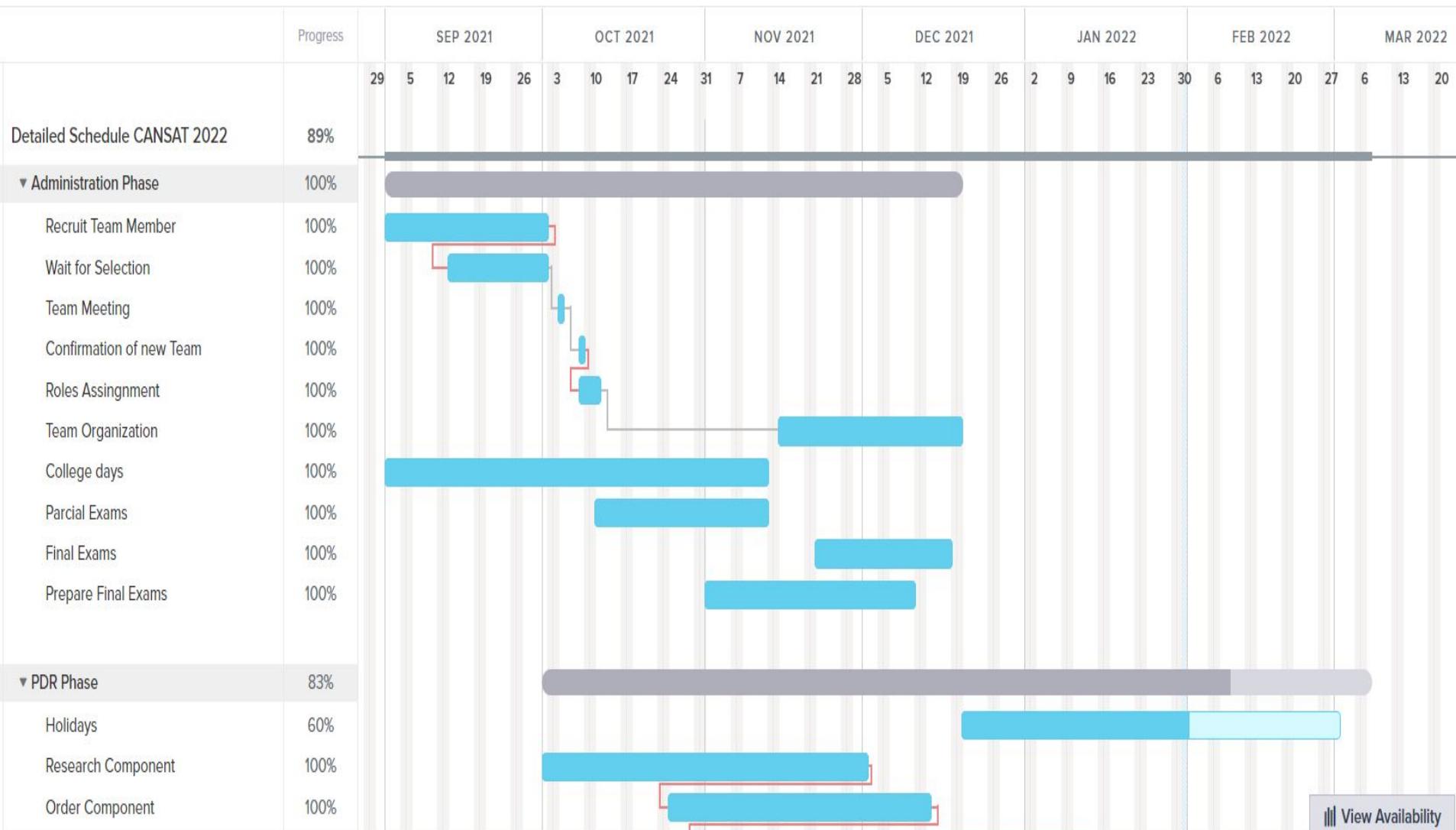


Program Schedule Overview



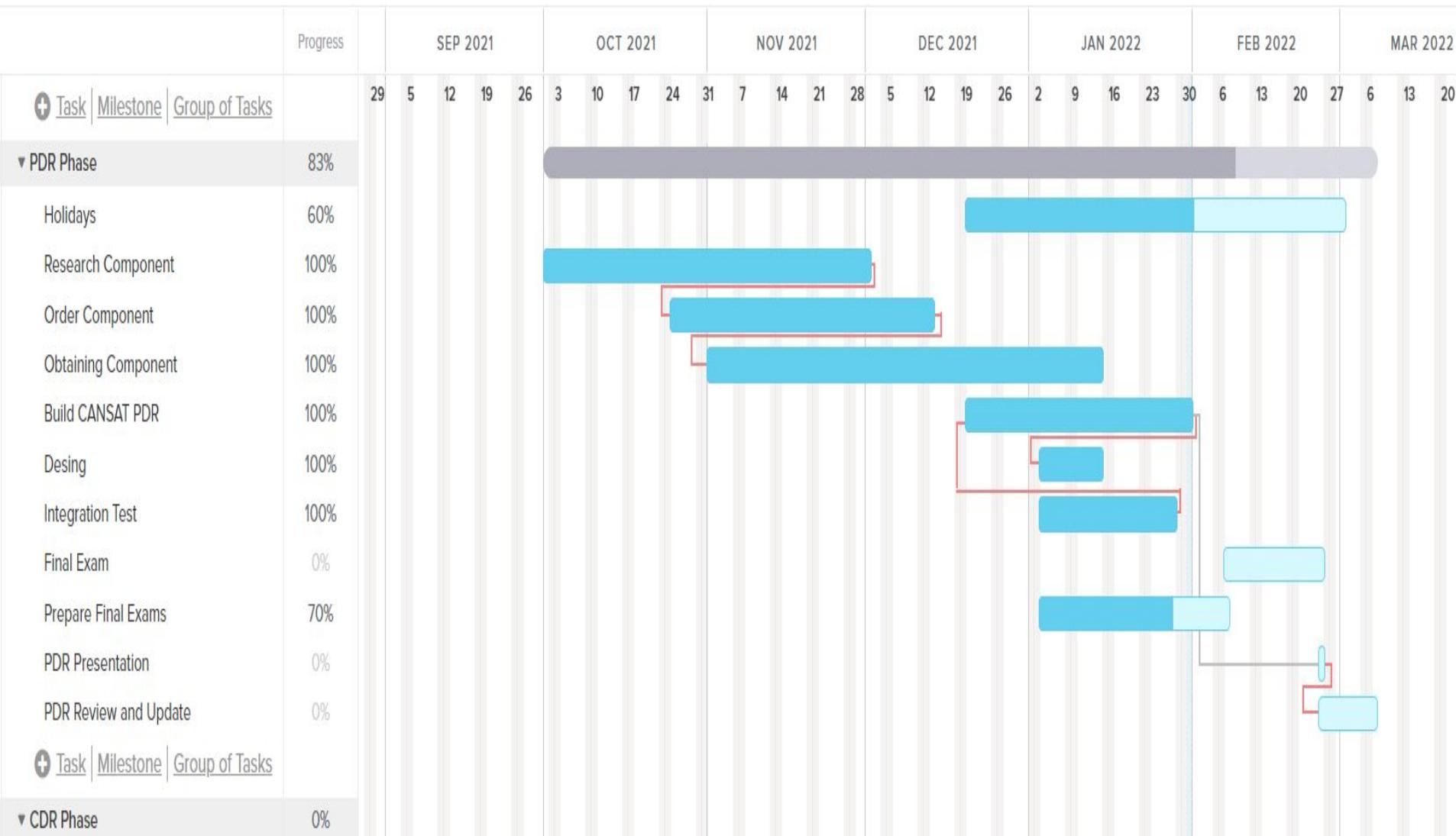


Detailed Program Schedule





Detailed Program Schedule





Conclusions



**We accomplish every requirement and develop the PDR with conscience and patience.
We already to proceed to CDR.**