CanSat 2025
Preliminary Design Review (PDR)

3133

CanBEE

Presentation Outline

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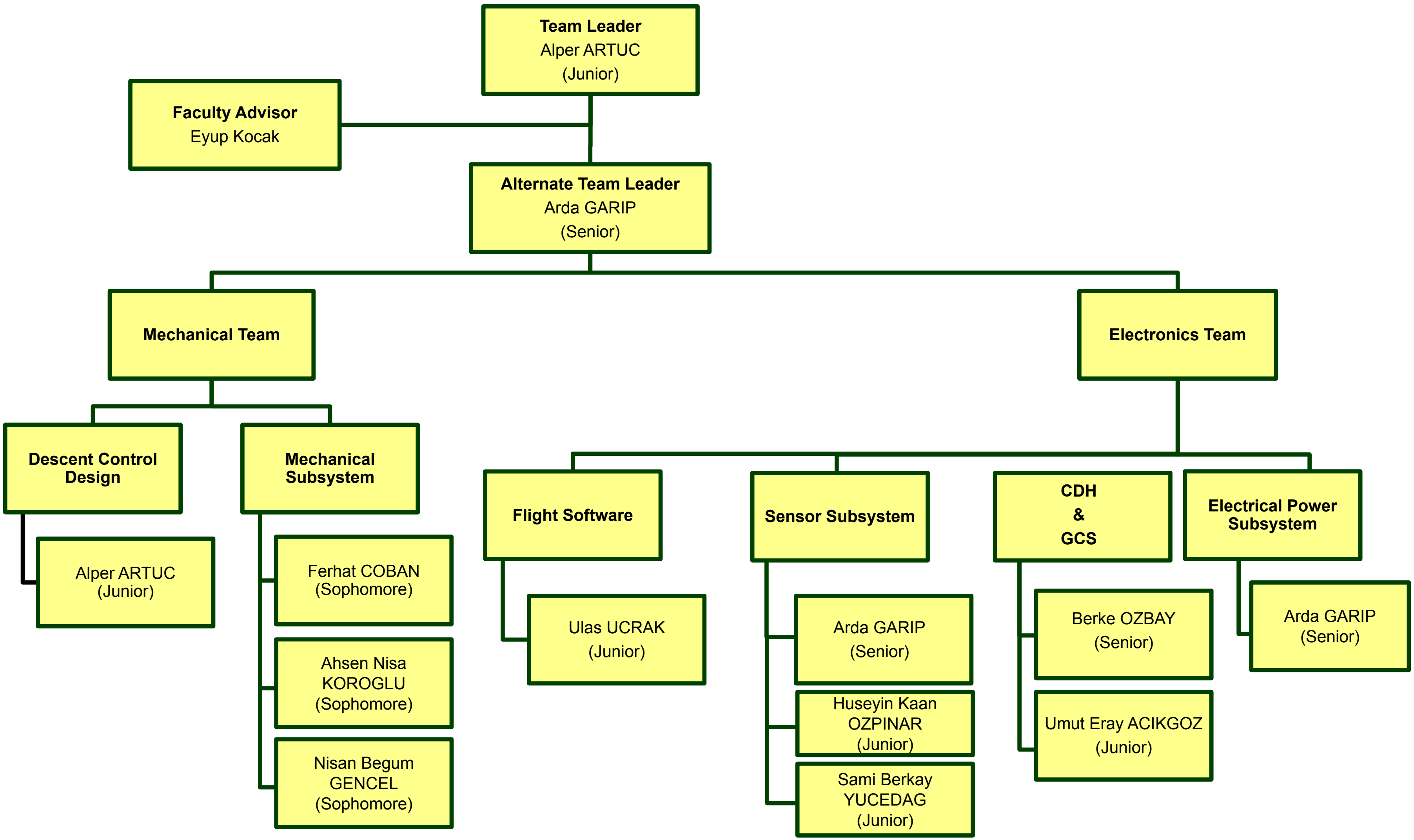
Team Organization



Acronyms

Acronym	Description
A	Analysis
CCW	Counter Clockwise
CDH	Communication and Data Handling
CR	Competition Requirement
CW	Clockwise
D	Demonstration
dB	Decibel
dBi	Decibel Isotropic
dBm	Decibel Milliwatts
DCS	Descent Control System
EEPROM	Electrically Erasable Programmable Read-Only Memory
EPS	Electrical Power System
FSW	Flight Software
Gb	Gigabyte
GCS	Ground Control System
GND	Ground
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GUI	Graphical User Interface

Acronym	Description
HLR	High Level Requirement
hPa	Hektopascal
I	Inspection
i	Current
I2C	Inter-Integrated Circuit
IR	Infrared
ISM	Industrial Scientific Medical
kB	Kilobyte
Kbps	Kilobit Per Second
kPa	Kilopascal
LoS	Line of Sight
mA	Milliampere
mAh	Milliampere Hour
Mbps	Megabit Per Second
MHz	Megahertz
MS	Mechanical Subsystem
Pa	Pascal
PCB	Printed Circuit Board
PCPC	Parallel Connection Protection Circuit
PID	Proportional Integral and Derivative

Acronym	Description
ppm	Parts Per Million
PWM	Pulse Width Modulation
RC	Radio Communication
RPPC	Reverse Polarity Protection Circuit
RTC	Real Time Clock
SD Card	Secure Digital Card
SMA RF	SubMiniature version A Radio Frequency
SMB RF	SubMiniature version B Radio Frequency
SMD	Surface-Mount Device
SPI	Serial Peripheral Interface
SR	System Requirement
SRAM	Static Random Access Memory
SSD	Sensor Subsystem Design
T	Test
THT	Through-Hole Technology
UART	Universal Asynchronous Receiver-Transmitter
V	Voltage
VM	Verification Method
Wh	Watt Hour

Systems Overview

Alper ARTUC

Mission Summary (1/2)

Design a Cansat that consists of a payload and a container that mounts on top of the rocket. The payload rests inside the container at launch and includes the **nose cone** as part of the payload. The container with the payload shall deploy from the rocket when the rocket reaches peak altitude and the rocket motor ejection forces a separation.

The container with the payload shall descend at a rate of **no more than 20 m/s** using a parachute that automatically deploys at separation. **At 75% peak altitude,** the payload shall separate from the container and **descend using an auto-gyro descent control system until landing**.

The descent rate shall be 5 m/s. A video camera shall show the separation of the parachute from the payload and the auto-gyro functioning. **A second video camera shall be pointing downward at 45 degrees from nadir and oriented north during descent and be spin stabilized so that the view of the earth is not rotating.**

The Cansat shall collect sensor data during ascent and descent and transmit the **data to a ground station at a 1 Hz rate.** The sensor **data shall include interior temperature, battery voltage, altitude, auto-gyro rotation rate, acceleration, rate, magnetic field, and GPS position.**

Mission Summary (2/2)

Bonus Mission Objectives

No bonus mission for this year.

External Objectives

In order to use the laboratories of our university and to get financial support, an application will be made to the rectorate.

System Requirement Summary (1/3)

No	Requirement Description	Rationale	A	I	T	D
1	After deployment, the Cansat payload and container shall descend at 20 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	CR-HRL	✔		✔	
2	At 75% flight peak altitude, the payload shall be released from the container.	CR-HRL			✔	
3	The payload shall descend at 5 +/- 3 meters/second with the auto-gyro descent control system.	CR-HRL	✔		✔	
4	The sensor telemetry shall be transmitted at a 1 Hz rate.	CR-HRL		✔	✔	
5	The payload shall record video of the release of the payload from the container and the operation of the auto-gyro descent control system.	CR-HRL			✔	✔
6	A second video camera shall point in the north direction during descent.	CR-HRL			✔	✔
7	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	CR-HRL			✔	✔
8	The Cansat and container mass shall be 1400 grams +/- 10 grams.	CR-HRL			✔	
9	Nose cone radius shall be exactly 72.2 mm.	CR-HRL		✔		
10	Nose cone shoulder length shall be a minimum of 50 mm.	CR-HRL			✔	✔
11	The nose cone height shall be a minimum of 76 mm.	CR-HRL				

System Requirement Summary (2/3)

No	Requirement Description	Rationale	A	I	T	D
12	Cansat structure must survive 15 Gs vibration.	CR-HRL			✔	
13	Cansat shall survive 30 G shock.	CR-HRL			✔	
14	The container shoulder length shall be 90 to 120 mm.	CR-HRL		✔		
15	The container shoulder diameter shall be 136 mm.	CR-HRL		✔		
16	Above the shoulder, the container diameter shall be 144.4 mm.	CR-HRL		✔		
17	The container length above the shoulder shall be 250 mm +/- 5%.	CR-HRL		✔		
18	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	CR-HRL			✔	
19	The Cansat shall transmit telemetry once per second.	CR-HRL		✔	✔	
20	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	CR-HRL			✔	✔
21	Cansat payload shall video record the release of the parachute and deployment of the auto-gyro at 75% peak altitude.	CR-HRL			✔	✔
22	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	CR-HRL			✔	✔

System Requirement Summary (3/3)

No	Requirement Description	Rationale	A	I	T	D
23	The camera video shall be spin stabilized and oriented in the north direction so the view of the ground is not rotating more than 10 degrees in either direction.	CR-HRL			✔	
24	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	CR-HRL				✔
25	Telemetry shall include mission time with 1 second resolution.	CR-HRL				✔
26	Teams shall plot each telemetry data field in real time during flight.	CR-HRL		✔	✔	✔
27	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	CR-HRL			✔	✔
28	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	CR-HRL			✔	✔

Configuration A - Container

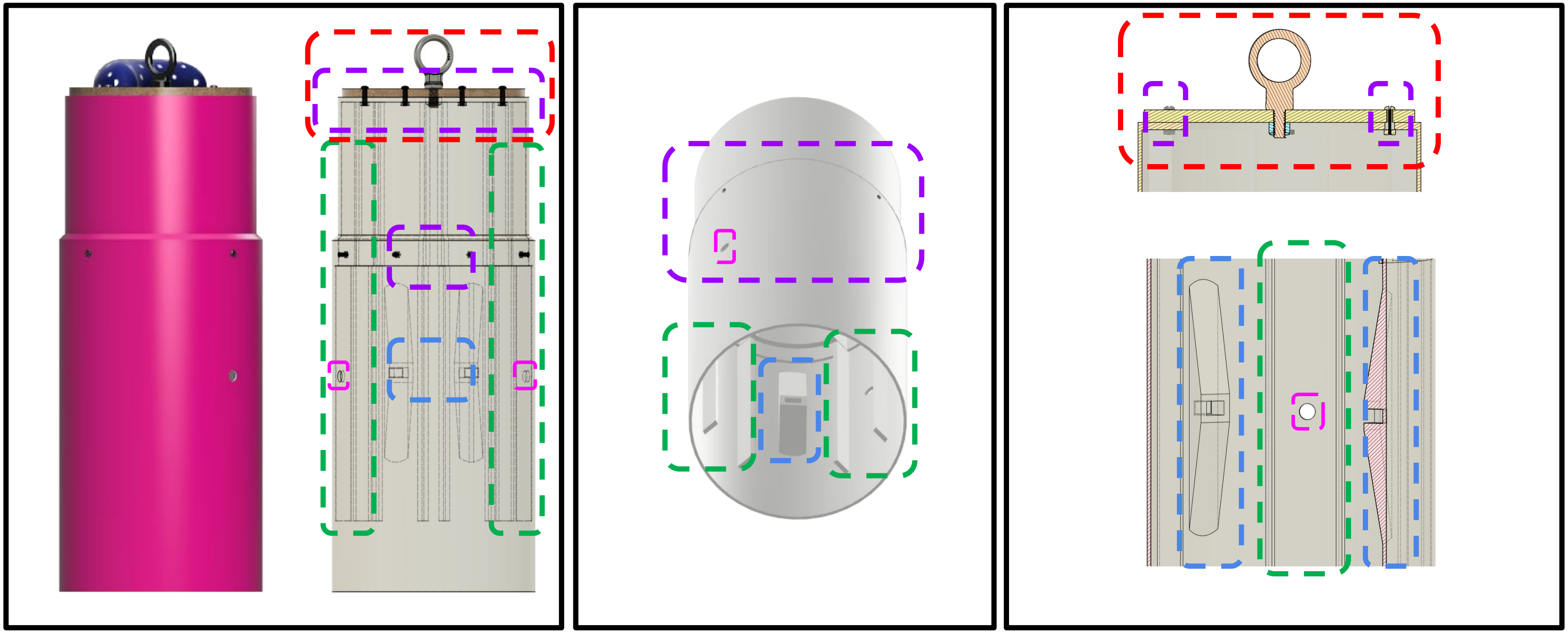
- - - Parachute Attachment Point ¼ in Eyebolt and ¼ in Lock Nut

- - - The connections of the container parts

- - - Vent Holes

- - - Propeller Wall Slots

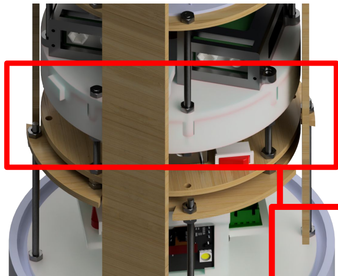
- - - Release Wall Attachment

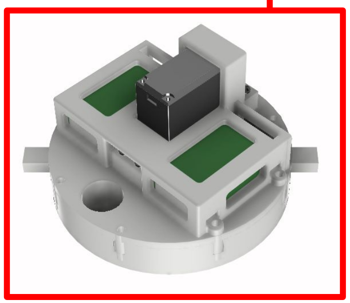


The container has been made white to make the system more understandable. The original will be pink.

System Level CanSat Configuration Trade & Selection (2/8)

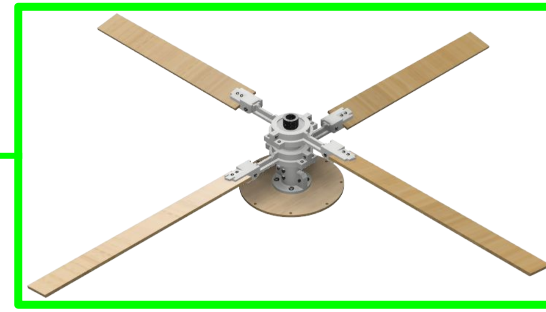
Configuration A - Payload



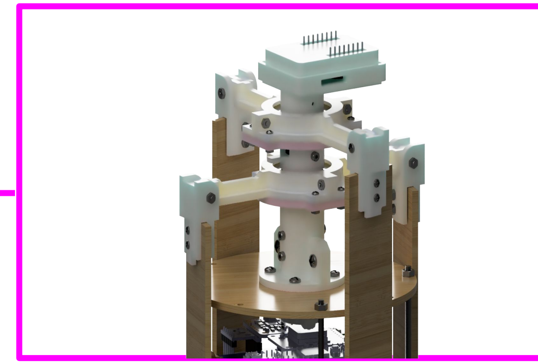


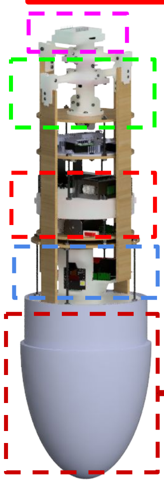
Release mechanism is mounted inside the satellite just below the PCB. It will operate at 75% peak altitude and ensure that the payload is separated from the container.

The coaxial propeller mechanism we designed for the autogyro descent mission is placed on top of the satellite.



Release Camera is placed on top of the propellers to record both the separation moment and the operation of the wings until the mission is completed.





Release Cam.

Coaxial Prop.

Release Mech.

Ground Cam.

Nose Cone

Ground Camera is designed using an encoder dc motor. It is mounted below the satellite, on top of the rocket nose cone, and performs the shooting mission 45 degrees north from nadir.

Elliptical rocket nose cone is manufactured as a single piece. It will continue its mission connected to the payload. (We will not separate the nose cone and the payload.)

System Level CanSat Configuration Trade & Selection (3/8)

Configuration A - Descent Method

From Peak Altitude to %75 Peak Altitude | 1

%75 Peak Altitude | 2

Landing | 3

Descent Method

1st Stage :

- Satellite starts to descend with payload and container at a **speed of 20m/s from peak altitude to 75% peak altitude**.

2nd Stage :

- When the satellite **reaches 75%** peak altitude, the **payload and container are separated from each other. Aerodynamic stability is maintained until this point thanks to the dome type parachute, center of mass and rocket nose cone.**

3rd Stage :

- When separation occurs, the propellers open automatically thanks to the rubbers on them. After the **wings open, the payload starts to land at a speed of 5m/s thanks to the passively working propellers. Since the propellers are designed as coaxial, the rocket nose cone is not separated from the payload and the center of mass remains at the bottom of the payload, the aerodynamic stability continues to be maintained** and the payload continues to land. **In this way, the coaxial propellers passively perform the autogyro function.**

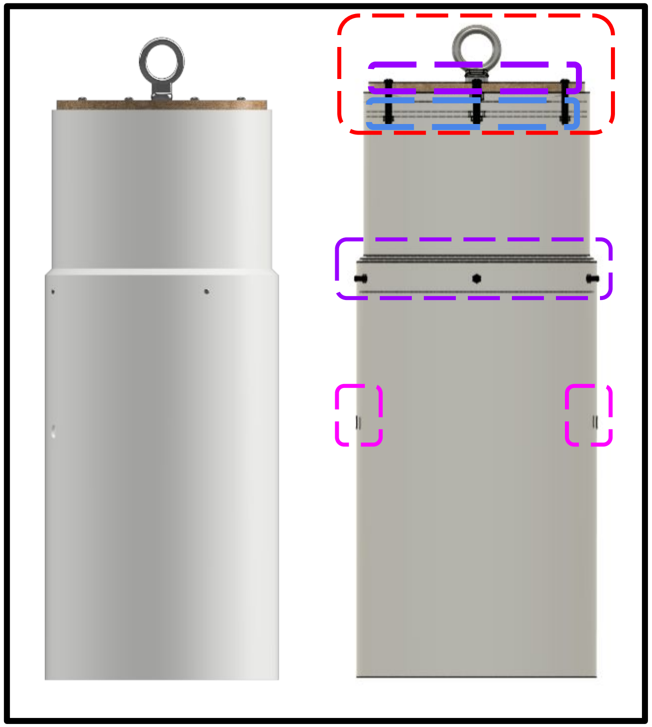
Configuration B - Container

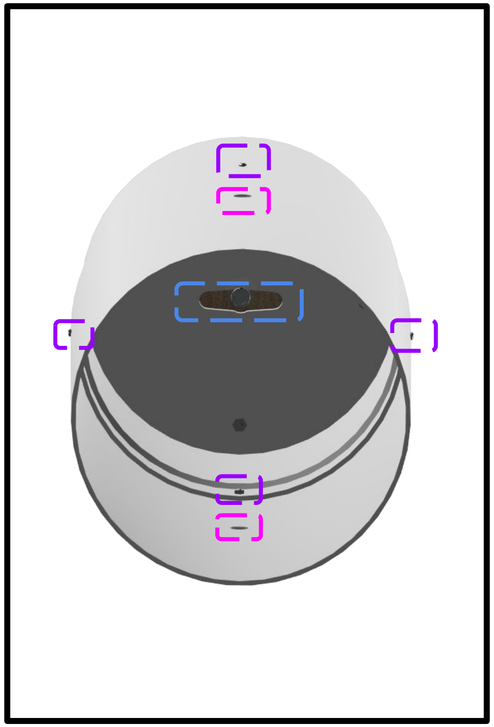
- - - Parachute Attachment Point ¼ in Eyebolt and ¼ in Lock Nut

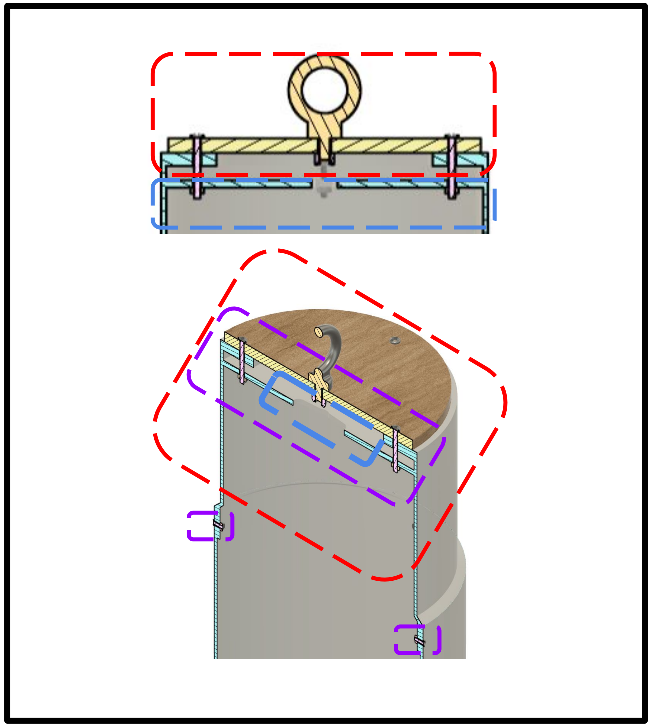
- - - Release Wall Attachment

- - - The connections of the container parts

- - - Vent Holes





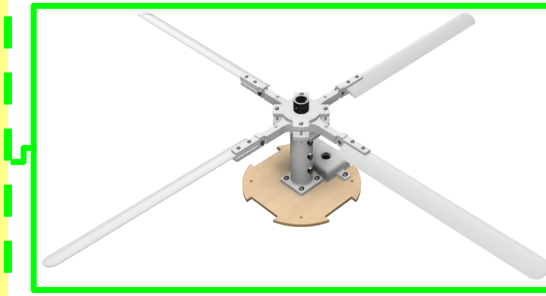


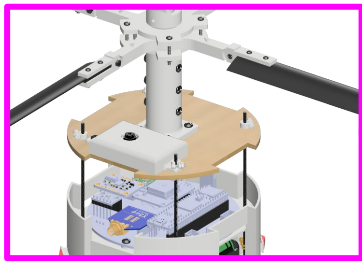
System Level CanSat Configuration Trade & Selection (5/8)

Configuration B - Payload

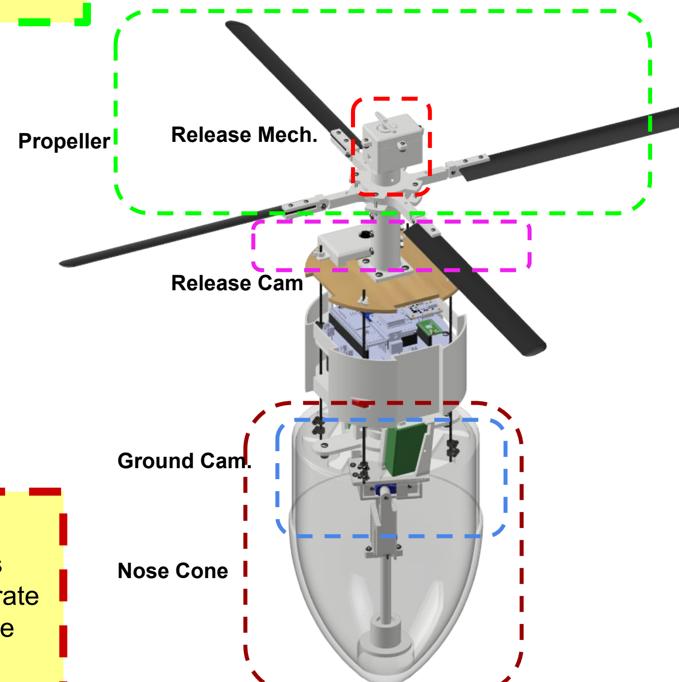
The **Release mechanism** consists of a single servo, and this servo apparatus ensures the unity of the load and the container by connecting it to the separation plate placed inside the container prepared according to its shape.
It will operate at 75% peak altitude and ensure that the payload is separated from the container.

Four blade propeller mechanism we designed for the autogyro descent mission is placed on top of the satellite.

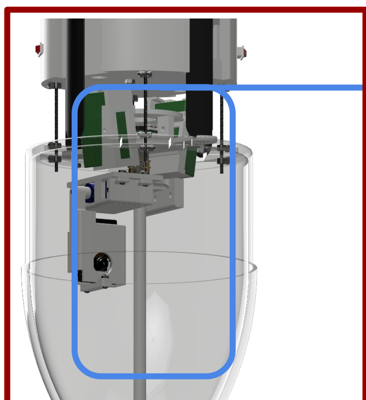




Release camera is positioned under the wings and the separation mechanism so that it can view both of them working simultaneously.



Ground camera is designed using an encoder dc motor. It is mounted under the satellite, inside the rocket nose cone, and performs the shooting task (encoder dc motor) from nadir to 45 degrees (servo motor) north.



Blunted tangent ogive rocket nose cone is manufactured as a single piece. It will continue its mission connected to the payload. (We will not separate the nose cone and the payload.)This product will be produced by heating and shaping plexiglass.

System Level CanSat Configuration Trade & Selection (6/8)

Configuration B - Descent Method

From Peak Altitude to %75 Peak Altitude | 1

%75 Peak Altitude | 2

Landing | 3

Descent Method

1st Stage :

- Satellite starts to descend with payload and container at a **speed of 20m/s from peak altitude to 75% peak altitude**.

2nd Stage :

- When the satellite **reaches 75%** peak altitude, the **payload and container are separated from each other. Aerodynamic stability is maintained until this point thanks to the dome type parachute, center of mass and rocket nose cone.**

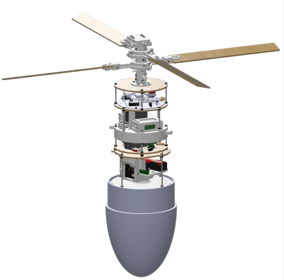
3rd Stage :

- When separation occurs, the four blade propellers open automatically thanks to the rubbers on them. After the **wings open, the payload starts to land at a speed of 5m/s thanks to the passively working propellers. Since the propellers and the rocket nose cone is not separated from the payload and the center of mass remains at the bottom of the payload, the aerodynamic stability continues to be maintained** and the payload continues to land. **In this way, the propellers passively perform the autogyro function.**

System Level CanSat Configuration Trade & Selection (7/8)

CONOPS

CanSat Config A



Payload Config A

SELECTED

CONOPS CONFIG A

Container parachute is fixed to plywood using eyebolt.
Additional design made inside the container. Separation mechanism ensures that the payload remains fixed inside up to 75% peak altitude. Its help the wings to maintain their positions.
Thanks to the camera placed on top of the wings, both the separation moment and the operation of the wings are recorded.
By using the Coaxial Propeller, both the upper wing feed is supported and a structure that helps balance is obtained. (Upper wing CW, lower wing CCW rotation) (Autogyro Landing Control Method).
A camera mechanism with 45 degrees by itself is designed. An encoder dc motor is used to fulfill the north duty.
The rocket nose cone is produced symmetrically using ASA filament and its connection is provided using lock nut. Rocket nose cone system will not be separated. (Autogyro Descent Control Method).

CONOPS CONFIG B

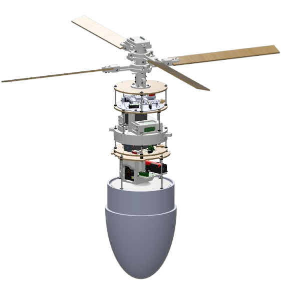
Container parachute is fixed to plywood using eyebolt.
Additional design made inside the container. The separation mechanism is provided to keep the payload connected to the container up to 75% peak altitude
Thanks to the camera placed under the wings, both the separation moment and the operation of the wings are recorded.
The payload starts to descend using a 4-Blade Propeller and the desired level drops. (Autogyro Descent Control Method).
A camera mechanism that captures 45 degrees with the servo motor is designed. An encoder dc motor is used to fulfill the north duty. And it is placed inside the rocket nose cone.
The rocket nose cone is produced symmetrically using plexiglass and its connection is provided using a lock nut. Rocket nose cone system will not be separated. (Autogyro Descent Control Method).

CanSat Config B

Payload Config B

Pros & Cons

CanSat Config A



Payload Config A

SELECTED

Configuration A

Configuration B

We now have two significantly different design as Configuration A and Configuration B. Considering Pros & Cons, we select Configuration A.

Configuration A – Pros

45 degrees passively given to the camera and the electrical and mechanical load of the system was reduced.
Coaxial propeller provided air supply to the upper wing. Since they were inverted to each other, they helped the overall system balance.
The system was assembled modularly.
Assembly and disassembly became easier.
The attachments designed into the container can guarantee the stability and safety of the system during flight.
Wings can be easily produced from hardboard using flat plates.
Rocket nose cone can be easily produced with 3D printing method.

Configuration A – Cons

There may be a weight problem because the system chassis design contains too many bolts and nuts. If the satellite cannot move as desired, it may miss 45 degrees. If the satellite cannot move as desired, it may miss 45 degrees.The system has very tight and difficult wiring.

Configuration B – Pros

There is an active mechanism in the system for 45 degrees.
It has a light chassis
The separation mechanism works easily, its production and use are simple

Configuration B – Cons

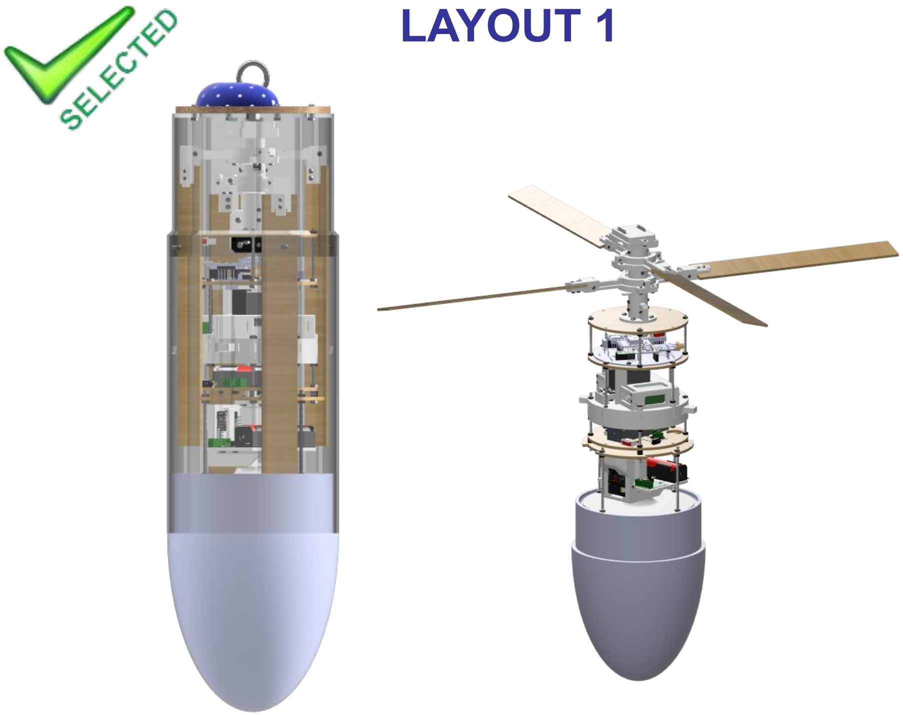
The camera mechanism power consumption is very high because both the servomotor and the dc motor will work.
The system assembly is very difficult
The system production rocket nose cone must be transparent, so it is made of plexiglass, the wings have a NACA 4412 profile and are made of carbon fiber material.
The chassis assembly consists of single-piece carbon fiber rods along the satellite, which makes assembly and disassembly difficult.
The system is not stable in the container.

CanSat Config B

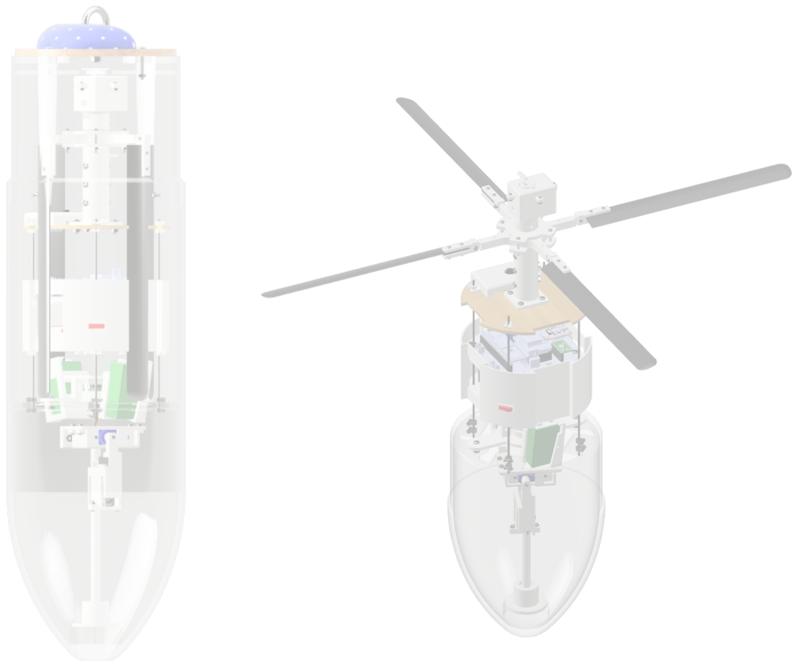
Payload Config B

System Level Configuration Selection

LAYOUT 1



LAYOUT 2



Rationale

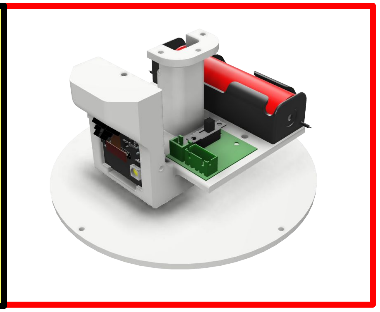
- *Coaxial propellers are better for tasks such as stable landing and speed limits.*
- *The rocket nose cone design is one where aerodynamic stability and drag coefficient are both at optimum levels.*
- *It is a cheap design to manufacture and easy to repair. (Cost Effective)*
- *The separation mechanism is reliable.*

The container has been made transparent to make the system more understandable. The original will be pink.

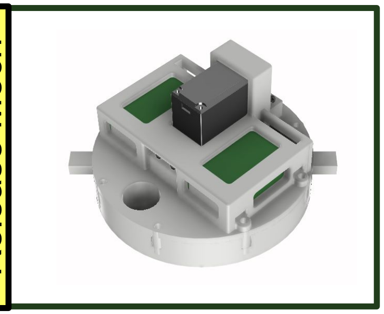
Physical Layout (1/4)

OVERVIEW

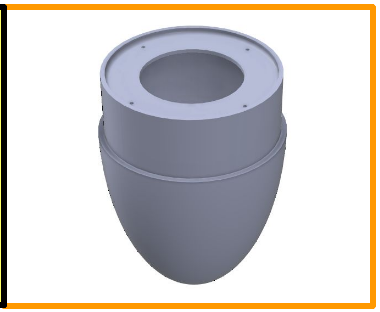
Ground Cam.



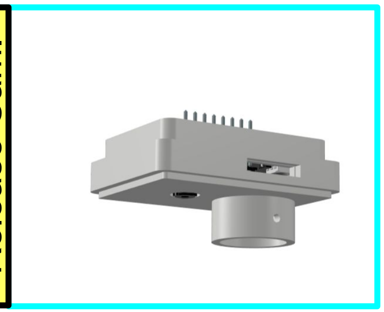
Release Mech



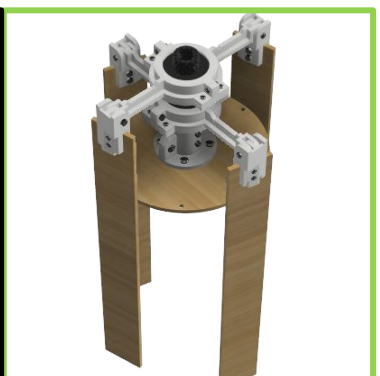
Nose Cone



Release Cam.

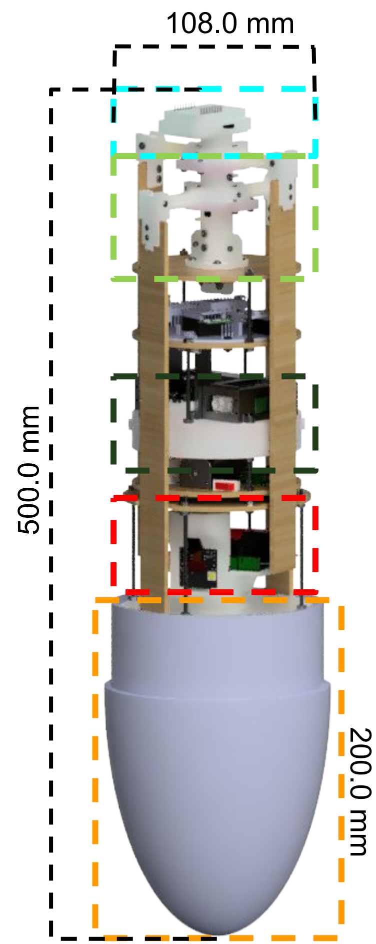


Propeller



Parachute Plate

PAYLOAD



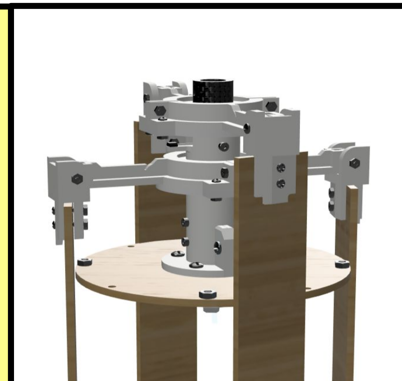
CONTAINER

Physical Layout (2/4)

PLACEMENT OF MAJOR COMPONENTS

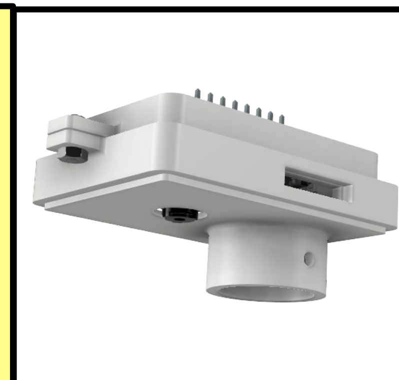
Upper Part

Upper Part



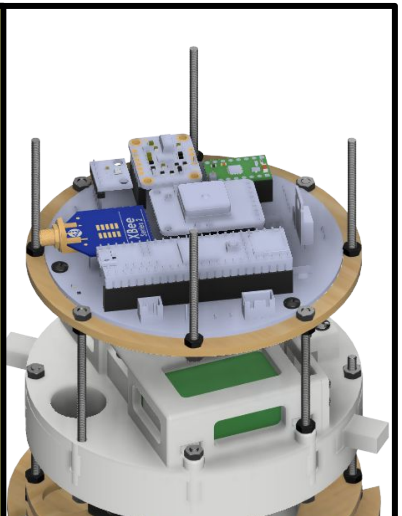
Coaxial Propeller + **Hall Sensor** + **Switch**

Upper Part



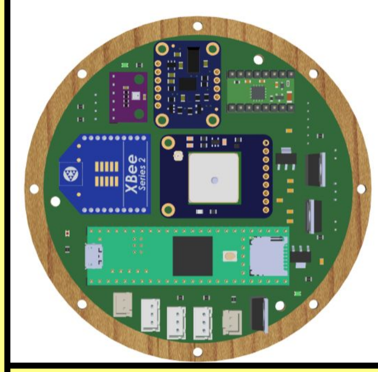
Release Camera

Middle Part



Middle Part

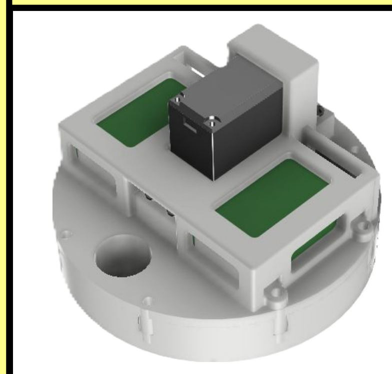
Radio Antenna on the PCB
GPS antenna on the PCB.



All Sensor on the PCB.

Middle Part

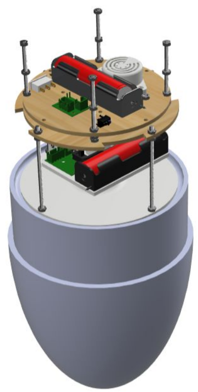
Release Mech.
9V Batteries for PCB



Servo Motor.

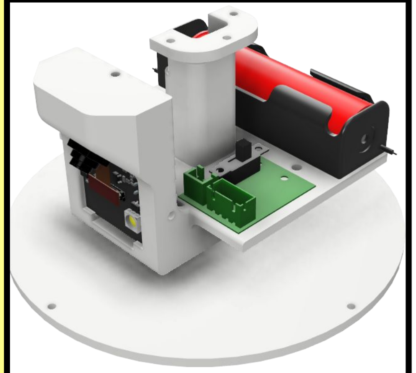
Physical Layout (3/4)

Bottom Part of the Payload



Bottom Part of the Payload

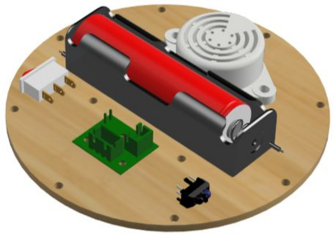
Camera Mechanism
Camera Board, Switch



Encoder DC Motor , Ground
Camera , 3.7V Battery

Bottom Part of the Payload

Buzzer , 3.7V Battery
Buzzer Board , Switch



Infrared Sensor

Container

Container

Container Wall Attachments

Container

Plywood , Eyebolt
Parachute

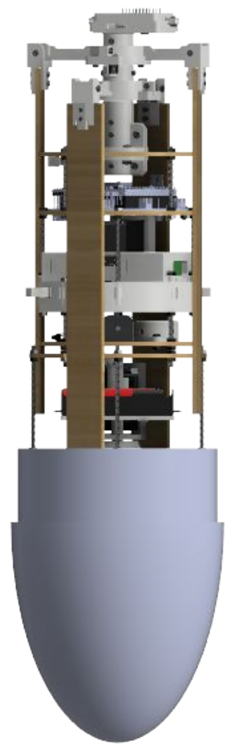
The container has been made white to make the system more understandable. The original will be pink.

Physical Layout (4/4)

LAUNCH CONFIGURATION

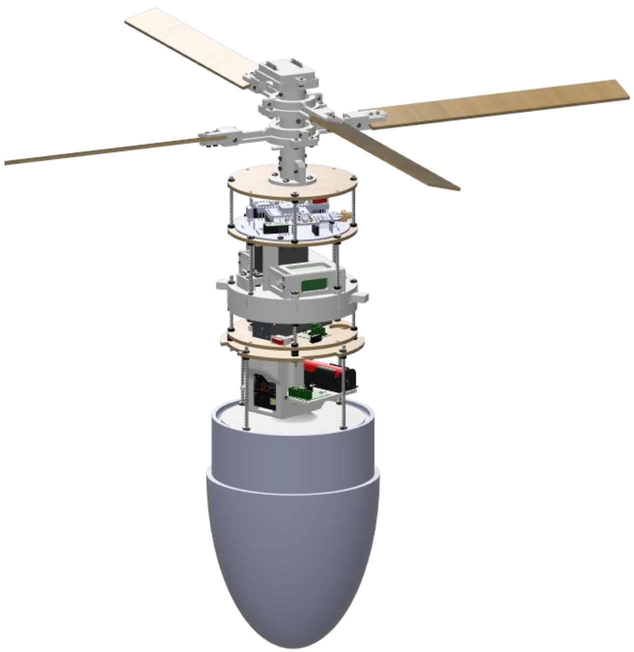
DEPLOYED CONFIGURATION

Stowed Config. of CanSat



Stowed Config. of Payload

Deployed Config. of Container



Deployed Config. of Payload

System Concept of Operations (1/2)

PRE-LAUNCH

Pre Launch Briefing

Buzzer, Ground camera and PCB switches are turned on

Mechanic and Electronic Controls

Placing the CanSat into the Rocket

Calibration of Barometric Altitude and Roll-Pitch Angles

CanSat begins collecting data and Telemetry at 1 Hz

LAUNCH

Rocket launch

Continue collecting data and telemetry

Deployment of the CanSat from the Rocket

The deployment of the parachute

Descent using parachute at rate of 20m/s.

The release camera captured the moment of separation and continues to capture the auto-gyro descending mechanism.

Payload release and opening the coaxial propeller.

Payload descent 5m/s.

The ground camera maintains its position and records 45 degrees north .

POST LAUNCH

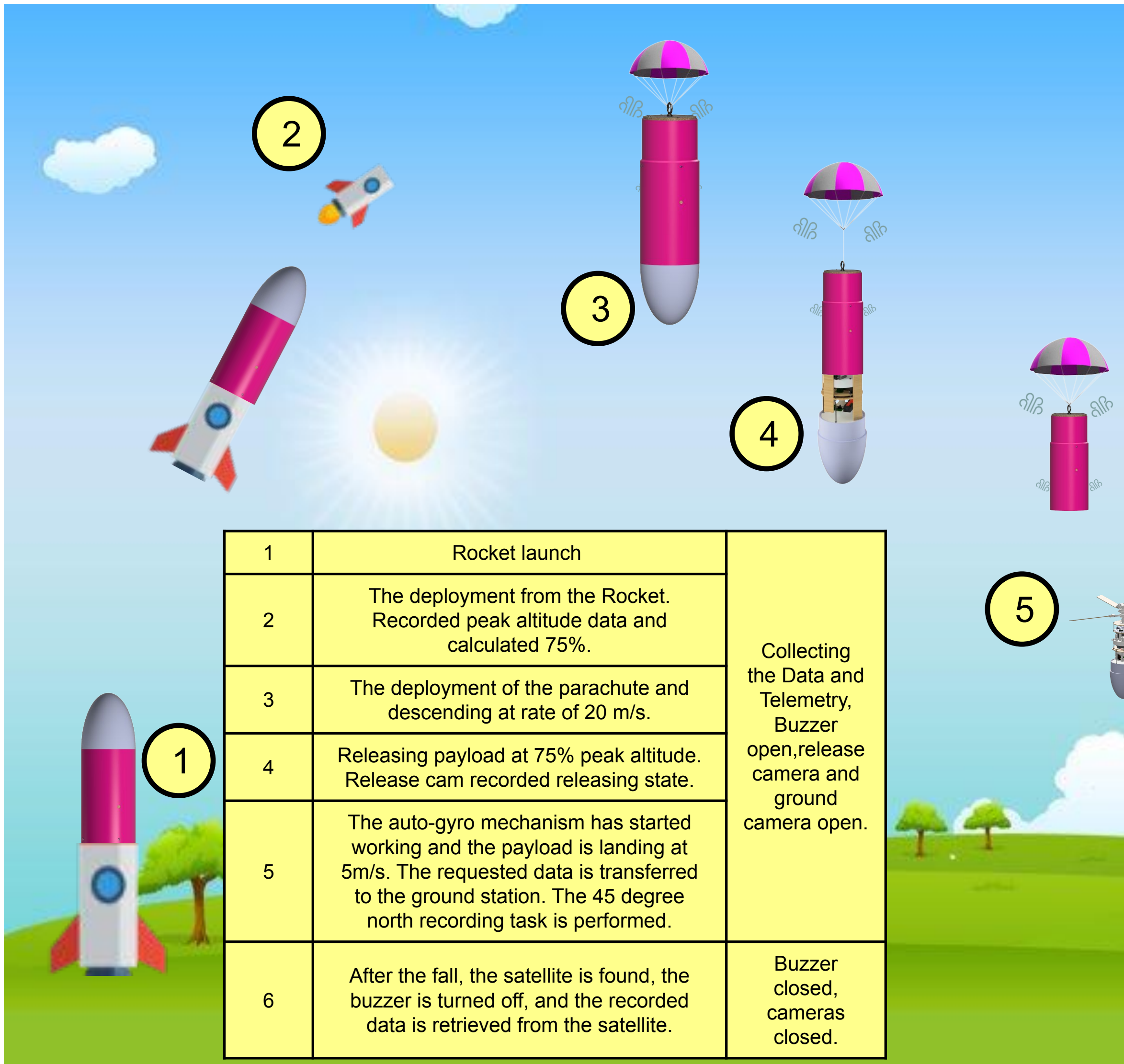
Locate and retrieve

Retrieve GCS data and SD Card data

Analysis of the data and reduce wrong values.

Prepare and present PFR

System Concept of Operations (2/2)

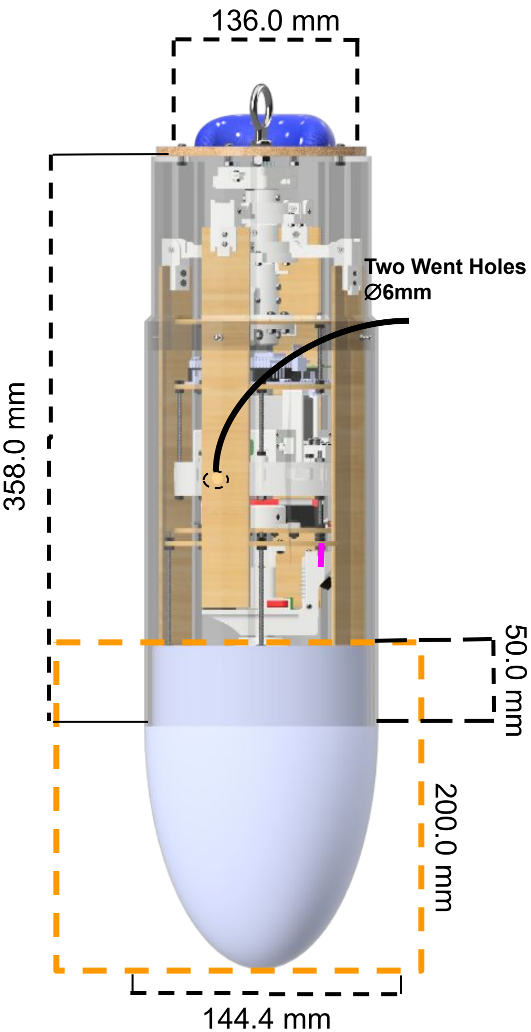


1	Rocket launch	Collecting the Data and Telemetry, Buzzer open,release camera and ground camera open.
2	The deployment from the Rocket. Recorded peak altitude data and calculated 75%.	
3	The deployment of the parachute and descending at rate of 20 m/s.	
4	Releasing payload at 75% peak altitude. Release cam recorded releasing state.	
5	The auto-gyro mechanism has started working and the payload is landing at 5m/s. The requested data is transferred to the ground station. The 45 degree north recording task is performed.	
6	After the fall, the satellite is found, the buzzer is turned off, and the recorded data is retrieved from the satellite.	Buzzer closed, cameras closed.

CONOPS

- **The system has a structure that forms the body and nose cone of the rocket.**
- **The buzzer is activated by a separate switch before the system starts flying.**
- **The system has an infrared sensor to really learn whether it will separate or not.**
- **The system has a parachute for a gradual descent speed and a passive auto-gyro mechanism.**
- **The selected configuration offers ease of production, cost-effectiveness, easy repair and simple integration.**
- **The release and ground cameras are positioned to perform their duties. The system passively gives the camera a 45 degree angle while actively turning to the north.**
- **In addition to the auto-gyro mechanism, the rocket nose cone and the system center of gravity being close to the base of the satellite increase our aerodynamic stability in terms of being able to perform the ground camera function.**

Launch Vehicle Compatibility(1/2)



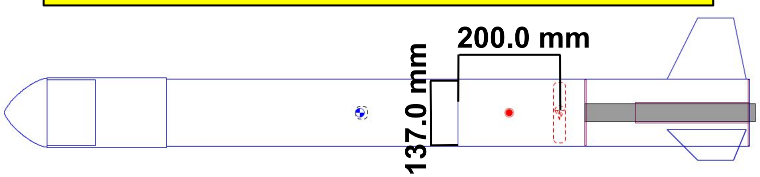
*Not in scale

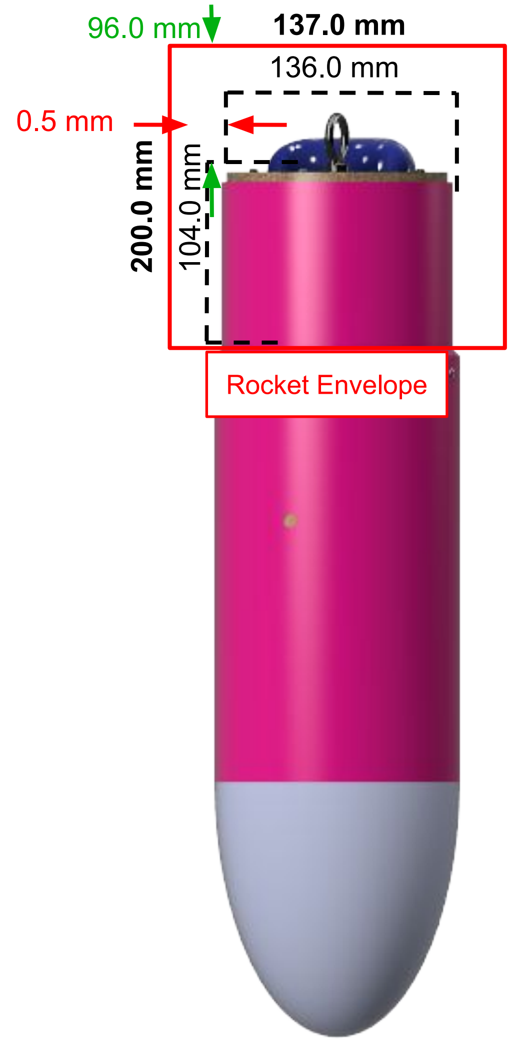
***No sharp protrusions.**

- The corners of the walls used to limit the wing movement inside the satellite will be sanded.
- The nuts of the eye bolts used to hold the parachute will be sanded.
- The outer surface of the nuts of the bolts used to connect the container parts will be sanded.

- In general, the satellite structure complies with all the limitations and conditions given in the mission manual.
- Work will be done for increasing the clearance size.
- Multiple Launch Vehicle Compatibility tests will be conducted to achieve better results.

Shared CanSat Rocket Model

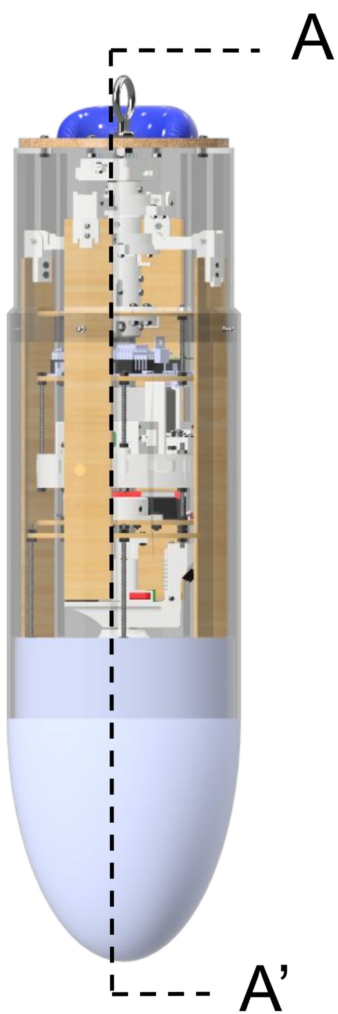




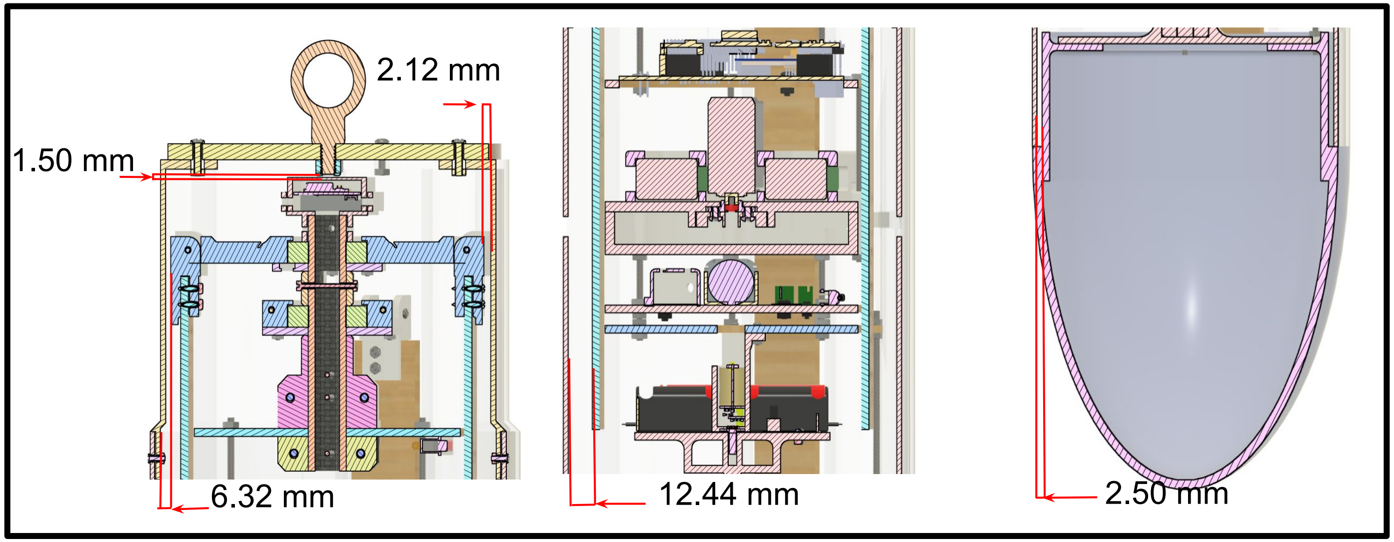
ENVELOPE CLEARANCE IS OBTAINED

The container has been made transparent to make the system more understandable. The original will be pink.

Launch Vehicle Compatibility(2/2)



Section A-A’



The container will be our rocket body in flight. That's why the clearances in this area are very important for a healthy flight.

ENVELOPE CLEARANCE IS OBTAINED

The container has been made transparent to make the system more understandable. The original will be pink.

Sensor Subsystem Design

Alper ARTUC

Sensor Subsystem Overview

Type	Selected Sensor	Function & Description
Air Pressure	BMP280	Measuring air pressure (altitude).
Air Temperature	BMP280	Measuring air temperature.
Battery Voltage	Teensy v4.1’s Analog Pin	Measuring battery voltage.
GNSS	Adafruit Ultimate GPS Breakout	Determining the position of CanSat.
Auto-Gyro Rotation Rate	US1881 Hall Effect Sensor	Determining the rotation rate of auto-gyro mechanism (propellers).
Tilt	Adafruit BNO055	Tracking the tilt of CanSat.
Ground Camera Orientation	Pololu Magnetic Encoder (with Pololu Micro Geared DC Motor and DRV8833 DC Motor Driver)	Driving and controlling the motor of ground camera mechanism by sensing its position and movement.
Ground Camera	ESP32-CAM	Recording the ground.
Release Camera	ESP32-CAM	Recording the release mechanism.

Payload Air Pressure Sensor Trade & Selection

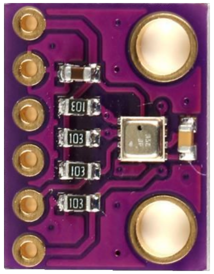
Sensor Name	Size [mm]	Mass [g]	Operating Voltage [V]	Operating Current [mA]	Range [hPa]	Resolution [Pa]	Accuracy [hPa]	Interface	Price [$]
BMP280	**12 x 15 x 2**	**1**	**1.71 - 3.6**	**0.0027**	**300 - 1100**	**0.18**	**±1**	**I2C SPI**	**0.62**
BMP388	27 x 32 x 2	1.3	3.3 - 5.5	0.004	300 - 1250	0.08	±0.5	I2C SPI	10.49
MPL3115A2	18 x 19 x 2	1.2	1.95 - 3.6	0.004	500 - 1100	1.5	±0.4	I2C	9.61

```
Temperature: 27.45°C
Pressure: 917.75 hPa
Relative Altitude: 0.14m
```

BMP280

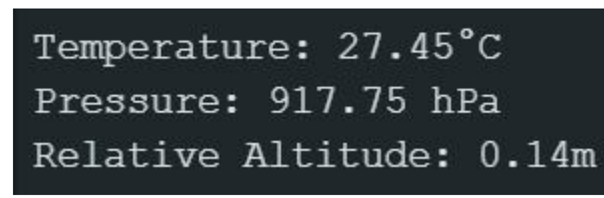
SELECTED

- **Good operating conditions**
- **Small size and low mass**
- **Perfect price**
- **Also used as temperature sensor**



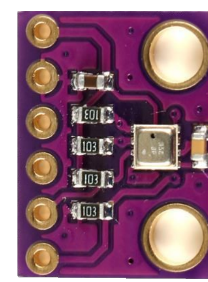
Payload Air Temperature Sensor Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Voltage [V]	Operating Current [mA]	Range [°C]	Resolution [°C]	Accuracy [°C]	Interface	Price [$]
BMP280	**12 x 15 x 2**	**1**	**1.71 - 3.6**	**0.0027**	**-40 to +85**	**0.01**	**±1**	**I2C SPI**	**0.62**
DHT22	27 x 59 x 14	2.4	3.3 - 5.5	0.3	-40 to +80	0.1	±0.5	Single-Wire (Digital)	3.64
MS5611	19 x 13 x 2	1.5	1.8 - 3.6	1.25	-40 to +85	0.01	±0.8	I2C	11.75



BMP280

- **Good operating conditions**
- **Small size and low mass**
- **Perfect price**
- **Also used as pressure sensor**



Payload Battery Voltage Sensor Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Current [mA]	Range [V]	Resolution [mV]	Interface	Cost [$]
Teensy 4.1's Analog Pin	**No extra area needed**	**-**	**0.74 (calculated)**	**0 - 3.3**	**3.22**	**Analog**	**Free**
MAX741	20 x 19.5	1.9	1	3.5 - 20	4.89	Analog	4.93

Voltage divider formula:

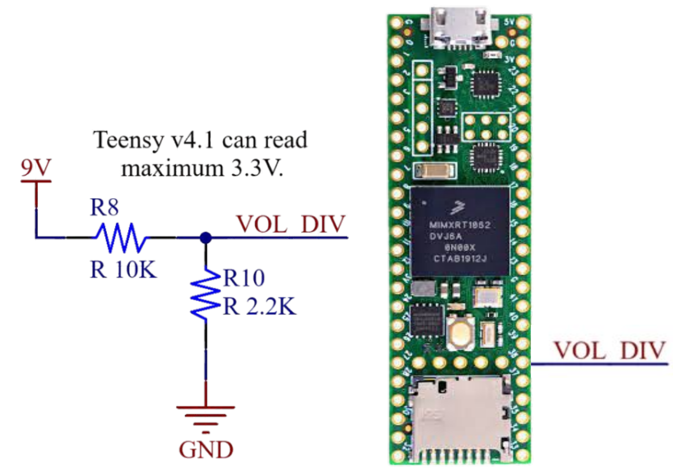
$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2}$$

```
Raw ADC Value: 1811
 - Measured Voltage: 1.459
 V - Power Supply Voltage: 8.093 V
```

Teensy v4.1's Analog Pin

SELECTED

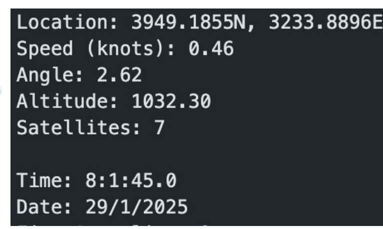
- **Free**
- **Low and controlled (by selecting resistors) power consumption**
- **Sufficient resolution**
- **SMD footprints need nearly zero additional space on PCB**

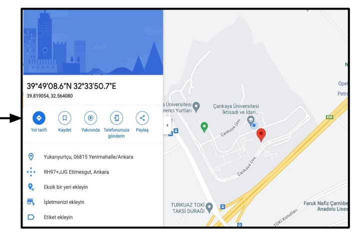


Payload GNSS Sensor Trade & Selection

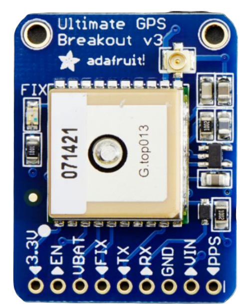
Sensor Name	Size [mm]	Mass [g]	Operating Voltage [V]	Operating Current [mA]	Resolution [m]	Acquisition Sensitivity [dBm]	Tracking Sensitivity [dBm]	Interfaces	Cost [$]
Adafruit Ultimate GPS Breakout	**25.5 x 30 x 6.5**	**8.5**	**3.0 - 5.5**	**20**	**3**	**-145**	**-165**	**UART**	**29.95**
SparkFun ZOE-M8Q GPS Breakout	25 x 25 x 4	40	3.3	21	2.5	-160	-167	UART I2C SPI	49.95

Adafruit Ultimate GPS Breakout





- **Lower mass**
- **Lower cost**
- **Satisfactory resolution and sensitivity**



Payload Auto-Gyro Rotation Rate Sensor Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Current [mA]	Operating Voltage [V]	Type	Resolution [Gauss]	Interface	Cost [$]
US1881	**3 x 3 x 1.5**	**0.25**	**5**	**3.5 - 24**	**Hall Effect**	**30**	**Digital**	**0.39**
SS411P	4.5 x 4.5 x 1.5	0.7	6	2.7 - 7.0	Hall Effect	10	Analog	1.29
KMZ60	5.5 x 5.5 x 2.2	2	12	2.7 - 7.5	Hall Effect	5	Analog	1.9

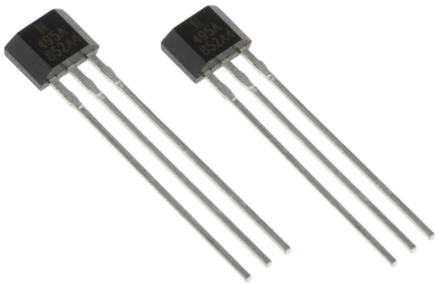
We use two sensors for each propeller, with each propeller having a dedicated sensor to measure its rotation. As the magnets on the propellers pass in front of the sensors, we record the measurements.

```
Auto Gyro Rotation Rate : 263.7843
```

US1881

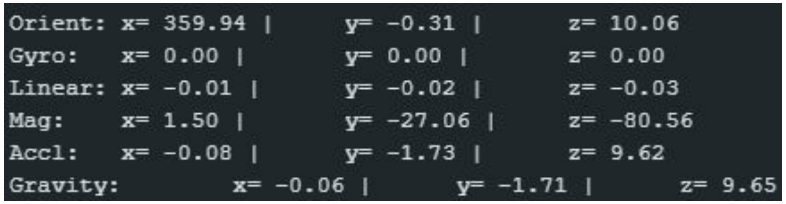
SELECTED

- **Small size**
- **Perfect price**
- **Low operating current**
- **Easy to place near the propellers**



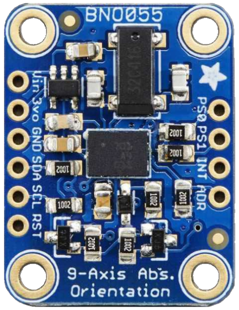
Payload Tilt Sensor Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Current [mA]	Operating Voltage [V]	Range [°/s]	Resolution [bits]	Interface	Cost [$]
BNO055	**20 x 27 x 4**	**3**	**12.3**	**2.4 - 3.6**	**±125 to ±2000**	**16**	**I2C UART**	**36.80**
BNO086	25.4 x 30.5 x 1.5	3	15	1.7 - 3.6	±125 to ±2000	16	I2C SPI	29.95
LSM9DS1	33.4 x 20.4 x 3	2.5	2	3.0 - 5.0	±245 to ±2000	16	I2C SPI	22.5



BNO055

- **Smaller size**
- **Wide range**
- **Perfect documentation**
- **Built-in sensor fusion algorithm**



Payload Ground Camera Orientation Sensor Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Current [mA]	Operating Voltage [V]	Resolution [°]	Microcontroller Interface	DC Motor Interface	Cost [$]
Pololu Magnetic Encoder	**10.6 x 11.6 x 1.2**	**1**	**5**	**2.7 - 18**	**0.0075**	**Two Quadrature Digital Signals**	**PWM**	**4.48**
AS5600 Module	23 x 23 x 4	3	10	3.3	0.0879	I2C	Analog PWM	1.97

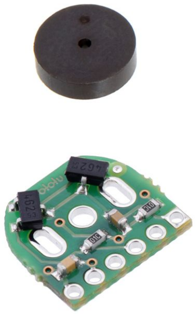
Magnetic encoder will detect the position of DC motor and provide a feedback to microcontroller, that compares our current position with the desired position (north). DC motor will then moved into required way, by the help of DRV8833 motor driver, supplying required current to the DC motor. This process will continue until the flight ends.

Pololu Magnetic Encoder

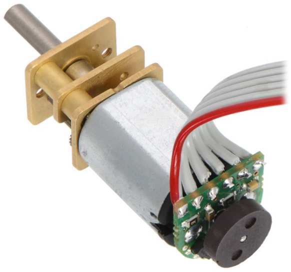
SELECTED

- **Small size and perfect mass**
- **Good operating conditions**
- **Manufactured for our DC Motor (Pololu Micro Geared DC Motor)**

Magnetic Encoder with its Magnet



Magnetic Encoder and Pololu DC Motor Connection



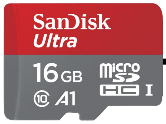
Parachute Release Camera Trade & Selection

Sensor Name	Size [mm]	Mass [g]	Operating Voltage [V]	Operating Current [mA]	Micro SD Card	Resolution [pixels]	Frames per second	Interface	Cost [$]
ESP32-CAM	**27 x 40.5 x 4.5**	**10**	**3.3 - 5.0**	**140**	**Yes**	**800x600**	**30**	**UART SPI I2C**	**9.1**
Turboving Cyclops V3	18 x 18 x 8	4.8	3.5 - 5.5	200	Yes	1280x720	30	GPIO	20
OV5640 Module	35.7 x 23.9 x 6	6	3.8 - 5.0	200	Yes	2592x1944	30 60	I2C	36

ESP32-CAM

SELECTED

- **Enough resolution**
- **Flexible camera selection option**
- **Good price**
- **Wide interface option**
- **Micro SD card for video storage**



Ground Camera Trade and Selection

Sensor Name	Size [mm]	Mass [g]	Operating Voltage [V]	Operating Current [mA]	Micro SD Card	Resolution [pixels]	Frames per second	Interface	Cost [$]
ESP32-CAM	**27 x 40.5 x 4.5**	**10**	**3.3 - 5.0**	**140**	**Yes**	**800x600**	**30**	**UART SPI I2C**	**9.1**
Turboving Cyclops V3	18 x 18 x 8	4.8	3.5 - 5.5	200	Yes	1280x720	30	GPIO	20
OV5640 Module	35.7 x 23.9 x 6	6	3.8 - 5.0	200	Yes	2592x1944	30 60	I2C	36

ESP32-CAM

SELECTED

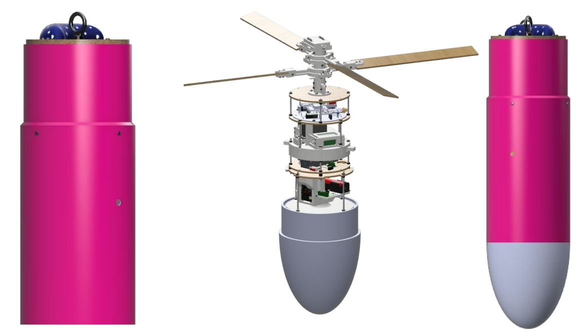
- **Enough resolution**
- **Flexible camera selection option**
- **Good price**
- **Wide interface option**
- **Micro SD card for video storage**

Descent Control Design

Alper ARTUC

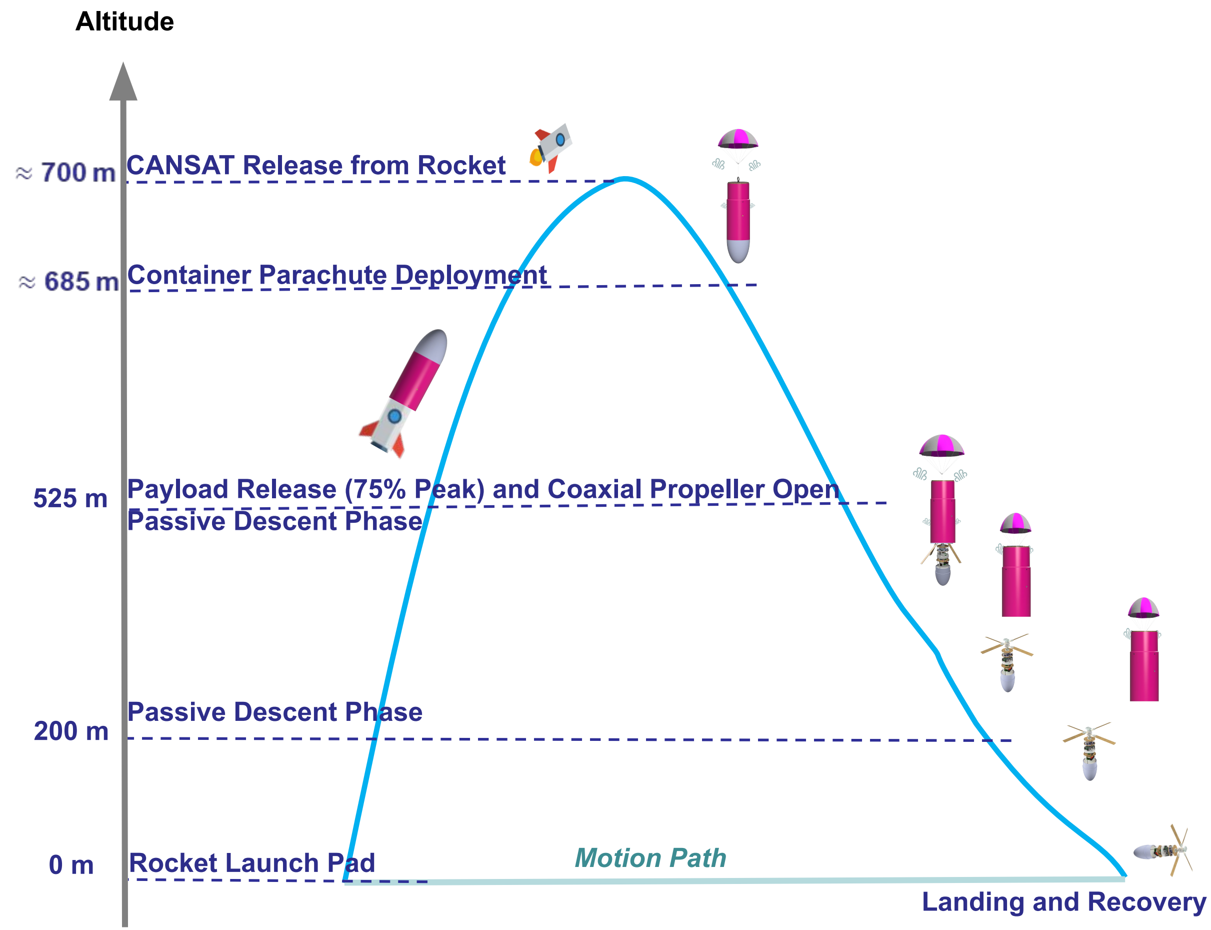
Descent Control Overview

COMPONENTS	MATERIALS
Coaxial Propeller	MDF
Parachutes	Parachute Fabric
Payload Chassis	Carbon Fiber , Cold-Drawn Steel Bolt and Nuts
Payload Internal Parts	PLA+ , MDF
Container	PLA+
Container Internal Parts	PLA +
Nose Cone	ASA



Container Payload CanSat

Descent Control will be provided by parachutes and Coaxial Propellers during descent phases.



Parachute Descent Control Strategy Selection and Trade

Container descent control is related with parachute design. It will be external and attached to the container so that it will open immediately when deployed from the rocket. Hence, parachute alternatives should be discussed. Among the parachute materials like Canvas, Silk, Dacron, Kevlar, and Nylon, we selected **Nylon** since its **low density**.

PARACHUTE CONFIGURATION

X-Type Parachute

- Low drag coefficient
- Stacking is easy
- High vertical speed
- No need modification to reduce sway.

Dome Type Parachute

- High drag coefficient
- Easy to fabricate
- Low horizontal displacement
- Spill hole is necessary to **reduce sway and maintain NADIR.**

Selection Reasons

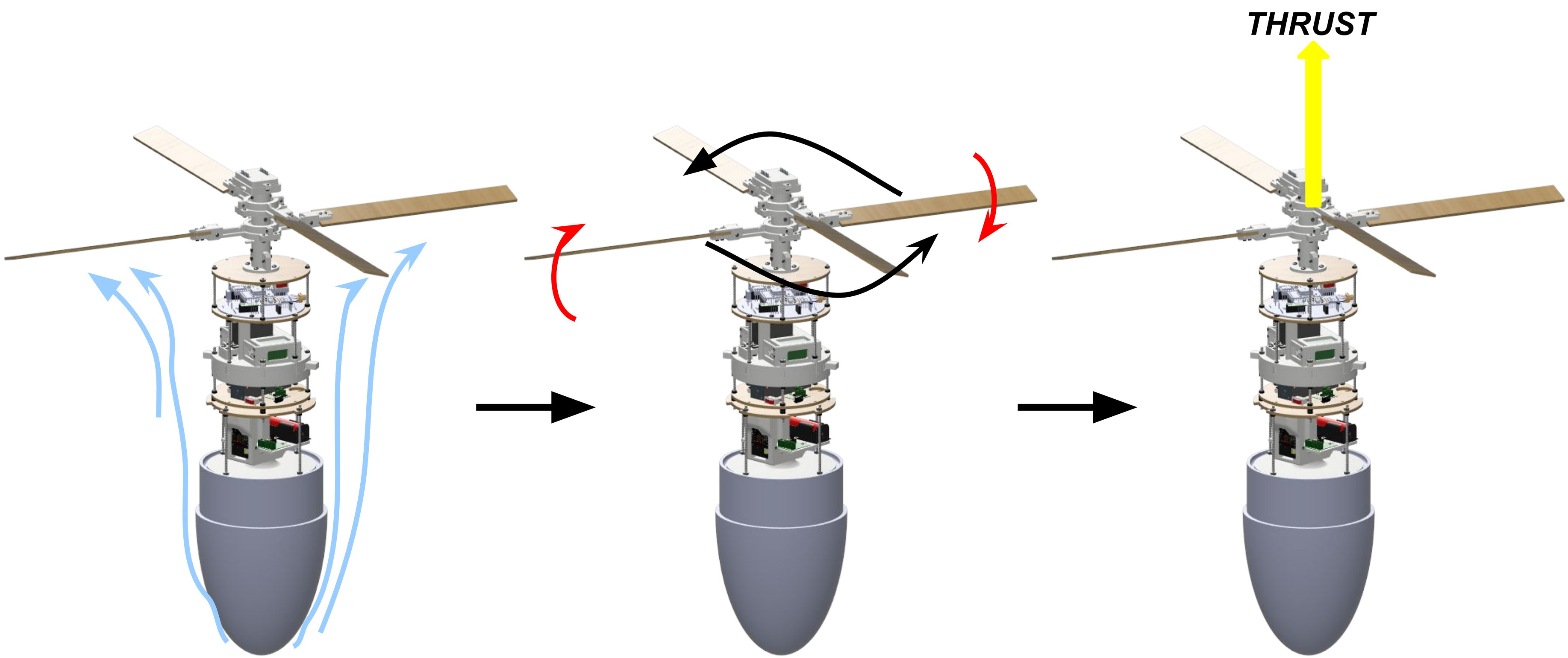
Para Foil Type Parachute

- High drag coefficient
- Very difficult to fabricate
- Higher horizontal speed
- Not suitable to operate unmanned

Auto-Gyro Descent Control Strategy Selection and Trade (1/6)

Strategy 1 : Auto-Gyro Operation-Passive

Auto-gyro spins its rotor blades using airflow. During forward motion, air passes from top to bottom over the rotor blades, and this airflow causes the rotor to spin (autorotation). As the rotor spins, a lift force is created by the shape of the blades, and this lift force keeps the vehicle in the air.

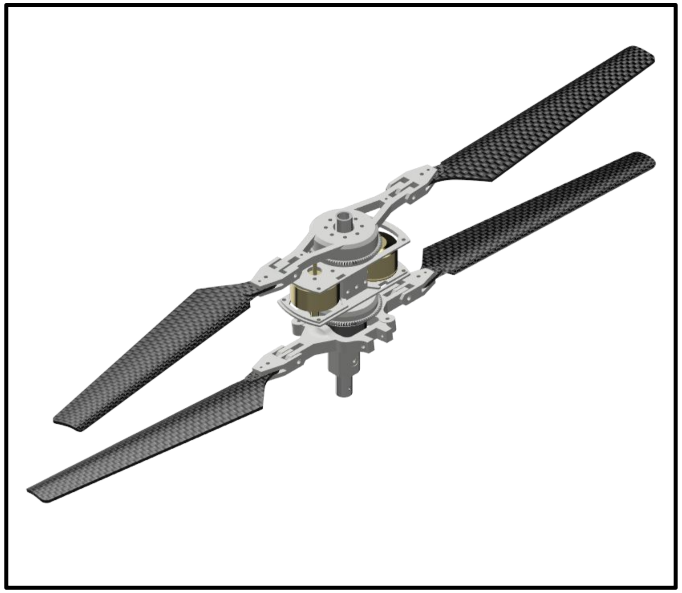


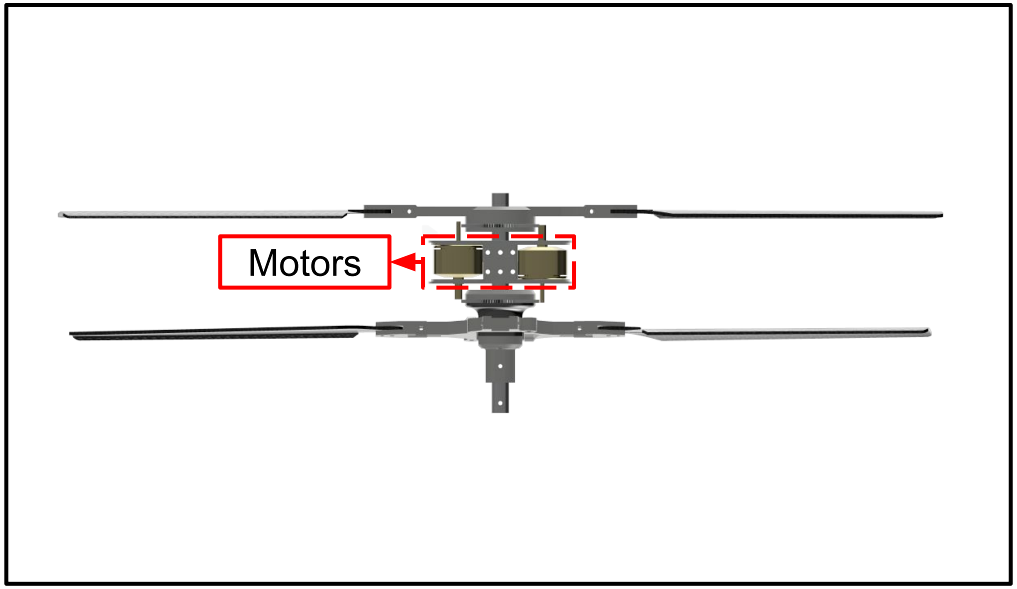
Air flow — *Rotor rotates* — *Lift force is produced*

Auto-Gyro Descent Control Strategy Selection and Trade (2/6)

Strategy 2 : Auto-Gyro Operation-Active

A motorized autogyro uses motor to drive a propeller that produces forward thrust. As the vehicle moves forward, airflow passes over the freely rotating rotor blades from top to bottom, allowing autorotation. **This autorotation creates lift due to the aerodynamic design of the rotor blades, allowing the vehicle to remain airborne.**

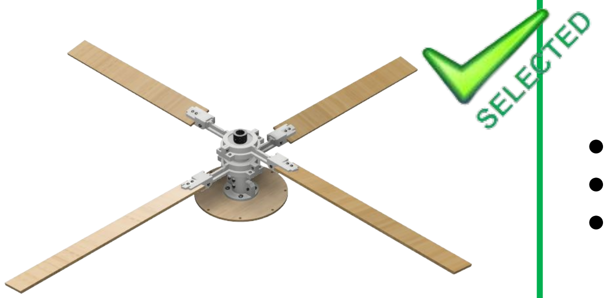




Dual engine Auto-Gyro design

Auto-Gyro Descent Control Strategy Selection and Trade (3/6)

Auto-Gyro Operation-Passive



- Cheap. Low maintenance cost. No power consumption.
- Simple Design. Easy to produce. Easy assembly.
- Light. Lighter since the number of materials and fasteners used is less than active.

Auto-Gyro Operation-Active

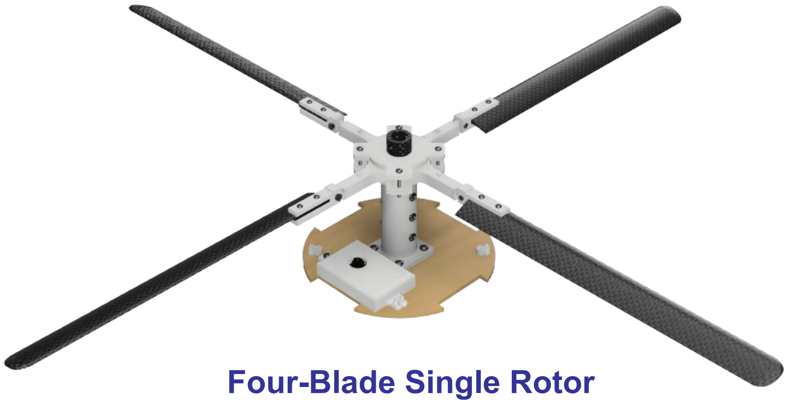
- Power Consumption. Continuous power requirement increases operating power consumption.
- Maintenance Requirement. Engine and propeller systems require regular maintenance and repair.
- Higher Weight. Weight of engine and power transmission gears.
- Complex design. Makes overall design more complex.

Auto-Gyro Descent Control Strategy Selection and Trade (4/6)

Passive - Propeller Configuration Trade Selection

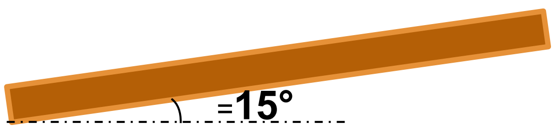
Criterion	Coaxial Propeller	Four-Blade Single Rotor
Lift Force	**Higher (Due to dual Rotor)**	High
Torque Balance	**Excellent**	Requires an extra mechanism
Mechanical Complexity	**High**	Simple
Mass	**Heavier**	Lighter
Compactness	**Compact**	Simple

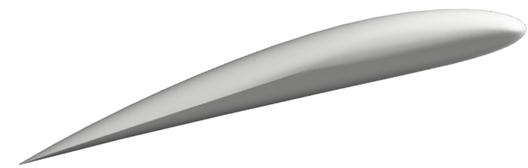
Coaxial Propeller



Four-Blade Single Rotor

Auto-Gyro Operation Airfoil Trade Selection





Flat Plate

- High Lift Coefficient
- High Drag Coefficient
- Easy to fabricate

$Cl=2\pi\alpha$ (α=radian) = 1.64
enough for us. (This formula is only for flat plate)

NACA 0012 Airfoil

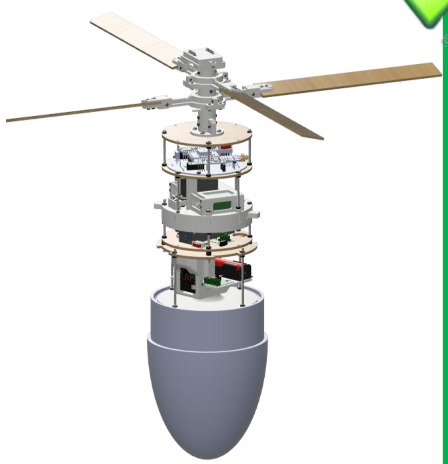
- High Lift Coefficient
- Low Drag Coefficient
- Difficult to fabricate

NACA4412

- High Lift Coefficient
- Low Drag Coefficient
- Difficult to fabricate

Auto-Gyro Descent Control Strategy Selection and Trade (6/6)

Coaxial Propeller



SELECTED

- **Increased stability.** Provides a more stable flight by balancing the torque values (yawing moment) of the counter-rotating propellers. These are especially advantageous in strong wind conditions.
- **Load carrying capacity**. Lift force can be increased to operate more than one propeller on the same axis.
- More lift power.
- **Better power density.** In the coaxial system, the counter-rotating propellers on each engine cancel each other out. This provides advantages in terms of both static and dynamic balance.
- **Wind resistance.** Coaxial arrangements are more stable against external forces thanks to better control of the center of gravity.
- **Vibration reduction.** Coaxial arrangements dampen vibrations more effectively.

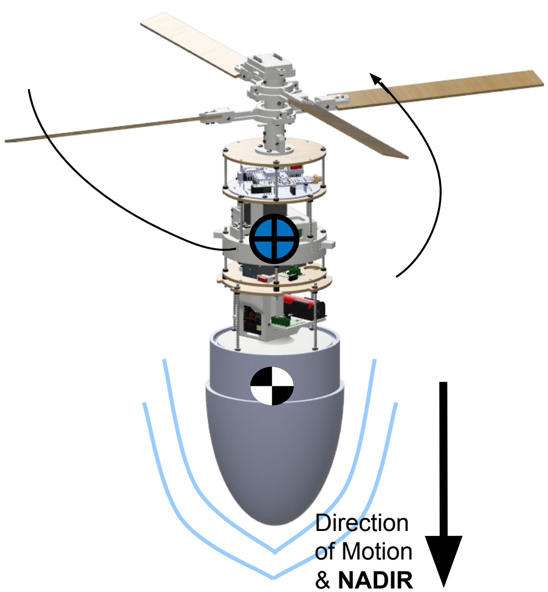
Four-Blade Single Rotor

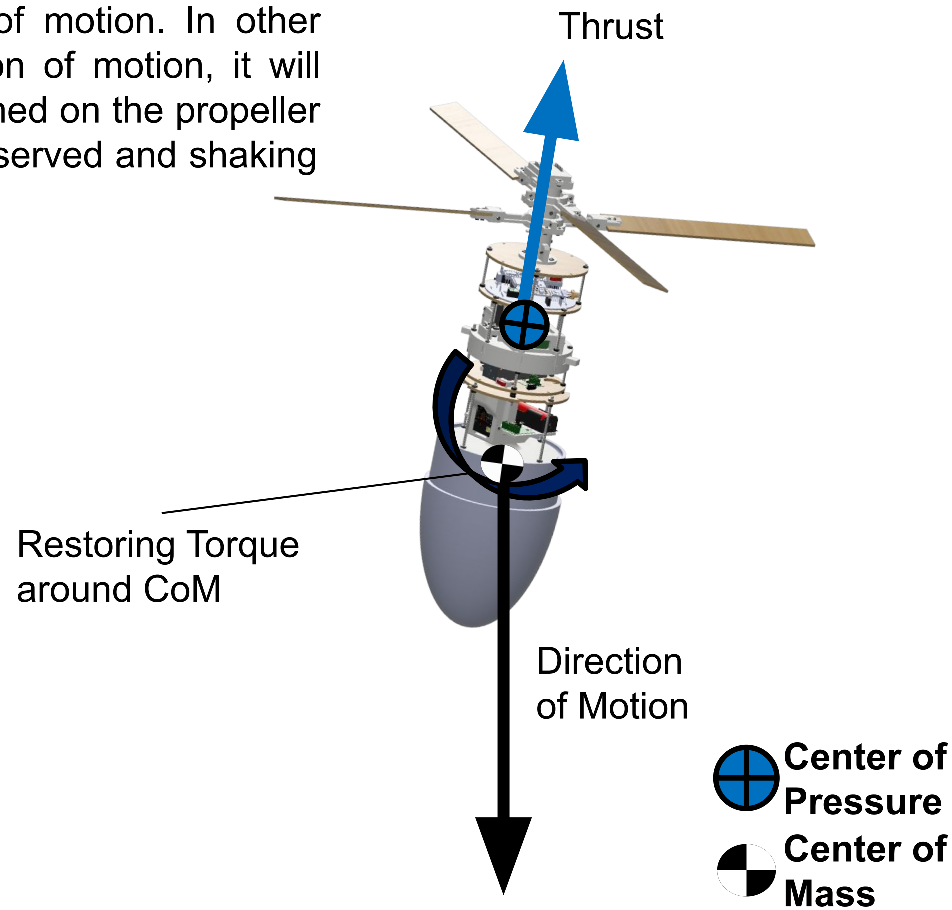
- **Low load carrying capacity.** Since it provides thrust in a single plane.
- **Low stability.** One rotation axis.

Auto-Gyro Descent Stability Control Strategy Selection and Trade (1/4)

Stability Strategy 1
a Passive Method

Like the balance methods of rockets, the center of mass will be in front of the center of pressure in the direction of motion. In other words, if the load axis deviates from the direction of motion, it will restore itself. The forces created by the forces formed on the propeller will support this recovery. Thus, NADIR will be preserved and shaking will be prevented.



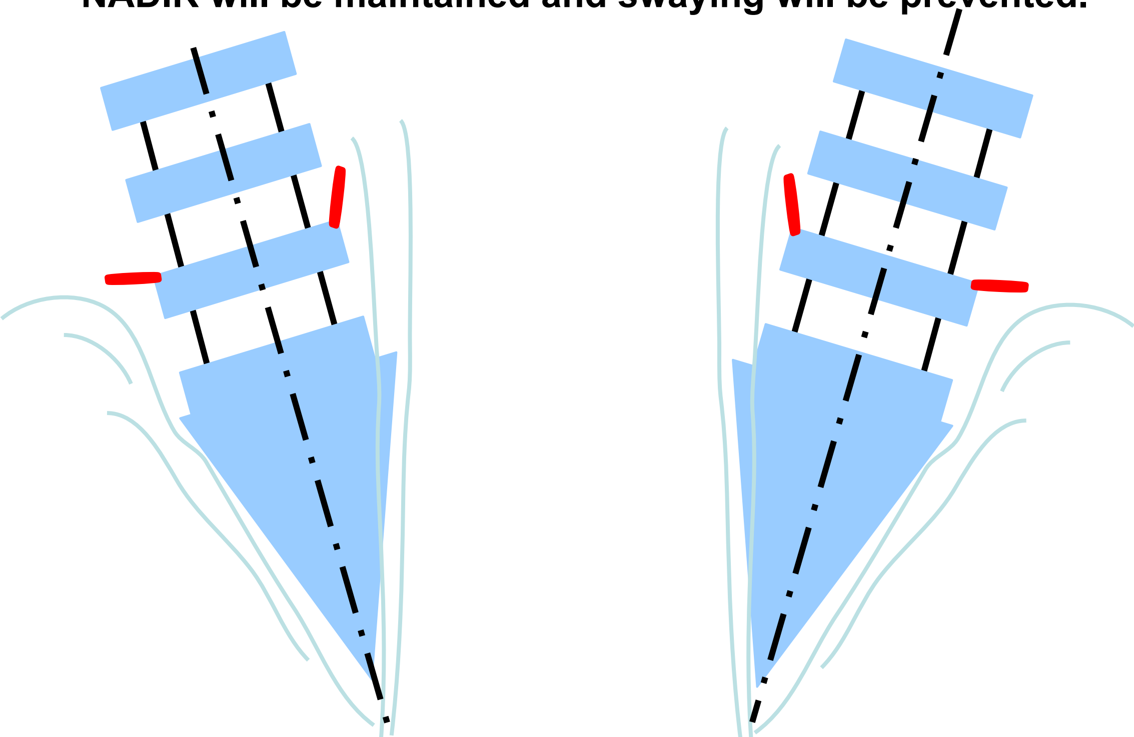


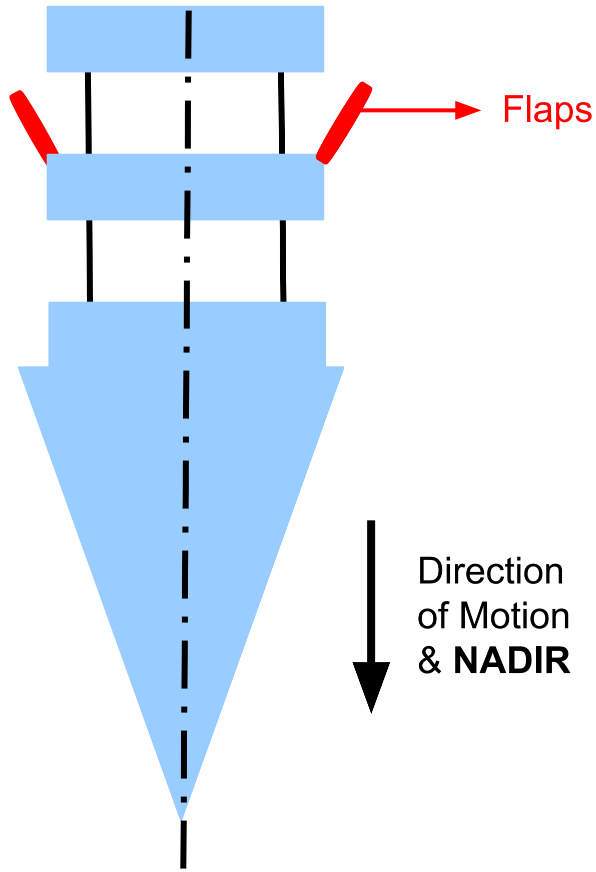
Auto-Gyro Descent Stability Control Strategy Selection and Trade (2/4)

Stability Strategy 2
an Active Method

Another option is placing flaps at the near side of payload in order to control swaying by using active control wing surface.

Flaps will produce lift, while descending with an angle of attack and the wing will exert a force on the air to stabilize descending. Thus, **NADIR will be maintained and swaying will be prevented.**





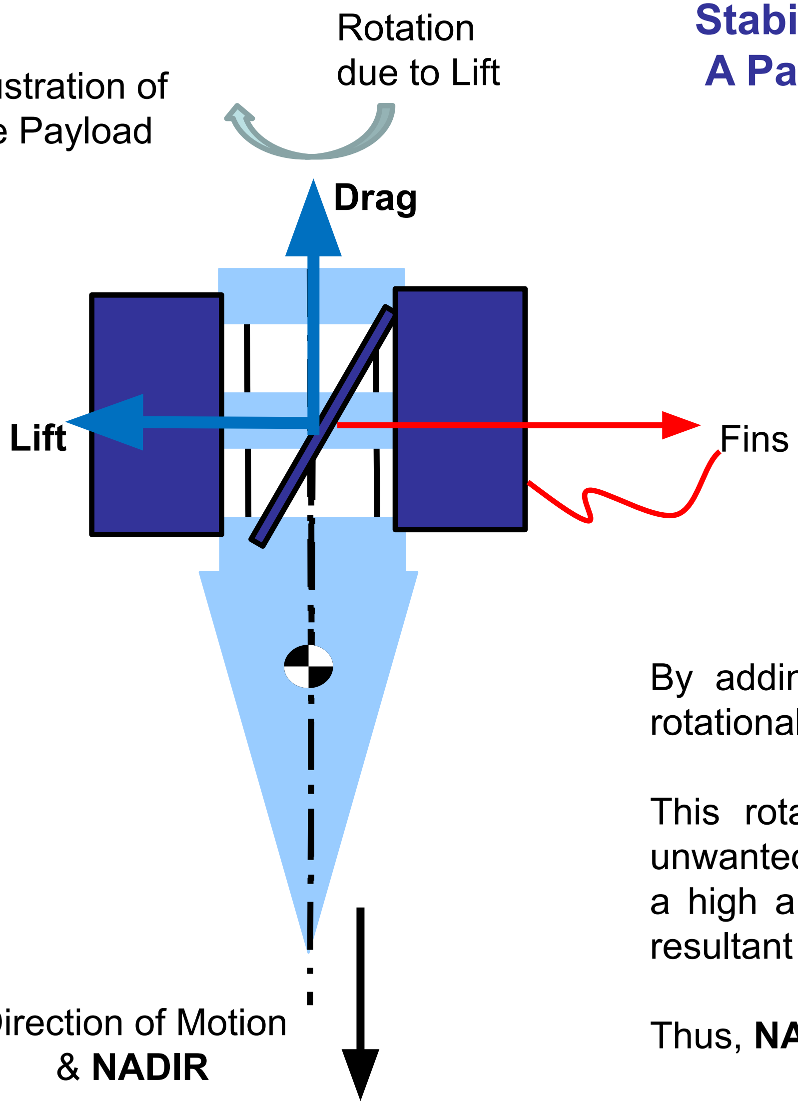


Illustration of the Payload

Stability Strategy 3
A Passive Method

$$L = I \times \omega$$

L: Angular Momentum
I: Moment of Inertia
ω: Angular Velocity

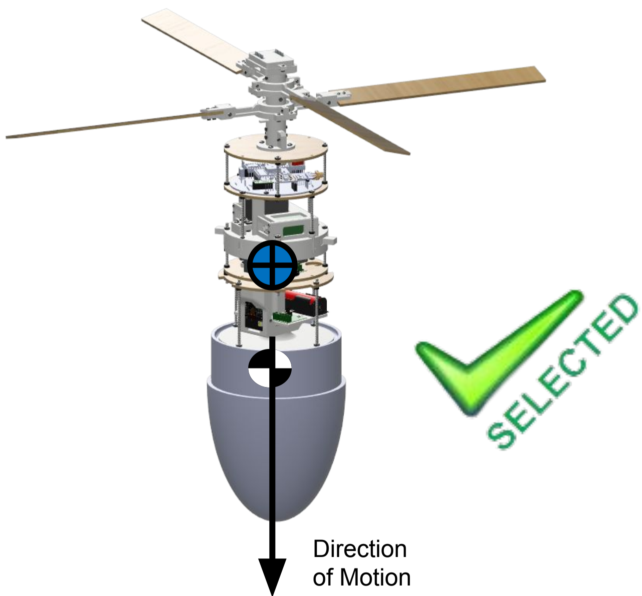
By adding angled wings on the Payload, creating and increasing rotational speed of the Payload with the lift on the wings is possible.

This rotation creates angular momentum. As a result, effects of unwanted forces like horizontal wind can be decreased because, with a high angular momentum, any effect from outside can change the resultant force or momentum of the system very little.

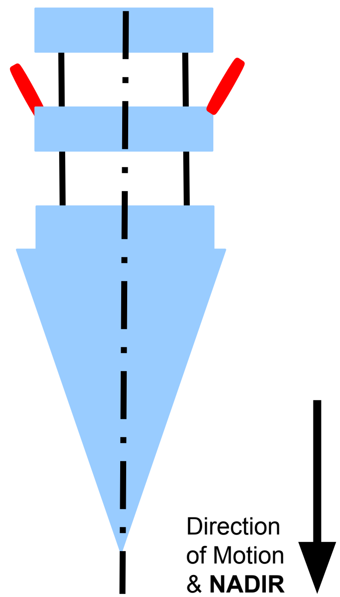
Thus, **NADIR will be maintained and swaying will be prevented.**

Auto-Gyro Descent Stability Control Strategy Selection and Trade (4/4)

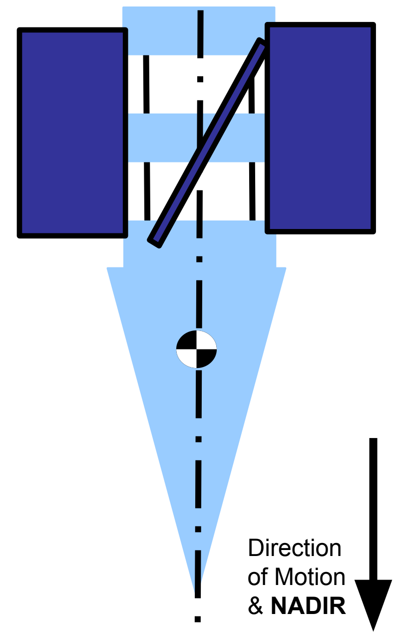
Stability Strategy Selection



CoM CoP Arrangement



Flaps



Increasing Angular Momentum

CoM CoP Arrangement

Pros
- Passive Control
- It is a must. Otherwise, payload will turn upside down.

Cons
- Assembly process is complex

Flaps

Pros
- Effective swaying control
- Lift force generation

Cons
- Active Control
- Needs **Extra Energy** and Mechanism
- Air passage through wings necessary

Increasing Angular Momentum

Pros
- Passive Control
- Lift force generation

Cons
- Air passage through wings necessary
- The possibility of creating needed momentum is low.

Descent Rate Estimates (1/5)

Container Parachute Configuration

Type	Material	Cd	Mass (g)	Appx. Price [$]
X-Type	Fabric	~1.35	18	1
Dome	Fabric	~1.5	10	2 SELECTED
Para Foil	Fabric	~0.75	21	2

Dome type parachute is selected due to the higher drag, low horizontal speed and ease of fabrication.

$$A_p = \frac{2\,F_D}{\rho\,V^2\,C_d} \qquad A_p = 0{,}95\,\pi\,{R_p}^2$$

R_p: Radius of the Parachute (m)
C_d: Drag Coefficient (Assumed 1,5 for dome type)
ρ : Air Density at Initial Height (kg/m^3)
A_p: Reference Area of the Parachute when Spill Hole is extracted (m^2)
V : Velocity (Limited ***20 m/s*** by competition requirements)
F_D: Drag Force (N)

Descent Rate Estimates (2/5)

Container Parachute Post Rocket-Separation Velocity Estimates

Vertical Speed of Parachute should be 20 +/- 3 m/s ;

$$R_p = \sqrt{\frac{2\,F_D}{\pi\,\rho\,V^2\,C_D}} = \quad 0.112\text{m}$$

$$A_p = 0.95\,\pi\,{R_p}^2 = \quad 0.037438\ \text{m}^2$$

C_d = 1.5 for dome type parachute

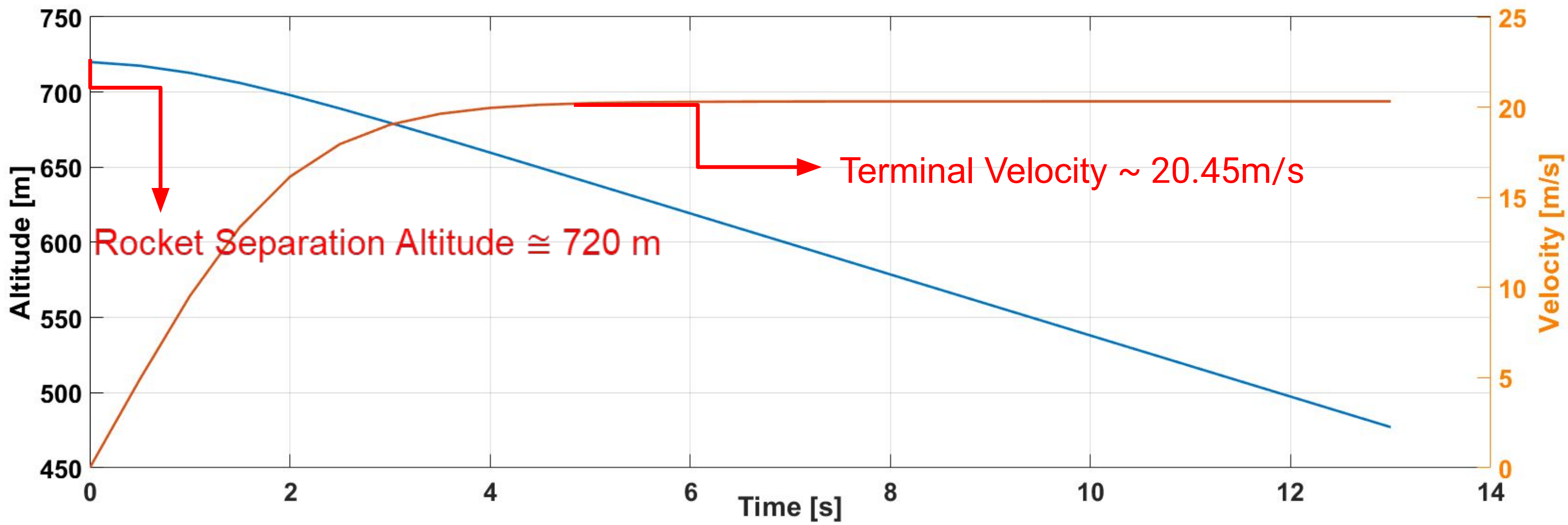
R_p: Radius of the Parachute (m)

ρ = 1.135 (kg/m³)

A_p = Reference Area

V = 20.45 m/s (Calculated Vertical Speed of Parachute)

$F_D = W_{container} + W_{Payload}$ = 13.784 N



*720m (Peak Altitude) is an assumption

Descent Rate Estimates (3/5)

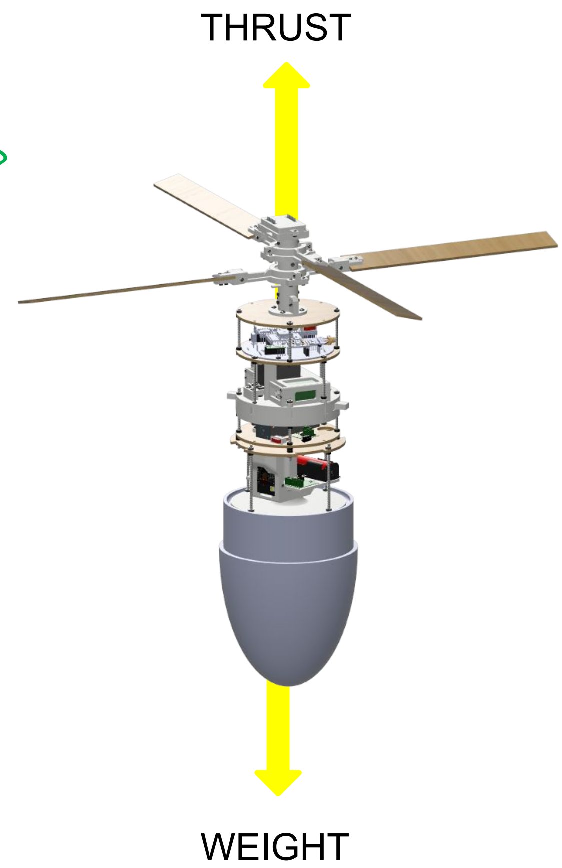
Payload Autogyro Configuration

Type	Material	Cd	Cl
Flat Plate	MDF	0.4	1.64
NACA4412	Carbon Fiber	0.002	1.7

SELECTED

$$F_L = \frac{A \rho V^2 C_l}{2} \qquad F_D = \frac{A \rho V^2 C_d}{2} \qquad T = F_D + F_L$$

R_p: Radius of the Propeller (m)
C_d: Drag Coefficient
C_l: Lift Coefficient
ρ : Air Density at 15°C (kg/m³)
A: Reference Area (m²)
V : Velocity (Limited 5 +/- 3 m/s by competition requirements)
F_D: Drag Force
F_L: Lift Force



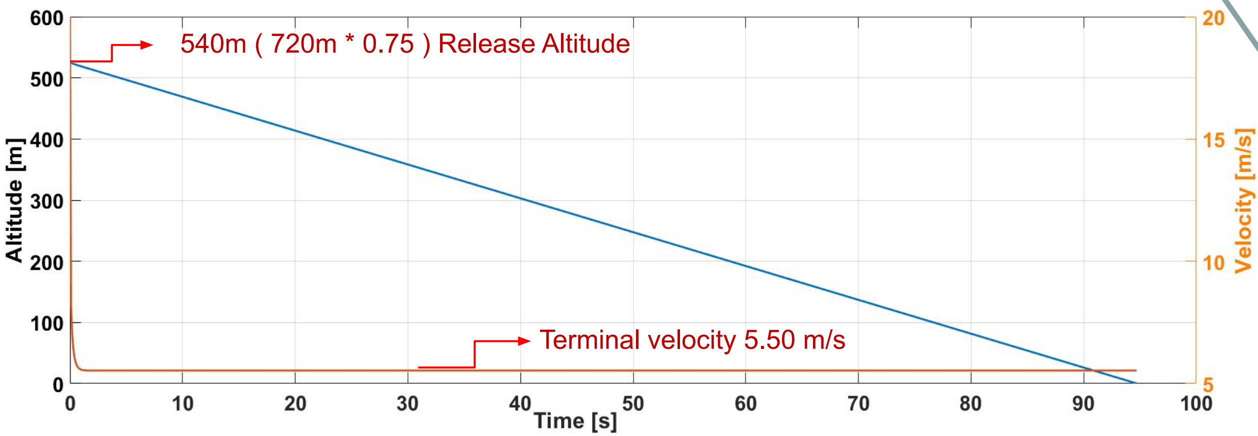
Descent Rate Estimates (4/5)

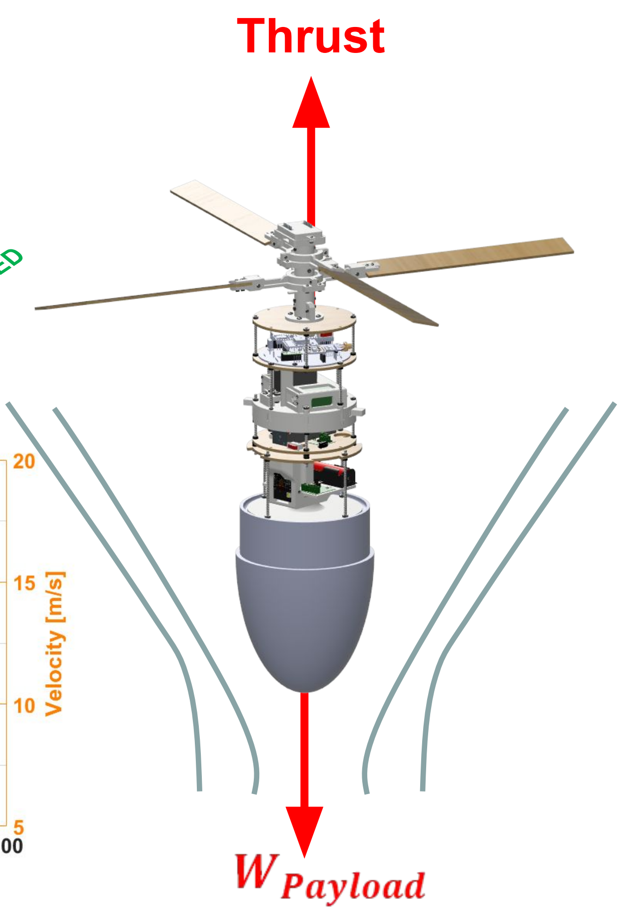
Payload Post Rocket-Separation Velocity Estimates

In order to keep terminal velocity approx. at 5 +/-3 m/s, the thrust should be equal to the payload weight.

Propeller Radius (m)	Total Area (m^2)	Terminal Velocity (m/s)
0.1	0.062832	12.0 m/s
0.2	0.251327	6.10 m/s
0.217	0.295769	5.50 m/s SELECTED

$$Trust = \text{Drag Force} + \text{Lift Force}$$





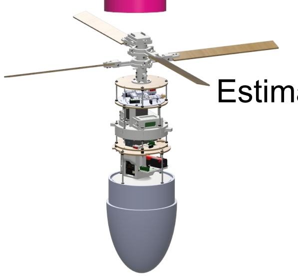
*720m (Peak Altitude) is an assumption

Descent Rate Estimates (5/5)

SUMMARY

Estimated Descent Rate of **the payload with the parachute deployed** is approximately 20.45 m/s.

Estimated Descent Rate of **the Container after deployment** is approximately 11.43 m/s.



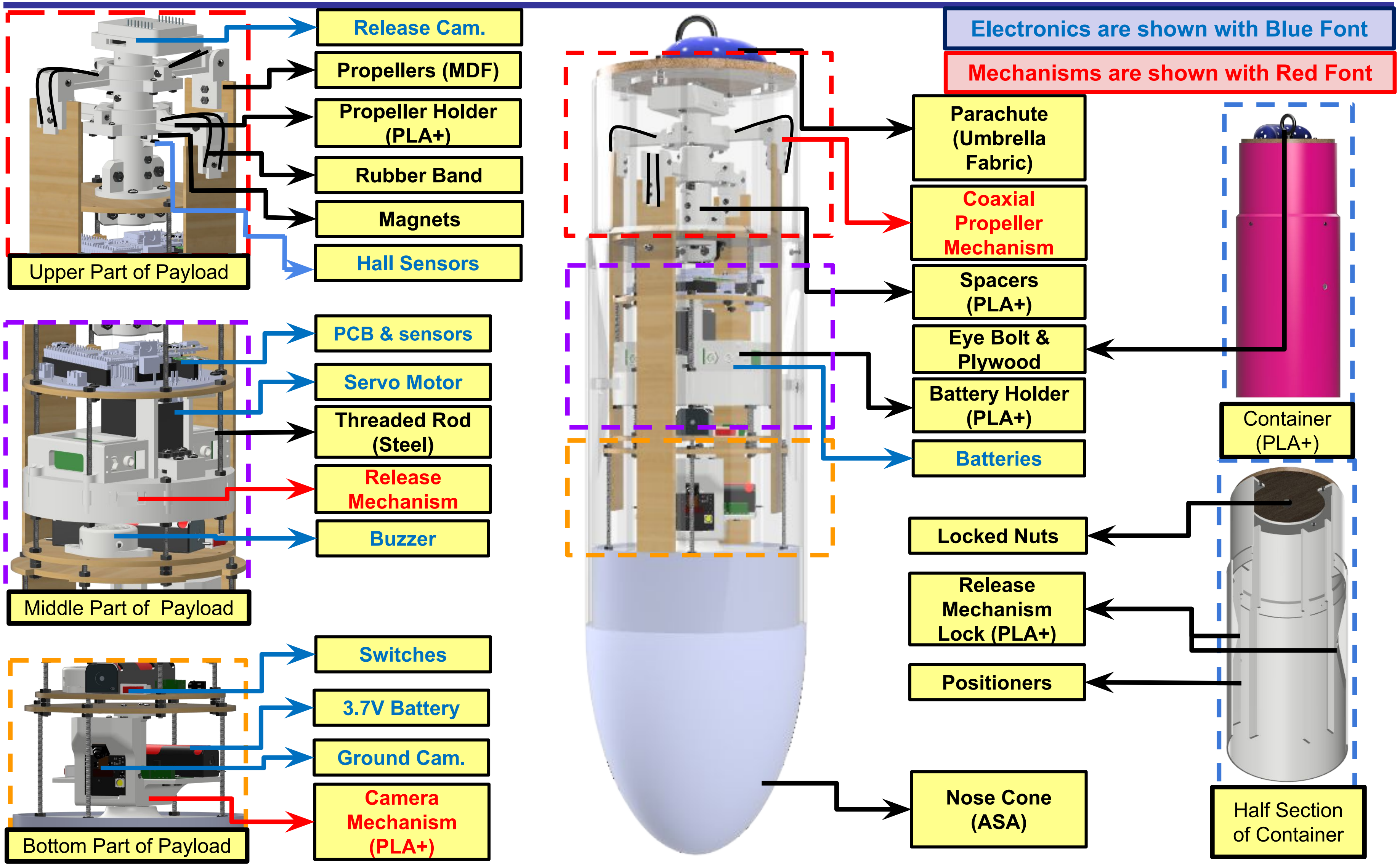
Estimated Descent Rate of **the Payload with auto-gyro** is approximately 5.50 m/s.

Configuration	Mass [g]	Descent Rate [m/s]
Container + Payload	1405.13	20.45
Container	437.14	11.43
Payload	967.99	5.50

Mechanical Subsystem Design

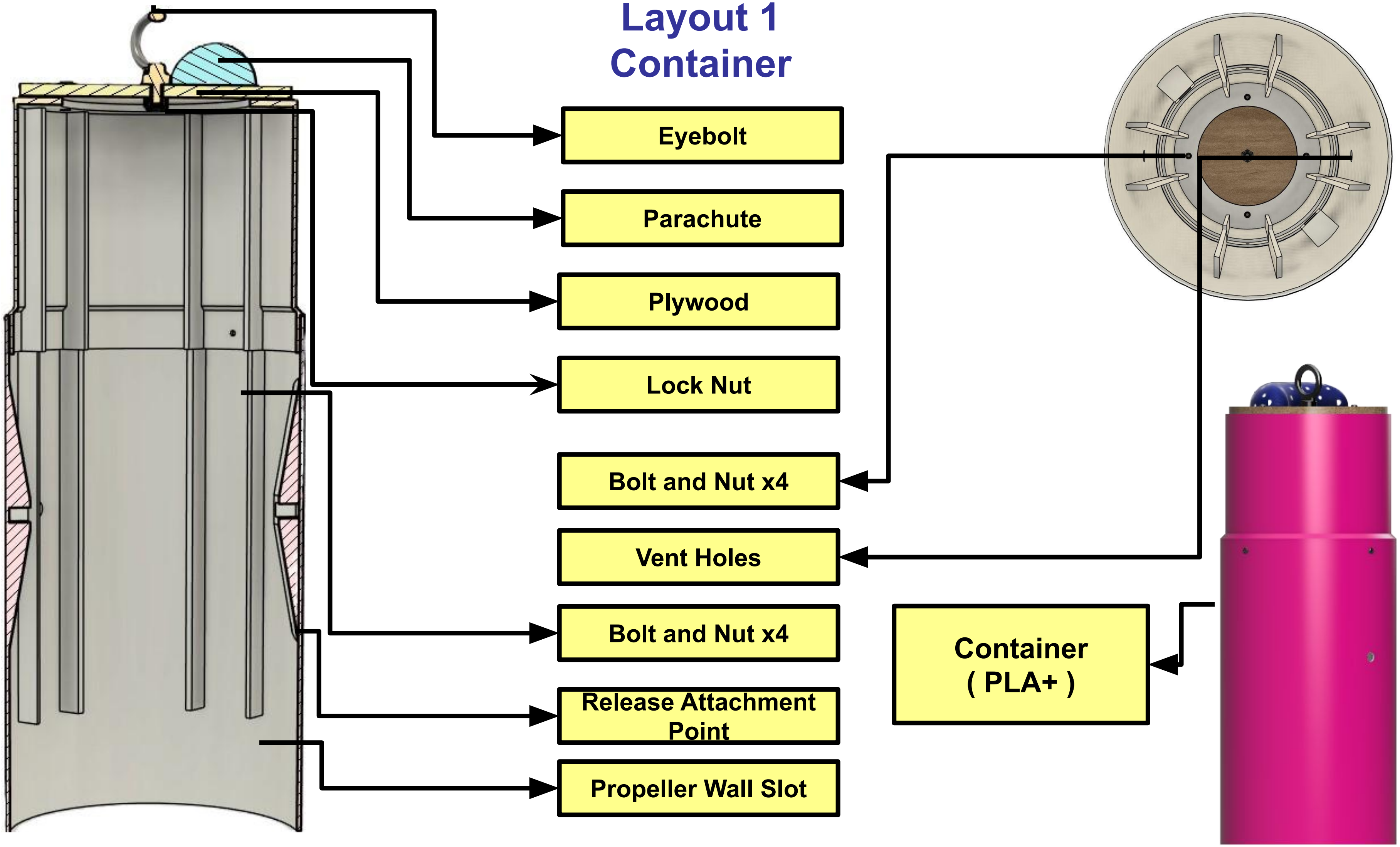
Alper ARTUC

Mechanical Subsystem Overview



Cansat Mechanical Layout of Components Trade & Selection (1/9)

Layout 1 Container

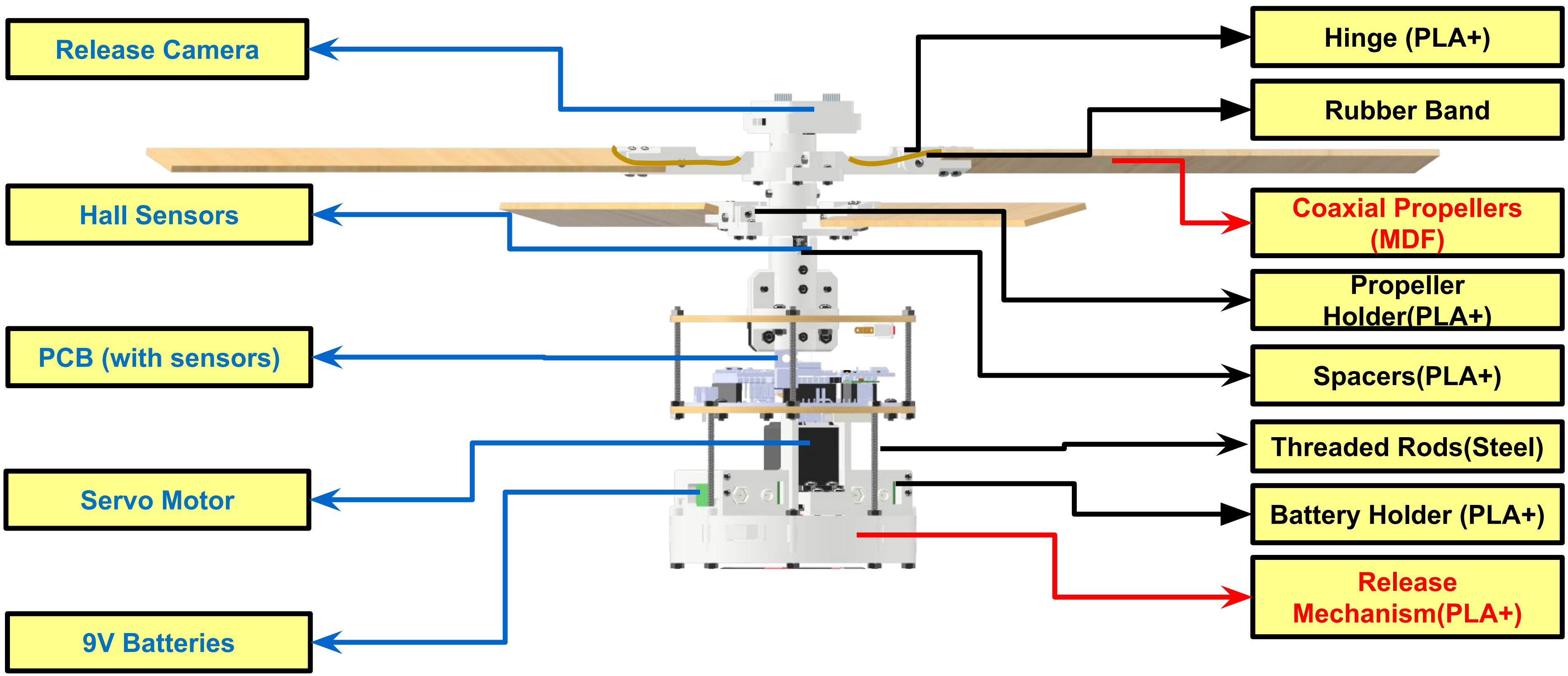


Cansat Mechanical Layout of Components Trade & Selection (2/9)

Layout 1
Upper Part of Payload

Electronics are shown with Blue Font

Mechanisms are shown with Red Font

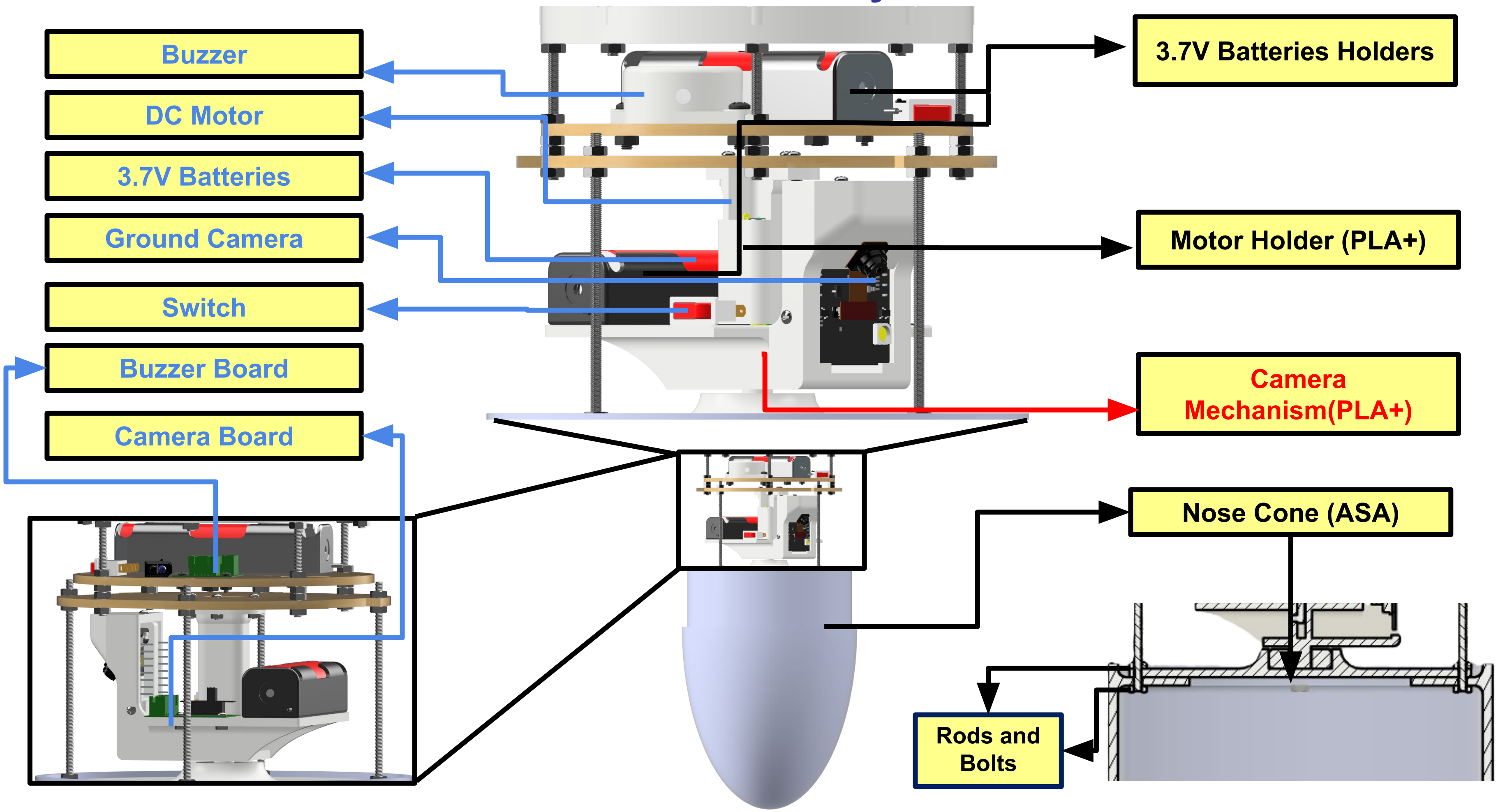


Cansat Mechanical Layout of Components Trade & Selection (3/9)

Electronics are shown with Blue Font

Layout 1
Bottom Part of Payload

Mechanisms are shown with Red Font

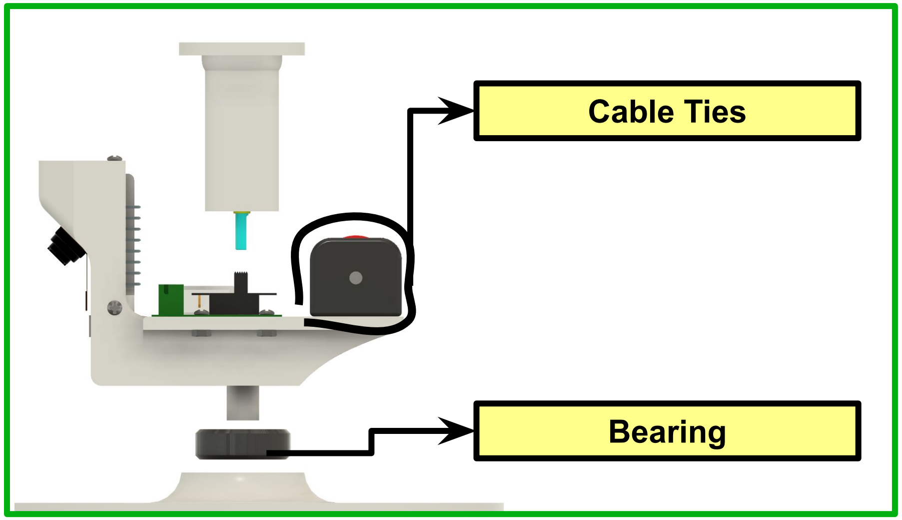


Cansat Mechanical Layout of Components Trade & Selection (4/9)

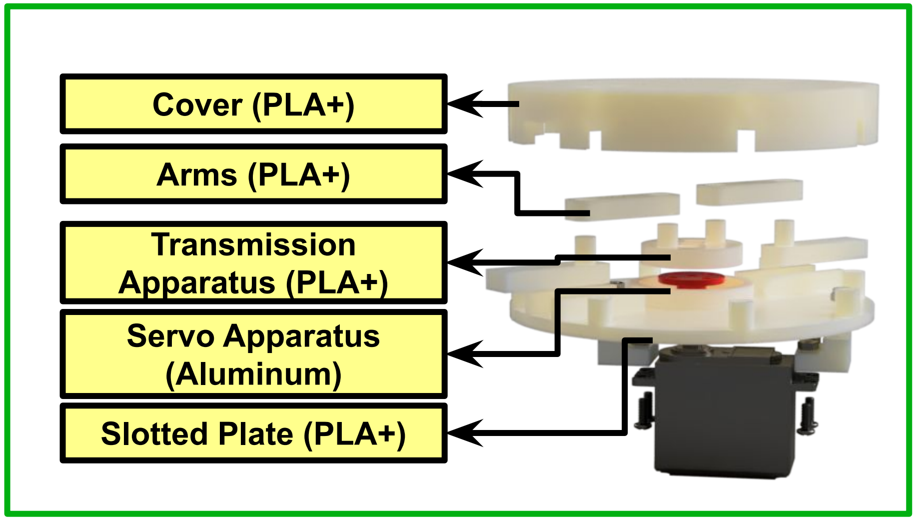
Layout 1

Components of the payload that are not visible in previous **Layout 1** slides. (Disassembled)

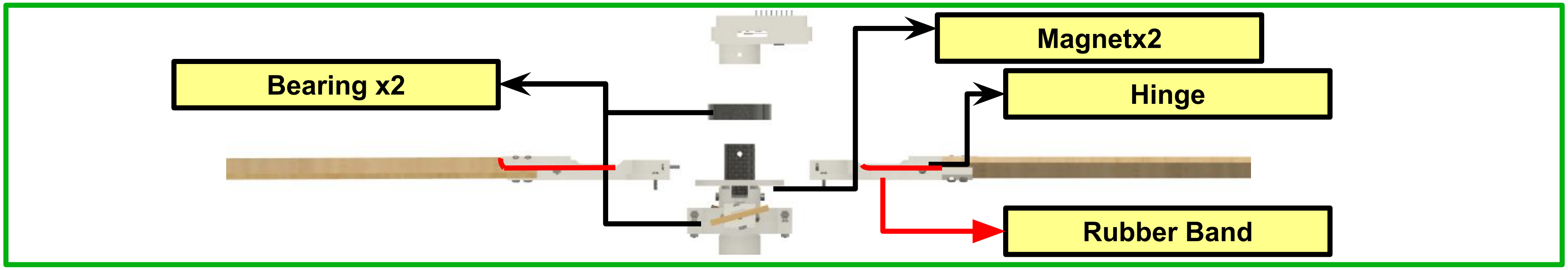
Camera mechanism invisible components



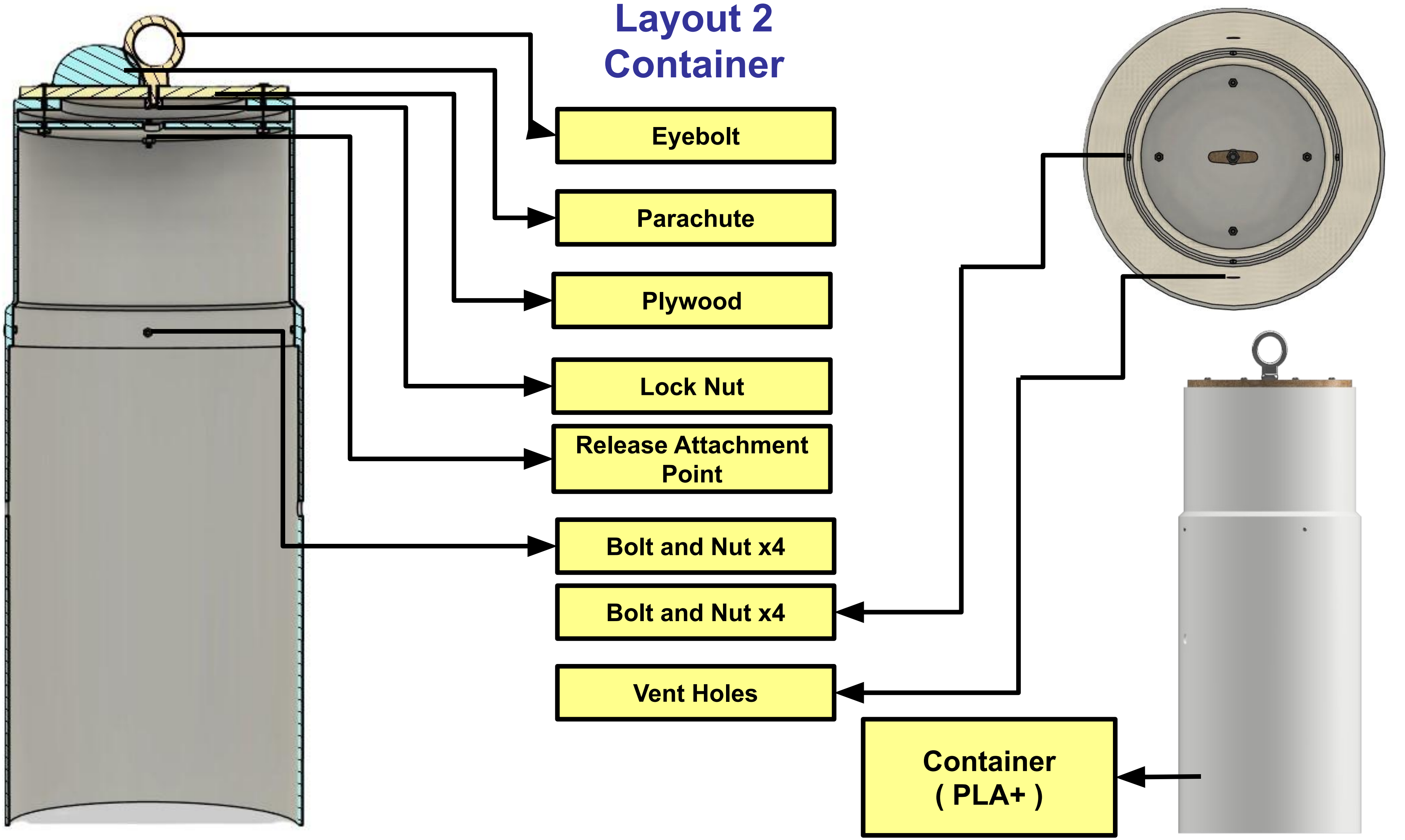
Release mechanism invisible components



Coaxial Propeller invisible components



Cansat Mechanical Layout of Components Trade & Selection (5/9)

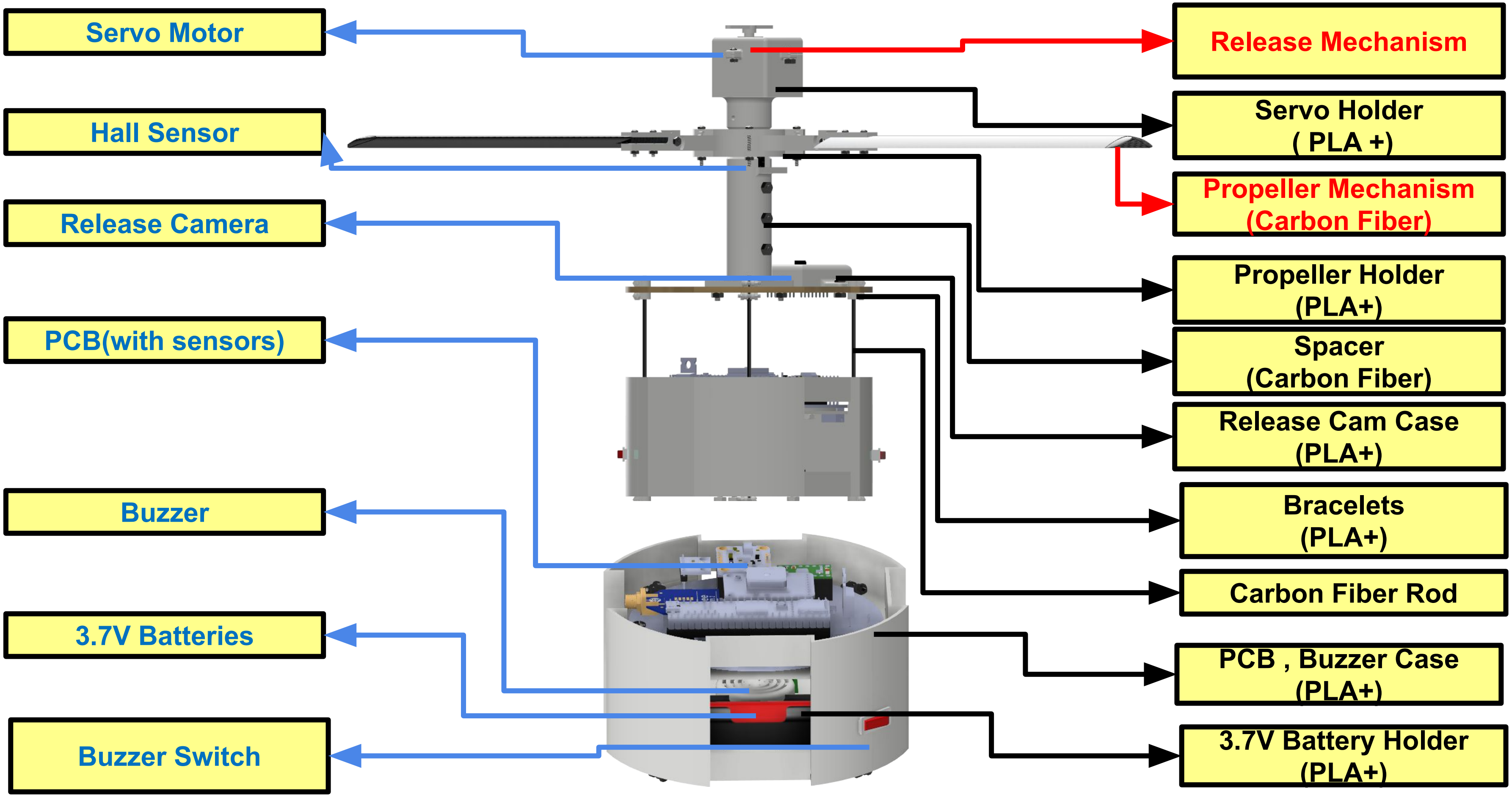


Cansat Mechanical Layout of Components Trade & Selection (6/9)

Layout 2
Upper Part of Payload

Electronics are shown with Blue Font

Mechanisms are shown with Red Font

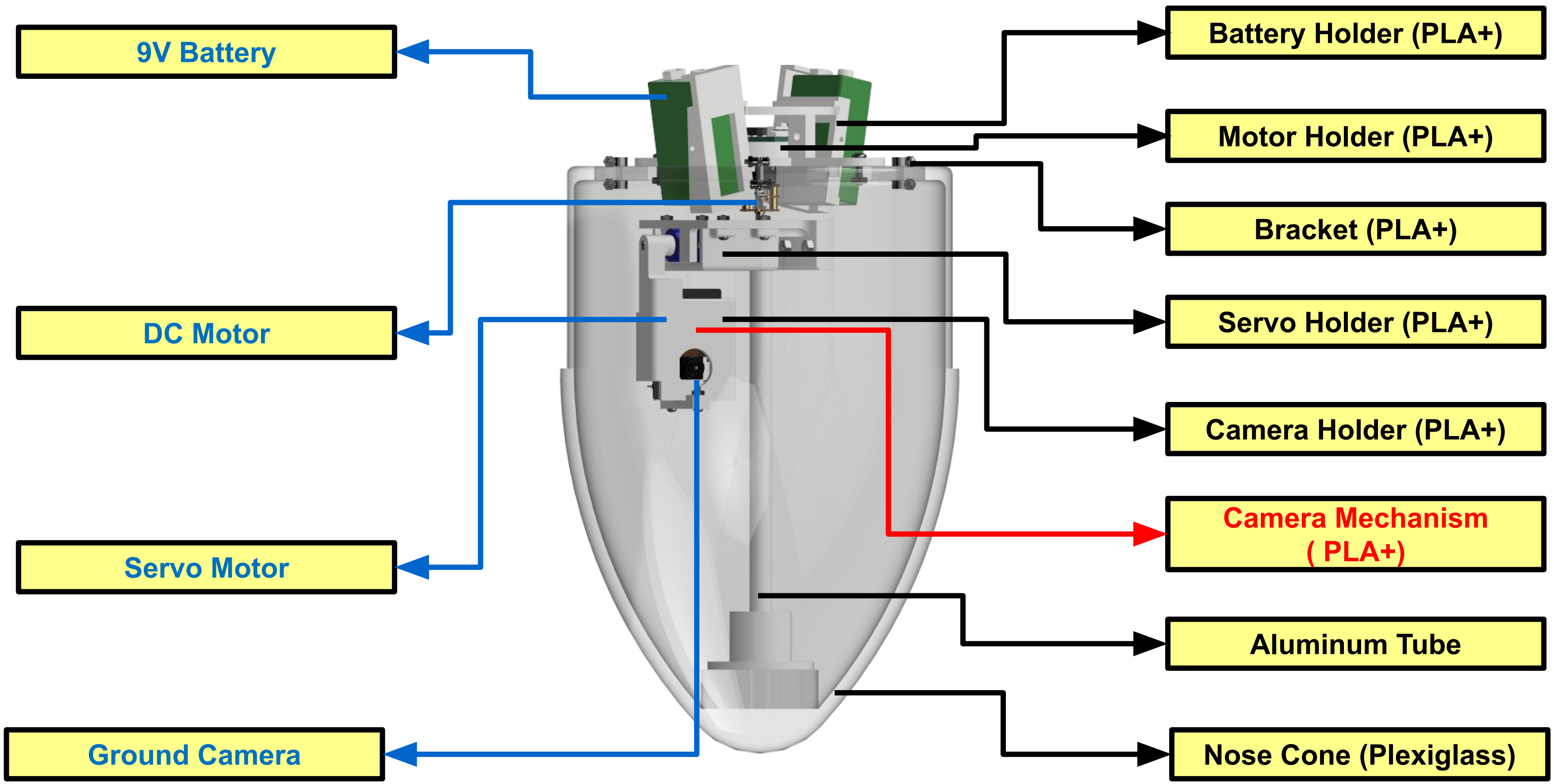


Cansat Mechanical Layout of Components Trade & Selection (7/9)

Layout 2
Bottom Part of Payload

Electronics are shown with Blue Font

Mechanism are shown with Red Font

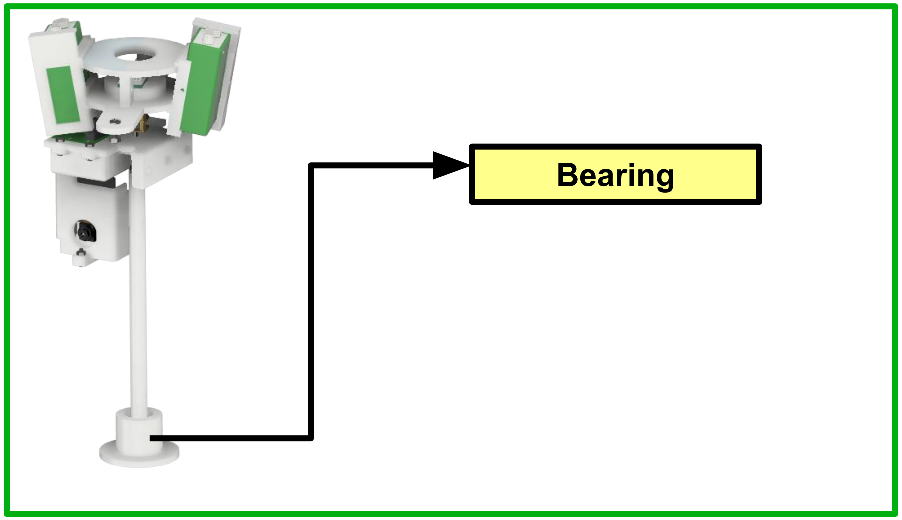


Cansat Mechanical Layout of Components Trade & Selection (8/9)

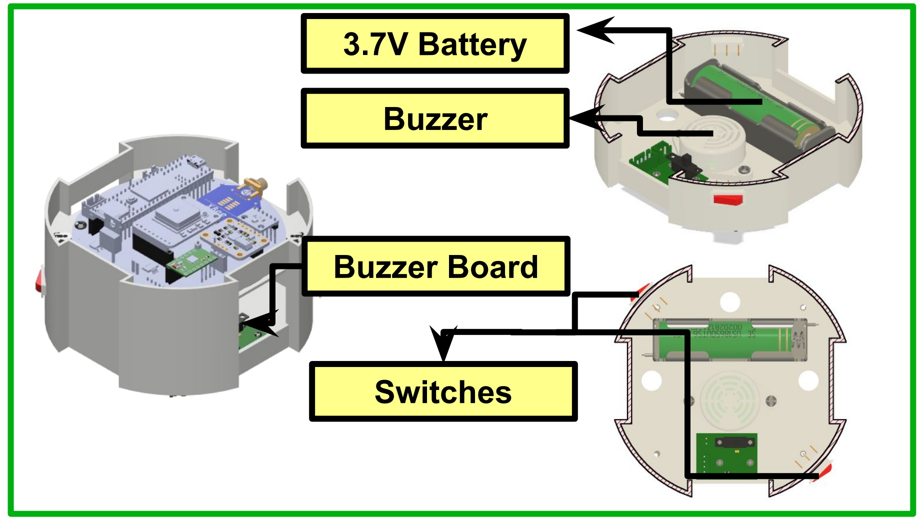
Layout 2

Components of the payload that are not visible in previous **Layout 2** slides. (Disassembled)

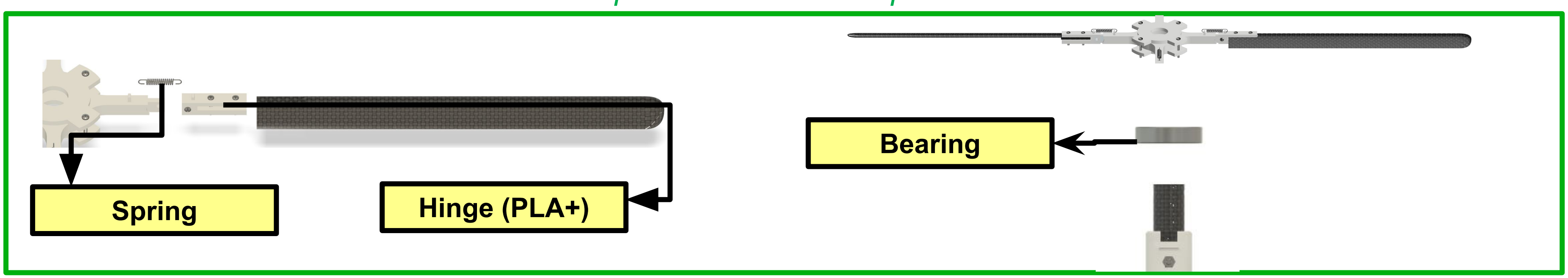
Camera Mechanism Invisible Components



PCB & Buzzer Cover Case

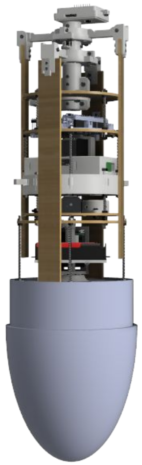


Propeller Invisible Components



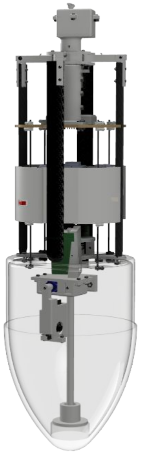
Selection and Reasons

LAYOUT 1



- More stable, more balanced grip. The release mechanism has 2 arms and works integrated with the closed attachments inside the container.
- More balanced. The coaxial propellers create a more balanced structure.
- Less power consumption. The camera mechanism has a passive 45 degree angle.
- Easy to produce.

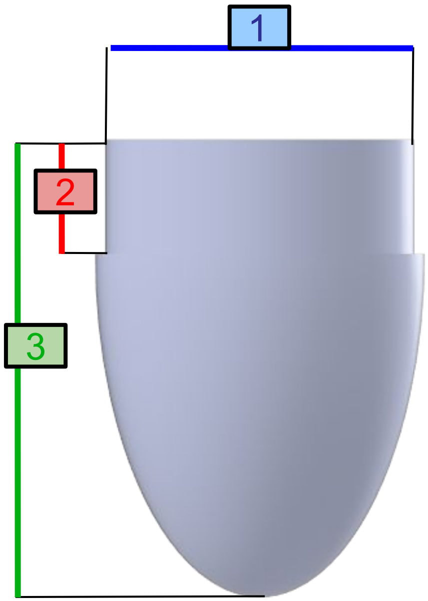
LAYOUT 2



- Unstable. The four blade propeller consist of a single configuration.
- Not a stable and balanced grip. The separation mechanism consists of a single servo.
- Difficult wiring, high power consumption and software difficulty. The camera mechanism can actively find 45 degrees.
- Hard and brittle. Rocket nose cone is made of a transparent material plexiglass.
- Production is difficult.

Nose Cone Design Trade & Selection (1/4)

Layout 1-Elliptical Nose Cone



1	Radius
2	Shoulder Length
3	Height

Mission guide requirements

Dimensions meets requirements

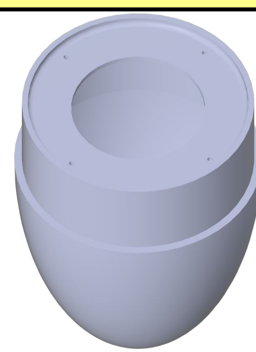
- **Nose cone shoulder length: 50 mm. = 50mm**
- **Nose cone radius is exactly 72.2 mm. = 72.2mm**
- **Nose cone height is 200 mm. >> 76mm**

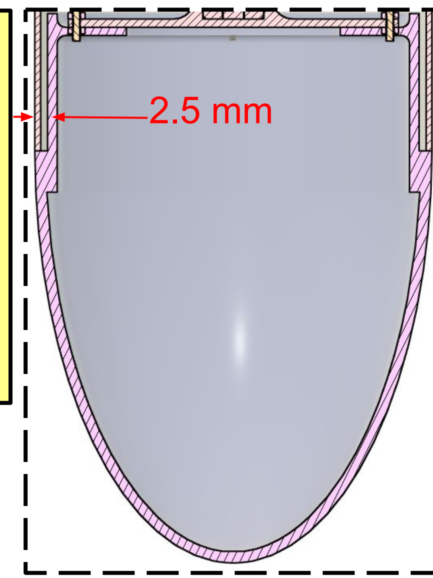
Drag Coefficient : ~0.30

Symmetric and Single piece design.

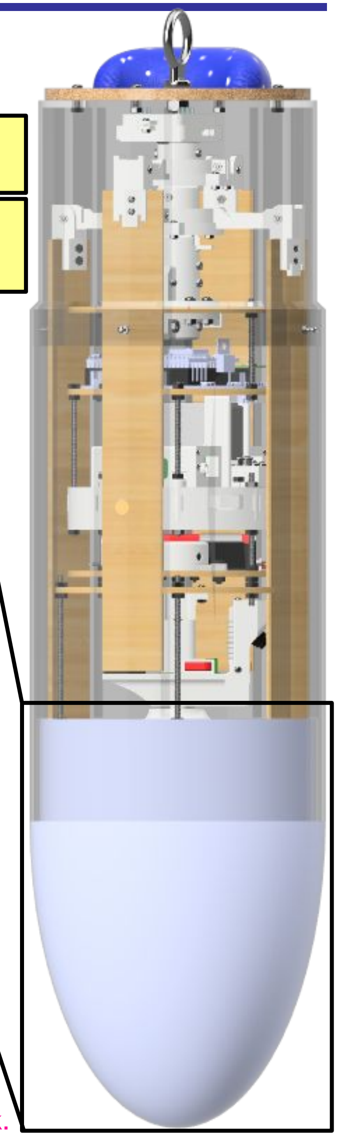
The nose cone will be mounted to the Payload using M3 nuts. The release mechanism will be connected to the container. With this configuration, the rocket nose cone container integrity will be ensured.

Nose cone has a 2.5 mm clearance between the shoulders of the rocket nose and the inner diameter of the container. In this way, there will be no jamming during separation and no difficulty during assembly.





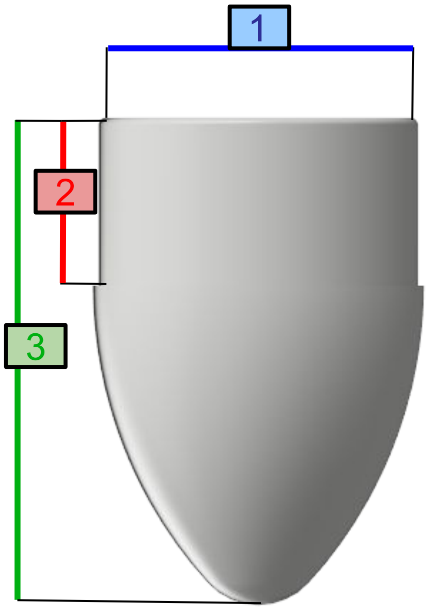
Nose Cone Fits into Container



The container has been made transparent to make the system more understandable. The original will be pink.

Nose Cone Design Trade & Selection (2/4)

Layout 2-Spherically Blunted Tangent Ogive



1 Radius

2 Shoulder Length

3 Height

Mission guide requirements

Dimensions meets requirements

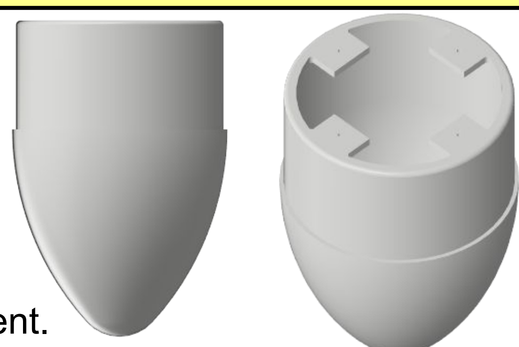
- **Nose cone shoulder length: 73 mm. >> 50 mm**
- **Nose cone radius is exactly 72.2 mm. = 72.2 mm**
- **Nose cone height is 212.02 mm. >> 76 mm**

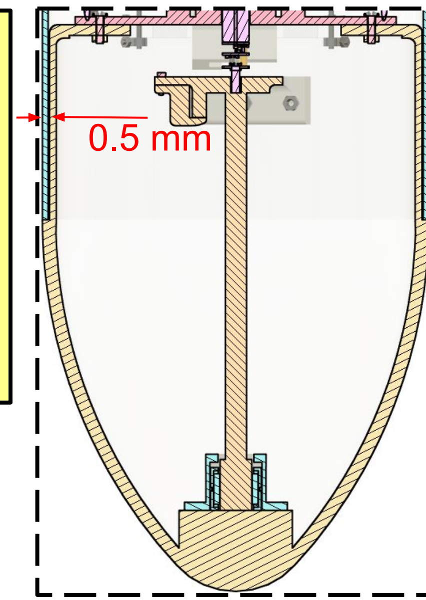
Drag Coefficient : ~0.25

Symmetric and Single piece design.

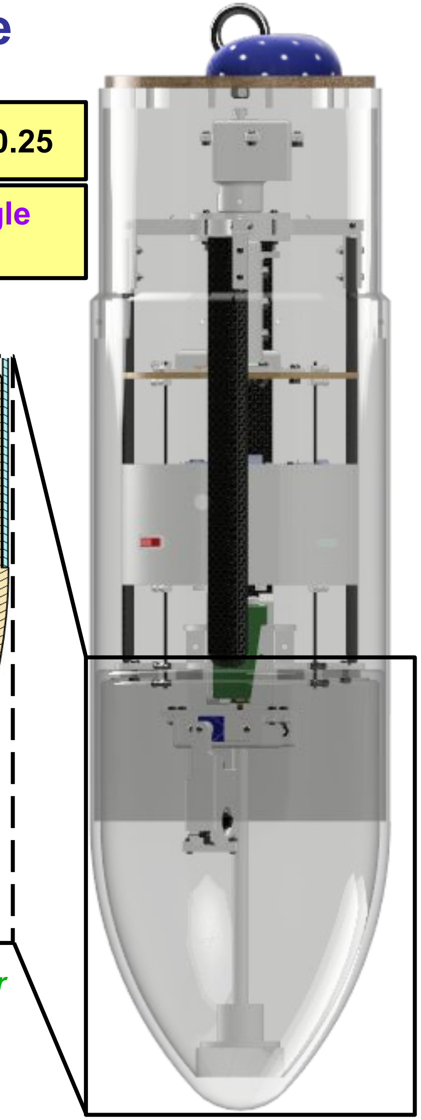
The nose cone will be mounted to the Payload using M3 nuts. The release mechanism will be connected to the container. With this configuration, the rocket nose cone container integrity will be ensured.

Nose cone has a 0.5 mm clearance between the shoulders of the rocket nose and the inner diameter of the container. In this way, there will be no jamming during separation and no difficulty during assembly.





Nose Cone Fits into Container

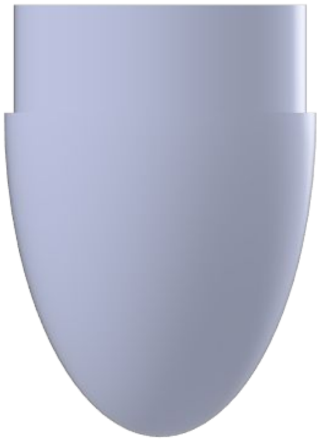


* Normally , cone is transparent.

The container has been made transparent to make the system more understandable.

Nose Cone Design Trade & Selection (3/4)

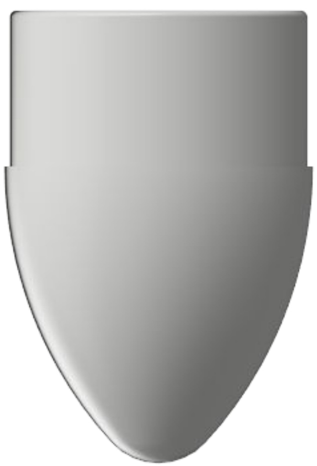
Layout 1-Elliptical Nose Cone



SELECTED

- **More Stable.** **Provides adequate aerodynamic stability for our mission**
- **High drag coefficient.Higher drag of nose cone will support slowing down for descending state.**
- **Easy Manufacturing.** **Simple geometry.**

Layout 2-Spherically Blunted Tangent Ogive



- **Low drag coefficient.** **It is lower than designed elliptical nose cone.**
- **Hard Manufacturing.** **It is more complex geometry than designed elliptical nose cone.**

Normally, the nose cone is transparent.

Nose Cone Design Trade & Selection (4/4)

Nose Cone Material Selection

Material Selection Options	Mechanical Strength	Thermal Resistance	UV Resistance	Cost
ASA (Acrylonitrile Styrene Acrylate) SELECTED	**Provides high durability and strength under mission conditions.**	**High thermal stability.**	**Highly resistant to UV radiation. Ideal for mission.**	**Slightly more expensive than ABS.**
ABS (Acrylonitrile Butadiene Styrene)	Sufficient durability and strength for the mission.	Less than ASA. Handles moderate heat.	Low UV resistance.	Generally affordable.
PLA (Polylactic Acid)	Low durability. Not suitable for mission.	Deforms start to occur at lower temperatures. Low heat resistance.	Low UV resistance, degards quickly.	Generally affordable.

1- Provides the best mechanical strength performance relative to other options.

2- High thermal stability and resistance of ASA fulfills the needs of mission.

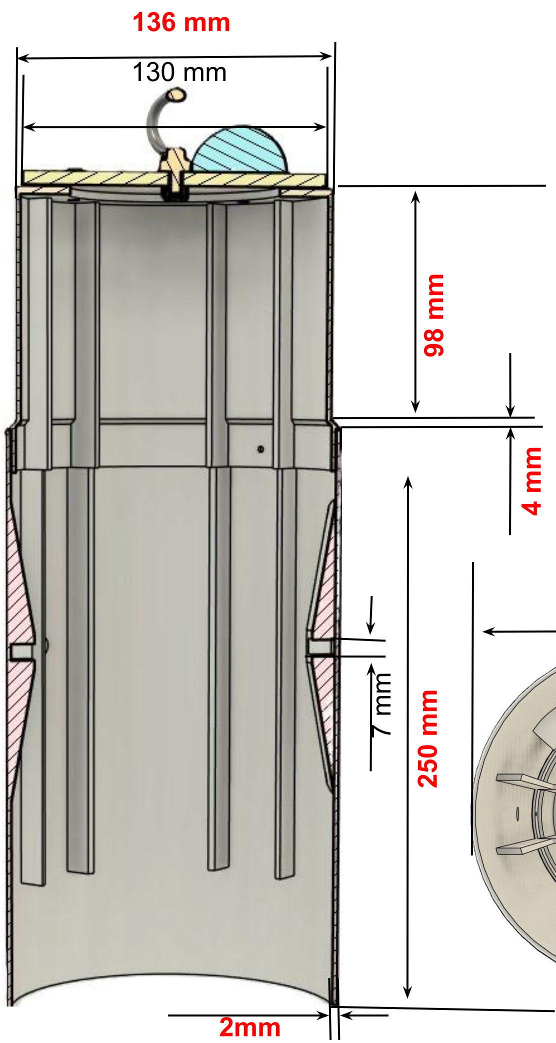
3- Under long-term exposure of UV radiation, high UV resistant material is needed. UV resistance of ASA is higher than the other options

Selection Reasons

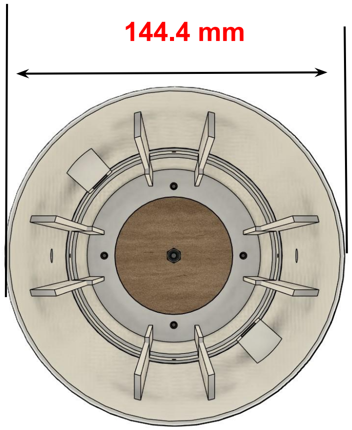
Container Design and Configuration Trade & Selection (1/3)

Layout 1-Slotted Container

Modification Used to Support Stowing of Payload

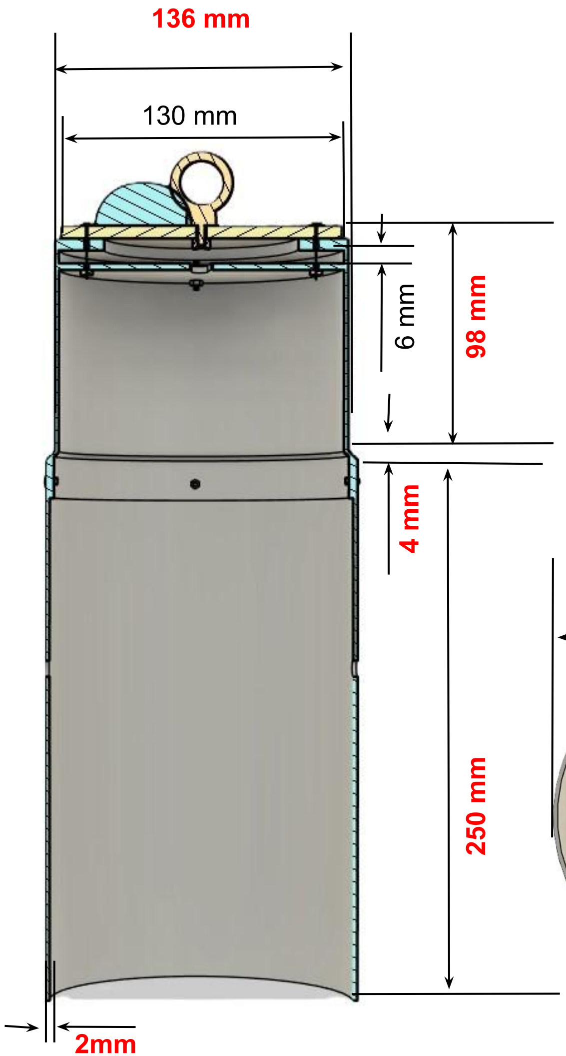


The inner surface of the container features special slots for each propellers. These slots ensure that the propellers are securely fixed without touching each other during the flight before separation. This prevents the wings from colliding during flight, and the separation mechanism perfectly separates the container from the payload. **The connection for the release mechanism will be made to slots on the side walls of the container.** These slots are designed to be 10 mm deep, 7 mm long, and 11 mm wide on the inner surface of the container. The separation mechanism slots are inclined towards the top and bottom of the container. The angled walls ensure that the mechanism is secure and durable.



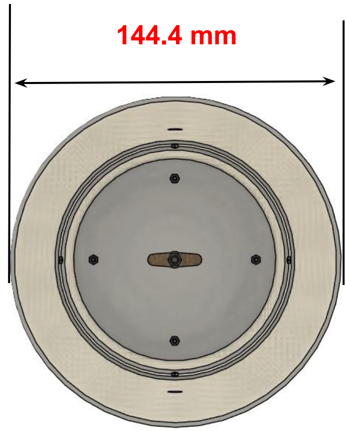
- **The container shall be 3D printed with a shoulder with a length of 90 to 120 mm and a diameter of 136 mm.**
- **The container shall be wider at 144.4 mm diameter above the shoulder and be 250 mm tall.**
- **The thickness of the container walls shall be at least 2 mm.**

Layout 2-Slotless Container



Modification Used to Support Stowing of Payload

There will be a 3 mm thick base 11.5 mm below the bottom surface of the wood disk, within the shoulder section of the container. **On this base, there will be a slot for the release mechanism servo horn, located at the uppermost part of the wing root.**



- **The container shall be 3D printed with a shoulder with a length of 90 to 120 mm and a diameter of 136 mm.**
- **The container shall be wider at 144.4 mm diameter above the shoulder and be 250 mm tall.**
- **The thickness of the container walls shall be at least 2 mm.**

Layout 1-Slotted Container

SELECTED

- **Higher stability, safe flight.** The payload is secured to the container via two separation mechanism arms that fit into slots on the container's side walls.
- **Prevents internal interference.** Four propeller slots are included to prevent the payload wings from contacting each other during flight, which could cause damage or hinder separation.
- **Minimal contact risk, higher stability.** The wing slots also ensure that the payload remains stable within the container during flight.

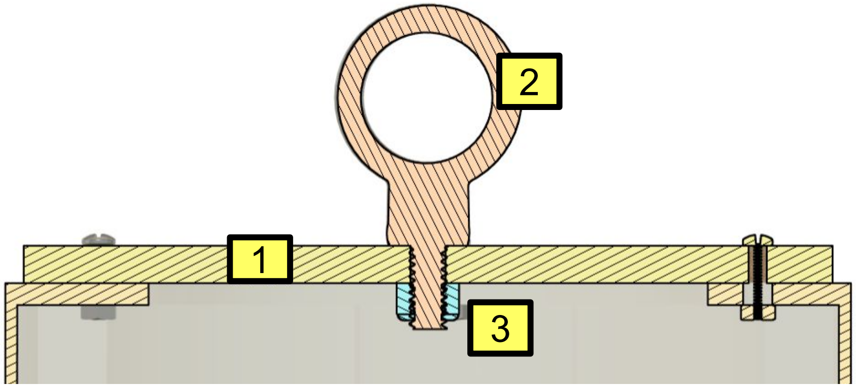
The container has been made transparent to make the system more understandable. The original will be pink.

Layout 2-Slotless Container

- **Lower stability, higher risk.** Unlike Design 1, there are no individual wing slots.While this simplifies the design, it increases the likelihood of wing movement or contact, which could potentially lead to interference during separation.

The container has been made transparent to make the system more understandable. The original will be opaque white.

Parachute Attachment

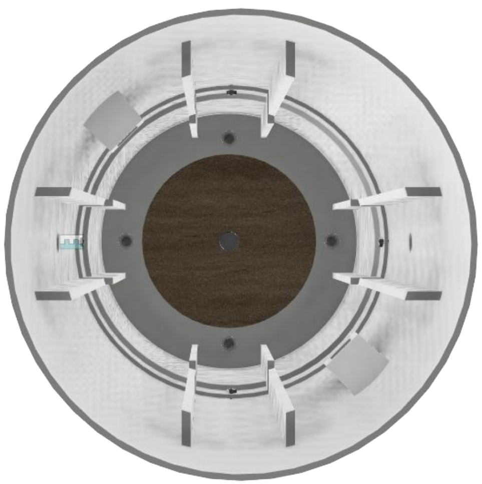


1 | Plywood

2 | ¼ in Eye bolt

3 | ¼ in Lock Nut

Parachute Rope



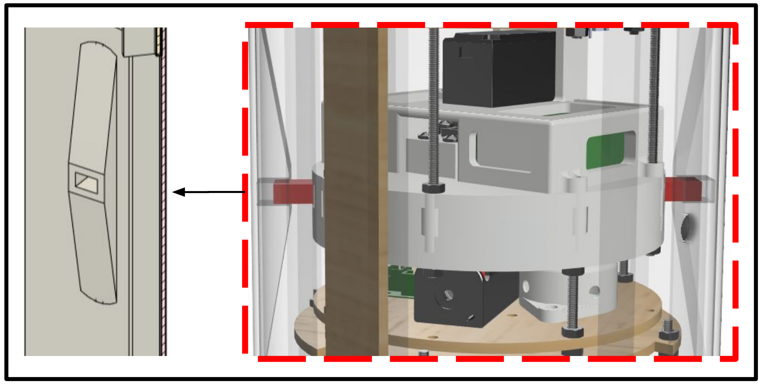
A plywood disk and eye bolt were used and the eye bolt is equivalent to 1/4 inch.
The requirement is to use an eye bolt and to attach the eye bolt to a wooden disk at the bottom of the container.
The parachute will be attached to this eye bolt with parachute cord

The container has been made transparent to make the system more understandable. The original will be pink.

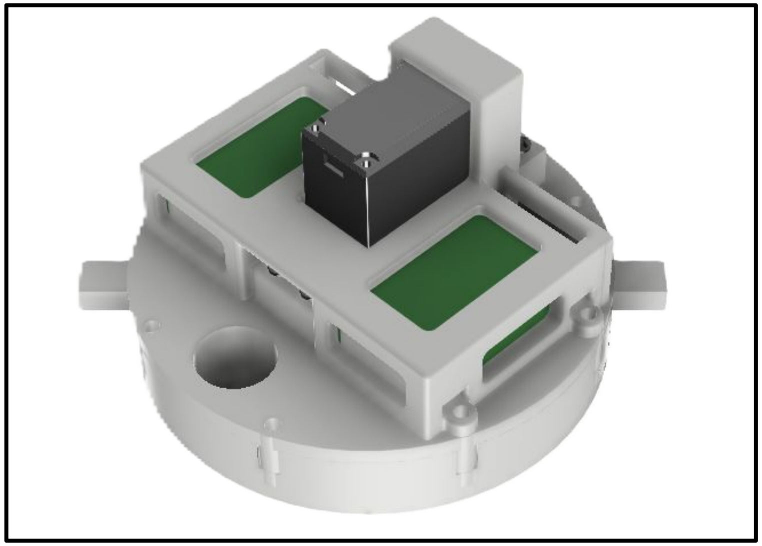
Payload Release Trade & Selection (1/6)

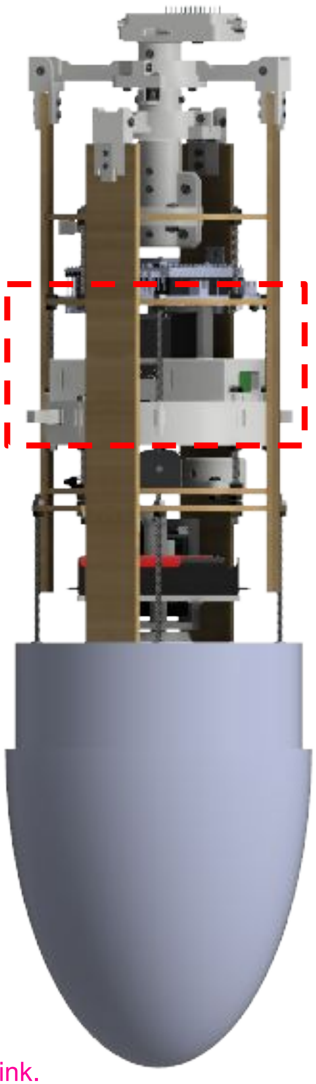
Mechanism 1- Slider Crank Mechanism

The payload release mechanism operates through a servo-controlled system. There are two arms that are attached to the servo head, which hold the container and the payload together by going through the holes of the container's wall.



When the servo rotates to a specific angle, two arms are pulled into the separation mechanism which releases the payload from the container.

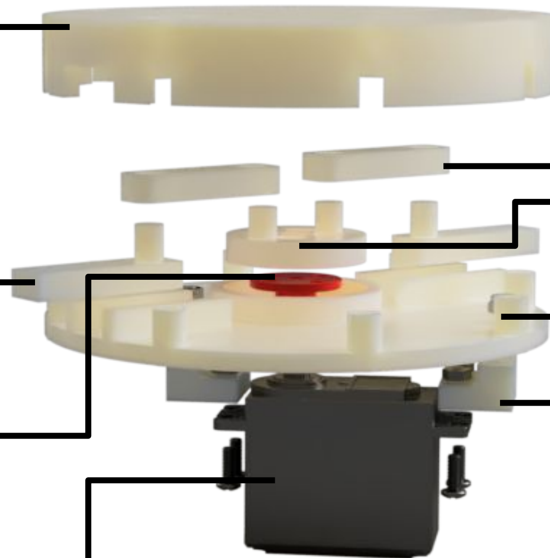




The release mechanism is shown separately to be understood alone.
The container has been made transparent to make the system more understandable. The original will be pink.

Payload Release Trade & Selection (2/6)

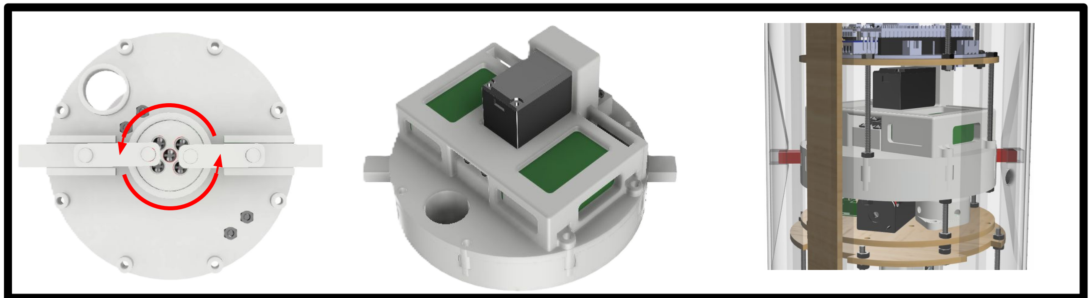
Mechanism 1- Slider Crank Mechanism



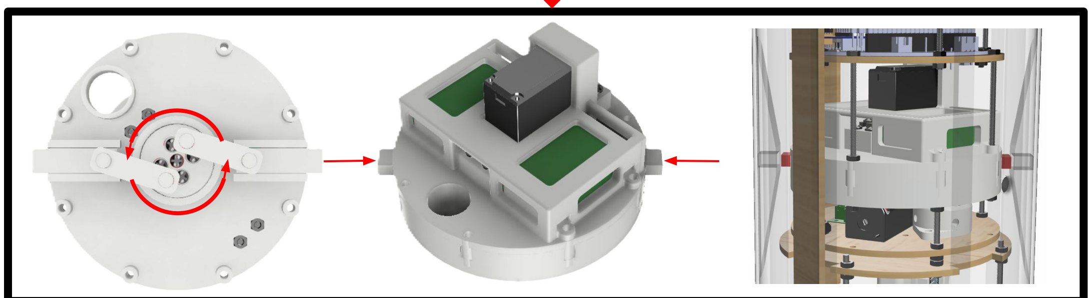
Top view without protection cover.

Payload Release Trade & Selection (3/6)

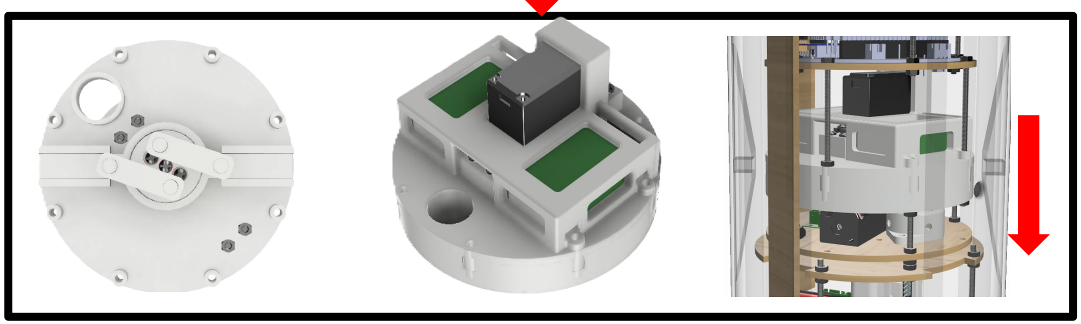
Mechanism 1- Slider Crank Mechanism



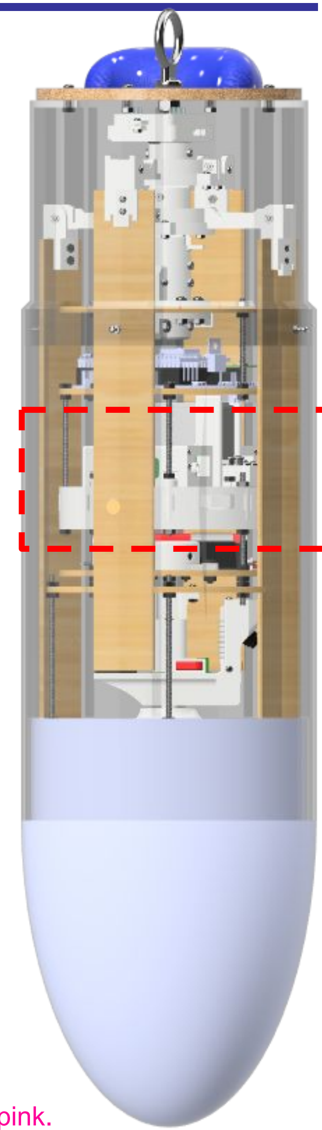
Both arms of the release mechanism enter 4.9 mm into the container.



The 90 degree clockwise rotation of the servo motor transmits force to pull the arms.



When the servo motor finishes its rotation, each arm is pulled in by 11 mm.

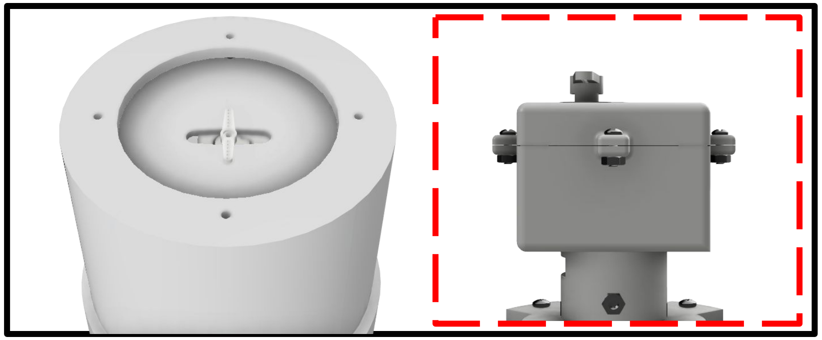


The container has been made transparent to make the system more understandable. The original will be pink.

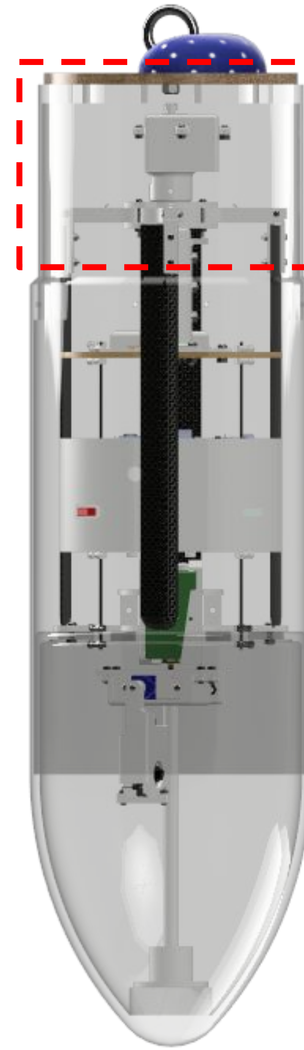
Payload Release Trade & Selection (4/6)

Mechanism 2 - Servo Lock Mechanism

This separation mechanism relies solely on a servo motor. **Inside the container, there is a slot designed to match the head of the servo motor. While the satellite is still secured, the servo head is positioned at a 90 degree angle with respect to the slot,** effectively locking the satellite in place.



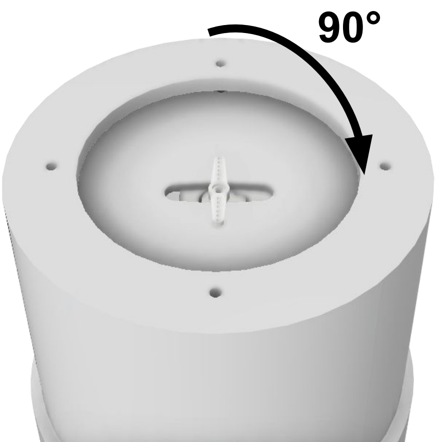
During the separation process, the servo motor rotates 90 degrees, aligning the servo head with the slot. This alignment allows the servo head to pass through the slot, enabling the satellite to separate successfully.



The container has been made transparent to make the system more understandable.

Payload Release Trade & Selection (5/6)

Mechanism 2 - Servo Lock Mechanism



Pre-Separation

During Separation

After Separation

While the satellite is securely held in place, the servo head is oriented at a 90 degree angle relative to the slot, ensuring the satellite remains firmly locked and stable.

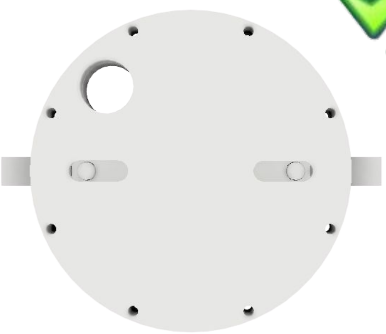
During the separation event, the servo motor rotates by 90 degrees, aligning its head with the opening.

Once aligned, the servo head moves through the opening, allowing the satellite to be released efficiently.

We only showed the release mechanism to demonstrate better.

Payload Release Trade & Selection (6/6)

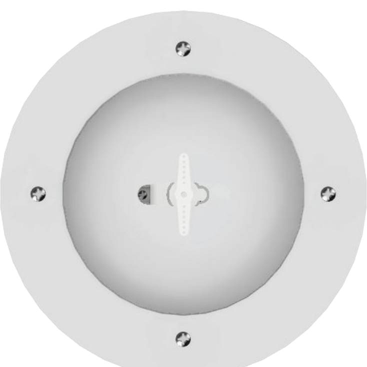
Mechanism 1 - Slider Crank Mechanism



SELECTED

- **Secure connection.** The arms mechanism holds the container and the payload together securely. Provides more stability during separation process.
- **More stable.** By being secured from both sides, the container maintains a balanced load distribution. Helps reduce stress on any single point and enhances the overall stability of the system
- **Better protection.** With the mechanism sealed inside a protective cover, it is better protected from external factors. Ensuring greater safety and durability during the mission.

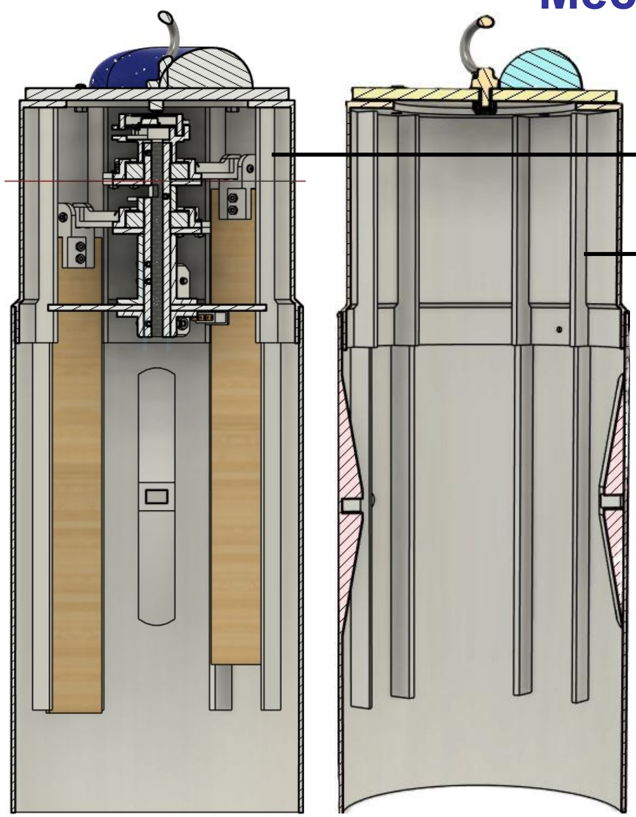
Mechanism 2 - Servo Lock Mechanism



- **Includes one servo motor.** There is a higher chance of misalignment or failure, especially under harsh conditions.
- **Harder to assemble.** Proper alignment of the servo head and slot tolerances is critical, making the assembly process more challenging.
- **Load distribution is weak.** Because the container is supported from one side, the load is not evenly distributed. This could potentially affect the performance and reliability of the mechanism.

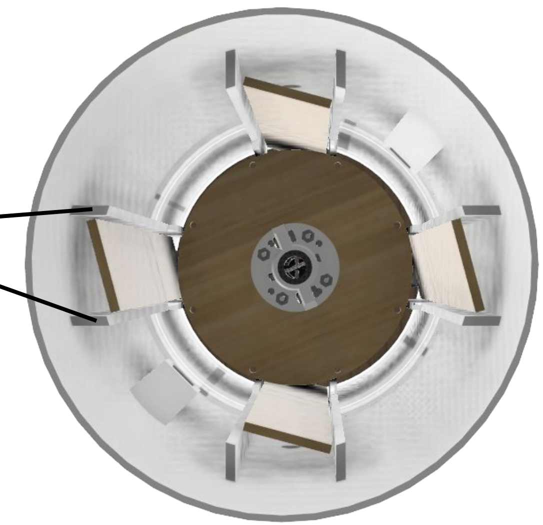
Auto-gyro Stow Configuration Trade & Selection (1/3)

Mechanism 1 - Slot On Container



Auto-gyro Stow Config

Slots



Auto-gyro Stow Config

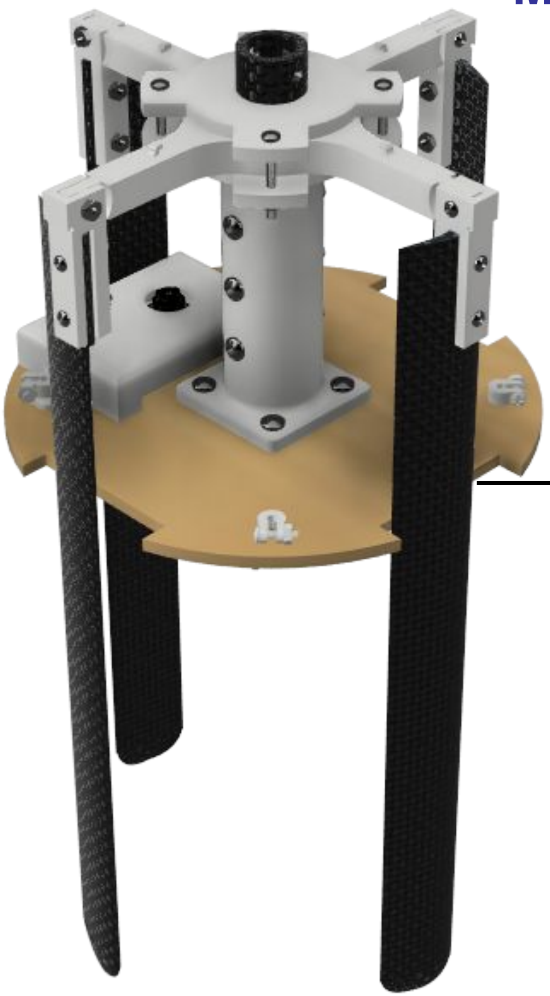
Auto-gyro mechanism is stowed during flight and before release

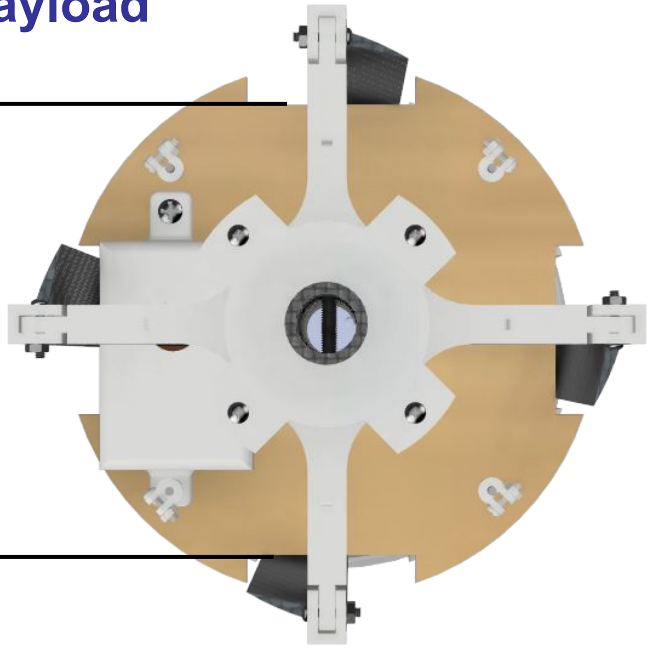
Before deployment, the propeller mechanism is secured within the container. The container is equipped with four slots, positioned 90 degrees apart, which hold the blades in place. These slots restrict the lateral movement of the blades before separation, ensuring they remain aligned.These slots maintain the position of the blades and prevent them from interfering with the separation arms during deployment.

To better demonstrate how the slots look downward, we only showed the upper part of the system, with the propeller.

Auto-gyro Stow Configuration Trade & Selection (2/3)

Mechanism 2 - Slot On Payload





Auto-gyro Stow Config

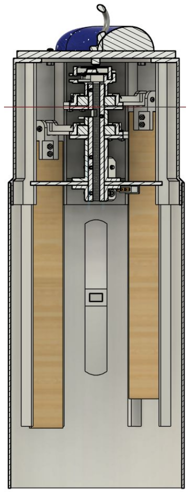
Auto-gyro mechanism is stowed during flight and before release

Prior to deployment, the propeller mechanism is safely contained within the container. The plate beneath the mechanism features four rectangular slots, evenly spaced at 90-degree intervals, ensuring the blades remain securely positioned.

To better demonstrate how the slots look downward, we only showed the upper part of the system, with the propeller.

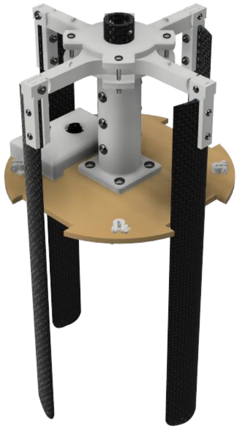
Auto-gyro Stow Configuration Trade & Selection (3/3)

Mechanism 1 - Slot On Container



- **The container has four slots.** Slots prevent lateral movement and blade misalignment effectively. Slots also prevent interference with separation arms, enabling smoother deployment.
- **Reliable design.** More intricate design with multi-functional slots improves alignment and reliability.

Mechanism 2 - Slot On Payload

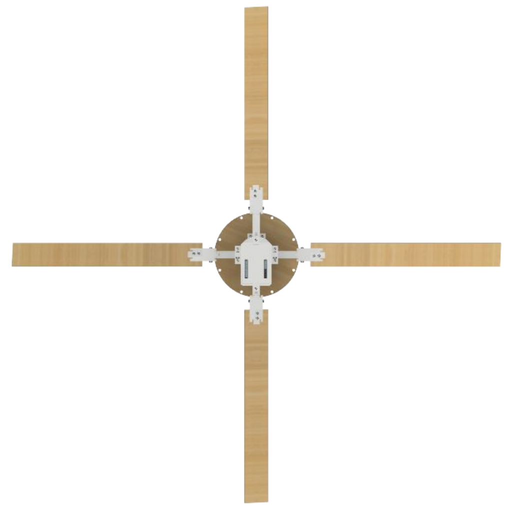


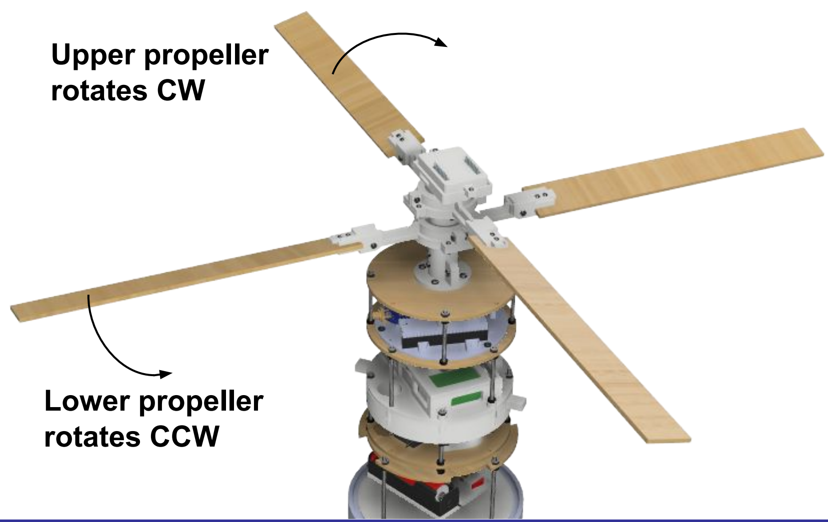
- **There are no slots on container.** This doesn't offer protection against potential internal interference.
- **Simpler design.** Sacrifices functionality, relying only on basic alignment.

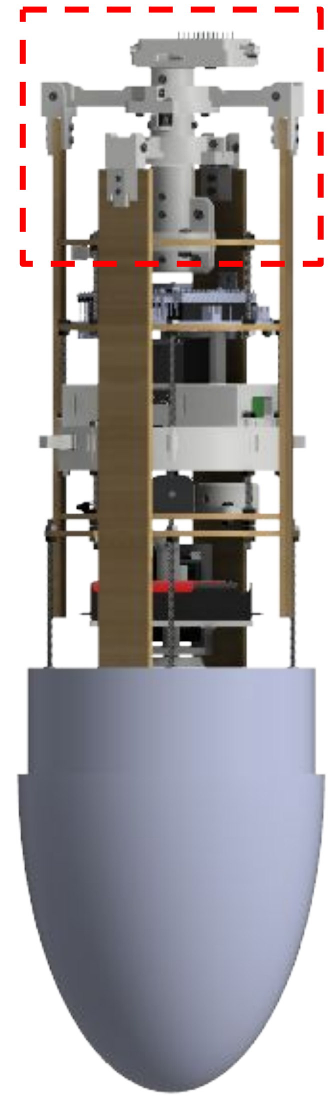
Auto-gyro Deployment Configuration Trade & Selection (1/7)

Mechanism 1 - Rubber Band Method

As the payload descends, the blades open due to the satellite's weight and the airflow, starting to rotate and thereby slowing the descent. To assist in the deployment of the blades, **elastic bands are attached to the blade holders and hinges, providing additional force to ensure the blades open effectively.**

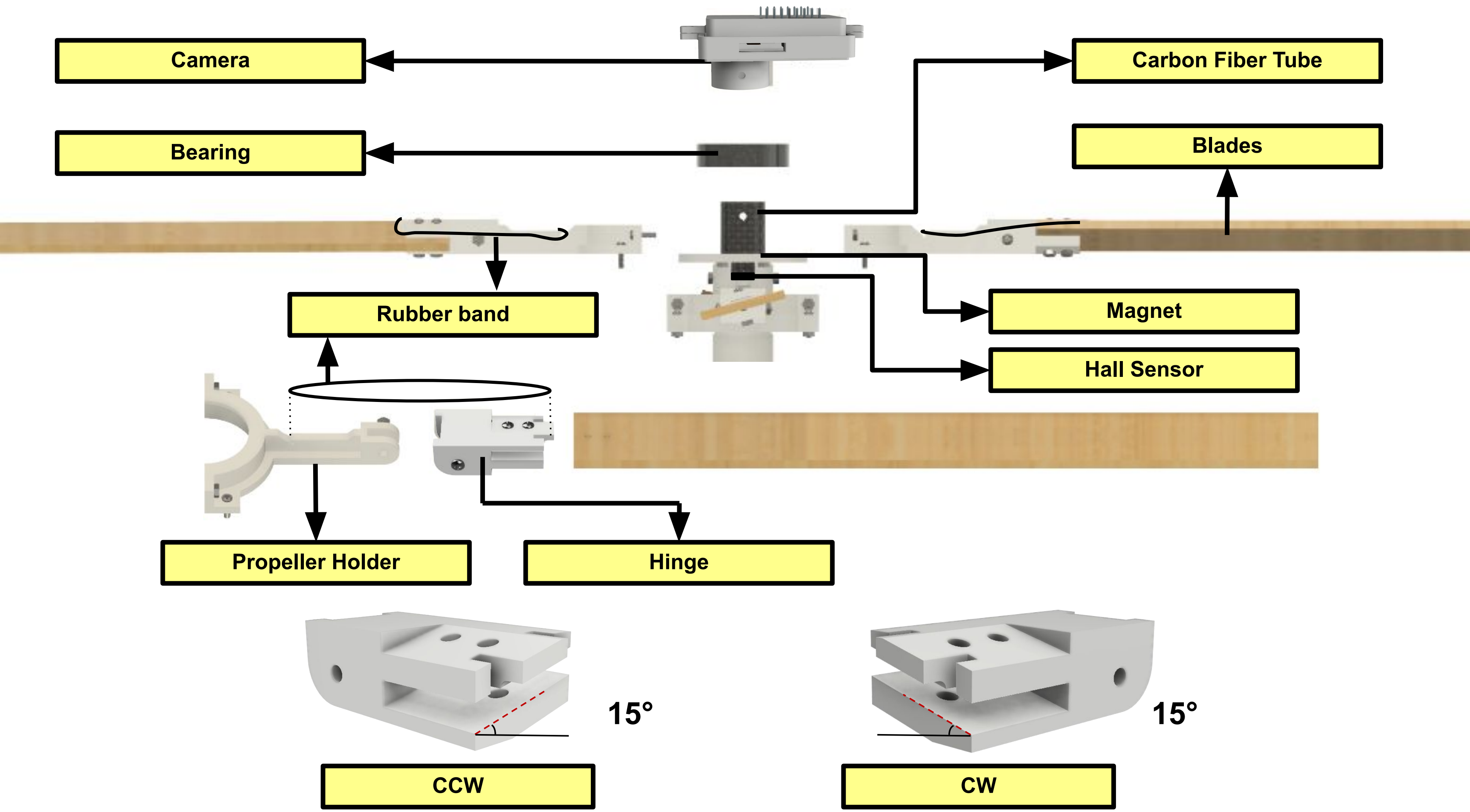






Auto-gyro Deployment Configuration Trade & Selection (2/7)

Mechanism 1 - Rubber Band Method



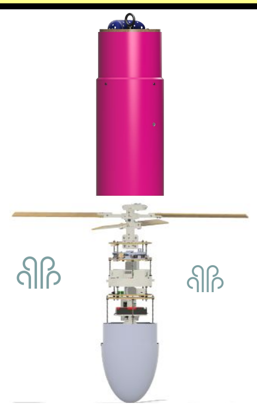
Mechanism 1 - Rubber Band Method

Pre-Deployment

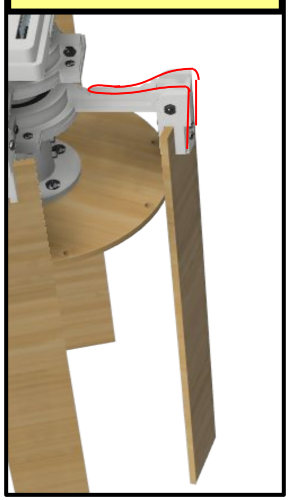
During Deployment

During Deployment

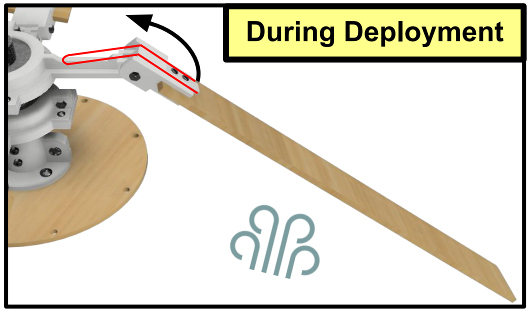
After Deployment



Pre-Deployment



During Deployment

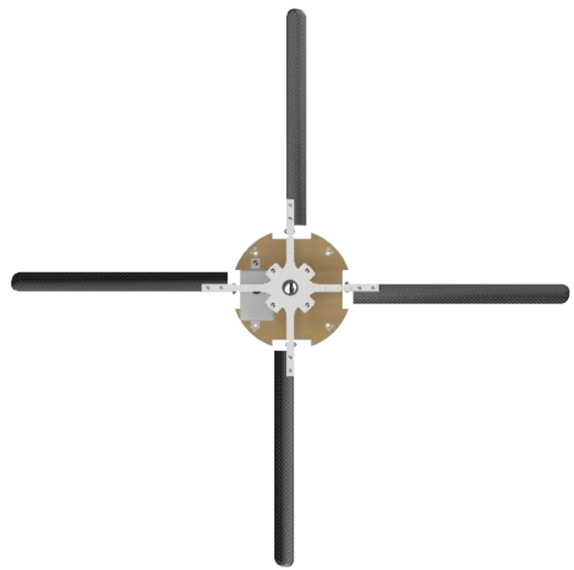


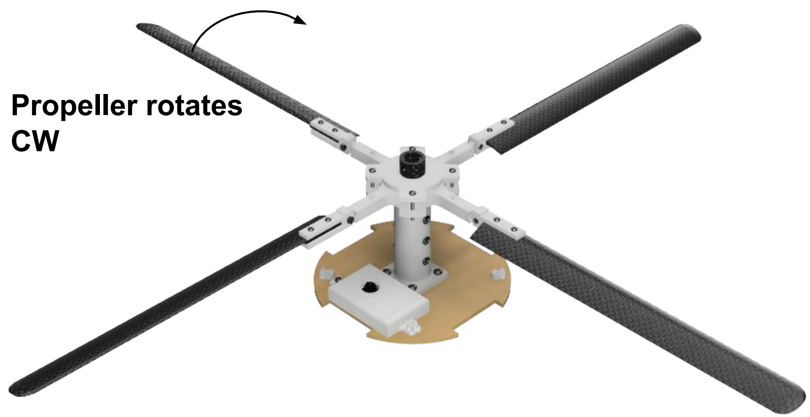
After Deployment

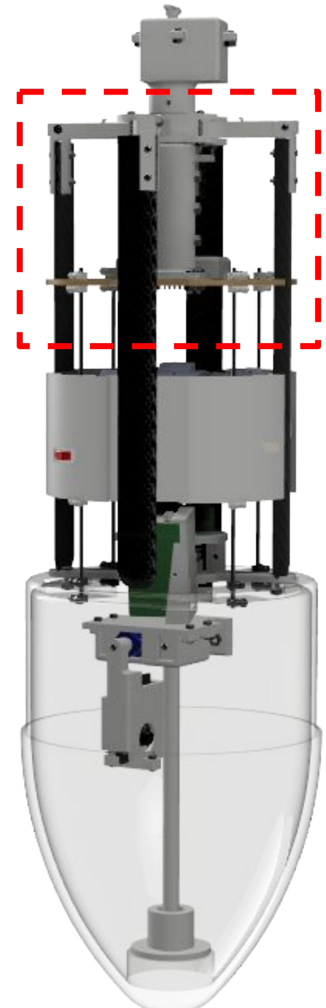
Before deployment, the propeller mechanism is secured within the container. The container is equipped with four slots, positioned 90 degrees apart, which hold the blades in place. After separation, the wings **open easily with help of the rubber bands.**

Mechanism 2 - Spring Method

As the payload descends, the blades open due to the payload's weight and the airflow, starting to rotate and thereby slowing the descent. To assist in the deployment of the blades, **springs are attached to the blade holders and hinges , providing additional force to ensure the blades open effectively.**

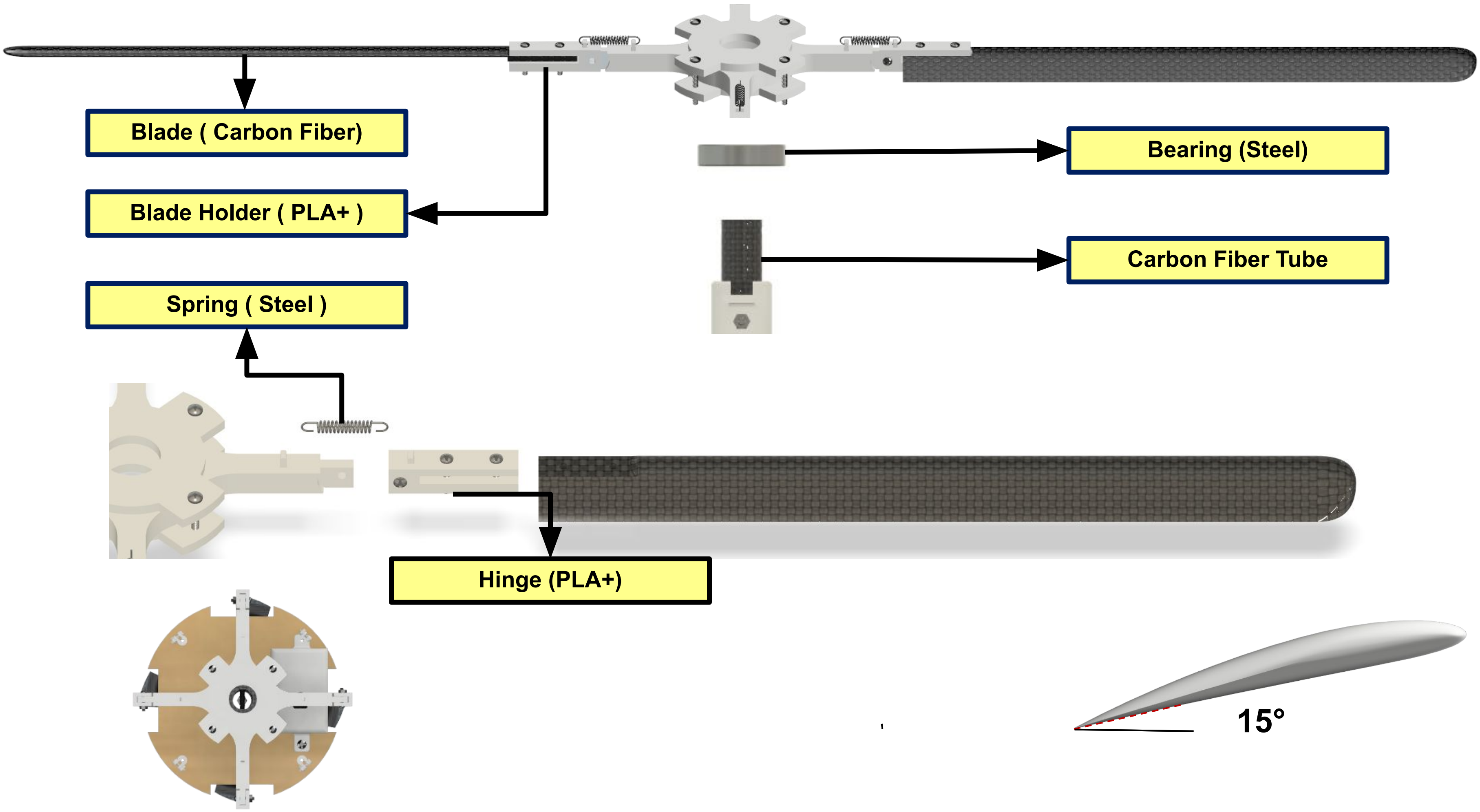






Auto-gyro Deployment Configuration Trade & Selection (5/7)

Mechanism 2 - Spring Method

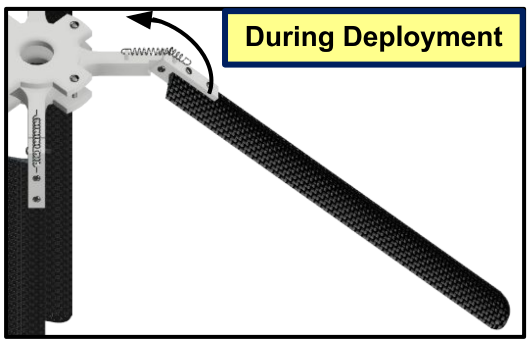


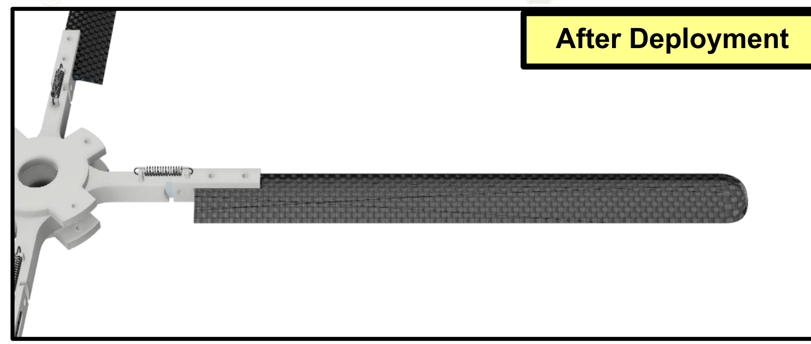
Auto-gyro Deployment Configuration Trade & Selection (6/7)

Mechanism 2 - Spring Method

Pre-Deployment | **During Deployment** | **During Deployment** | **After Deployment**

Pre-Deployment

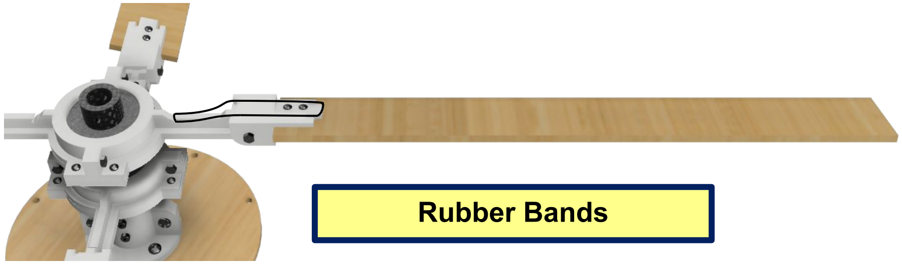




Prior to deployment, the propeller mechanism is safely contained within the container. The plate beneath the mechanism features four rectangular slots, evenly spaced at 90-degree intervals, ensuring the blades remain securely positioned. **Once separated, the wings deploy aided by the action of springs.**

Auto-gyro Deployment Configuration Trade & Selection (7/7)

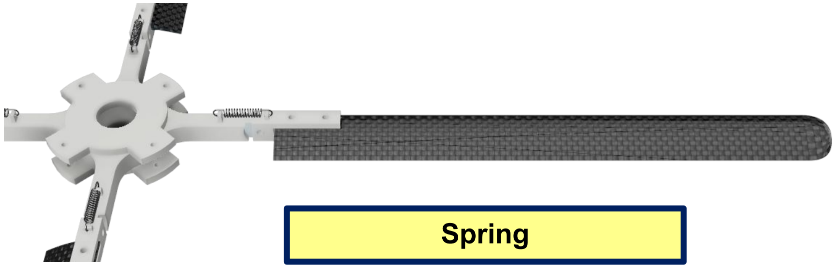
Mechanism 1 - Rubber Method



SELECTED

- Simplicity. Elastic bands are simpler to integrate and require less precision during installation.
- Less weight. Lightweight and contribute minimally to the system's total mass.
- Cost Efficiency. Cost-effective and readily available in various sizes and strengths.

Mechanism 2 - Spring Method



- More complex. Springs are more complex and demand precise alignment and installation.
- Increasing weight. Springs are typically heavier, adding unnecessary weight to the mechanism.

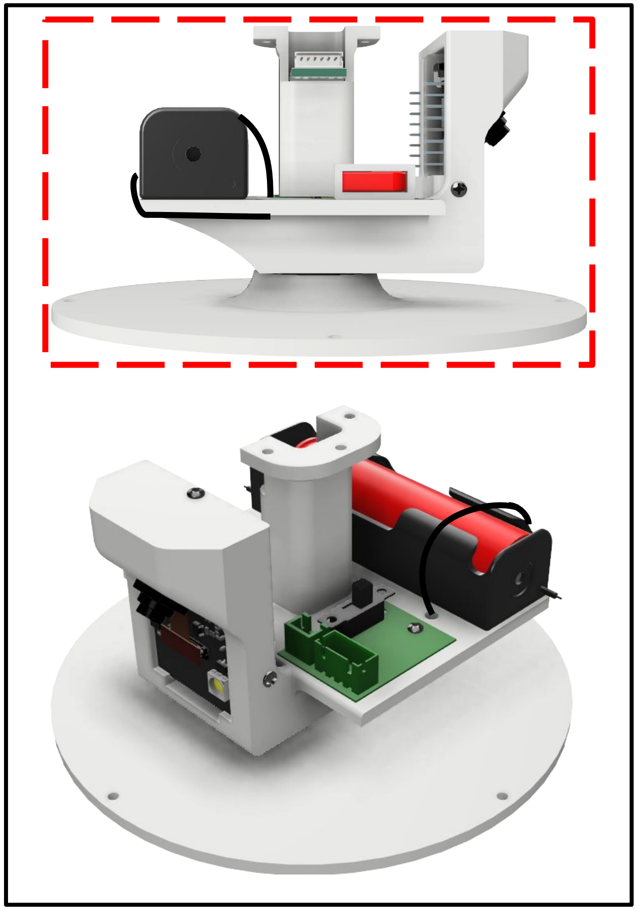
Ground Pointing and Orientation Trade & Selection (1/6)

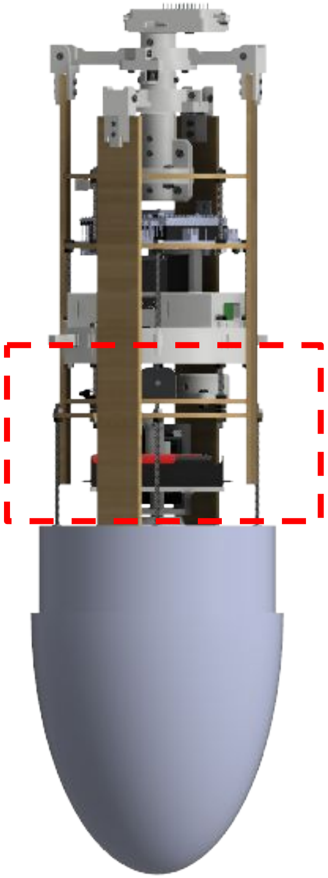
Mechanism 1 - Passive 45 Degree Pointing

The ESP-32 Cam has a flexible camera module which is fixed to a 45 degree inclined surface in our mechanism. This inclined surface ensures that the camera is angled at 45 degrees from nadir.

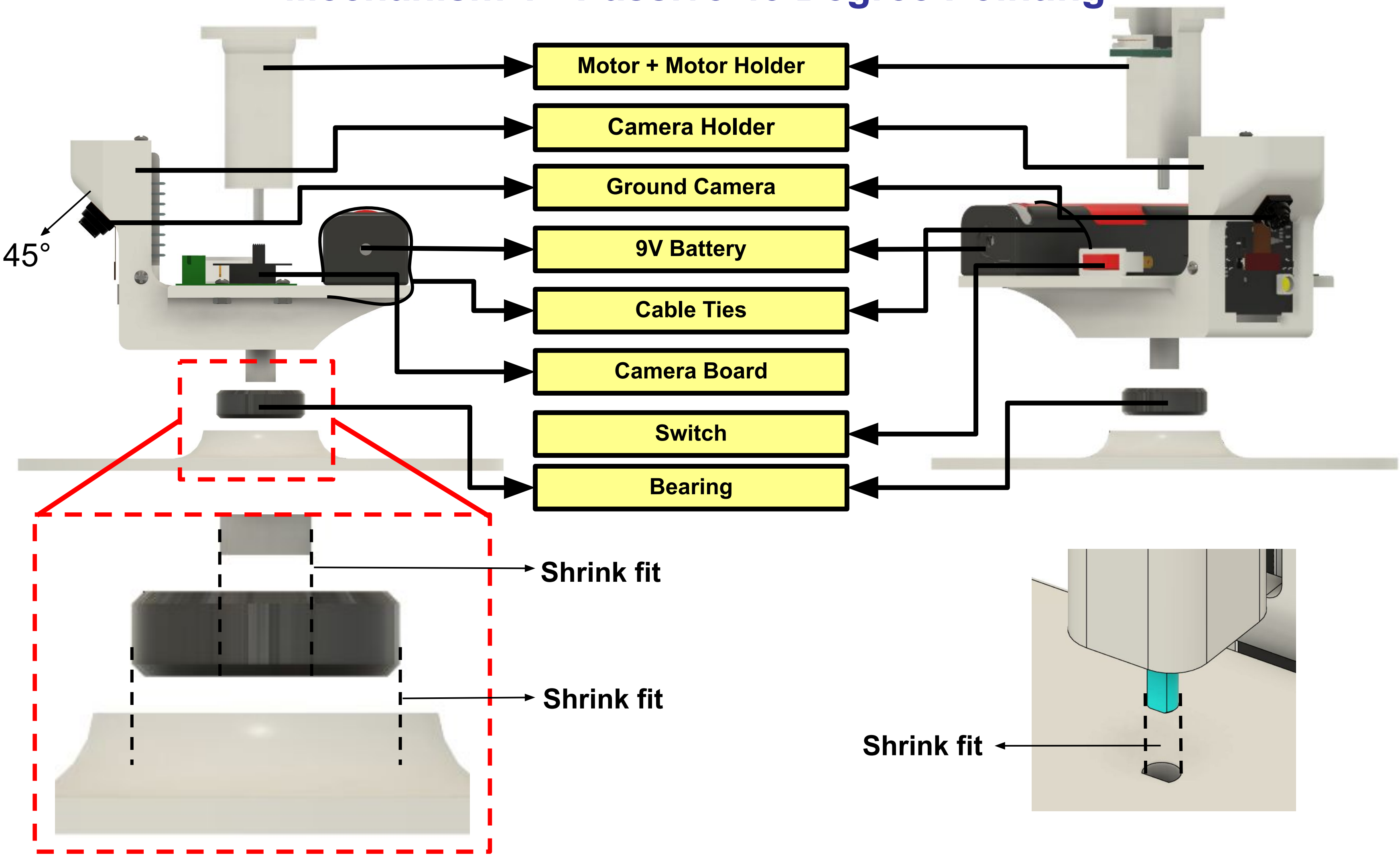
The camera holder is supported by the bearing underneath. A motor is attached to the holder to control the rotation. This motor rotates according to the signal it receives and adjusts the camera's rotation to maintain consistent alignment with the northern direction.

We used two cable ties to mount the battery holder to the camera holder and to secure the battery to the holder.





Mechanism 1 - Passive 45 Degree Pointing

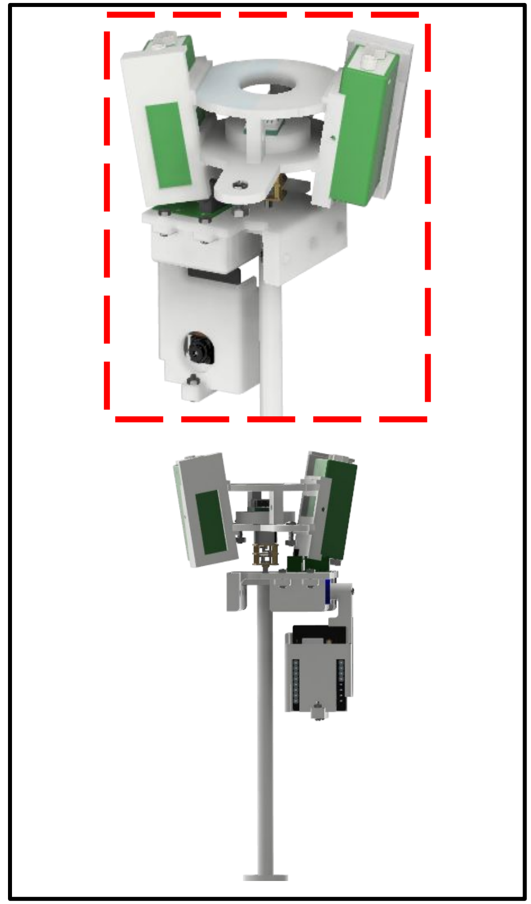


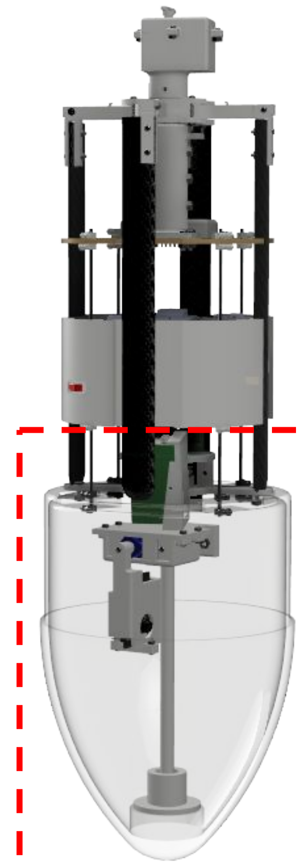
Mechanism 2 - Active 45 Degree Pointing

We have developed a camera mechanism that actively points 45 degrees north, utilizing the precise control of a servo motor. The camera itself is securely mounted on the servo motor, which is responsible for maintaining the camera at a 45 degree angle.

This assembly, consisting of the camera and the servo motor, is further mounted onto a separate Pololu motor. The Pololu motor is responsible for rotating the entire mechanism, ensuring it consistently faces north during operation.

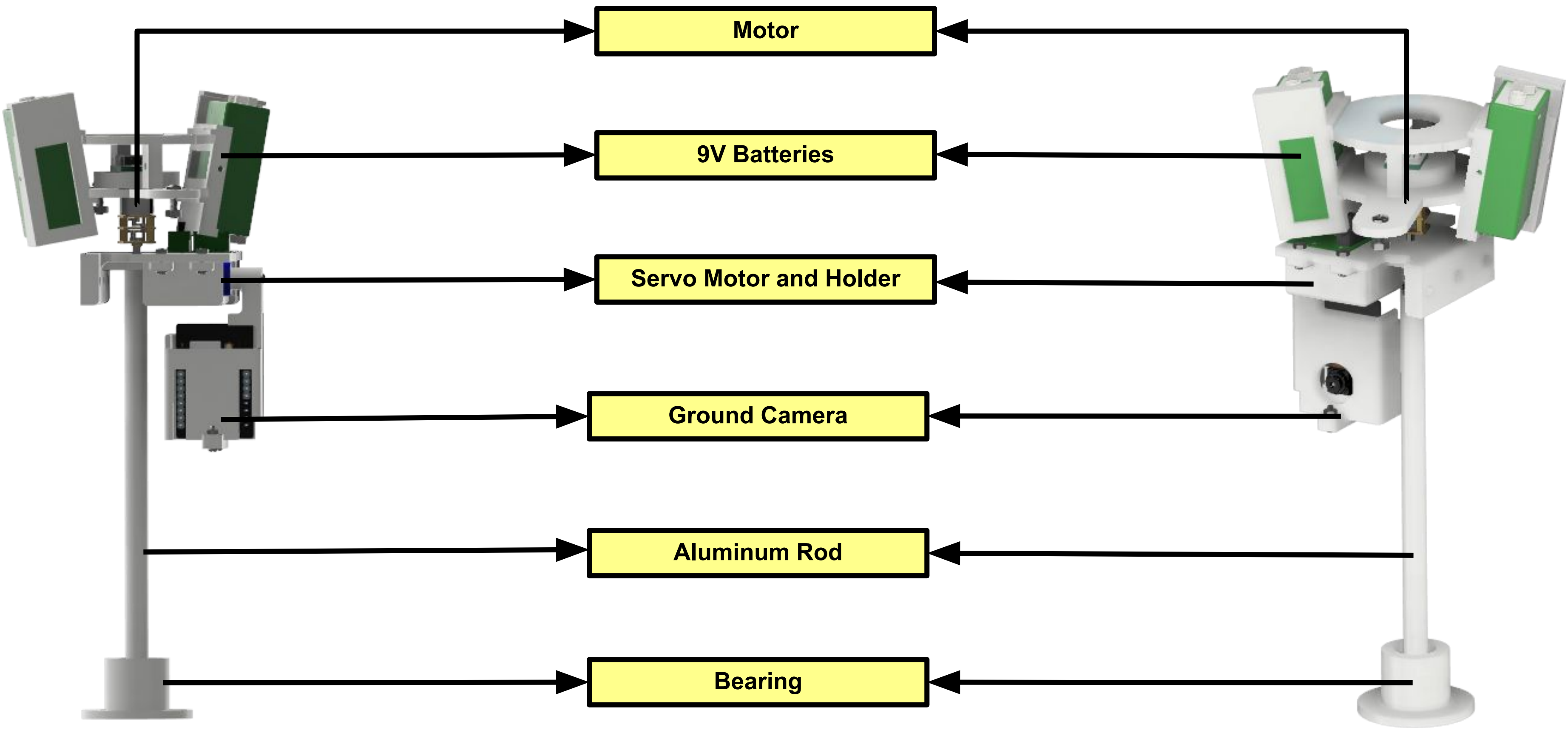
For additional stability and smooth operation, the system is supported from below by a bearing, which minimizes wobbling and ensures reliable performance.





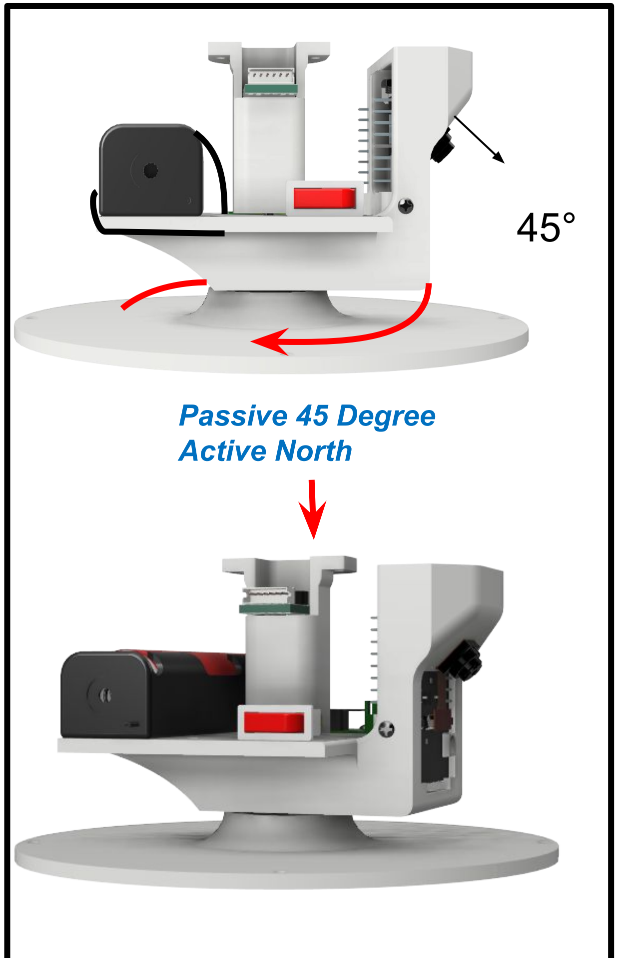
Ground Pointing and Orientation Trade & Selection (4/6)

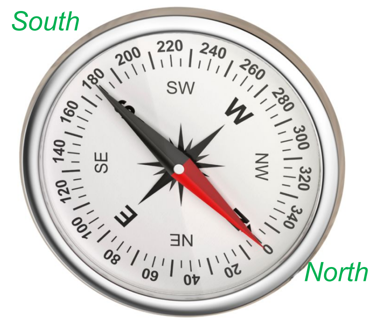
Mechanism 2 - Active 45 Degree Pointing



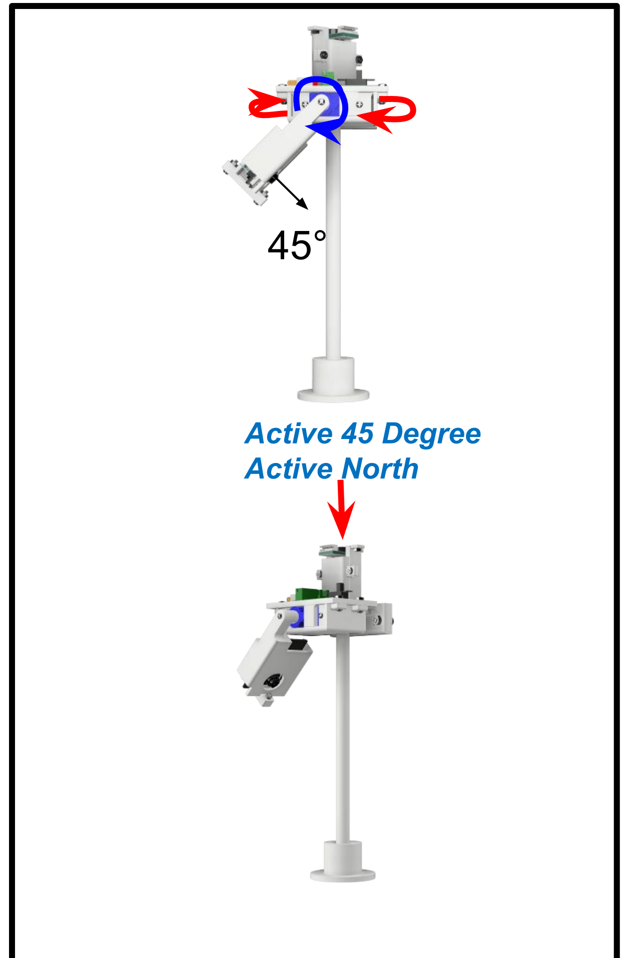
Ground Pointing and Orientation Trade & Selection (5/6)

Mechanism 2 - Passive 45 Degree Pointing





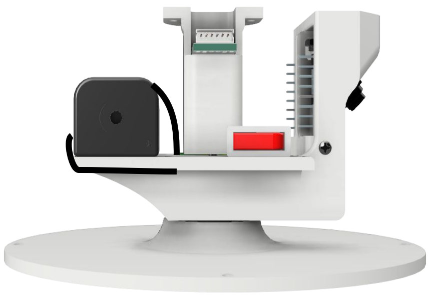
Mechanism 2 - Active 45 Degree Pointing



To better better demonstrate how the second mechanism looks, we didn't show the upper part, with the batteries.

Ground Pointing and Orientation Trade & Selection (6/6)

Mechanism 1 - Passive Pointing

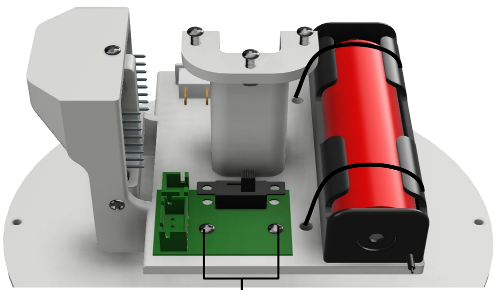


- **One motor.** Less power consumption.
- **Fewer components.** Overall weight of the mechanism is reduced.
- **Simple design.** Allows faster and easier assembly.

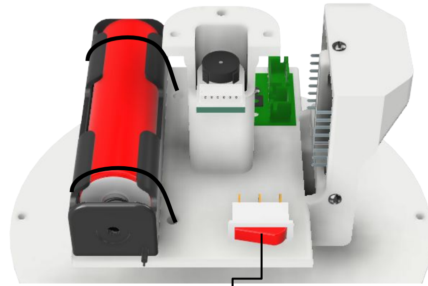
Mechanism 2 - Active Pointing

- **Dual motor.** The mechanism has a dual motor system to face north actively which increases power consumption and weight.
- **More components.** May be prone to errors.
- **Complex.**

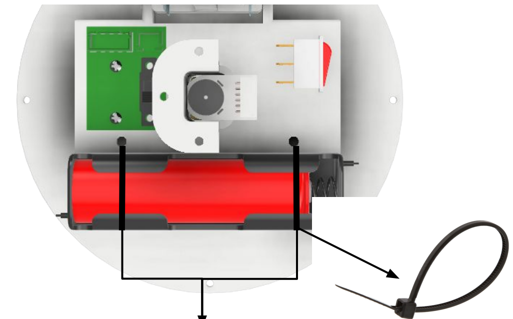
Electronics Structural Integrity (1/6)



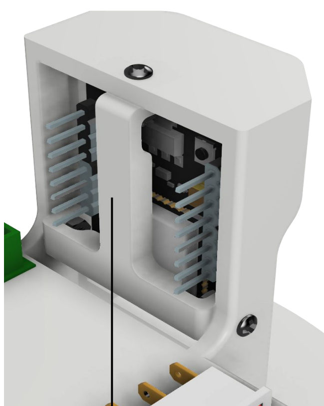
Screws and Bolts



Glued

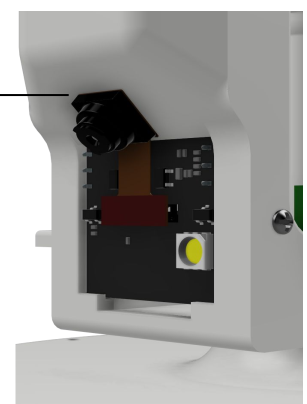


Cable Ties



Double-Sided Tape

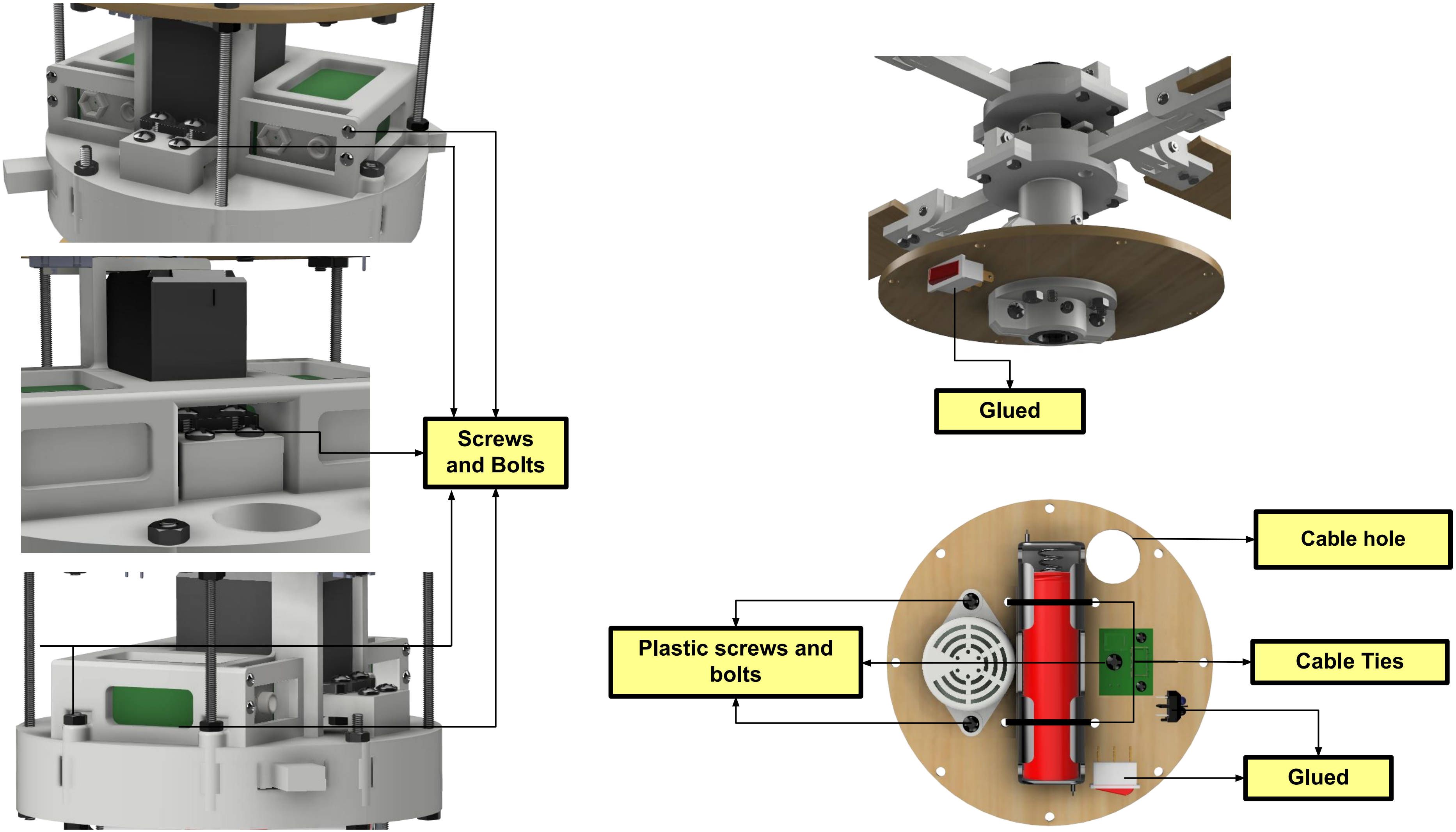
We secured the camera module using double-sided tape to ensure it remains firmly in place throughout the flight.



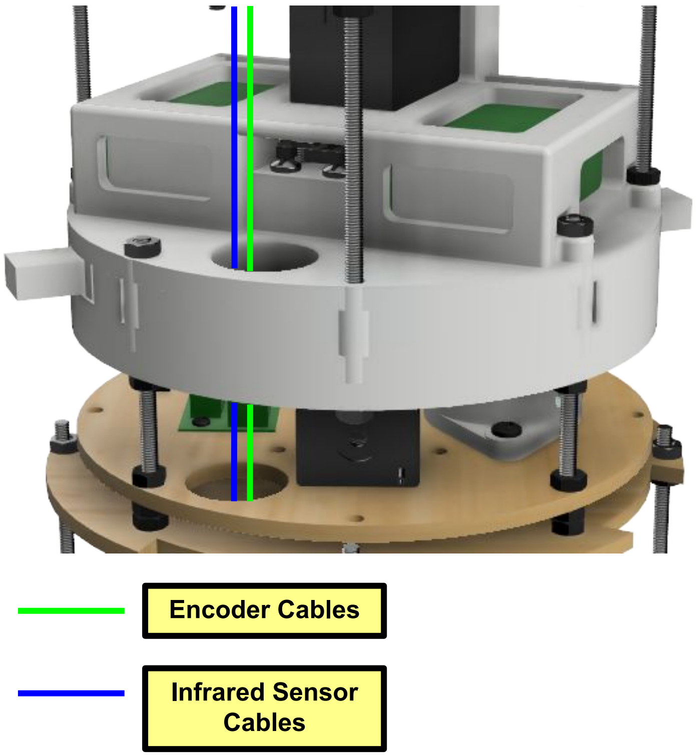
We shrink fitted the motor to the motor holder. We screwed the holder to the upper plate of camera mechanism.

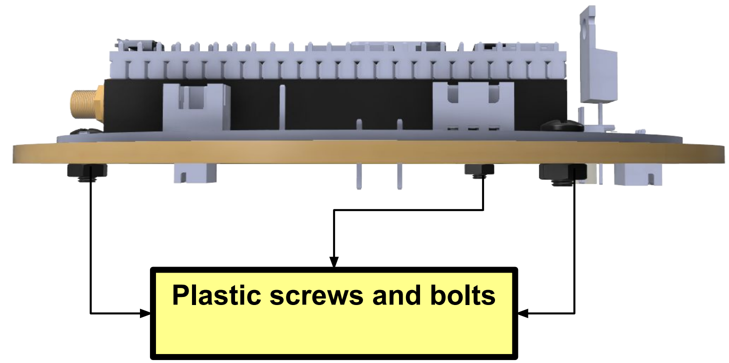
We designed a belt-like component to secure the camera.

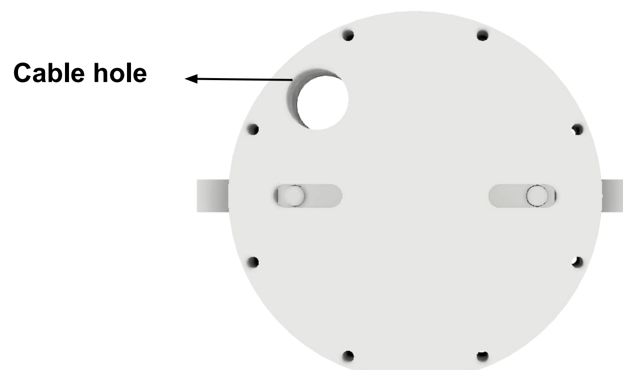
Electronics Structural Integrity (2/6)



Electronics Structural Integrity (3/6)



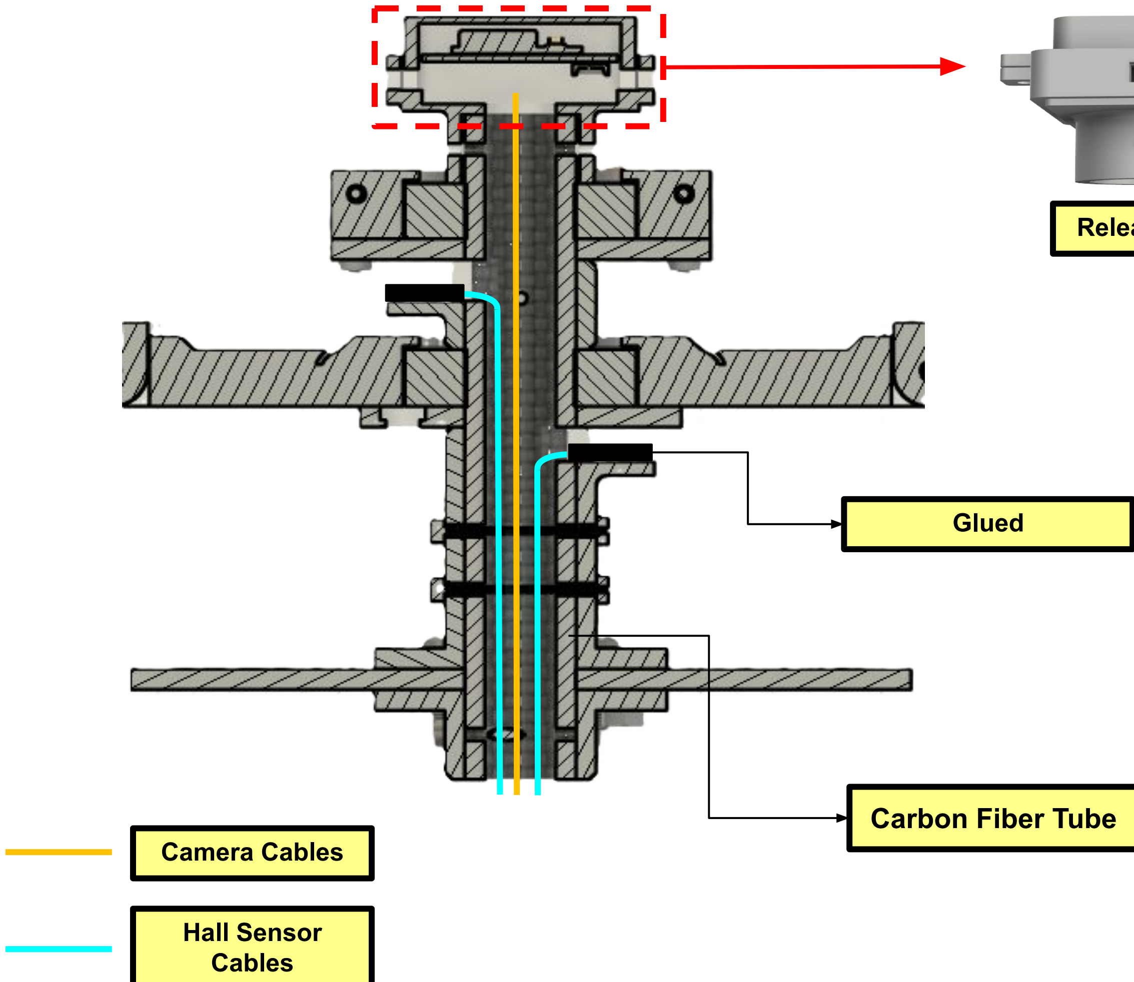




Cable colors may change. These colors are representative.

Electronics Structural Integrity (4/6)

Descent Control Integrity



We took these steps to make sure all electrical and mechanical components are securely held in place and remain undamaged throughout the flight.

The necessary judge verification was taken into consideration during the pre-flight check-in.

All systems were securely fixed before the flight.

After the wiring process is completed, the necessary fixing processes will be carried out with plastic clamps, super glue and tape.

Cable colors may change. These colors are representative.

Electronics Structural Integrity (5/6)

Criteria	Method	Rationale
Electronic Component Mounting Methods	Batteries will be secured using Battery cases designed in the structure of payload and container.	With the experience from previous years. Special case designs for batteries are more rigid, light and appropriate for the general design.
	Electronic parts will be secured by using tapes or glue as non-conductive materials at critical points where open circuit can take place.	Electronic parts with minimum need for assembly and disassembly will be placed in their places more firmly with a non-conductive adhesive.
	Electronics will be fixed on PCB where it is mounted to structure with PCB Base in the payload. PCB will be mounted on the Base using plastic screws and nuts.	PCB is one of the most effective ways to fix electronics. In addition, it prevents short circuits and creates a more integrated structure. Mounting the electronics onto it is also quicker.
	DC motors will be mounted through the 3D printed holders in the payload. The motor holder is connected with screws to the base chassis.	It plays an important role in keeping the DC motors firmly in place.
	3.7V batteries were installed using ready-made cases and plastic clamps were placed around them.	The ready case contained a spring and a plastic clamp was placed over it to withstand shock and to prevent connection problems. Such a method was developed to avoid the need for constant re-soldering when changing batteries.

Electronics Structural Integrity (6/6)

Criteria	Method	Rationale
Electronic Component Enclosures	The container will protect the components from external factors during flight. Produced with special closed holder for release camera, ground camera and encoder motor	The container will protect electronic components during flight with its durable structure. The holders of the components that are important for the mission and are risky are produced more closed and robust.
Acceleration and Shock Force Requirements and Testing	The Payload and the container prototype will be tested by dropping them from certain heights. The use of damped structures will be increased to absorb shock forces.	Acceleration and shock force requirements will be extensively tested during full system's test launches. It is planned to complete the test using the drone in the same conditions as real-time flight.
Securing Electrical Connections	To secure electrical connections epoxy and similar adhesives will be used.	The majority of electronic components are fixed on PCBs. In this way, most of the connection problems are eliminated. Stronger connections will be established by using various adhesives when it is needed.
Descent Control Attachments	The container parachute is mounted on plywood using a 1/4 inch eyebolt. Eyebolt is connected to the plate with locked nut. Parachute and eyebolt connection is provided using parachute rope.	This method is the same as the method specified in the competition specifications. Plywood absorbs the impact well during parachute opening. Eyebolt is a logical option for parachute connection. Locked nut is the most logical choice for eyebolt and parachute safety.
	There are 2 bearings in the coaxial propeller. The wings, wing holders and spacers are fixed to each other using m2 bolts and nuts. Removable loctite is used between the nuts and bolts.	Bearings are necessary for the wings to rotate and the most robust and retractable way to connect them is to use bolts and nuts. In order for these connections not to be affected by vibrations, loctite bolt and nut stabilizer, which loses its properties when it reaches a certain temperature, was used.

Mass Budget (1/6)

		Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Margin (g)
Payload	Propeller	Camera Holder	1	-	5	C	1.25
		Propeller Arm	4	3.75	15	C	3.75
		Hinge (CW+CCW)	4	2.5	10	C	2.5
		Propeller Magnet Holder	2	2.5	5	C	1.25
		Propeller Bearings	2	25	50	D	-
		Propeller Hall Sensor Holder	1	-	2	C	0.5
		Lower Hall Sensor Holder	2	4	8	C	2
		Blades	4	10	40	M	10
		Propeller Plate	1	-	15	M	3.75
		Propeller-Plate Fixer	2	2	4	C	1
	Release Mechanism	Protective Cover	1	-	30	C	7.5
		Base	1	-	25	C	6.25
		Arm	2	2	4	C	1
		Transmission Arm	2	2	4	C	1
		Servo Apparatus	1	-	3	C	0.75
		Servo Holder	2	2	4	C	1
		Battery Holder	1	-	15	C	3.75
	Plates	Buzzer Plate	1	-	8	M	2.5
		PCB Plate	1	-	5	M	1.25
		Nose Cone	1	-	227	M	56.75

Mass Budget (2/6)

		Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Margin (g)
Payload	Ground Camera	Camera Holder	1	-	25	C	6.25
		Bearing Plate	1	-	25	C	6.25
		Motor Holder	1	-	2	C	0.5
		Bearing	1	-	10	D	-
		Belt	1	-	1	C	0.25
		Camera Upper Plate	1	-	15	M	3.75
	Electronics	ESP32-Cam	2	10	20	D	-
		PCB	1	-	70	C	17.5
		Servo MG995	1	-	55	D	-
		9V Battery	2	35	70	D	-
		Switch	3	0.5	1.5	D	-
		Buzzer	1	-	3	D	-
		Infrared Sensor	1	-	1	D	-
		Buzzer Board	1	-	1	M	0.25
		DC Motor	1	-	13	D	-
		3.7V Battery and Holder	2	33	66	D	-
		Hall Sensor	2	0.5	1	D	-
		Camera Board	1	-	2	M	0.5
		Encoder	1	-	1	D	-
		Real Time Clock Coin Cell	1	-	1	D	0.25
		Leaf Antenna	2	0.5	1	D	0.25
		Micro SD Card	3	0.33	1	D	-

Mass Budget (3/6)

	Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Margin (g)
Assembly Components	M2 4mm	4	0.12	0.48	D	-
	M2 8mm	15	0.27	4.04	D	-
	M2 12mm	8	0.34	2.72	D	-
	M2 18mm	4	0.45	1.8	D	-
	M2 22mm	5	0.50	2.5	D	-
	M3 4mm	4	0.65	2.6	D	-
	M3 8mm	4	0.79	3.16	D	-
	M3 10mm	5	0.87	4.35	D	-
	M3 12mm	4	0.95	3.8	D	-
	M3 16mm	4	1	4	D	-
	M3 5mm Plastic	2	0.2	0.4	D	-
	M3 6mm Plastic	3	0.25	0.75	D	-
	M3 8mm Plastic	6	0.33	1.98	D	-
	M3 10mm Plastic	2	0.42	0.84	D	-
	M2 Nuts	32	0.14	4.48	D	-
	M3 Nuts	52	0.33	17.16	D	-
	M3 Nuts Plastic	45	0.05	2.25	D	-

Mass Budget (4/6)

	Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Margin (g)
Assembly Components	50mm Rod	4	2.1	8.4	D	-
	74mm Rod	4	3.12	12.48	D	-
	58mm Rod	2	2.35	4.7	D	-
	65mm Rod	2	2.7	5.4	D	-
	80mm Rod	4	3.3	13.2	D	-
	Plastic Cable Ties	4	0.5	2	D	-
Container	Plywood	1	-	20	C	5
	Container First Part	1	-	260	C	67.5
	Container Second Part	1	-	125	C	32
	Parachute	1	-	10	C	2.5
	Parachute Rope	1	-	1	C	0.25
	Eyebolt ¼ Inch	1	-	18	D	-
	Eyebolt's Lock Nut	1	-	0.38	D	-
	M2 6mm	4	0.13	0.52	D	-
	M2 12mm	4	0.28	1.12	D	-
	M2 Nut	8	0.14	1.12	D	-

Mass Budget (5/6)

Total Mass of Container (g)	437.14
Total Mass of Payload (g)	967.99
Total Mass of CanSat (g)	1405.13

Total Mass of Electronic Components (g)	307.5
Total Mass of Structural Elements (g)	1097.63

Total Mass Margin of CanSat
|Mass Requirement - Total Mass of CanSat| = Margin
|1410-1405.13| = 4.87
Mass Budget Meets The Requirements!

Acronyms:
C: Calculation
D: Data Sheet
E: Estimation
M: Measured

Error margin for estimated data is selected as 25% **(Uncertainty)**.

- Calculations are done using reasonable data from CAD program.
- Estimations are done by literature survey.

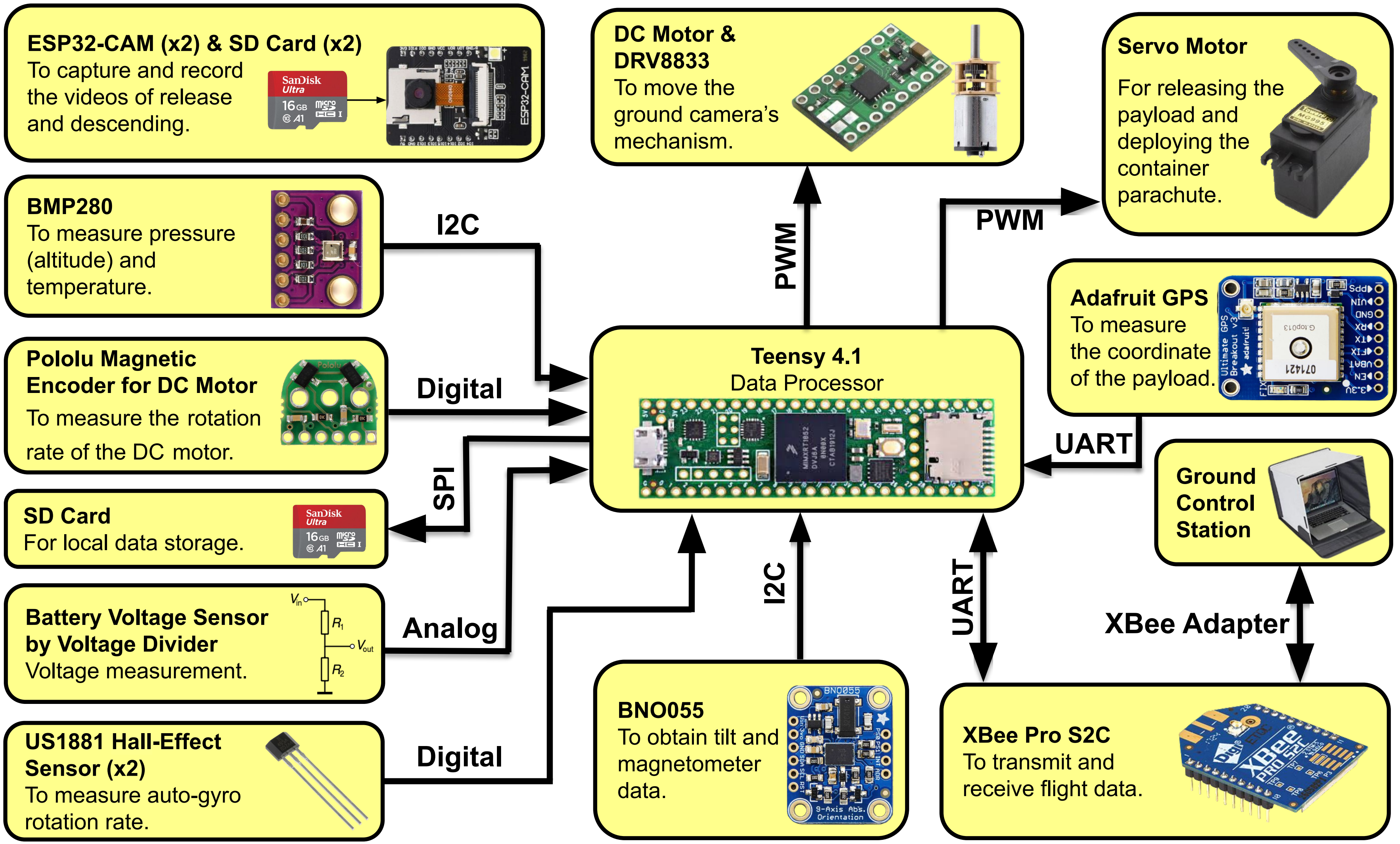
Mass Budget (6/6)

Method of Correction	
CanSat > 1410g	• Topology optimization on Finite Element Analysis • Decreasing infill density of 3D printed parts • Decreasing number of fasteners • Using plastic screws on safe zones • Shortening Nose Cone design
CanSat < 1390g	• Increasing infill density of 3D printed parts • Increasing number of fasteners • Designing more robust structure with greater mass

Communication and Data Handling (CDH) Subsystem Design

Berke OZBAY

Payload Command Data Handler (CDH) Overview



Payload Processor & Memory Trade & Selection (1/3)

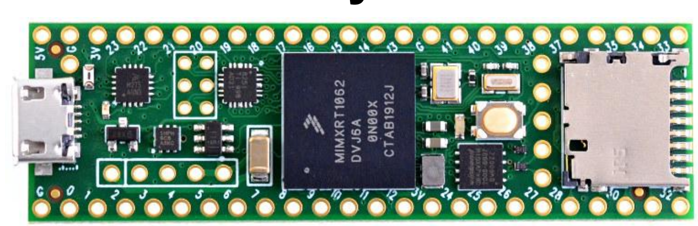
Microcontroller Board	Processor Speed [MHz]	Boot Time [ms]	Types of Interfaces	Number of Interfaces	Form Factor [mm]	Cost [$]	Mass [g]	Current Consumption [mA]	Non-Volatile Memory Options [kB]		Volatile Memory Options [kB]
Teensy 4.1 Microcontroller	**600**	**200**	**I2C** **SPI** **UART**	**3** **3** **8**	**60.96 x 17.78**	**30.85**	**16.95**	**100**	**EEPROM (4)**	**Flash (7936)**	**SRAM (1536)**
Arduino Uno	16	1000	I2C SPI UART	1 1 1	68.66 x 53.4	22	25	200	EEPROM (1)	Flash (32)	SRAM (2)
Teensy 3.5 Microcontroller	120	300	I2C SPI UART	3 3 6	62.3 x 18	24.95	4.8	60	EEPROM (4)	Flash (512)	SRAM (256)

Teensy 4.1

SELECTED

- **Satisfactory processor speed**
- **Small form factor**
- **Programmable with Arduino IDE**
- **Larger size of non-volatile and volatile memory options**
- **Lower current consumption at specified processor speed**

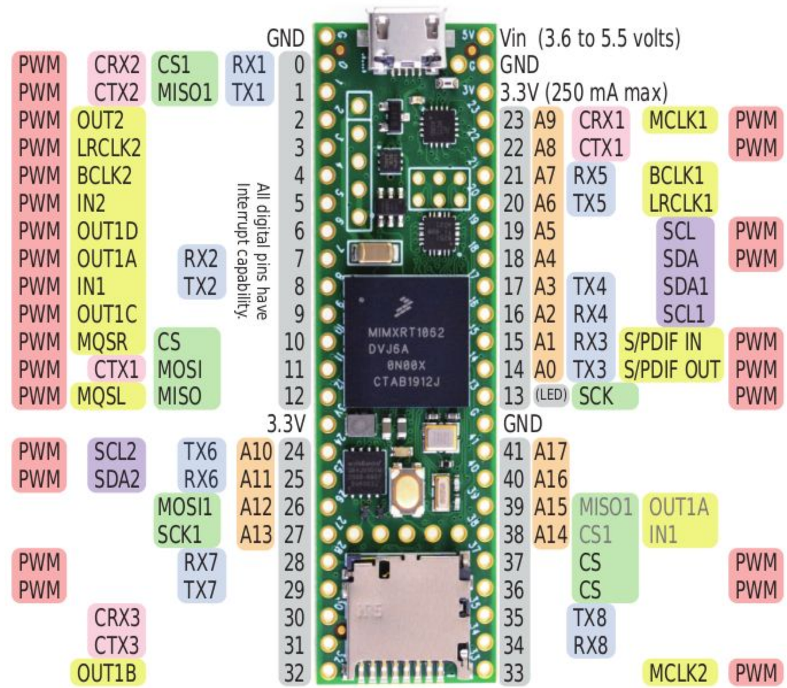
Teensy 4.1



Payload Processor & Memory Trade & Selection (2/3)

No	Pin Type	Description	Number of Available Pins
1	Analog Input	The pins that can read analog signal as input.	18
2	CAN Bus	The pins that can be used in Controller Area Network(CAN) Bus.	3
3	Digital Input	The pins that can read digital signal as input.	55
4	Digital Output	The pins that can send digital signal.	55
5	PWM	The pins that can generate PWM signals.	35
6	UART (TX-RX)	The pins that can be used for asynchronous serial communication.	8
7	SPI	The pins that can be used for synchronous serial communication.	3
8	I2C	The pins that can be used as synchronous, multi-controller/multi-target, packet switched, single-ended, serial communication bus.	3

The Pinout Diagram of the Teensy 4.1 (Data Interface Bus)



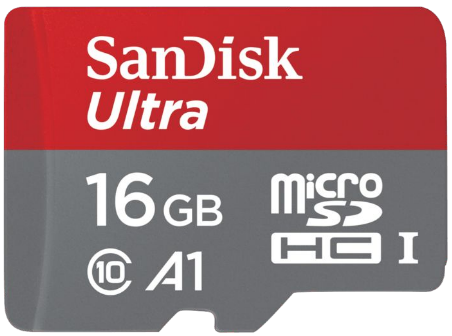
Payload Processor & Memory Trade & Selection (3/3)

Model	Capacity [GB]	Transfer Speed [Mbps]	Cost [$]
Sandisk Ultra	**16**	**48**	**5.61**
Samsung EVO	16	48	7.5
Syrox	16	48	5.9

- **Requirement 1 : Selected SD card shall compatible with the processor in terms of size factor, storage capacity and writing and reading.**
- **Requirement 2 : Selected SD card shall capable of maintain its working status under shock and vibration conditions.**

SanDisk Ultra

- **Waterproof**
- **Temperature proof (-25 to 85 °C)**
- **Shock and vibration proof**
- **Impact proof**



Payload Real-Time Clock

Model	Voltage [V]	Reset Tolerance	Accuracy [ppm]	Interface	Mass and Size [g & mm]	Hardware / Software
Teensy 4.1 RTC	**3.3**	**Durable due to independent coin battery for unpredicted power outages.**	**±50**	**Internal to CPU**	**No extra mass and size**	**Hardware**
DS1307	5	Durable due to independent coin battery for unpredicted power outages.	±23	I2C	Mass: 2.3 Size : 26 x 22 x 5	Hardware
Adafruit PCF8523 RTC	5	Durable due to independent coin battery for unpredicted power outages.	±25	I2C	Mass: 1.2 Size : 25.5 x 21.7 x 4.8	Hardware

Reset Control: In Teensy 4.1, each phase and packet count are stored in the EEPROM. If the reset is performed, Teensy 4.1 receives values via EEPROM.

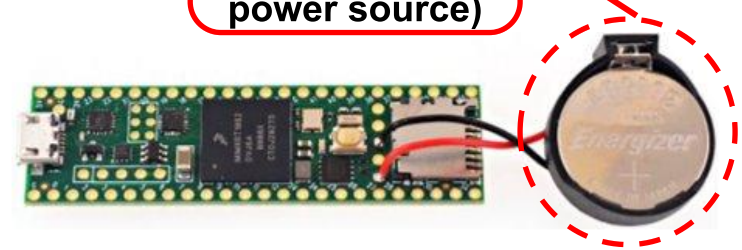
RTC Power: Coin cell is attached to the power input of the internal RTC. Thus, time is maintained through power transients.

Teensy 4.1 RTC

SELECTED

- **Integrated into Teensy 4.1**
- **Compact size saves space**
- **Offers high accuracy compared to other trades**
- **No extra cost**

3V coin cell battery (Independent power source)



Payload Antenna Trade & Selection

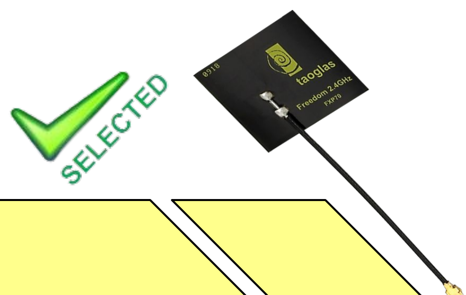
Model	Type and Connector	Gain [dB]	Dimensions [mm]	Mass [g]	Frequency Range [GHz]	Radiation Pattern	Cost [$]
FXP70	**U.FL**	**5.0**	**27 x 25**	**1.2**	**2.4 - 2.5**	**Omni Directional**	**3.59**
HG2403RD -RTF	N-Male	3.0	137 x 13	23	2.4 - 2.5	Omni Directional	15.0
Buccaneer Antenna Px0407	Connector Supplied With SMB Plug	2.0	105 x 19	15	2.4 - 2.5	Omni Directional	23.69

Selection Criteria: **XBee operates at 2.4 GHz, and the frequency range of the antenna that we selected is compatible with XBee.**

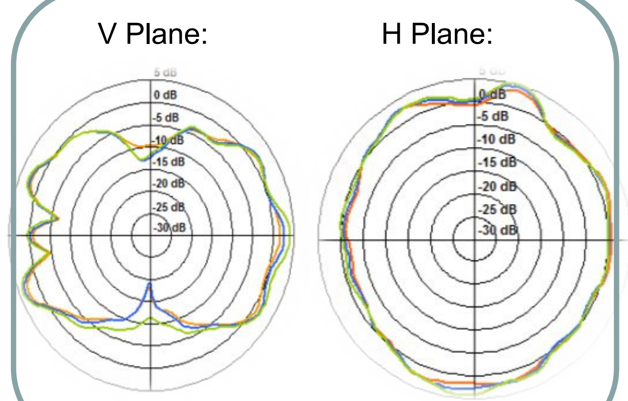
Selected Antenna

FXP70

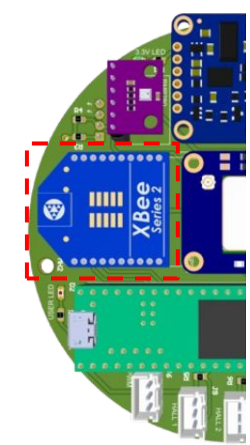
- **High Gain**
- **High Performance**
- **Small size**
- **Easy connection with XBee**



Radiation Patterns



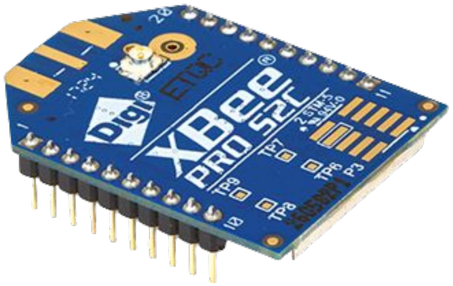
Antenna Location on PCB



Payload Radio Configuration

Device	Voltage [V]	Transmit Current [mA]	Receive Current [mA]	Operating Frequency [MHz]	Transmit Power [mW]	RF Data Rate up to [Kbps]	LoS Range [Km]	Cost [$]
XBee Pro S2C	**3.3**	**120**	**31**	**2400**	**63**	**250**	**3.2**	**31.32**
XBee 3	3.3	40	17	2400	6.3	250	1.2	25.11
XBee Pro 900HP	3.3	215	29	900	250	200	15.5	18.44

- PANID / NETID will be set to: **3133**



XBee Pro S2C

SELECTED

- **Low transmit current**
- **Low receive current**
- **High transmit power**
- **High range**

Transmission Control:

- The XBee will use direct addressing, not broadcasting. **Telemetry will be active during all phases.** Data will be transmitted at a rate of **1 Hz.**
- After **landing**, telemetry will be stopped.

Payload Telemetry Format (1/3)

No	Data Format	Description	Example Value
1	<TEAM_ID>	Team identification.	<3133>
2	<MISSION_TIME>	The time since initial power up in HH:MM:SS format.	<06:08:01>
3	<PACKET_COUNT>	The count of transmitted packets, which is to be maintained through processor reset.	<732>
4	<MODE>	Flight (F) or Simulation (S) status telemetry data.	Flight (F) or Simulation (S) status telemetry data.
5	<STATE>	The operating state of the software.	<APOGEE>
6	<ALTITUDE>	Altitude with 0.1 meters resolution. (meter)	<336.7>
7	<TEMPERATURE>	Measured temperature in degrees. (Celcius)	<42.1>
8	<PRESSURE>	Measured air pressure from sensor in kPa. (kPa)	<15.5>
9	<VOLTAGE>	Measured voltage of the CanSat power bus. (Volt)	<8.6>
10	<GYRO_R>	The roll degree generated by the gyro (Gauss)	<-0.37>
11	<GYRO_P>	The pitch degree generated by the gyro (Gauss)	<0.12>
12	<GYRO_Y>	The yaw degree generated by the gyro (Gauss)	<-0.05>

Payload Telemetry Format (2/3)

No	Data Format	Description	Example Value
13	<ACCEL_R>	Accelerometer reading for the roll (degree/second^2)	<-0.05>
14	<ACCEL_P>	Accelerometer reading for the pitch (degree/second^2)	<0.47>
15	<ACCEL_Y>	Accelerometer reading for the yaw (degree/second^2)	<9.72>
16	<MAG_R>	The roll degree generated by the magnetometer (Gauss)	<-22.50>
17	<MAG_P>	The pitch degree generated by the magnetometer (Gauss)	<-9.69>
18	<MAG_Y>	The yaw degree generated by the magnetometer (Gauss)	<-39.19>
19	<AUTO_GYRO_ROTATION_RATE>	The rotation rate of the auto-gyro relative to the Cansat structure. (degree/second)	<2864.772>
20	<GPS_TIME>	The time generated by the GPS receiver.	<11:40:53>
21	<GPS_ALTITUDE>	Altitude generated by the GPS receiver. (meter)	<212.5>
22	<GPS_LATITUDE>	The latitude generated by the GPS receiver. (degree)	<53.4851>
23	<GPS_LONGITUDE>	The longitude generated by the GPS receiver.(degree)	<5.1234>
24	<GPS_SATS>	The number of GPS satellites being tracked by the GPS receiver.	<7>

Payload Telemetry Format (3/3)

25	<CMD_ECHO>	The fixed text command id and argument of the last received command with no commas.	<CXON>
26	<IR_STATUS>	Checks whether payload deployed or not	<TRUE>

CanBEE(Team 3133) Telemetry Format

<TEAM_ID>,<MISSION_TIME>,<PACKET_COUNT>,<MODE>,<STATE>,<ALTITUDE>,<TEMPERATURE>,<PRESSURE>,<VOLTAGE>,<GYRO_R>,<GYRO_P>,<GYRO_Y>,<ACCEL_R>,<ACCEL_P>,<ACCEL_Y>,<MAG_R>,<MAG_P>,<MAG_Y>,<AUTO_GYRO_ROTATION_RATE>,<GPS_TIME>,<GPS_ALTITUDE>,<GPS_LATITUDE>,<GPS_LONGITUDE>,<GPS_SATS>,<CMD_ECHO>,,<IR_STATUS>

Sample Telemetry Format

3133,06:08:01,732,F,APOGEE,336.7,42.1,15.5,8.6,-0.37,0.12,-0.05,-0.05,0.47,9.72,-22.50,-9.69,-39.19,2864.772,11:40:53,212.5,53.4851,5.1234,7,CXON,,TRUE

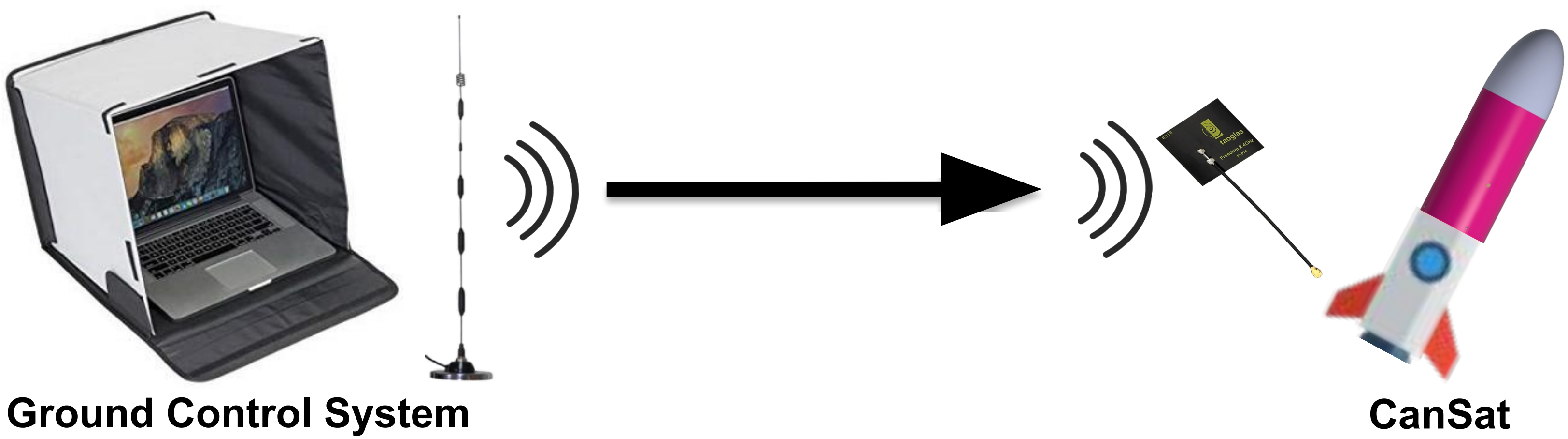
- Data will be transmitted at a rate of **1 Hz**.
- The XBee will use direct addressing, not broadcasting.
- After **landing**, telemetry will be stopped.
- **The telemetry data file shall be named as follows: Flight_3133.csv**

CanBEE telemetry format satisfies the telemetry format specified in Competition Guide

Payload Command Formats (1/2)

Command Samples

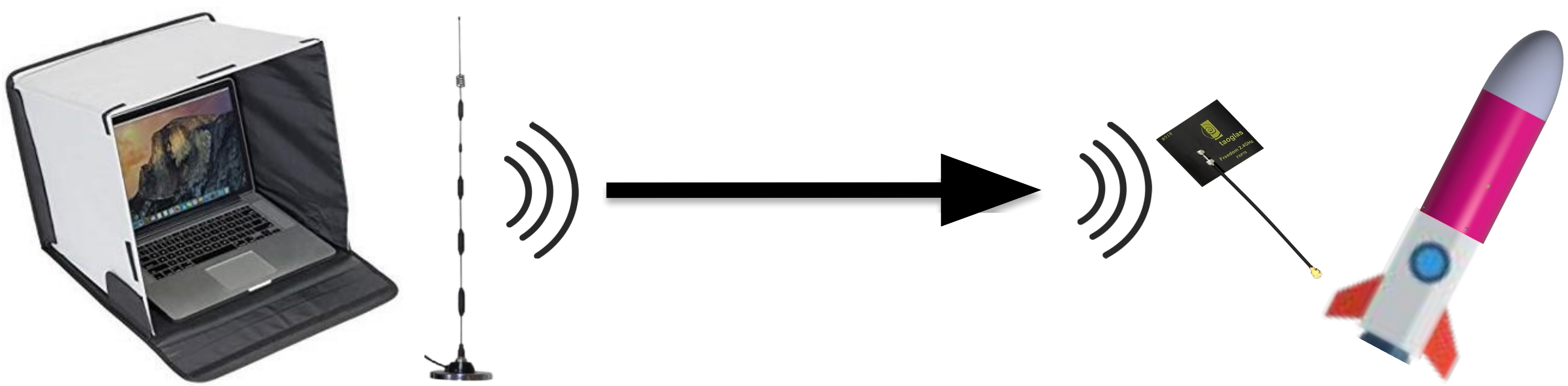
CMD,3133,CX,<ON>	→ CX - Payload Telemetry "ON" Command.
CMD,3133,CX,<OFF>	→ CX - Payload Telemetry "OFF" Command.
CMD,3133,ST,<16:33:06>	→ ST - Set Time.
CMD,3133,SIM,<ENABLE>	→ Enable Simulation Mode Control Command.
CMD,3133,SIM,<ACTIVATE>	→ Activate Simulation Mode Control Command.
CMD,3133,SIM,<DISABLE>	→ Disable Simulation Mode Control Command.



Payload Command Formats (2/2)

Command Samples

CMD,3133,SIMP,<93948>	Simulated Pressure Data [Pa] (to be used in Simulation Mode only).
CMD,3133,CAL	Calibrating the telemetered altitude to 0 meter.
CMD,3133,MEC,<SERVO>,<ON>	Activate the release mechanism if separation doesn’t occur autonomously



Ground Control System **CanSat**

Sample commands satisfy the requirements for commands specified in the Mission Guide

Electrical Power Subsystem (EPS) Design

Berke OZBAY

EPS Overview

Batteries: Provide electrical energy to the system/subsystem.

Parallel Connection Protection Circuit and Reverse Polarity Protection Circuit (PCPC & RPPC): Protects parallel connected batteries against potential damage caused by voltage difference between each other, and main system against wrong (reverse) power connection.

Mechanical Switches: Give ability to turn on and off the system/subsystem with their easy accessible placement.

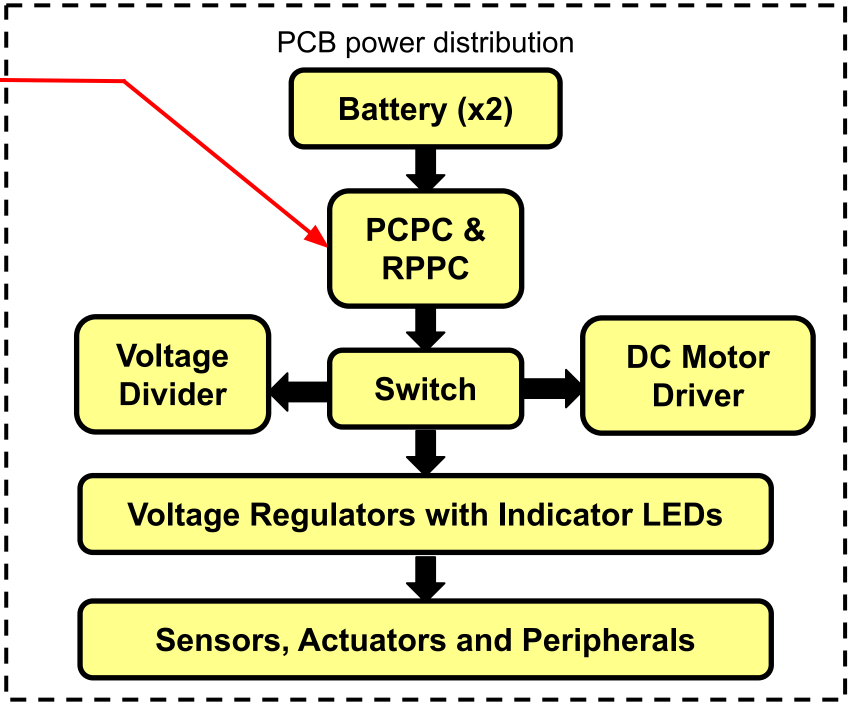
Voltage Regulators: Provide the power to all sensors, actuators and peripherals according to their needs.

Power Indicator LEDs: Show whether power is on or off.

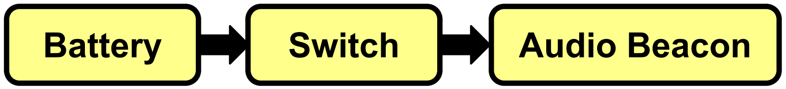
Voltage Divider Circuit: Connected directly to batteries to determine the voltage level.

Sensors, Actuators and Peripherals: Sensors are used to gather flight information; actuators and peripherals are used to perform required actions accordingly.

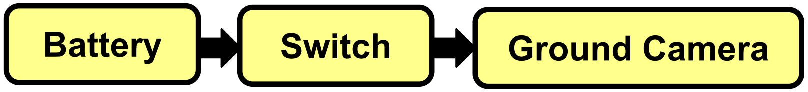
Simplified power diagram of CanSat:



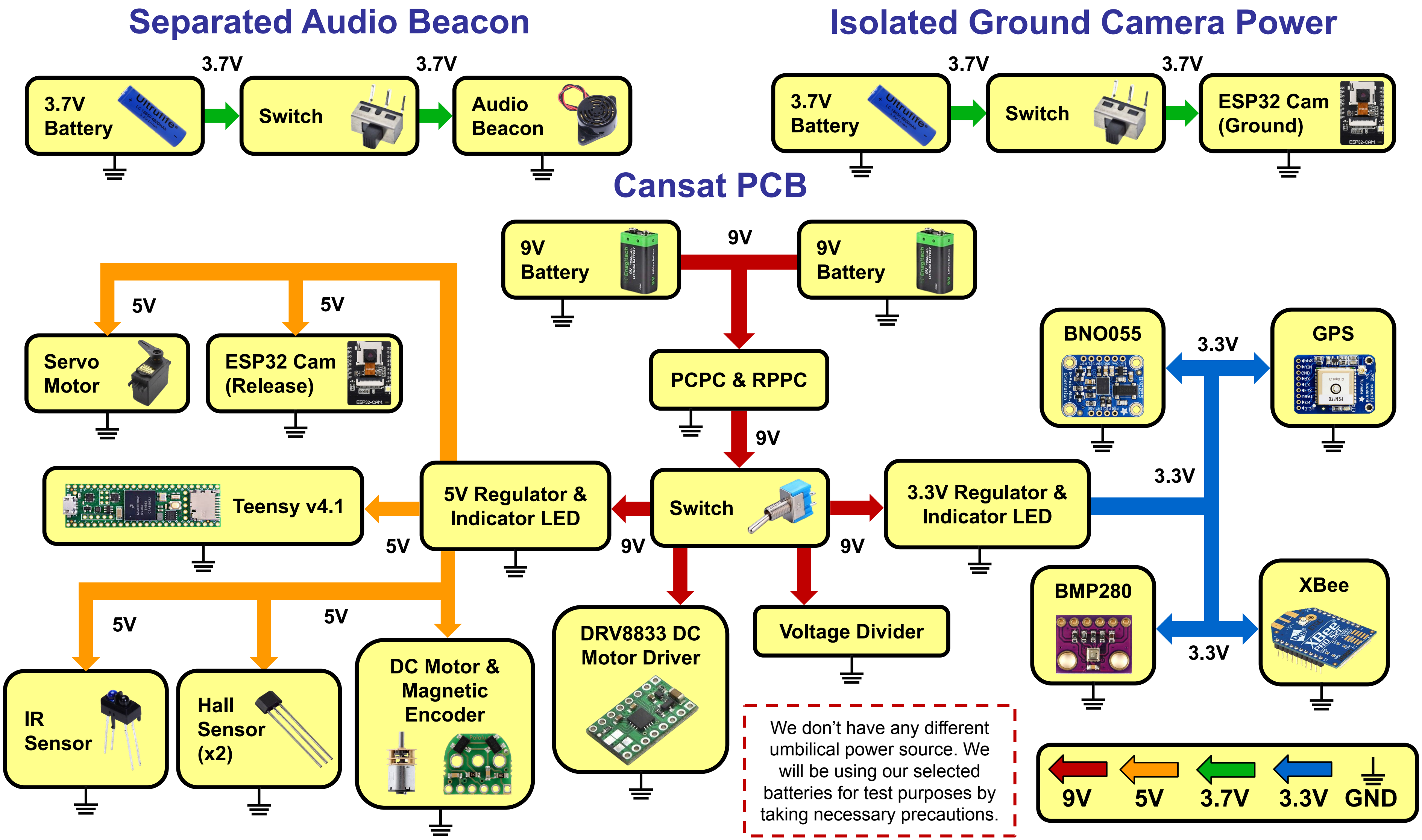
Audio beacon has a separated battery and an easy accessible switch.



Ground camera's power is isolated to avoid potential risks, because the system will move continuously towards the north.



Payload Electrical Block Diagram



Payload Power Trade & Selection (1/4)

9V Battery Selection

Battery	Battery Type	Voltage [V]	Maximum (Instantaneous) Current [mA]	Current Capacity [mAh]	Power Capacity [Wh]	Mass [g]	Size [mm]	Cost [$]
Enegitech	**Lithium**	**9**	**1500**	**1200**	**10.8**	**40**	**16.5 x 26 x 48**	**5.9**
Energizer Ultimate	Lithium	9	1000	800	7.2	33.9	17.5 x 26.5 x 49	13.56
Duracell (MN1604)	Alkaline	9	800	692	6.228	48.7	17.5 x 26.5 x 48.5	1.17

Configuration and connection: We use two of them **in parallel**. They are connected to PCB. JST connectors will be used to connect them to PCB.

Enegitech

SELECTED

- **High power rate**
- **Good mass according to its capacity**
- **Acceptable cost**

Payload Power Trade & Selection (2/4)

3.7V Battery Selection

Battery	Battery Type	Voltage [V]	Maximum (Instantaneous) Current [mA]	Current Capacity [mAh]	Power Capacity [Wh]	Mass [g]	Size [mm]	Cost [$]
Ultrufife 18650	**Lithium-ion**	**3.7**	**6000**	**4800**	**17.76**	**24**	**18 x 65**	**2.67**
Orion 18650p	Lithium-ion	3.7	3000	2000	7.4	45	18 x 65	2.21

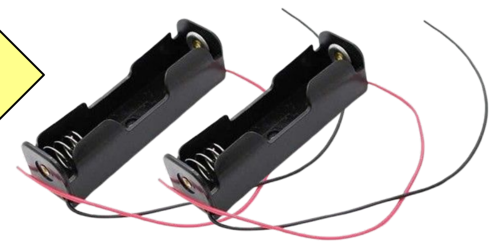
Configuration and connection: We use two of the selected battery, but they are not connected to each other. Camera and buzzer board are designed and JST connectors is placed on this boards to ensure the secure connection.
- One battery is supplying the **ESP32-Cam (Ground Camera).**
- The other one is supplying the **separated audio beacon.**

Ultrufife 18650

SELECTED

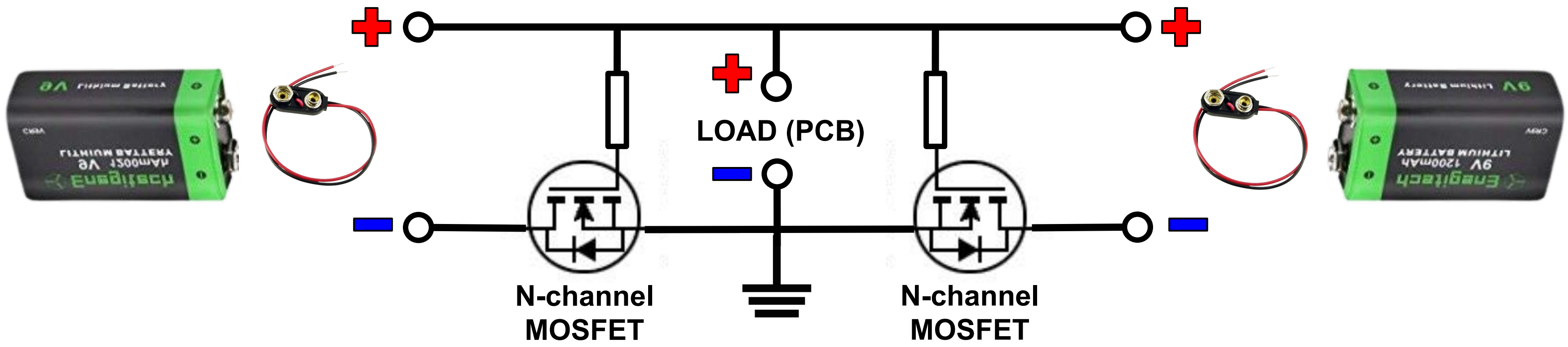
- **High power rate**
- **Good mass according to its capacity**
- **Can be easily found in Turkiye**
- **18650 connector makes easier to connect, disconnect, recharge and mount the battery**

18650 connector for each battery:



Payload Power Trade & Selection (3/4)

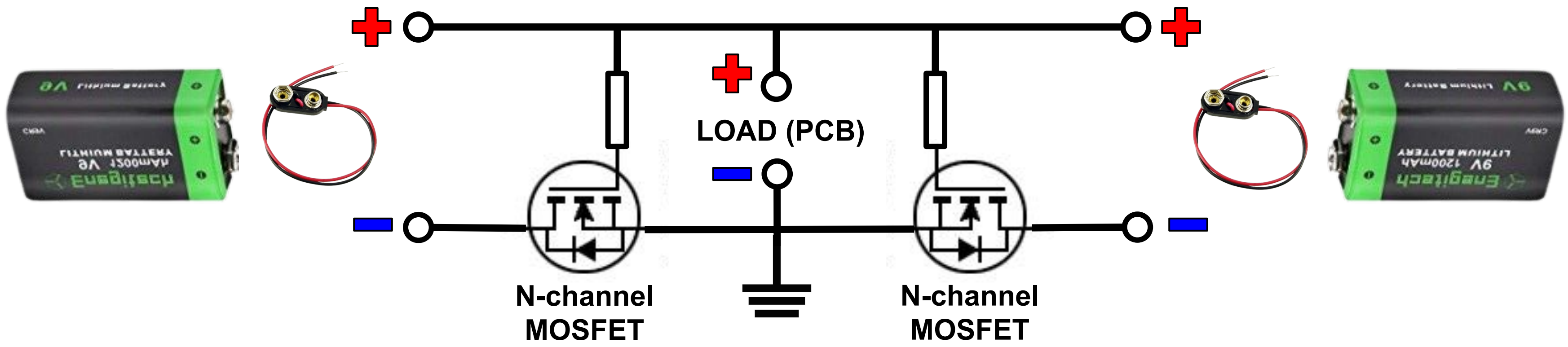
Parallel Connection Protection Circuit (PCPC)



PCPC Explanation: **The body diode of each MOSFET is oriented such that it blocks the current path from one battery to the other. When a battery tries to discharge directly into the other battery due to a voltage difference, the body diode of corresponding MOSFET blocks this reverse current by disconnecting the ground of low voltage side battery. Also, MOSFETs experience nearly zero power loss due to its very low $R_{DS(ON)}$ resistance, whereas traditional diodes result in considerable power losses due to their inevitable voltage drop.**

Claim: This circuit configuration blocks the current flow between one cell to another cell. Therefore, batteries don't damage each other even they have different voltage levels.

Reverse Polarity Protection Circuit (RPPC)



RPPC Explanation: This N-channel MOSFETs provide reverse polarity protection by ensuring that wrongly (reversed polarity) connected batteries cannot deliver power to the load. If a battery is connected in reverse, MOSFET remains "OFF", since V_{GS} voltage of MOSFET is negative in this case.

Claim: This circuit configuration protects the load (PCB) from wrong power connection. Our sensors, actuators and peripherals are also becomes safe against this situation.

Payload Power Budget (1/4)

PCB Power Budget (1/2)

No	Component Name	Quantity	Voltage [V]	Current [mA]	Duty Cycle [%]	Duty Cycle [s]	Power Consumption [Wh]	Source
1	Teensy v4.1	1	5	100	100	7200	1.0000	Datasheet
2	DRV8833 DC Motor Driver	1	9	10	100	7200	0.1800	Datasheet
3	Pololu Micro Geared DC Motor	1	5	150	5	360	0.0750	Datasheet
4	Pololu Magnetic Encoder	1	5	5	5	360	0.0025	Datasheet
5	Adafruit BNO055	1	3.3	12.3	100	7200	0.0812	Datasheet
6	Adafruit GPS	1	3.3	20	100	7200	0.1320	Datasheet
7	XBee Pro S2C	1	3.3	120	100	7200	0.7920	Datasheet
8	BMP280	1	3.3	0.0027	100	7200	~0.0000	Datasheet
9	ESP32 Cam (Release)	1	5	140	100	7200	1.4000	Datasheet
10	TCRT5000 IR Sensor	1	5	60	100	7200	0.6000	Datasheet

Payload Power Budget (2/4)

PCB Power Budget (2/2)

No	Component Name	Quantity	Voltage [V]	Current [mA]	Duty Cycle [%]	Duty Cycle [s]	Power Consumption [Wh]	Source
11	US1881 Hall Effect Sensor	2	5	5	100	7200	0.1000	Datasheet
12	Voltage Divider (10kΩ + 2.2kΩ)	1	9	0.7377	100	7200	0.0133	Calculated
13	5V Indicator LED	1	5	13.18	100	7200	0.1318	Calculated
14	3.3V Indicator LED	1	3.3	5.45	100	7200	0.0360	Calculated
						Total [Wh]	**4.5437**	

Ground Camera and Audible Beacon Power Budget

Component Name	Quantity	Voltage [V]	Current [mA]	Duty Cycle [%]	Duty Cycle [s]	Power Consumption [Wh]	Source
ESP32 Cam (Ground)	1	3.7	140	100	7200	**1.0360**	Datasheet
Audible Beacon	1	3.7	12	100	7200	**0.0888**	Datasheet

Payload Power Budget (3/4)

PCB Power Budget Result	
Total Power Consumption [Wh]	Calculated as **4.5437** Wh from the table.
Total Available Capacity [Wh]	We use two 9V 1200mAh batteries in parallel. Total Capacity = 2 x 9V x 1.2Ah = **21.6 Wh**
Total Efficient Capacity [Wh]	Efficiency is taken as 70%, resulting: Efficient Capacity = 21.6 Wh x 0.5 = **15.12 Wh**
Margin [Wh]	Assuming that all datasheet, estimated and calculation parameters of the PCB components also have 10% error, resulting: Total Consumption with Error = 4.5437 Wh x 1.1 = **4.9981 Wh** Margin = Efficient Capacity (Wh) - Total Consumption with Error (Wh) Margin = 15.12 Wh - 4.9981 Wh = **10.1219 Wh**
Run Time [h]	Run time = 15.12 / 4.9981 = **3.03 hours**

Claim: PCB can operate for a minimum of two hours when integrated into the rocket.

Payload Power Budget (4/4)

	Ground Camera Power Budget Result	Audio Beacon Power Budget Result
Total Power Consumption [Wh]	Calculated as **1.0360** Wh from the table.	Calculated as **0.0888** Wh from the table.
Total Available Capacity [Wh]	We use a 3.7V 4800mAh battery. Total Capacity = 3.7V x 4.8Ah = **17.76 Wh**	We use a 3.7V 4800mAh battery. Total Capacity = 3.7V x 4.8Ah = **17.76 Wh**
Total Efficient Capacity [Wh]	Efficiency is taken as 33%, resulting: Efficient Capacity = 17.76 Wh x 0.33 = **5.86 Wh**	Efficiency is taken as 33%, resulting: Efficient Capacity = 17.76 Wh x 0.33 = **5.86 Wh**
Margin [Wh]	Assuming that parameters of the ground camera also have 10% error, resulting: Total Consumption with Error = 1.0360 Wh x 1.1 = **1.1396 Wh** Margin = Efficient Capacity (Wh) - Total Consumption with Error (Wh) Margin = 5.86 Wh - 1.1396 Wh = **4.7204 Wh**	Assuming that parameters of the audio beacon also have 10% error, resulting: Total Consumption with Error = 0.0888 Wh x 1.1 = **0.0977 Wh** Margin = Efficient Capacity (Wh) - Total Consumption with Error (Wh) Margin = 5.86 Wh - 0.0977 Wh = **5.7623 Wh**
Run Time [h]	Run time = 5.86 / 1.1396 = **5.14 hours**	Run time = 5.86 / 0.0977 = **59.98 hours**

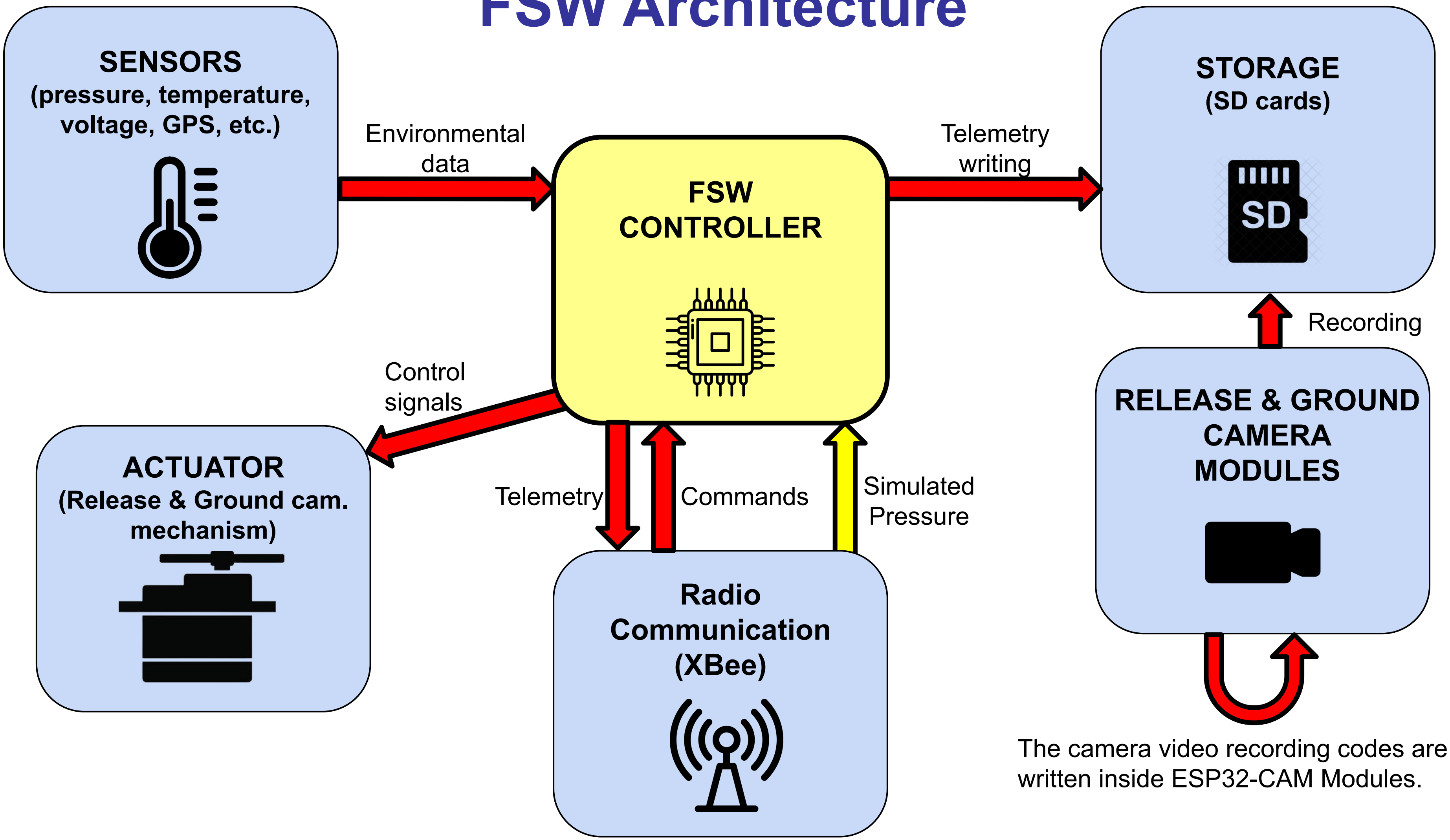
Claim: Ground camera and audio beacon can operate for a minimum of two hours when integrated into the rocket.

Flight Software (FSW) Design

Ulas UCRAK

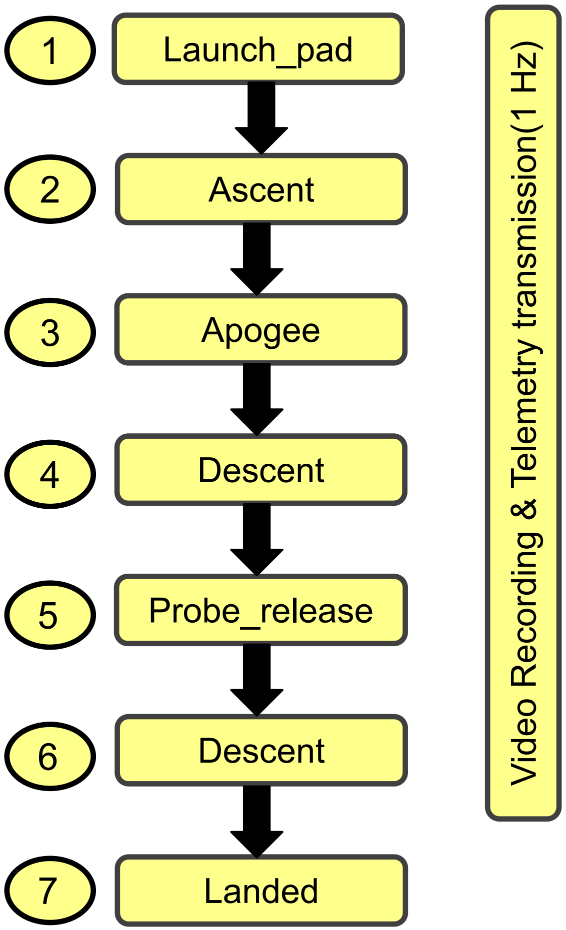
FSW Overview (1/3)

FSW Architecture



FSW Overview (2/3)

Software Flow



1	The software will initialize the system, check for errors, and prepare for launch and telemetry transmission will start at a 1 Hz after CXON command received.	After payload release, the first video camera will be recording the separation of the payload from the container & auto-gyro functioning.The second camera will be pointing downward at 45 degrees from nadir & oriented north without spinning.
2	The Cansat shall collect sensor data during ascent and transmit the data to a ground station at a 1 Hz rate.	
3	The container with the payload shall deploy from the rocket when the rocket reaches peak altitude and the rocket motor ejection forces a separation.	
4	The container with the payload shall descend at a rate of no more than 20 meters/second using a parachute that automatically deploys at separation.	
5	At 75% peak altitude, the payload shall separate from the container and descend using an auto-gyro descent control system until landing.	
6	The descent rate shall be 5 meters/second.	
7	Probe landed and telemetry stopped	

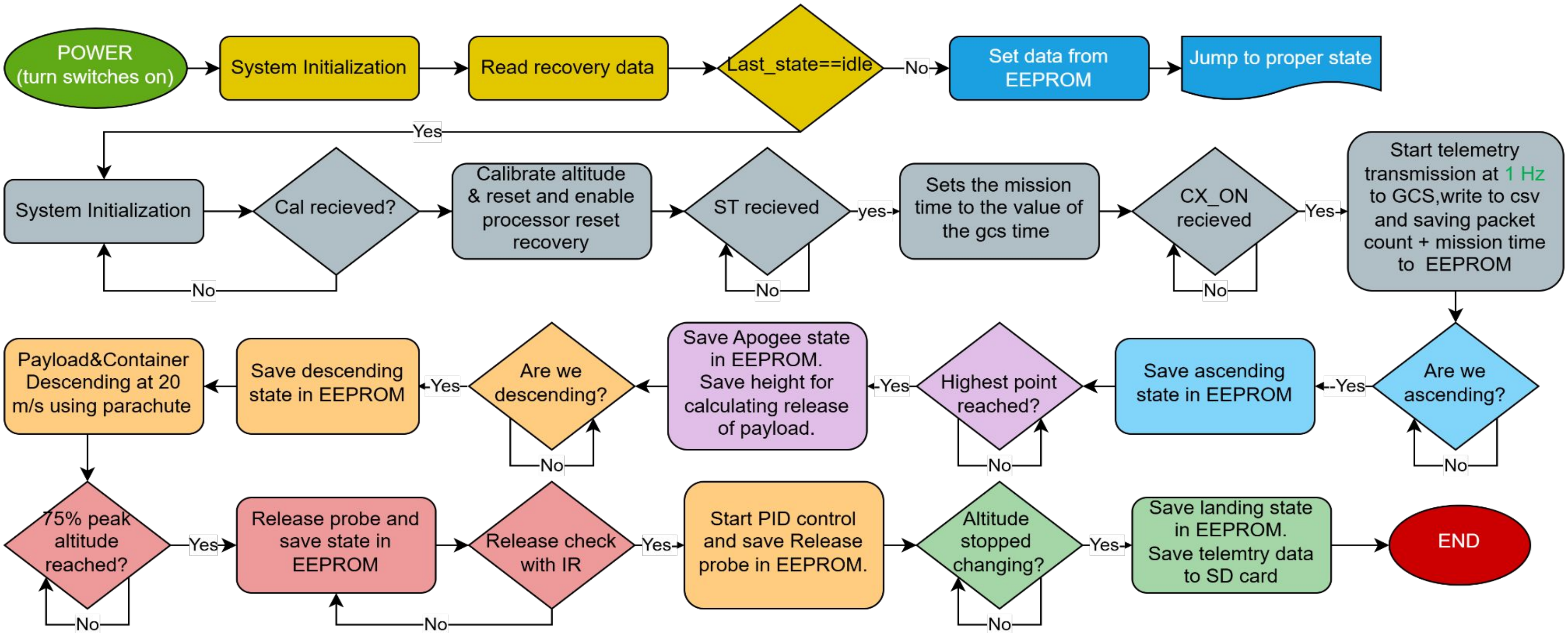
FSW Overview (3/3)

FSW Tasks

- Initializing sensors, modules, and power systems; starting timer and resetting packet counter, calibrating sensors and verifying system health.
- Maintaining ground station connection, collecting and analyzing commands from Ground Station.
- Recording raw sensor values and translating them to standardized units
- Getting sensor data from payload and sending it to the Ground Station.
- Swapping pressure data for received values in simulation mode.
- Transmitting telemetry data to Ground Station and writing telemetry data on SD card at 1 HZ.
- Controlling the deployment from rocket at apogee.
- Controlling the release of probe at %75 peak altitude.
- Controlling ground camera mechanism PID.
- Detecting landing.
- Implementing recovery protocols, restore timer and states after resets/power interruptions.

Programming Language	Development Environment
C++	Arduino IDE Teensyduino

Payload FSW State Diagram (1/2)



Colors represents states:
LAUNCH_PAD( ), ASCENT( ), APOGEE( ), DESCENT( ), PROBE_RELEASE( ), LANDED( )

Sampling of Sensors	Communications	Extra data storage
Data is sampled from the sensors at a rate of 1Hz.	Telemetry is transmitted over XBee at a rate of 1Hz.	Data is saved to the SD Card at a rate of 1Hz.

Payload FSW State Diagram (2/2)

- Ascent and descent checking is done by comparing consecutive sensor readings of air pressure and confirming descent transitions at 75% peak altitude.
- Sensor baseline values will be set to their launchpad values. Time will be manually set to UTC time within one second before launch.
- FSW polls for commands **(telemetry and simulation mode activation)** from GCS in all states
- All telemetry data, including auto-gyro rotation rate, is obtained from sensors at a rate of **1 Hz** and saved to the SD Card.
- Data is sent to GCS at **1 Hz**.
- Power management is keep tracked with the help of voltage divider and plotting on GCS..

Possible Reason for Reset

If a watchdog timer error or momentary power loss occurs, FSW might reset itself. A reset will correct any software error and restore the last state from EEPROM.

If reset operation is done, microcontroller gets data from EEPROM. This data is used for recovery.

Reset Control and Recovering

For System Recovery, we are saving the following data in Teensy's non-volatile memory (EEPROM) :

● **prevState:** The last known software state the processor has been in.

● **packetCount:** The running count of the packets transmitted throughout the mission.

●**missionTime:** The time passed throughout the entire mission.

Simulation Mode Software

The Ground Station receives simulated barometric pressure values from a .csv file provided by the competition and transmits them to the Cansat. These values are then used for altitude calculations and flight software logic in place of actual pressure sensor readings. To prevent unintentional activation of simulation mode, ground station transmits two commands (SIM ENABLE and SIM ACTIVATE) to the payload.

SIM - Simulation Mode Control Commands

CMD,3133,SIM,ENABLE	Enables the simulation mode.
CMD,3133,SIM,ACTIVATE	Activates the simulation mode.
CMD,3133,SIM,DISABLE	Both disables and deactivates the simulation mode.

SIMP - Simulated Pressure Data

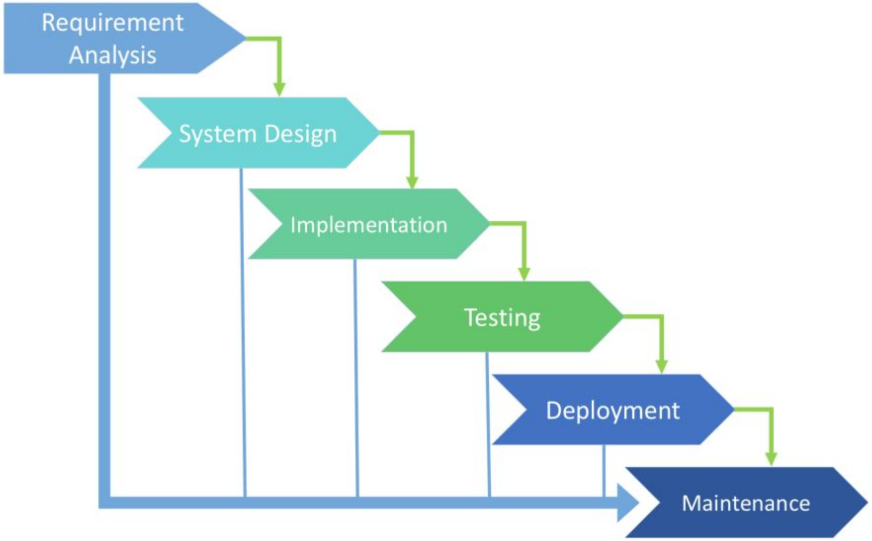
CMD,3133,SIMP,<PRESSURE>	Provides a simulated pressure reading to the payload.

Simulation Mode:

- Probe must receive both SIM_ENABLE and SIM_ACTIVATE to start Sim mode.
- Sim mode will transmit pressure data at rate of 1Hz to the probe.
- The probe will read all other data except pressure data.
- The probe will determine the flight state and the send telemetry packets throughout Sim Mode.

Avoiding Late Software Development

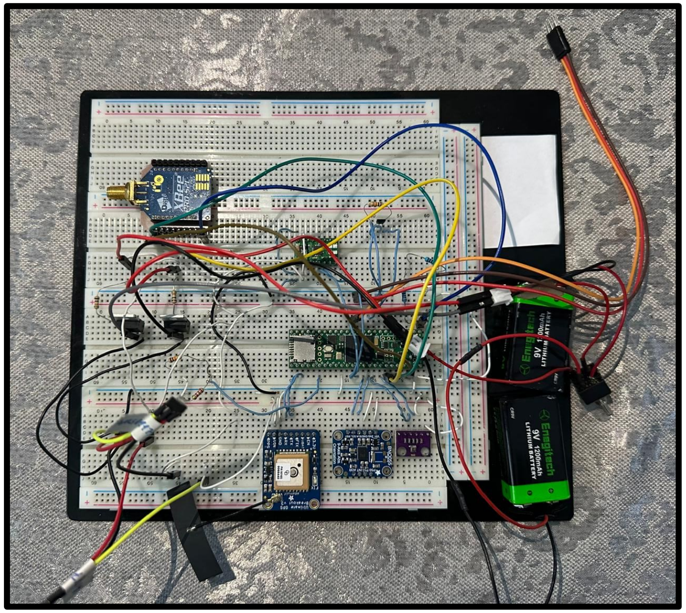
Using Iterative and Incremental development methodology, we will resolve the risk of late software development. Through this method the project will contain different sprints. For each sprint, there will be a process of testing and verification before proceeding to the next sprint. The efficiency of this method was proved in previous years.



Software Development Plan(2/2)

Prototyping and Prototyping Environments

A prototype will be substantiated through a breadboard by combining all components on it. After this operation, the circuit board will be printed on PCB. Fake transition values will be used in testing and running the software.



Test Methodology

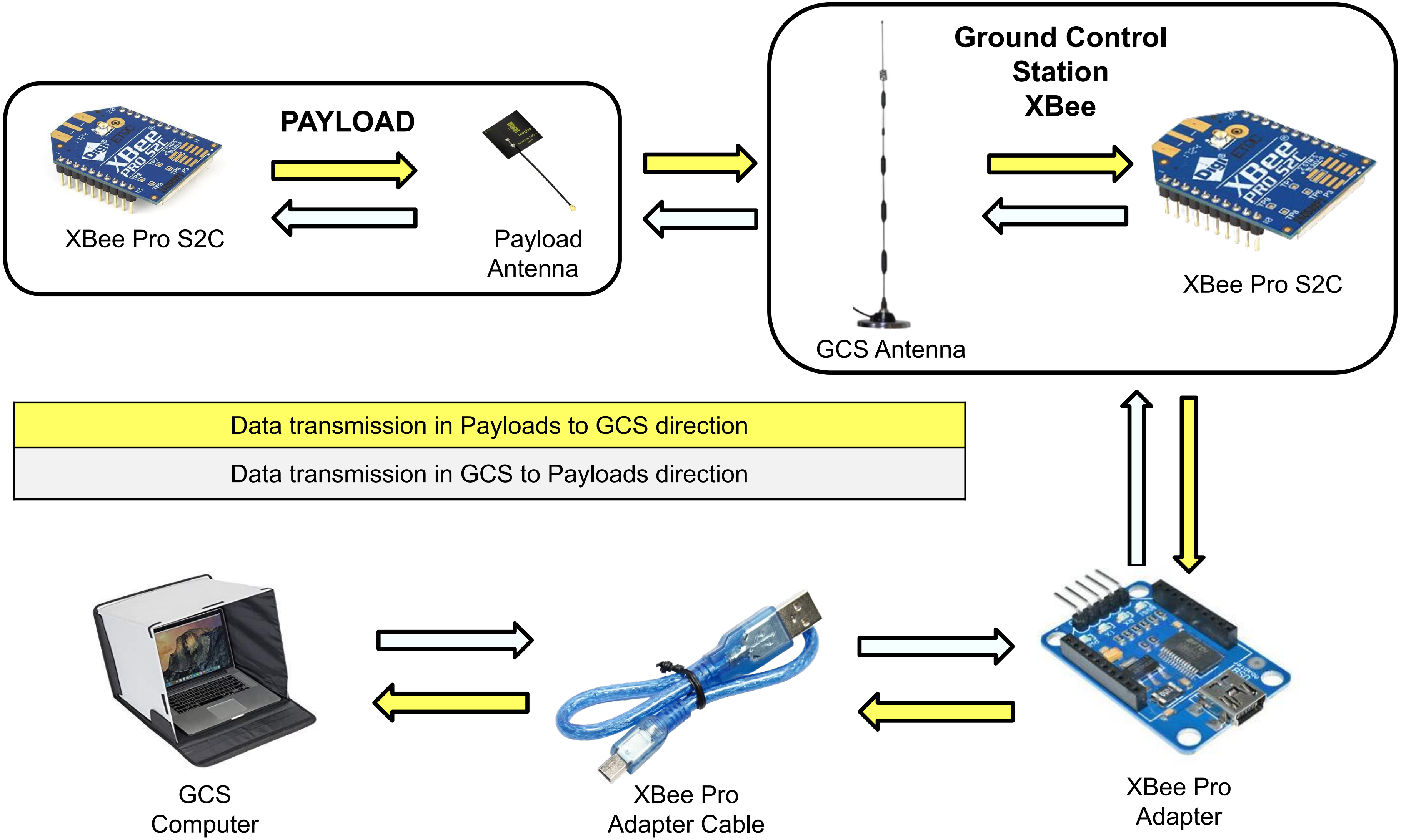
There will be an individual testing process for each subsystem when each iteration and sprint is over. After this procedure is done, compliance tests will be applied to control whether all components work together correctly or not. Types of tests at this phase can be exemplified as free-fall drop test, power test, communication test.

Development Team: Ulas Ucrak

Ground Control System (GCS) Design

Ulas UCRAK

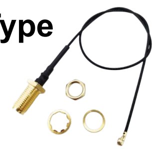
GCS Overview



GCS Design

GCS Antenna

Connection Type
Antenna connected to XBee with N - Female to U.FL cable.



XBee Pro S2C

Connection Type
XBee module will be connected to XBee adapter with slot.

GCS Computer

Specifications	
Battery	Can operate more than 2 hours.
Overheating Precautions	Laptop will be placed under the sun hood External cooler under the laptop.
Auto Update Precautions	Internet connection will be turned off. Auto update function will be disabled from update center before the launch.

GCS Antenna Trade & Selection (1/5)

Model	Connector Type	Beam Width [H°/V°]	Gain [dBi]	Length [mm]	Antenna Radiation Pattern	Frequency Range [GHz]	Cost [$]
LTE-Q7027I22	**SMA Male**	**360 - 6**	**15**	**895**	**Omni directional**	**2.4 - 2.5**	**22.79**
MRTK-D24Y16	N Female	36 - 35	16	650	Vertical	2.4 - 2.483	65.70

Selection Criteria: **XBee operates at 2.4 GHz and the frequency range of the antenna we selected is compatible with XBee.**

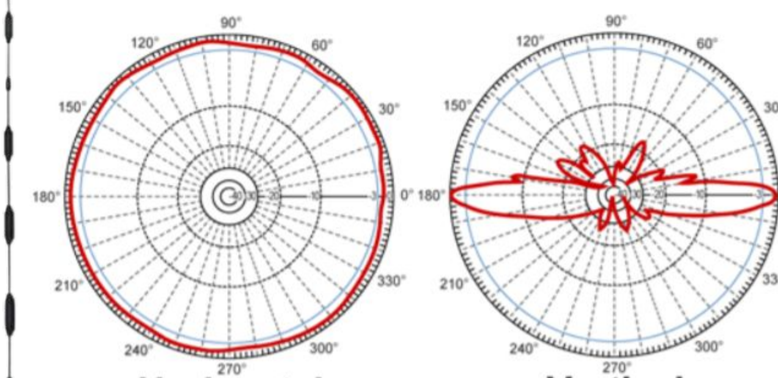
LTE-Q7027I22

- **Can receive signals from all directions**
- **Has a wide communication range according to the radiation pattern**
- **High dB**
- **Better beam width**

SELECTED

Antenna

Radiation Patterns



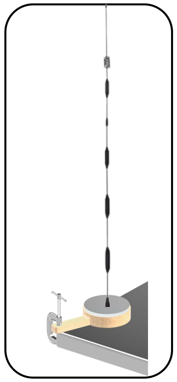
Horizontal　　Vertical

GCS Antenna Trade & Selection (2/5)

MOUNTING ANTENNA DESIGN

Design	Type	Design	Mass [kg]	Price [$]
Design 1	**3D Printed**	**Handheld**	**0.126**	**1.3**
Design 2	Aluminum sheet with a clamp	Tabletop	≥1	12

Design 1: 3D Printed Handheld Antenna Design



Design 2: Aluminum Sheet with a Clamp Design

Handheld 3D Printed Design

- **Lower cost**
- **Easy to operate**
- **Small and lightweight, therefore easy to transport**

GCS Antenna Trade & Selection (3/5)

SIMPLE LINK BUDGET EQUATION

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_{M} + G_{RX} - L_{RX}$$

P_{RX}: Received Power	dBm
P_{TX}: Transmitter Power Output	dBm
G_{TX}: Transmitter Antenna Gain	dBi
L_{TX}: Transmitter Feeder and Connector Losses Power	dB
L_{FS}: Path Loss or Free Space Loss	dB
L_{M}: Miscellaneous Signal Propagation Losses	dB
G_{RX}: Receiver Antenna Gain	dBi
L_{RX}: Receiver Feeder and Associated Losses	dB

Distance Link Predictions and Margins:

Maximum predicted link distance = 2 km

- Where is f = 2400 MHz and d = 2 km
  Free-Space Path Loss (L_{FS}) is = 81 dB

- Receiver Sensitivity (XBee Pro S2C) = **-101 dBm**
- Transmitter Output Power = **18 dBm**
- Transmitter Antenna Gain = **5dBi**
- Receiver Antenna Gain = **15 dBi**
- Miscellaneous Signal Propagation Losses = **10 dB** (estimated)
- Receiver Feeder and Associated Losses = **3 dB** (estimated)
- Transmitter Feeder and Connector Losses Power = **1 dB** (estimated)

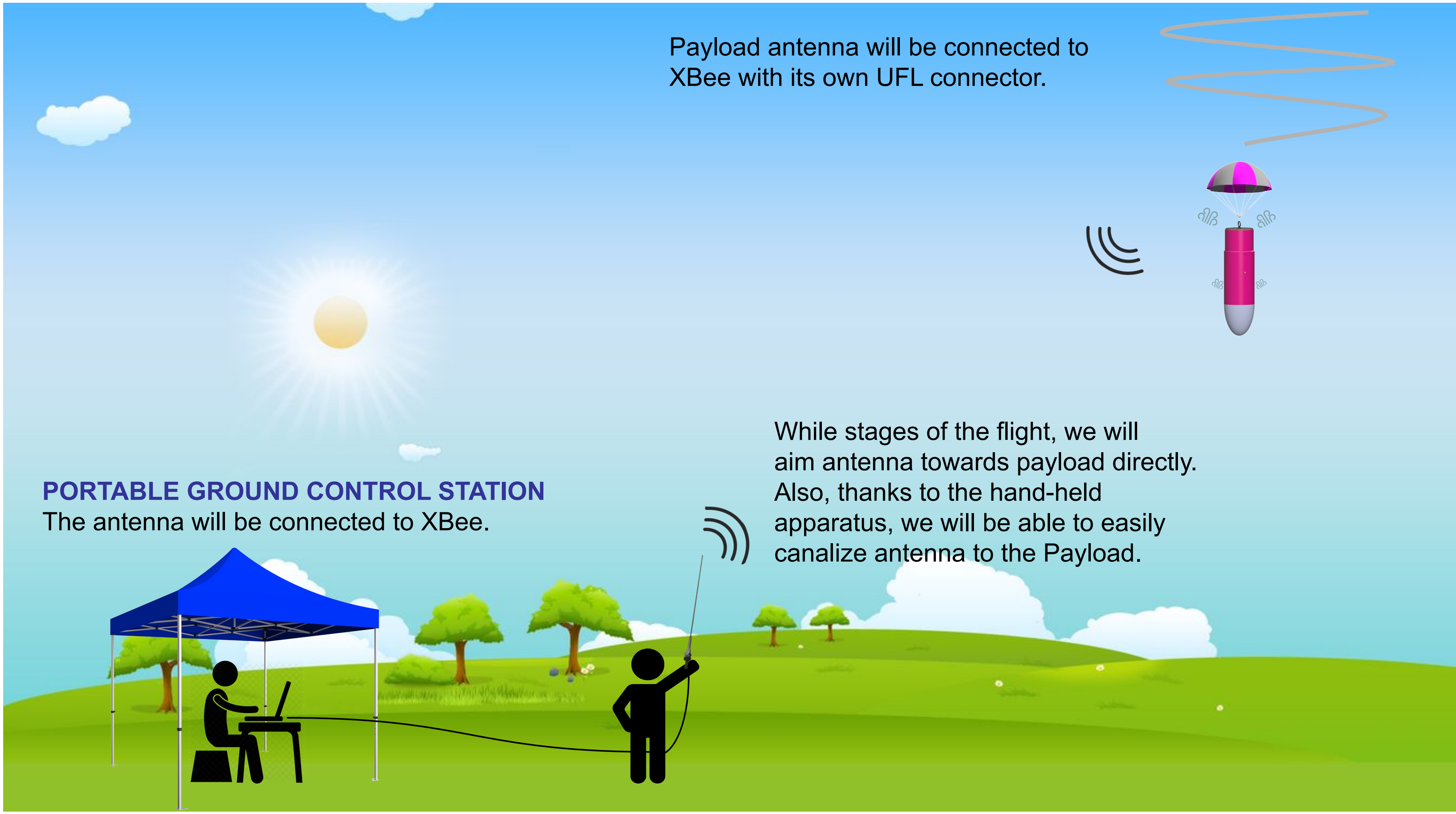
Note:
- Losses other than L_{FS} are estimated because they are not calculated
- Distance value is an estimation

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} = 18 + 5 - 1 - 81 - 10 + 15 - 3 = -57 \text{ dBm}$$

$$P_{RX} = -57 \text{ dBm} > -101 \text{ dBm}$$

Namely; margin of our design is approximately **−44 dBm** which is **reliable**.

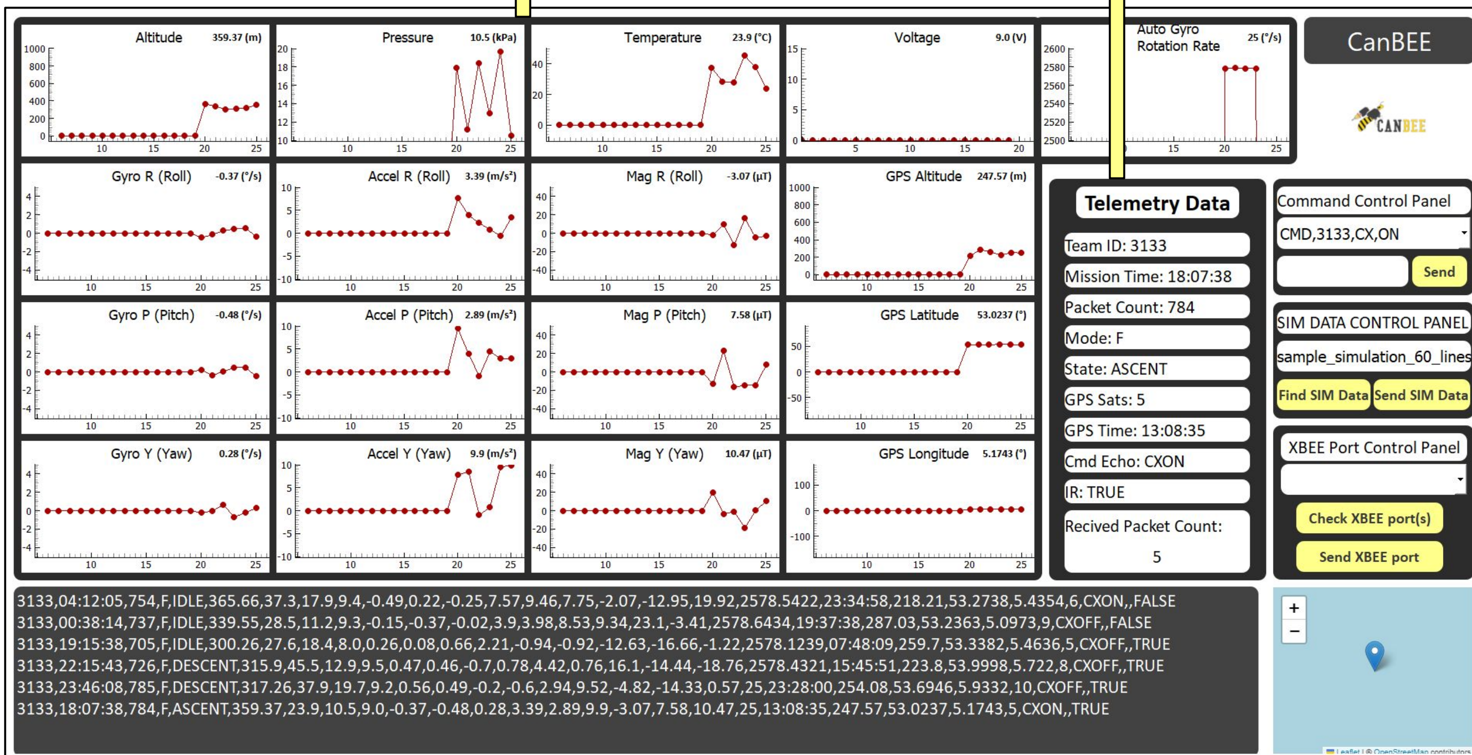
COMMUNICATION SYSTEM DEMONSTRATION



GCS Software (1/3)

Real plotting of the telemetry values

Telemetry data that is not displayed as graph



Let us to select the desired command and send it to payload

Let us to select csv file for Simulation mode

Used to manage communication with XBee devices

Raw telemetry display

GPS data representation on map

GCS Software (2/3)

Commercial Off the Shelf Software Packages Used

- GUI will be created using PyQt5 and Python.
- XCTU will be used to configure, receive data and transmit commands via XBee adapter.

Calibration

- Sensors that need to be calibrated, such as the barometric sensor, will be initialized to zero.
- The payload time will be set to UTC time in one second.
- Data will be transmitted and received after initialization through XBee adapter.

Python is the programming language we're using for the GCS implementation

PyQt library is used for the Graphical User Interface

GCS Software (3/3)

Payload

<TEAM_ID>,<MISSION_TIME>,<PACKET_COUNT>, <MODE>,<STATE>,<ALTITUDE>,<TEMPERATURE>, <PRESSURE>,<VOLTAGE>,<GYRO_R>,<GYRO_P>, <GYRO_Y>,<ACCEL_R>,<ACCEL_P>,<ACCEL_Y>, <MAG_R>,<MAG_P>,<MAG_Y>, <AUTO_GYRO_ROTATION_RATE>,<GPS_TIME>, <GPS_ALTITUDE>,<GPS_LATITUDE>,<GPS_LONGITUDE>, <GPS_SATS>,<CMD_ECHO>,,<IR_STATUS>

GCS to Payload

Payload to GCS

1. If simulation mode is enabled, provided CSV sensor values will be sent to Payload FSW at a 1 Hz rate. Otherwise, there will be no consistent data flow from GCS to Payload direction.
2. Raw Telemetry Data received from XBee Adapter.
3. Raw data will be parsed and converted into an internal representation for real-time graphs.
4. Real-time graphs will have 1 second resolution and show the data in engineering units.
5. The parsed data will be exported to **CSV** format and added to existing **CSV** file.
6. **CSV file(Flight_3133.csv) and video recordings will be presented to the judges.**

CanSat Integration and Test

Arda GARIP

CanSat Integration and Test Overview (1/4)

Goals at PDR

- CanBee members discussed and decided each requirement including the assembly phase. The meetings were made face to face.
- The test are planned to be made at an open field using a drone to pick up the Cansat and physically operate the mission.

Subsystem Level Test

- Requirements that can be tested are identified as which section they belong.
- Components of subsystems are tested individually.
- Each subsystem is tested separately to check integrated subsystems can operate all together without any failure.

INTEGRATION AND TEST OVERVIEW
• MS
• Sensors Subsystem
• DCS
• Electrical Power Subsystem
• Communication Subsystem Design
• Flight Software
• Radio Communication

Integrated Level Test

- Integrated test operation is performed to observe if whole system can operate in common or not.

: Subsystem Level Test
: Integrated Level Test

CanSat System

Sensor
- Sensor Calibrations
- Operable Sensors Test

CDH
- Accurate Data Transfer Test

Radio Communications
- XBee Data Transfer Range and Configuration

EPS
- Voltage Measurement Test
- Current Measurement Test
- Prototype PCB Working Time

Subsystems

FSW
- Algorithm Test
- Simulation Mode Test

MS
- Aerodynamic Test
- Weight Control Test
- Servo and DC Motor Adjustment
- Mechanisms Tests

DCS
- Parachute Deployment Tests
- Auto-gyro Deployment Tests
- Velocity Tests

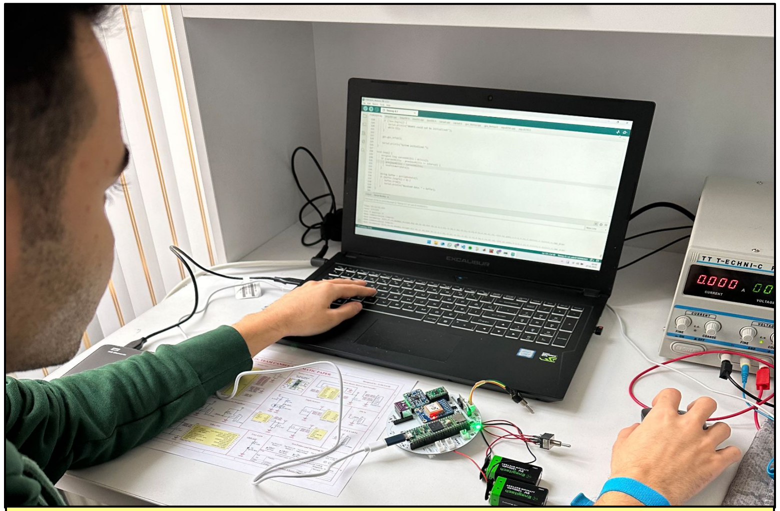
Environmental Test Plan

- Finally, environmental test plan is carried out as vibration test, drop test, thermal test and fit check according to their requirements.

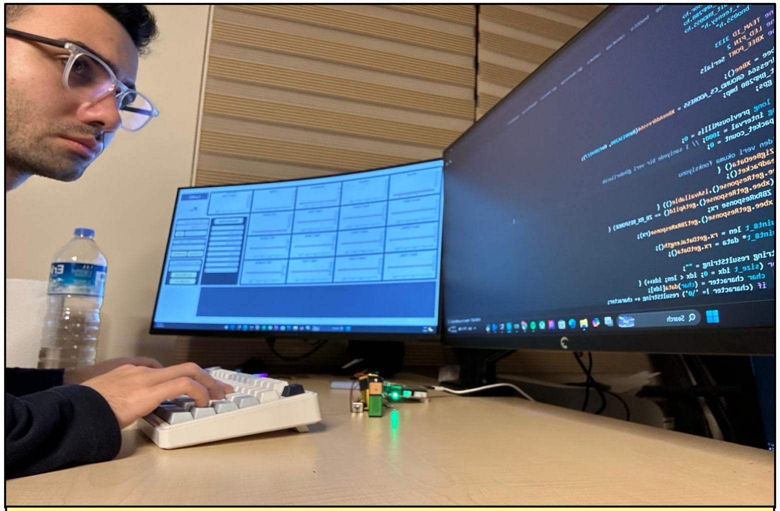
CanSat System	
Drop Test	The test must verify the container, parachute, and payload resistance against the deployment from the rocket.
Fit Check	This test must verify the CanSat dimensions.
Vibration Test	This test must verify the accurate mounting and connections of all components.
Thermal Test	Test must verify the payload can operate accurately up to specified temperatures.
Vacuum Test	This test must verify deployment of payload. The data from pressure sensor data will be used as altitude.

Simulation Test Plans

- Simulation testing will start before the prototypes are completed, making sure each part is tested thoroughly.
- A simulation test will be performed with a prototype PCB.
- Electronics parts that are available for testing, such as communication equipment and sensors, will be stress tested.



Algorithm Test



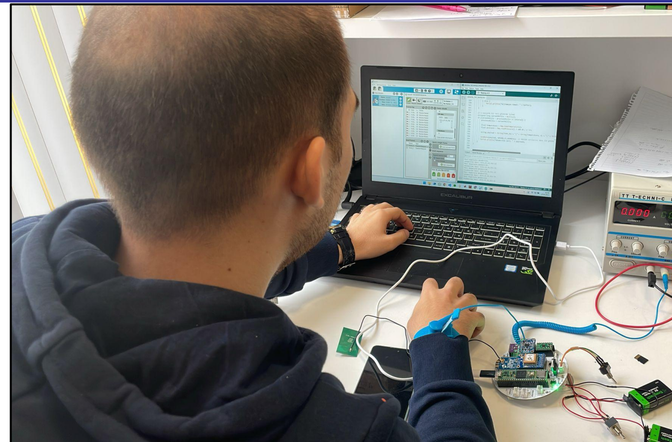
Algorithm Test

Subsystem Level Testing Plan (1/3)

Sensors	
Test	**Description**
Operable Sensors	All sensor are separately checked on breadboard to see whether they are working or not.
Sensor Calibration	All sensors are calibrated by considering a verified source.

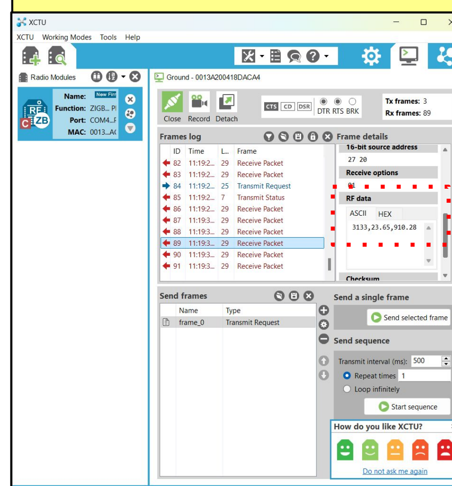
Communication Data Handling (CDH)	
Test	**Description**
Data Transfer Tests	Data transfer speed and accuracy between GCS and CanSat are tested with XCTU and Arduino IDE.

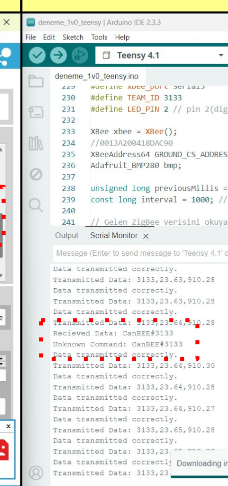
Radio Communications	
Test	**Description**
XBee Range and Configuration Test	XBee module is tested for accurate data transfer over a set distance, with indoor and outdoor trials using XCTU and Arduino IDE.
Signal Level Measurement	The XBee receiver and transmitter signal levels will be measured in XCTU indoors and outdoors using specified antennas.



Data Transfer Tests

GCS	Payload

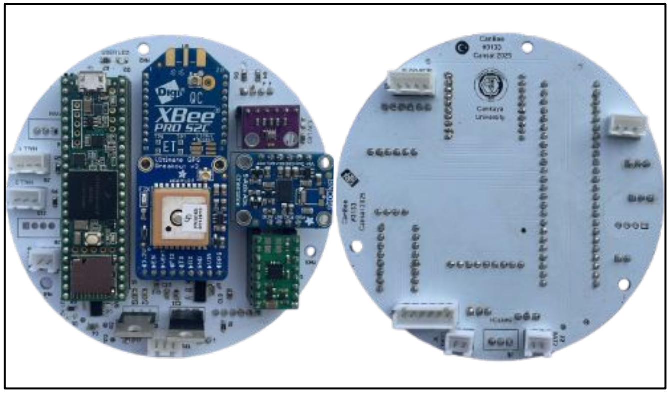




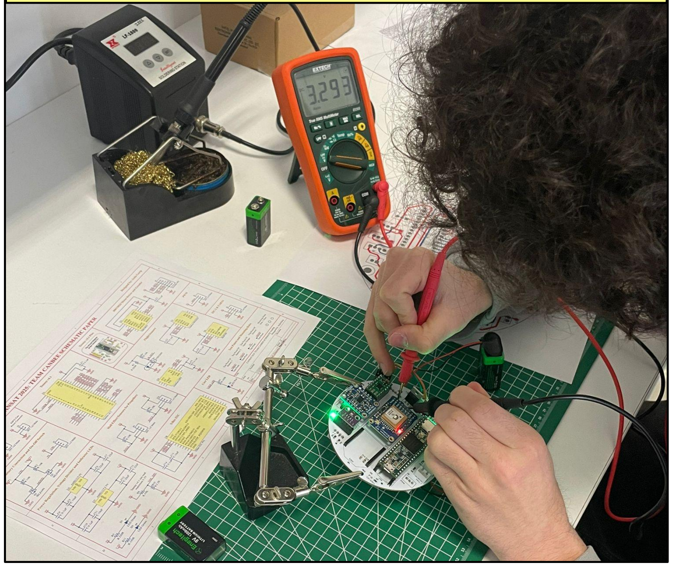
Subsystem Level Testing Plan (2/3)

Electrical Power Subsystem (EPS)	
Test	**Description**
Voltage Measurement	Batteries is connected to components and voltage values are measured with multimeter.
Current Measurement	Operation currents are checked with reference to EPS calculations.
Prototype PCB Working Time	Batteries and all sensors are connected to the prototype PCB, and run time of this PCB will be observed.

Flight Software (FSW)	
Test	**Description**
Algorithm Test	Prototype will run with realistic fake values and phases will be observed.
Simulation Mode Test	Simulation mode computation will be compared with real sensor values.

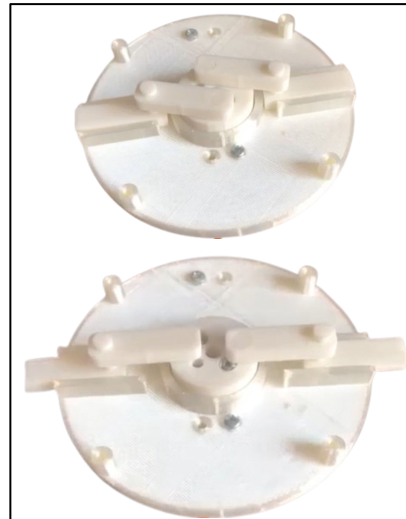


Voltage Measurement



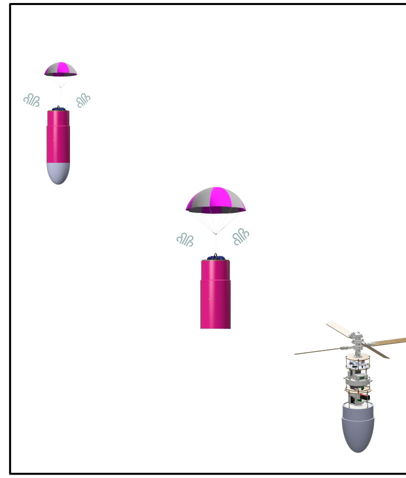
Subsystem Level Testing Plan (3/3)

Mechanical	
Test	**Description**
Aerodynamic Test	Container and parachute design is inspected for aerodynamic flow by releasing from drone.
Mass Control Test	Total mass is checked according to the requirements by measuring mass using precision scale.
Servo & DC Motor Adjustment	Servo & DC rotation calibration will be done by conducting operational test many times.



Release Mechanism Servo Motor Calibration

Descent Control	
Test	**Description**
Parachute Deployment Test	Parachute deployment mechanism is tested during descent process by releasing from drone.
Auto-gyro Test	Auto-gyro descending test of the propellers, opening and rotating passively by releasing from drone.
Velocity Test	CanSat's descent velocity will be checked for parachutes and aerobraking by releasing from drone.



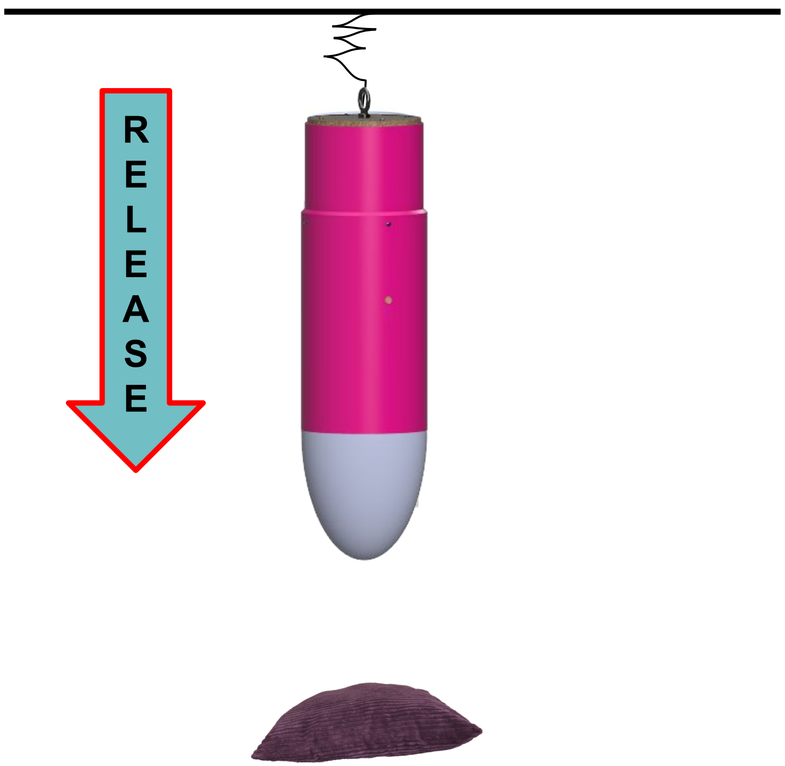
Integrated Level Functional Test Plan

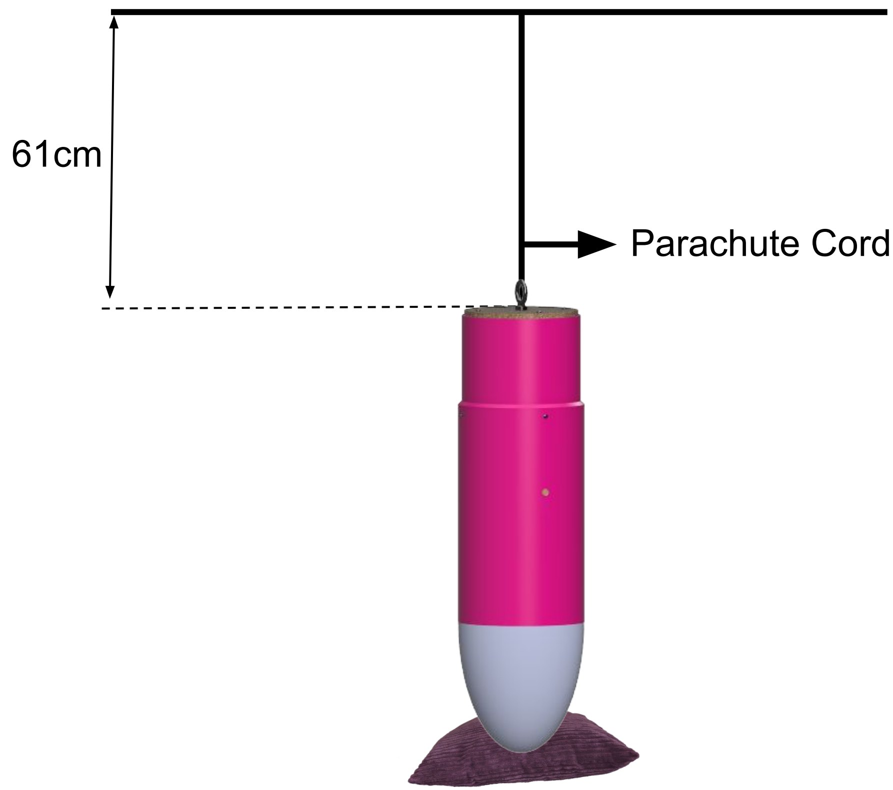
- Even though the subsystems operate without a malfunction at a steady state, Integrated level test is related with problems may occur between subsystems due to interaction.
- **CanSat is released with a drone at 750m height and free fall test is operated. During the descent, all test can be conducted.**

Descent Testing	Communications	Mechanisms	Deployment
• Propeller test. If it works at the desired speeds using an axial fan. • Aerobraking velocity will be observed. • Descent rate will be tested after all the systems such as parachutes and release mechanisms are deployed. • Container deployment will be tested with a fan to check if the airflow is enough.	• XBee range will be tested. It should be able to communicate with ground station at appropriate distance. • Frequency and data processing throughput will be tested. (Payload XBee must have 1Hz frequency. GCS should have enough processing throughput to handle the data.) • Signal Quality with antenna will be tested.	• Release mechanism will be tested if it releases payload or not. • Camera mechanism will be tested. Does it find the north or not? • Propeller Deployment Test. Does the propeller open after separation or not?	• Parachute deployment will be tested. The parachute should open smoothly, they shouldn’t fold after deployment at certain altitudes. • Release mechanism parts and payload deployments will be tested. Mechanism parts and the payload should not be stuck in any structure. • Payload should be released at %75 peak altitude.

Drop Test:

One side of the cord will be attached to the fixed surface and other cord will be attached to the parachute. Drop test will be processed with 1/8 thick Kevlar cord to verify if telemetry is still working and test the response against 30Gs of shock system after releasing operation.





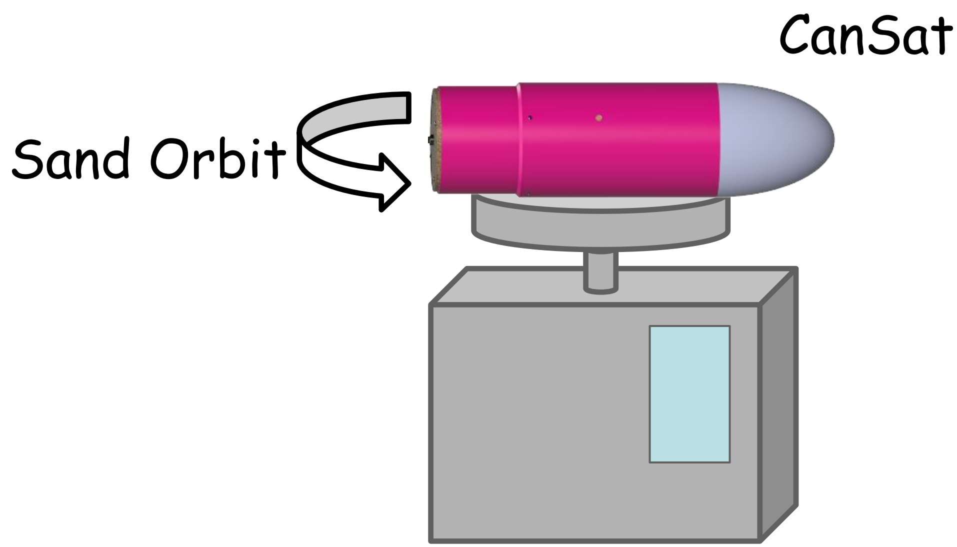
Environmental Test Plan (2/5)

Thermal Test:

- The CanSat will be heated up to 60˚C in a thermal chamber and it will be kept hotter than 55 ˚C.
- Components are going to be examined to verify that they continue to function under thermal exposure for two hours when they are still hot.
- Epoxy joints or components will be controlled.

Vibration Test:

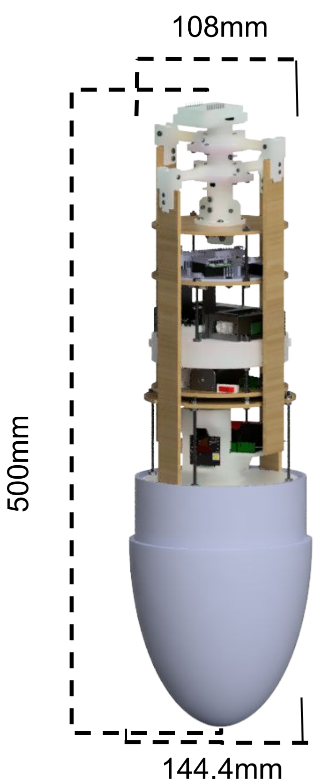
Components and connections substantiality will be verified during vibration test with an orbit sander. It shakes the CanSat around with 13,000 opm. Total test time will be adjusted as one minute. Accelerometer data will be checked while sander is at highest Speed for 5 seconds. This process will be repeated 4 times. Test will be carried out at the university laboratory in case of any hazardous event .

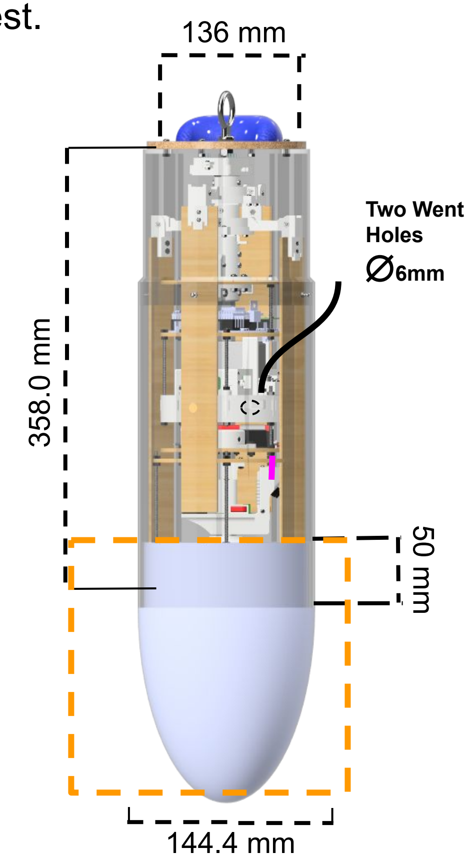


Environmental Test Plan (4/5)

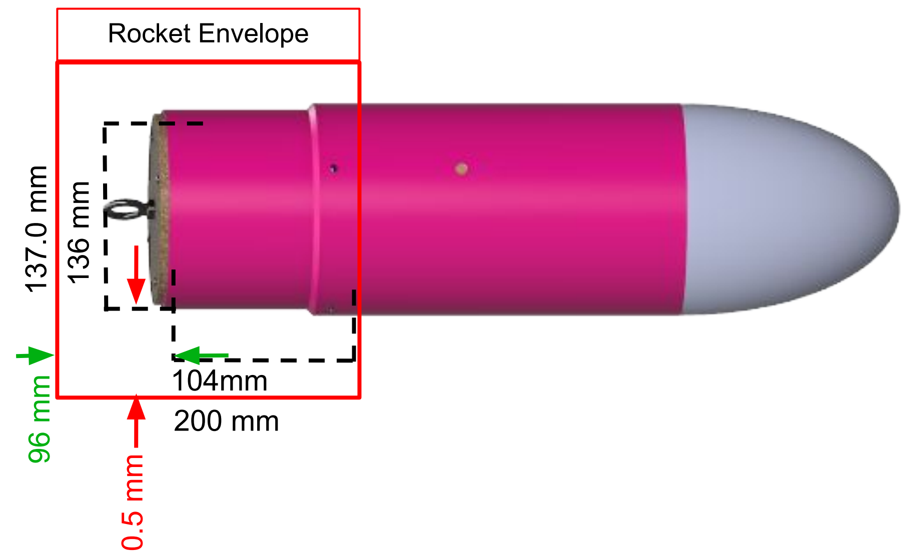
Fit Check

- CanSat container sizes will be manufactured with respect to payload sizes in university laboratory.
- Payload will be placed into the container and will be inspected along the test.





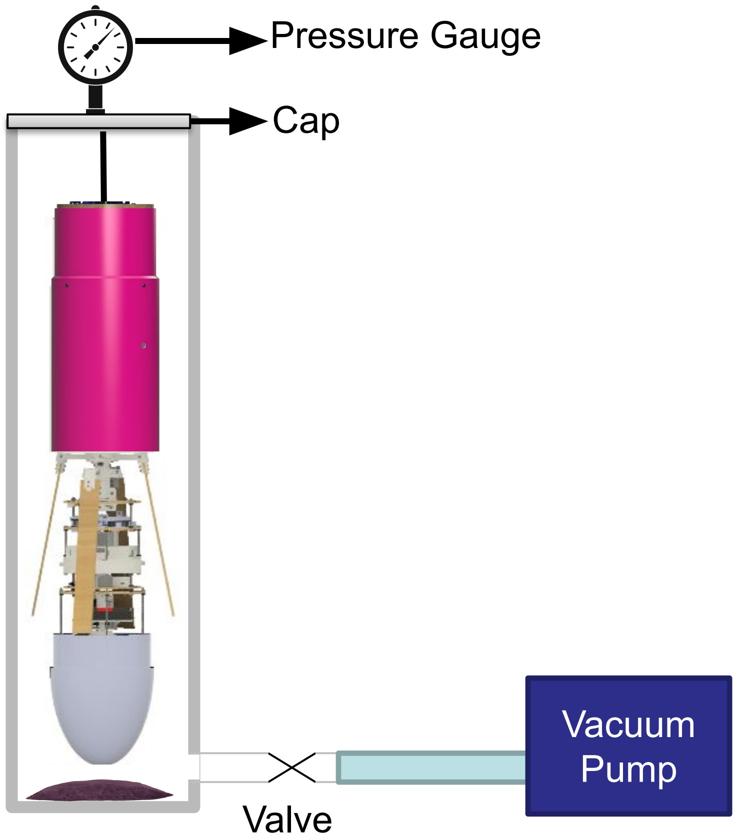
- In order to ensure easy deployment from the rocket this test will be conducted.
- The CanSat will be placed into the container and the container will be turned downwards. Cansat will fall on a surface covered by pillows.
- A pipe the size of a rocket envelope will be produced and the dimensions will be tested.



Environmental Test Plan (5/5)

Vacuum Test:

- The vacuum test will be done at the laboratory of the university.
- Sealed vacuum chamber of the university will be used.
- A vacuum pump will be used to evacuate the air of the chamber from the valve.
- Pressure Gauge will be used to verify the data coming from the pressure sensors of the CanSat.



Simulation Test Plan

- We will start simulation tests as soon as possible. The data obtained from electronic parts or software parts that are not yet ready will be substituted with realistic random data. Dummy interfaces will be created, if necessary.

Parts that are tested during the simulations:

- Flight Software,
- Ground Control Software,
- XBee Communication Equipment for GCS and Payload.
- Other electronic parts that are controlled by the FSW during flight.

Implementation

- FSW has one procedure that requests the pressure sensor data from the sensor. After the pressure value is obtained, other operations such as altitude calculation are done according to this information.
- Said procedure should be trivially editable to return the simulated data instead of the actual data obtained from the sensor.

Mission Operations & Analysis

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Overview of Mission Sequence of Events (1/4)

1) Team Arrival

- Team Arrival to the launch site

2) Setting Up GCS and Antenna

- Prepare Ground Control Station
- Assemble the GCS antenna

3) CanSat Assembly & Test

- Battery Status check
- Assemble of all electronics into the payload
- Assemble all mechanical components of payload

4) Power Turned On & Calibration of Sensors

- Open all the power switches
- Calibration of all the sensors
- Check all mechanisms
- Check for buzzer operation

5) Mass & Dimension Controls by Staff

- Bringing the integrated Cansat module to the staff for mass and measurement control

6) Container Flight Software Telemetry Check

- Check the payload antenna, telemetry module and flight software are ready for launch

7) CanSat Integrated into Rocket

- Stow configuration test of payload into the container for launch
- Place the Cansat to the Rocket for the launch

8) Launch

- Launch of Cansat unit

Overview of Mission Sequence of Events (2/4)

9) Payload Flight Software Collects and Saves Data

- Collected data from sensor saves data inside local memory and SD card during flight
- Send collected data to the GCS in given telemetry format during flight

10) Payload Released

- Payload will be released from container at 75% at the peak altitude

11) Descent Completed

- Descent of payload and container completed.

12) Telemetry OFF

- Telemetry will be "OFF" autonomously when descent of payload completed

13) Recovery Team Retrieves Payload & Container

- The recovery crew get back payload and container with help of GPS location and audio beacon.

14) Handing Over the SD Card

- SD Card is removed to hand over to staff

15) Data Check

- Data will be analyzed and plotted to graph for the PFR presentation

16) Preparations for the PFR

- Preparation of collected data and recorded video for PFR presentation

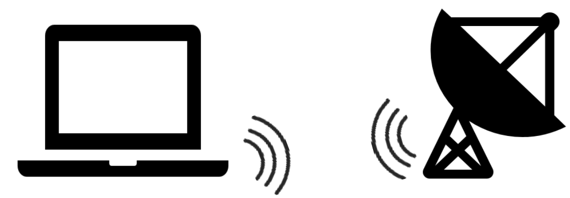
Team Member Roles & Responsibilities

- **Mission Control Officer:**
  Alper Artuc (AA)
- **Ground Station Crew:**
  Ulas Ucrak (UU)
- **Recovery Crew:**
  Berke Ozbay (BO), Arda Garip (AG)
- **CanSat Crew:**
  Ahsen Nisa Koroglu (ANK), Nisan Begum Gencel (NBG),
  Ferhat Coban (FC), Huseyin Kaan Ozpinar (HKO),
  Sami Berkay Yucedag (SBY), Umut Eray Acikgoz (UEA)

Overview of Mission Sequence of Events (4/4)

Ground Control System setup consists of 4 main items:

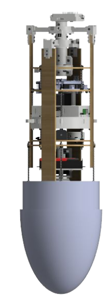
- Computer with 3 hours battery
- XBee adapter
- XBee telemetry sensor
- Antenna



✔ Final tests of the payload and containers going to be completed and CanSat unit is assembled before putting it into the rocket.

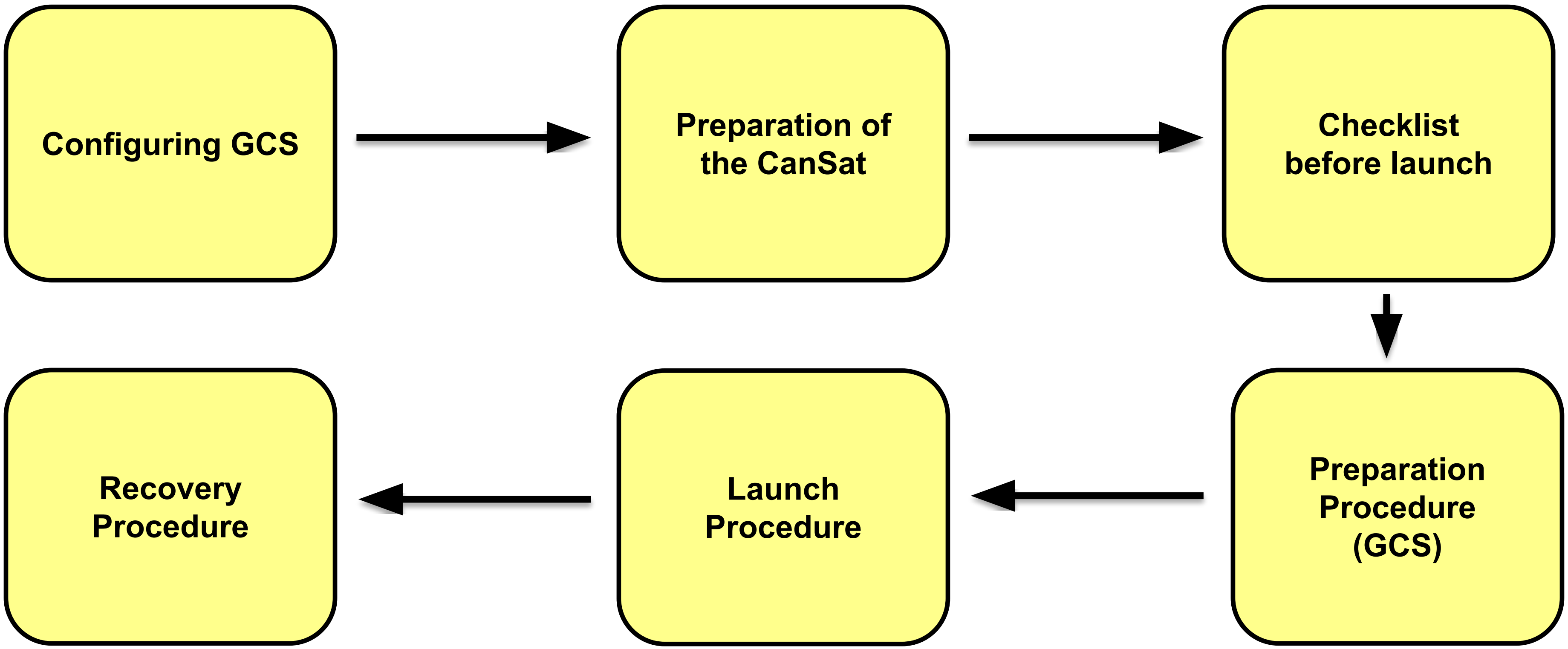
✔ Telemetry data file will be delivered to judges with SD card.

Container

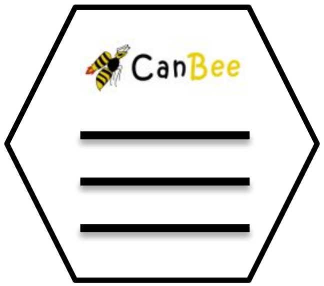


Payload

Mission Operations Manual Development Plan



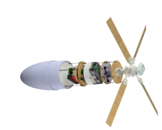
- This checklist will be ready according to experiences that we had during the tests. So, we will add the problems detected to the checklist and we will check these before launch.



A sticker that indicates team leader name, team number, contact details and email address will be placed on the payload and container.

Visible Components Selected Color:
Fluorescent Pink

- The recovery crew will contain members in order to get back payload and container.
- Parachutes, payload and container body will be painted in an easily detectable color; **pink.**
- Container will has a **loud** buzzer of 90 dB.
- GPS output will be used to find location



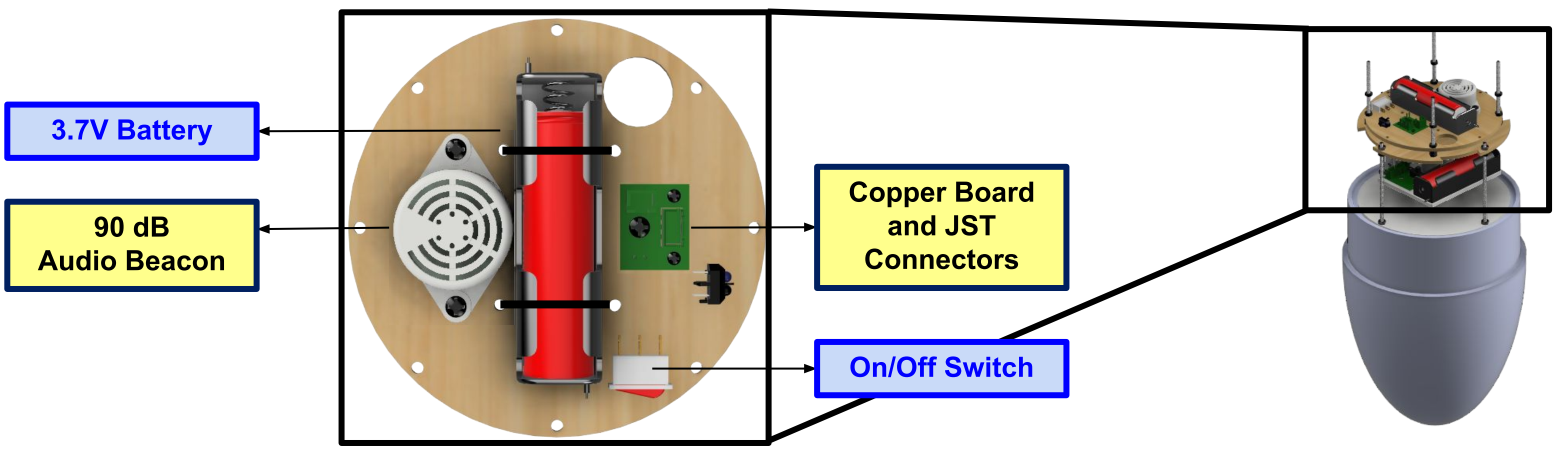
CanSat Beacon Design

- Audio beacon has its own separated 3.7V battery.
- Audio beacon has an easy accessible on/off switch.
- Audio beacon is totally separated from electronics.
- A copper board is designed and JST connectors is placed to ensure the power and switch connection.
- 90 dB audio beacon is selected so that we can easily hear it even at further distances.

Audio Beacon Power Budget

Component Name	Quantity	Voltage [V]	Current [mA]	Duty Cycle [%]	Duty Cycle [s]	Power Consumption [Wh]	Source
Audio Beacon	1	3.7	12	100	7200	**0.0888**	Datasheet

- Audio beacon can operate at least 2 hours, as shown in the slide “Payload Power Budget (4/4)”.



Requirements Compliance

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Requirements Compliance Overview

- We designed the payload and container by taking the competition guide in to consideration.
- There are components that we have designed for now but need to test in terms of mechanical and descent subsystem.
- **Considering this our design meets all competition requirements.**
- The detailed compliance of requirements of our design are given following slides.

Requirements Compliance (1/11)

Operational Requirements (1/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	25, 26, 27, 68	-
C2	The Cansat container shall be mounted on top of the rocket with the shoulders section inserted in the airframe.	Comply	26, 27, 68	-
C3	The Cansat payload and container shall be deployed from rocket when the rocket motor ejection charge fires.	Comply	56	-
C4	After deployment, the Cansat payload and container shall descend at 20 meters/second using a parachute that automatically deploys. Error is +/-3 m/s.	Partial	24, 25, 40	Will be tested.
C5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	24, 25, 136, 138	-
C6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	24, 25, 136, 138	-
C7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Partial	24, 25, 55	Will be tested.
C8	The sensor telemetry shall be transmitted at a 1Hz rate.	Comply	138, 139, 153	
C9	The payload shall record video of the release of the payload from the container and operation of the auto-gyro descent control system.	Comply	24, 25, 58, 136	-

Requirements Compliance (2/11)

Operational Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
C10	A second video camera shall point in the north direction during descent.	Comply	24, 25, 96, 138	-
C11	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	Comply	24, 25, 92, 96	-
C12	The second video camera shall be spin stabilized so the ground view is not rotating in the video.	Comply	36, 92, 96	-
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat electronics.	Comply	176	-
C14	Cost of the Cansat shall be under $1000. Ground support and analysis tools are not included in the cost of the Cansat. Equipment from previous years shall be included in this cost,based on current market value.	Comply	193	

Requirements Compliance (3/11)

Structural Requirements (1/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
S1	The Cansat and container mass shall be 1400 grams +/-10 grams.	Comply	108,109	-
S2	Nose cone shall be symmetrical along the thrust axis.	Comply	68	-
S3	Nose cone radius shall be exactly 72.2 mm.	Comply	68	-
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	68	-
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	68	-
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	68	-
S7	The nose cone height shall be a minimum of 76 mm.	Comply	68	-
S8	Cansat structure must survive 15Gs vibration.	Partial	165	Will be tested.
S9	Cansat shall survive 30G shock.	Partial	163	Will be tested.
S10	The container shoulder length shall be 90 to 120 mm.	Comply	72	-
S11	The container shoulder diameter shall be 136 mm.	Comply	72	-
S12	Above the shoulder, the container diameter shall be 144.4 mm.	Comply	72	-

Requirements Compliance (4/11)

Structural Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
S13	The container wall thickness shall be at least 2 mm.	Comply	72	-
S14	The container length above the shoulder shall be 250 mm+/-5%.	Comply	72	-
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	24, 25	-
S16	The Cansat container can be used to restrain any deployable parts of the Cansat payload but shall allow the Cansat to slide out of the payload section freely.	Comply	26, 27	-
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	98, 99, 100, 101, 102, 103	-
S18	The Cansat container shall meet all dimensions in section F.	Comply	72	-
S19	The Cansat container materials shall meet all requirements in section F.	Comply	72	-
S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Comply	-	Nose cone will not be separated.
S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15Gs acceleration.	Comply	-	Nose cone will not be separated.

Mechanism Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
M1	No pyrotechnical or chemical actuators are allowed.	Comply	77, 86, 93	-
M2	Mechanisms that use heat (e.g.,nichromewire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	Comply	77, 86, 93	-
M3	All mechanisms shall be capable of maintaining their configuration or states underall forces.	Comply	77, 86, 93	-
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	77, 86, 93	-

Requirements Compliance (6/11)

Electrical Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
E1	Lithium polymer batteries are not allowed.	Comply	126, 127	-
E2	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Comply	126, 127	-
E3	Easily accessible power switch is required.	Comply	21, 22, 58, 98, 99, 176	-
E4	Power indicator is required.	Comply	32, 124, 125	-
E5	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	132, 133	-
E6	The audio beacon shall operate on a separate battery.	Comply	176	-
E7	The audio beacon shall have an easily accessible power switch.	Comply	22, 58, 99, 176	-

Requirements Compliance (7/11)

Communications Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	117, 146	-
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	117	-
X3	XBEE radios shall not use broadcast mode.	Comply	117, 120	-
X4	The Cansat shall transmit telemetry once per second.	Comply	117, 120, 136, 137, 138, 139	-
X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	118, 119, 120, 151, 153	-

Requirements Compliance (8/11)

Sensor Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
SN1	Cansat payload shall measure its altitude using air pressure.	Comply	30	-
SN2	Cansat payload shall measure its internal temperature.	Comply	31	-
SN3	Cansat payload shall measure its battery voltage.	Comply	32	-
SN4	Cansat payload shall track its position using GPS.	Comply	33	-
SN5	Cansat payload shall measure its acceleration and rotation rates.	Comply	35	-
SN6	Cansat payload shall measure auto-gyro rotation rate.	Comply	34	-
SN7	Cansat payload shall video record the release of the parachute and deployment of the auto-gyro at 75% peak altitude.	Comply	34, 136, 137, 138, 139, 171	-
SN8	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	Comply	38	-
SN9	The camera video shall be spin stabilized and oriented in the north direction so the view of the ground is not rotating more than 10 degrees either direction.	Comply	36, 92, 96	-
SN10	The video cameras shall record video in color and with minimum resolution of 640x480.	Comply	37, 38	-
SN11	The Cansat shall measure the magnetic field.	Comply	35	-

Requirements Compliance (9/11)

Ground Station Requirements (1/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
G1	The ground station shall command the Cansat to calibrate the altitude to zero when the Cansat is the launch pad prior to launch.	Comply	121,	-
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	117, 120, 153	-
G3	Telemetry shall include mission time with 1 second resolution.	Comply	153	-
G4	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Comply	136,139,152	-
G5	Each team shall develop their own ground station.	Comply	151, 152, 153	-
G6	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	120, 151, 152, 153	-
G7	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	118, 119, 120, 151	-
G8	Teams shall plot each telemetry data field in real time during flight.	Comply	151	-
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	145, 173	-
G10	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	150	-

Requirements Compliance (10/11)

Ground Station Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Comply	121, 122, 140	-
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the Cansat.	Comply	122, 140, 153	-
G13	The ground station shall use a table top or handheld antenna.	Comply	147, 150	-
G14	Because the ground station must be viewed in bright sunlight, the displays shall be designed with that in mind, including using larger fonts (14 point minimum), bold plot traces and axes,and a dark text on light background theme.	Comply	151	-
G15	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	Comply	151	-
G16	The ground station shall be able to activate all mechanisms on command.	Comply	122, 135	-

Requirements Compliance (11/11)

Flight Software Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	138, 139	-
F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	138, 139	-
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	138, 139	-
F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile file.	Comply	140	-
F5	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Comply	140	-
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	140	-
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	122,123	-

Management

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CanSat Budget – Hardware (1/4)

	No	Name	Explanation	Quantity	Cost [$]	Verification Method
ELECTRONICS	1	9V Battery	Battery for Cansat PCB.	2	5.9	Actual
	2	3.7V Battery	Battery for ground camera and separated audio beacon.	2	2.67	Owned
	3	Toggle Switch	On-off control.	1	0.66	Actual
	4	SPDT Switch	On-off and video recording control.	3	0.08	Actual
	5	Voltage Regulator	Same cost for both 3.3V one and 5V one.	2	0.28	Owned
	6	Teensy v4.1	Microcontroller board for Cansat.	1	30.85	Owned
	7	BMP280	Barometric pressure (altitude) and temperature sensor.	1	0.62	Owned
	8	BNO055	9-axis absolute orientation sensor with built-in sensor fusion for precise orientation.	1	36.80	Actual
	9	Adafruit Ultimate GPS Breakout	GPS module providing real-time location.	1	29.95	Owned
	10	XBee S2C Pro	Used to communicate between payload and ground control station.	2	31.32	Owned
	11	DRV8833	H-Bridge motor driver module is used to drive the ground camera's DC motor, so that the ground camera is moved to the north.	1	13.12	Actual
	12	Pololu Micro Geared DC Motor	Move the camera mechanism to the north.	1	17.45	Actual

CanSat Budget – Hardware (2/4)

	No	Name	Explanation	Quantity	Cost [$]	Verification Method
ELECTRONICS	13	Pololu Magnetic Encoder	Detect the position of DC motor and provide a feedback to microcontroller.	1	4.48	Actual
	14	ESP32 Cam	Ground and release camera.	2	9.1	Actual
	15	US1881 Hall Effect Sensor	Measure propeller rotation rate (in rpm).	2	0.39	Actual
	16	TCRT5000 IR Sensor	Understand whether Cansat is successfully released or not.	1	1.11	Actual
	17	Real Time Clock Coin Cell	Coin cell to activate Teensy v4.1 Real Time Clock.	1	1	Actual
	18	SanDisk Ultra SD Card 16GB	Save the flight data and video recordings.	3	5.61	Owned
	19	Audio Beacon	Recovery of Cansat.	1	0.66	Actual
	20	SMD & THT Components	All components required for our PCB, i.e resistors, capacitors, LEDs etc.	-	20	Actual
	21	Prototype PCB	Prototype PCB is ordered for testing. Shipping cost is included.	-	11.08	Actual
	22	MG95 Servo Motor	Release mechanism.	1	1.92	Actual
	23	FXP70 Leaf Antenna	Antenna that send the telemetry data to ground control station in 1Hz rate. Also used by GPS to communicate with satellites.	2	3.59	Owned
	24	LTE-Q7027I22	Antenna used in ground control station that receives the telemetry data sent by payload.	1	22.79	Owned

CanSat Budget – Hardware (3/4)

	No	Name	Explanation	Quantity	Cost [$]	Verification Method
MECHANICS	1	Esun PLA+ Filament	Prototype Production.	2	19.10	Owned
	2	Esun ASA Filament	Actual Production.	1	22.45	Actual
	3	M3 Screw & Nut Set	Assembly Of Mechanical Subsystem And Chassis.	1	6.11	Owned
	4	M2 Screw & Nut Set	Assembly Of Mechanical Subsystem.	1	6.68	Owned
	5	1/4 in Lock Nut	Parachute Attachment	1	0.026	Actual
	6	M3 Plastic Screw + Nut Set	Assembly Of Electronic Subsystem.	1	8.79	Owned
	7	Loctite	Gluing M2-M3 Steel Nuts.	1	5.00	Owned
	8	Duralite 50x70cm	Production Of Basic Plates.	2	1.05	Owned
	9	Bearings	Ensuring Movement Of The Wings And The Second Camera.	3	2.44	Actual
	10	Activator Adhesive	Repair And Assembly.	1	2.30	Owned
	11	Parachute Fabric	Container Parachute.	1	2.39	Actual
	12	Parachute Rope	Parachute Attachment	1	2.30	Owned
	13	¼ in Eye Bolt	Parachute Attachment	1	3.93	Actual
	14	Plywood	Parachute Attachment	1	5.00	Actual

CanSat Budget – Hardware (4/4)

Hardware Budget Summary			
Subsystem	**Number of Actual Components**	**Number of Owned Components**	**Total Cost ($)**
Electronics	15	9	360.380
Mechanics	6	8	112.596
		Grand Total	**472.976**

Grand Total Cost of Cansat is less than $1000, that stated in requirement C14.

CanSat Budget – Other Costs

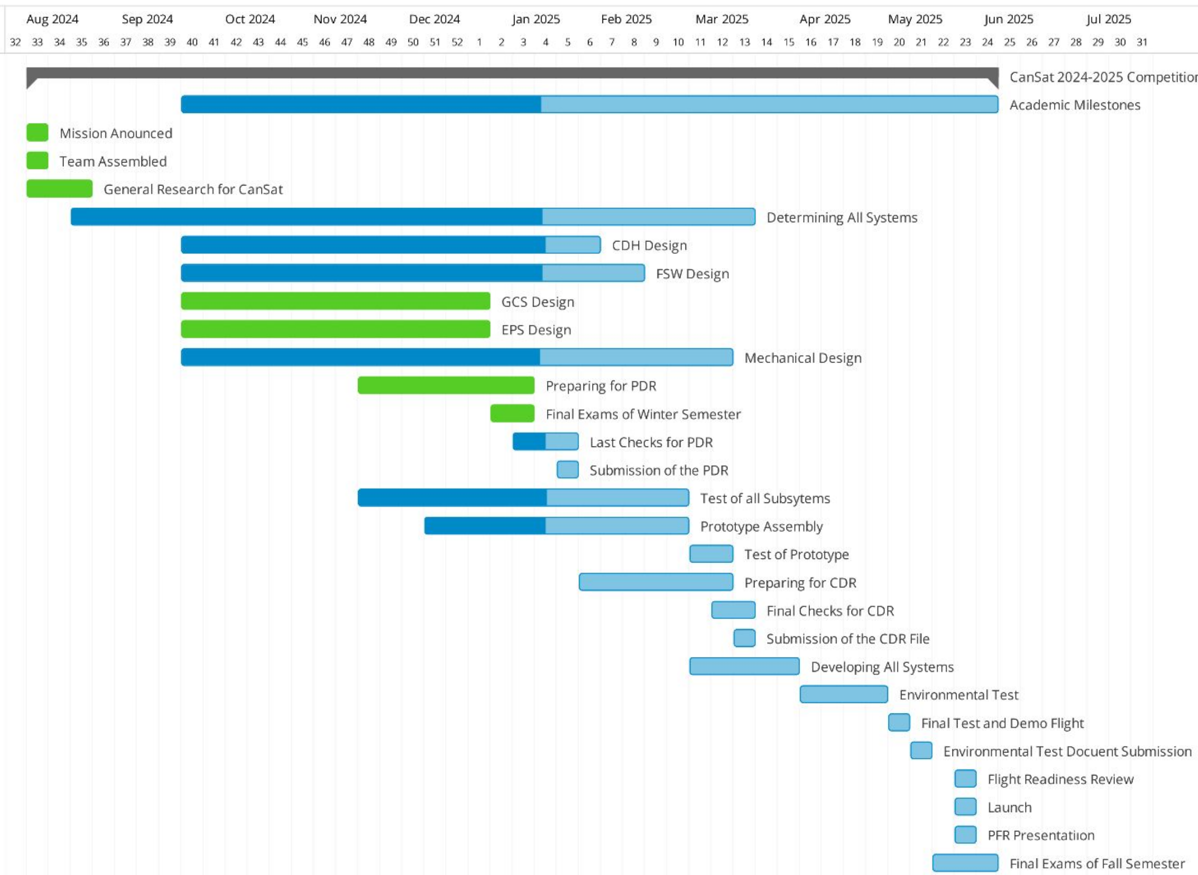
Other Costs	Quantity	Cost($)	Total Cost($)	Determination
Travel	10	930	9300	Estimated
Hotel	10 (5 days)	300	3000	Estimated
Rental Cars	2 (5 days)	300	1500	Estimated
Computer	1	0	0	Owned
Umbrella and cooler for GCS	1	69	69	Estimated
Food	10 (5 days)	200	2000	Estimated
Prototyping	2	472.976	945.952	Estimated
Grand Total			**16,814.952**	

Program Schedule Overview

Gantt Chart of Major Milestones

CanBEE(Team 3133) Gantt Chart

	ACTIVITIES	START	DUE	STATUS	%
	CanSat 2024-2025 Competition:	12/Aug	13/Jun		63%
1	Academic Milestones	30/Sep	11/Jun	Started	44%
2	Mission Anounced	12/Aug	12/Aug	Finished	100%
3	Team Assembled	12/Aug	18/Aug	Finished	100%
4	General Research for CanSat	18/Aug	31/Aug	Finished	100%
5	Determining All Systems	31/Aug	28/Mar	Started	69%
6	CDH Design	30/Sep	07/Feb	Started	87%
7	FSW Design	30/Sep	21/Feb	Started	78%
8	GCS Design	30/Sep	03/Jan	Finished	100%
9	EPS Design	30/Sep	03/Jan	Finished	100%
10	Mechanical Design	30/Sep	21/Mar	Started	65%
11	Preparing for PDR	30/Nov	17/Jan	Finished	100%
12	Final Exams of Winter Semester	06/Jan	17/Jan	Finished	100%
13	Last Checks for PDR	17/Jan	31/Jan	Started	50%
14	Submission of the PDR	01/Feb	01/Feb	Not starte	0%
15	Test of all Subsytems	29/Nov	07/Mar	Started	57%
16	Prototype Assembly	16/Dec	07/Mar	Started	46%
17	Test of Prototype	10/Mar	21/Mar	Not starte	0%
18	Preparing for CDR	09/Feb	22/Mar	Not starte	0%
19	Final Checks for CDR	23/Mar	27/Mar	Not starte	0%
20	Submission of the CDR File	28/Mar	28/Mar	Not starte	0%
21	Developing All Systems	10/Mar	11/Apr	Not starte	0%
22	Environmental Test	14/Apr	09/May	Not starte	0%
23	Final Test and Demo Flight	12/May	16/May	Not starte	0%
24	Environmental Test Docuent Submiss...	23/May	23/May	Not starte	0%
25	Flight Readiness Review	06/Jun	06/Jun	Not starte	0%
26	Launch	07/Jun	07/Jun	Not starte	0%
27	PFR Presentatiion	08/Jun	08/Jun	Not starte	0%
28	Final Exams of Fall Semester	26/May	13/Jun	Not starte	0%



Note : Tasks and milestones in the Gantt Chart are ordered and recorded in line with weekly progress.

Detailed Program Schedule (1/2)

		Teams	Begin Date	End Date	Duration (Day)
Academic Schedule		All Team	09.30.24	06.15.25	259
Holidays	New Year	All Team	01.01.25		1
	Semester	All Team	01.19.25	02.17.25	30
Competition Milestones	PDR	All Team	01.31.25		1
	CDR	All Team	03.28.25		1
	Environmental Test Document	All Team	05.23.25		1
	Flight Telemetry Data	All Team	06.7.25		1
	PFR	All Team	06.8.25		1
Academic Milestones	First Semester	All Team	09.30.24	01.19.25	112
	First Semester Exam	All Team	11.18.24	11.29.24	12
	First Semester Final	All Team	01.06.25	01.19.25	14
	Second Semester	All Team	02.17.25	06.15.25	119
	Second Semester Exam	All Team	04.07.25	04.18.25	12
	Second Semester Final	All Team	05.26.25	06.15.25	21
Flight Software Design		Software Team	09.30.24	02.21.25	145
Development of FSW and GCS		Software Team	09.30.24	02.21.25	145
Checking the Interface		Software Team	03.01.25	03.15.25	15
Telemetry and GCS Test		Software Team	02.21.25	03.22.25	30
Electronic Subsystems		Electrical Team	09.30.24	01.03.25	96
Selecting & Purchasing & Delivering Electronic Components		Electrical Team	09.30.24	11.30.24	62
Combining Electronic Modules on a PCB		Electrical Team	01.13.25	01.17.25	5
Testing of Electronic Components		Electrical Team	01.17.25	02.09.25	24
Performance Tests and Improvements for Electronics		Electrical Team	01.03.25	03.23.25	80

Detailed Program Schedule (2/2)

	Teams	Begin Date	End Date	Duration(Day)
Mechanical Subsystems	Mech. Team	09.30.2024	05.23.2025	236
Determining the System	Mech. Team	09.30.2024	10.19.2024	20
Designing the Payload and Container	Mech. Team	10.19.2024	03.21.2025	154
Manufacturing the Payload and Container	Mech. Team	12.04.2024	05.23.2025	171
Mechanical Design Tests	Mech. Team	02.19.2025	05.23.2025	94
Improvements to the Payload and Container Design	Mech. Team	02.13.2025	03.25.2025	41
Tests	All Team	03.11.2025	05.15.2025	65
Deployment & Vacuum Test	All Team	03.11.2025	03.22.2025	11
Fit Check Test	All Team	03.22.2025	04.02.2025	11
Thermal Test	All Team	04.02.2025	04.13.2025	11
Vibration Test	All Team	04.13.2025	04.24.2025	11
Drop Test	All Team	04.24.2025	05.04.2025	10
Drone (Demo) Test	All Team	05.04.2025	05.15.2025	11

ALL TEAM	
Mechanic Team	A. Artuc, F. Coban, A. Koroglu, N. Gencel
Electronic Team	B. Ozbay, A. Garip, K.Ozpinar, B. Yucedag
Software Team	U. Ucrak, E. Acikgoz

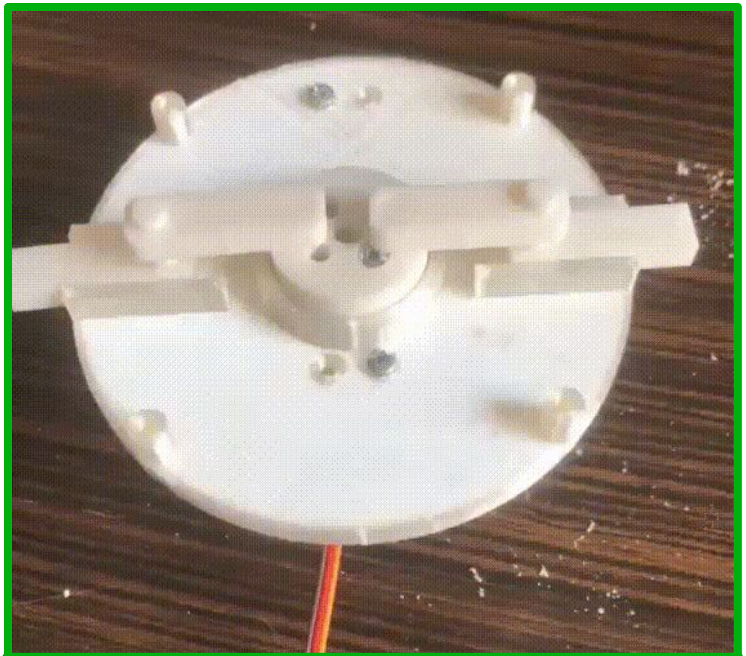
Conclusions (1/2)

At this point, we have explained our design with all mechanical, electrical and management systems. The tasks which are accomplished and unfinished are listed below.

Major Accomplishments	Major Unfinished Works
• Needed components and prototype PCB are ordered. • All sensors are tested on the breadboard separately and together. • First tests of prototype PCB is done. • Release mechanism manufactured and tested. • Auto-gyro is manufactured and tested with hall sensors. • Ground camera mechanism is manufactured. • Rocket nose cone is manufactured. • GUI Software is completed and tested. • XBee and GUI Communication is tested.	• Prototyping is not completely finished. • Camera mechanism is not activated. • XBee Communications are not tested in long distance. • Flight software is still being worked on. • Environmental Tests are not started yet.

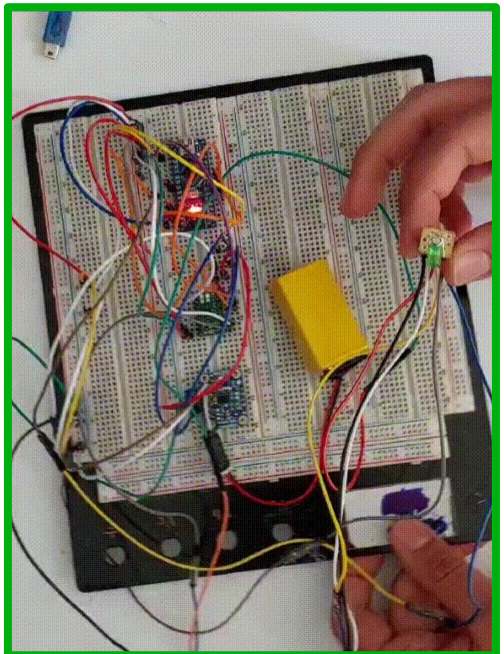
We have achieved to complete preliminary design specifications and we are ready to apply all the designs and calculations in real world.

Conclusions (2/2)



Release Mechanism
Prototype

Auto-Gyro
Prototype



PID Control
Prototype

Team CanBEE is ready for CDR and Auto-Gyro Descender mission.