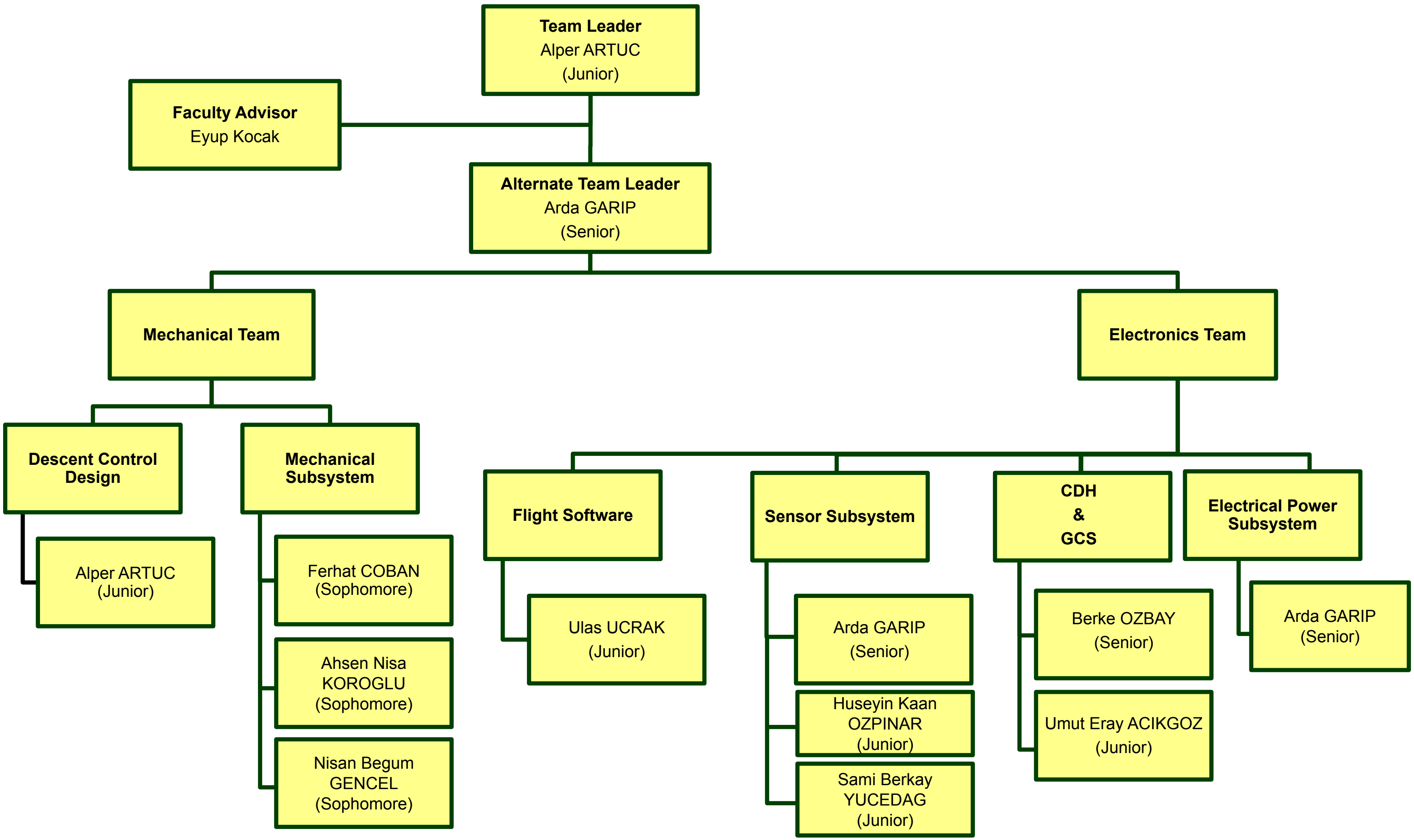
CanSat 2025
Critical Design Review (CDR)

3133

CanBEE

Presentation Outline

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

System 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.

Selectable Objectives

CanSat and nose cone can be designed to be separated. In our design, **CanSat and nose cone are not separable.**

Rationale

An extra mechanism is required for a controlled separation. In order to reach a fall speed of 5m/s, a parachute must be used. These bring with them extra mass and power consumption.

Summary of Changes Since PDR (1/2)

Sensor Subsystem Design Changes	
*	No change(s) have been made since the PDR.

Descent Control Design Changes	
1	Holes were opened with topology optimization.
2	Wings extended 4 mm, reach 221 mm.

Mechanical Subsystem Design Changes	
1	Topology optimization was made to the Release Mechanism Cover.
2	The chassis structure was redesigned with a structure consisting of carbon fiber rods and clamps.
3	Topology optimization was made to the camera mechanism and its layout was redesigned.
4	Special plate for Buzzer cancelled.
5	The design made inside the container was rearranged.
6	Rocket nose cone reduced in size adhering to mission guide.
7	3.7V Battery holders redesigned.

Summary of Changes Since PDR (2/2)

Communication & Data Handling Subsystem Design Changes	
*	No change(s) have been made since the PDR.

Electrical Power Subsystem Design Changes	
1	3.7V battery selection is changed for both ground camera and audio beacon.
2	Switching voltage regulator is added to supply ground camera.
3	Schottky diodes are used to ensure safe parallel battery connection, instead of MOSFETs.

Flight Software Design Changes	
*	No change(s) have been made since the PDR.

Ground Control System Design Changes	
1	Unnecessary plots have been removed from GCS design, 3D CanSat model orientation plot added.

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			✔	✔

System Concept of Operations (CONOPS) (1/3)

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 at peak altitude.

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 at 75% peak altitude.

Payload release and opening the coaxial propeller.

Payload descent 5m/s.

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

POST LAUNCH

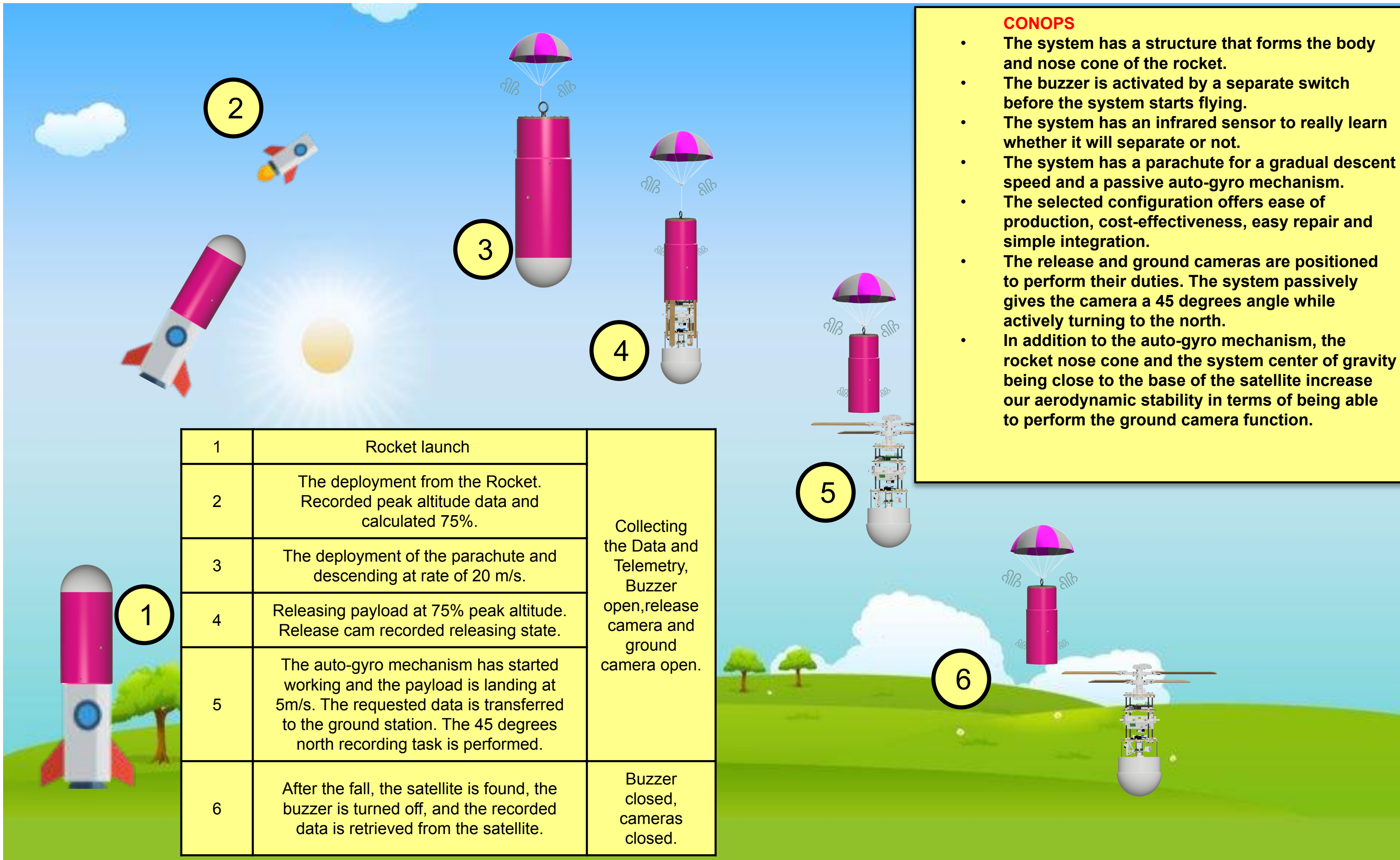
Locate and retrieve

Retrieve GCS data and SD Card data

Analysis of the data and reduce wrong values.

Prepare and present PFR

System Concept of Operations (CONOPS) (2/3)



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 degrees 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

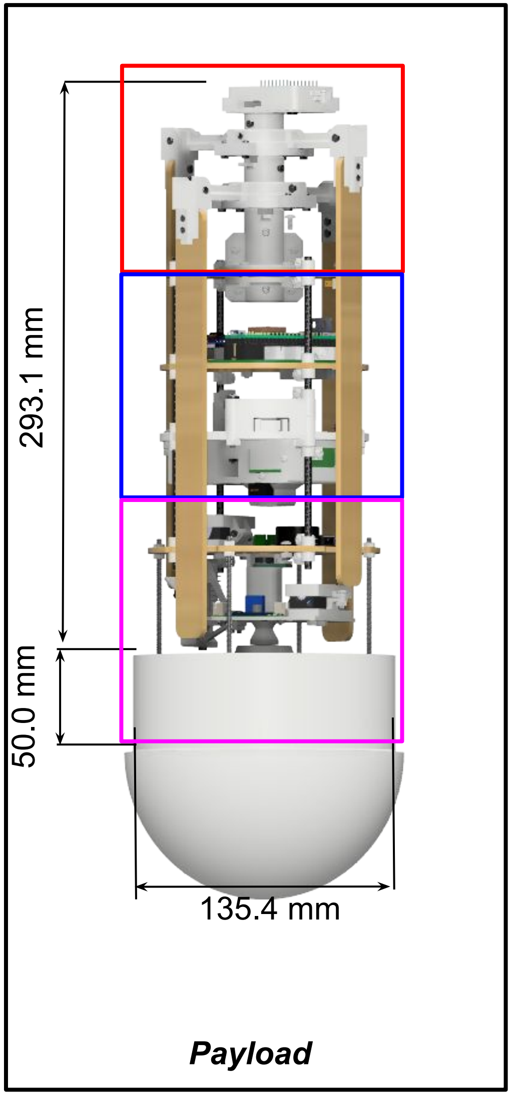
- **The system has a structure that forms the body and nose cone of the rocket.**
- **The buzzer is activated by a separate switch before the system starts flying.**
- **The system has an infrared sensor to really learn whether it will separate or not.**
- **The system has a parachute for a gradual descent 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 degrees 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.**

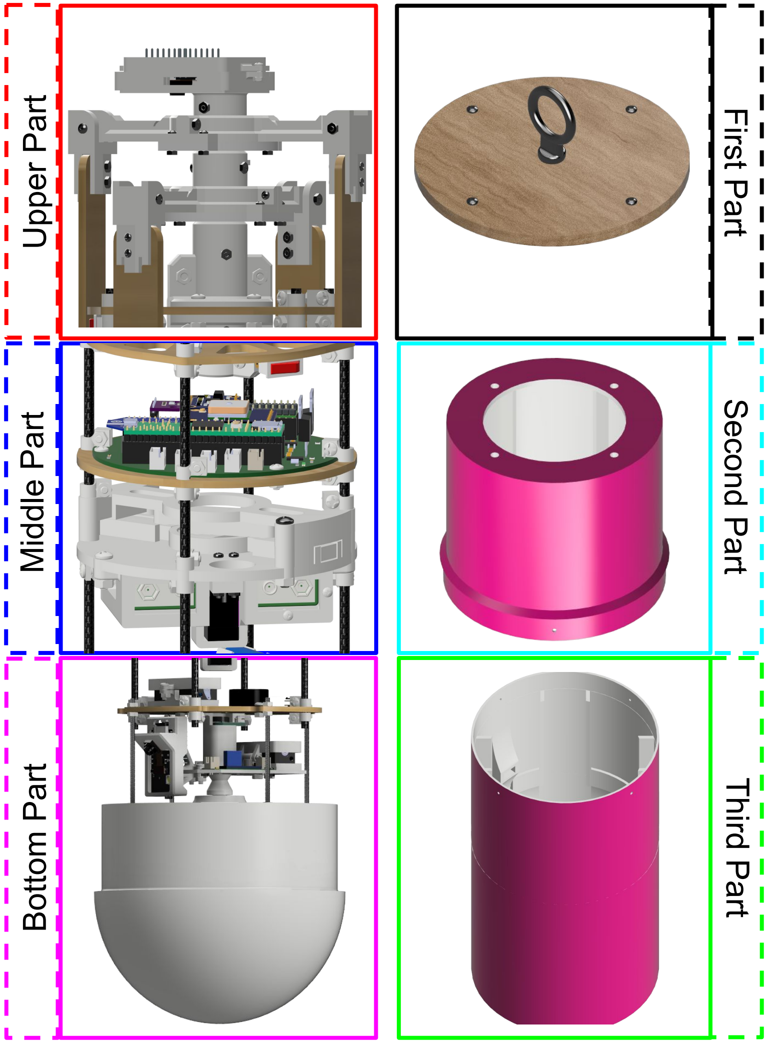
System Concept of Operations (CONOPS) (3/3)

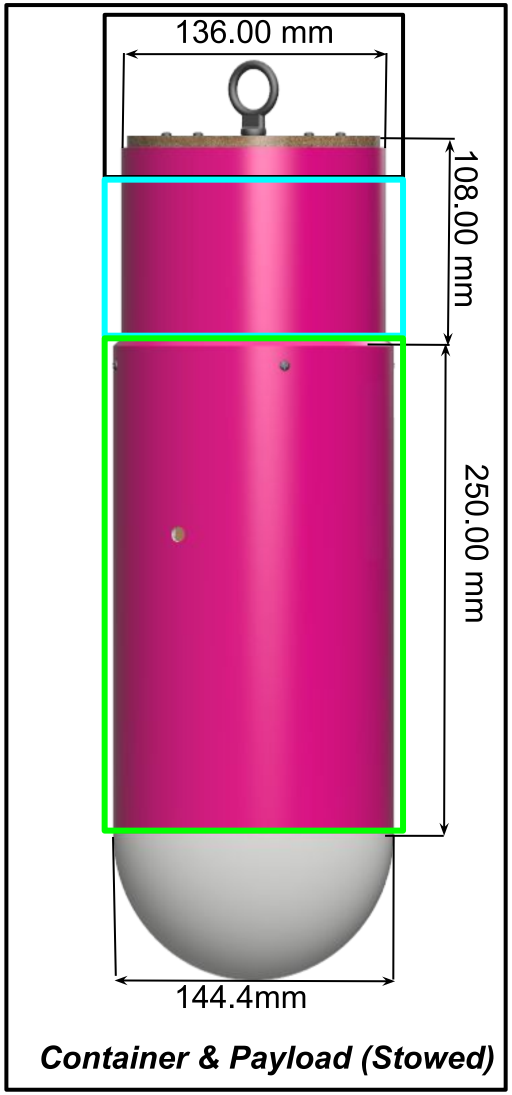
Roles	Team Members	Responsibilities
Mission Control Officer	Alper Artuc	Mission Control Officer will coordinate team members and give them to mission.
Ground Station Crew	Berke Ozbay, Ulas Ucrak	Ground Station Crew will control coming telemetries and real time plots and setting up GCS and antenna.
Recovery Crew	Ahsen Nisan Koroglu, Ferhat Coban, Nisan Begum Gencel, Huseyin Kaan Ozpinar, Sami Berkay Yucedag, Umut Eray Acikgoz	Recovery Crew will search and find CanSat after mission is done.
CanSat Crew	Alper Artuc, Arda Garip, Berke Ozbay, Ulas Ucrak	CanSat Crew will do requirement setups and prepare CanSat to the flying.

CanSat Physical Layout (1/4)

OVERVIEW & DIMENSIONS



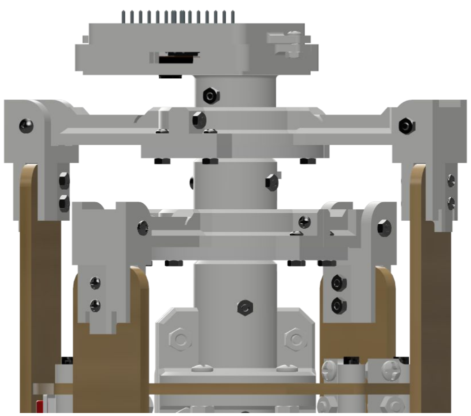




CanSat Physical Layout (2/4)

PLACEMENT OF MAJOR COMPONENTS

Upper Part



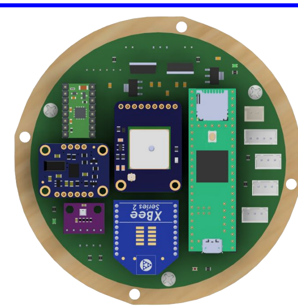
Coaxial Propeller Mechanism

Release Camera

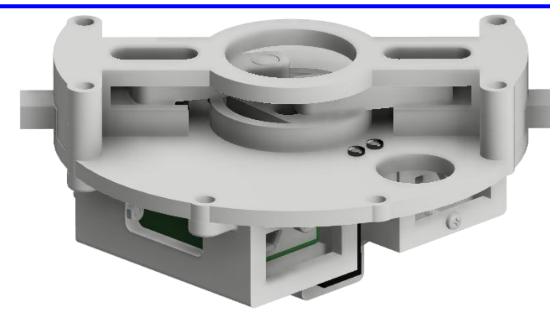
Upper part of payload consists of **Two Hall Sensors** positioned under the propellers, **One PCB Switch** positioned under the plate and a **Release Camera** positioned on the **Coaxial Propeller Mechanism.**

Middle Part

PCB



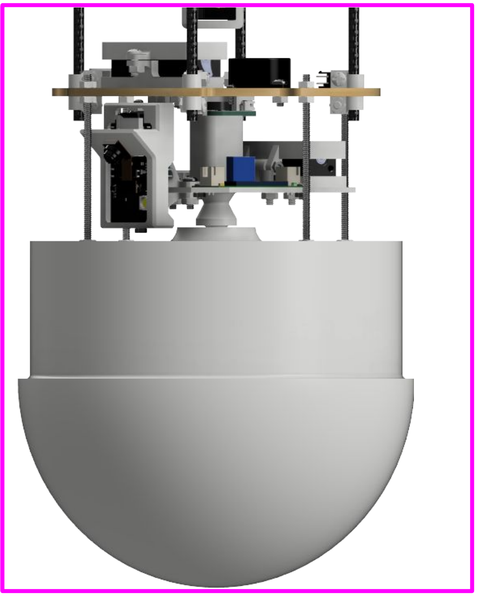
Release Mechanism



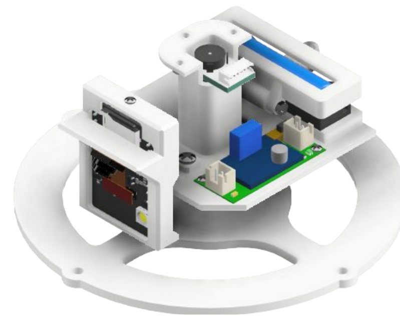
There is a **PCB** in the middle part of payload and this **PCB contains the Radio Antenna, GPS Antenna and All sensors.** There is a **Servo Motor** and **two 9 Volt Batteries** in the section where the **Release Mechanism** is located in the middle part of payload.

CanSat Physical Layout (3/4)

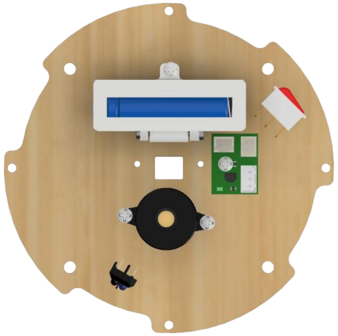
Bottom Part



Camera Mechanism



Buzzer Placement



The **camera mechanism** placed at the bottom of the payload contains **a camera, camera card, battery, and encoder dc motor.** The plate placed on top of the camera mechanism contains a **buzzer, buzzer card switch, and battery.**

Container

First Part

Second Part

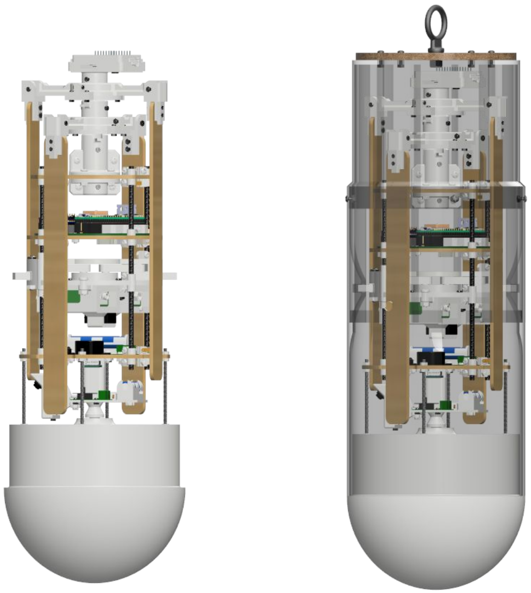
Third Part

The container consists of three main parts. The first part is used for the **parachute connection and consists of eyebolt and plywood.** The second and third parts form the main body of the container and contained **wall connections and slots** for release mechanism and propellers.

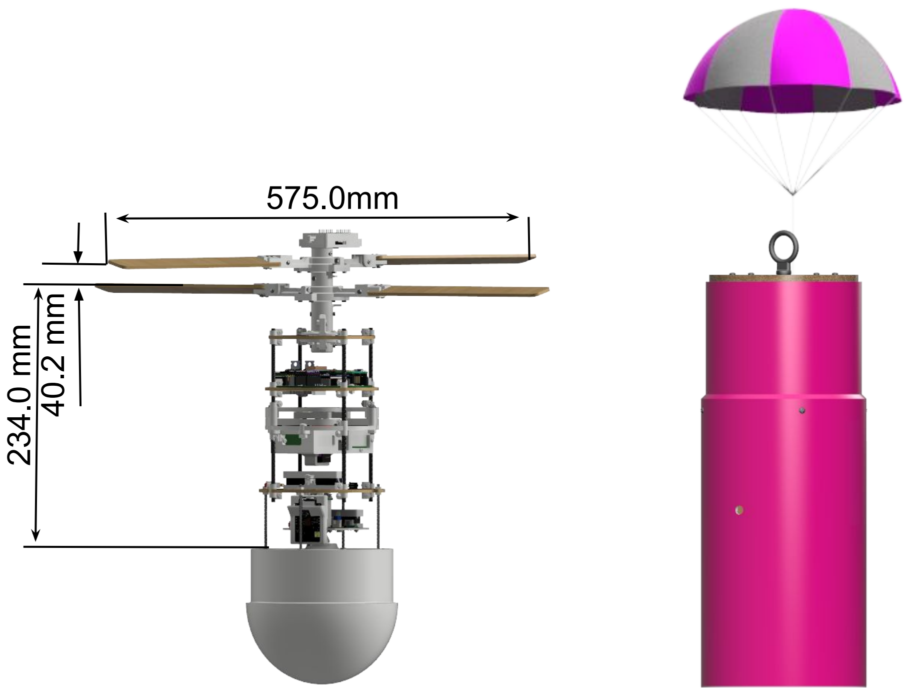
CanSat Physical Layout (4/4)

Configurations

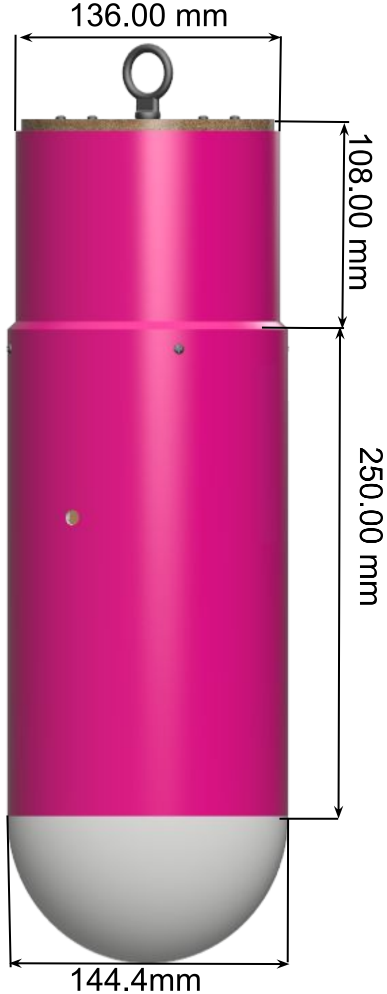
Container & Payload Launch Configuration



Container & Payload Deployment Configuration



Launch Vehicle Compatibility (1/2)



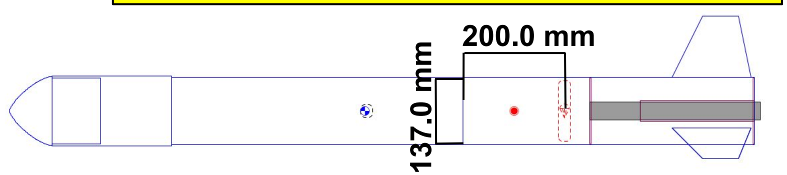
Container & Payload (Stowed)

***No sharp protrusions.**

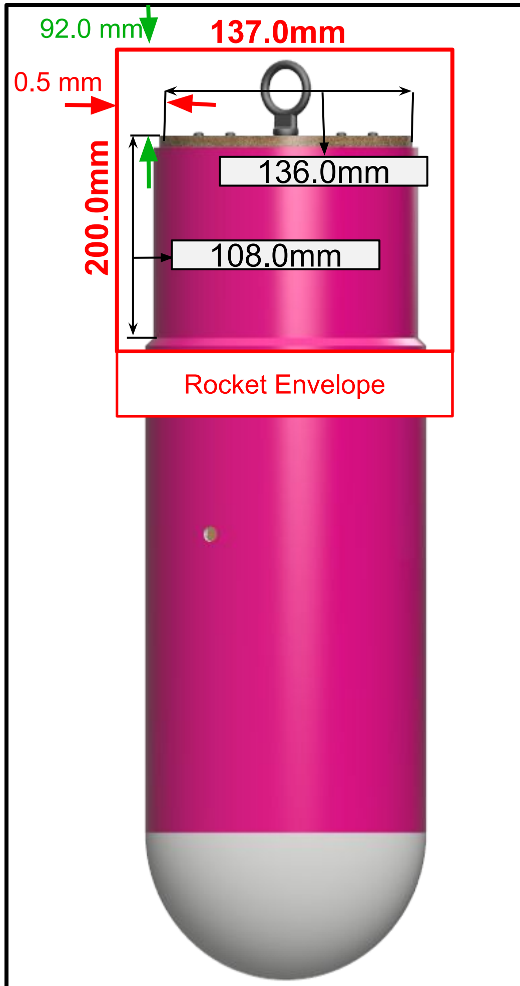
- The corners of the walls used to limit the wing movement inside the satellite will be sanded.
- The nuts of the eye bolts used to hold the parachute will be sanded.
- The outer surface of the nuts of the bolts used to connect the container parts will be sanded.

- 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

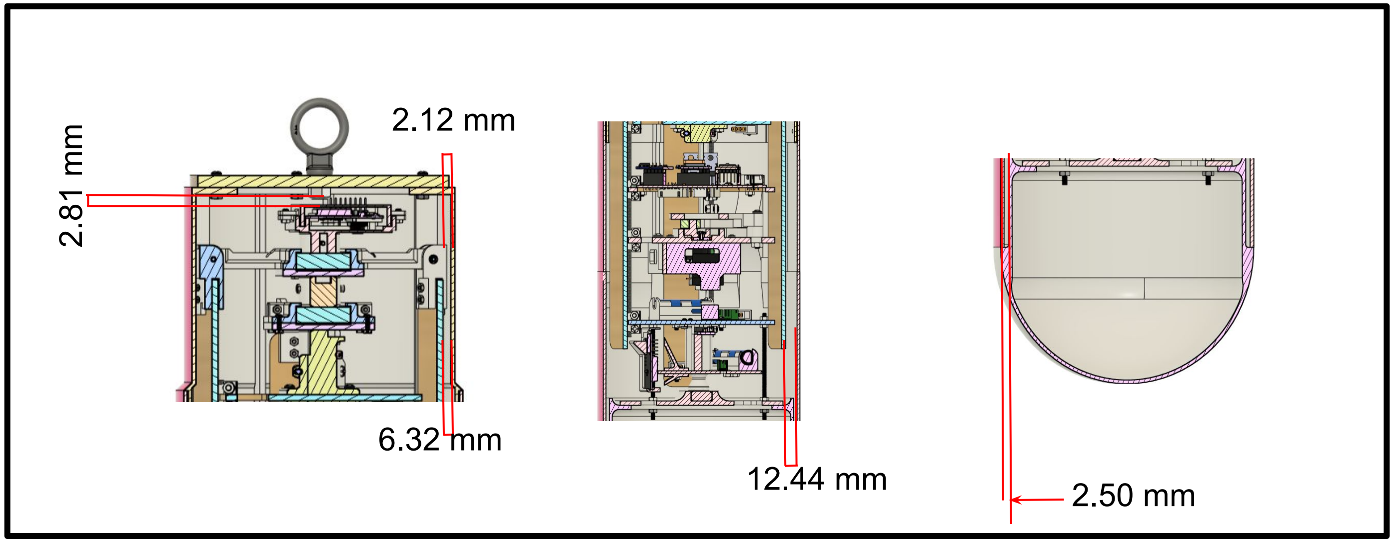


ENVELOPE CLEARANCE IS OBTAINED



CanSat Rocket Configuration

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

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.

Sensor Changes Since PDR

No change(s) have been made since the PDR.

Payload Air Pressure Sensor Summary

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

Data Processing

Altitude = $44330 \times \left(1 - \frac{P}{P_0}\right)^{1/5.255}$

P : Atmospheric pressure at current location
P_0 : Atmospheric pressure at sea level

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

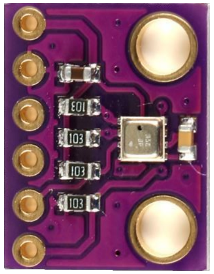
Absolute Accuracy: ±1 hPa
Relative Accuracy: ±0.12 hPa

Data Format

The pressure data is stored in IEEE 754 double (8 bytes).

BMP280

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



Payload Air Temperature Sensor Summary

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

Data Processing

Temperature = $\frac{P}{R \times \rho_{dry\,air}}$

$\rho_{dry\,air}$ = Density of dry air (kg/m^3)

P = Air pressure (P_a)

R = Specific gas constant for dry air, 287.05 J(kg.K)

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

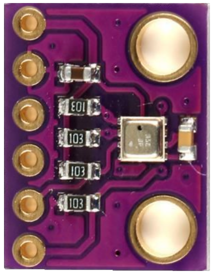
Absolute Accuracy: ±1°C
Resolution: 0.01°C

Data Format

The temperature data is stored in IEEE 754 float (4 bytes).

BMP280

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



Payload Voltage Sensor Summary

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

Data Processing

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
```

Accuracy

10-bit mode: 3.3V / 2^{10} = 3.22 mV per step.

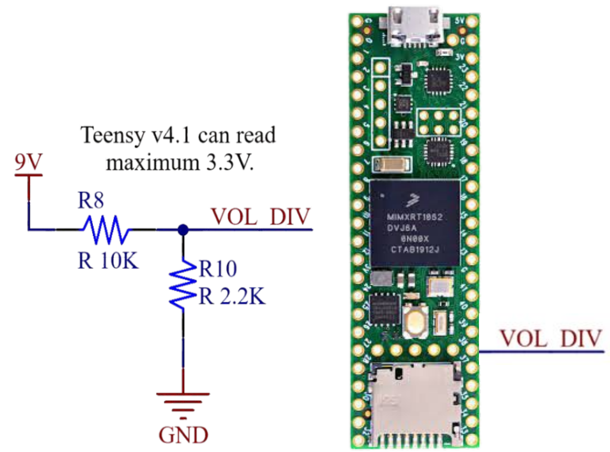
Data Format

The data is stored in IEEE 754 float (4 byte).

Teensy v4.1's Analog Pin

SELECTED

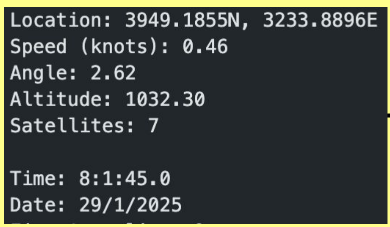
- **Free**
- **Low and controlled (by selecting resistors) power consumption**
- **Sufficient resolution**
- **SMD footprints need nearly zero additional space on PCB**

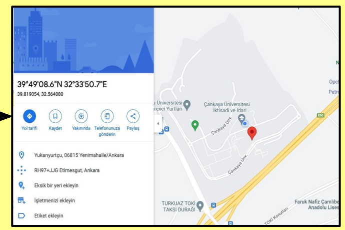


Payload GNSS Sensor Summary

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

Data Processing





Accuracy

- **Positioning:** ±3 meters
- **Velocity:** ±0.1 m/s
- **Time:** ±10 nanoseconds
- **Altitude:** ±10 meters (varies with satellite quality)

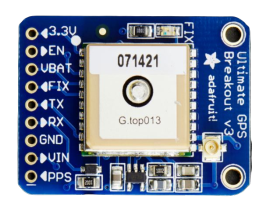
Adafruit Ultimate GPS Breakout

SELECTED

- Lower mass
- Lower cost
- Satisfactory resolution and sensitivity

Data Format

The altitude and location (longitude & latitude) data is stored in IEEE 754 float (4-byte), satellites data is stored in IEEE 754 unsigned integer (4-byte) and time data is stored in IEEE 754 string (8-byte).



Auto-gyro Rotation Rate Sensor Summary

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

Data Processing

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.

$$\frac{pulseCount\ X\ 60000}{Interval}$$

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

pulseCount= Counter, **interval**= Period

Accuracy

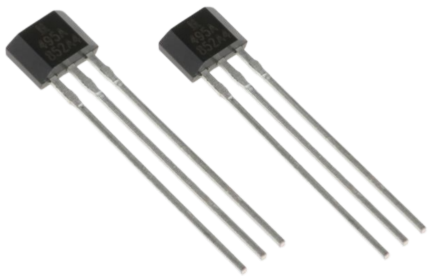
Accuracy depends on the magnet position. We try to get the most accurate measurement by placing the magnet very close to the sensor.

Data Format

The data is stored in IEEE 754 float (4-byte).

US1881

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



Payload Tilt Sensor Summary

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

Data Processing

BNO055 has its own embedded sensor fusion algorithm.

$$Tilt_X = \arctan 2\left(\frac{-ACC_R}{\sqrt{ACC_P^2 + ACC_Y^2}}\right) \times \frac{180}{\pi}$$

$$Tilt_Y = \arctan 2\left(\frac{ACC_P}{\sqrt{ACC_R^2 + ACC_Y^2}}\right) \times \frac{180}{\pi}$$

```
Orient: x= 359.94 |      y= -0.31 |       z= 10.06
Gyro:   x= 0.00 |        y= 0.00 |        z= 0.00
Linear: x= -0.01 |       y= -0.02 |       z= -0.03
Mag:    x= 1.50 |        y= -27.06 |      z= -80.56
Accl:   x= -0.08 |       y= -1.73 |       z= 9.62
Gravity:        x= -0.06 |       y= -1.71 |       z= 9.65
```

Accuracy

- **Accelometer:** ±3 mg
- **Gyroscope:** ±3°/s
- **Magnetometer:** ±2.5°

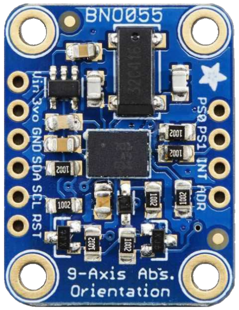
Data Format

The data is stored in IEEE 754 float (4-byte).

BNO055

SELECTED

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



Payload Ground Camera Orientation Sensor

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	0.143°	Two Quadrature Digital Signals	PWM	4.48

Data Processing

DC motor will point the ground camera to the north, using **PID control**.

$$u(t) = K_p\left(e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau + T_d\frac{d}{dt}e(t)\right)$$

- u(t) is the drive coming from the Controller (Teensy v4.1), at time t
- e(t) = y_{sp}(t) - y(t) is the difference between the north and current pointing direction, at time t
- K_p, K_i, K_d are the respective P, I, and D constants.

Accuracy

- Encoder provides 12 counts per revolution (CPR). For the 210:1 ratio DC motor:

12 x 210 = 2520 CPR

360° / 2520 = 0.143° (resolution)

Data Format

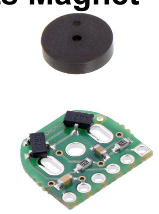
All data in the PID control equation is stored in IEEE 754 float (4-byte).

Pololu Magnetic Encoder

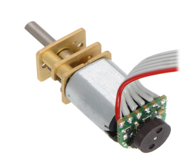
SELECTED

- **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



Ground Camera Sensor Summary

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

Our camera has the resolution of **800x600** pixels.

Our camera meets the requirement SN10, that states:
- The video cameras shall record video in color and with a minimum resolution of 640x480.

ESP32-CAM

SELECTED

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

Auto-Gyro Deploy Camera Summary

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

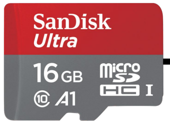
Our camera has the resolution of **800x600** pixels.

Our camera meets the requirement SN10, that states:
- The video cameras shall record video in color and with a minimum resolution of 640x480.

ESP32-CAM

SELECTED

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



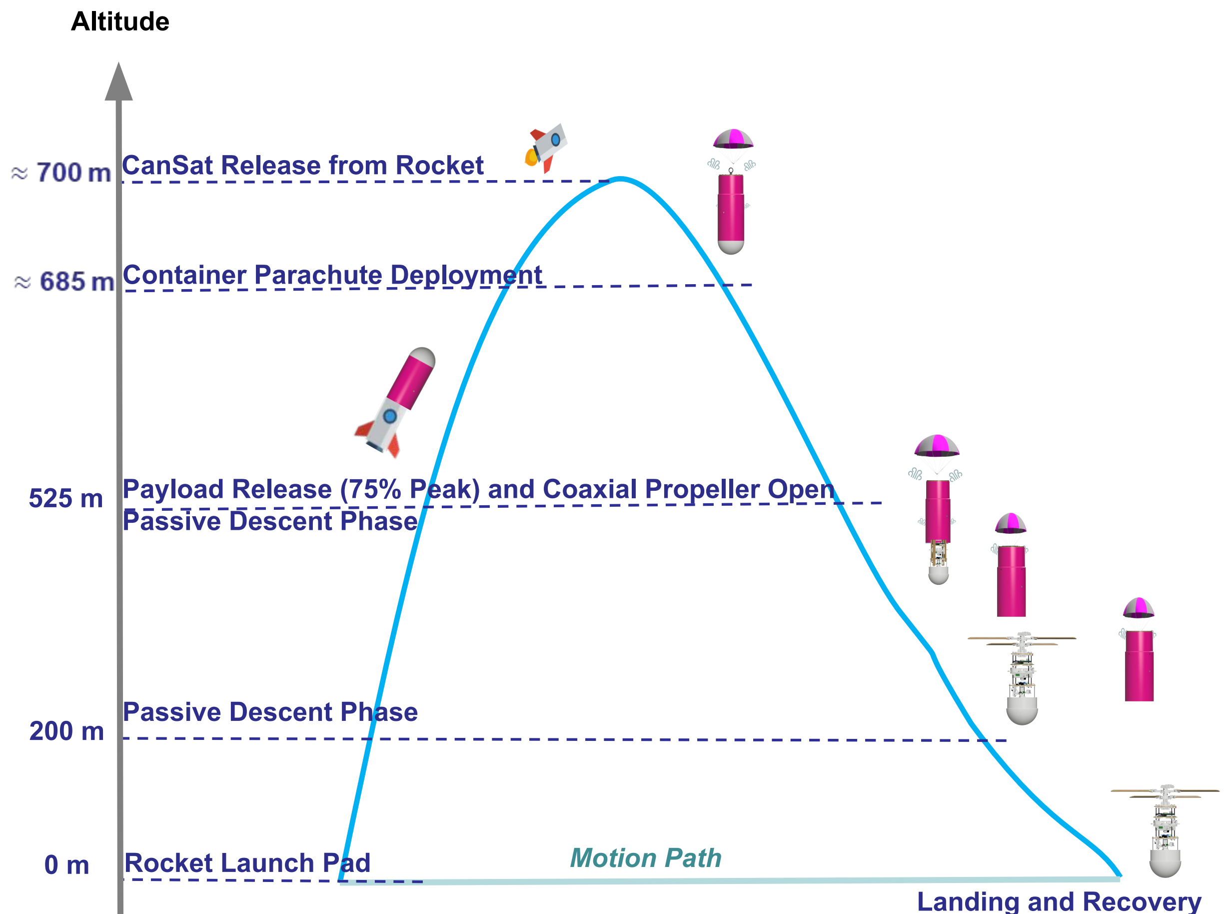
Descent Control Design

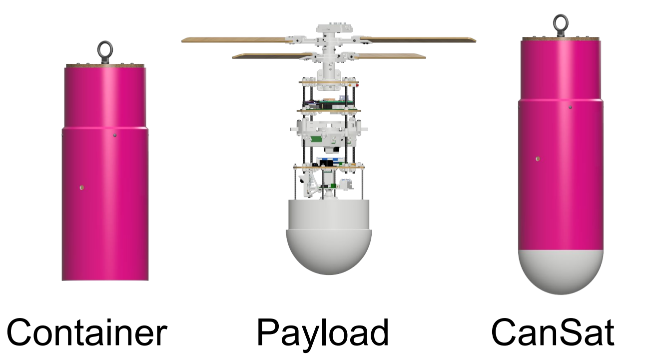
Alper ARTUC

Descent Control Overview

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

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





Descent Control Changes Since PDR

Components	PDR	CDR	Rationale
Propeller	Wings are 217mm and have sharp edges.	Wings are 221mm and no sharp edges.	Increasing lift and regulating air flow.
Propeller Plate	Closed design did not support wings for airflow.	Holes were opened with topology optimization.	Increased airflow from below to the wings during descent.

Test Gif

Prototype Testing

All of the changes are done as a result of prototype testing.These mechanism is produced and improved according to test result. Better results are obtained.

Parachute strength and connection point strength tests were performed. Autogyro airflow strength and rpm tests were performed. Short-distance and long-distance drop tests are performing.

Container Descent Control Hardware & Key Design Considerations

PARACHUTE CONFIGURATION

- **Container** parachute is **Dome Type**
- **High drag** coefficient
- **Easy** to fabricate
- **Low** horizontal displacement
- **Spill hole** is necessary to reduce **sway**

PARACHUTE COMPARTMENT

Container descent control is related with parachute design. It will be external and attached to the container so that it will open immediately when the CanSat deployed from the rocket.

Stability

Stability is maintained by several designs:

The center of mass of all the system designed to be on the axis of parachute's main rope, so there are not force components to disturb stability except wind.

Spill hole provides additional stability because it eliminates side spill of air from the chute.

Center of mass is in front of the center of pressure in the direction of motion, so the self restoring torque take away the possibility of tumbling

Parachute Material

The material of the parachute fabric will be **nylon fabric. It is also named as polymer fabric** in the market. This material stands out with its high flexibility, lightness, resistance to water and moisture. A parachute with these features will easily withstand the conditions that will occur during the descent.

Parachute Deployment

There are windows at container wall for the airflow increase inside the parachute compartment.
Parachute is passively and immediately deployed after CanSat is separated from the rocket.

Color Selections

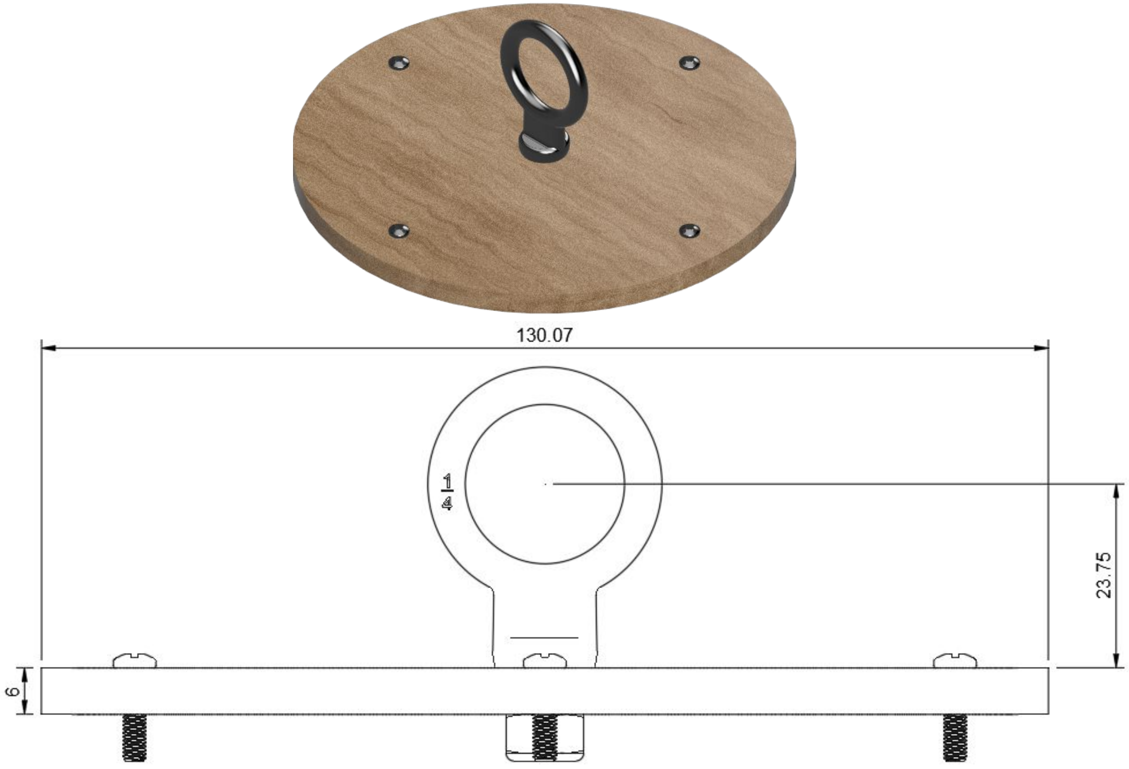
For the easy visibility, parachute will be **fluorescent pink**.
Parachute rope will have color gradiently changing like **rainbow**.

Parachute Component Sizing

Container Parachute Projected Area: $\mathbf{0.03611}\ \boldsymbol{m^2}$

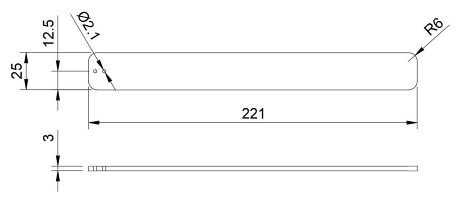
Container Parachute Rope Lenght: $\mathbf{1.5}\ \boldsymbol{m}$

Parachute Base Sizing

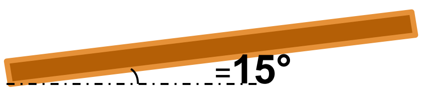


Overview

General Dimensions of Propeller Wings



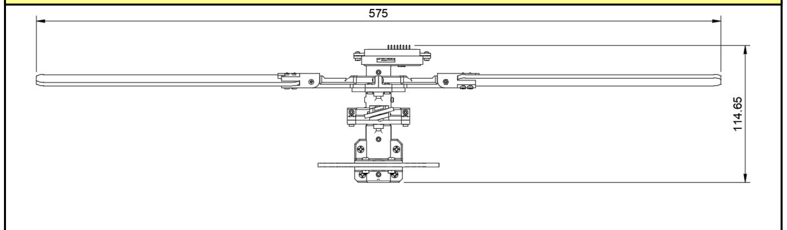
Flat Plate Airfoil and 15 Degree Angle of Attack

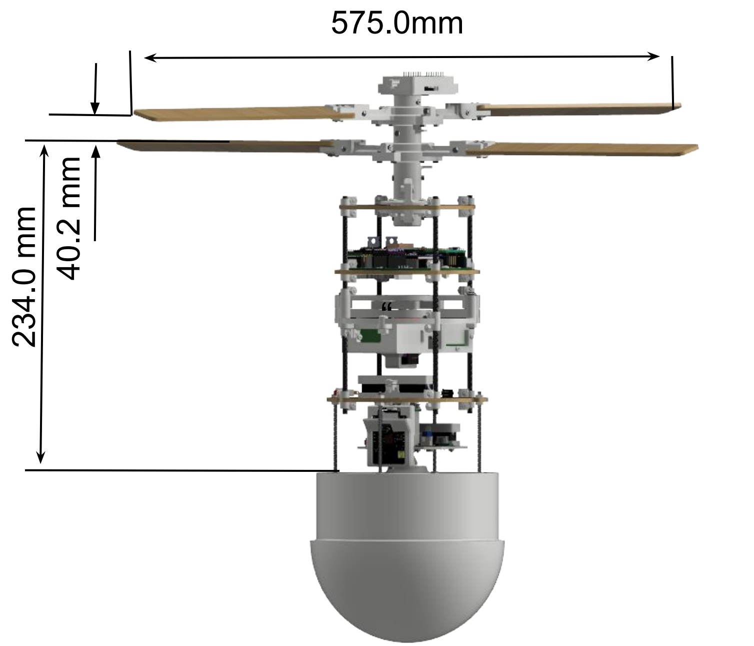


Coaxial Propeller

Reduces torque effect.
More stable landing
More efficient thrust and stability
Supports autorotation by optimizing airflow

General Dimensions Of Mechanism





Wing Profile: Flat plate profile is used, this profile is simple in terms of production and provides sufficient lift.
Wing Planform: Rectangular shape is preferred because its aerodynamic response is stable and predictable.
Wing Assembly: Wings are connected to a freely rotating center and maintain autorotation with airflow.
Wing Length: 221 mm
Chord Length: 25 mm
Wing Thickness: 3 mm
Coaxial Propeller Mechanism: During landing, airflow passes over the wings from top to bottom, maintaining autorotation.
Wing Angle of Attack (15°): Optimized for ideal autorotation and controlled landing.

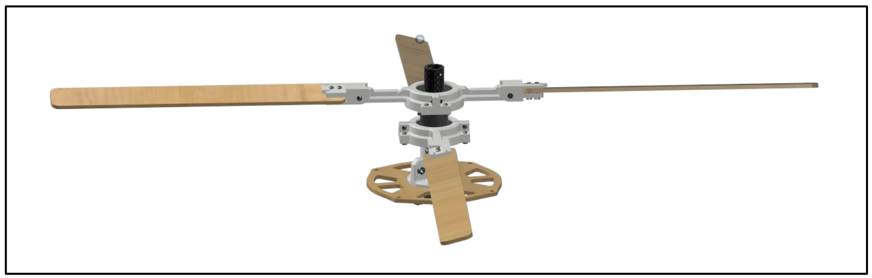
Expected Rotation Rate

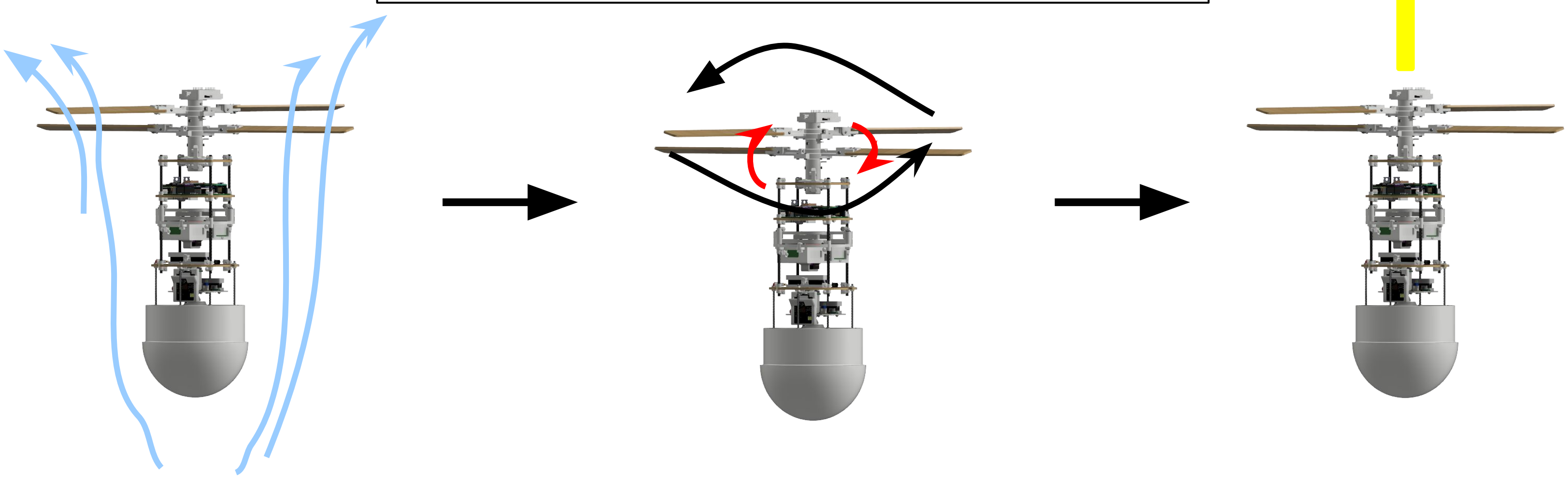
24 rad/s ~229 rpm

Auto-gyro Descent Control Summary (2/6)

Auto-gyro Descent Control Key Design Considerations

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 (auto rotation). 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.



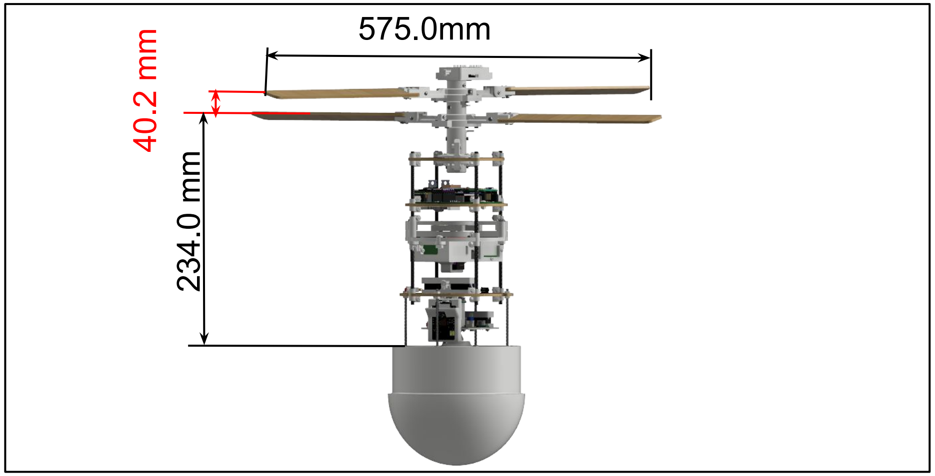


Air flow *Rotor rotates* *Lift force is produced*

Auto-gyro Descent Control Summary (3/6)

Auto-gyro Descent Control Hardware & Key Design Considerations

In coaxial propellers, **the distance between the two propellers** is a critical design parameter and directly affects performance. The reasons why this distance is important are as follows:



1. Aerodynamic Interaction:
The upper propeller produces an accelerated downward airflow. If the propellers are too close together, the lower propeller is exposed to the turbulent airflow of the upper propeller, which reduces efficiency.
When the distance between the two propellers is increased, the lower propeller is exposed to a more regular and less turbulent airflow. This increases the total thrust efficiency.

2. Vibration and Noise Levels:
When the distance between the propellers is small, vibration and noise levels increase due to turbulence and pressure fluctuations.
Sufficiently increasing the distance reduces turbulent vibrations, providing quieter and more stable operation.

3. Power and Performance Optimization:
Sufficient distance allows the lower propeller to operate more efficiently.
Choosing the appropriate distance optimizes the overall performance of the system by providing a more homogeneous airflow.

4. Mechanical Strength and Safety:
When the propellers are too close to each other, the risk of collision may increase due to flexing, vibration or deformation.
The ideal distance increases mechanical safety and reduces the risk of physical damage.

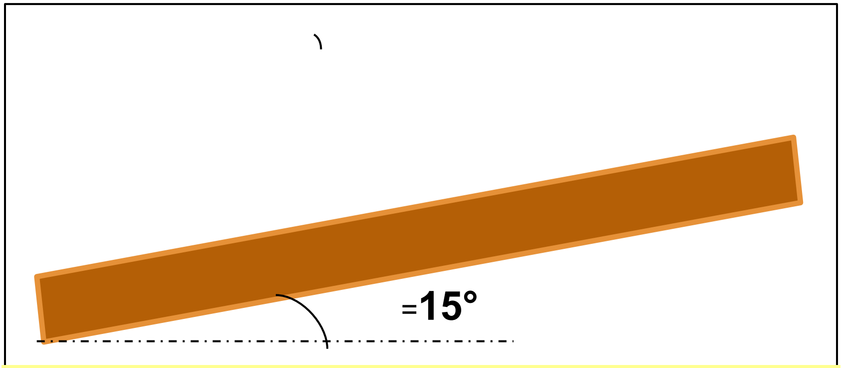
Auto-gyro Descent Control Hardware & Key Design Considerations

Flat plate airfoil is used especially in small-sized and low Mach number systems. (If we assume that the flight will take place at 750m, we conclude that separation will occur at 562.5m. If we are to perform a flight at this altitude at 5m/s, our Mach number will be 0.0148, which is a very low Mach number.) The advantages offered by the flat plate profile in these applications are as follows:

1. Low Structural Weight
Due to the lack of aerodynamic thickness, very light wings can be produced with lightweight materials.

2. Efficient Operation at Low Mach Number
At low speeds (Mach < 0.3), it works with simple aerodynamic principles; there is no complex shock formation or serious pressure changes.
Flat plate provides acceptable aerodynamic performance at low Reynolds numbers.

3. Low Manufacturing Tolerance Sensitivity
Small errors or deformations during manufacturing do not have a serious negative effect on aerodynamic performance.
This allows good results to be obtained even with simple manufacturing methods.



Flat Plate Airfoil

4. Simple Aerodynamic Behavior
Since the aerodynamic characteristics are simple and predictable, control and stability calculations are easy to make.

Flat plate airfoils are quite useful in simple, lightweight, low-cost systems with small dimensions, low speeds and low Mach numbers.

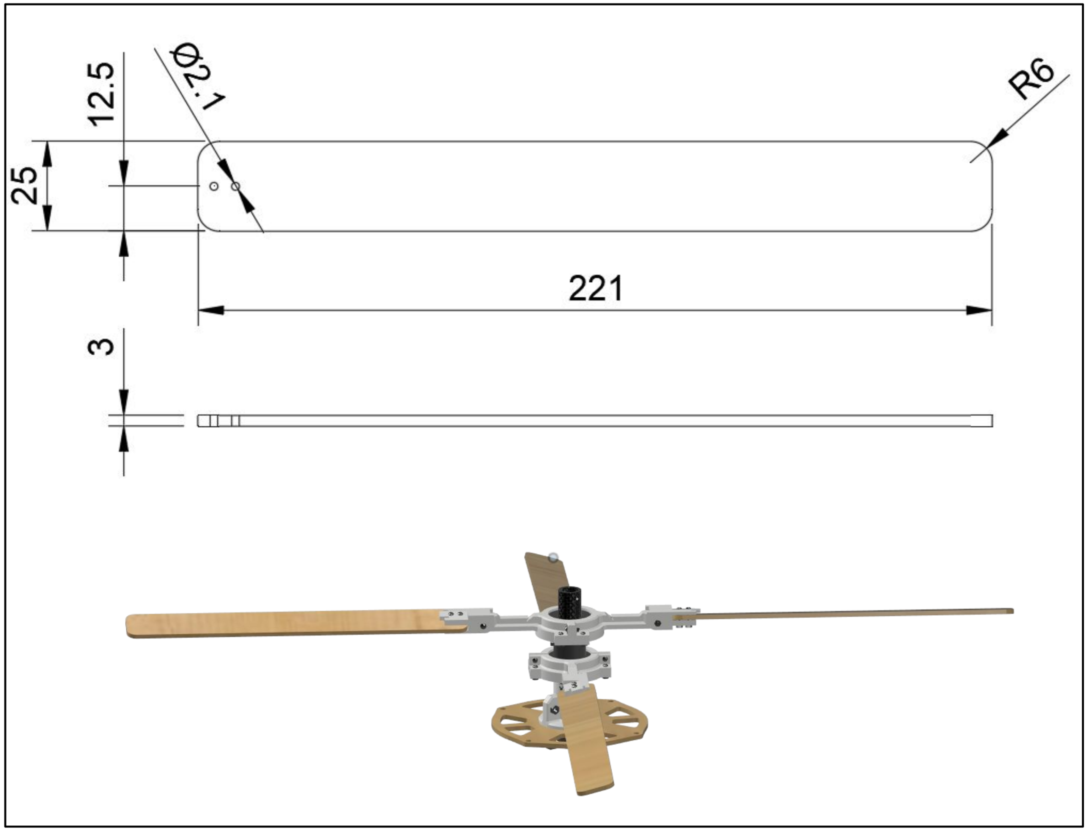
Auto-gyro Descent Control Summary (5/6)

Auto-gyro Descent Control Hardware & Key Design Considerations

Upper and lower **propeller dimensions** are same.
Its causes are;

1. Symmetrical Aerodynamic Load Distribution:
Propellers with the same diameter distribute the aerodynamic load in a balanced manner in the radial direction.
This ensures that the loads on the wing roots and connecting elements are distributed more symmetrical and balanced.

2. Moment Balance and Stability:
When the diameters are equal, the aerodynamic moments are more balanced.
Symmetrical moments occur in the yaw axis, reducing the vehicle's tendency to turn and making yaw control easier.

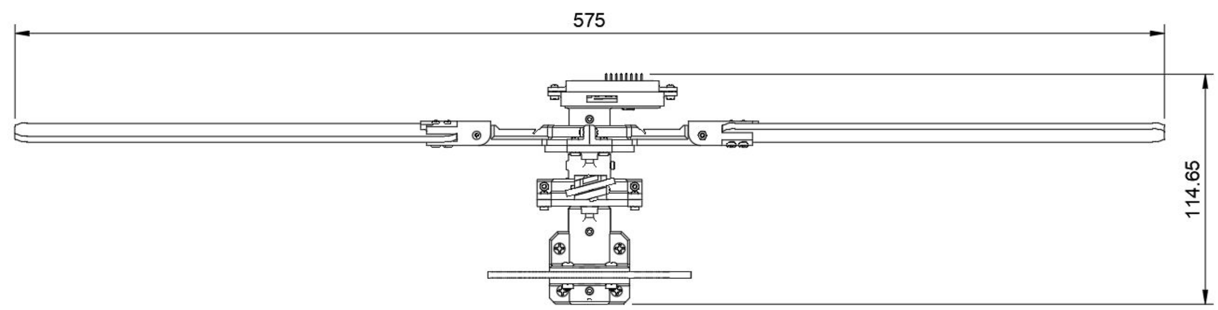


Wing Length: 221 mm
Chord Length: 25 mm
Wing Thickness: 3 mm
Upper and lower propeller dimensions are the same

Auto-gyro Descent Control Hardware & Key Design Considerations

1. Torque Elimination

•Two propellers in the coaxial structure rotate in opposite directions, completely eliminating the aerodynamic torque created by each other.
•In this way, an aerodynamically balanced structure is created in the system.



Coaxial Propeller

2. High Thrust Production

•Two propellers work together to provide higher aerodynamic thrust in the same area compared to a single propeller system.
•This creates higher lift capacity in smaller sizes.

3. Stable and Balanced Flight

• Thanks to the coaxial structure, the air flow is more balanced; stability is increased.
•Better aerodynamic stability and fixed position maintenance are provided, especially in hover situations.

4. Stability Against Wind and Side Air Currents

• The air flow effect created by two counter-rotating propellers reduces the disturbances created by environmental turbulences, providing a smoother and more stable flight.

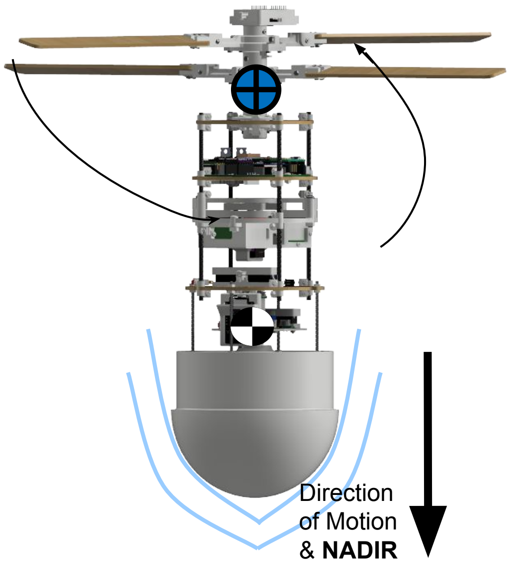
5.Reduced Aerodynamic Vibration

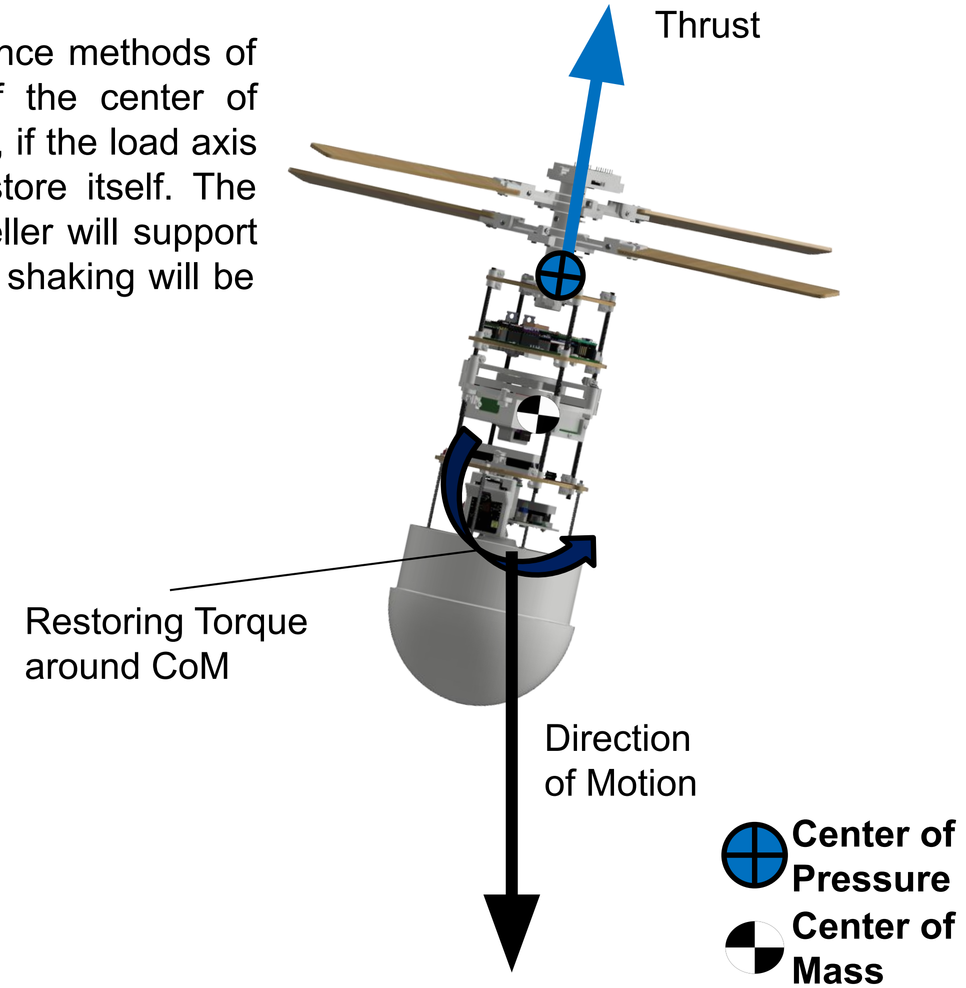
•Counter-rotation balances vibrations.

Auto-gyro Descent Stability Control Design (1/2)

Stability Strategy a Passive Method

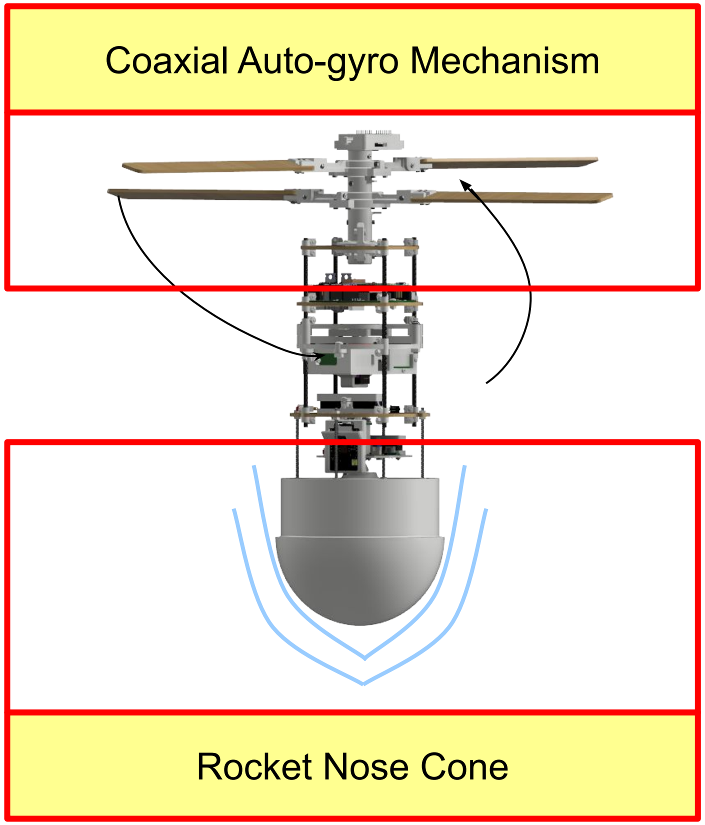
Selected passive method behaves like the balance methods of rockets, the center of mass will be in front of the center of pressure in the direction of motion. In other words, if the load axis deviates from the direction of motion, it will restore itself. The forces created by the forces formed on the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





Stability Strategy a Passive Method

The rocket nose cone and auto-gyro system work together to provide passive stability control and maintain nadir orientation. The nose cone improves aerodynamic stability by regulating airflow and minimizing unwanted yaw, while the auto-gyro's free-spinning rotors create a gyroscopic effect that dampens unbalanced movements. Relying on the balance between the center of mass and center of pressure, aerodynamic shaping, and rotor damping, this passive system ensures effective and consistent stability control throughout the flight.



Descent Rate Estimates (1/5)

Container Parachute Configuration

Type	Material	Cd	Mass (g)	Appx. Price [$]
Dome	Fabric	~1.5	10	2

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

$$A_p = \frac{2\,F_D}{\rho\,V^2\,C_d}$$

$$A_p = 0{,}95\,\pi\,{R_p}^2$$

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 (m²)
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

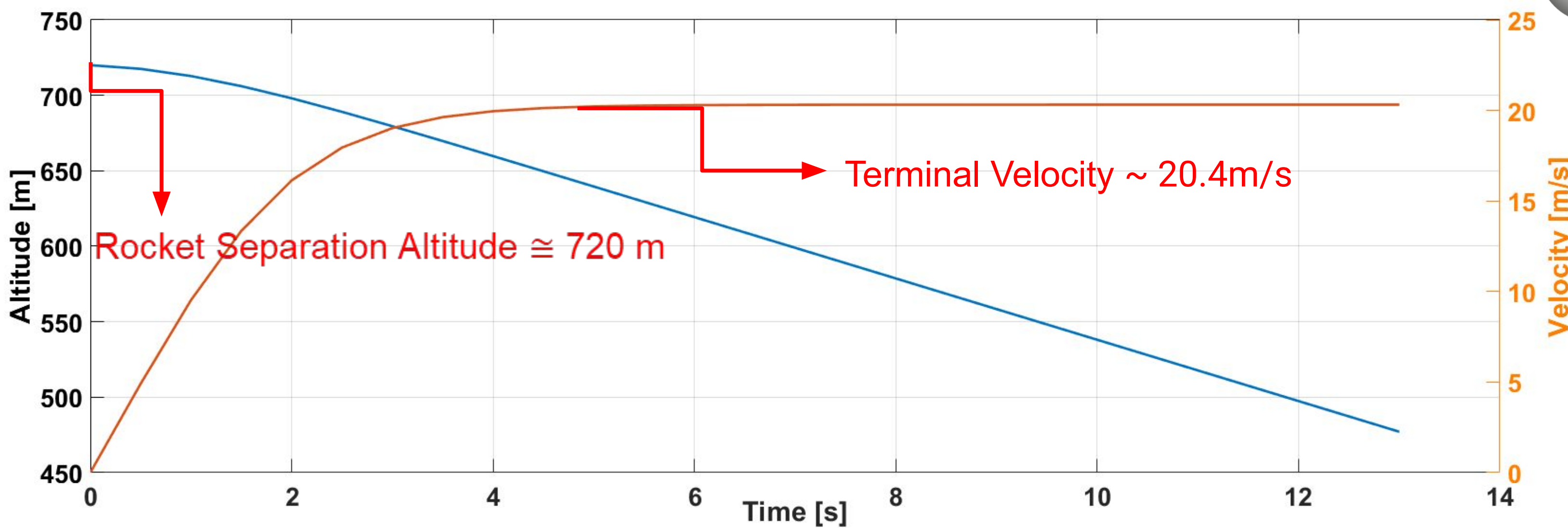
R_p: Radius of the Parachute (m)

ρ = 1.135 (kg/m³)

A_p = Reference Area

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

$F_D = W_{container} + W_{Payload} =$ 13.73 N



*720m (Peak Altitude) is an assumption

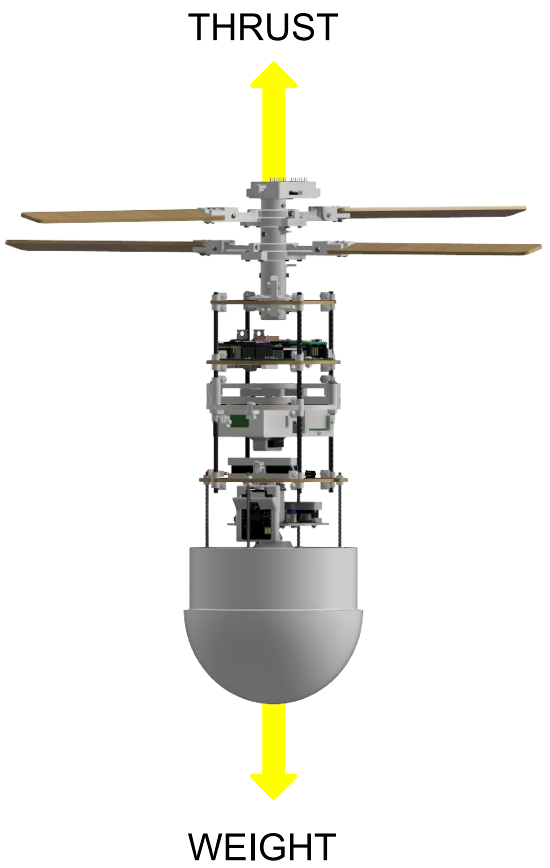
Descent Rate Estimates (3/5)

Payload Auto-gyro Configuration

Type	Material	Cd	Cl
Flat Plate	MDF	0.4	1.64

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

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



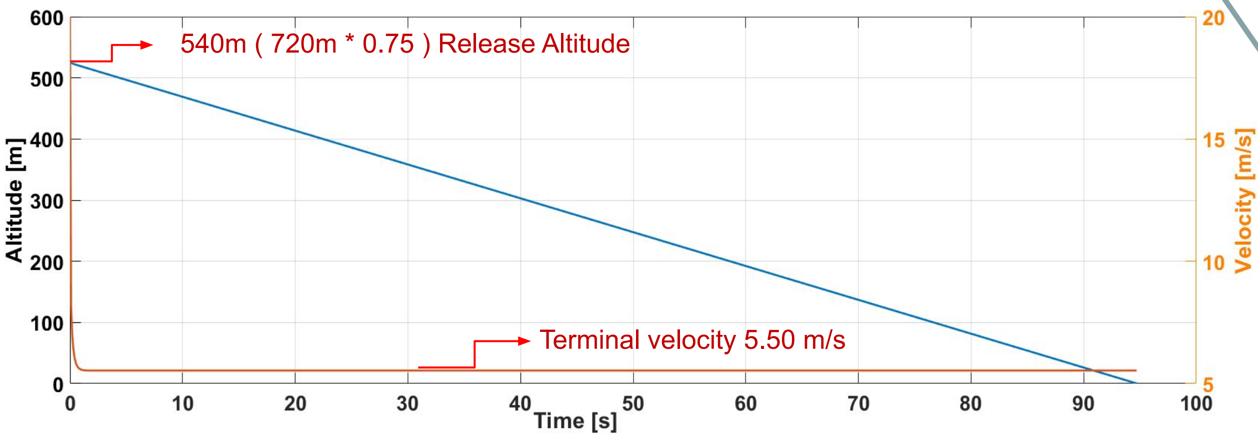
Descent Rate Estimates (4/5)

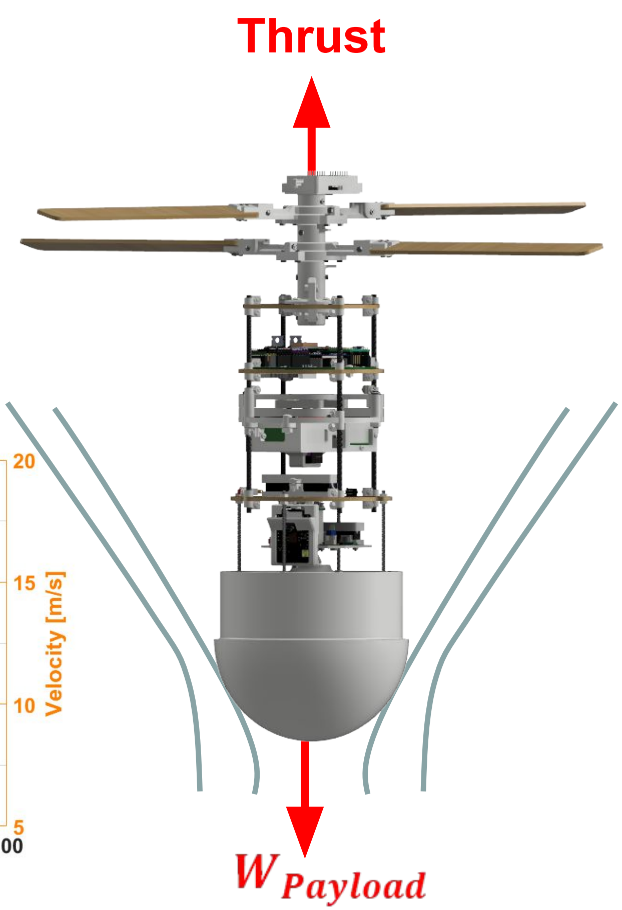
Payload Post Rocket-Separation Velocity Estimates

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 (m²)	Terminal Velocity (m/s)
0.221	0.30688	5.5 m/s

Thrust = Drag Force + Lift Force





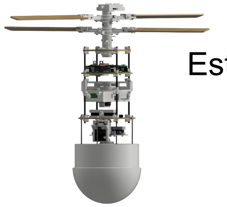
*720m (Peak Altitude) is an assumption

Descent Rate Estimates (5/5)

SUMMARY

Estimated Descent Rate of **the payload with the parachute deployed** is approximately 20.4 m/s.

Estimated Descent Rate of **the Container after deployment** is approximately 11.4 m/s.



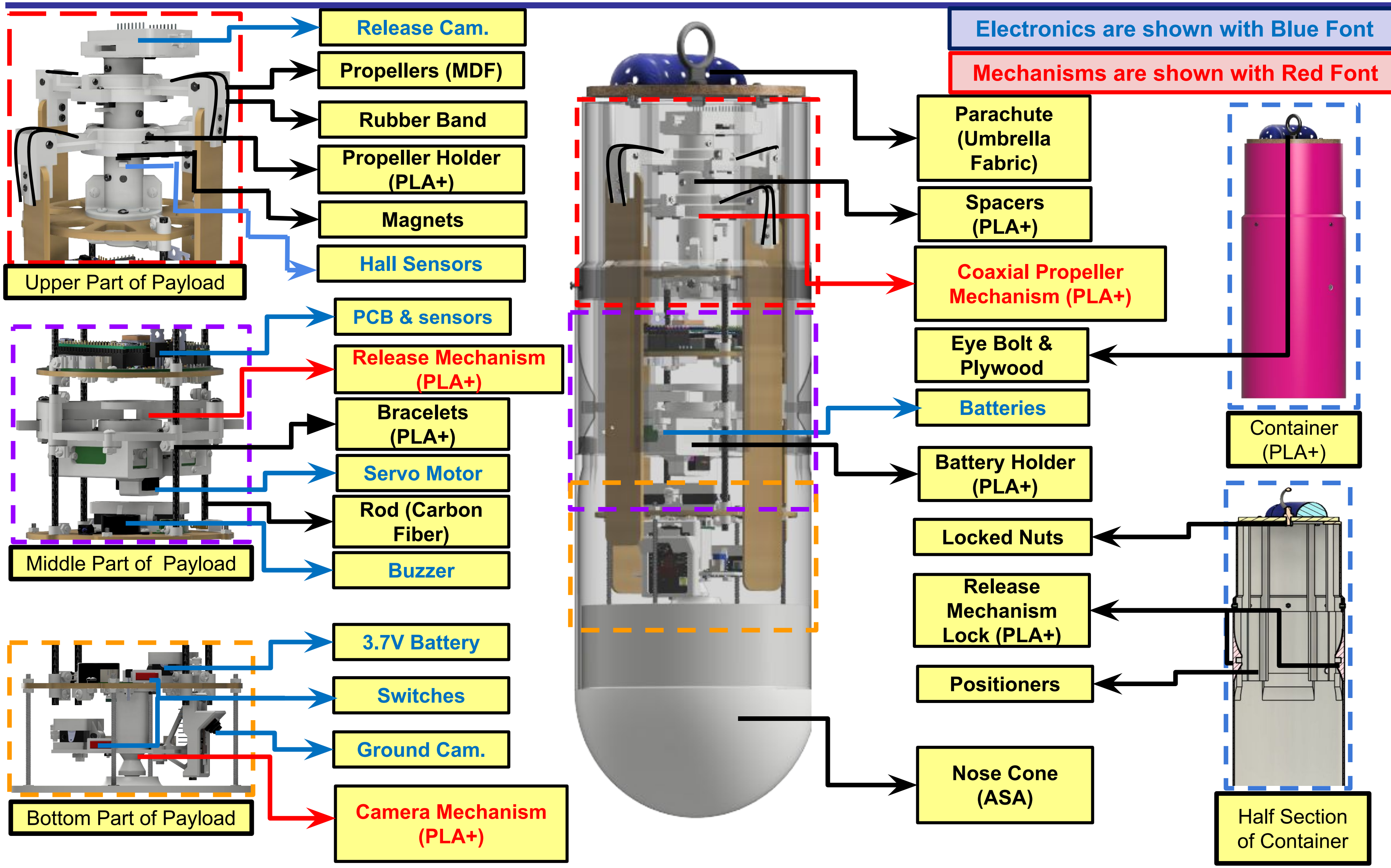
Estimated Descent Rate of **the Payload with auto-gyro** is approximately 5.5 m/s.

Configuration	Mass [g]	Descent Rate [m/s]
Container + Payload	1400.01	20.4
Container	619.04	11.4
Payload	780.97	5.5

Mechanical Subsystem Design

Alper ARTUC

Mechanical Subsystem Overview



Mechanical Subsystem Changes Since PDR (1/5)

Changes Overview

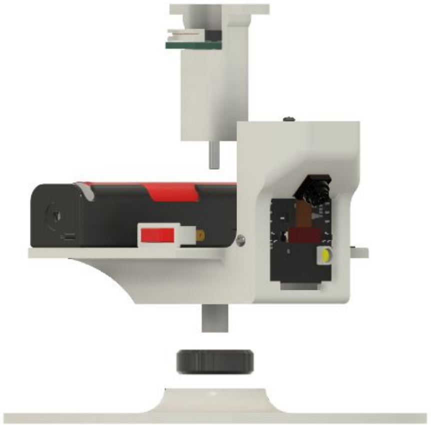
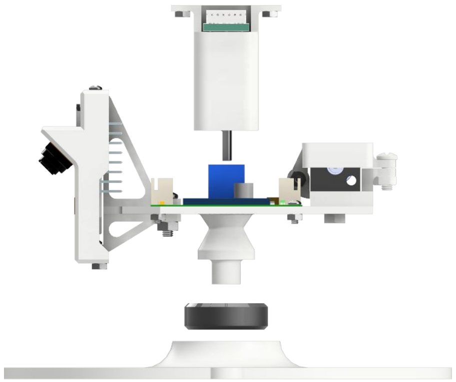
Components	PDR	CDR	Rationale
Release Mechanism Cover	Cover is covering all of the mechanism.	Cover only covers the arms.	Unnecessary mass.
Chassis	Consists steel rods.	Consists carbon fiber rods and clamps.	Decreases the mass.
Ground Camera Mechanism	Produced as one piece. Camera is close to the center.	Produced as two pieces. Camera is away from the center.	Easier to produce. Improved video angle for the camera.
Buzzer MDF Plate	Buzzer had its own special plate.	Buzzer is placed on the plate above the ground camera mechanism.	Unnecessary mass and obtain a more spacious structure.
Container	Propeller slots are the same length as propellers.	Propeller slots are shorter than propellers.	Unnecessary mass.
Rocket Nose Cone	Nose Cone Length: 200 mm	Nose Cone Length: 126 mm	Unnecessary mass.
3.7V Battery Holder	Were secured with clamps.	A separate cover was designed.	The clamp had to be cut and replaced constantly. A more reliable solution was developed.

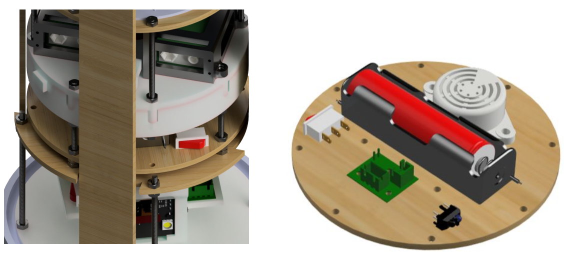
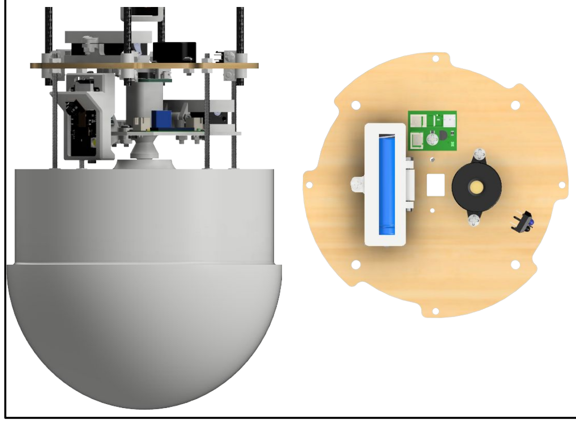
More detailed explanations are discussed in subsequent slides.

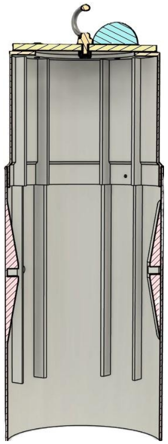
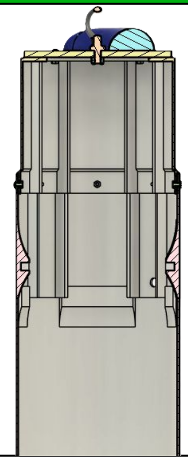
Mechanical Subsystem Changes Since PDR (2/5)

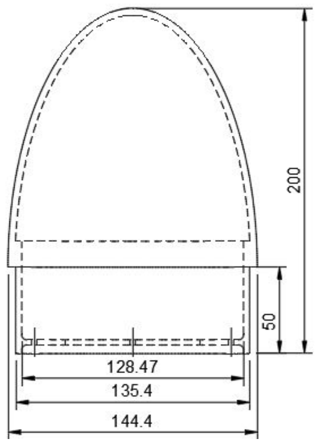
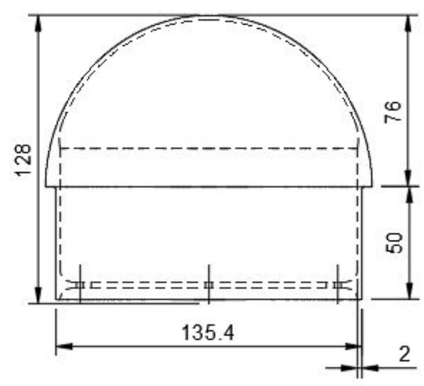
PDR - Release Mech. Cover	Rationale	CDR - Release Mech. Cover.
	The separation tests and the loads on the cover under force were analyzed. And the cover was redesigned and produced with only the necessary areas. At the same time, we increased the thickness of the load-bearing areas and obtained a more durable cover.	

PDR - Chassis	Rationale	CDR - Chassis
	The old chassis was modular and its levels had to be adjusted by measuring them one by one with bolts. There is no such problem with the new carbon fiber chassis, and we achieved the same performance with a flat structure. Since the new chassis only has a region where we want the connection security to be high between the rocket nose cone and the camera plate, and the diameter is different from the diameter of the satellite in that region, we preferred that only that region be a steel chassis. We use our own designed clamps instead of nuts on the carbon fiber chassis.	

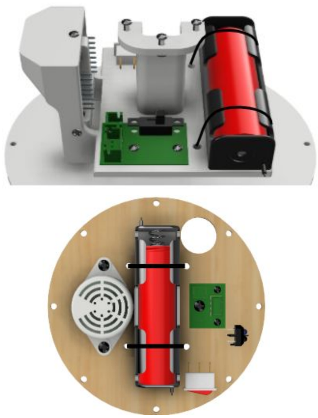
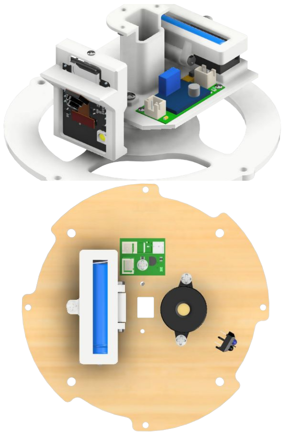
PDR - Ground Cam Mech.	Rationale	CDR - Ground Cam Mech.
	In the tests, when the camera mechanism was shooting 45 degrees north, the rocket nose cone borders were visible from below. We made changes to the design to lengthen the structure. The changes made to the same design were to remove unnecessary parts and add only necessary components, increasing the camera's viewing angle and achieving a lighter camera mechanism with the same durability.	

PDR - Buzzer MDF Plate	Rationale	CDR - Buzzer MDF Plate
	In the old design, the buzzer battery was large and it was difficult to place a buzzer that worked with a separate switch without a separate plate. When testing for CDR, the same performance was obtained from the buzzer with smaller batteries. A separate plate for the buzzer was cancelled. The buzzer was mounted on the camera mechanism.	

PDR - Container	Rationale	CDR - Container
	As a result of the tests, short slots and long slots showed the same level of performance between the pre-deployment and deployment stages. Since the structure's strength decreased slightly after the slots were shortened, an addition was made in the middle to strengthen it. Since the distances within the structure changed with the new arrangements, the connection point of the separation mechanism also changed.	

PDR - Rocket Nose Cone	Rationale	CDR - Rocket Nose Cone
	When rocket nose cone calculations and analyses were made, it was realized that they showed approximately the same performance. It saved the structure from unnecessary weight. It reduced production time and costs.	

Mechanical Subsystem Changes Since PDR (5/5)

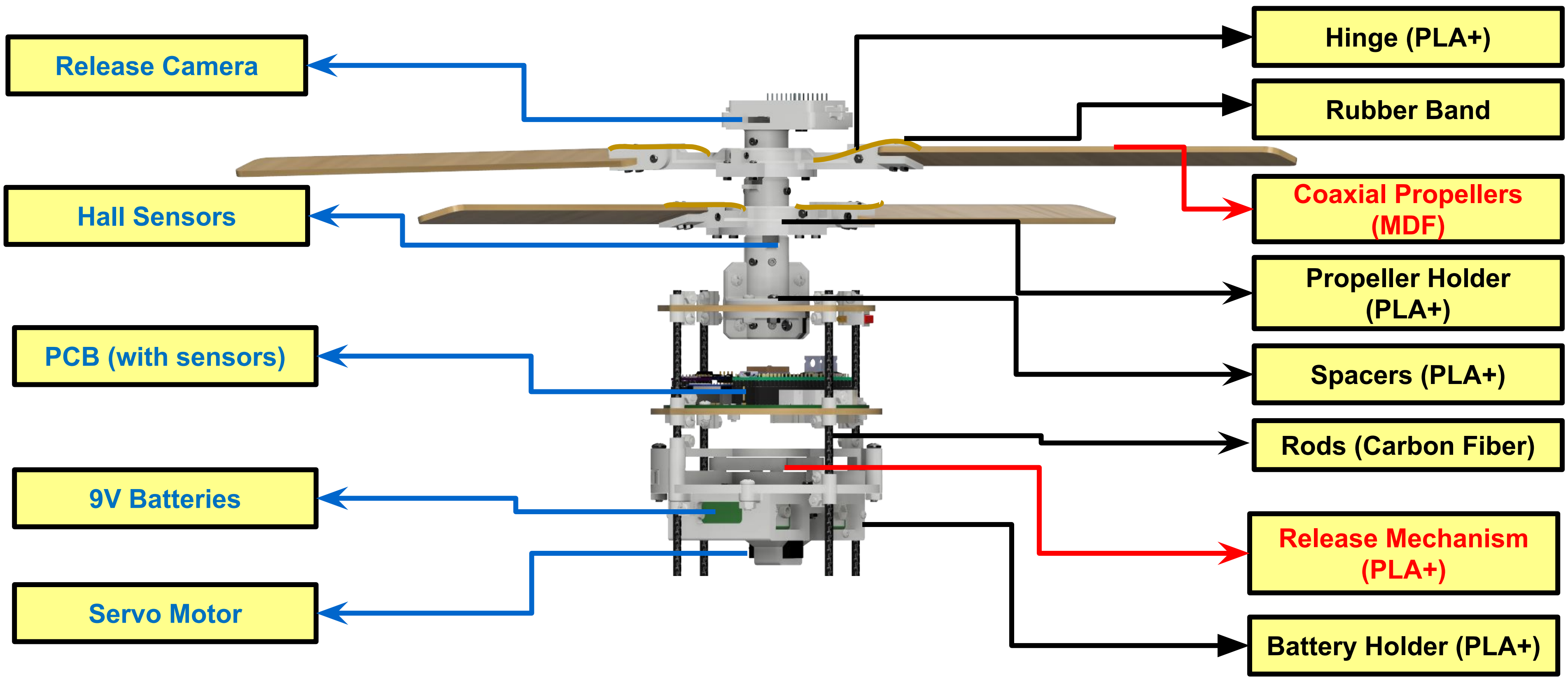
PDR - 3.7V Battery Holder	Rationale	CDR - 3.7V Battery Holder
	The clamp had to be cut and replaced constantly. A more reliable solution was developed. In addition to obtaining a structure that is more resistant to shock and vibration, a structure that can be used continuously was obtained.	
	PDR → CDR	

Cansat Mechanical Layout of Components (1/10)

Upper Part of Payload

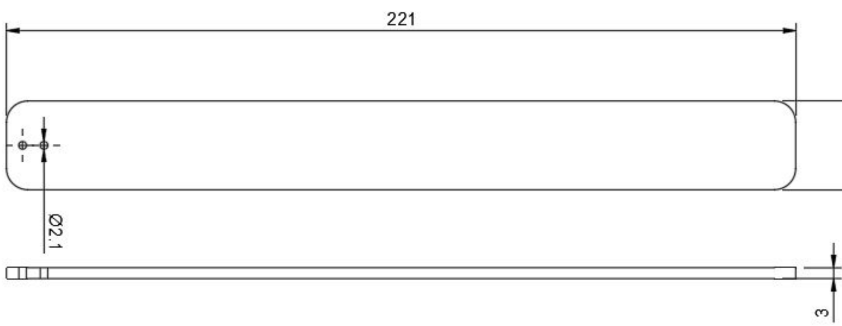
Electronics are shown with Blue Font

Mechanisms are shown with Red Font

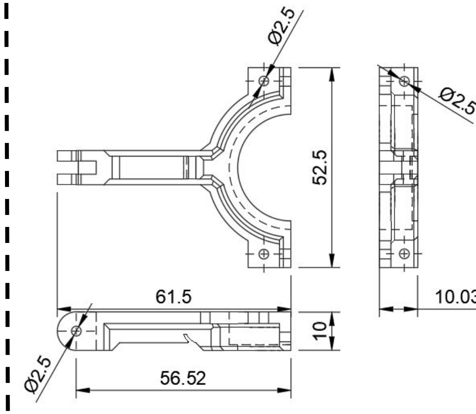


Cansat Mechanical Layout of Components (2/10)

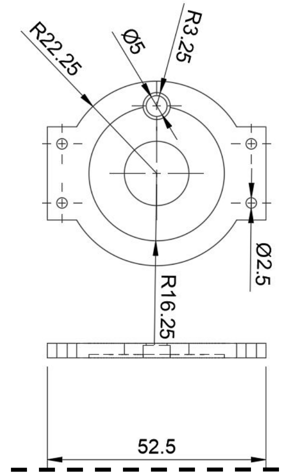
Coaxial Propellers



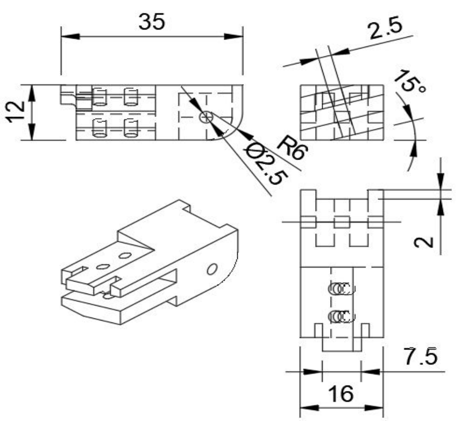
Propeller Holder



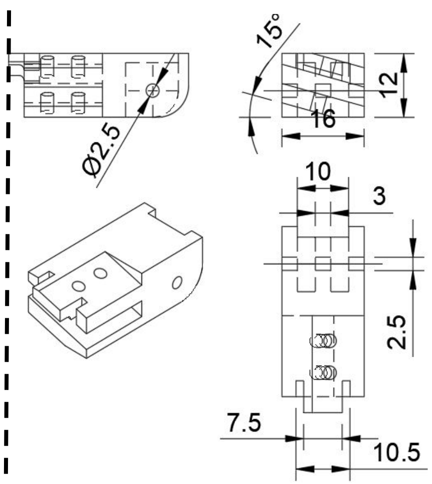
Propeller Holder Bottom Cover



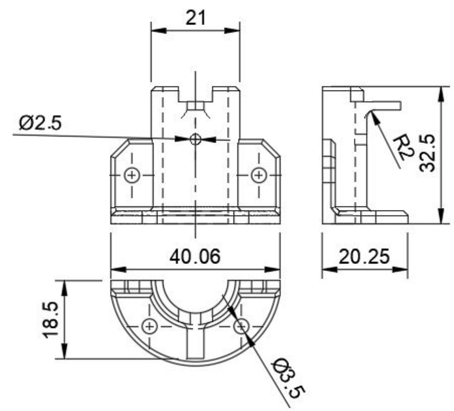
Hinge CCW



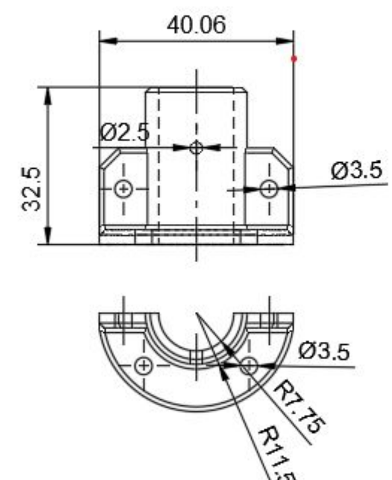
Hinge CW



Spacers

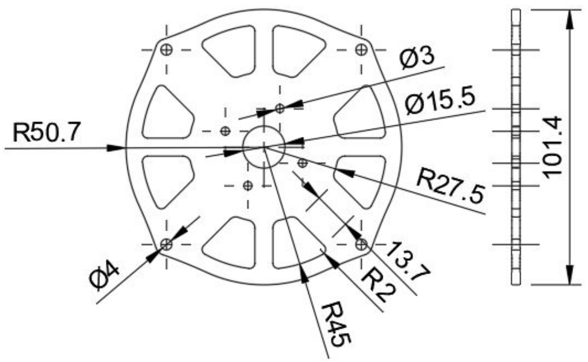


Spacers

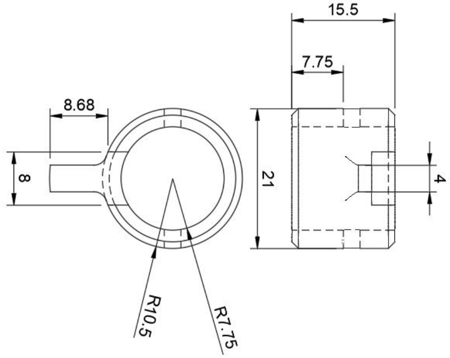


All dimensions are in mm

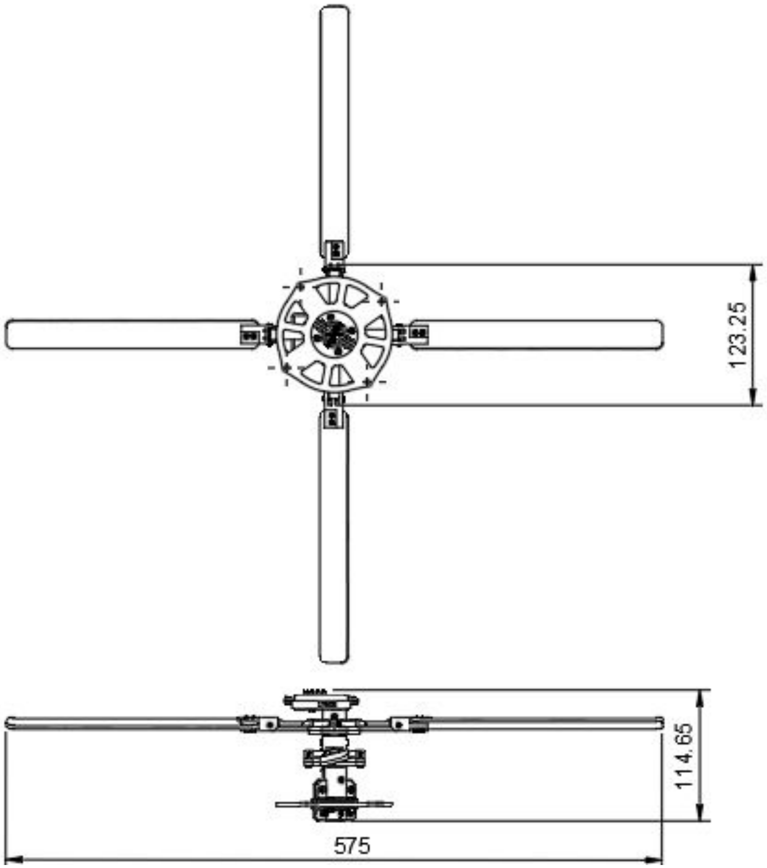
Propeller Plate



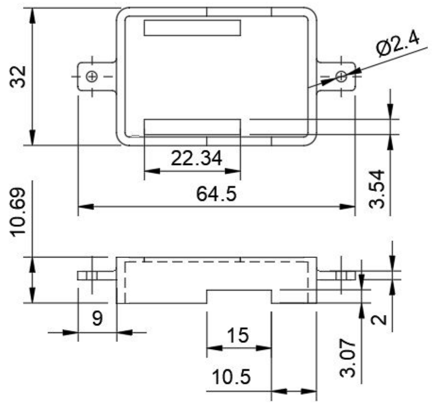
Propeller



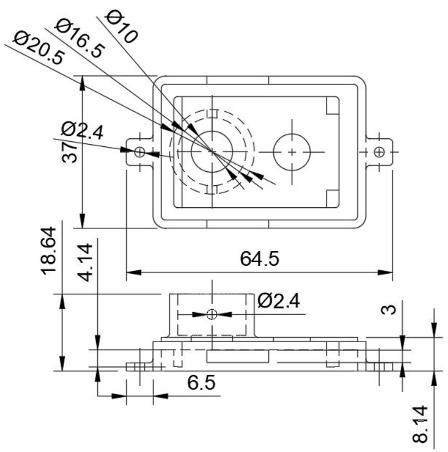
Coaxial Propeller Mechanism



Release Camera Holder Cover



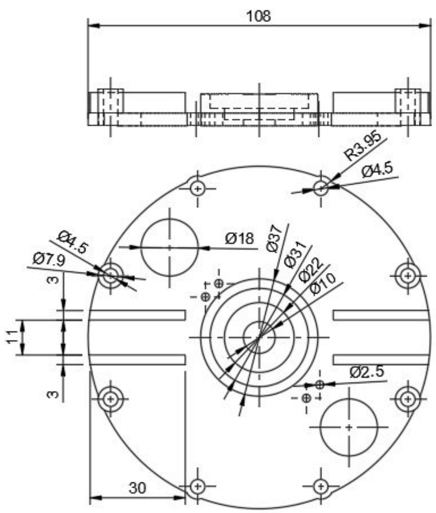
Release Camera Holder



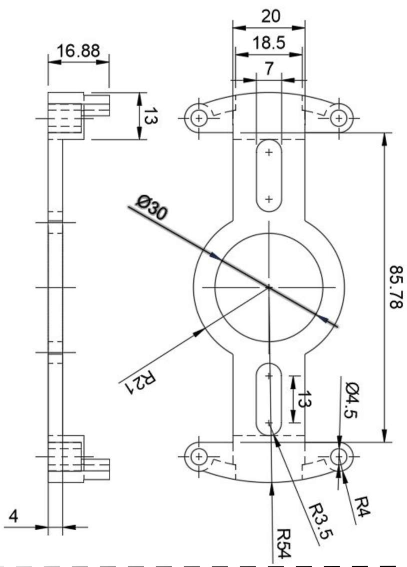
All dimensions are in mm

Cansat Mechanical Layout of Components (4/10)

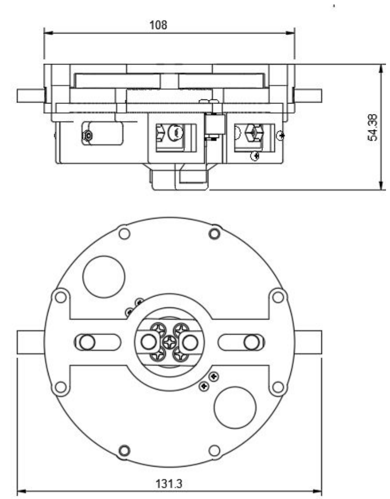
Release Mechanism Plate



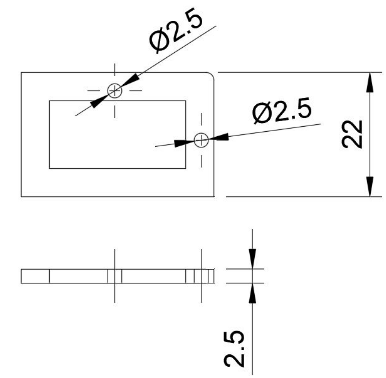
Release Mechanism Cover



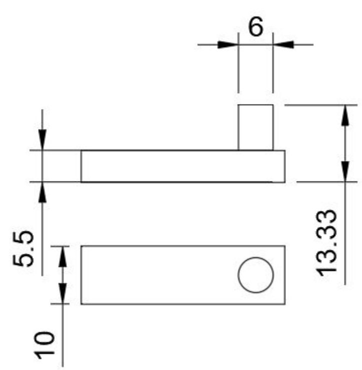
Release Mechanism



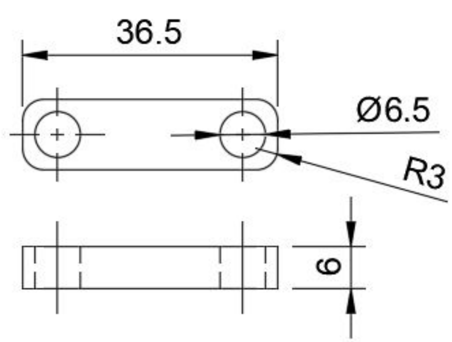
Battery Holder Cover



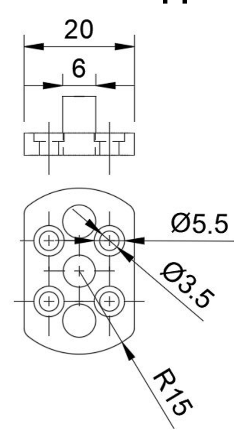
Release Mechanism Arm



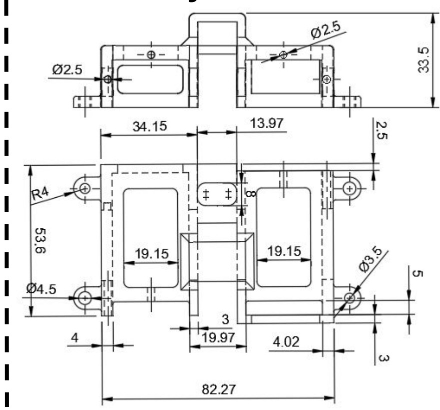
Release Mechanism Transmission Arm



Release Mechanism Transmission Apparatus



Battery Holder



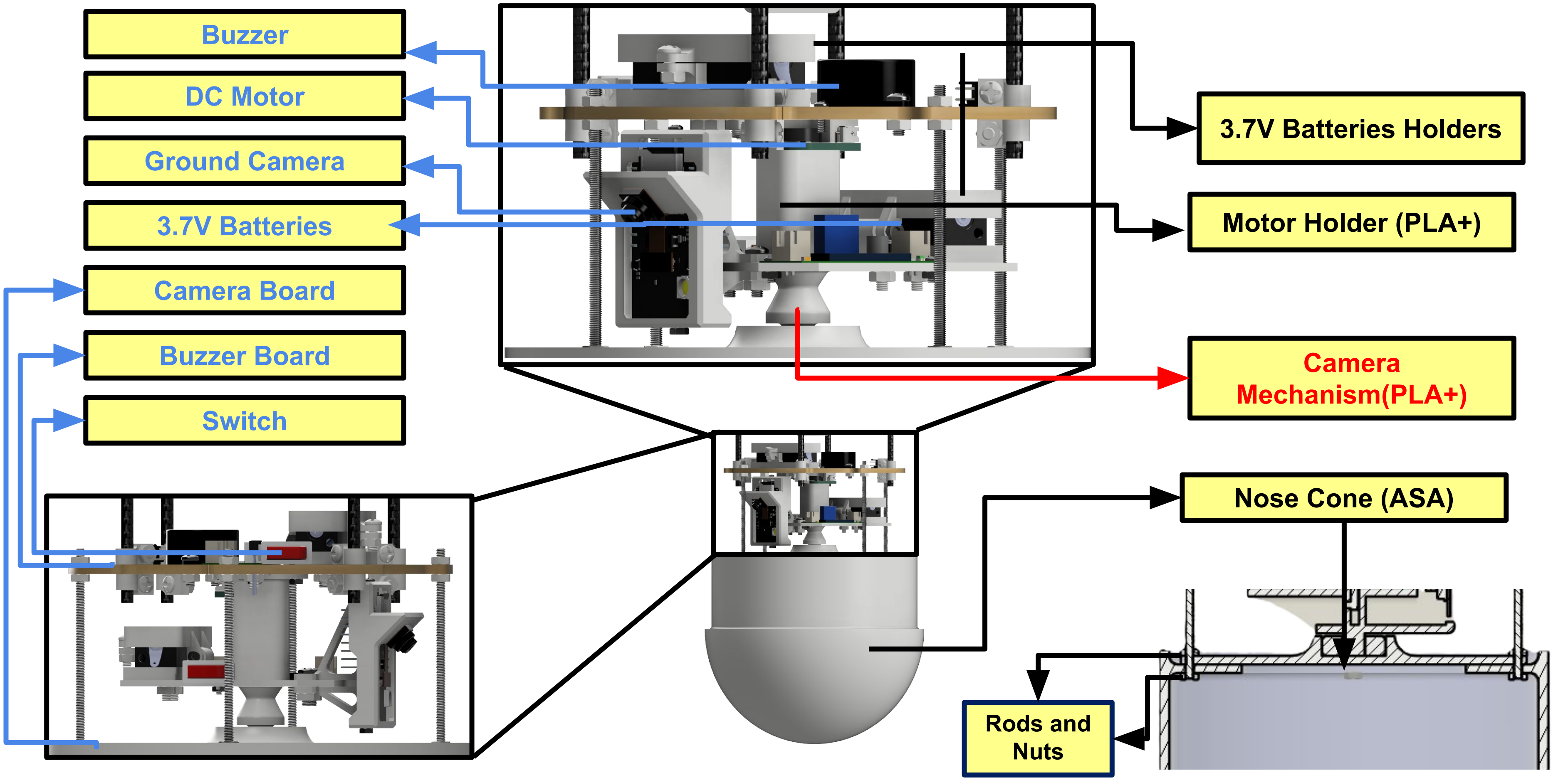
All dimensions are in mm

Cansat Mechanical Layout of Components (5/10)

Bottom Part of Payload

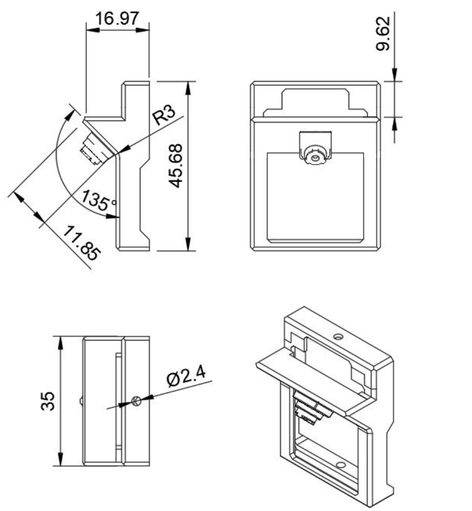
Electronics are shown with Blue Font

Mechanisms are shown with Red Font

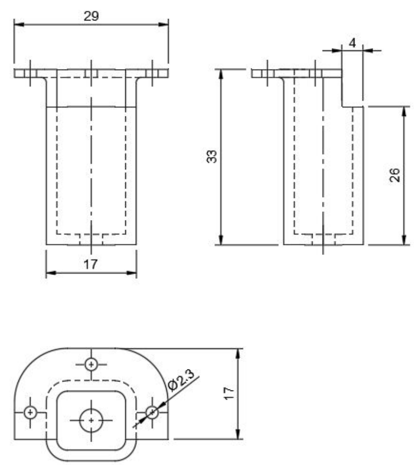


Cansat Mechanical Layout of Components (6/10)

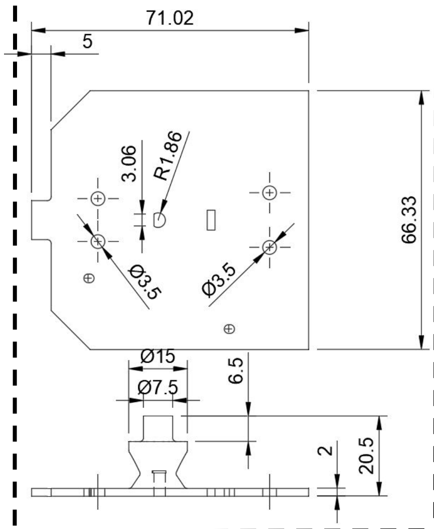
Camera Holder



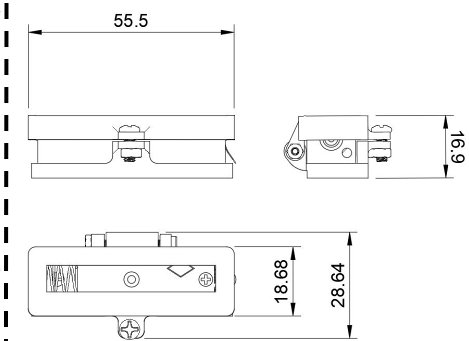
Motor Holder



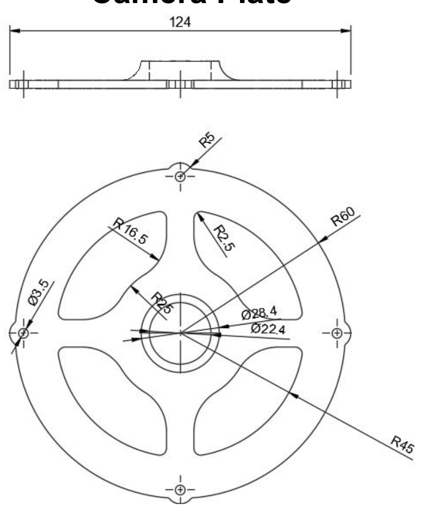
Camera Mechanism Plate



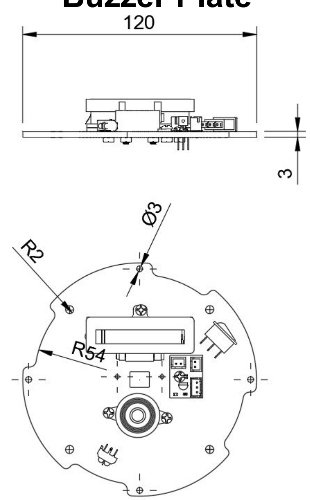
Battery Holder Cover



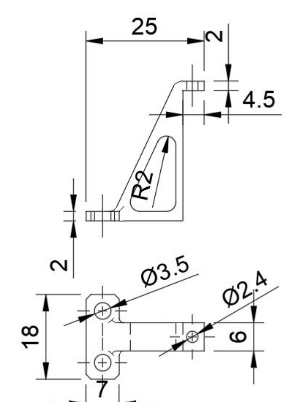
Camera Plate



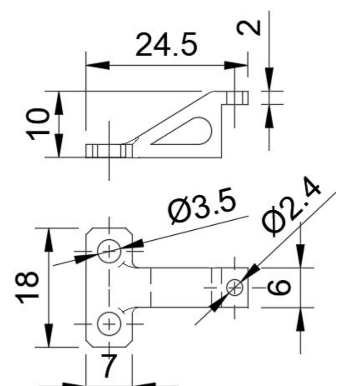
Buzzer Plate



Camera Holder 1

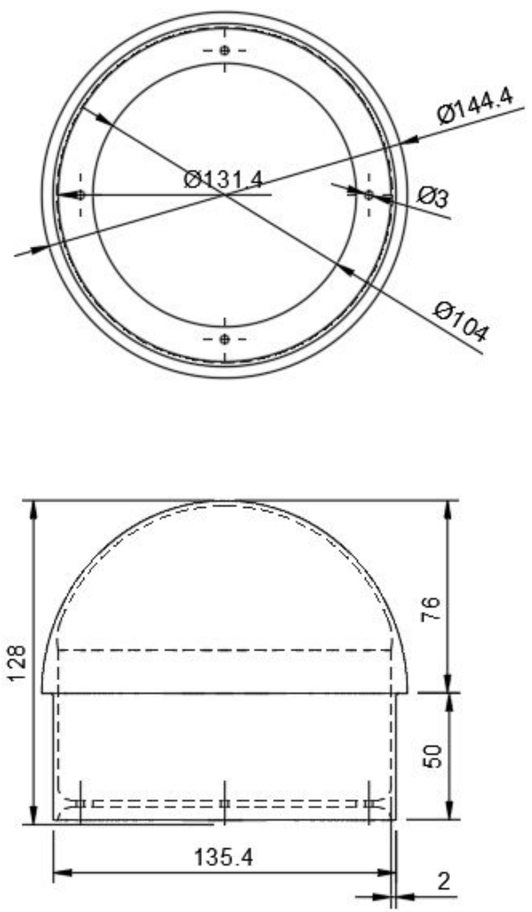


Camera Holder 2

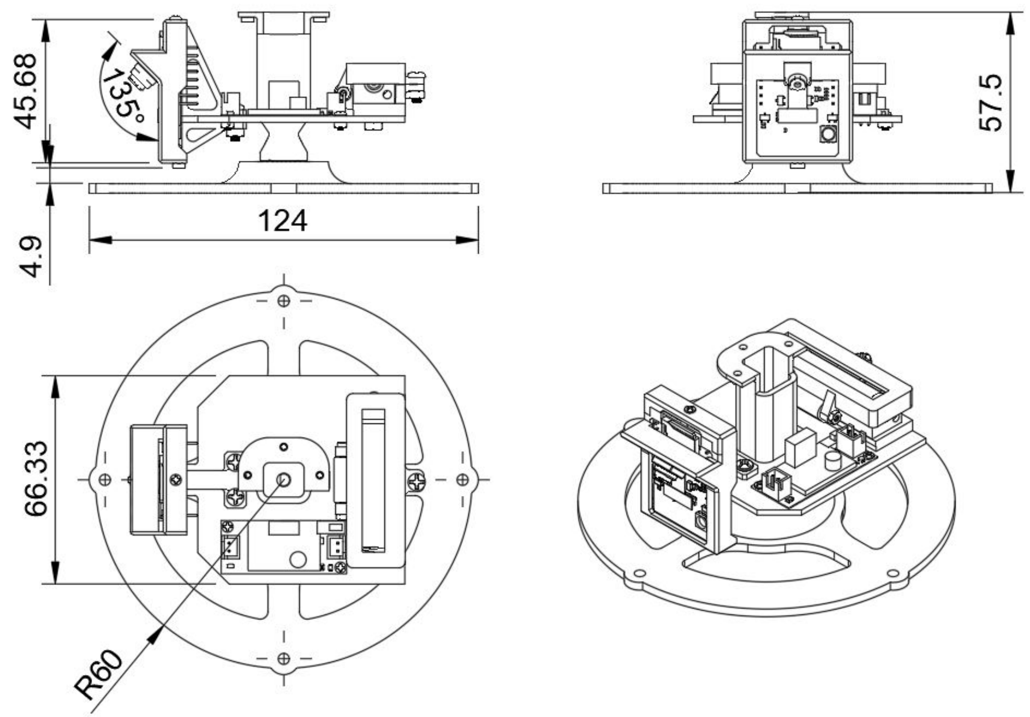


All dimensions are in mm

Nose Cone



Camera Mechanism



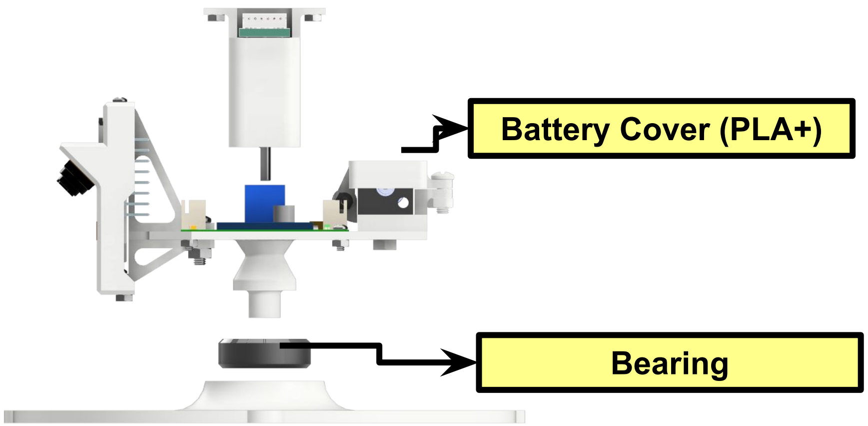
All dimensions are in mm

Cansat Mechanical Layout of Components (8/10)

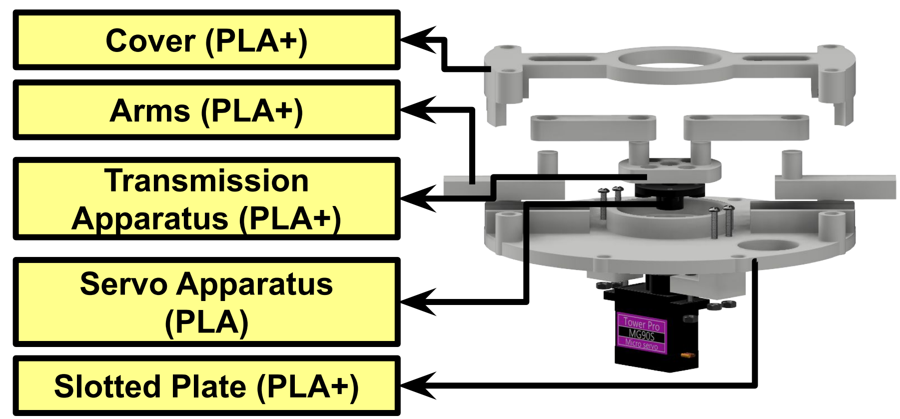
Payload

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

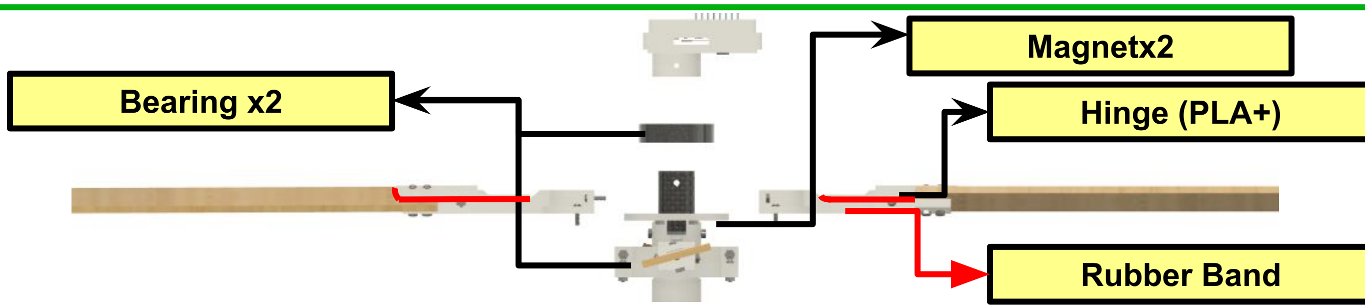
Camera mechanism invisible components



Release mechanism invisible components



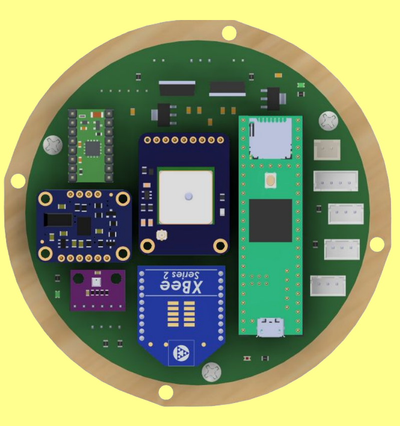
Coaxial Propeller invisible components



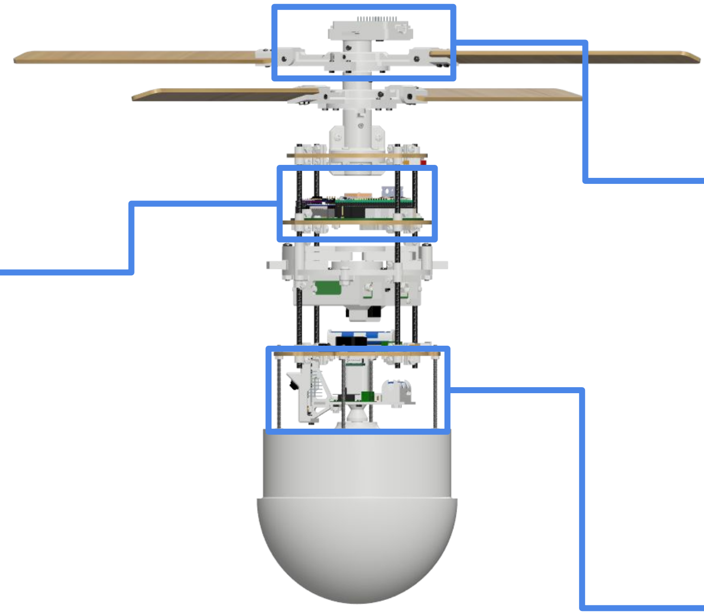
Cansat Mechanical Layout of Components (9/10)

Payload Components Shown

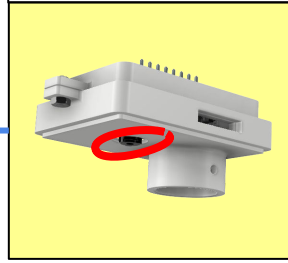
PCB



PCB is located on upper part of the payload. PCB contains the CDH, Radio Antenna, GPS Antenna and All sensors.

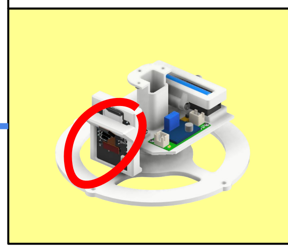


Release & Auto-gyro Camera



The auto-gyro and release camera upper part of the payload is located on top of the coaxial propellers.

Ground Pointing Camera



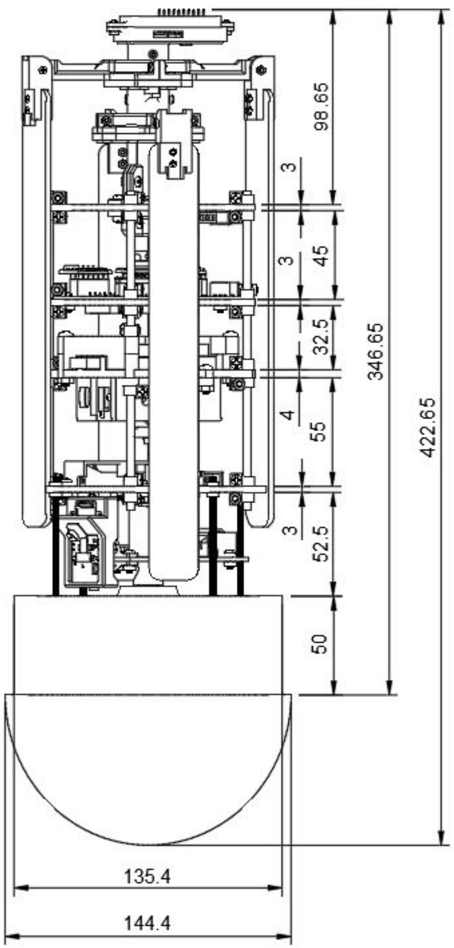
Ground pointing camera bottom part of payload is located in the camera mechanism.

Payload has no any tether attachment point.

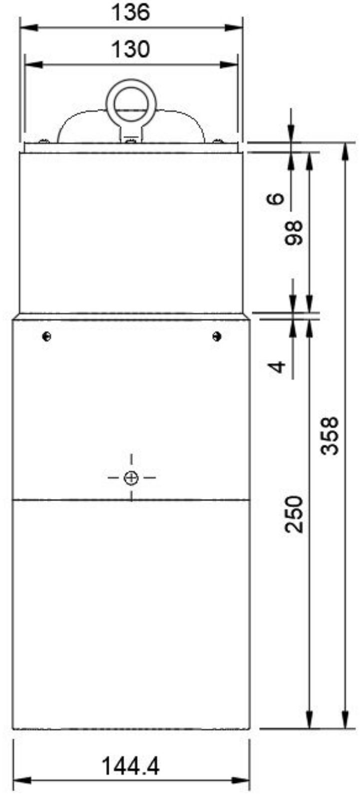
All the remaining details of the payload are previous sections of the report, together with the upper part of payload and bottom part of payload titles and related measurements.

Cansat Mechanical Layout of Components (10/10)

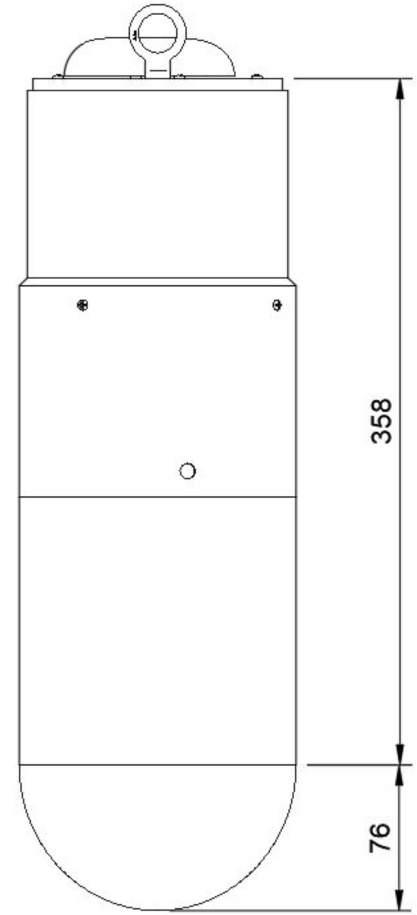
Payload Dimensions (Stowed)



Container Dimensions



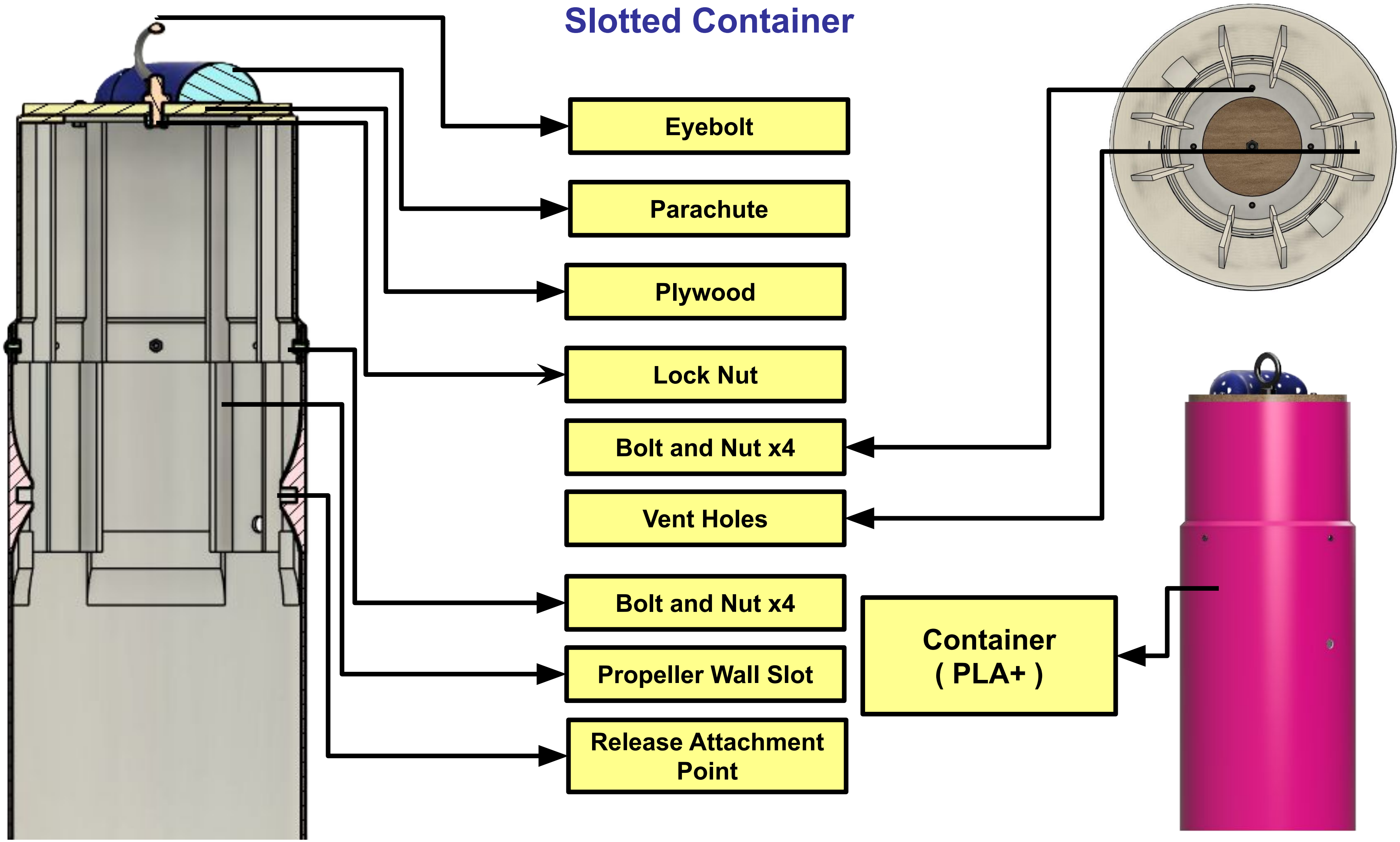
Container+Payload Dimensions



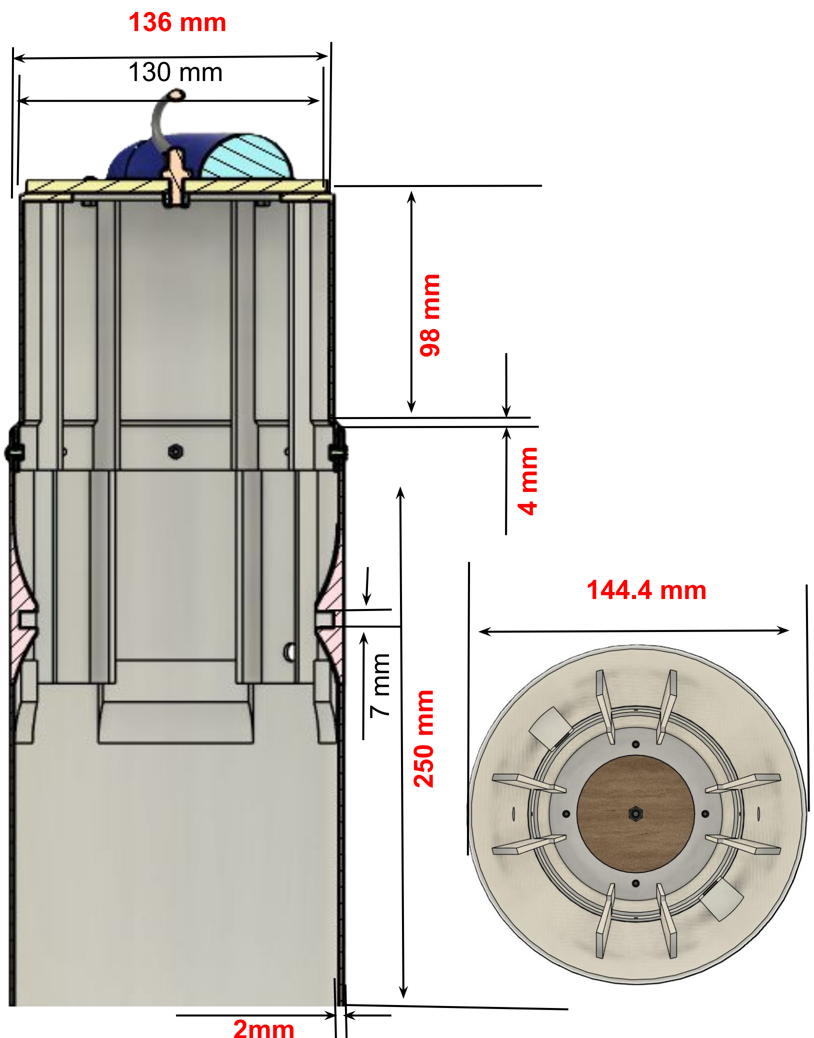
All dimensions are in mm

Container Design (1/3)

Slotted Container



Slotted Container

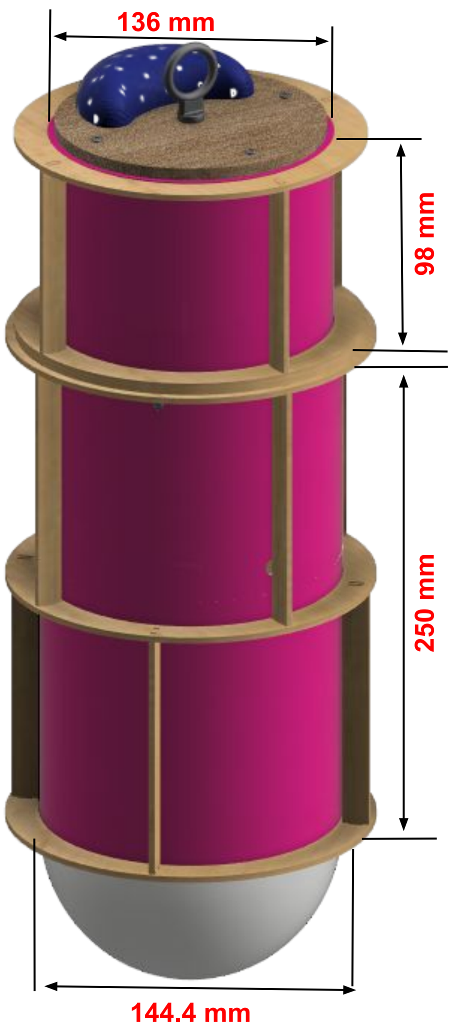


Modification Used to Support Stowing of Payload

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 7.5 mm deep, 7 mm long, and 12 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.

Container Design (3/3)

Proper Fit Control Mold



Shoulder Dimensions Verified For Proper Fit

A mold will be designed to ensure the accuracy of the dimensions. The accuracy of the container's shoulder dimensions and all other dimensions will be checked by placing it inside this mold.

Defectiveness caused by 3D printing during the production of the container will be corrected with the help of sandpaper, complying with the minimum 2 mm wall thickness requirement.

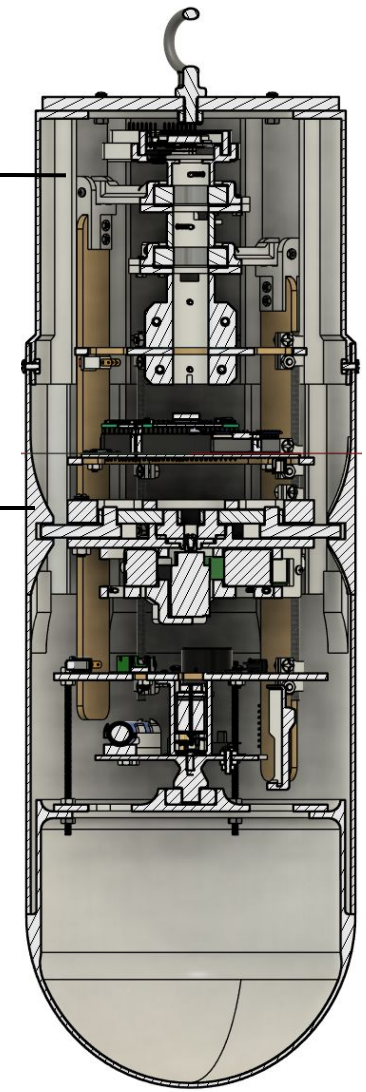
- **The container shall be 3D printed with a shoulder with a length of 90 to 120 mm and a diameter of 136 mm.**
- **The container shall be wider at 144.4 mm diameter above the shoulder and be 250 mm tall.**
- **The thickness of the container walls shall be at least 2 mm.**

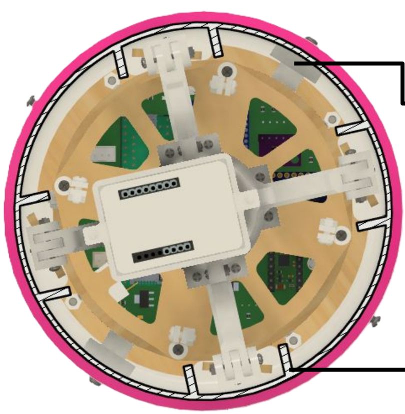
The mold was produced by laser cutting. In order to have clear and close dimensions as desired.

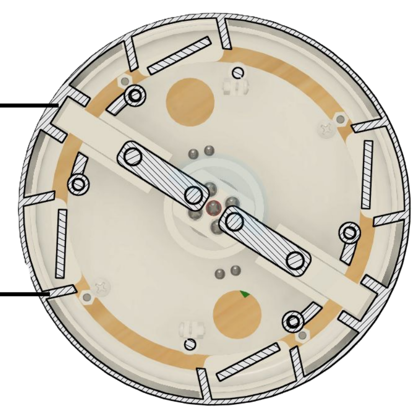
Payload Pre-Deployment Configuration (1/3)

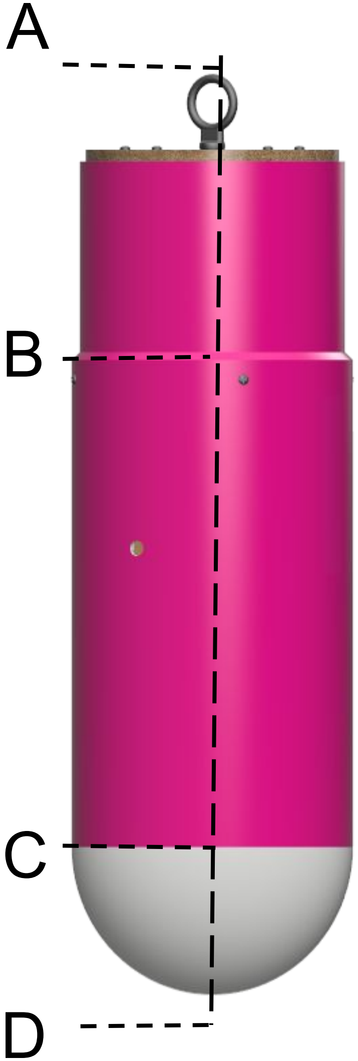
The propeller blades remain positioned within their own slots, contributing to the overall stability and security of the container.

Before deployment, the payload is secured by the separation arms, which fit into designated slots in the container.

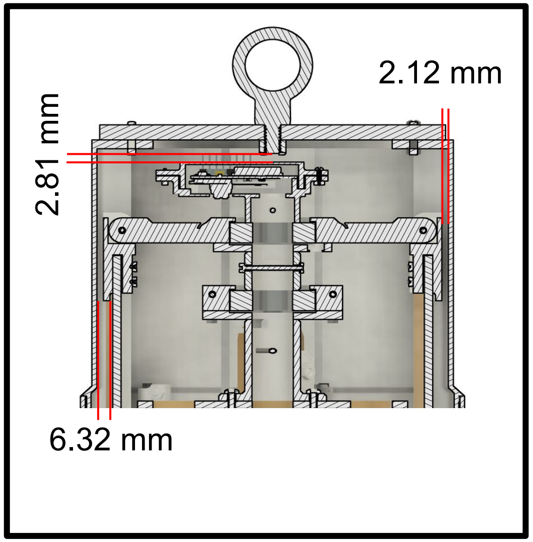




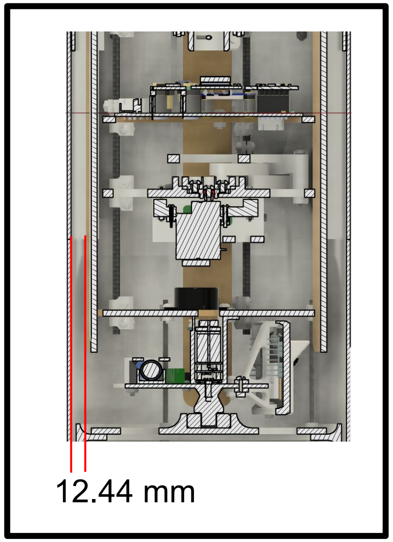




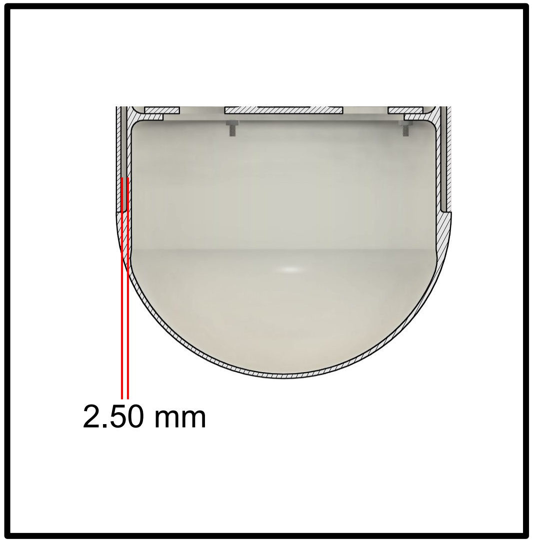
Section A-B Clearances



Section B-C Clearances

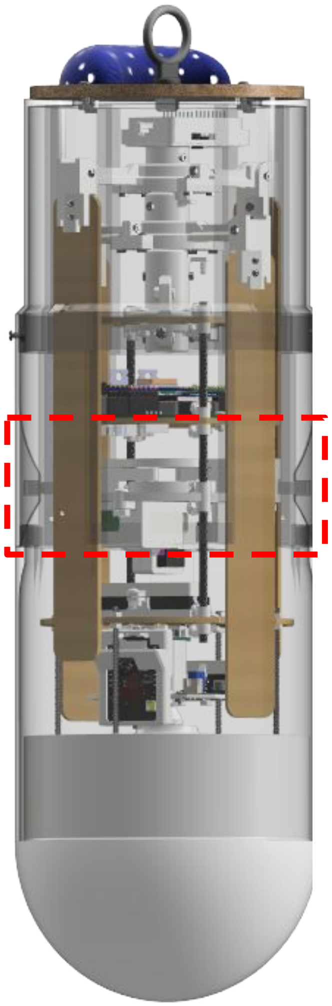


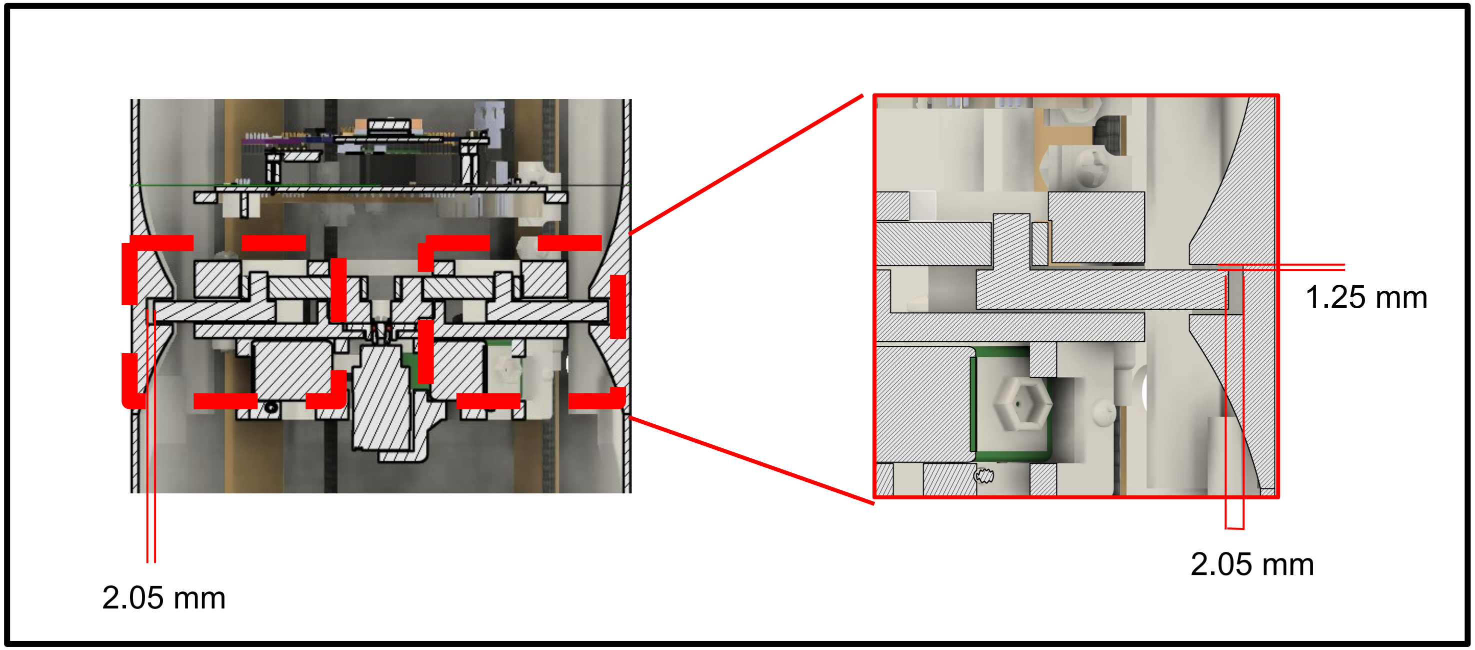
Section C-D Clearances



- **The wing slots were added to prevent the load from losing its configuration before separation and to prevent any collisions.**
- **Wing slots were designed for the container to protect the wing positions while being placed inside the cargo container.**
- **In order to protect this structure healthily and to prevent any damage and protection of the mechanism and plate, the necessary clearances were given between the container and the payload.**

Payload Pre-Deployment Configuration (3/3)

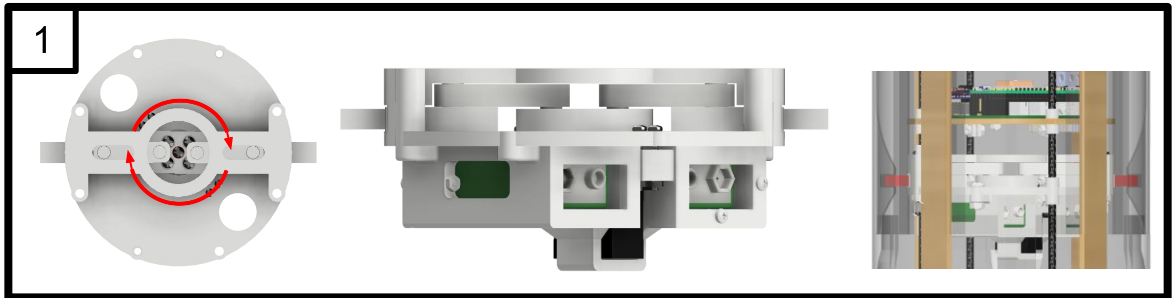




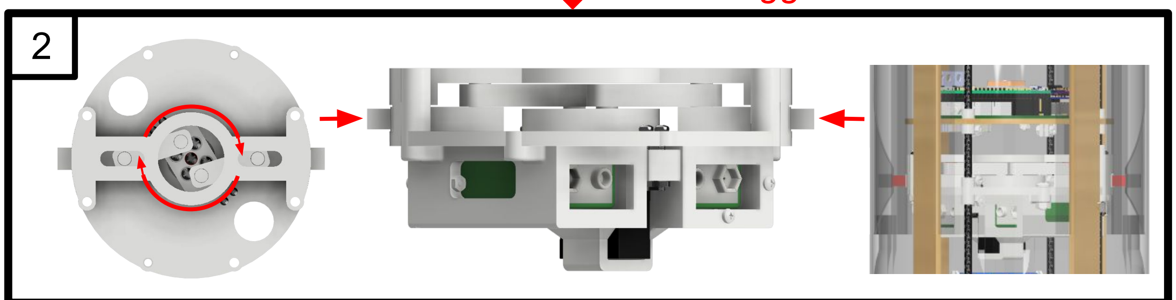
- The dimensions were carefully adjusted to minimize the swinging movement before the load is separated inside the attachment where the separation arms will enter.
- The release mechanism was preferred to be a two-arm mechanism for pre-deployment configuration protection.

Payload Release (1/3)

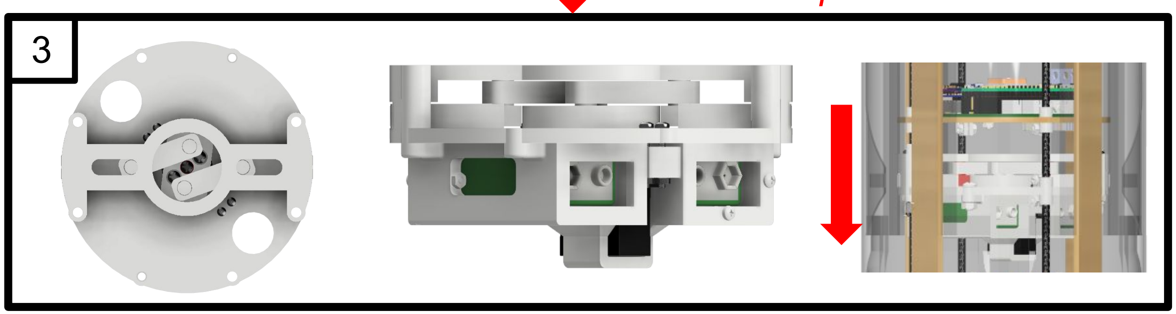
Stages of Releasing Process at 75% Peak Altitude

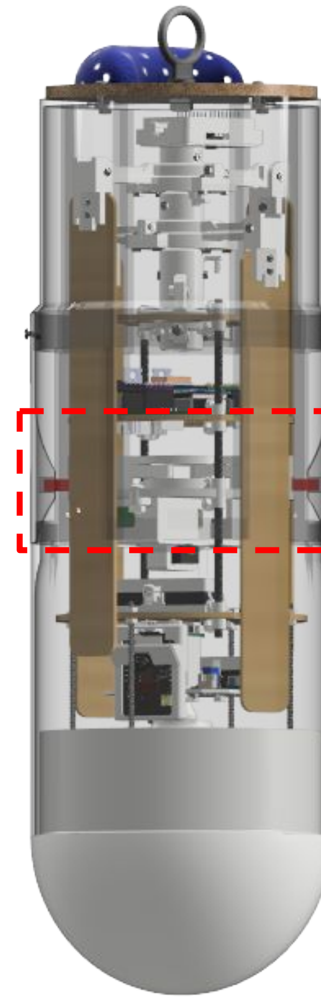


Servo triggered at 75% Peak Altitude.



The release process has been completed.



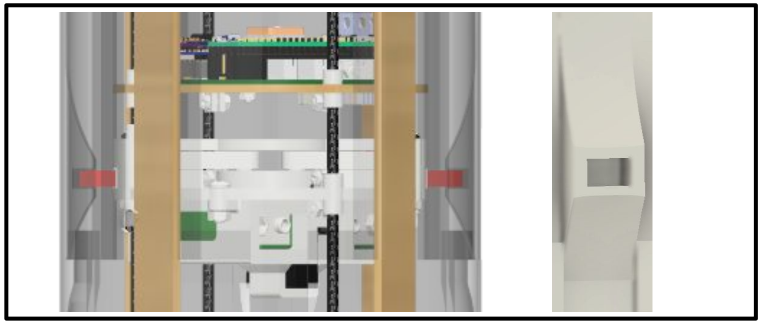


The container has been made transparent to make the system more understandable. The original will be pink.

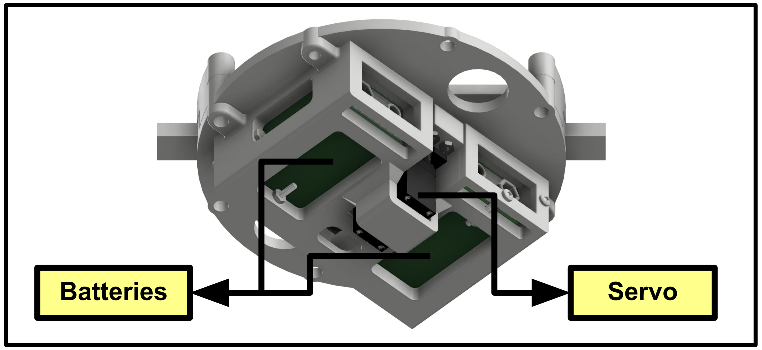
Payload Release (2/3)

Slider Crank Release Mechanism - Working Principle

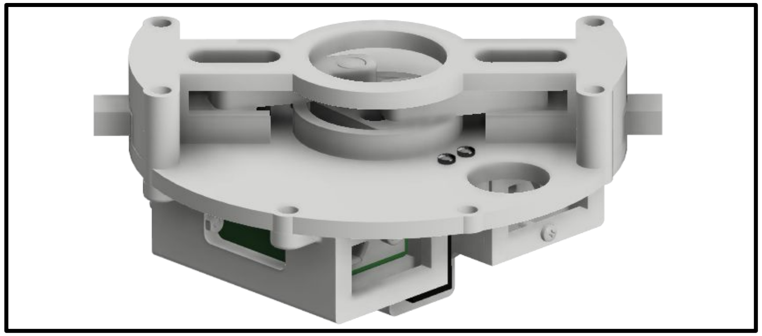
The release mechanism secures the payload within the container using two arms inserted into the container's wall slots.

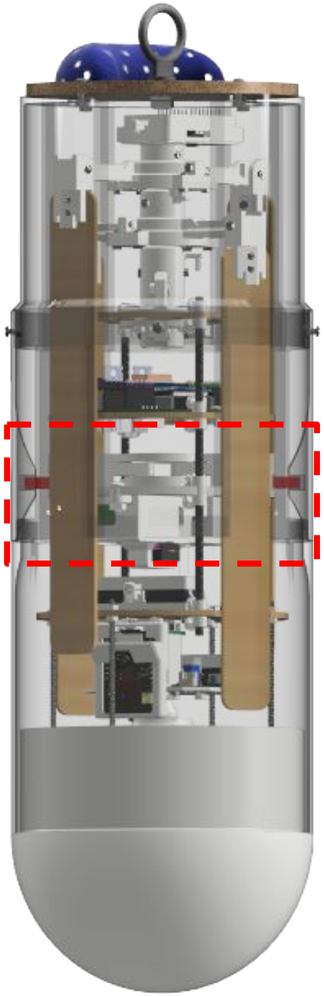


The trigger for the servo is the CanSat reaching 75% of its peak altitude.



When the servo turns to a designated angle, the arms retract into the separation system, allowing the payload to be released.

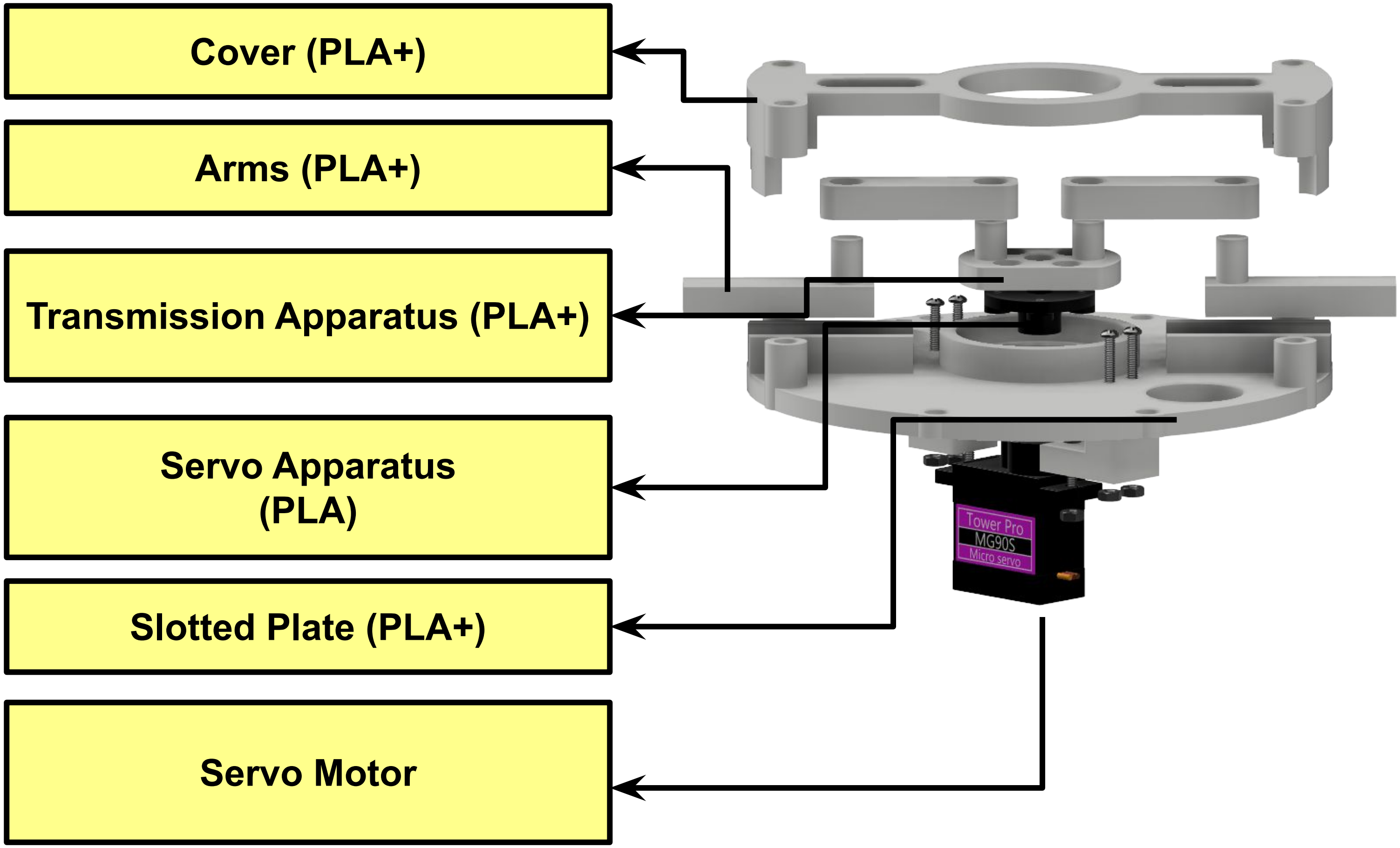




The container has been made transparent to make the system more understandable. The original will be pink.

Payload Release (3/3)

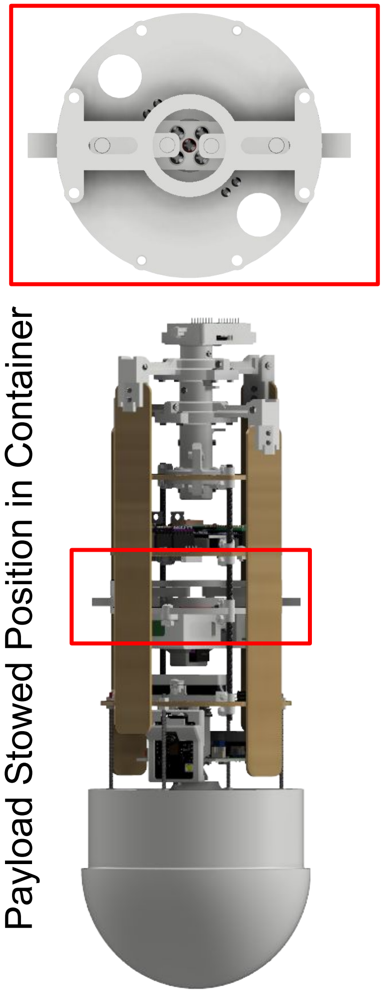
Slider Crank Release Mechanism



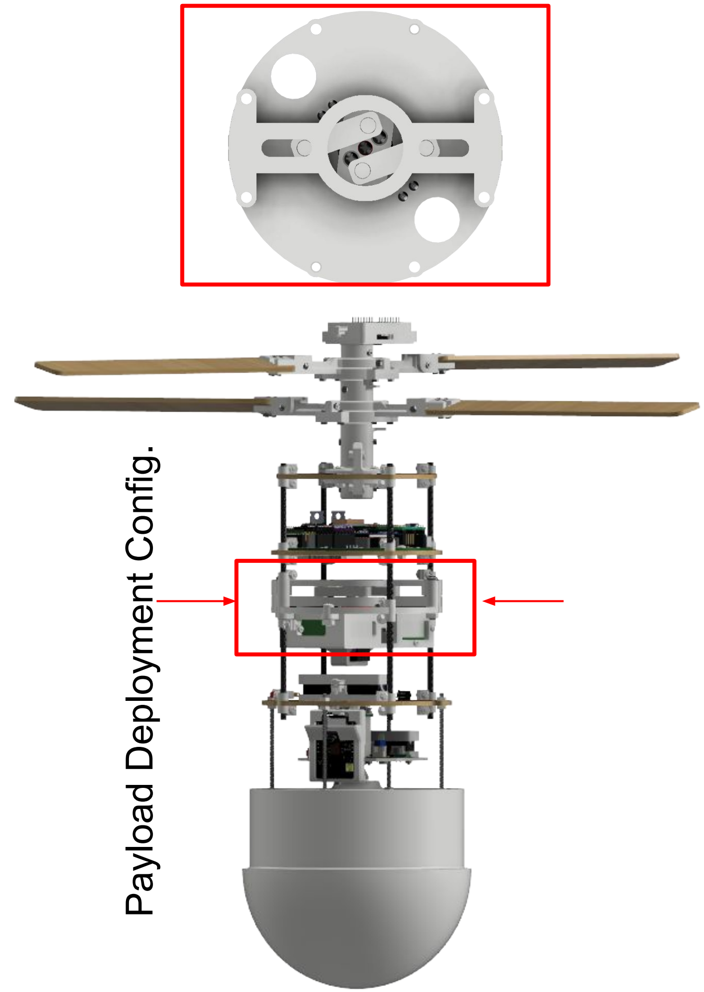
Payload Deployment Configuration

When the payload is released from the container, the arms of the release mechanism retract smoothly into the mechanism itself, allowing the payload to be freed from its secured position. Aside from the retraction of these arms, the overall structure and configuration of the payload remain completely unchanged, ensuring that the integrity and stability of the payload are preserved throughout the release process.

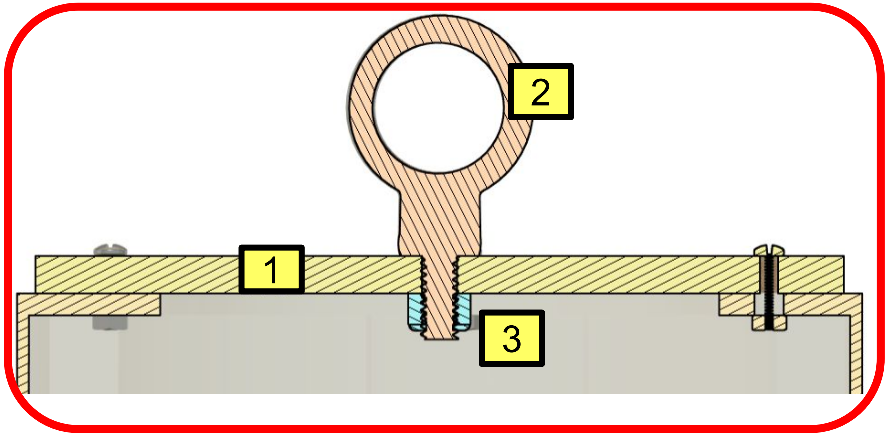
Pre-Deployment



After Deployment



Parachute Attachment to Container



1 Plywood

2 ¼ in Eye bolt

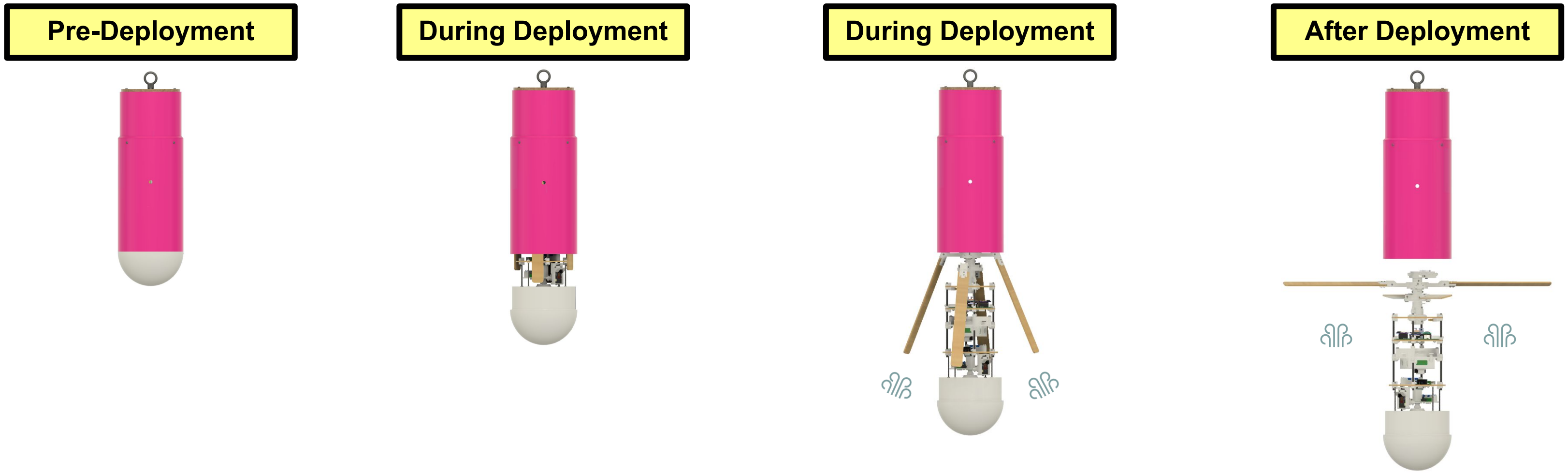
3 ¼ in Lock Nut

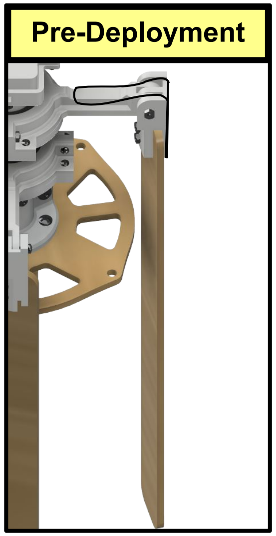
Parachute Rope

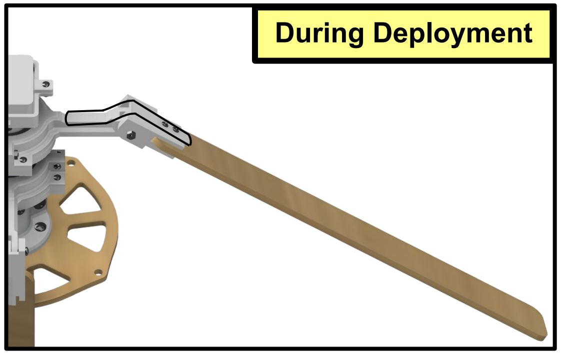
A plywood disk and eye bolt were used and the eye bolt is equivalent to 1/4 inch.
The requirement is to use an eye bolt and to attach the eye bolt to a wooden disk at the bottom of the container.
The parachute will be attached to this eye bolt with parachute cord

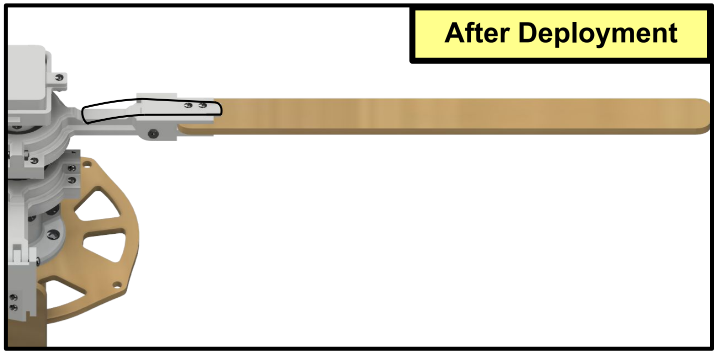
Auto-gyro deployment (1/5)

Coaxial Propeller-Rubber Band Method Deployment



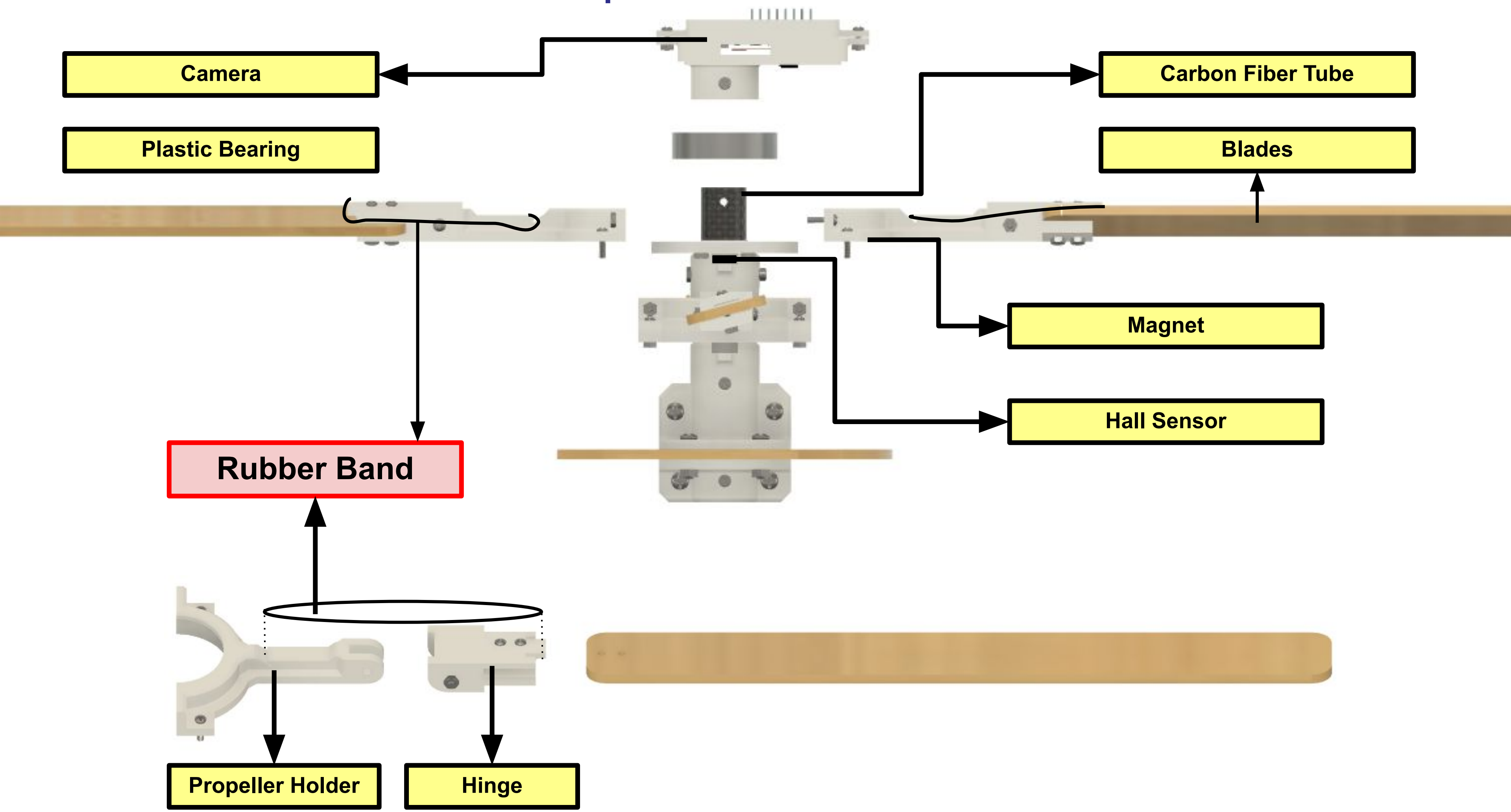






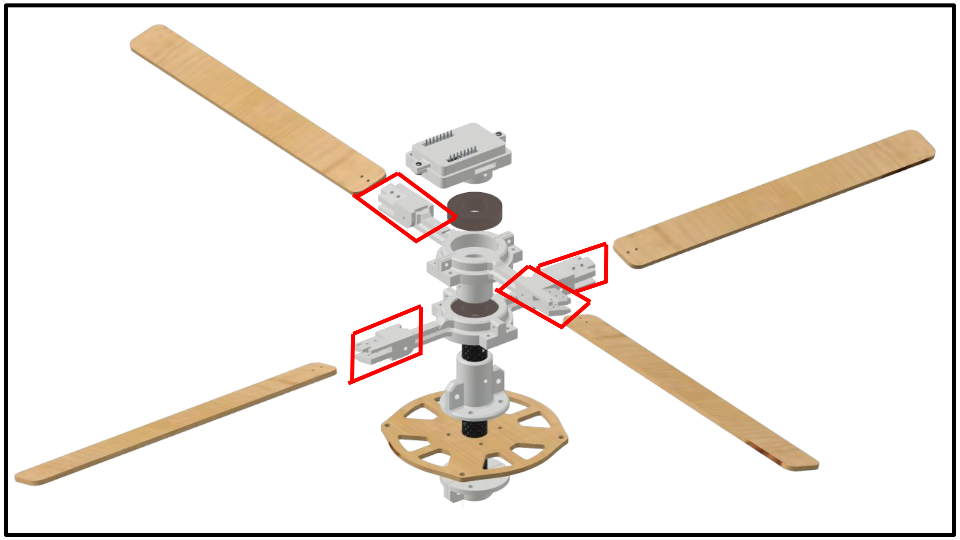
As the payload descends, the blades deploy due to the combined effect of gravity and airflow, initiating rotation to slow the descent. Elastic bands are strategically attached to the blade holders and hinges, adding extra force to ensure the blades open smoothly and efficiently.

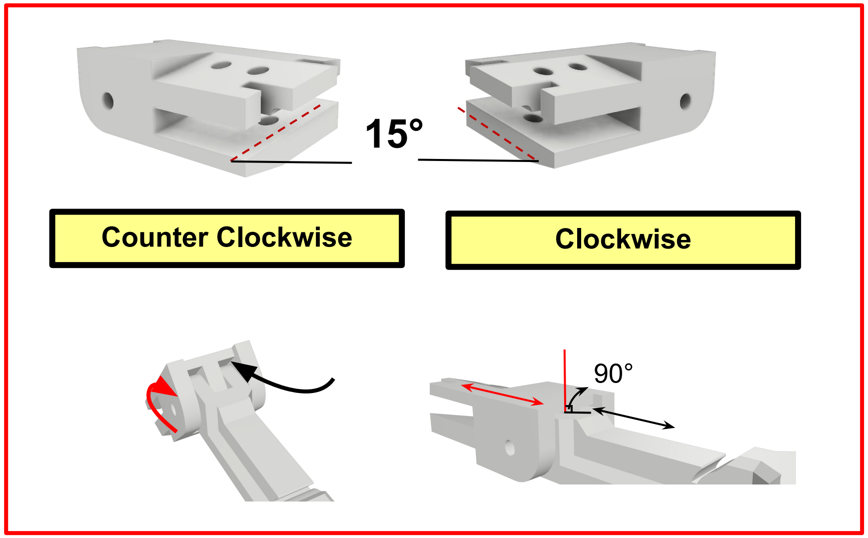
Coaxial Propeller-Rubber Band Placement



Auto-gyro deployment (3/5)

Working Principle of Auto-gyro Mechanism and Its Activation During Deployment

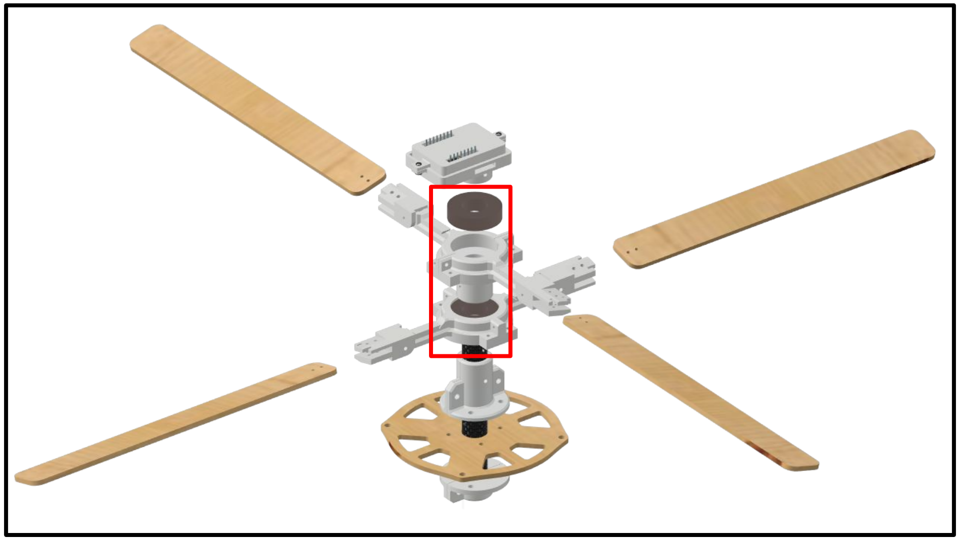


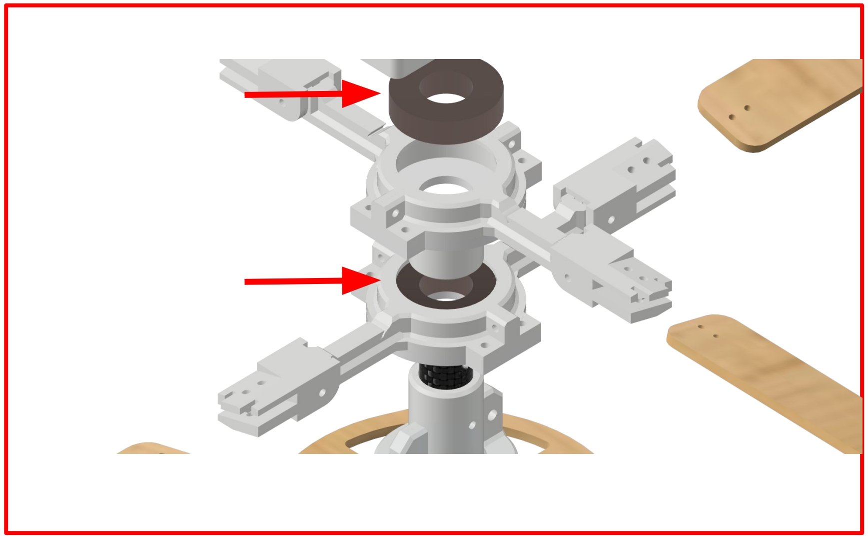


The propellers are designed in a structure where the upper part rotates clockwise (CW) and the lower part counterclockwise (CCW). In order to do this indirectly with the air flow without using any motor system, the wing angles need to be adjusted. A separate wing holder is designed for both directions. So, we were able to rotate one of the propellers clockwise and the other counterclockwise separately only with the air flow.

The parts that give the propellers the necessary angles for CCW and CW turns also have a design that will prevent the propellers from exhibiting an unwanted upward movement and limit their opening while the wings are opening after the separation phase has taken place.

Working Principle of Auto-gyro Mechanism and Its Activation During Deployment

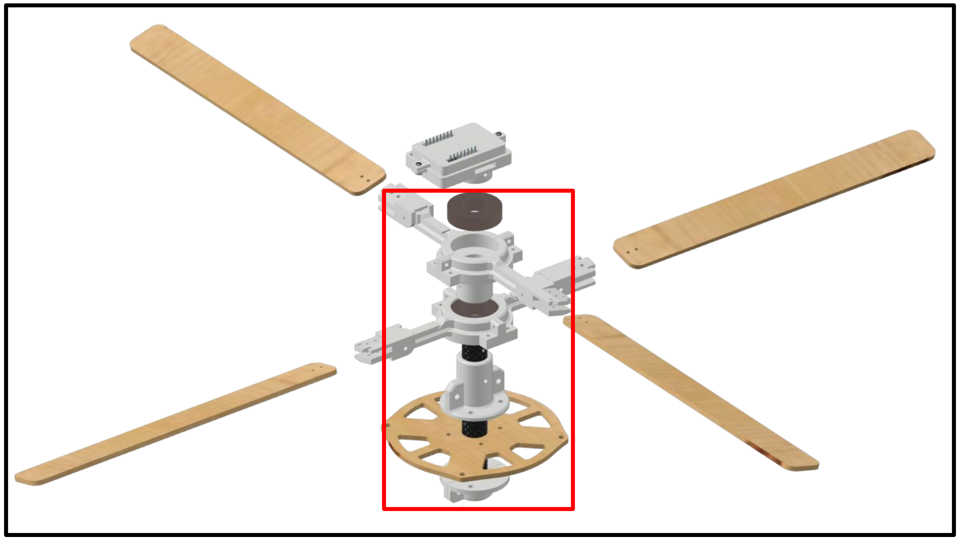


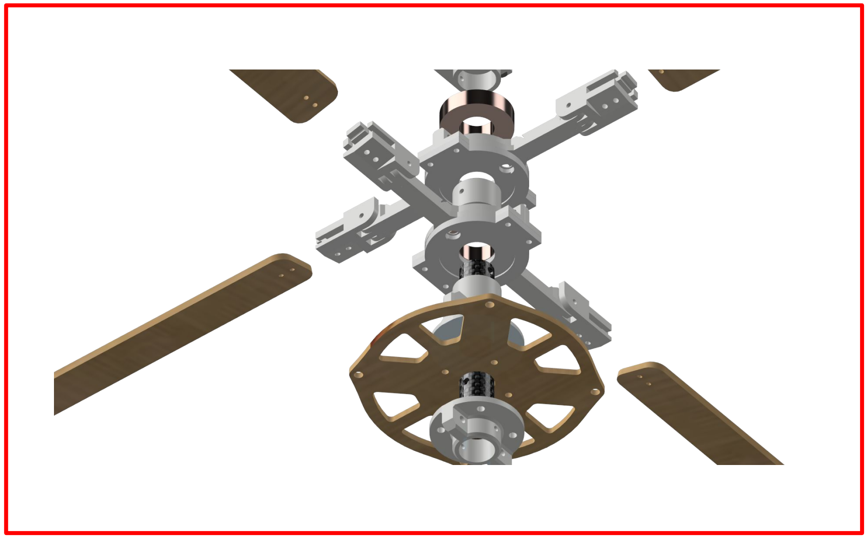


The movement of coaxial propellers is based on **bearings**. These bearings are located in the center of the arms to which the wings are connected and there are 2 bearings in the system. The bearing is shrink fitted from the inside and its outer part rotates. In order to prevent the up and down movement of the bearing and to exhibit only radial movement, necessary supports are placed from above and below.

Auto-gyro deployment (5/5)

Working Principle of Auto-gyro Mechanism and Its Activation During Deployment

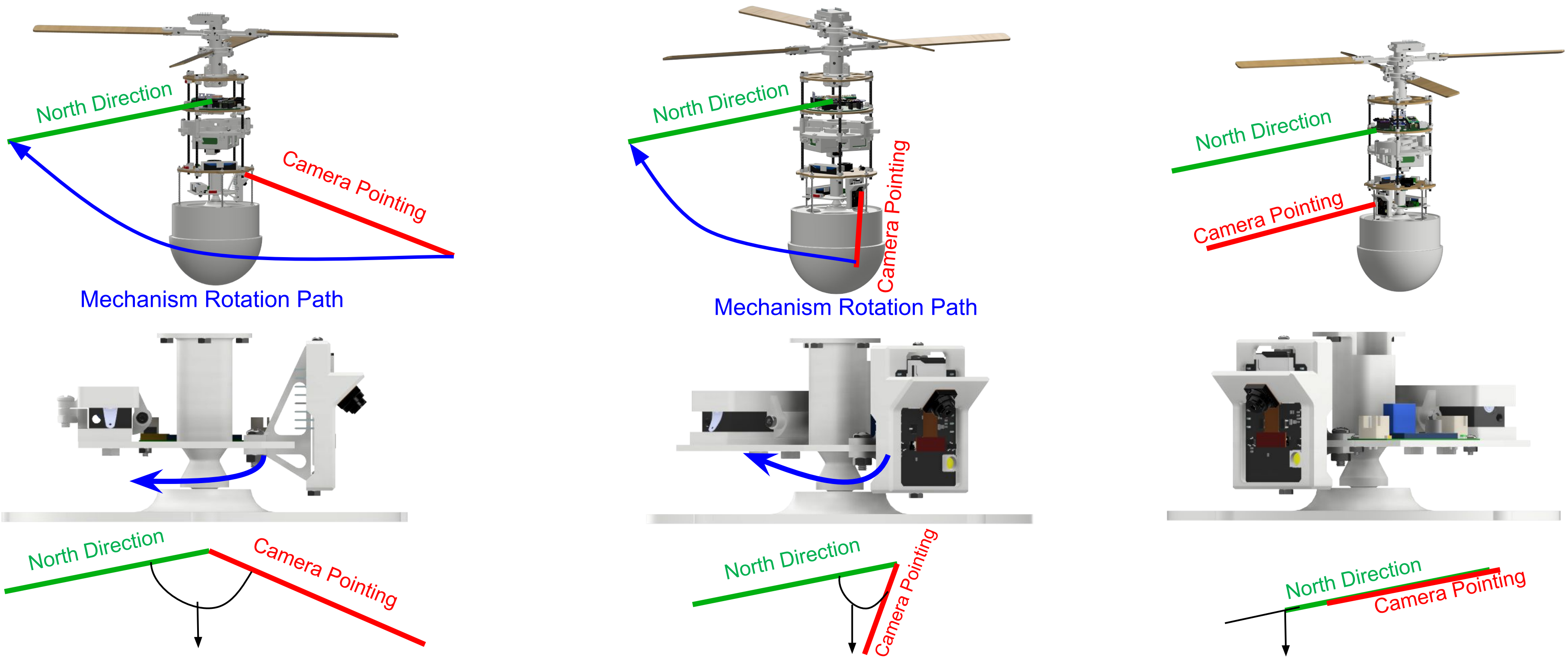




In order to bring the system together and ensure integrity with the payload, a plate that can help the propellers with appropriate spacers and air flow has been designed. This plate integrates the propeller mechanism with the payload around a carbon fiber tube passing through its center.

Ground Camera Pointing (1/4)

Passive 45 Degrees North Pointing Mechanism Illustrated Working Principle



100 Degrees

75 Degrees

0 (+/-10) Degrees

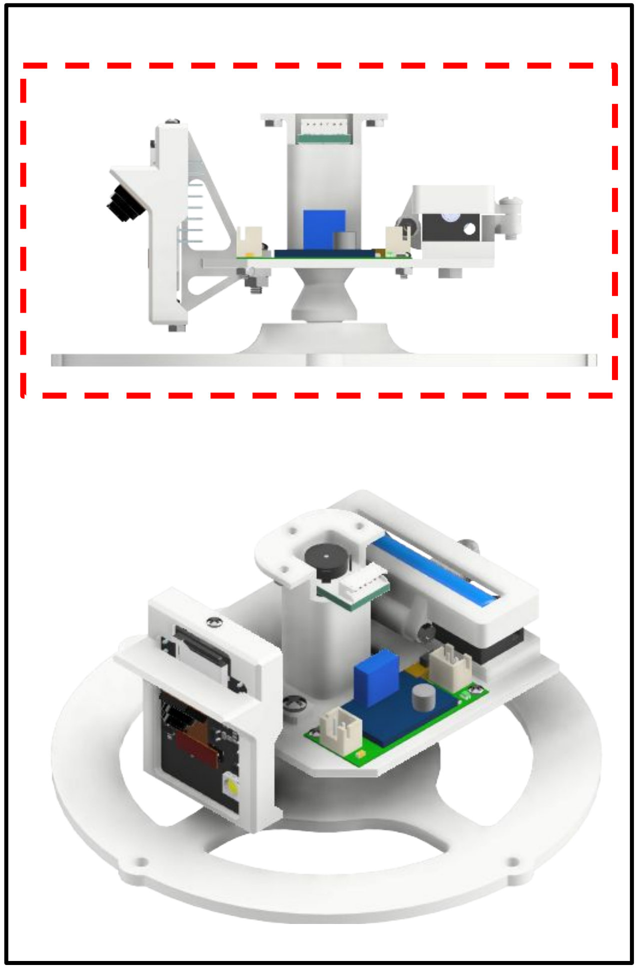
The camera mechanism performs calculations on the Teensy with the north data coming from BNO055 and the data coming from the encoder motor and turns the mechanism towards the north data coming from BNO055.

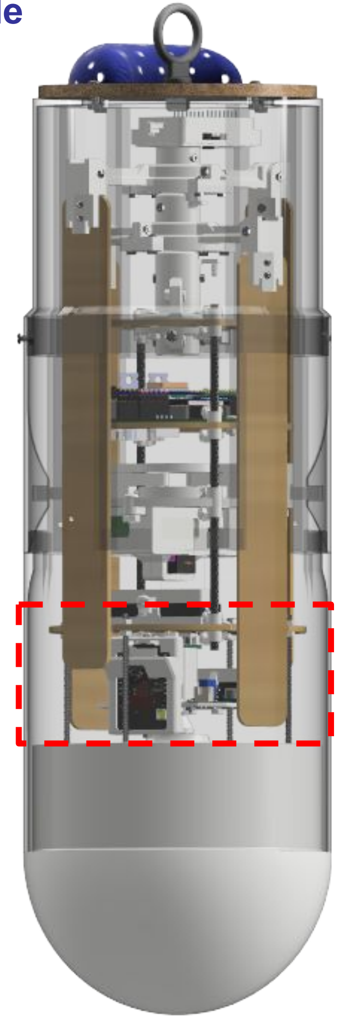
Ground Camera Pointing (2/4)

Passive 45 Degrees North Pointing Mechanism and Working Principle

The ESP-32 Cam's flexible camera module is mounted on a surface inclined at 45 degrees in our mechanism, ensuring it remains angled at 45 degrees from NADIR.

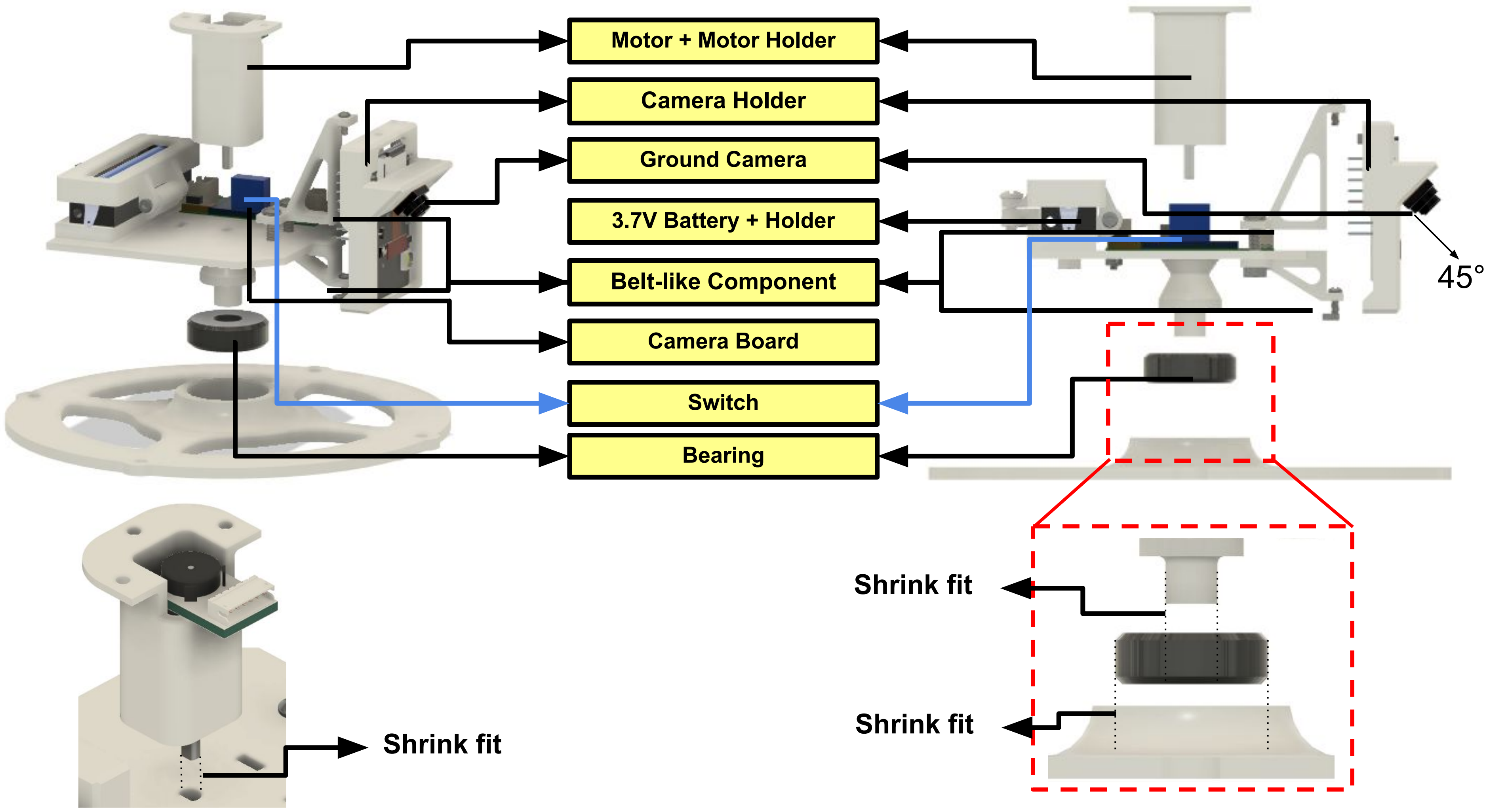
A bearing beneath the camera holder provides support, while a motor attached to the holder controls its rotation. This motor adjusts the camera's direction based on received signals, ensuring it consistently aligns with the northern direction.





Ground Camera Pointing (3/4)

Passive 45 Degrees North Pointing Mechanism

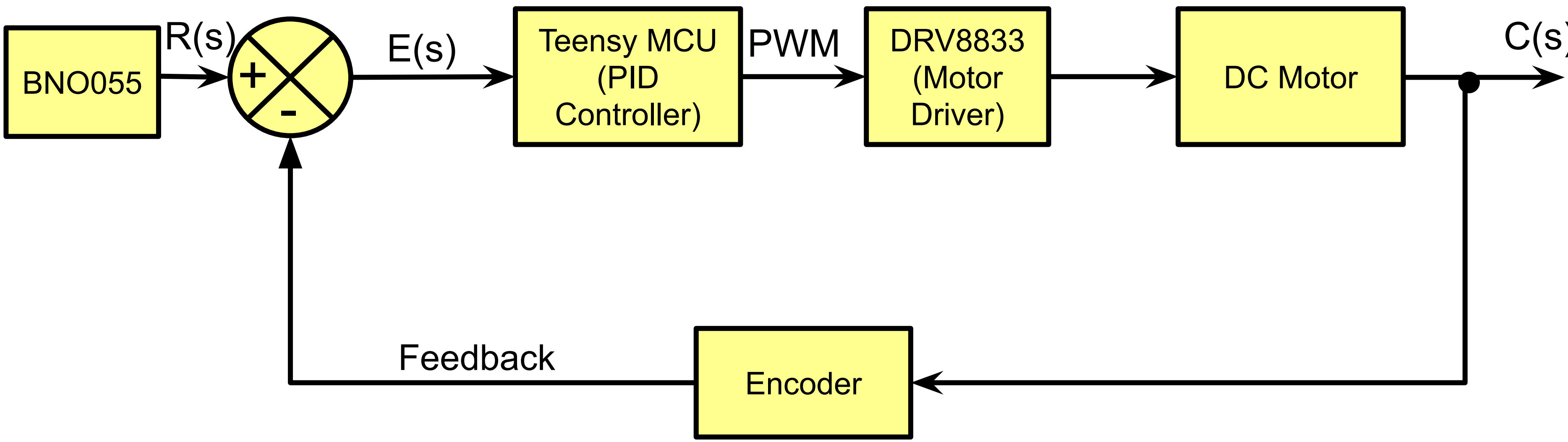


Ground Camera Mechanism Pointing Algorithm

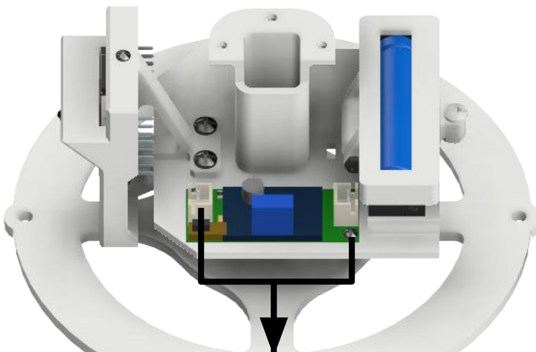
The system is initially calibrated so that 0° (±10°) is considered zero error, meaning the CanSat's north and the camera's north are aligned. **During flight,** the PID control system ensures the camera remains aligned with the CanSat's north by comparing the north data from the BNO055 sensor with the encoder feedback from the motor connected to the DRV8833 and Teensy.

The error E(s) ,E(s) is calculated as the difference between **the reference input R(s),** R(s) (CanSat north) and the **encoder feedback C(s),** C(s) (camera position). The PID control system processes this error and generates a PWM signal, which is sent to the DRV8833 to adjust the motor and realign the camera.

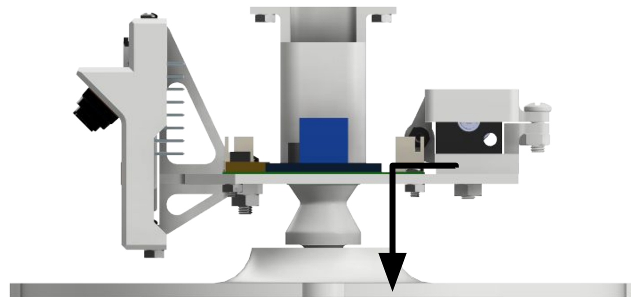
- The **P (Proportional) term** adjusts the motor speed based on the angular error, providing a direct correction.
- The **I (Integral) term** gradually corrects small errors over time, improving precision and reducing steady-state error.
- The **D (Derivative) term** prevents overshooting by responding to sudden changes, stabilizing the system.



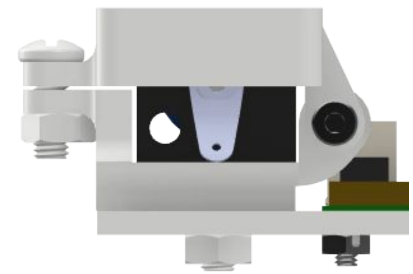
Structure Survivability (1/7)



Screws and Nuts

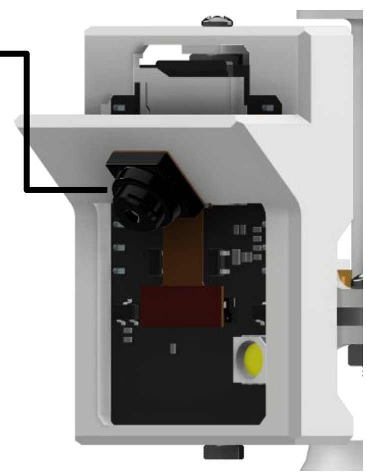


Screws and Nuts

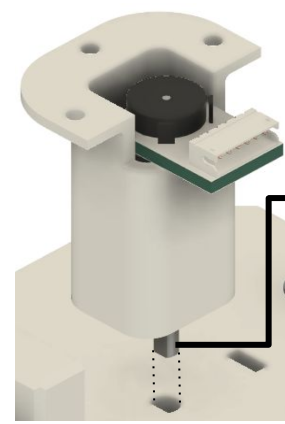


Double-Sided Tape

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

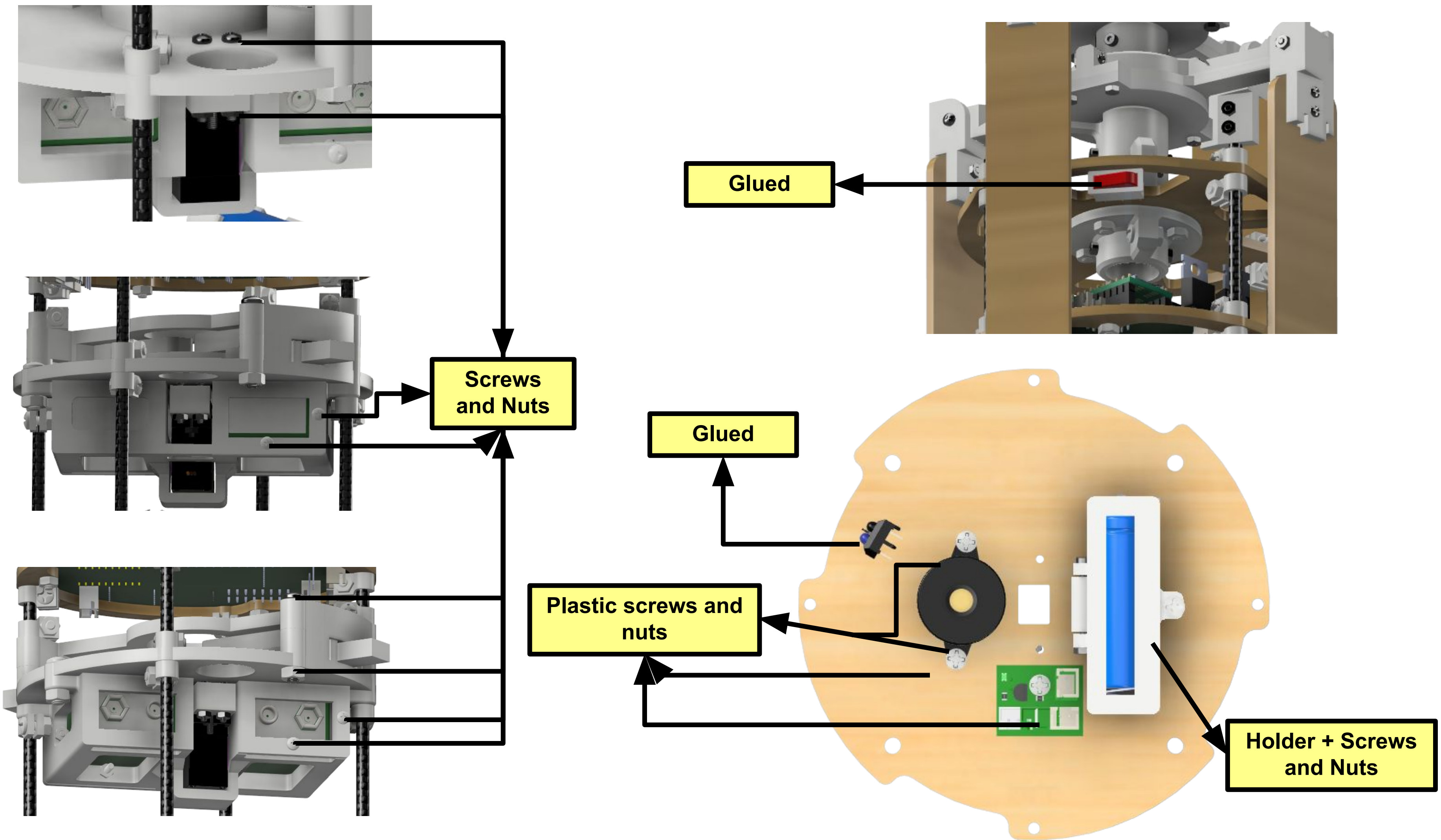


We designed a belt-like component to secure the camera.

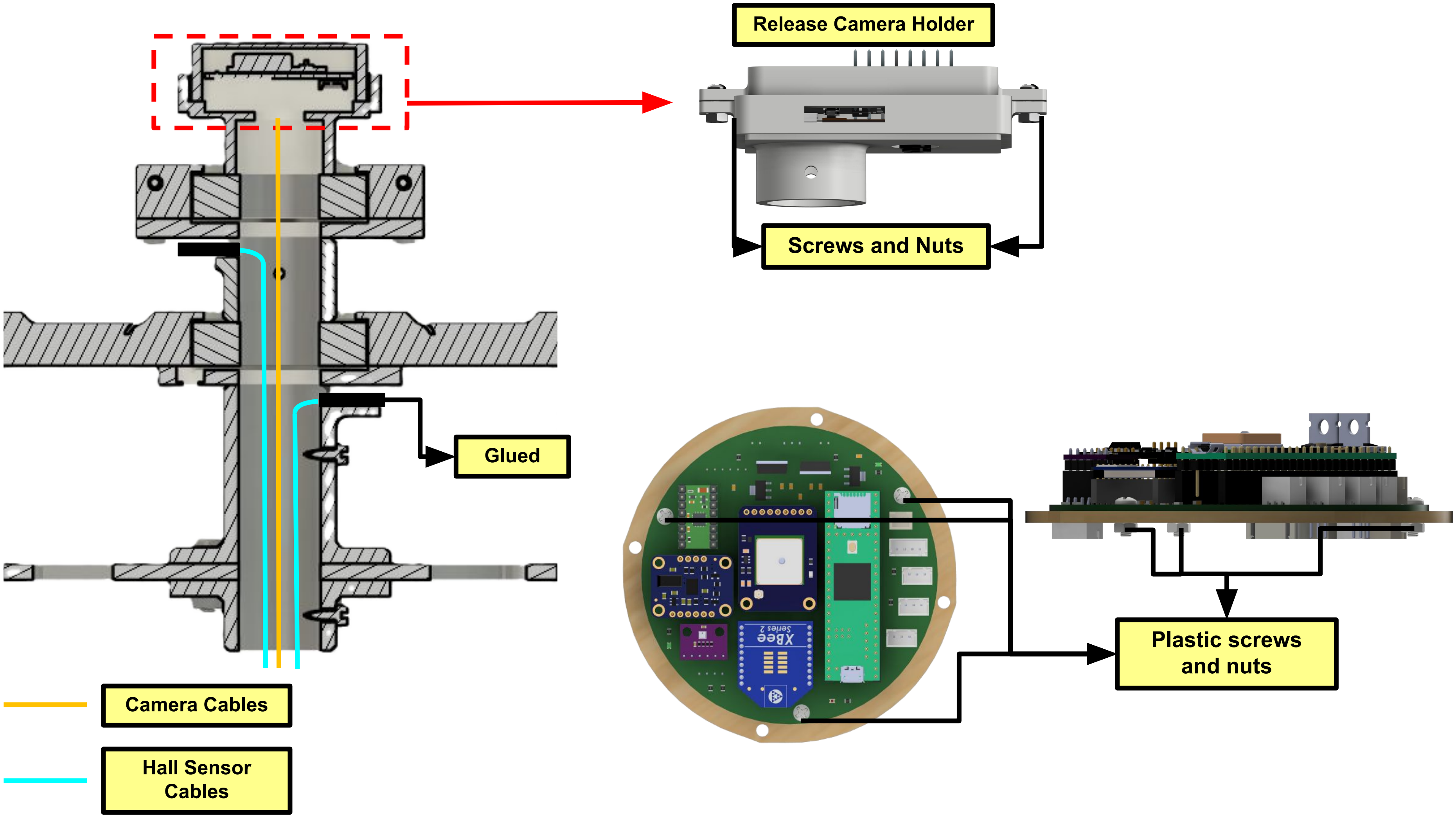


We shrink fitted the motor to the motor holder. We screwed the holder to the upper plate of camera mechanism.

Structure Survivability (2/7)

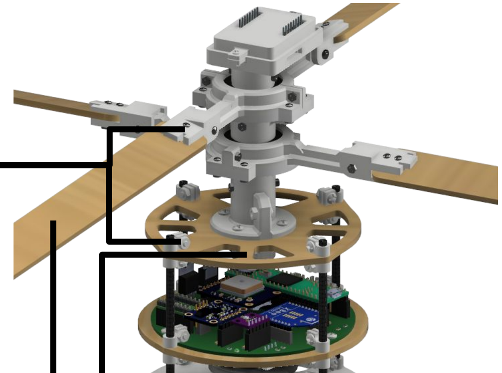


Structure Survivability (3/7)



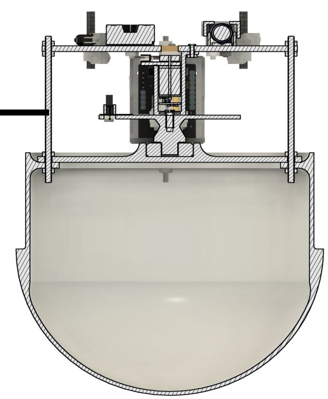
Structure Survivability (4/7)

Propeller mechanism is mounted with M2 screws and nuts. The mechanism is mounted to its plate with M3 plastic screws.



The MDF plates and propeller blades are coated with adhesive.

The payload structure consists of plates attached onto carbon fiber rods with clamps.



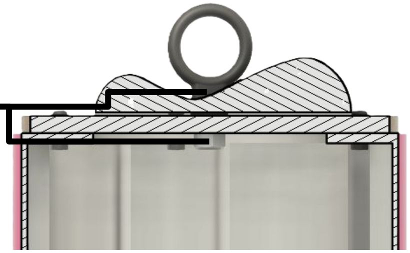
The nose cone and the chassis are mounted together with a steel threaded rod and a locked nut, with internal bolts fixed using Loctite.

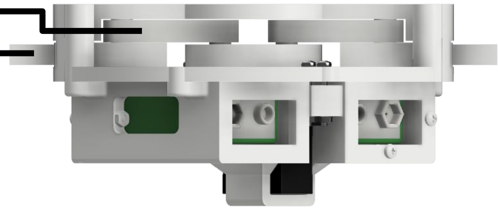
The parachute is connected to the eyebolt with a parachute rope. The eyebolt is secured with a locknut.

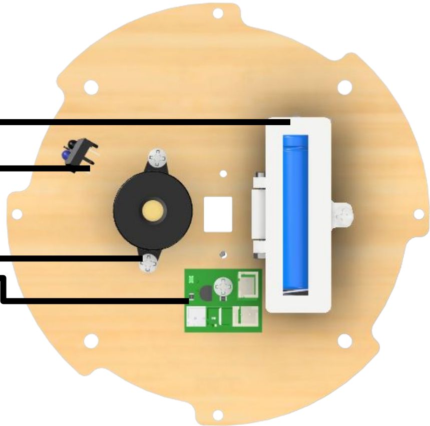
The separation arms are designed to resist shock.

The cables are secured with plastic cable ties and electrical tape.

All electronics are secured with screws, nuts or glue.







Structure Survivability (6/7)

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 3D printed cover were placed around them.	The ready case contained a spring and a 3D printed cover 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.

Structure Survivability (7/7)

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 eye bolt. 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	Uncertainty(g)
Payload	Propeller	Camera Holder	1	-	5	C	1.25
		Propeller Arm	4	5	20	C	5
		Hinge (CW+CCW)	4	4	16	C	4
		Propeller Magnet Holder	2	3	6	C	1.5
		Propeller Bearings	2	10	20	D	-
		Propeller Hall Sensor Holder	1	-	3	C	0.75
		Lower Hall Sensor Holder	2	6	12	C	3
		Blades	4	11	44	M	11
		Propeller Plate	1	-	15	M	3.75
		Propeller-Plate Fixer	2	4	8	C	2
	Release Mechanism	Protective Cover	1	-	14	C	3.5
		Base	1	-	30	C	7.5
		Arm	2	2	4	C	1
		Transmission Arm	2	2	4	C	1
		Servo Apparatus	1	-	2	C	0.5
		Servo Holder	2	1	2	C	0.5
		Battery Holder	1	-	24	C	6
	Plates	Buzzer Plate	1	-	25	M	6.25
		PCB Plate	1	-	4	M	1
		Nose Cone	1	-	142	C	35.5

Mass Budget (2/6)

		Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Uncertainty (g)
Payload	Ground Camera	Camera Holder	1	-	16	C	4
		Bearing Plate	1	-	22	C	5.5
		Motor Holder	1	-	5	C	1.25
		Bearing	1	-	10	D	-
		Belts	1	-	6	C	1.5
	Electronics	ESP32-Cam	2	10	20	D	-
		PCB	1	-	75	M	18.75
		Servo	1	-	13.4	D	-
		9V Battery	2	35	70	D	-
		Switch	3	1	3	D	-
		Buzzer	1	-	3	D	-
		Infrared Sensor	1	-	1	D	-
		Buzzer Board	1	-	1	M	0.25
		DC Motor	1	-	18	D	-
		3.7V Battery and Holder	2	10 (8+2)	20	M	-
		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	-
		Leaf Antenna	2	0.5	1	D	-
		Micro SD Card	3	0.33	1	D	-
		Switching Voltage Regulator Board	1	-	4	D	-

Mass Budget (3/6)

	Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Uncertainty (g)
Assembly Components	M2 4mm	2	0.12	0.24	D	-
	M2 6mm	4	0.20	0.40	D	-
	M2 8mm	15	0.27	4.05	D	-
	M2 10mm	2	0.30	0.60	D	-
	M2 12mm	8	0.34	2.72	D	-
	M2 18mm	12	0.45	5.4	D	-
	M3 22 mm	2	1.3	2.6	D	-
	M3 6mm Plastic	2	0.25	0.50	D	-
	M3 8mm Plastic	46	0.33	15.18	D	-
	M3 12mm Plastic	4	0.35	1.4	D	-
	M2 Nuts	43	0.14	6.02	D	-
	M3 Nuts	2	0.33	0.66	D	-
	M3 Nuts Plastic	68	0.05	3.40	D	-
	Plastic Clamps	32	0.25	8	D	-
	Carbon Fiber Rods	4	7.5	30	D	–
	65mm Rod	2	2.7	5.4	D	-

Mass Budget (4/6)

	Structural & Electronic Elements	Quantity	Unit Weight (g)	Weight (g)	Sources	Uncertainty (g)
Container	Plywood	1	24	48	M	12
	Container First Part	1	-	317	C	79.25
	Container Second Part	1	-	174	C	43.5
	Parachute	1	-	10	C	2.5
	Parachute Rope	1	-	1	C	0.25
	Eyebolt ¼ Inch	1	-	60	D	-
	Eyebolt's Lock Nut	1	-	0.5	D	-
	M3 6mm	4	0.70	2.10	D	-
	M3 12mm	4	0.95	3.80	D	-
	M3 Nut	8	0.33	2.64	D	-

Mass Budget (5/6)

Total Mass of Container (g)	619.04
Total Mass of Payload (g)	780.97
Total Mass of CanSat (g)	**1400.01**

Total Mass of Electronic Components (g)	235.4
Total Mass of Structural Elements (g)	1164.61

Total Mass Margin of CanSat
|Mass Requirement - Total Mass of CanSat| = Margin
|1410-1400.01| = 9.99
Mass Budget Meets The Requirements!

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

Uncertainty for estimated data is selected as 25%.

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

Mass Budget (6/6)

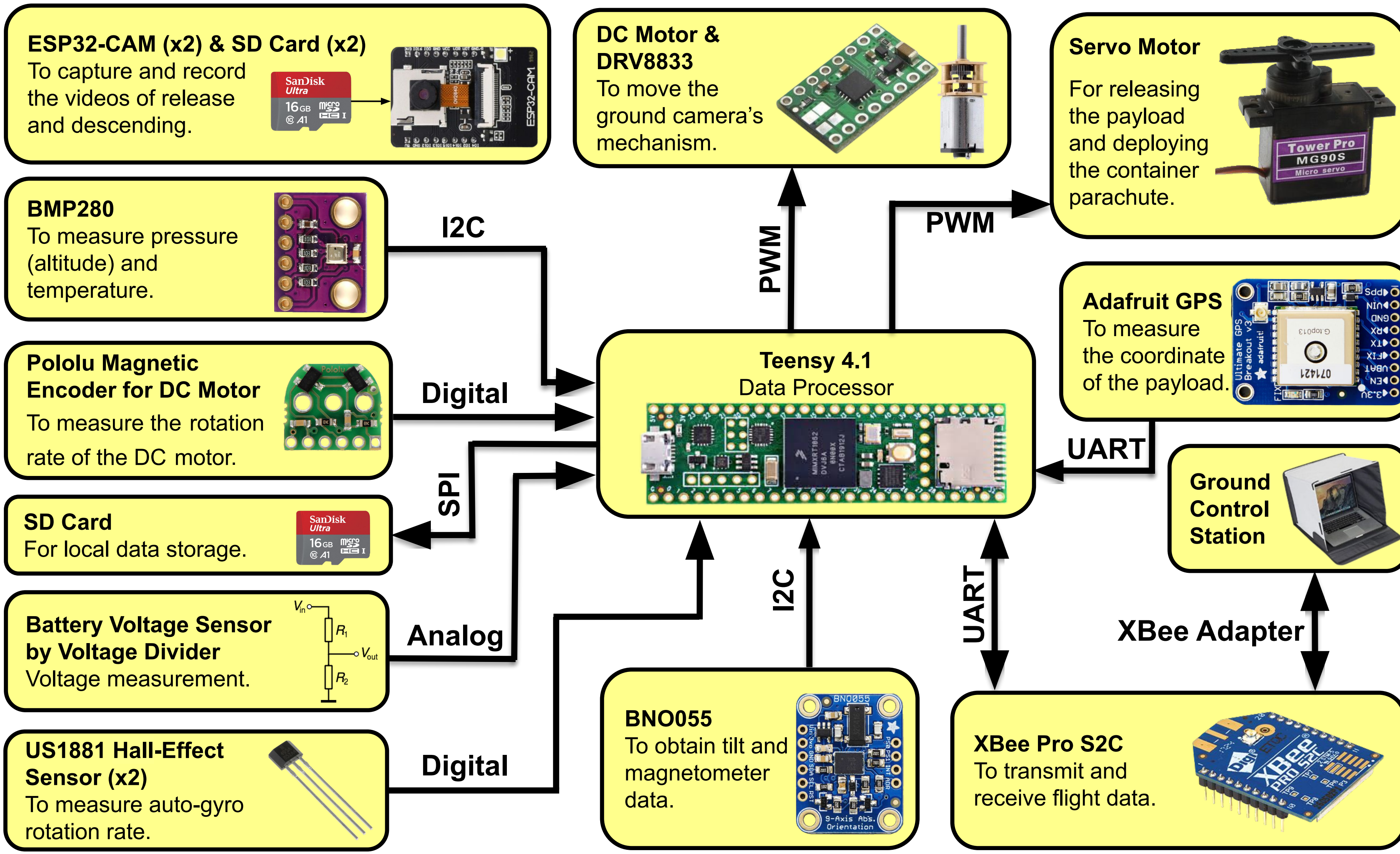
Since no major changes can be made to the design after the Critical Design phase, if a weight problem is encountered, the problems will be solved based on the materials used and the density of the material.

Method of Correction	
CanSat > 1410g	• Decreasing infill density of 3D printed parts • Decreasing number of fasteners • Using plastic screws on safe zones • The amount of adhesive impregnated into MDF materials will be reduced. • Material change
CanSat < 1390g	• Increasing infill density of 3D printed parts • Increasing number of fasteners • The amount of adhesive impregnated into MDF materials will be increased • Material change

Communication and Data Handling (CDH) Subsystem Design

Berke OZBAY

CDH Overview



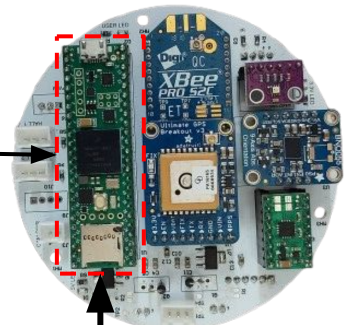
CDH Changes Since PDR

No change(s) have been made since the PDR.

Payload Processor & Memory Selection (1/3)

Microcontroller Board	Processor Speed [MHz]	Boot Time [ms]	Data Bus Width	Power Consumption [mA]	Types of Interfaces	Number of Interfaces	Form Factor [mm]	Cost [$]	Mass [g]
Teensy 4.1 Micro Controller	600	200	32 bit Float & 64 bit double	100	I2C	3	60.96 x 17.78	30.85	16.95
					SPI	3			
					UART	8			

Place of Teensy 4.1 on the Payload PCB



Attachment of SD Card

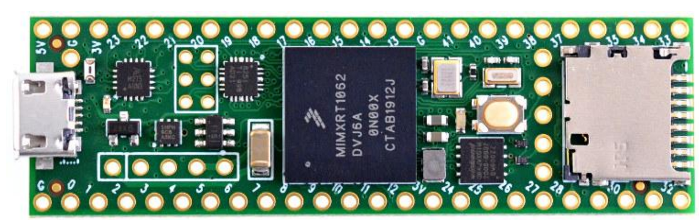
Non-Volatile Memory options (Kb)		Volatile memory Options (Kb)
EEPROM (4)	Flash (7936)	SRAM (1024)

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**

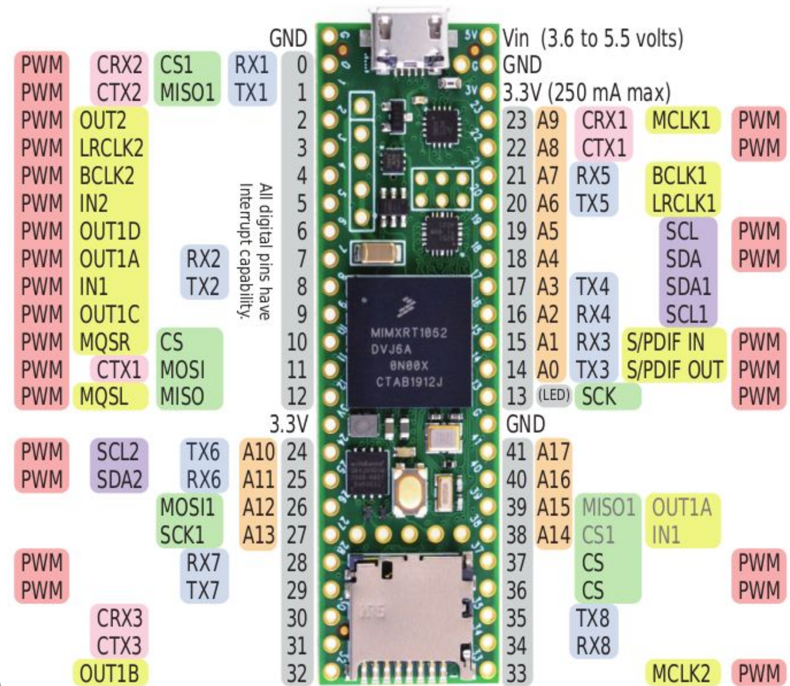
Teensy 4.1



Payload Processor & Memory 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 Selection (3/3)

Model	Capacity [GB]	Transfer Speed [Mbps]	Cost [$]
Sandisk Ultra	16	48	5.61

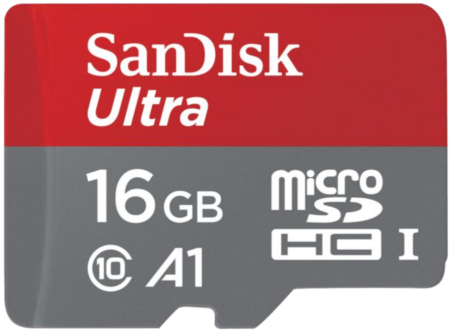
- **Requirement 1 : Selected SD card shall compatible with the processor in terms of size factor, storage capacity and writing and reading.**

- **Requirement 2 : Selected SD card shall capable of maintain its working status under shock and vibration conditions.**

SanDisk Ultra

SELECTED

- **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

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.

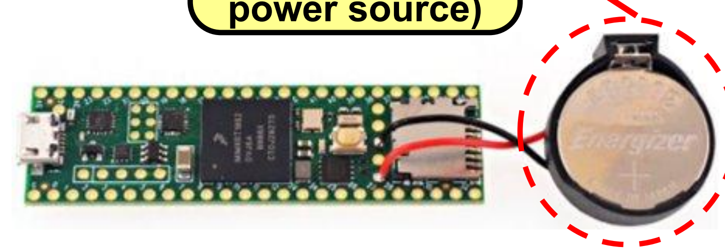
RTC Power: Coin cell is attached to the power input of the internal RTC. Thus, time is maintained through power transients.

Teensy 4.1 RTC

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

SELECTED

3V coin cell battery (Independent power source)

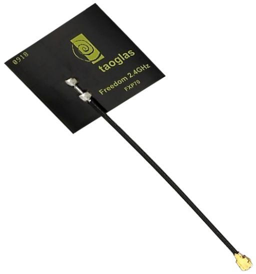


Payload Antenna Selection

Model	Type and Connector	Gain [dB]	Dimensions [mm]	Mass [g]	Frequency Range [GHz]	Radiation Pattern	Cost [$]
FXP70	U.FL	5.0	27 x 25	0.5	2.4 - 2.5	Omni Directional	3.59

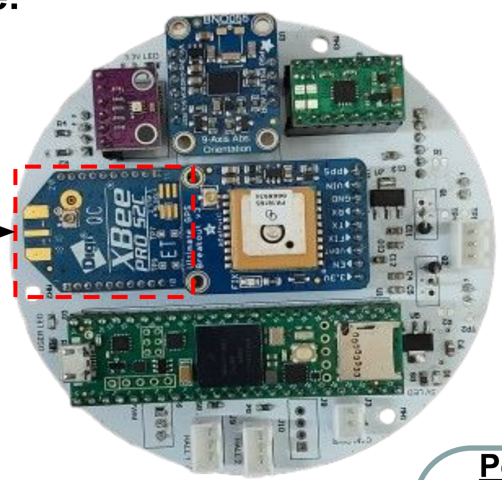
Selection Criteria: **XBee operates at 2.4 GHz, and the frequency range of the antenna that we selected is compatible with XBee.**

Selected Antenna



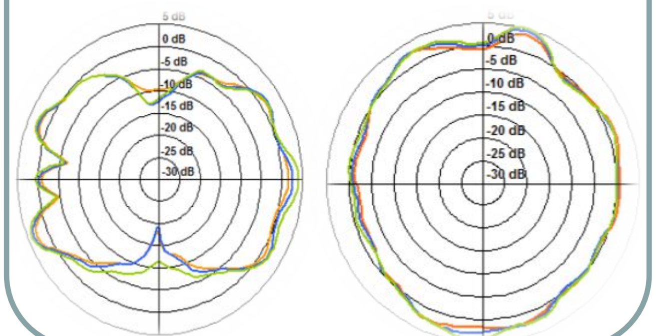
FXP70

Antenna Location on PCB

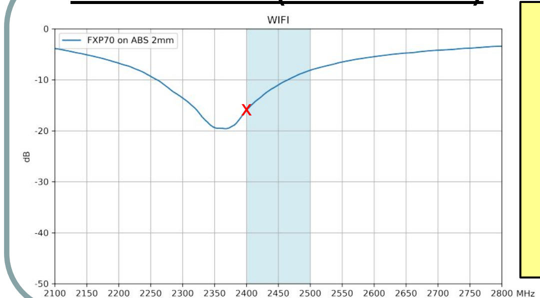


- **High Gain**
- **High Performance**
- **Small size**
- **Easy connection with XBee**

Radiation Patterns



Performance (Return Loss)

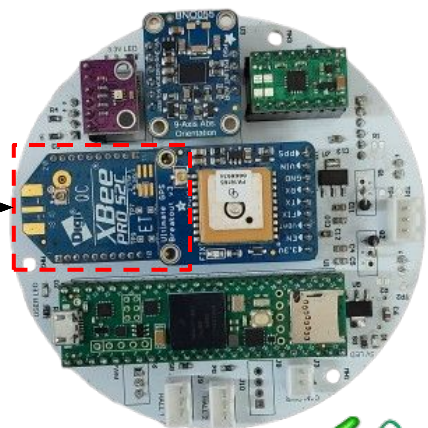


According to the graph from the datasheet, the return loss performance for 2.4 GHz is more than -15 dB

Payload Radio Configuration (1/2)

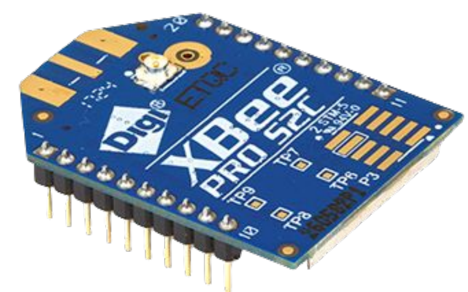
Device	Voltage [V]	Operating Frequency [MHz]	Transmit Power [mW]	Transmit Current [mA]	Receive Current [mA]	RF Data Rate up to [Kbps]	LoS Range [Km]	Cost [$]
XBee Pro S2C	3.3	2400	63	120	31	250	3.2	31.32

Place of selected XBee Radio Module on the Payload PCB



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

Selected XBee Radio Module



XBee Pro S2C

SELECTED

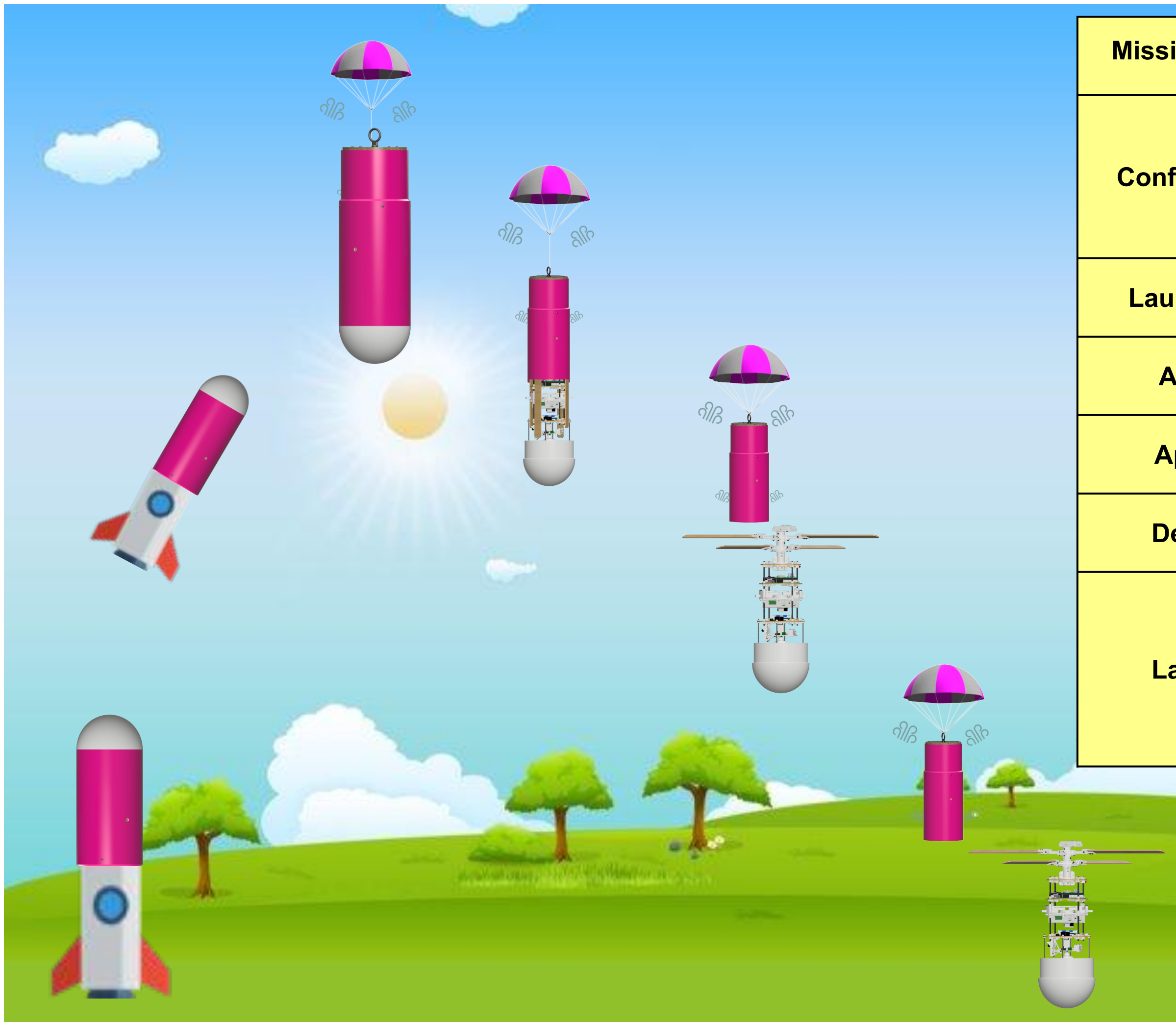
- **Low transmit current**
- **Low receive current**
- **High transmit power**
- **High range**

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 Radio Configuration (2/2)

Detailed Transmission Control During Each Phase



Mission Phase	Transmission Control
Configuration	Before stow configuration, “CMD,3133,CX,ON” will sent to payload XBee by GCS and start the telemetry.
Launch Pad	Telemetry will be active during all these phases.
Ascent	
Apogee	
Descent	
Landing	After landing, telemetry will be stopped autonomously. Otherwise,"CMD,3133,CX,OFF" will be sent to the payload XBee by GCS to stop telemetry.

NOTE:
1)The XBee will use **direct addressing**, not broadcasting.
2)Data will be transmitted at a rate of **1 Hz**.

Payload Telemetry Format (1/4)

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

Payload Telemetry Format (2/4)

No	Data Format	Description	Data Size & Format	Example Value
11	<GYRO_P>	The pitch degree generated by the gyro (degree/second).	4-byte Float	<0.12>
12	<GYRO_Y>	The yaw degree generated by the gyro (degree/second).	4-byte Float	<-0.05>
13	<ACCEL_R>	Accelerometer reading for the roll (degree/second^2).	4-byte Float	<-0.05>
14	<ACCEL_P>	Accelerometer reading for the pitch (degree/second^2).	4-byte Float	<0.47>
15	<ACCEL_Y>	Accelerometer reading for the yaw (degree/second^2).	4-byte Float	<9.72>
16	<MAG_R>	The roll degree generated by the magnetometer (Gauss).	4-byte Float	<-22.50>
17	<MAG_P>	The pitch degree generated by the magnetometer (Gauss).	4-byte Float	<-9.69>
18	<MAG_Y>	The yaw degree generated by the magnetometer (Gauss).	4-byte Float	<-39.19>
19	<AUTO_GYRO _ROTATION_RATE>	The rotation rate of the auto-gyro relative to the CanSat structure. (degree/second).	4-byte Float	<2864.772>

Payload Telemetry Format (3/4)

No	Data Format	Description	Data Size & Format	Example Value
20	<GPS_TIME>	The time generated by the GPS receiver in HH:MM:SS format.	8-byte String	<11:40:53>
21	<GPS_ALTITUDE>	Altitude generated by the GPS receiver (meter).	8-byte Double	<212.5>
22	<GPS_LATITUDE>	The latitude generated by the GPS receiver (degree).	8-byte Double	<53.4851>
23	<GPS_LONGITUDE>	The longitude generated by the GPS receiver (degree).	8-byte Double	<5.1234>
24	<GPS_SATS>	The number of GPS satellites being tracked by the GPS receiver.	4-byte Unsigned Integer	<7>
25	<CMD_ECHO>	The fixed text command id and argument of the last received command with no commas.	8-byte String	<CXON>
26	<IR_STATUS>	Checks whether payload deployed or not.	1-byte Boolean	<TRUE>
		Total Telemetry Size	130-byte(1040-bit)	

Note that telemetry data will be transmitted at a rate of 1 Hz.

Data Rate of CanBEE (Team 3133) Telemetry

Data Rate = Total Telemetry Size(bit) x Transmit Frequency(Hz)
Data Rate = 1040-bit x 1Hz
Data Rate = 1040 bps = 1.04 Kbps

Since the maximum data rate of XBee Pro S2C is 250 Kbps, we can handle transmission control easily.

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

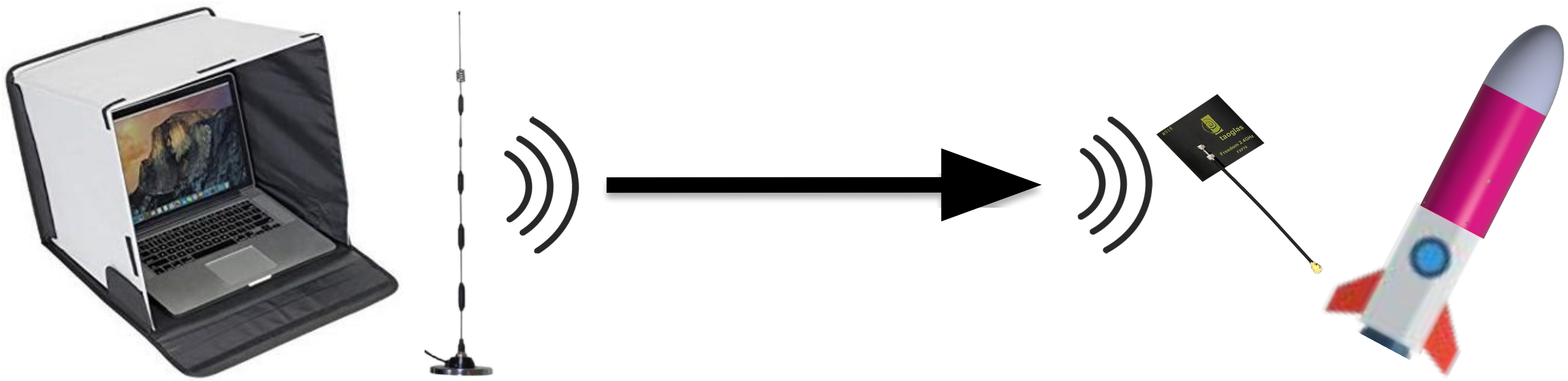
- Data will be transmitted at a rate of **1 Hz.**
- The XBee will use direct addressing, not broadcasting.
- After **landing**, telemetry will be stopped.
- **The telemetry data file shall be named as follows: Flight_3133.csv**

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 Command to set the time directly from GCS Computer.
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.

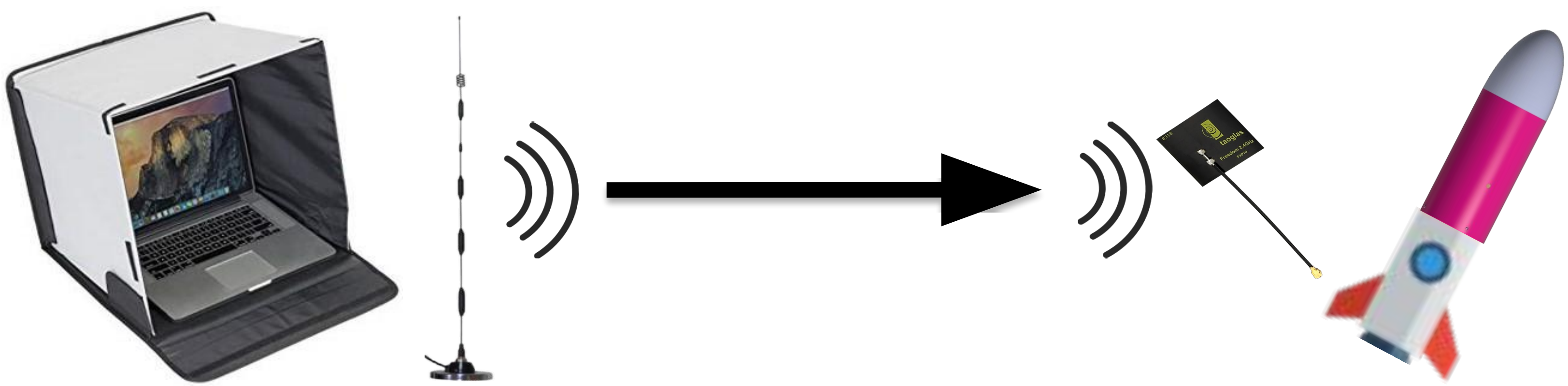


Ground Control System **CanSat**

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.
CMD,3133,MEC,<SERVO>,<OFF>	Activate the release mechanism for stowing the payload inside container.



Ground Control System **CanSat**

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

Electrical Power Subsystem 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.

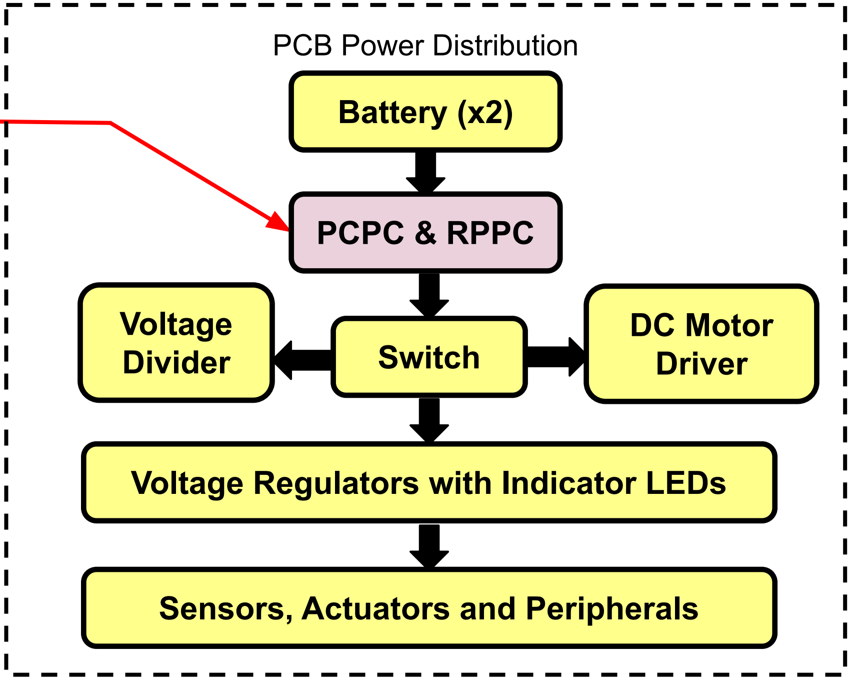
Power Indicator LEDs: Show whether power is on or off.

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

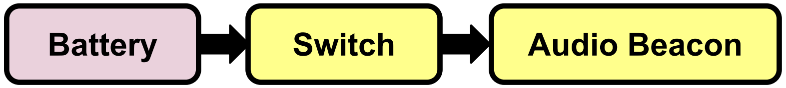
Sensors, Actuators and Peripherals: Sensors are used to gather flight information; actuators and peripherals are used to perform required actions accordingly.

Change(s) are shown with pink blocks.

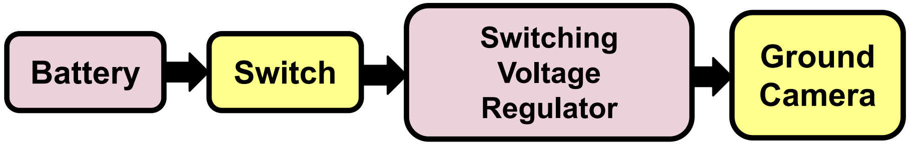
Simplified power diagram of CanSat:



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 continuously point towards the north.



EPS Changes Since PDR (1/4)

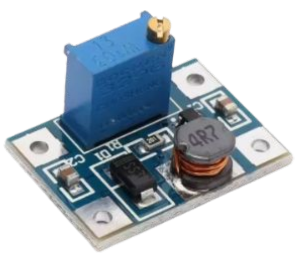
Changes Overview

Components	PDR	CDR	Rationale
3.7V battery for audio beacon and ground camera	Ultrufife 18650, 3.7V 4800mAh battery is selected.	Orion 10440, 3.7V 400mAh battery is selected.	Our previous battery was listed as 24 g, but in reality it weighed 32 g, which affected our mass budget calculations. So we replaced it with the Orion battery, which weighs 8 grams.
Switching voltage regulator for ground camera	No such a choice was made.	Switching voltage regulator is added to improve the input power efficiency of the ground camera.	Since we switched to a much smaller capacity battery, we had to increase the battery's working life by using it more efficiently.
Parallel connection protection circuit and reverse polarity protection circuit	Body diodes of MOSFETs are used to protect batteries from discharging to each other.	Schottky diodes are used to protect batteries from discharging to each other.	We had problems with the MOSFET circuit in long distance communication and sending commands with XBee. We solved this problem by using Schottky diodes.

More detailed explanations are discussed in subsequent slides.

EPS Changes Since PDR (2/4)

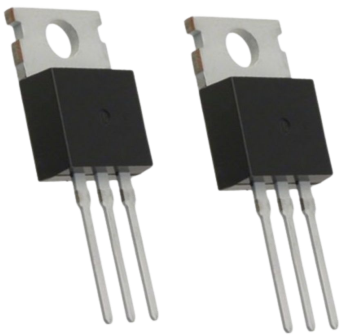
PDR - 3.7V Battery for audio beacon and ground camera	Rationale	CDR - 3.7V Battery for audio beacon and ground camera
	The Ultrufife 18650 battery was listed as 24 g but actually weighed 32 g when we measured at its full capacity. To maintain accuracy of the mass budget, we switched to the 8 g Orion 10440 battery. We measured and claimed that Orion battery weights actually 8 g at full capacity as listed.	

PDR - Switching regulator for ground camera	Rationale	CDR - Switching regulator for ground camera
No such a choice was made.	As we moved to a smaller capacity battery, we would need to use it more efficiently for our ground camera. Therefore, we chose a switching voltage regulator. This reduces the duty cycle of the battery and improves working time. $D = 1 - \frac{V_{in}}{V_{out}}$ $D = 1 - \frac{3.7}{5}$ Here, duty cycle is calculated as **D = %26**, and **power budget is calculated with this new duty**.	

EPS Changes Since PDR (3/4)

Parallel Connection Protection Circuit (PCPC) & Reverse Polarity Protection Circuit (RPPC) Changes

PDR - MOSFETs

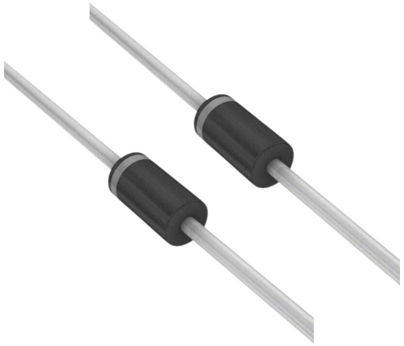


Rationale

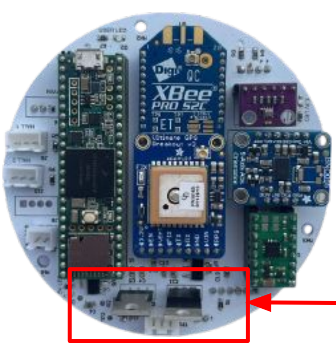
Although we did not have any problems during prototyping on the breadboard, there were some problems in sending telemetry data and commands over long distances with XBee, when MOSFET circuit was present. This problem disappeared when we switched from MOSFETs to diodes.

Schottky diodes is selected because of their low voltage drop feature.

CDR - Schottky Diodes



PDR - PCB Overview



There is no need to change the prototype PCB with a new one. Schottky diodes are soldered to replace the MOSFETs.

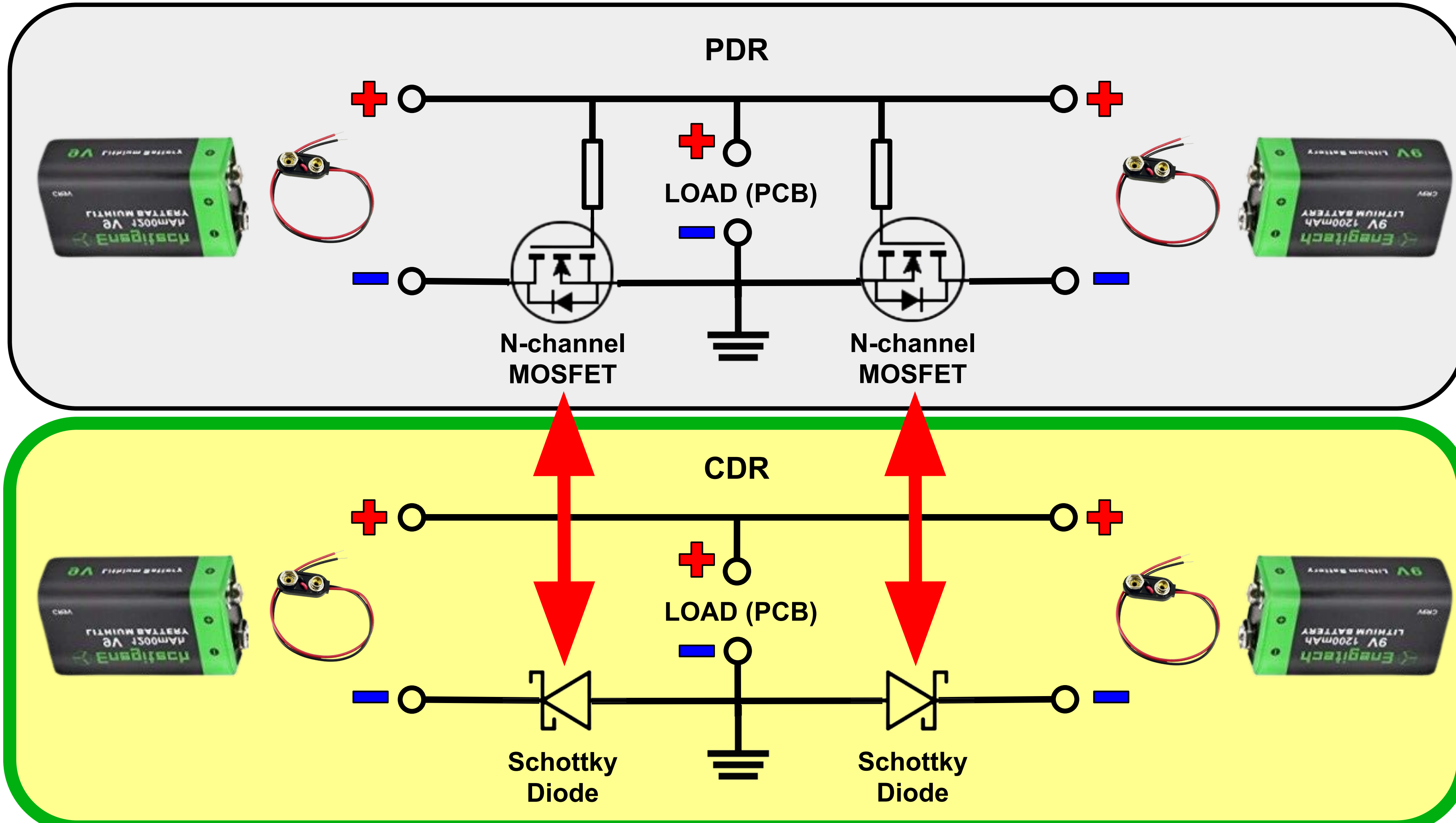
MOSFETs

Schottky Diodes

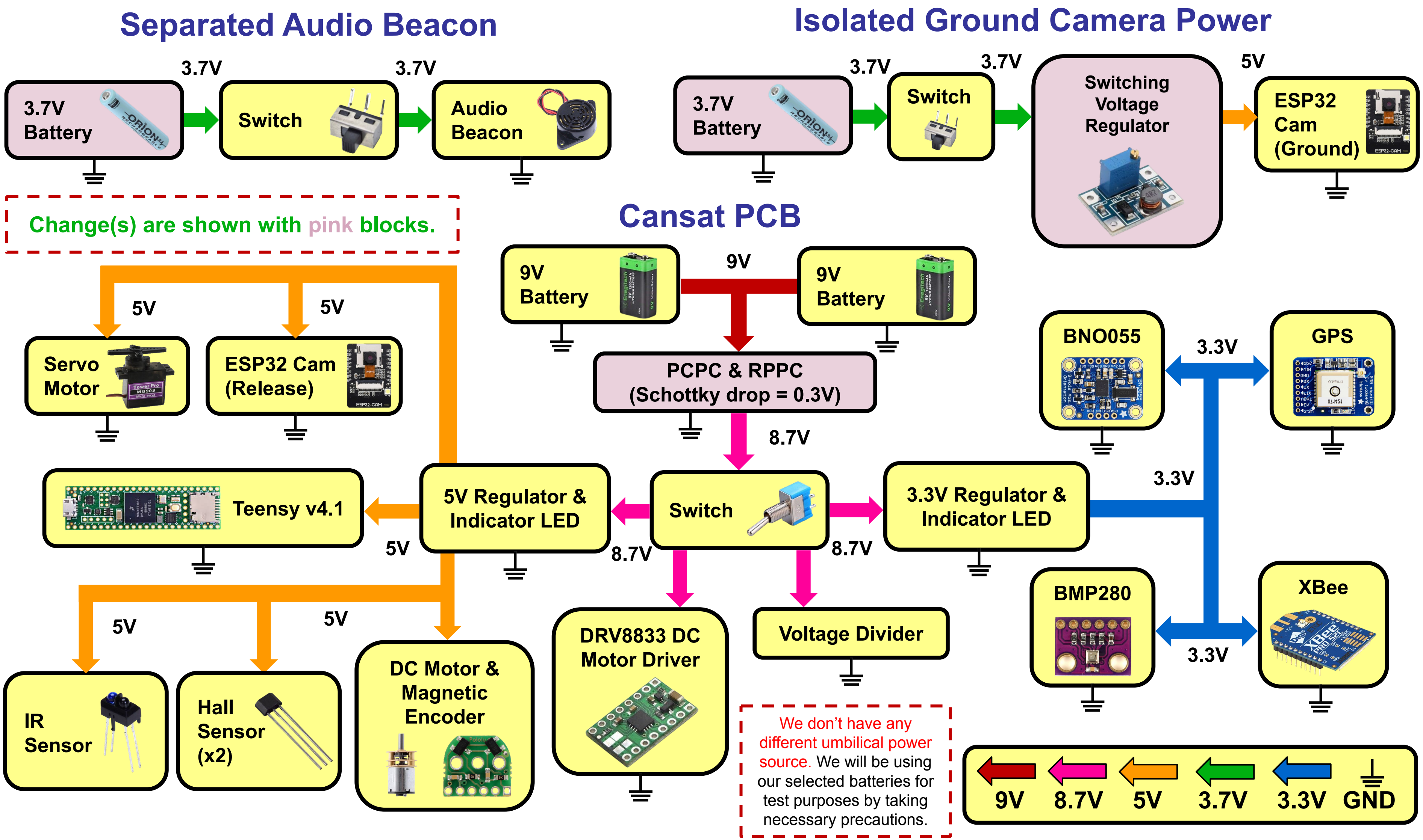
CDR - PCB Overview

EPS Changes Since PDR (4/4)

Parallel Connection Protection Circuit (PCPC) & Reverse Polarity Protection Circuit (RPPC) Changes



Payload Electrical Block Diagram



Payload Power Source (1/3)

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

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

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

3.7V Battery Selection

Battery	Battery Type	Voltage [V]	Maximum (Instantaneous) Current [mA]	Current Capacity [mAh]	Power Capacity [Wh]	Mass [g]	Size [mm]	Cost [$]
Orion 10440	Lithium-ion	3.7	500	400	1.48	8	10 x 44	1.43

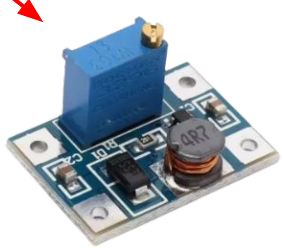
Configuration and connection:

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)**, with **switching regulator.**
- The other one is supplying the **separated audio beacon.**

Orion 10440

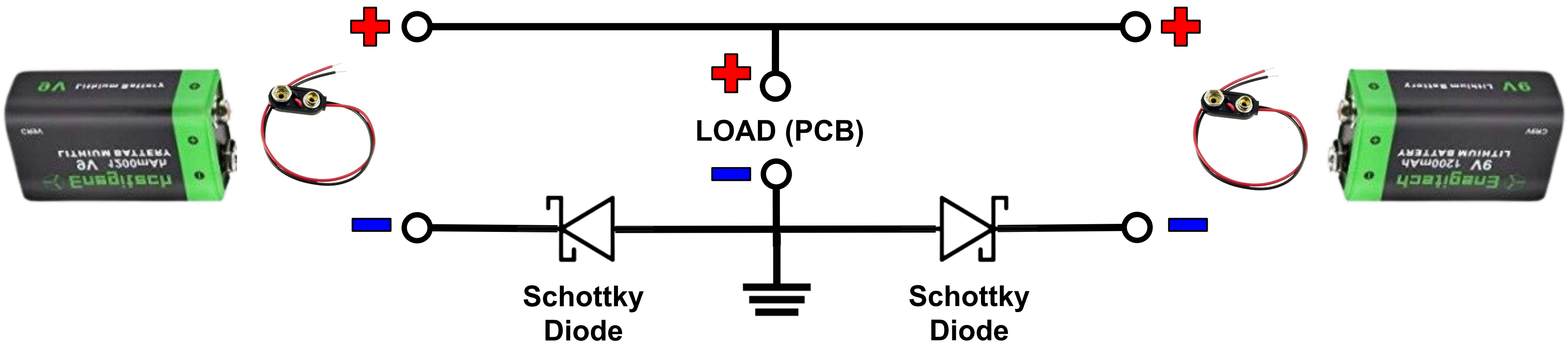
- **Good price**
- **Small weight**
- **Small size allows us to fit it on the plate together with the voltage regulator module**



This switching regulator board is connected to ground camera to operate at better efficiency.

Payload Power Source (3/3)

Parallel Connection Protection Circuit (PCPC) & Reverse Polarity Protection Circuit (RPPC)



PCPC Explanation: This **Schottky diodes** are oriented such that they block 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, Schottky diodes block this reverse current by disconnecting the ground of low voltage side battery.

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

RPPC Explanation: This **Schottky diodes** 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, corresponding diode blocks the current flow.

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.

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 Metal 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**	

Duty cycle of the ground camera is taken as 26%, because of the switching regulator.
Change(s) are shown with pink blocks.

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	5	140	26	1872	**0.3640**	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. Schottky diode voltage drop: 0.3V Remaining voltage: 9 - 0.3 = 8.7V Total Capacity = 2 x 8.7V x 1.2Ah = **20.88 Wh**
Total Efficient Capacity [Wh]	Efficiency is taken as 70%, resulting: Efficient Capacity = 20.88 Wh x 0.7 = **14.62 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 = 14.62 Wh - 4.9981 Wh = **9.6219 Wh**
Run Time [h]	Run time = 14.62 / 4.9981 = **2.93 hours**

All the values are recalculated for PCB, by considering the Schottky diode voltage drop.

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 **0.3640** Wh from the table.	Calculated as **0.0888** Wh from the table.
Total Available Capacity [Wh]	We use a 3.7V 400mAh battery. Total Capacity = 3.7V x 0.4Ah = **1.48 Wh**	We use a 3.7V 400mAh battery. Total Capacity = 3.7V x 0.4Ah = **1.48 Wh**
Total Efficient Capacity [Wh]	Efficiency is improved by using switching regulator, and taken as 80%, resulting: Efficient Capacity = 1.48 Wh x 0.8 = **1.18 Wh**	Efficiency is taken as 33%, resulting: Efficient Capacity = 1.48 Wh x 0.33 = **0.49 Wh**
Margin [Wh]	Assuming that parameters of the ground camera also have 10% error, resulting: Total Consumption with Error = 0.3640 Wh x 1.1 = **0.4004 Wh** Margin = Efficient Capacity (Wh) - Total Consumption with Error (Wh) Margin = 1.18 Wh - 0.4004 Wh = **0.7796 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 = 0.49 Wh - 0.0977 Wh = **0.3923 Wh**
Run Time [h]	Run time = 1.18 / 0.4004 = **2.95 hours**	Run time = 0.49 / 0.0977 = **5.02 hours**

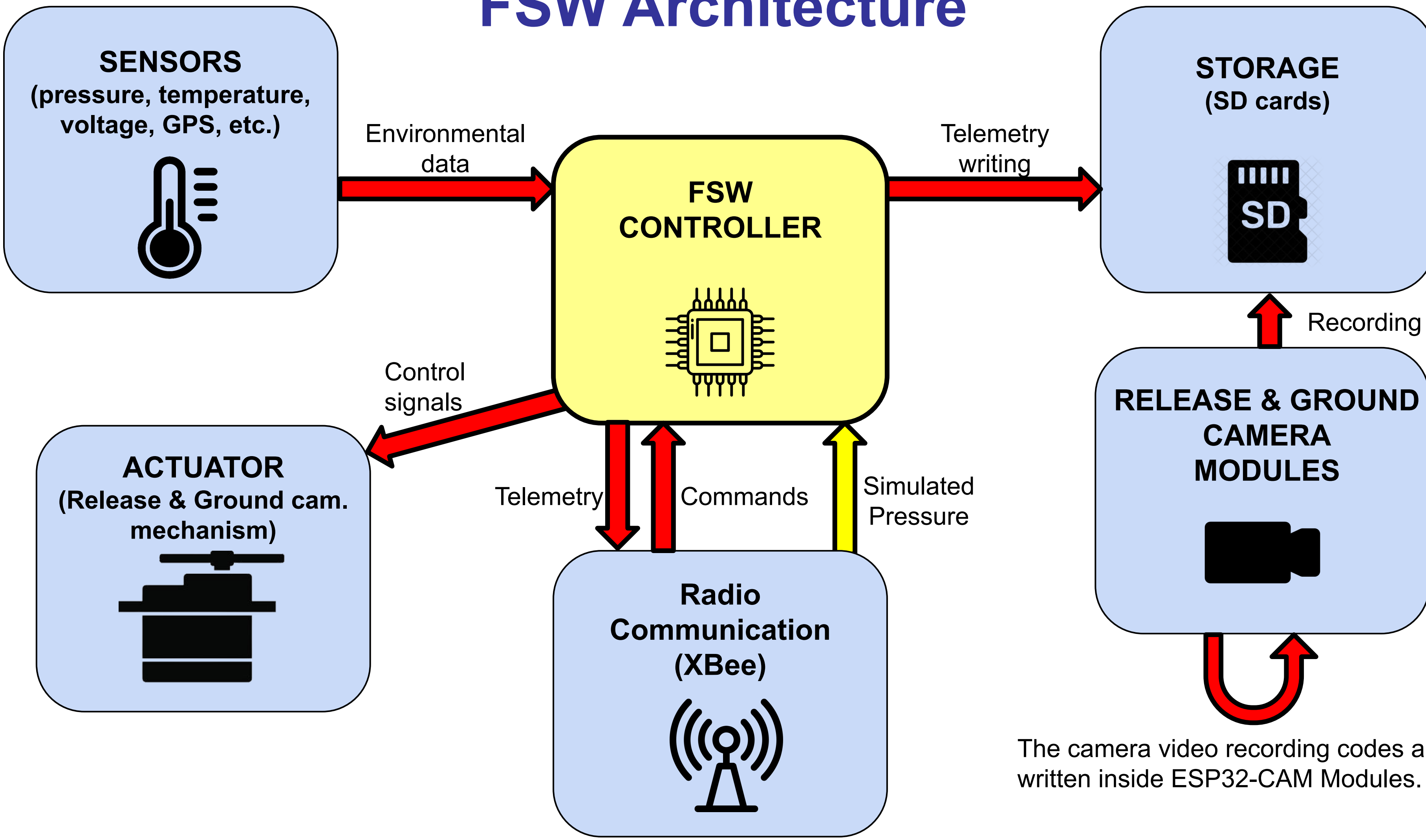
All the values are recalculated for ground camera and audio beacon, by considering the EPS changes.

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

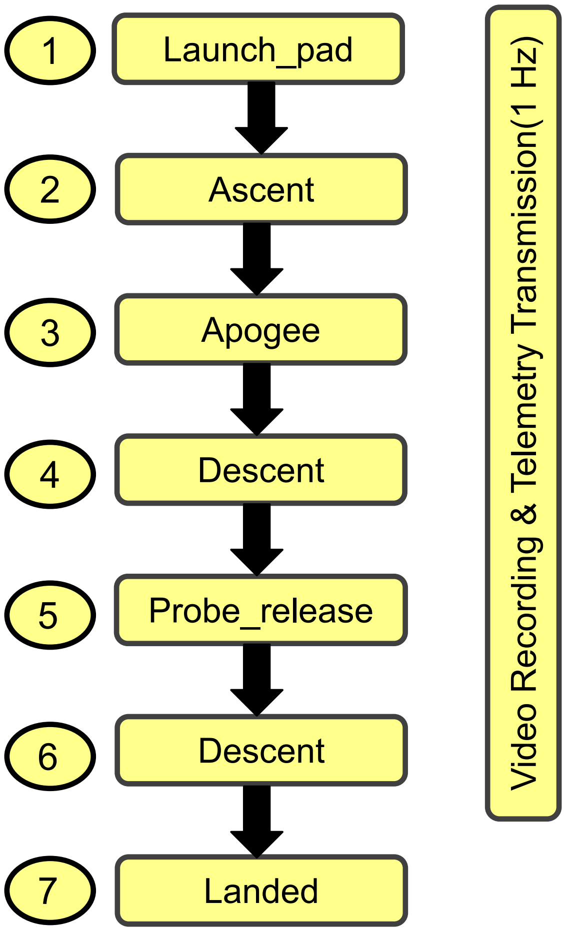
FSW Architecture



The camera video recording codes are written inside ESP32-CAM Modules.

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

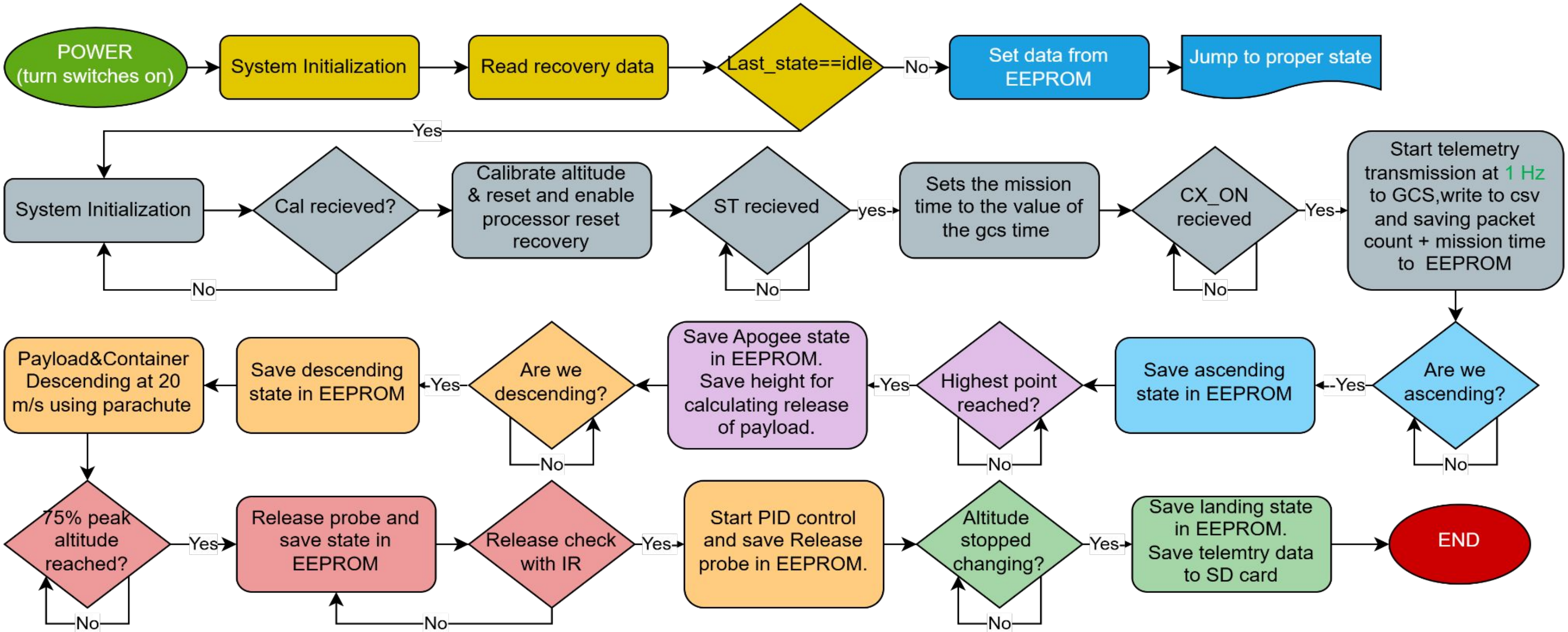
- Initializing sensors, modules, and power systems; starting timer and resetting packet counter, calibrating sensors and verifying system health.
- Maintaining ground station connection, collecting and analyzing commands from Ground Station.
- Recording raw sensor values and translating them to standardized 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

FSW Changes Since PDR

No change(s) have been made since the PDR.

Payload CanSat FSW State Diagram (1/4)



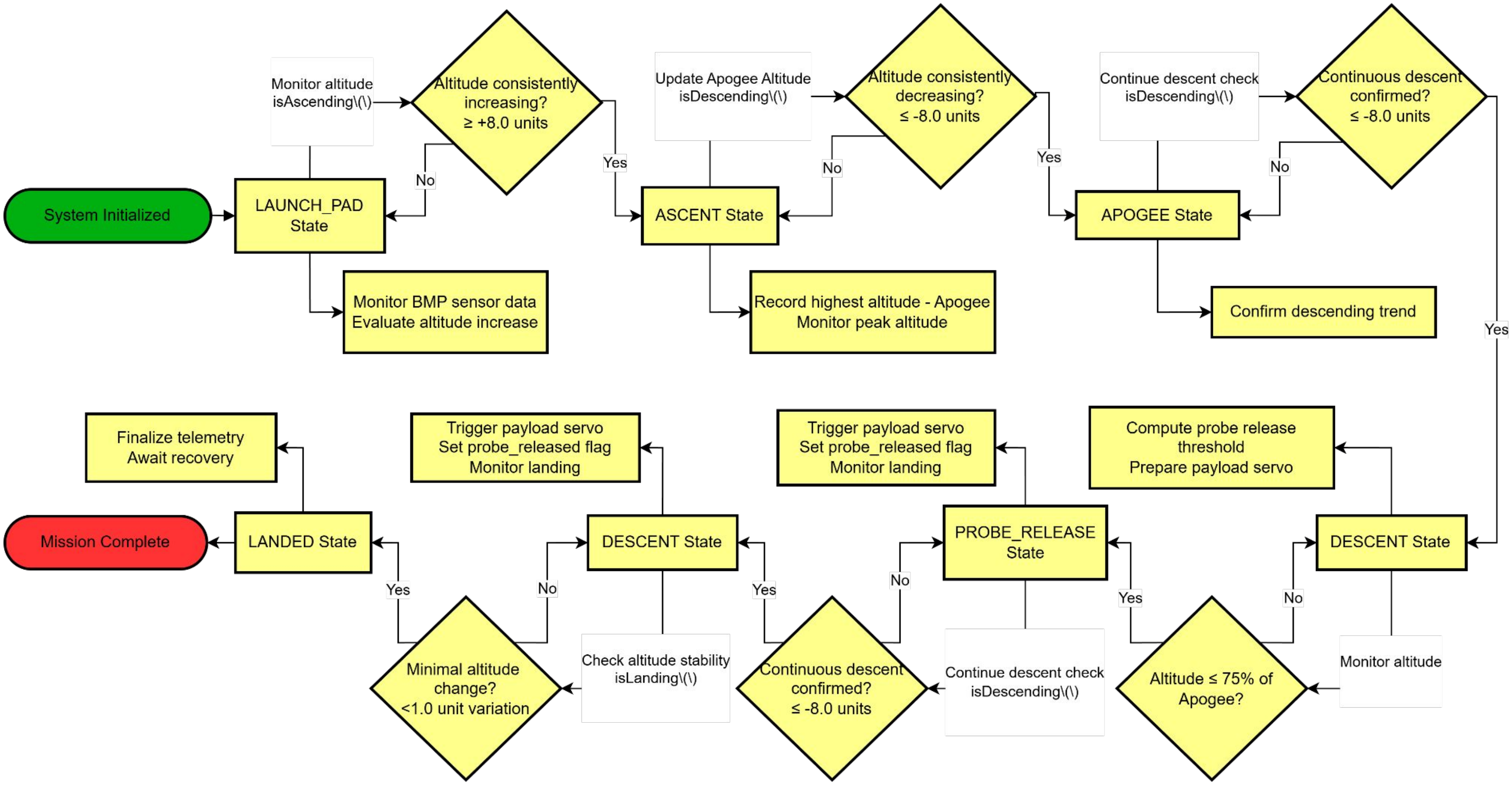
Colors represents states:

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.

Detailed explanation of state machine transition logic continues on the next slides.

Detailed State Decision Mechanism



Variables and Functions Under the State Logic

- **Essential Variables and Functions Variables:**
  1. **state:** The current flight state (e.g., LAUNCH_PAD, ASCENT, APOGEE, etc.).
  2. **apogee_altitude:** Tracks the highest altitude reached during ascent.
  3. **probe_release_threshold:** Computed as 75% of the apogee altitude; used to determine when to release the probe.
  4. **probe_released:** A flag indicating whether the probe has been deployed.
  5. **sendTelemetry:** A flag to control the sending of telemetry data.
  6. **mode:** Determines whether the system is in Flight or Simulation mode.
  7. **lastSimPressure:** Used in simulation mode to simulate pressure readings.
- **Key Functions:**
  1. **bmp.update() and bmp.sim_update():** Update sensor readings from the BMP280 sensor or replace simulation value.
  2. **isAscending(), isDescending(), isLanding():** Helper functions that determine the flight condition based on altitude differences.
  3. **payloadServo.update(int angle):** Controls the servo for probe release.

The method uses helper functions to compare the current altitude (from the BMP280) with altitude values from one and two seconds ago:

- **isAscending:** Checks if the difference between the current altitude and the previous two readings is at least +8.0 units consistently. This indicates a strong upward (launch) movement.
- **isDescending:** Checks if the altitude differences are at least –8.0 units, which signals a significant downward trend.
- **isLanding:** Determines landing by checking if the differences between successive altitude measurements are below 1.0 unit, indicating that the altitude is no longer changing much.

These helper functions encapsulate the logic for detecting various flight conditions.

Payload CanSat FSW State Diagram (4/4)

• 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 set to UTC time directly from GCS computer 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

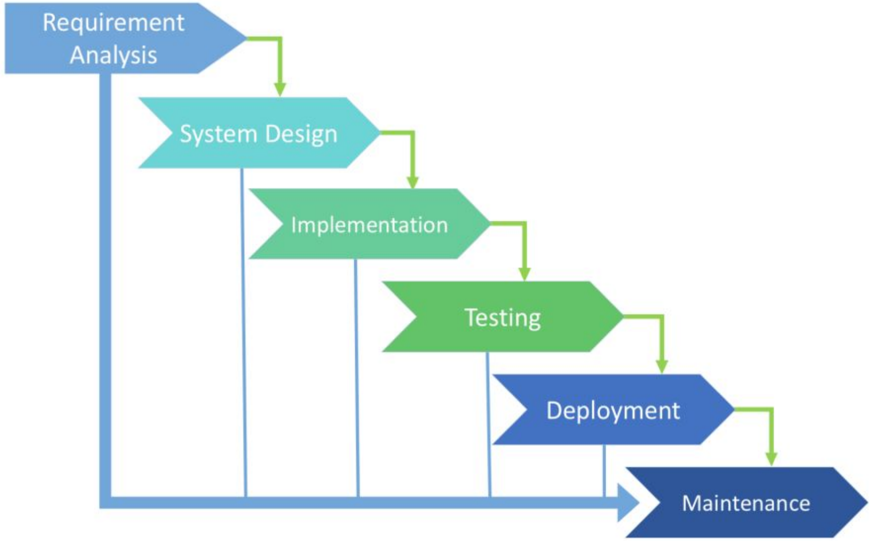
CMD,3133,SIMP,<PRESSURE>	Provides a simulated pressure reading to the payload.

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

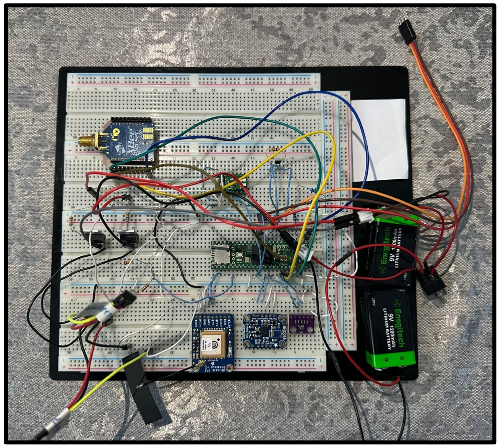
Using **"Iterative and Incremental Development"** methodology, we will resolve the risk of late software development. Through this method the project will contain different sprints. For each sprint, there will be a process of testing and verification before proceeding to the next sprint. The efficiency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



Software Development Plan (2/3)

Prototyping and Prototyping Environments

A prototype had substantiated through a breadboard by combining all components on it. After this operation, the circuit board printed on PCB. Dummy transition values used in testing and running the software. Final prototype of the model tested as a complete system.



Test Methodology

Subsystem testing has been completed at the conclusion of each iteration and sprint. Currently, compliance tests are being performed to verify the correct integration and functionality of all components working together. The compliance tests in progress include examples such as free-fall drop tests, power tests, and communication tests.

Development Team: Ulas Ucrak

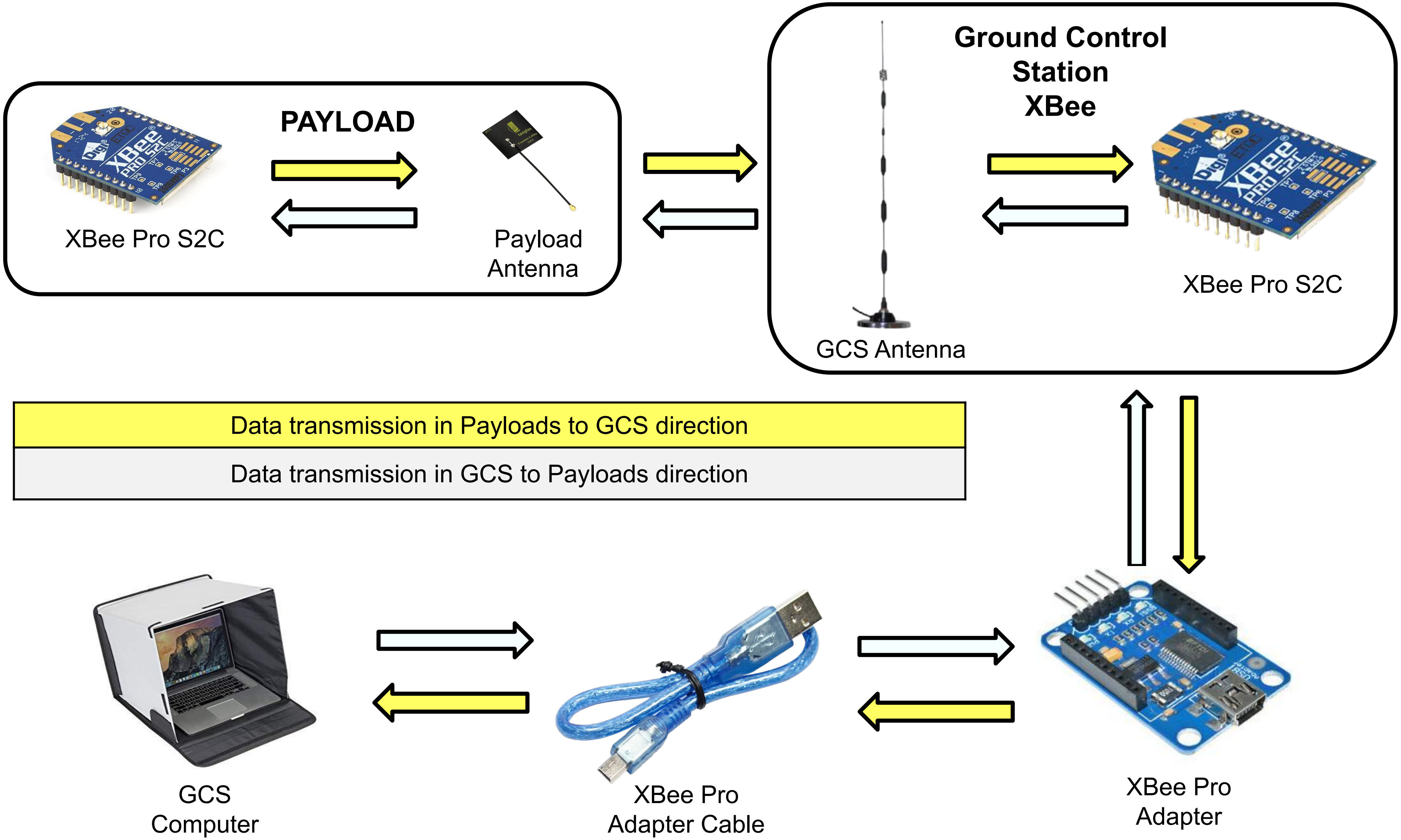
Software Development Plan (3/3)

Progress since PDR	
Sensor communication & Libraries for each sensor	Done
Telemetry generation	Done
Servo connection and control	Done
PID control	Done
XBee communication between payload & GCS	Done
Command handler	Done
Backing-up telemetry data on SD cards	Done
Recovery from EEPROM	In progress

Ground Control System (GCS) Design

Ulas UCRAK

GCS Overview



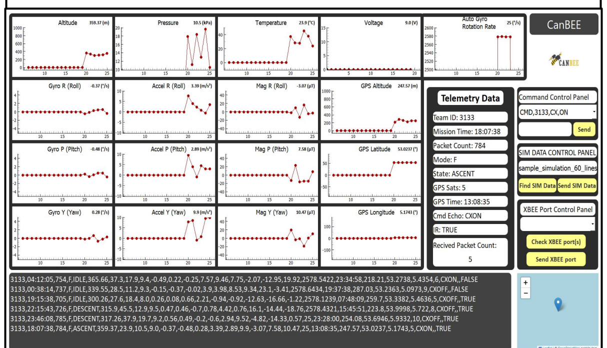
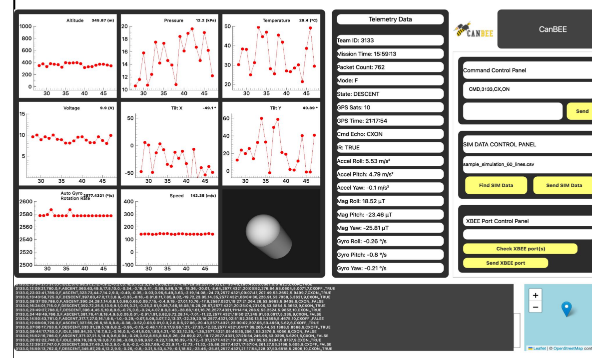
GCS Changes Since PDR (1/3)

Changes Overview

Components	PDR	CDR	Rationale
Number of graphs in GUI	17 plot graphs for telemetry datas	8 plot graphs for telemetry datas & 3D CanSat Visualization	We reduced the number of plots from 17 to 8 by removing separate **MAG**, **ACCEL**, and **GYRO** axes, instead of focusing **Tilt X** and **Tilt Y** for clearer orientation. We also used sensor data to generate a 3D CanSat model, offering a more intuitive view of its attitude and movement during descent.

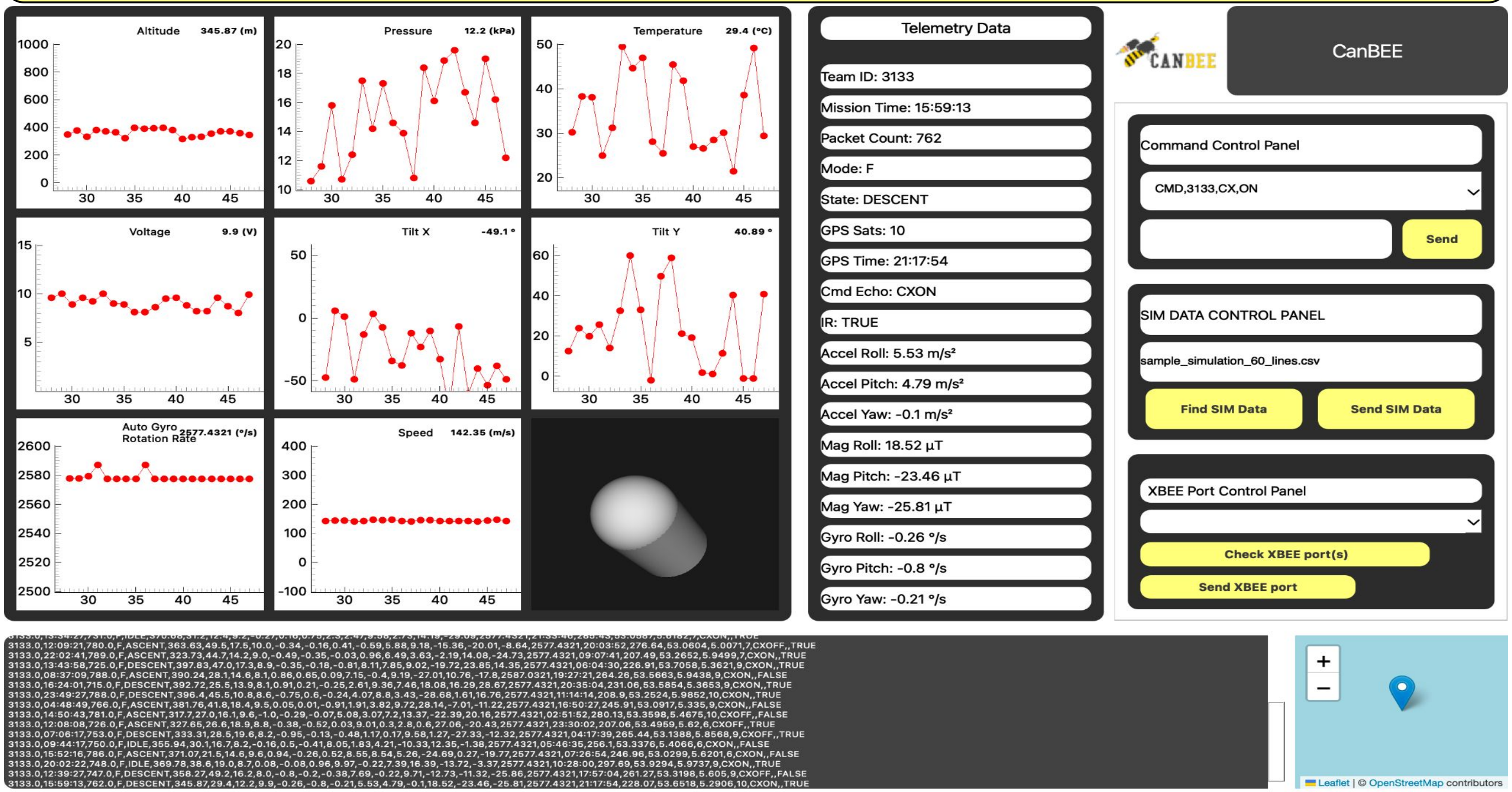
More detailed explanations are discussed in subsequent slides.

GCS Changes Since PDR (2/3)

PDR - GUI with 17 Plot Data	Rationale	CDR - GUI with 8 Plot Data
	We reduced the number of plots from 17 to 8 because we found it unnecessary to plot **MAG_R, MAG_P, MAG_Y, ACCEL_R, ACCEL_P, ACCEL_Y, GYRO_R, GYRO_P, and GYRO_Y** separately. Instead, we focused on **Tilt X and Tilt Y** for a clearer representation of the CanSat's orientation. Additionally, we utilized incoming sensor data to create a **3D satellite model visualization**, providing a more intuitive way to monitor the CanSat's behaviour and movement during descent.	

GCS Changes Since PDR (3/3)

GUI with 8 Plot Data & CanSat visualization



Detailed visual of the GUI that changes during the CDR phase

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 (1/8)

Model	Gain [dBi]	Connector Type	Beam Width [H°/V°]	Length [mm]	Antenna Radiation Pattern	Frequency Range [GHz]	Cost [$]
LTE-Q7027I22	15	SMA Male	360 - 6	895	Omni directional	2.4 - 2.5	22.79

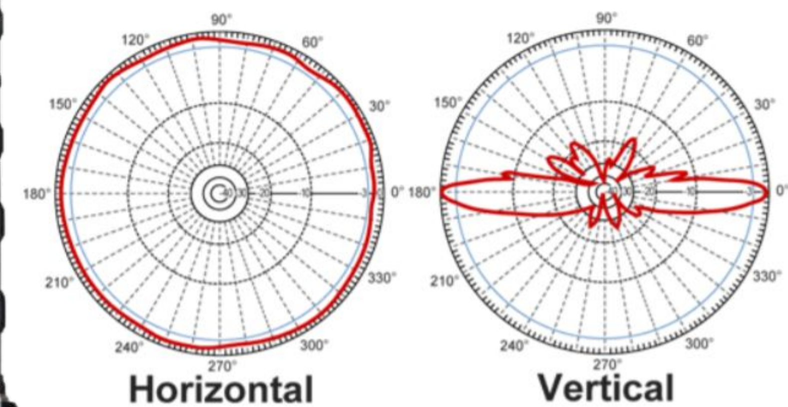
Selection Criteria: **XBee operates at 2.4 GHz and the frequency range of the antenna we selected is compatible with XBee.**

LTE-Q7027I22

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

Antenna

Radiation Patterns



GCS Antenna (2/8)

MOUNTING ANTENNA DESIGN

Design	Type	Design	Mass [g]	Price [$]
Design 1	3D Printed	Handheld	126	1.3

Our antenna mounting meets the requirement G13, that states:
- The ground station shall use a table top or handheld antenna.

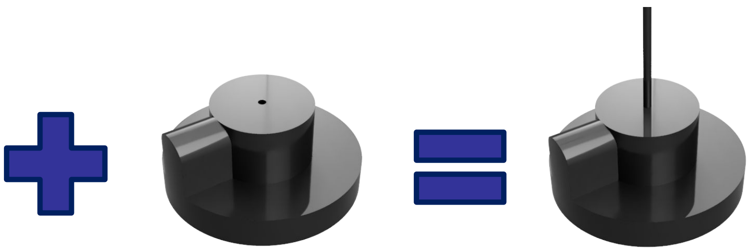
Handheld 3D Printed Design

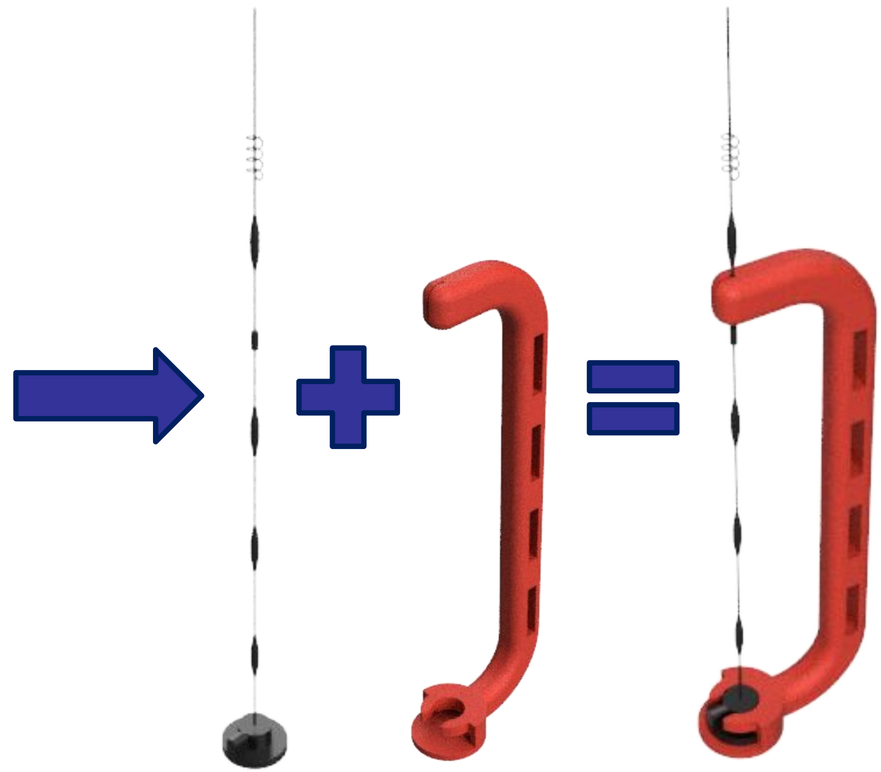
- **Lower cost**
- **Easy to operate**
- **Small and lightweight, therefore easy to transport**

Selected Mounting Design

ANTENNA CONSTRUCTION

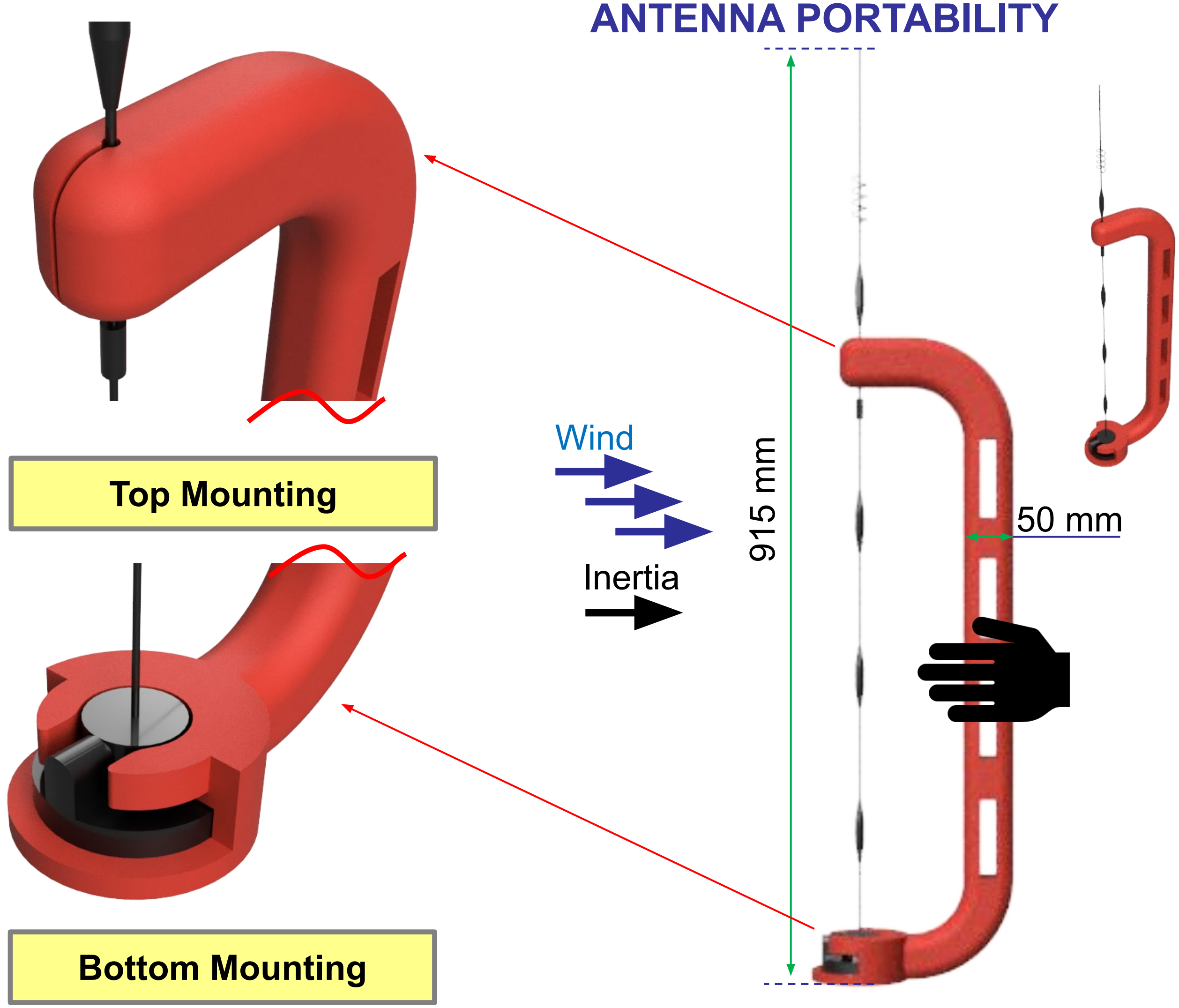
Antenna is originally consists of two parts. It has rod and magnetic base. Rod is inserted into the hole of the base by screwing.





After this process, the entire antenna structure is inserted into the hand-carrying apparatus.

ANTENNA PORTABILITY



Hand-Held Antenna holder is designed for stable carrying in the area.

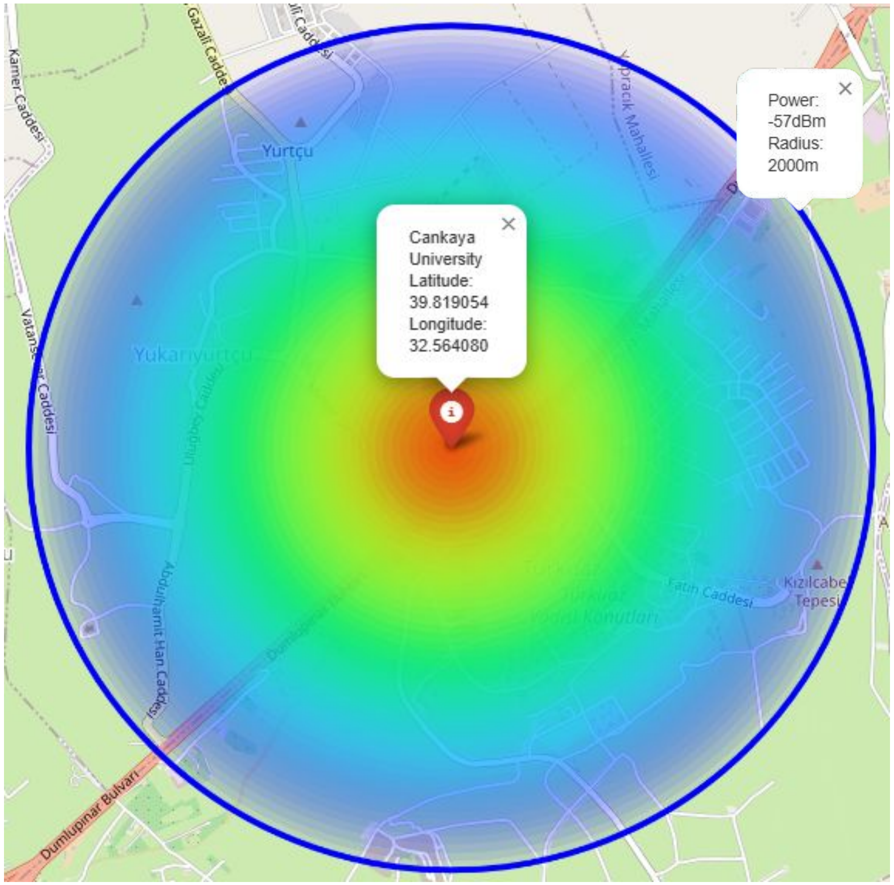
50 mm grapple is comfortable to hold in hand.

PLA material is used as holder material, so the design will be around 200 g. That is alright for carrying in hand.

Wind and inertial force of antenna is a problem while carrying because of unwanted bending of the antenna. This problem is solved by top mounting.

GCS Antenna (5/8)

ANTENNA COVERAGE AREA



Max. Antenna Coverage Area (R=2 km)

Result Values Shown on Terminal

```
Maximum Coverage Radius: 2000m
Map Generated: antenna_coverage.html
```

NOTE:
The antenna coverage area is calculated based on a 2 km (2000 m) predicted link distance. The color transitions from red to blue on the graph indicate the signal level. The red center represents the strongest signal, green represents intermediate strength, and blue shows the weakest.

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:

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

Maximum predicted link distance = 2 km

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

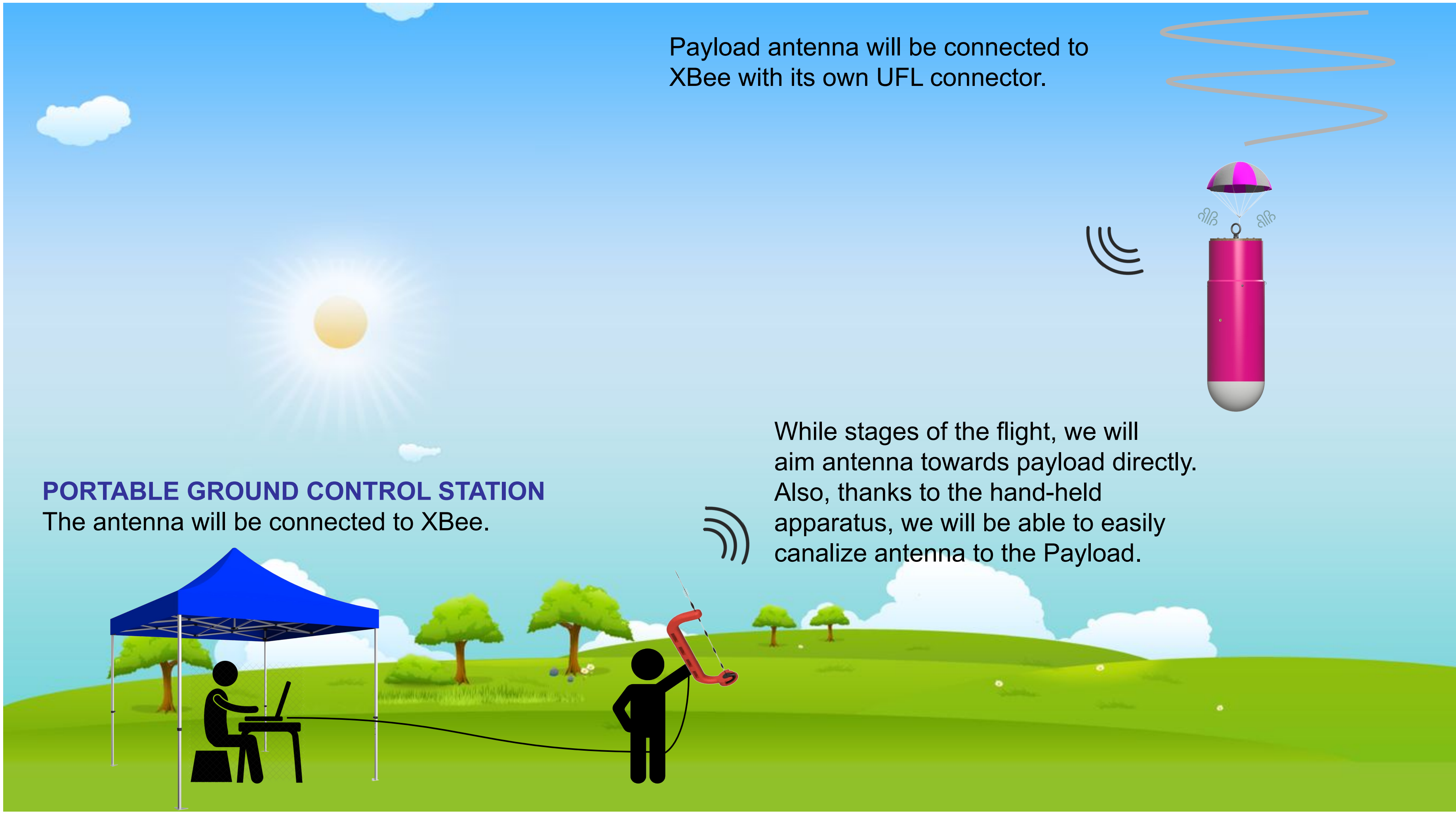
- Receiver Sensitivity (XBee Pro S2C) = **-101 dBm**
- Transmitter Output Power = **18 dBm**
- Transmitter Antenna Gain = **5 dBi**
- Receiver Antenna Gain = **15 dBi**
- Miscellaneous Signal Propagation Losses = **10 dB** (estimated)
- Receiver Feeder and Associated Losses = **3 dB** (estimated)
- Transmitter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

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

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

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

COMMUNICATION SYSTEM DEMONSTRATION



GCS Software (1/5)

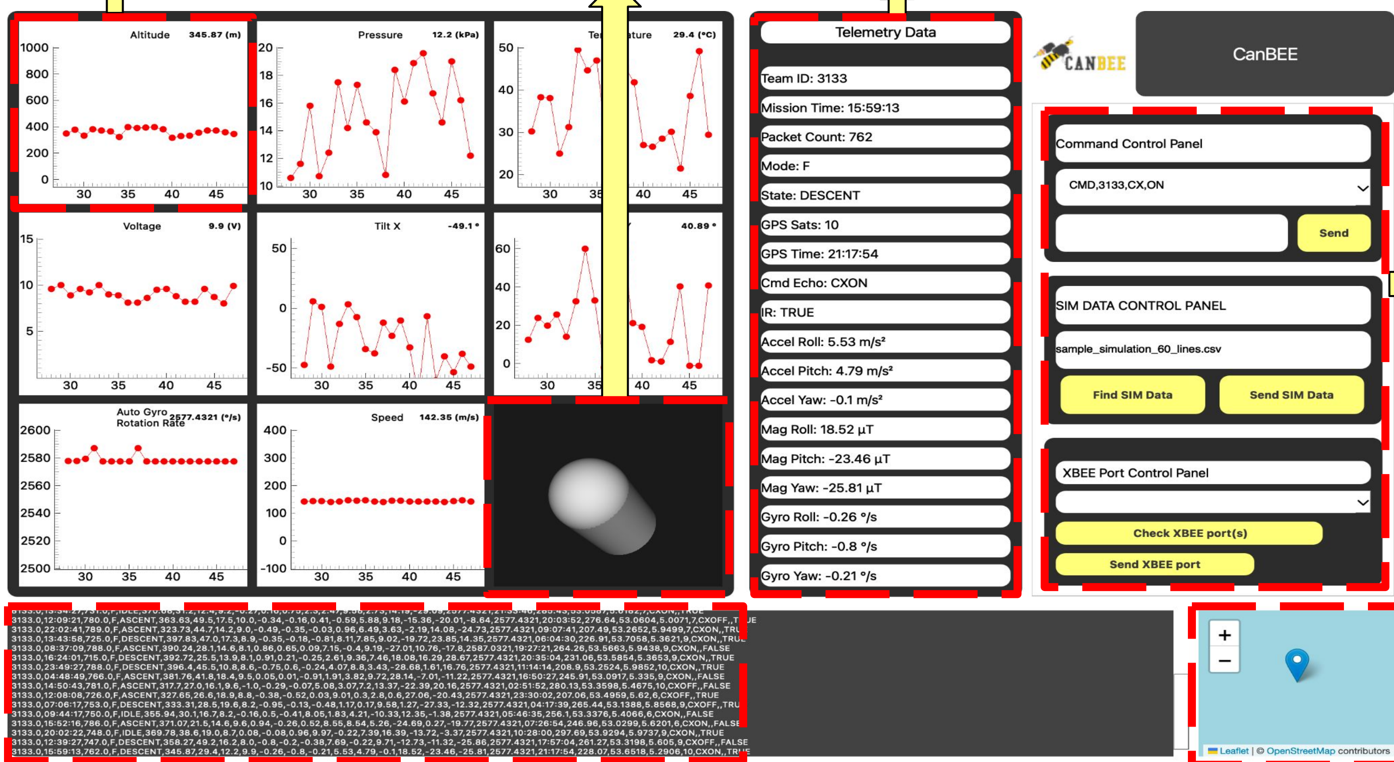
Telemetry Display Screenshots

Real-time plotting data

Real-time CanSat visualization

Telemetry data that is not displayed as graph.

Command control panels



GPS data representation on map.

Telemetry display text-box will displayed bottom-left part of the screen.

GCS Software (2/5)

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 (3/5)

Payload

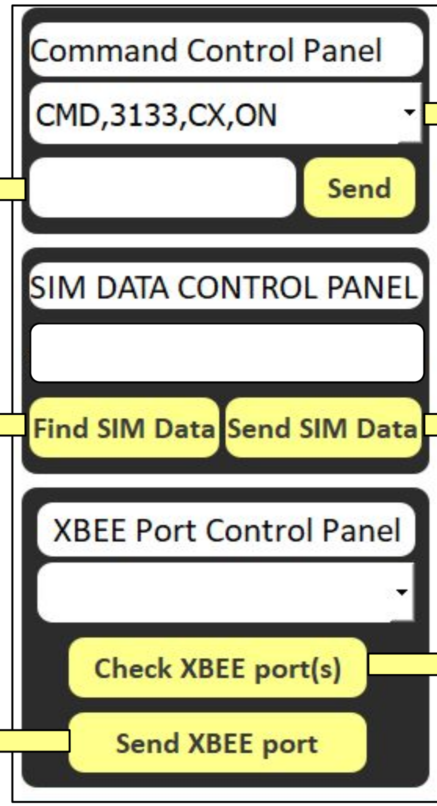
**<TEAM_ID>,<MISSION_TIME>,<PACKET_COUNT>,
<MODE>,<STATE>,<ALTITUDE>,<TEMPERATURE>,
<PRESSURE>,<VOLTAGE>,<GYRO_R>,<GYRO_P>,
<GYRO_Y>,<ACCEL_R>,<ACCEL_P>,<ACCEL_Y>,
<MAG_R>,<MAG_P>,<MAG_Y>,
<AUTO_GYRO_ROTATION_RATE>,<GPS_TIME>,
<GPS_ALTITUDE>,<GPS_LATITUDE>,<GPS_LONGITUDE>,
<GPS_SATS>,<CMD_ECHO>,,<IR_STATUS>**

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 recorded to **CSV** format and added to existing **CSV** file.
6. **CSV file (Flight_3133.csv) and video recordings will be presented to the judges by flash memory.**

GCS Software (4/5)

Command Software & Interface



Text box for sending commands by typing

List box for selecting prepared commands (CXON, SIMP etc.).

Button for browse and select simulation data.

Sends the selected simulation data to payload.

Initializes the selected XBee port, establishes communication, and starts receiving telemetry data from payload.

Scans and lists available XBee ports connected to the system.

Progress since PDR	
PyQt GUI	Done
Telemetry read through GUI	Done
Release mechanism control through GUI	Done
GCS Laptop & XBee communication	Done
Command handler	Done

CanSat Integration and Test

Arda GARIP

CanSat Integration and Test Overview

	CanSat Test Consists of 4 Main Branches			
	1.Subsystem Tests	**2.Integrated Tests**	**3.Simulation Tests**	**4.Environmental Tests**
Purpose	All the subsystems will be tested separately	Subsystems will be integrated and tested together	Integrated subsystems will be tested in simulation mode to test flight level software logic	Mechanical, electrical, electronic and software checks.
Test	Sensors, CDH, EPS, Radio Communications, FSW, Mechanical, Descent Control	Descent Testing, Communication Testing, Mechanisms, Deployment	Flight Software	Drop test, Thermal test, Vibration test, Fit Check, Vacuum test

Component to Fully Integrated

1. First, the payload, body, and mechanism will be manufactured separately and subjected to independent tests. At the same time, the electronic circuits will be soldered, programmed, and debugged.

2. After confirming that all components function correctly, the mechanism and electronic systems will be integrated, followed by a full system test.

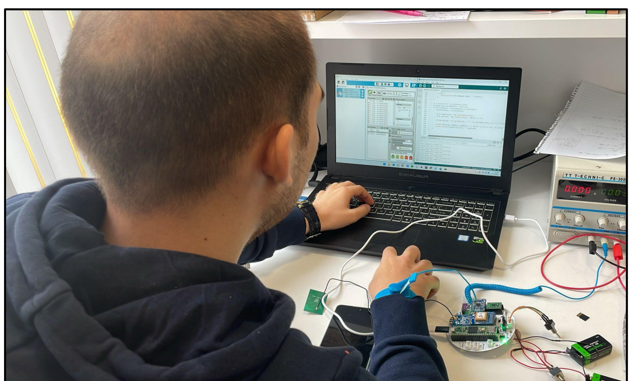
3. Once the integration test is completed, simulation tests will be conducted to verify the accuracy of the algorithms.

4. In the final stage, environmental tests will be carried out to assess the functionality of the CanSat under specified conditions.

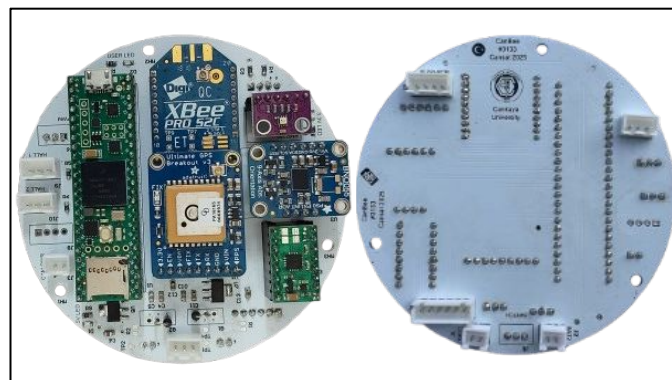
Subsystem Level Testing Plan (1/6)

Sensors		PASS FAIL CRITERIA
Test	**Description**	
Operable Sensors	All sensor are separately checked on breadboard to see whether they are working or not.	If the sensor works, then it passes the test; otherwise fails.
Sensor Calibration	All sensors are calibrated by considering a verified source.	If the sensor data is true according to the verified source, it passes; otherwise fails.

Communication Data Handling (CDH)		PASS FAIL CRITERIA
Test	**Description**	
Data Transfer Tests	Data transfer speed and accuracy between GCS and CanSat are tested with XCTU and Arduino IDE.	If the data transferred at 1Hz with no packet loss, it passes; otherwise, it fails.



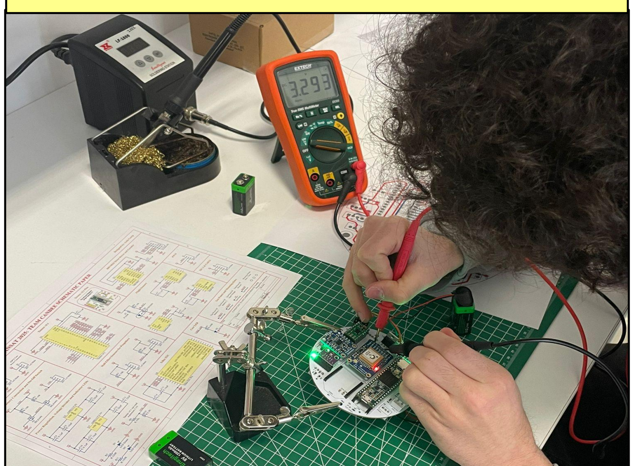
Data Transfer Tests



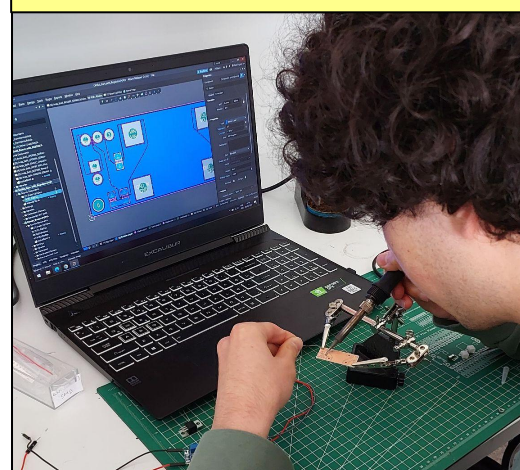
CanBEE Payload PCB

Electrical Power Subsystem (EPS)		PASS FAIL CRITERIA
Test	**Description**	
Voltage Measurement	Batteries is connected to components and voltage values are measured with multimeter.	If every component has its required voltage on it, then no problem; otherwise fails.
Current Measurement	Operation currents are checked with reference to EPS calculations.	If every component has its expected current on it, then no problem; otherwise fails.
EPS Components Working Time	All the batteries are connected to the corresponding components, and run time of each component is observed.	If all the EPS components can operate more than 2 hours, then it passes; otherwise fails.

Voltage Measurement

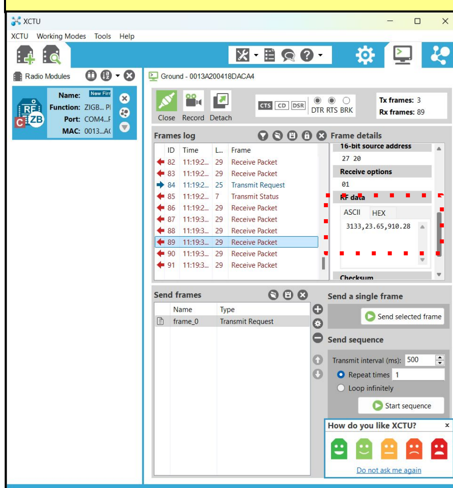
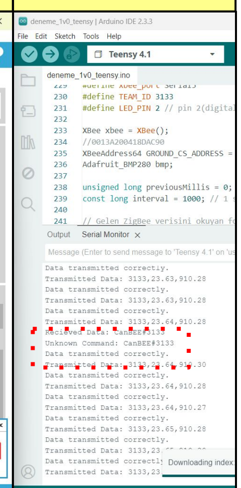


Soldering the Electronics



Subsystem Level Testing Plan (3/6)

Radio Communications		PASS FAIL CRITERIA
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.	If XBee transmits data accurately within the defined indoor and outdoor ranges, it passes; otherwise, it fails.
Signal Level Measurement	The XBee receiver and transmitter signal levels will be measured in XCTU indoors and outdoors using specified antennas.	If indoor and outdoor signal levels exceed the threshold, it fails; otherwise, it passes.

GCS	Payload
	

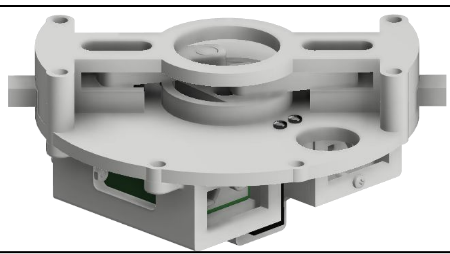
Subsystem Level Testing Plan (4/6)

Flight Software (FSW)		PASS FAIL CRITERIA
Test	**Description**	
Algorithm Test	Prototype will run with realistic dummy values and phases will be observed.	All algorithm phases execute correctly and transition as expected. Any failure or freeze in logic results in failure.
Simulation Mode Test	Simulation mode computation will be compared with real sensor values.	Simulated outputs match real sensor data within acceptable error margins. Deviation beyond threshold causes failure.

Algorithm Test

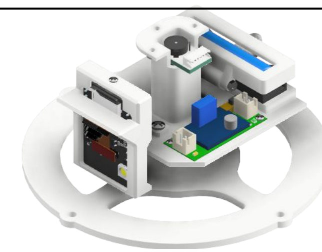
Subsystem Level Testing Plan (5/6)

Mechanical and Mechanism		PASS FAIL CRITERIA
Test	**Description**	
Mass Control Test	Total mass is checked according to the requirements by measuring mass using precision scale.	The mass is within the desired limits. If not, it fails.
Servo & DC Motor Adjustment	Servo & DC rotation calibration will be done by conducting operational test many times.	Servo and DC motor mechanisms work in accordance with their design purpose. If not, it fails.
Release Mechanism Test	The servo is connected to the release mechanism, integrated into the CanSat, and activated via ground command at various CanSat angles.	If the release mechanism can perform the release process at different angles with the ground control command, the test is considered valid.
Ground Cam. Mechanism Test	The camera mechanism is calibrated to a north data and it is turned on and the mechanism is synchronized to ensure that the camera is shooting north.	If the camera cannot capture the north with a 10 degree error, the test fails.



Release Mech

Ground Cam Mech



Subsystem Level Testing Plan (6/6)

Descent Control and Mechanism		PASS FAIL CRITERIA
Test	**Description**	
Parachute Deployment Test	Parachute deployment is tested during descent process by releasing from drone.	The parachute opens passively as expected.
Auto-gyro Test	Auto-gyro descending test of the propellers, opening and rotating passively by releasing from drone.	Stabilization and deployment configuration are realized in accordance with the design purpose of the mechanism.
Velocity Test	CanSat's descent velocity will be checked for parachutes and aerobraking by releasing from drone.	CanSat meets the speeds in the mission guide during flight stages.

Integrated Level Functional Test Plan (1/3)

- 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 750 m height and free fall test is operated. During the descent, all test can be conducted.**

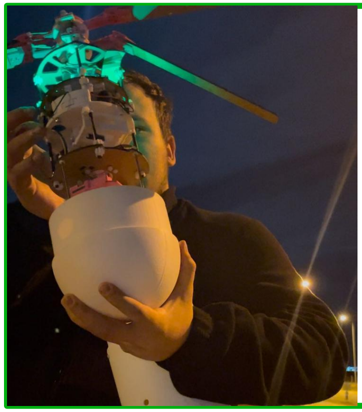
Descent Testing	• Propeller test. If it works at the desired speeds using an axial fan. • Aerobraking velocity will be observed. • Descent rate will be tested after all the systems such as parachutes and release mechanisms are deployed. • Container deployment will be tested with a fan to check if the airflow is enough.
Communications	• 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 1 Hz frequency. GCS should have enough processing throughput to handle the data.) • Signal Quality with antenna will be tested.
Mechanisms	• 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?
Deployment	• 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.
Simulation	• After sending the command SIMULATION ACTIVE, then the command SIMULATION ENABLE, pressure data will be sent to the payload from ground station. Recorded data frames will be checked and compared with our prepared mission state diagram.

Payload Release from Container

Release Trigger	The test for the release trigger of the release at 75% of the peak altitude will be carried out during the vacuum tests of the integrated CanSat.
Mechanisms	Tests of Mechanical and Descent Control Subsystem, such as release mechanism and parachute, and drop test will be performed with the CanSat at Integrated Level.
Payload Rotor Release	Dummy payload with the same mass as the actual one will be placed inside the container and released from specific heights to test parachute deployment. The parachute attachment component will undergo a tensile test with a load exceeding the expected deployment force to ensure a safety margin. Similarly, a tensile test will be conducted on the container's eyebolt to verify the strength of the attachment point. Once parachute deployment is deemed reliable, the container will be released from a set height with the real payload to perform the final release test

Communication Test Plan

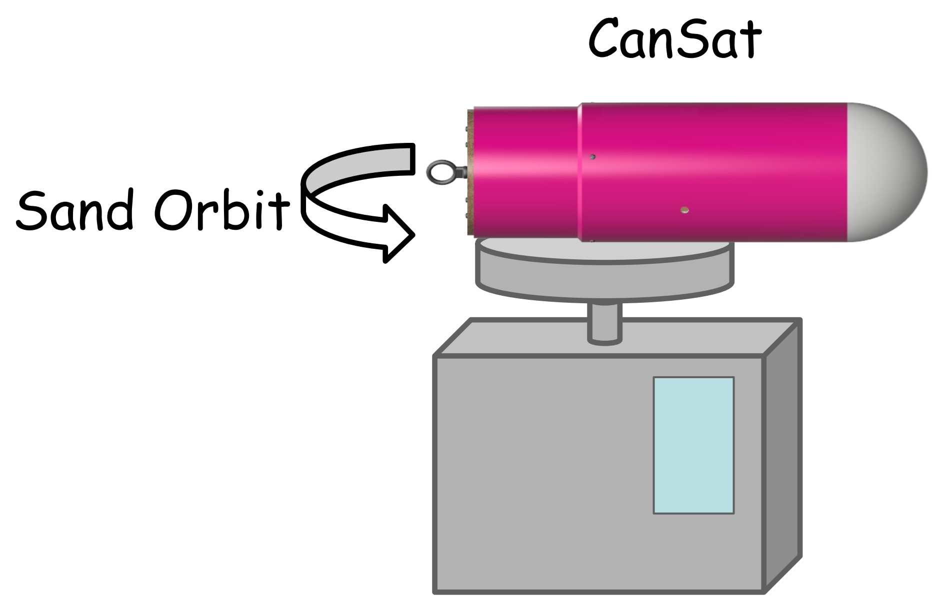
Ground Station Software	• GCS should have enough processing throughout to handle the data. • It will be tested whether the prepared commands are sent to the payload via GCS. • Signal Quality with antenna will be tested.
Telemetry	• XBee packet count and data format will be tested from ground station whether it is received appropriately or not. • Frequency and data processing throughout will be tested. (Payload XBee must have 1 Hz frequency.
Antennas	• Range test between payload and ground station will be tested by creating distance up to 1.5 km



An image from our long-distance and short-distance tests. We performed a releasing test with a command sent from the station, 1 km away from the ground station.

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 .



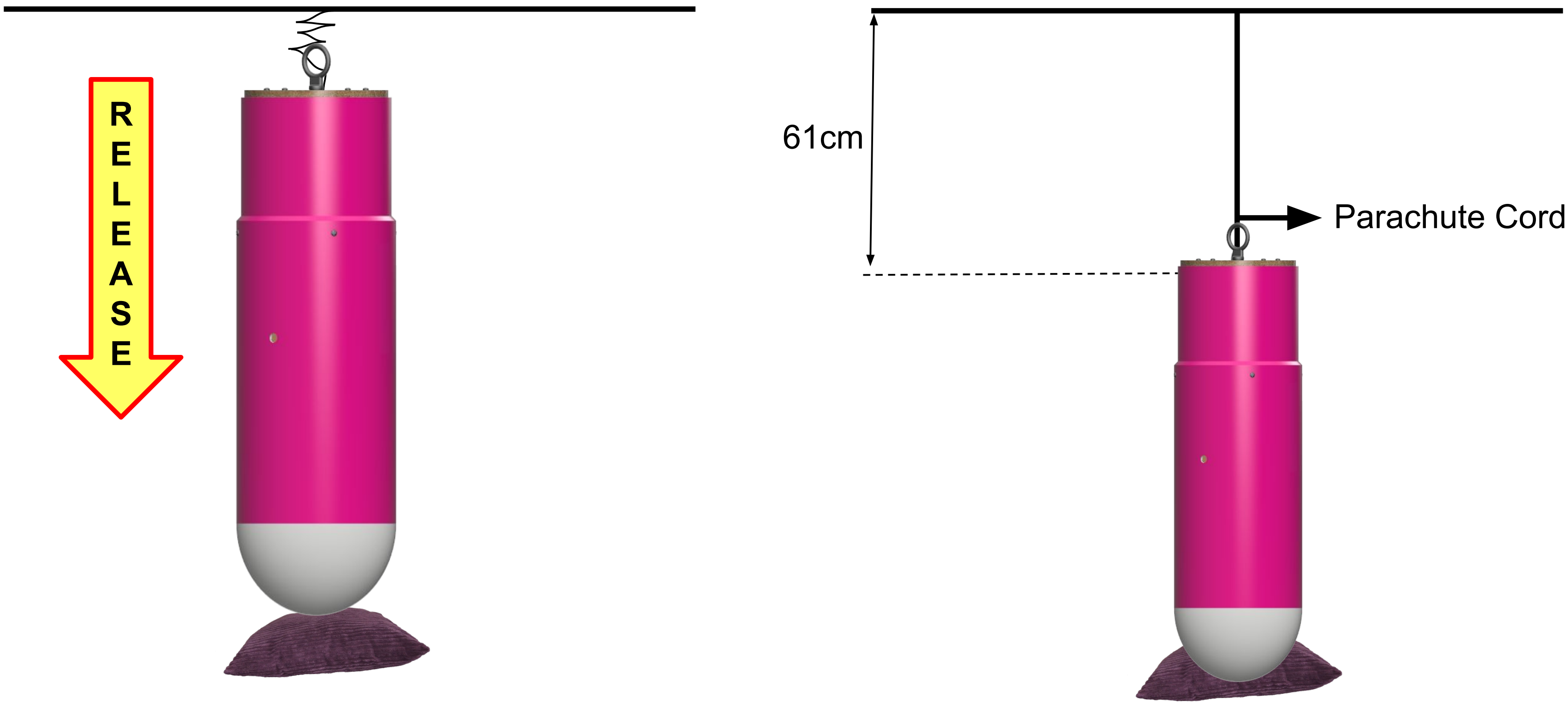
Environmental Test Plan (2/5)

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.

Drop Test:

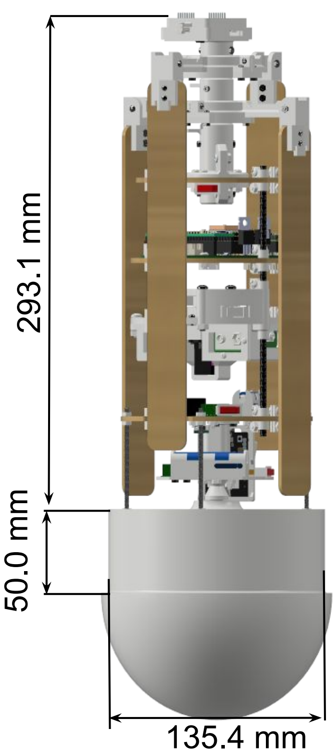
One side of the cord will be attached to the fixed surface and other cord will be attached to the parachute. Drop test will be processed with 1/8 thick Kevlar cord to verify if telemetry is still working and test the response against 30Gs of shock system after releasing operation.



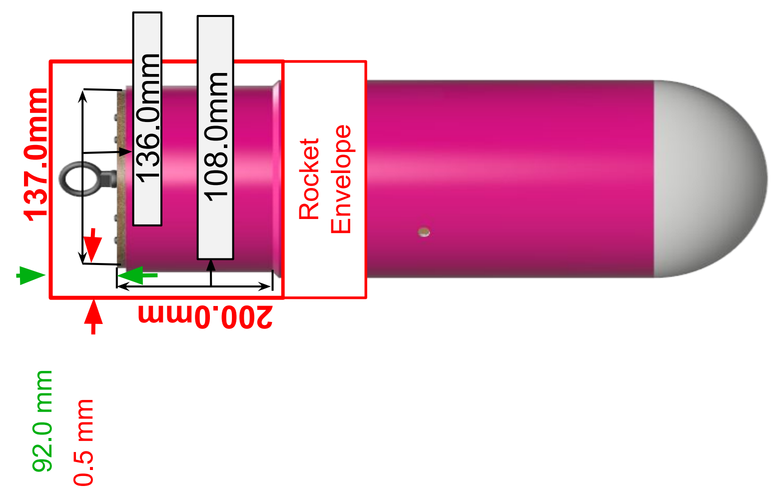
Environmental Test Plan (4/5)

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.

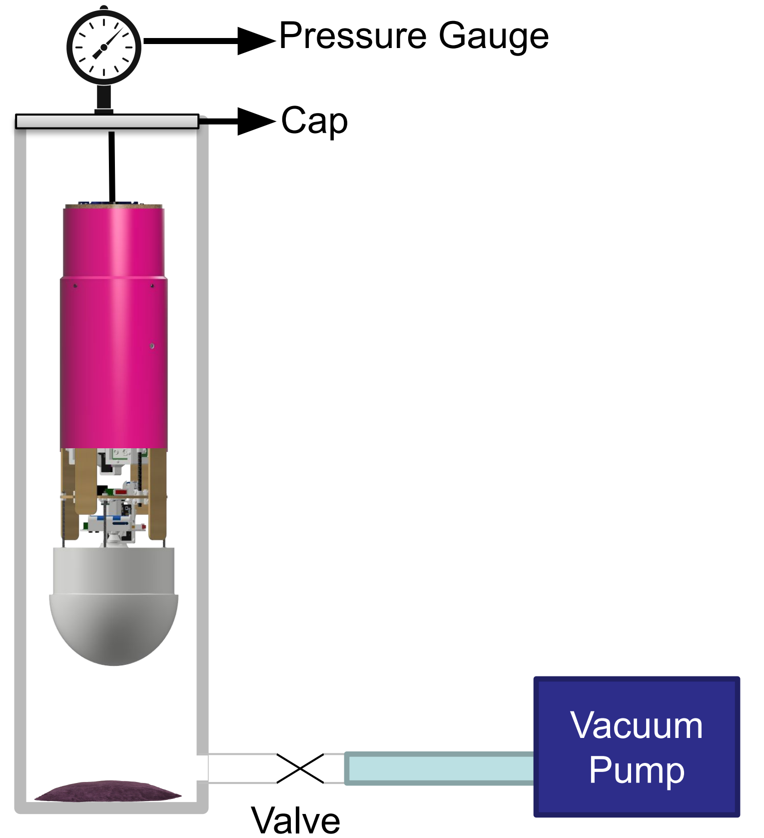


- In order to ensure easy deployment from the rocket this test will be conducted.
- The CanSat will be placed into the container and the container will be turned downwards. Cansat will fall on a surface covered by pillows.
- A pipe the size of a rocket envelope will be produced and the dimensions will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



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.



Test Procedures Descriptions (1/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
1	The CanSat payload is mounted in accordance with the instructions in a mold measuring the position defined as the nose cone of the rocket.	C1, C2	The CanSat payload remains fixed on the rocket without displacement or damage throughout the ascent phase means pass, otherwise fail.
2	The rocket ejection charge system is fired in a controlled environment on the ground, during which the CanSat payload and container are observed and recorded as they successfully separate from the rocket.	C3	Once the ejection charge is fired, the CanSat payload and container are successfully separated from the rocket, otherwise fail.
3	It will be taken to a height of 750 m by drone and released from there. Descent rate test for each “parachute” phase.	C4, C5	CanSat must deploy at 75% peak altitude and descend between 17–23 m/s. Outside of the range means fail.
4	It will be taken to a height of 750 m by drone and released from there. Descent rate test for each “auto-gyro” phase.	C6, C7	Payload must successfully separate at 75% of the target altitude, and the auto-gyro system must power on without issues. Failure in either condition results in a failed test.
5	The CanSat system is powered up, and sensor telemetry is transmitted to the ground station or recording system. Data transmission is monitored for at least 1 minute. A data packet is checked every second to see if it arrives.	C8	Telemetry must transmit consistently at 1 Hz (1 packet/sec). Any delay or irregularity means fail.
6	The integrated camera system is activated during the test. It records the payload separation from the container and the deployment of the auto-gyro descent system. After the flight, the video is reviewed to verify both events occurred correctly.	C9	Video must show payload separation and landing with visible auto-gyro operation. Missing visuals means fail.
7	The ground camera, mounted on a north-pointing mechanism, records during descent while maintaining its orientation. After the flight, the footage is reviewed to assess directional accuracy.	C10, C11, C12	Camera must steadily point 45° north, verified by compass. Any deviation means fail.

Test Procedures Descriptions (2/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
8	The audible beacon has its own power and switch system, allowing it to operate independently from the payload. During testing, it's manually activated and verified, with sound levels checked from a distance in an open field.	C13	The beacon system can be operated independently with a separate power supply. If not it fails.
9	Invoices and purchase records for all CanSat components (body, electronics, sensors, parachute, power system, etc.) are collected and compiled into a detailed cost table, ensuring the total remains under $1000. GCS and analysis software are excluded from this total.	C14	All CanSat component receipt are compiled. Total under $1000 is pass; over $1000 is fail.
10	The CanSat and container are weighed together. The total mass is measured on a digital scale.	S1	If the total mass is within the range of 1390 – 1410 g, it passes; if outside this range, it fails.
11	The nose cone is measured and visually/physically inspected. Symmetry, one-piece production, clearance and dimensions are verified.	S2, S3, S4, S5, S6, S7	Nose cone meets shape, size, and seamless build specs. Any mismatch means fail.
12	The CanSat structure undergoes 15 G vibration testing to simulate axial and radial launch forces. Post-test, it is visually inspected and functionally verified.	S8	Structure shows no damage or malfunction after 15G's vibration test. If not, its failed.
13	CanSat is subjected to shock testing in a test rig simulating a 30G shock loading. After the test, structural integrity and system density are checked.	S9	CanSat shows no structural damage and operates normally after the 30G shock. If not, its failed.
14	Dimensional measurements of the container are made with digital calipers or appropriate measuring devices. All dimensions are compared according to technical drawings and requirements.	S10, S11, S12, S13, S14	All container dimensions are within specified tolerances.If not, its failed.
15	The CanSat is mounted in the nose cone of the rocket and its structural integrity, aerodynamic compliance and stability are observed during lift-off.	S15	CanSat must stay secured and intact as nose cone during ascent. Detachment or damage means fail.

Test Procedures Descriptions (3/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
16	Once the CanSat payload is placed inside the container, it is tested to hold the fixed deployable parts. It is then observed whether the payload slides out freely without any obstruction.	S16	Deployables secured; smooth ejection required. Obstruction means fail.
17	All electronic and mechanical components are inspected for assembly. Manual play test and vibration test are performed.	S17	All components must be securely fixed with no loose parts. Any looseness results in test failure.
18	The container is checked for compliance with the dimensions and material requirements in Section F. After placing the payload inside, it is tested to hold all fixed and deployable parts securely. The payload is then removed to confirm it slides out freely without obstruction.	S18, S19	Container must meet Section F specs, hold payload securely, and allow free release. Any deviation results in failure.
19	Our Nose Cone is not separable from CanSat.	S20, S21	—
20	All separation and movement mechanisms are designed and tested without the use of pyrotechnic or chemical actuators in the systems.	M1	No pyrotechnic or chemical actuators included in CanSat system. If present, it means fail.
21	All heat producing mechanisms are checked on the system. It is observed whether they are exposed to the external environment.	M2	All heat-based mechanisms must be fully enclosed, not exposed externally. If exposed, it means fail.
22	All mechanisms are tested under loading. It is observed whether they maintain their configuration despite the applied forces.	M3	Mechanisms must retain their configuration under expected forces without any malfunction. Otherwise it fails.

Test Procedures Descriptions (4/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
23	All electrical connections to the batteries are examined. It is checked whether spring contact connections are used.	M4	No spring contacts in battery connections. If used, it means fail.
24	All battery types used are examined and verified from the label, technical documentation or manufacturer data.	E1	No Li-Po batteries used in CanSat system. If used, it means fail
25	All battery types and bodies used are examined. Verification is performed in line with battery labels, technical documents and manufacturer information.	E2	Battery must be alkaline, Ni-Cad, Ni-MH, or metal-cased lithium (e.g., 18650); no Li-Po batteries. Coin cells allowed. If not, it means fail.
26	The position of the power switch is checked. It is observed whether it can be easily accessed from the outside, and scenarios such as access with gloves are tested.	E3	Power switch must be visible and accessible from the outside without disassembly. If not, it means fail.
27	When the system is turned on, it is observed whether the power indicator (LED) is working or not will be observed.	E4	Power indicator must be visible when the system is powered on. If not, it means fail.
28	It is run after CanSat integration is completed. The system is monitored continuously for at least 2 hours.	E5	CanSat must operate continuously for at least 2 hours after integration. If not, it means fail.
29	The audio beacon system is examined. It is checked whether it is powered by a battery independent of the main system and whether the power switch is easily accessible from the outside.	E6, E7	Audio beacon must have a separate battery and an easily accessible external power switch. If not, it fails.

Test Procedures Descriptions (5/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
30	Frequency of XBee radio will be checked if they are 2.4 GHz (900MHz XBee radios are also allowed.) or not.	X1	2.4 GHz or 900 Mhz Series means pass, otherwise fail.
31	During the test, XBEE modules are connected to the computer using the XCTU program and it is checked whether the NETID/PANID value is the same as the team number. Then, the telemetry data received from the Cansat system is monitored at the ground station. It is verified that this data includes altitude, air pressure, temperature, battery voltage, command echo and GPS information (latitude, longitude, GPS altitude and number of satellites tracked).	X2, X5	The NETID/PANID of the XBEE modules must match the kit number exactly and all telemetry data must reach the ground station complete and in the correct format. If not, it fails
32	It is observed whether the transmitted and received telemetry data are sent at 1Hz intervals using XCTU.	X3	Telemetry data cannot be readable through a separate XBee that is not used in the payload or GCS. If so, it means fail.
33	It is observed whether the transmitted and received telemetry data are sent at 1Hz intervals using XCTU.	X4	The time difference between two incoming telemetry data packets must be 1 Hz. If it's high or low, it means fail.
34	The CanSat payload system is powered up and all sensors are activated. The relevant data from each sensor is read or recorded in real time. The accuracy of each measurement is observed or compared with calibration data.	SN1, SN2, SN3, SN4, SN5, SN6	Payload must provide valid readings for altitude, temperature, battery voltage, GPS, acceleration, rotation rates, and auto-gyro. If any is invalid, it fails.
35	The CanSat system is configured to record video during flight at 75% peak altitude when the auto-gyro system is turned on. The recording is verified by reviewing the video after the flight.	SN7	Payload must record clear video of auto-gyro deployment at 75% of peak altitude. Otherwise, it fails.
36	The camera is positioned so that it views the ground surface at a 45° angle relative to the nadir (vertical downward) direction during the descent. Video is recorded during the descent and the viewing angle is analyzed after the flight.	SN8	Payload must record clear video of the ground at approximately 45° from nadir during descent. Otherwise,it fails.

Test Procedures Descriptions (6/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
37	The camera with mechanism is mounted fixed to the north direction and the spin stabilization system is activated. The video taken during landing is analyzed in terms of the rotation angle of the ground image.	SN9	The camera must remain oriented north, with the ground view rotating no more than ±10° during descent. If it exceeds, it fails.
38	Video cameras are turned on and video is recorded during the test flight. After recording, file format, resolution and color information are checked.	SN10	Cameras must record video in color with a minimum resolution of 640×480 pixels. Otherwise it fails.
39	The CanSat system is powered up and measurements are taken via the magnetometer (magnetic field sensor). The values are read and it is checked that the magnetic field data is provided properly.	SN11	CanSat must successfully measure and output valid magnetic field data. If not, it fails.
40	While CanSat is waiting on the launch pad, a reset command is sent via the ground station. The altimeter data is observed to check whether the altitude is calibrated to zero.	G1	Upon ground station command, CanSat must calibrate altitude to zero while on the launch pad. If not, it fails.
41	The ground station that communicates with CanSat is powered on. After receiving telemetry data, it is checked whether the system automatically creates a file in CSV format. The file content is verified according to the Telemetry Requirements section.	G2	The ground station must generate CSV files containing all required sensor data as specified in the Telemetry Requirements section. Otherwise fails.
42	Telemetry data is monitored in real time at the ground station or the saved CSV file is examined. Each data line is checked for mission time information and whether it increases with a resolution of 1 second.	G3	Telemetry must include mission time with 1-second resolution, increasing consistently with each data entry. If not, fails.
43	While the system is running, configuration settings such as zero altitude calibration are made. Then, a controlled processor reset is applied. After the reset, it is checked whether the system retains the settings.	G4	Configuration states (e.g., zero altitude calibration) must be retained after a processor reset during launch or mission. Otherwise it fails.

Test Procedures Descriptions (7/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
44	The ground station software and hardware developed by the team are introduced. Telemetry reception, data processing and command sending functions are demonstrated.	G5	The team must use a ground station fully developed by themselves, capable of receiving telemetry and sending commands. If not, it fails.
45	The ground station is operated during the flight. It is observed whether the telemetry data (altitude, temperature, acceleration, etc.) is displayed on the screen in real time during takeoff and landing.	G6	All telemetry must be displayed in real time on the ground station during both ascent and descent. Otherwise fails.
46	The telemetry data displayed at the ground station is examined. It is checked that all measurements are in SI units (meters, degrees Celsius, volts, etc.) and that the units are clearly displayed.	G7	All telemetry must be displayed using SI units, with units clearly indicated on the display. If not,it fail.
47	During the flight, real-time graphical plotting of each telemetry data (e.g. altitude, temperature, acceleration, voltage, etc.) is observed at the ground station.	G8	Each telemetry data field must be plotted in real time during flight on the ground station display. If not, fail.
48	The ground station system is examined. A laptop that can work continuously for at least 2 hours, the XBee radio module and the antenna are checked to see if they are present in the system.	G9	Ground station must include a laptop with ≥2 hours of battery life, an XBee radio, and an antenna. Otherwise it fails.
49	The ground station is prepared in accordance with field conditions. It is tested whether it can be operated in a portable structure without AC (mains) power. The team is positioned at the operation point along the flight path.	G10	The ground station must be fully portable, operate without AC power, and be deployable at the designated flight line site. If not, fail.
50	Using the ground station software, the SIMULATION ENABLE and SIMULATION ACTIVATE commands are sent to the CanSat payload, respectively. It is observed whether the system switches to simulation mode in accordance with these commands.	G11	The ground station must successfully send “SIMULATION ENABLE” and “SIMULATION ACTIVATE” commands, causing the payload to enter simulation mode. If not, fail.

Test Procedures Descriptions (8/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
51	When the simulation mode is active, the ground station sends the pressure data in the CSV file provided by the competition to the CanSat system at a frequency of 1 Hz. It is observed that CanSat receives and processes this data.	G12	In simulation mode, the ground station must transmit pressure data from the provided CSV file to the CanSat at 1 Hz, and the CanSat must successfully receive it. If not, fail.
52	The type of antenna used at the ground station is observed. It is checked whether the antenna is in desktop (tabletop) or handheld format.	G13	The ground station must use a handheld antenna as required. If not, fail.
53	The ground station interface is tested in bright sunlight. Font size, graph lines, axes, and background-theme contrast are evaluated.	G14	The ground station display must use ≥14pt fonts, bold plot traces and axes, and a dark text on a light background theme for sunlight visibility. If not, fail.
54	During the flight, the telemetry packets received by the ground station are monitored. The system is checked to see if it can independently count and display the number of packets received.	G15	The ground station must count and display the number of successfully received packets during the flight, independent of the transmitted packet count. Otherwise, it fail.
55	A mechanism control command (for example: servo, release system, etc.) is sent from the ground station to CanSat. With the command sent, it is observed whether the mechanism works properly.	G16	The ground station must successfully activate all payload mechanisms on command. Otherwise, it fail.
56	Start telemetry communication with CXON command from GCS and inspect values transmitted from CanSat prototype, reset processor consciously compare count of packets transmitted and mission time before and after reset to see recovery has done successfully.	F1, F2	Packet count and mission time must remain the same after a reset. If not, fail.
57	Start simulation mode with the required commands SIMULATION ENABLE and SIMULATION ACTIVATE.We will try to activate simulation without enabling it.	F6	The mode must switch to simulation only if the commands "simulation enable" and "simulation activate" are received in that order. If not, fail.

Test Procedures Descriptions (9/9)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
58	Check the sended air pressure values in the simulated flight mode with the received back telemetry value and manually do the altitude calculation and check that it is the same value transmitted from CanSat.	F4, F5	The transmitted pressure value from the file and the received pressure value from the CanSat must be the same. If not, fail.
59	While the system operating simultaneously send set time command and check the transmitted telemetry time equal to the local.	F3	The received time and system time must be the same. Otherwise it fail.
60	While the system operating simultaneously send SERVO,ON command to release payload and SERVO,OFF to but payload back in container.	F7	Separation and attachment must be successful. If not, fail.

Simulation Test Plan

- Simulation mode tests Flight Software logic and demonstrates CanSat missions when actual launches aren't possible.
- In Simulation Mode, the probe uses pressure sensor data from the ground station instead of actual readings, other sensor data readings remain unaffected.

Parts that are tested during the simulations:

Our main goal is to test FSW logic with simulation mode we will observe:

- Flight Software operation
- Ground Control Software plotings
- XBee Communication Equipment for GCS and Payload.
- Other electronic parts that are controlled by the FSW during flight, especially servo mechanism 75% altitude separation will be observed.

Implementation

- We send sequence of two commands through ground station (SIM ENABLE and SIM ACTIVATE).
- FSW enters simulation mode.
- Ground station starts to send simulated air pressure values at a 1 Hz rate as barometric pressure sensor commands, using a provided CSV file.
- FSW uses received air pressure values instead of real data from the pressure sensor.
- To disable simulation mode, we send SIM DISABLE command through ground station.
- FSW goes back to Flight mode.

Mission Operations & Analysis

Arda GARİP

Overview of Mission Sequence of Events (1/6)

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
- Configure the radio modules

5) Mass & Dimension Controls by Staff

- Stow configuration of payload into the container for launch
- 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

- Bring the integrated CanSat to the launch pad
- Place the CanSat to the Rocket for the launch

8) Launch

- Launch of CanSat unit

Overview of Mission Sequence of Events (2/6)

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 judge for review

→

15) Data Check

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

→

16) Preparations for the PFR

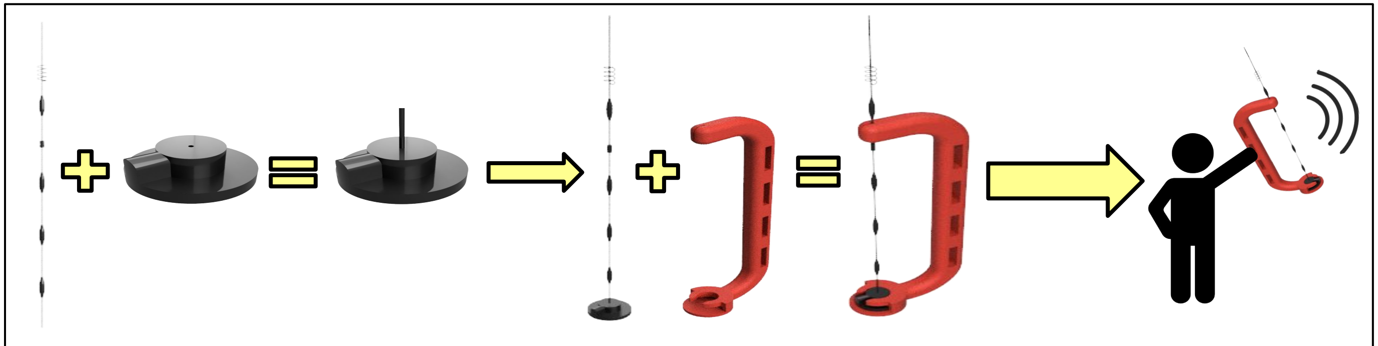
- Preparation of collected data and recorded video for PFR presentation

Overview of Mission Sequence of Events (3/6)

Roles	Team Members	Responsibilities
Mission Control Officer	Alper Artuc	Mission Control Officer will coordinate team members and give them to mission.
Ground Station Crew	Berke Ozbay, Ulas Ucrak	Ground Station Crew will control coming telemetries and real time plots and setting up GCS and antenna.
Recovery Crew	Ahsen Nisan Koroglu, Ferhat Coban, Nisan Begum Gencel, Huseyin Kaan Ozpinar, Sami Berkay Yucedag, Umut Eray Acikgoz	Recovery Crew will search and find CanSat after mission is done.
CanSat Crew	Alper Artuc, Arda Garip, Berke Ozbay, Ulas Ucrak	CanSat Crew will do requirement setups and prepare CanSat to the flying.

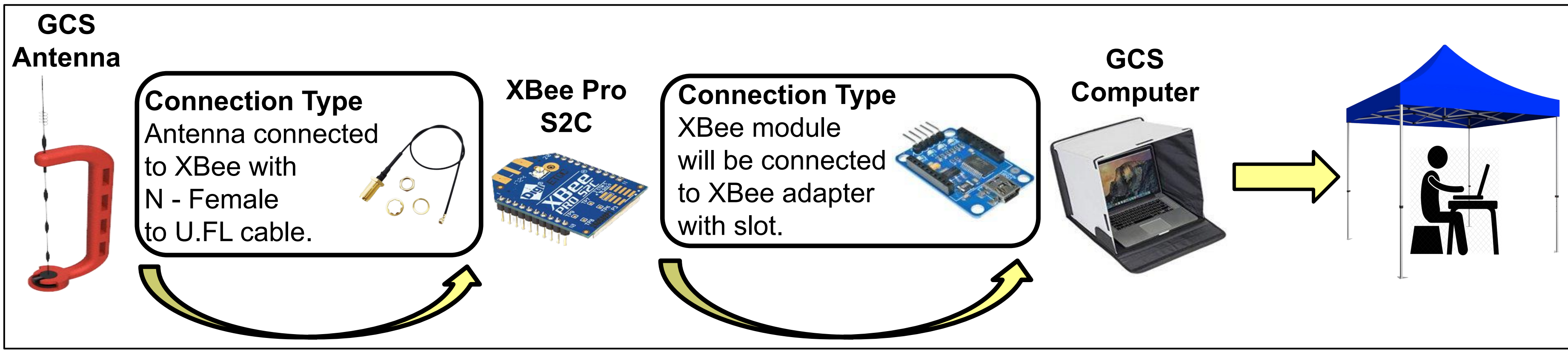
Overview of Mission Sequence of Events (4/6)

Antenna Construction



1- The rod of antenna assembled to the base.
2- Integrated antenna inserted into the hand-carrying apparatus.
3- GCS antenna is ready to use.

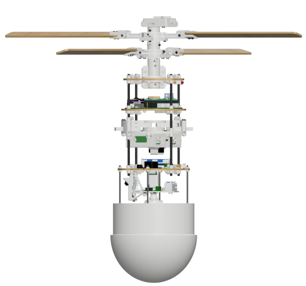
Ground System Setup



1- XBee radio module will be connected to the hand-held antenna structure by N-Female to U.FL cable
2- XBee radio module will be connected to the
3- XBee adapter will be connected to the GCS Computer
4- GUI will be opened and send “**CMD,3133,CX,ON**” command to connect to the payload XBee module
5- GCS is ready

Overview of Mission Sequence of Events (5/6)

Cansat Assembly and Test



1) CanSat Assemble
All the electronic and mechanical components will be assembled and battery status check will be done.

2) CanSat Test
Ground crew open all the power switches, connect XBee modules to themselves, calibrate all the sensors, check whether mechanism work or not and finally check for buzzer operation.

3) Stow Configuration
After the tests are complete, "**CMD,3133,MEC,SERVO,ON**" command send for activating the servo to stow the payload to the container. Then, "**CMD,3133,MEC,SERVO,OFF**" command send for the integrate the payload to the container. Later that, stated CanSat crew bring the integrated CanSat module to the staff for mass and measurement control. Finally, ground crew check the payload antenna, telemetry module and flight software to ready for launch.

4) Ready to Launch
After the controls, CanSat crew bring the integrated CanSat to the launch pad and place the CanSat to the rocket for the launch with assist of staff member.

5) Launch of CanSat
Countdown of launch for start the mission. When countdown is finished, the rocket is fired and the mission begins

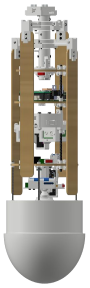
Overview of Mission Sequence of Events (6/6)

Ground Control System setup consists of 4 main items:

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

Container

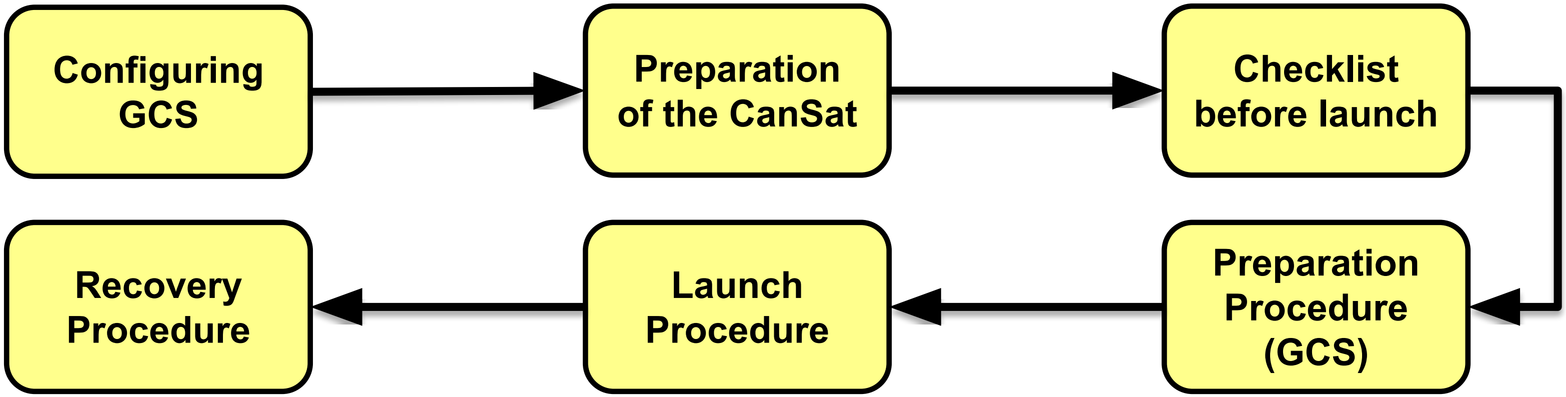
✔ Final tests of the payload and containers going to be completed and CanSat unit is assembled before putting it into the rocket.



Payload

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

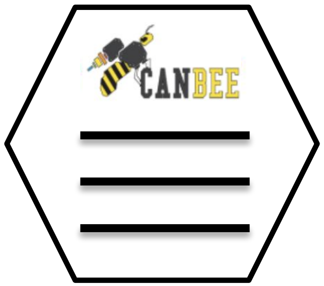
Field Safety Rules Compliance



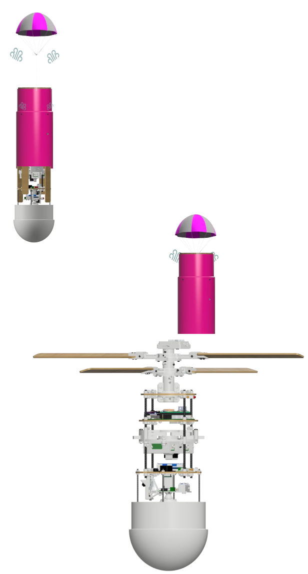
- **Mission Operations Manual (MOM)** will contain instructions (with pictures if needed) for each step in the flowchart above.
- Multiple copies of the manual will be created and assembled in three ring binder.
- Each member will familiarize themselves with the manual and one person will be tasked with checking every step is followed correctly.
- A draft for mission operations manual is being prepared, we are expecting changes in the draft as the CanSat unit is tested and problems are detected.

- We planned development procedure and we will develop our MOM as soon as possible.

CanSat Location and Recovery

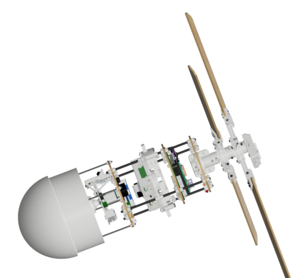


A sticker that indicates team leader name, team number, contact details and email address will be placed on the payload and container.



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.



Mission Rehearsal Activities

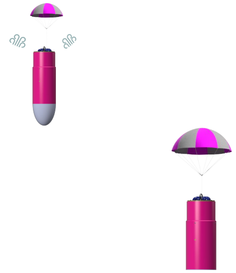
Description of mission operations rehearsal activities	
Ground system radio link check procedures	• Check XBee communication *without* placing them in CanSat. • Check XBee communication on the CanSat device. • Check that commands sent from GCS are working.
Powering on/off the CanSat	• Check that CanSat powers on when switch is in on position and vice versa. • Run software in diagnostics mode and check electronics parts are functioning.
Launch configuration preparations	• Fit check. • Parachute deployment check. • Release mechanism, coaxial propeller mechanism and camera mechanism check. • Stowed configuration check. • Deployment configuration check. • Release test with Ground Control Station command for propeller rubber bands and hinges activation check.
Loading the CanSat in the launch vehicle	• CanSat will be placed in manufactured envelope similar to rocket in the competition.
Telemetry processing, archiving, and analysis	• Check that GCS is getting data in diagnostic mode. • Check that the collected data is plotted on graphs in the GUI. • Check that data is saved to the SD card and in the GCS .csv file.
Recovery	• Locate and retrieve the CanSat. • Retrieve GCS data and SD Card data to the judges to review.

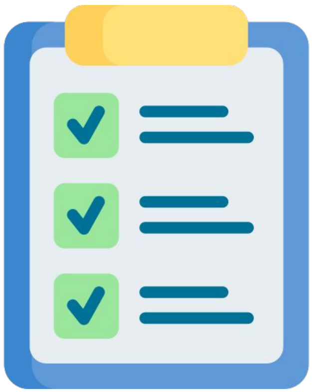
Requirements Compliance

Arda GARIP

Requirements Compliance Overview

- We designed the payload and container by taking the competition guide into consideration.
- After the PDR phase, we **tested the prototype** that we designed and **identified our final changes**. All of these changes are the result of testing on the prototype. We explained these changes in detail in our CDR report.
- **Considering this test results, our design with final changes meets all the 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	14, 35	-
C2	The Cansat container shall be mounted on top of the rocket with the shoulders section inserted in the airframe.	Comply	14, 20, 35	-
C3	The Cansat payload and container shall be deployed from rocket when the rocket motor ejection charge fires.	Comply	14, 35	-
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.	Comply	48, 52	-
C5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	13, 14, 76, 135, 136, 138	-
C6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	13, 14, 35, 81, 135, 136, 138	-
C7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Comply	50, 51, 52, 135, 138	-
C8	The sensor telemetry shall be transmitted at a 1Hz rate.	Comply	13, 14, 111, 116, 135, 136, 138, 141, 162	-

Requirements Compliance (2/11)

Operational Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
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	13, 14, 17	-
C10	A second video camera shall point in the north direction during descent.	Comply	86, 89	-
C11	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	Comply	13, 14, 86, 89	-
C12	The second video camera shall be spin stabilized so the ground view is not rotating in the video.	Comply	86, 89	-
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat electronics.	Comply	125	-
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	216, 217, 218, 219	-

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	97, 98, 99, 100, 101	-
S2	Nose cone shall be symmetrical along the thrust axis.	Comply	66, 69	-
S3	Nose cone radius shall be exactly 72.2 mm.	Comply	66	-
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	66	-
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	66	-
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	66	-
S7	The nose cone height shall be a minimum of 76 mm.	Comply	66	-
S8	Cansat structure must survive 15Gs vibration.	Comply	176	-
S9	Cansat shall survive 30G shock.	Comply	178	-
S10	The container shoulder length shall be 90 to 120 mm.	Comply	69, 71, 72	-
S11	The container shoulder diameter shall be 136 mm.	Comply	69, 71, 72	-
S12	Above the shoulder, the container diameter shall be 144.4 mm.	Comply	69, 71, 72	-

Structural Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
S13	The container wall thickness shall be at least 2 mm.	Comply	69, 71, 72	-
S14	The container length above the shoulder shall be 250 mm+/-5%.	Comply	69, 71, 72	-
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	13, 14, 35, 47, 54, 64	-
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	20, 21, 70, 71, 74, 75	-
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	90, 91, 92, 93, 94, 95, 96	-
S18	The Cansat container shall meet all dimensions in section F.	Comply	69, 71, 72	-
S19	The Cansat container materials shall meet all requirements in section F.	Comply	69, 71, 72, 80	-
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	17, 18, 54, 60, 64, 67, 68, 70	-
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	17, 18, 54, 60, 64, 67, 68, 70, 77, 78, 81, 82, 87, 88	-
M3	All mechanisms shall be capable of maintaining their configuration or states underall forces.	Comply	171, 174, 178	-
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	90, 91, 92, 93, 94, 95, 96	-

Requirements Compliance (6/11)

Electrical Requirements

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
E1	Lithium polymer batteries are not allowed.	Comply	122, 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	122, 126, 127	-
E3	Easily accessible power switch is required.	Comply	120, 125	-
E4	Power indicator is required.	Comply	120, 125	-
E5	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	131, 132	-
E6	The audio beacon shall operate on a separate battery.	Comply	125	-
E7	The audio beacon shall have an easily accessible power switch.	Comply	125	-

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	110, 111 , 152	-
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	111	-
X3	XBEE radios shall not use broadcast mode.	Comply	111, 112 , 116	-
X4	The Cansat shall transmit telemetry once per second.	Comply	111, 112, 116, 135, 138, 141, 162	-
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	113, 114, 115, 116, 162	-

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	23, 25	-
SN2	Cansat payload shall measure its internal temperature.	Comply	23, 26	-
SN3	Cansat payload shall measure its battery voltage.	Comply	23, 27	-
SN4	Cansat payload shall track its position using GPS.	Comply	23, 28	-
SN5	Cansat payload shall measure its acceleration and rotation rates.	Comply	23, 30	-
SN6	Cansat payload shall measure auto-gyro rotation rate.	Comply	23, 29	-
SN7	Cansat payload shall video record the deployment of the auto-gyro at 75% peak altitude.	Comply	23, 33	-
SN8	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	Comply	23, 32	-
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	23, 31, 86, 89	-
SN10	The video cameras shall record video in color and with minimum resolution of 640x480.	Comply	32, 33	-
SN11	The Cansat shall measure the magnetic field.	Comply	23, 29	-

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	118	-
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	116, 142, 162	-
G3	Telemetry shall include mission time with 1 second resolution.	Comply	111, 112, 116, 135, 136, 151, 162	-
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	135, 141, 161	-
G5	Each team shall develop their own ground station.	Comply	160, 161, 162, 163, 164	-
G6	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	160, 162	-
G7	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	113, 114, 115, 116, 160	-
G8	Teams shall plot each telemetry data field in real time during flight.	Comply	141, 150, 160	-
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	151, 195, 197	-

Requirements Compliance (10/11)

Ground Station Requirements (2/2)

Re#	Requirement Description	Compliance	Reference Slide(s)	Comments
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	151, 159	-
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	117, 142	-
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	118, 142, 162	-
G13	The ground station shall use a table top or handheld antenna.	Comply	152, 153, 154, 155, 156	-
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	150, 160	-
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	150, 160	-
G16	The ground station shall be able to activate all mechanisms on command.	Comply	118, 134, 196	-

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, 141	-
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, 141	-
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	117, 138, 141	-
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	142, 162	-
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	142	-
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	142	-
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	117 ,118	-

Management

Arda GARIP

Status of Procurements

We do not have any problems with product supply.

Mechanical
All mechanical elements have been obtained. CanSat prototype is available. 3D printer material is prepared for possible changes. We have enough material to produce our replacements.
Electronics
All sensors, actuators, electronic components, PCBs are already procured, shipped and assembled. We are waiting for only some backup components that are listed below: - We are waiting for four 9V Enegitech Batteries as backup. (We have 6 batteries.) - We are waiting for two DC Motor and two magnetic encoder as backup. (We have 3 DC motor and 2 magnetic encoder.) The above mentioned components will be available to us in April.
Ground Station
All ground station materials have been identified, prepared and tested.
Software
No need for any procurement process for software.

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	1.47	Actual
	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 Metal 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 RTC.	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	CanSat PCB with 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.	1	22.79	Owned
	25	Switching Voltage Regulator Board	Ground camera supply.	1	0.71	Actual

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.	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
	15	4mm Diameter Carbon Fiber Rod 1 meter	Assembly of Chassis	1	9,79	Owned
	16	15mm Diameter Carbon Fiber Rod 1 meter	Assembly of Chassis	1	11.80	Actual

CanSat Budget – Hardware (4/4)

Hardware Budget Summary			
Subsystem	**Number of Actual Components**	**Number of Owned Components**	**Total Cost [$]**
Electronics	17	8	358.69
Mechanics	7	9	134.186
		Grand Total	**492.876**

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	492.876	985.752	Estimated
Grand Total			**16,854.752**	

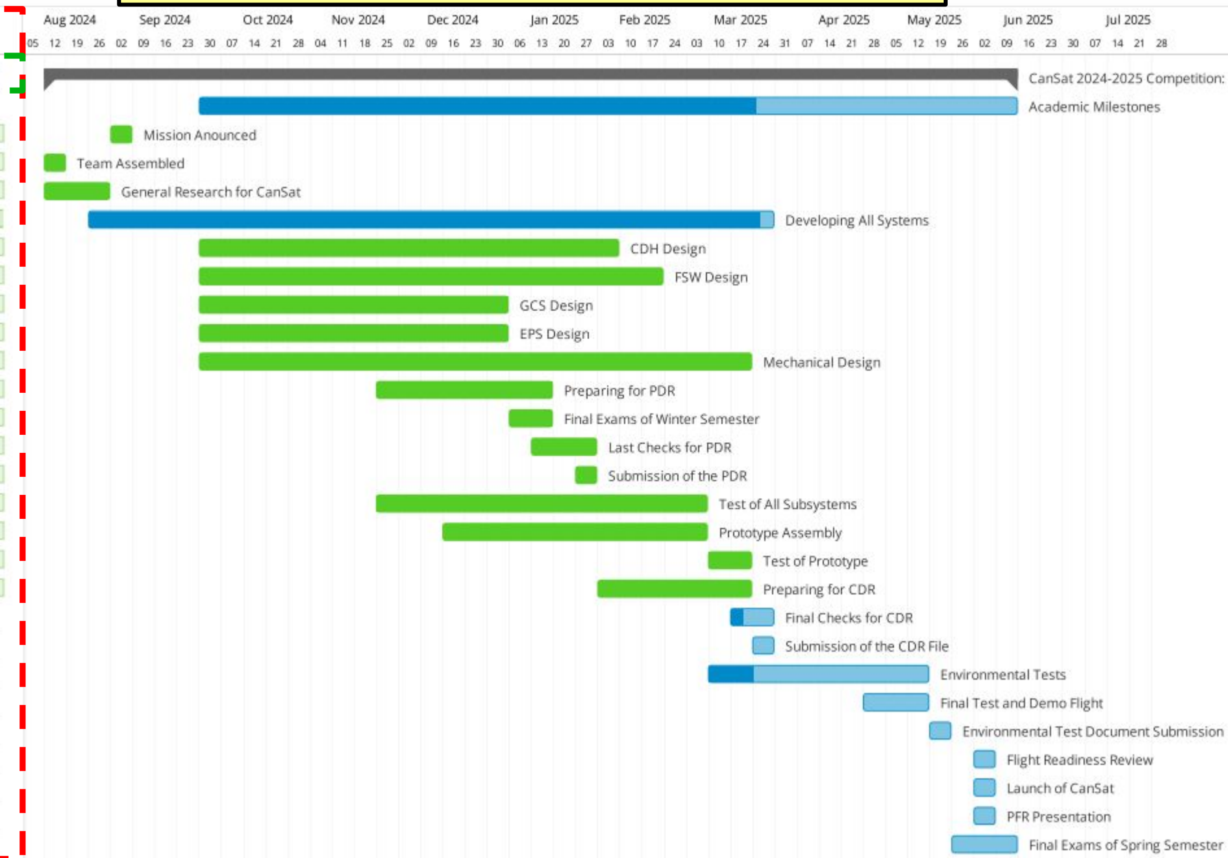
Program Schedule Overview

Gantt Chart of Major Milestones

CanBEE(Team 3133) Gantt Chart

Total percentage of competition stated here

	ACTIVITIES	START	DUE	STATUS	%
	CanSat 2024-2025 Competition:	12/Aug	13/Jun		88%
1	Academic Milestones	30/Sep	13/Jun	Started	68%
2	Mission Anounced	04/Sep	04/Sep	Finished	100%
3	Team Assembled	12/Aug	18/Aug	Finished	100%
4	General Research for CanSat	18/Aug	31/Aug	Finished	100%
5	Developing All Systems	31/Aug	28/Mar	Started	98%
6	CDH Design	30/Sep	07/Feb	Finished	100%
7	FSW Design	30/Sep	21/Feb	Finished	100%
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	Finished	100%
11	Preparing for PDR	30/Nov	17/Jan	Finished	100%
12	Final Exams of Winter Seme...	06/Jan	17/Jan	Finished	100%
13	Last Checks for PDR	17/Jan	31/Jan	Finished	100%
14	Submission of the PDR	01/Feb	01/Feb	Finished	100%
15	Test of All Subsystems	29/Nov	07/Mar	Finished	100%
16	Prototype Assembly	16/Dec	07/Mar	Finished	100%
17	Test of Prototype	10/Mar	21/Mar	Finished	100%
18	Preparing for CDR	09/Feb	23/Mar	Finished	100%
19	Final Checks for CDR	23/Mar	27/Mar	Started	30%
20	Submission of the CDR File	28/Mar	28/Mar	Not started	0%
21	Environmental Tests	11/Mar	15/May	Started	20%
22	Final Test and Demo Flight	04/May	16/May	Not started	0%
23	Environmental Test Docume...	23/May	23/May	Not started	0%
24	Flight Readiness Review	06/Jun	06/Jun	Not started	0%
25	Launch of CanSat	07/Jun	07/Jun	Not started	0%
26	PFR Presentation	08/Jun	08/Jun	Not started	0%
27	Final Exams of Spring Seme...	26/May	13/Jun	Not started	0%



Percentage of individual works stated here

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

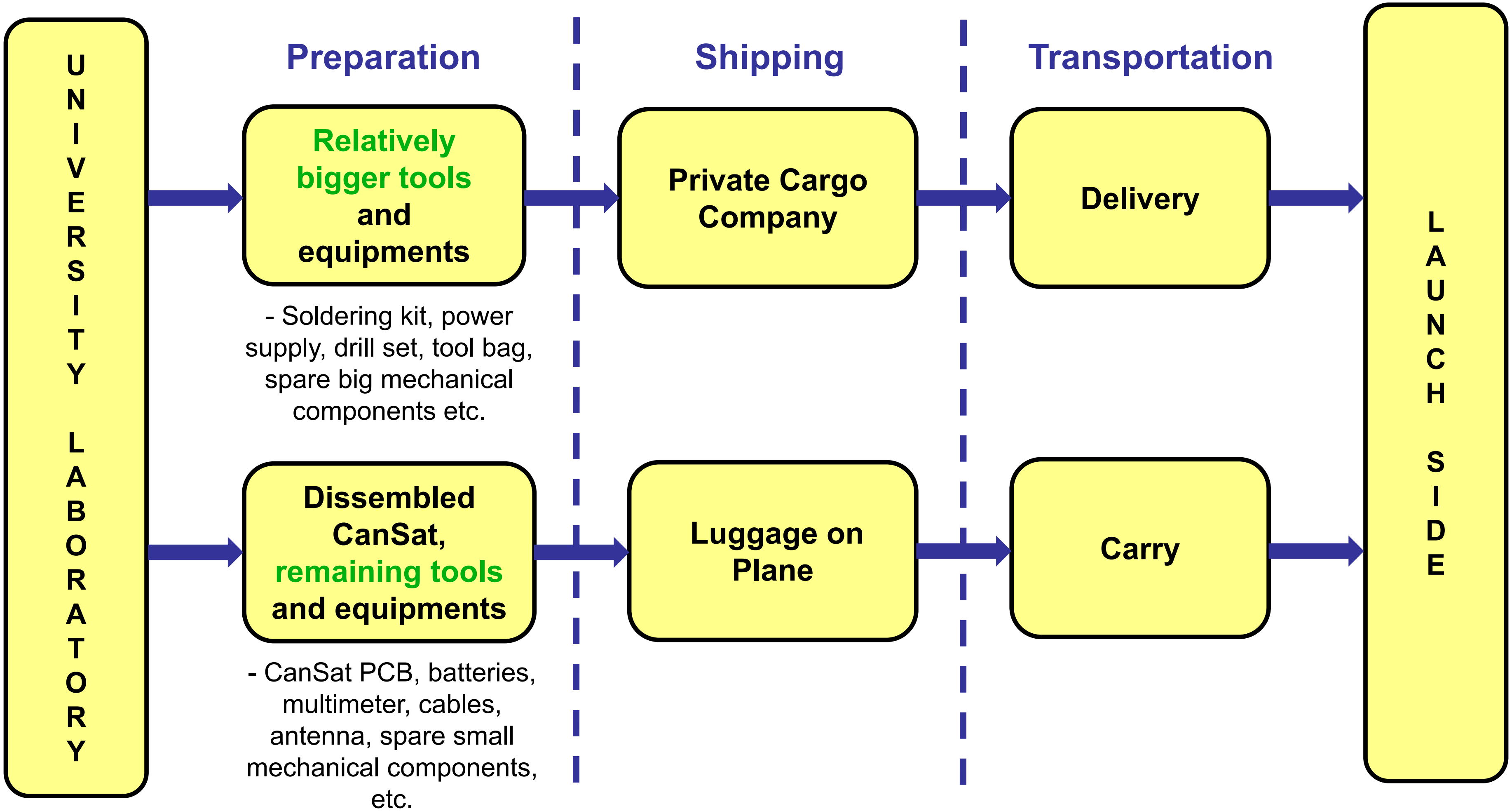
Detailed Program Schedule (2/2)

	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

Shipping and Transportation

Transportation: Team members are going to fly JFK Airport and then drive to Virginia.
Shipment: We have different processes simultaneously for shipment.



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
• The manufactured PCB has tested and some changes were made according to test results. • Release mechanism tested with payload and container from GCS. • GUI and FSW is completed in general. • GCS and Payload communication is tested. • XBee Communications tested in long distance with using payload. • GCS has been done. • Prototyping is finished.	• Environmental Tests are ongoing. • FSW and GUI troubleshooting continues.

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

Conclusions (2/2)

We wanted to share with you some videos of the Release tests we performed from different angles.

Release Test with Lower Angle

Final Design of CanSat

Release Test Under Dense Vibration

CanBEE team is ready for ENVIRONMENTAL TESTS.