CanSat 2025
Preliminary Design Review (PDR)

#3145

Apastron

Presentation Outline

Team Organization

- **Gürkan ALKAN** – Team Leader – 4th Bachelor, EE Eng.
  - **Aleyna YILMAZ** – Software Dev. Leader – Graduate Student, EE Eng.
    - **Muhammed Said GÖNÜL** – Software #2
  - **Muhammed Said GÖNÜL** – CDH & GCS Leader – 4th Bachelor, Com. Eng.
    - **Muhammet Akın ÖZEL** – CDH & GCS #2 – 4th Bachelor, EE Eng.
  - **Enes KALENDER** – Sensor-Electric Sbs. Leader – 4th Bachelor, EE Eng.
    - **Atakan SAYDAM** – Sensor Sbs. #2 – 4th Bachelor, EE Eng.
    - **Metin SATI** – Electric Sbs. #3 – 2nd Bachelor, EE Eng.
  - **Bugrahan DEGIRMENCI** – Mechanics Sbs. Leader – 4th Bachelor, Mech. Eng.
    - **Göktuğ KOÇCENK** – Mechanics #2 – 4th Bachelor, Mech. Eng.
    - **Alperen Ragıp SÖYLER** – Mechanics #3 – 3rd Bachelor, Mech. Eng.

Prof. Dr. Fırat HARDALAÇ – Faculty Advisor

Acronyms

Acronyms	Definition
3D	Three Dimensional
A	Analysis
CDH	Communication & Data Handling
CONOPS	Concept of Operation
CSV	Comma Separated Value
D	Demonstration
dB	Decibel
dBi	Decibel Isotropic
DCS	Descent Control Subsystem
EPS	Electrical Power Subsystem
FSW	Flight Software
G	Gravitational Force
GCS	Ground Control Station
GSC	Ground Station Crew

Acronyms	Definition
GND	Ground
GPIO	General Purpose Input Output
GPS	Global Positioning System
I	Inspection
I2C	Inter-Integrated Circuit
IDE	Integrated Development Environment
IMU	Internal Measurement Unit
LCO	Launch Control Officer
Li-Ion	Lithium-Ion
MCU	Microcontroller Unit
m/s	Meters/Second
PLA+	Polylactic Acid +
PWM	Pulse Width Modulation
RAM	Random Access Memory

Acronyms	Definition
RPM	Revolutions Per Minute
RP-SMA	Reverse Polarity SMA
RTC	Real Time Clock
SPI	Serial Peripheral Interface
T	Test
TTL	Time to Live
UART	Universal Asynchronous Receiver/Transmitter (Serial)
XCTU	Next Generation Configuration Platform for XBEE/RF Solutions

Systems Overview

Gürkan ALKAN

Mission Summary

Main Objectives

The mission: Auto Gyro Descender

1. Design a Cansat that consists of a payload and a container that mounts on top of the rocket.
2. The payload rests inside the container at launch and includes the nose cone as part of the payload.
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. The descent rate shall be 5 meters/second.
6. A video camera shall show the separation of the payload from the container and the auto-gyro functioning.
7. 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.
8. The Cansat shall collect sensor data during ascent and descent and transmit the data to a ground station at a 1 Hz rate.
9. The sensor data shall include interior temperature, battery voltage, altitude, auto-gyro rotation rate, acceleration, rate, magnetic field, and GPS position.
10. The Cansat container shall meet the mechanical requirements in Mission Guide section F.

External Objectives

- **Our team goal for this year is to be first place in the CanSat Competition 2025.**

System Requirement Summary (1/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.	Operational	x	x	x	
C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Operational	x	x	x	
C3	The Cansat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Operational	x		x	x
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	Operational	x		x	x
C5	At 75% flight peak altitude, the payload shall be released from the container.	Operational		x	x	x
C6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Operational	x		x	x
C7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Operational	x		x	x
C8	The sensor telemetry shall be transmitted at a 1 Hz rate.	Operational	x	x	x	
C9	The payload shall record video of the release of the payload from the container and the operation of the auto-gyro descent control system.	Operational		x	x	x
C10	A second video camera shall point in the north direction during descent.	Operational	x	x		x
C11	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	Operational	x	x		
C12	The second video camera shall be spin stabilized so the ground view is not rotating in the video.	Operational			x	x

System Requirement Summary (2/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat electronics.	Operational	x	x	x	
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.	Operational	x	x		
S1	The Cansat and container mass shall be 1400 grams +/- 10 grams.	Structural	x	x	x	
S2	Nose cone shall be symmetrical along the thrust axis.	Structural	x	x	x	
S3	Nose cone radius shall be exactly 72.2 mm	Structural	x	x	x	
S4	Nose cone shoulder length shall be a minimum of 50 mm	Structural		x	x	
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Structural		x	x	
S6	The nose cone shall not have any openings allowing air flow to enter.	Structural		x	x	
S7	The nose cone height shall be a minimum of 76 mm	Structural		x	x	
S8	Cansat structure must survive 15 Gs vibration	Structural	x		x	x
S9	Cansat shall survive 30 G shock	Structural	x		x	x
S10	The container shoulder length shall be 90 to 120 mm.	Structural		x	x	
S11	The container shoulder diameter shall be 136 mm.	Structural		x	x	x
S12	Above the shoulder, the container diameter shall be 144.4 mm	Structural		x	x	
S13	The container wall thickness shall be at least 2 mm.	Structural		x	x	
S14	The container length above the shoulder shall be 250 mm +/- 5%.	Structural		x	x	

System Requirement Summary (3/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Structural	x	x		x
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.	Structural		x		x
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Structural	x	x	x	
S18	The Cansat container shall meet all dimensions in Mission Guide section F.	Structural		x	x	
S19	The Cansat container materials shall meet all requirements in Mission Guide section F	Structural		x	x	
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.	Structural	x		x	x
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 15 Gs acceleration	Structural		x	x	x
M1	No pyrotechnical or chemical actuators are allowed.	Mechanism		x	x	
M2	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	Mechanism		x	x	x
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Mechanism	x		x	x
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Mechanism		x	x	

System Requirement Summary (4/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
E1	Lithium polymer batteries are not allowed.	Electrical		x	x	
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.	Electrical		x	x	
E3	Easily accessible power switch is required	Electrical		x	x	x
E4	Power indicator is required	Electrical		x	x	
E5	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Electrical	x	x		x
E6	The audio beacon shall operate on a separate battery.	Electrical	x		x	x
E7	The audio beacon shall have an easily accessible power switch.	Electrical		x	x	
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Communications	x		x	x
X2	XBEE radios shall have their NETID/PANID set to their team number.	Communications		x	x	
X3	XBEE radios shall not use broadcast mode.	Communications	x		x	x
X4	The probe shall transmit telemetry once per second.	Communications	x		x	x
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.	Communications	x		x	x

System Requirement Summary (5/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
SN1	Cansat payload shall measure its altitude using air pressure.	Sensor	x		x	x
SN2	Cansat payload shall measure its internal temperature.	Sensor	x		x	x
SN3	Cansat payload shall measure its battery voltage.	Sensor	x		x	
SN4	Cansat payload shall track its position using GPS.	Sensor	x		x	x
SN5	Cansat payload shall measure its acceleration and rotation rates.	Sensor	x		x	x
SN6	Cansat payload shall measure auto-gyro rotation rate.	Sensor	x		x	x
SN7	Cansat payload shall video record the release of the parachute and deployment of the auto-gyro at 75% peak altitude.	Sensor	x	x	x	x
SN8	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	Sensor	x		x	x
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 in either direction.	Sensor	x	x	x	x
SN10	The video cameras shall record video in color and with a minimum resolution of 640x480.	Sensor		x	x	
SN11	The Cansat shall measure the magnetic field.	Sensor	x		x	

System Requirement Summary (6/8)

RN	Requirement	Subsystem	Verification			
			A	I	T	D
G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Ground Station	x		x	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Ground Station	x		x	x
G3	Telemetry shall include mission time with 1 second resolution.	Ground Station	x	x	x	x
G4	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Ground Station	x	x	x	x
G5	Each team shall develop their own ground station.	Ground Station	x	x	x	x
G6	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Ground Station	x	x	x	x
G7	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Ground Station	x	x	x	x
G8	Teams shall plot each telemetry data field in real time during flight.	Ground Station	x		x	x
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Ground Station	x		x	x
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.	Ground Station	x		x	

System Requirement Summary (7/8)

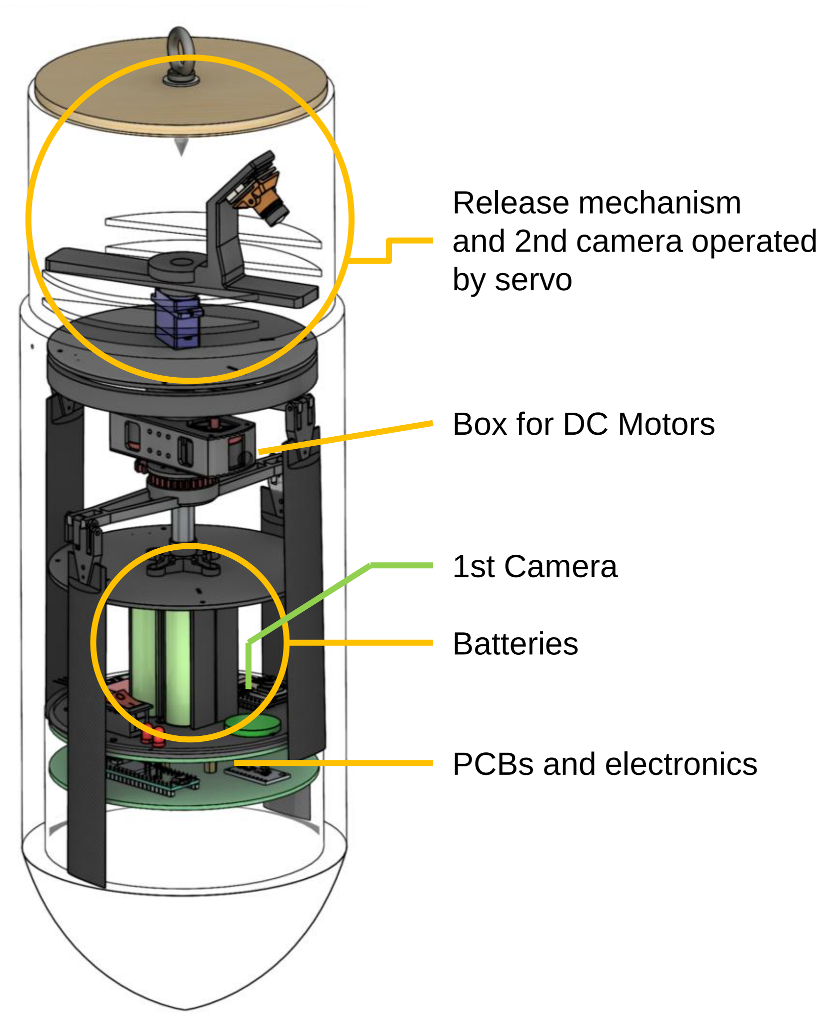
RN	Requirement	Subsystem	Verification			
			A	I	T	D
G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Ground Station	x		x	x
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the Cansat.	Ground Station	x		x	x
G13	The ground station shall use a table top or handheld antenna.	Ground Station	x	x	x	x
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.	Ground Station	x	x	x	x
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.	Ground Station	x	x	x	x
G16	The ground station shall be able to activate all mechanisms on command.	Ground Station	x	x	x	x

System Requirement Summary (8/8)

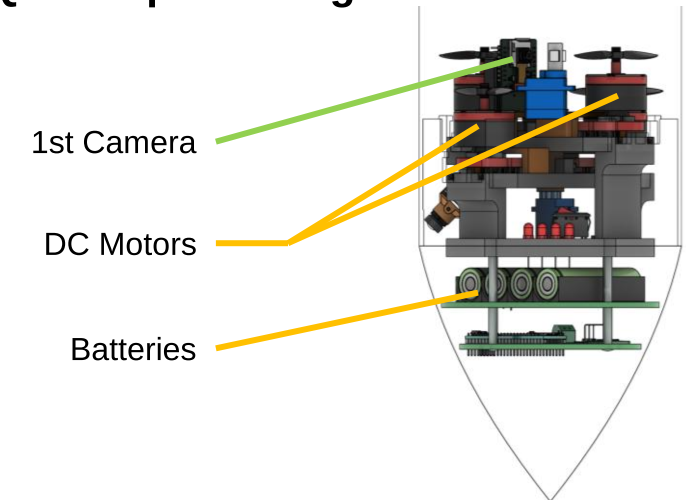
RN	Requirement	Subsystem	Verification			
			A	I	T	D
F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Flight Software	x		x	
F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Flight Software	x		x	x
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Flight Software	x	x	x	x
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.	Flight Software	x	x	x	x
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	Flight Software	x	x	x	x
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Flight Software	x	x	x	x
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Flight Software	x	x	x	x

System Level CanSat Configuration Trade & Selection (1/4)

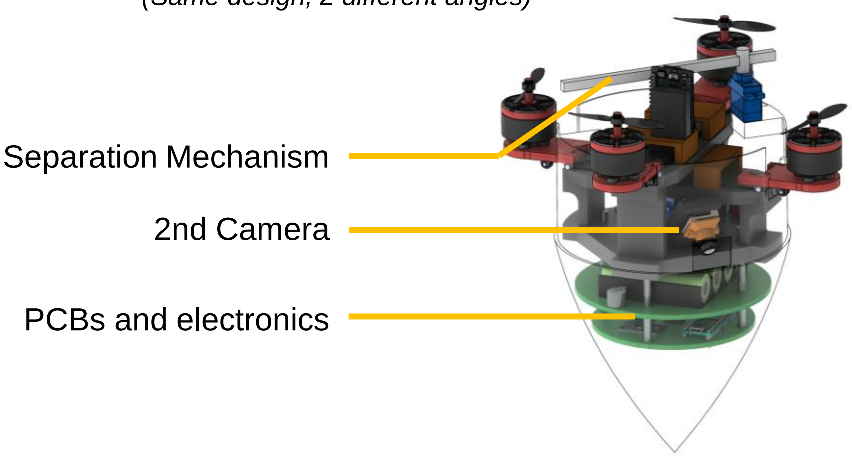
Coaxial Rotor Design



Quadcopter Design

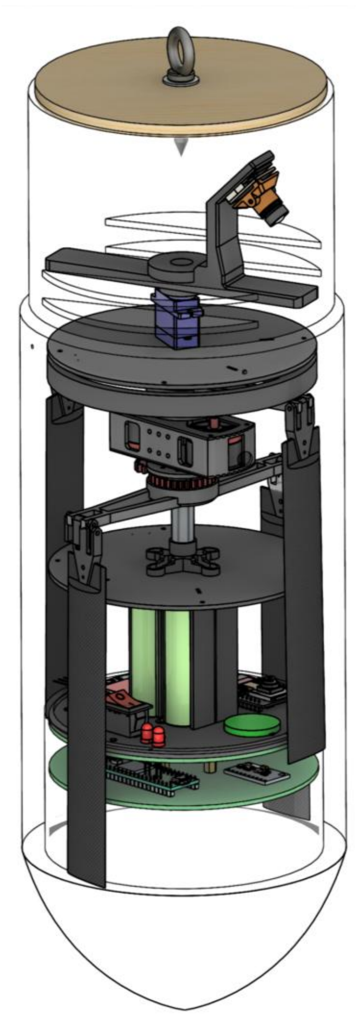


(Same design, 2 different angles)



System Level CanSat Configuration Trade & Selection (2/4)

Coaxial Rotor Design



CONOPS 1

After the released from container, propellers open up with inside springs placed in propeller arms.

During descent, propellers turn in the opposite directions. This prevents it from rotating around itself.

The camera, which must face north during landing, is turned in the correct direction by the servo connected to the release mechanism.

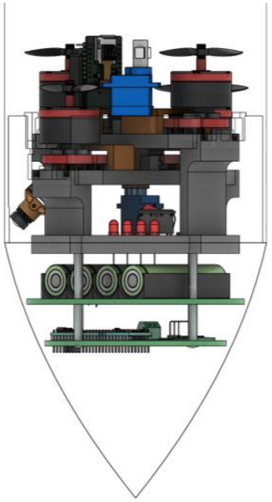
Quadcopter Design

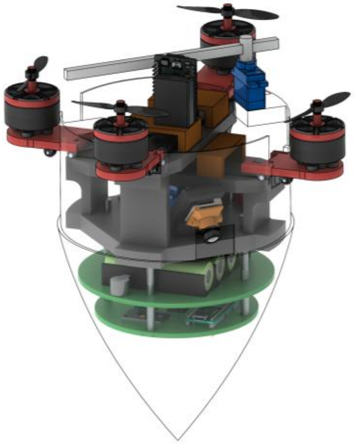
CONOPS 2

After the released from container, motors and propellers open up with spring-servo mechanism.

The quadcopter design prevents the payload from spinning around itself during landing, ensuring a stable landing.

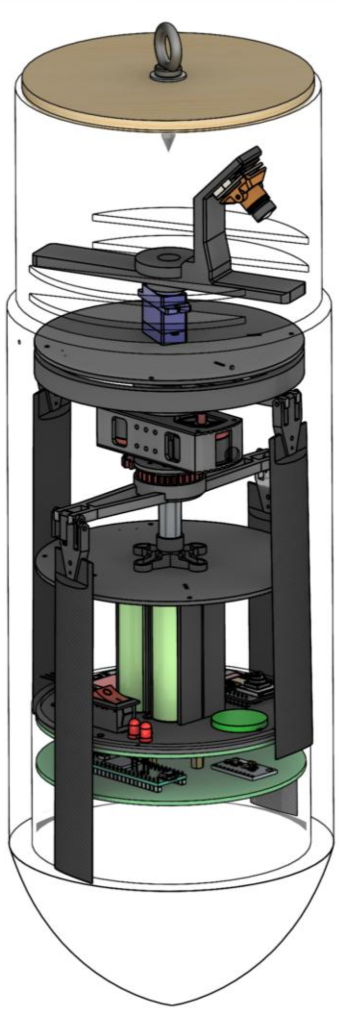
In order for the camera to look north during landing, the torque produced by the motors is can be changed so that the payload faces north.





System Level CanSat Configuration Trade & Selection (3/4)

Coaxial Rotor Design



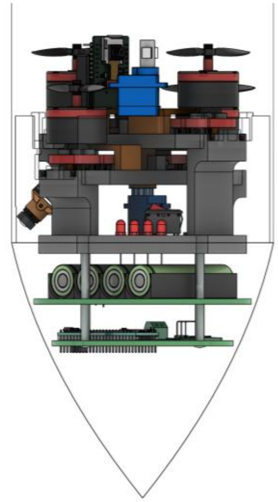
Pros

+ Since the motors are far from the electronics, the signals are less affected by vibration.
+ It's much easier to rotate the camera
+ The opening mechanism of the propellers is safer

Cons

- The center of gravity is slightly higher due to the motors.
- A taller design

Quadcopter Design

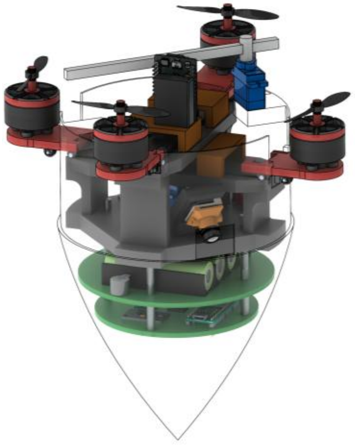


Pros

+ More compact design
+ Center of gravity is more useful.

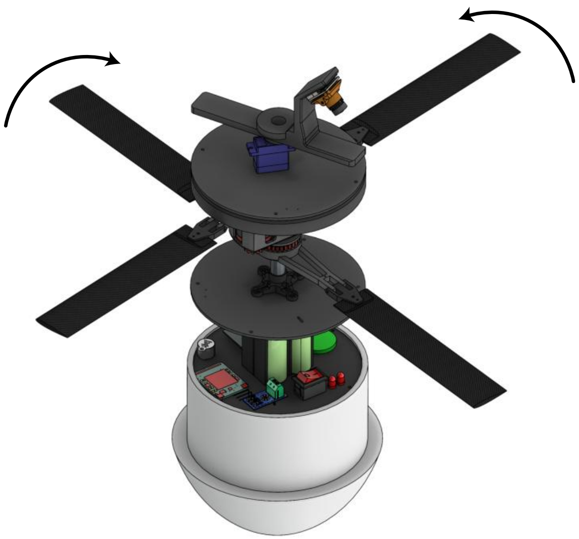
Cons

- Since 4 motors are used, it is both heavier and consumes more power.
- The possibility of the signal being affected because the motors are close to the electronics
- The camera that will show the opening of the propellers cannot see all motors.



System Level CanSat Configuration Trade & Selection (4/4)

Selected Configuration	Reasons
Coaxial Rotor Design	The **coaxial rotor design** was chosen because it would provide much more stable and vibration-free design for the payload. It would also be much safer system for camera rotation and auto-gyro deployment.



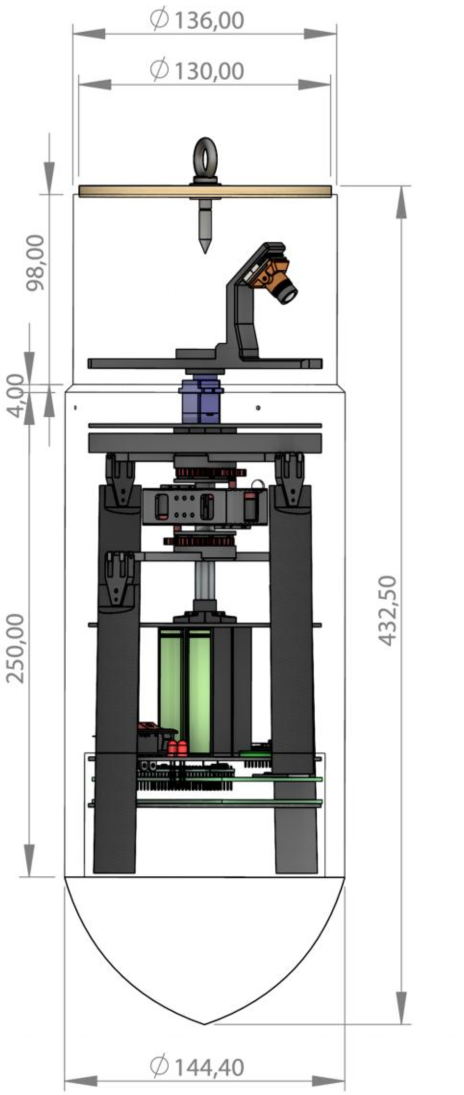
System Level Configuration Selection

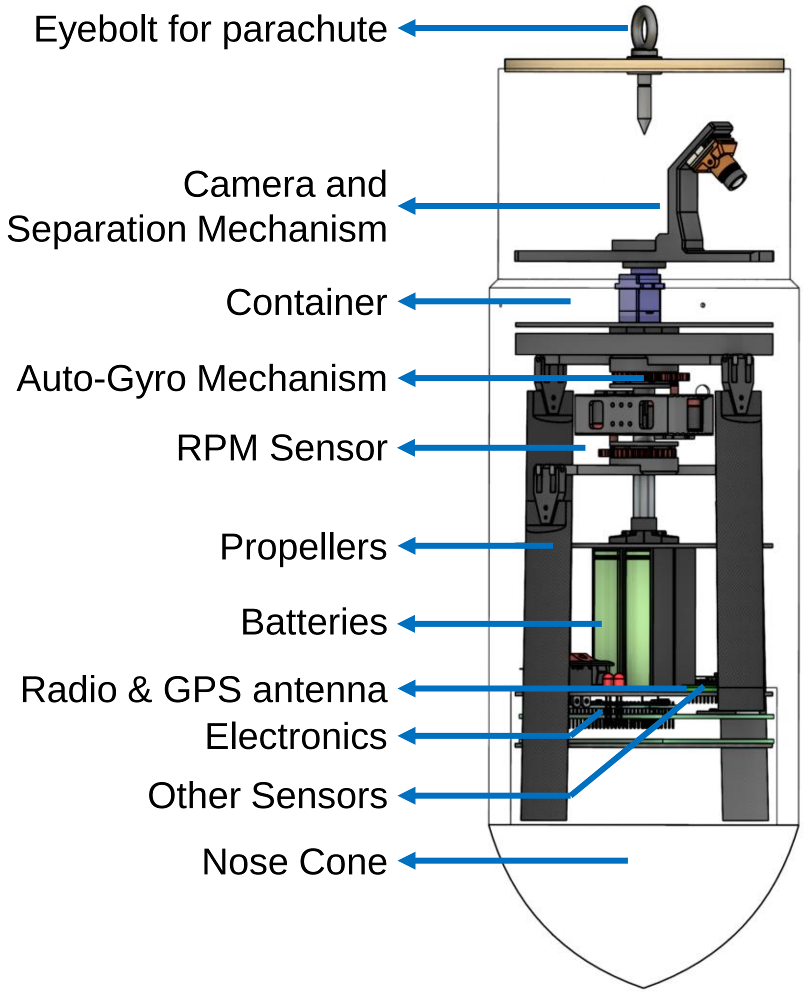
The selected configuration is the **Coaxial Rotor Design**. This configuration features two propeller arms rotating in opposite directions, ensuring the payload descends stably. The design, which includes a total of two motors, is superior to the other concept in several aspects, including:

- Reduced vibration environment
- Easier alignment of the downward-facing camera towards the north during descent
- A safer propeller deployment mechanism
- Greater efficiency in terms of weight and power consumption

We believe that this design will help us achieve our objectives in the competition.

Physical Layout (1/3)

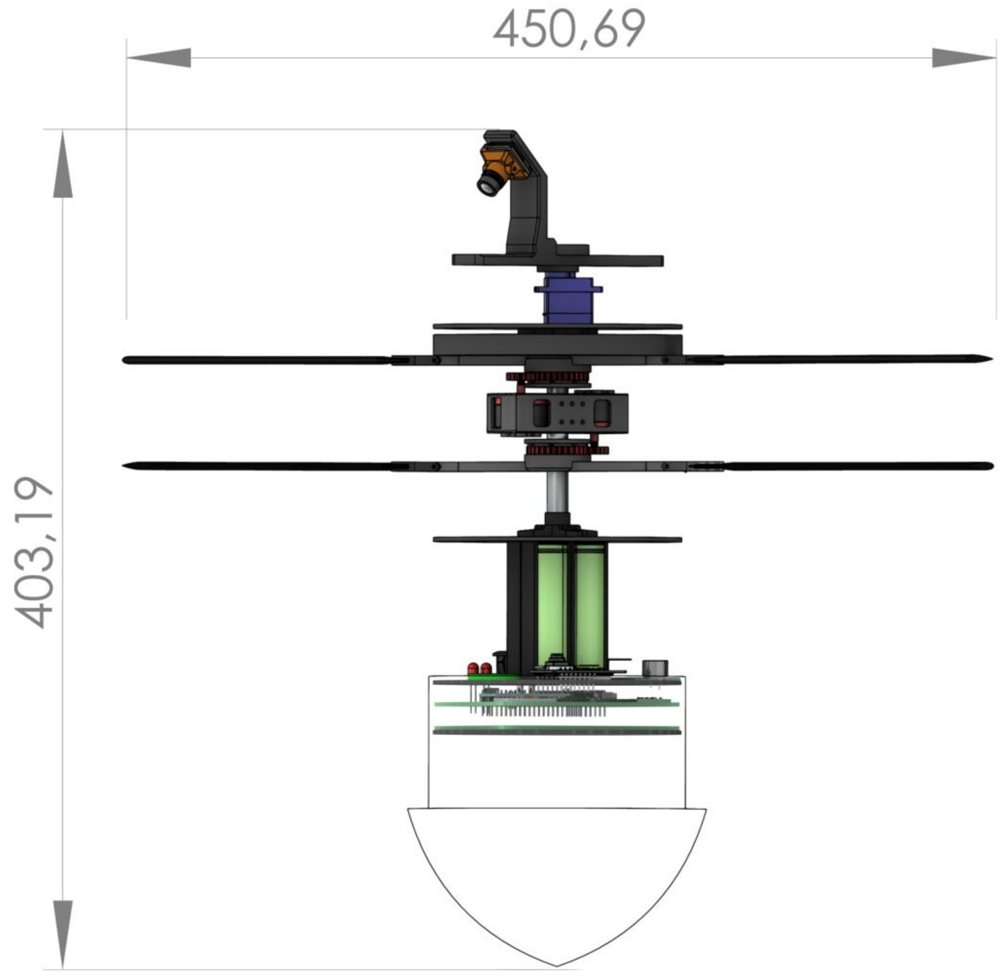




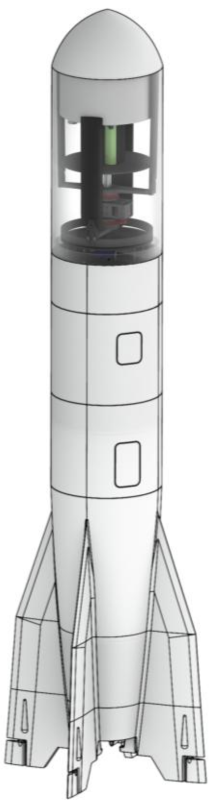
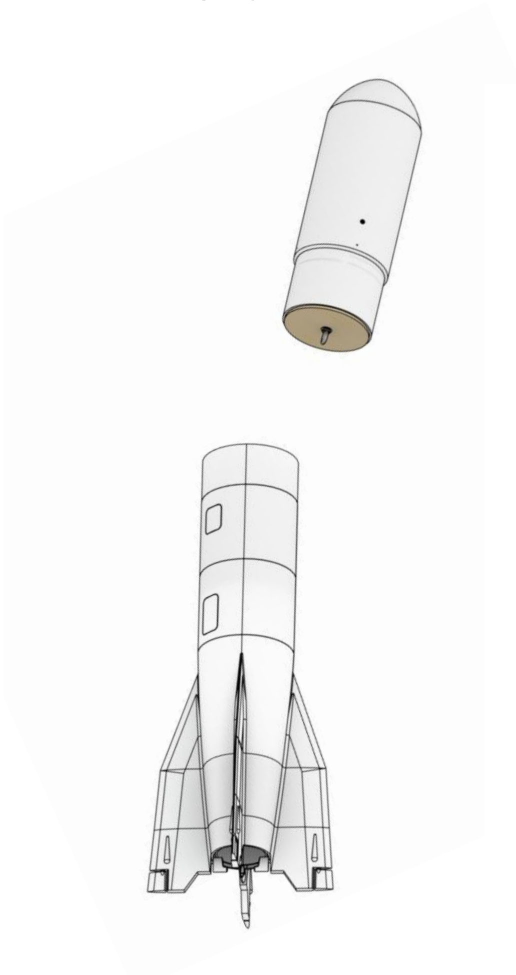
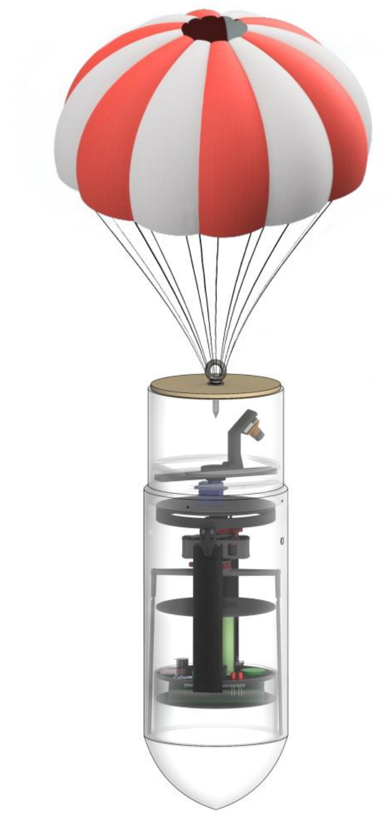
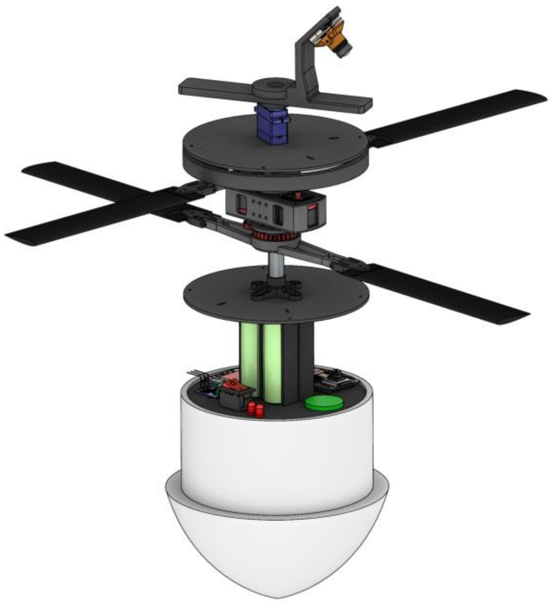
All dimensions are in mm

Physical Layout (2/3)

Deployed configuration

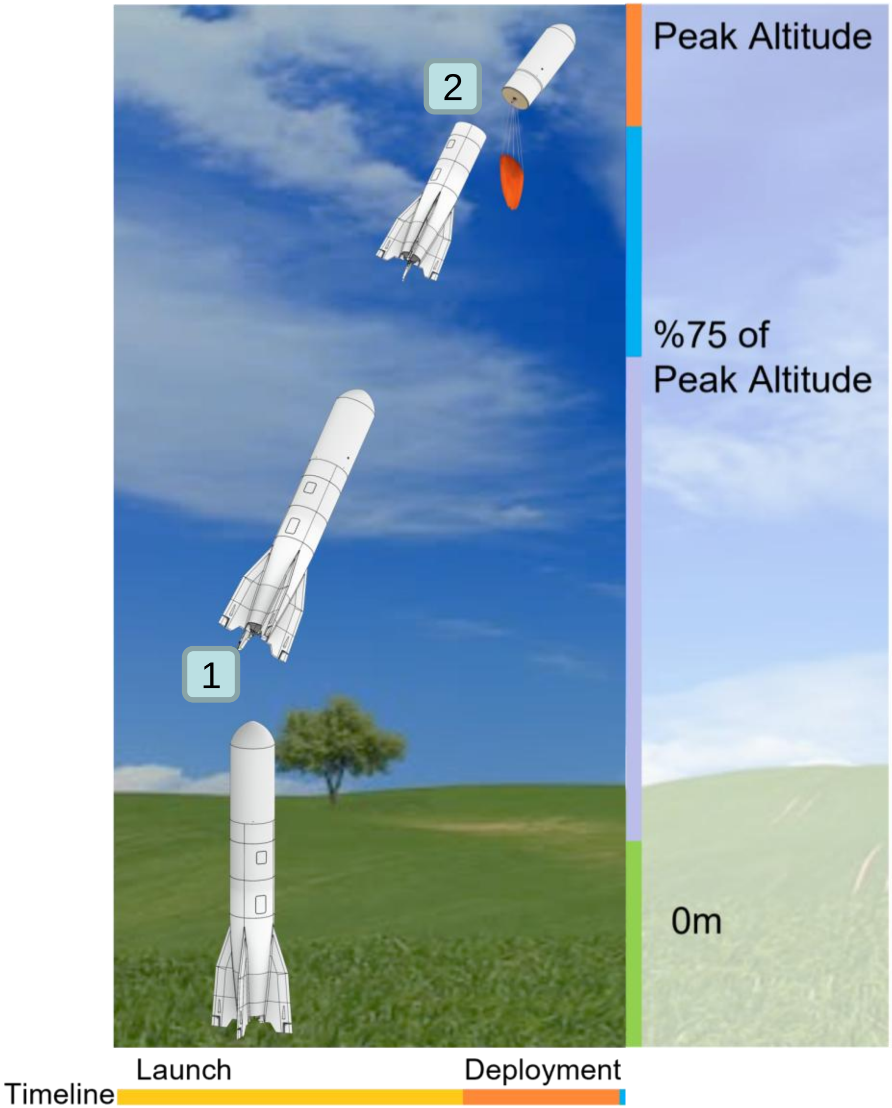


Physical Layout (3/3)

Launch	Deployment	Container + Payload Parachute Descent	Auto-Gyro Descent
			

System Concept of Operations (1/4)

System Concept of Operations (2/4)



Launch 1

Corresponding States:
LAUNCH_PAD & ASCENT

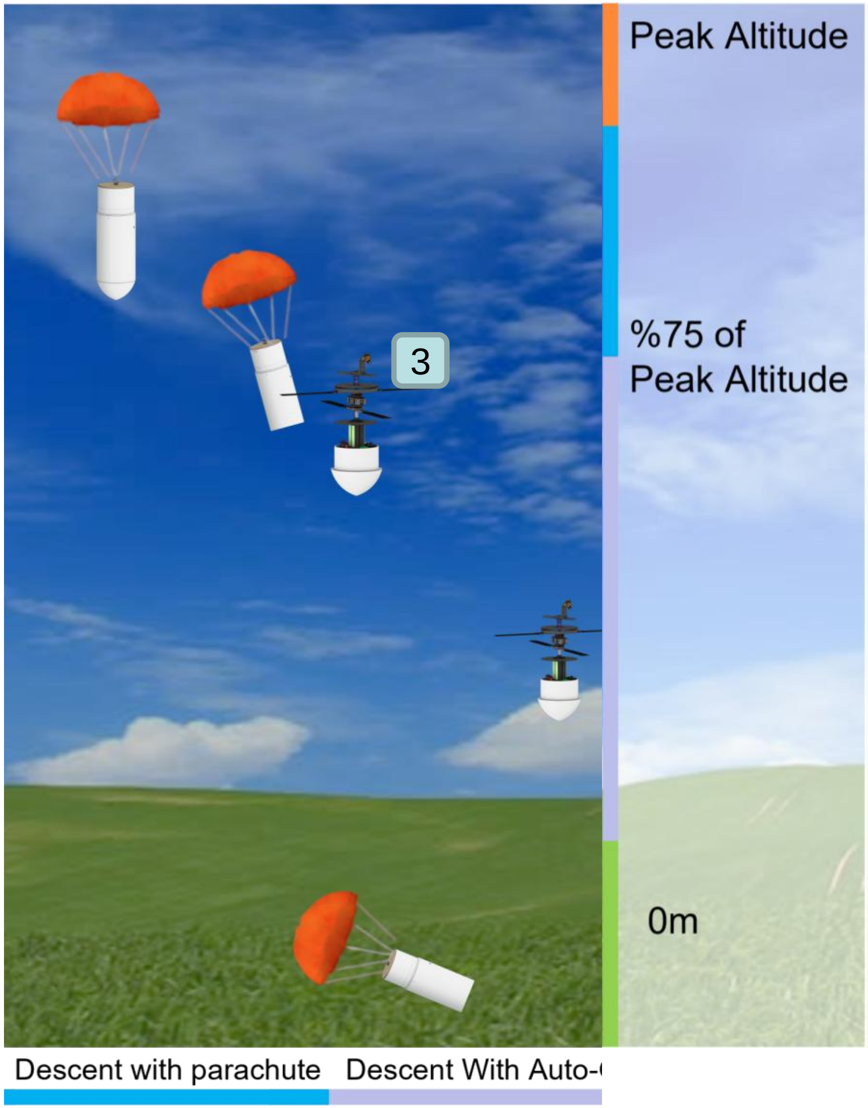
The CanSat (container and payload) will take the place and function of the nose cone and some part of rocket during ascent. Cansat shall ascent the peak altitude with rocket. The cansat transmits telemetry once per second (1Hz) to the ground station, from launch to landing.

Deployment 2

Corresponding State:
APOGEE

The container with the payload shall deploy from the rocket when the rocket reaches peak altitude and the rocket motor ejection forces a separation. Once the Cansat is deployed from the rocket, the parachute will deploy automaticly

System Concept of Operations (3/4)



Descent 3

Corresponding States:
DESCENT & PROBE_RELEASE

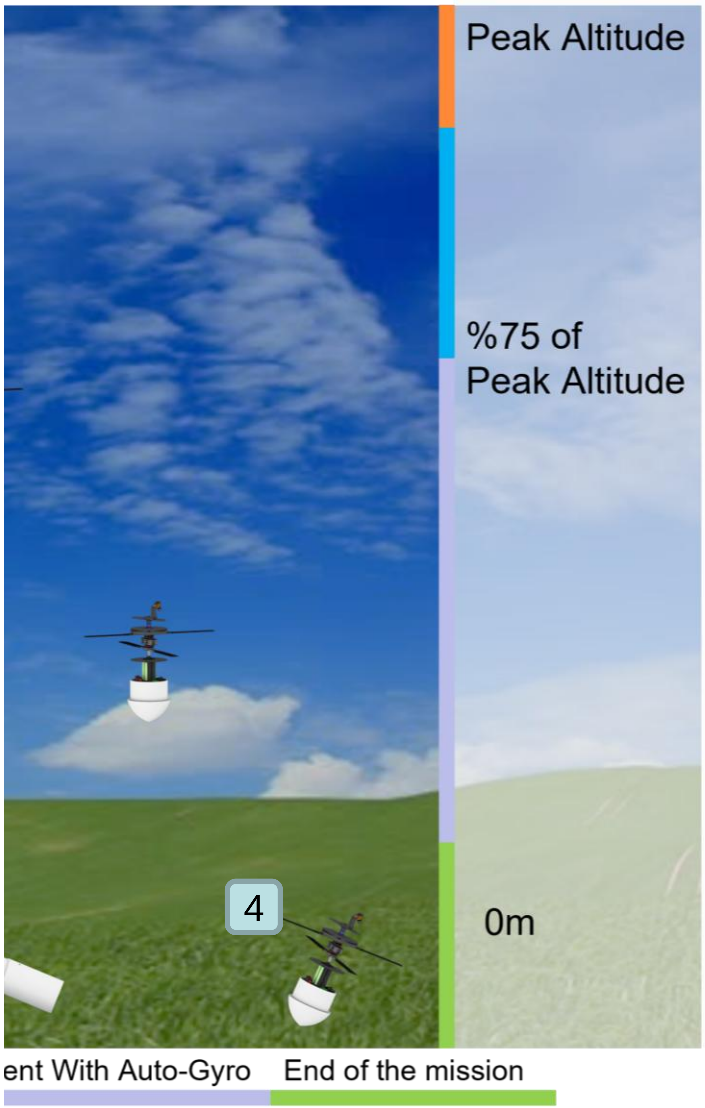
The container with the payload shall descend at a rate of no more than 20 meters/second using a parachute that automatically deploys at separation. Error is +/- 3 m/s.

At 75% peak altitude, the payload shall separate from the container and descend using an auto-gyro descent control system until landing. A video camera shall show the separation of the payload from the container and the auto-gyro functioning.

After separation from the container the auto-gyro descent control system until landing. The descent rate shall be 5 meters/second.

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.

System Concept of Operations (4/4)



Landing 4

Corresponding State:
`LANDED`

Upon landing, the Cansat will stop transmitting data.

- Recovery crew will track the payload & container and going out into the field for recovery.
- CanSat is found, and flight data is retrieved from SD cards.
- Camera views are retrieved from SD cards.

Launch Vehicle Compatibility

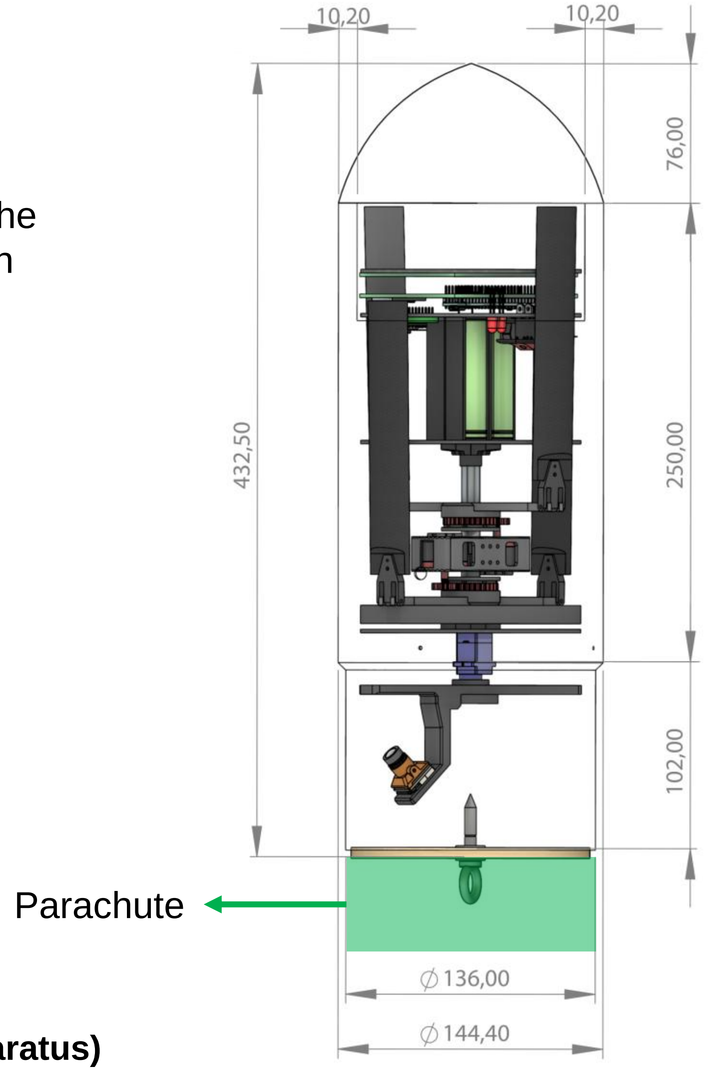
On the side is a diagram with the necessary dimensions. All dimensions are in mm.

For ease of release, 10.2 mm gaps are left on both sides between the shoulder of the Nose Cone and the wall of the container. Other dimensions are shown in the diagram. There is no protrusion on the shell.

Container + Payload Dimensions
- Height: 432,5 mm
- Diameter: 144,4 mm

Parachute Dimensions
- Diameter: 26.13 cm
- Spill Hole Diameter: 8.3 cm

Payload Dimensions after Deployment
- Height: 403,19 mm
- Rotor Diameter: 450,69 mm
- Structure Diameter: 144,4mm

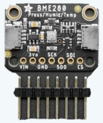
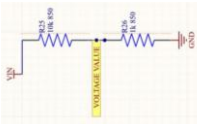
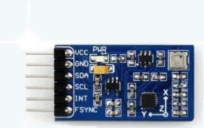


(There are no sharp protrusions at any control apparatus)

Sensor Subsystem Design

Atakan SAYDAM

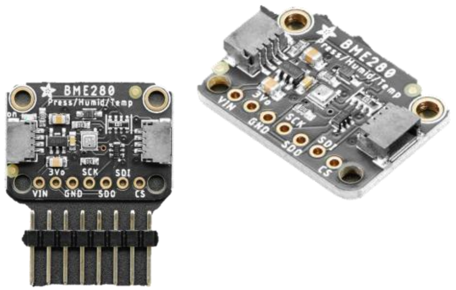
Sensor Subsystem Overview

Sensor Type	Model	Function Overview
AIR PRESSURE AIR TEMPERATURE	BME280 	High precision air pressure and temperature measurement
BATTERY VOLTAGE	Voltage Divider 	Minimize errors in analog binding and increase security
GPS	NEO-M9N 	Determining the position with high sensitivity, high accuracy, ease of use and accessibility
AUTO-GYRO ROTATION RATE SENSOR	HC-020K RPM Sensor 	Measuring the rotational speed of the propeller
TILT SENSOR CAMERA ORIENTATION SENSOR	MPU9255 10 DOF IMU 	High precision 9 axes gyro acceleration magnetometer measurement, stability will be verified
PARACHUTE RELEASE CAMERA	ESP32-CAM 	Provides SD card support , easy to integrate and small size
GROUND CAMERA	B19 FPV DRONECAM 	High video resolution, provides SD card support and easy to assemble

Payload Air Pressure Sensor Trade & Selection

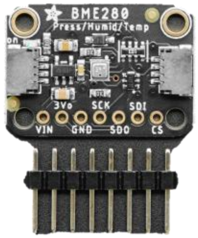
SENSOR MODEL	INTERFACES	ACCURACY (hPa)	RESOLUTION (Pa)	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	PRESSURE RANGE (hPa)	COST ($)
Adafruit BME280	**I2C OR SPI**	**±1.00 hPa**	**0.18**	**25.2 x 18.0 x 4.6**	**1**	**3 to 5**	**0.0036 mA**	**300 – 1100 hPa**	**14.95**
MPL3115A2	I2C	±0.5 hPa	1.5	16 x 16 x 2.5	1.2	1.95 to 3.6	0.04 mA	200 - 1100 hPa	16
BMP585 Shuttle Board	I2C OR SPI OR I3C	±0.05 hPa	0.08	30 × 22	1.1	3.3 to 5	0.0013 mA	300–1250 hPa	27.59

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
Adafruit BME280	• Two in one • Small and light • Has a lot of resources • Has its own regulator • Familiarity with sensor • Already have in inventory



Payload Air Temperature Sensor Trade & Selection

SENSOR MODEL	INTERFACES	ACCURACY (hPa)	RESOLUTION (°C)	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	TEMPERATURE RANGE (°C)	COST ($)
BME280	**I2C OR SPI**	**±1.00**	**0.01**	**25.2 x 18 x 4.6**	**1**	**3V-5V**	**0.036**	**-40/85**	**14.95**
MCP9808	I2C	±0.5-1	0.06	21 x 13 x 2	0.9	2.7V - 5.5V	0.2	-40/125	11.85
BMP585 Shuttle Board	I2C OR SPI OR I3C	±0.05 hPa	0.08	30 × 22	1.1	3.3 to 5	0.0013 mA	300–1250 hPa	27.59



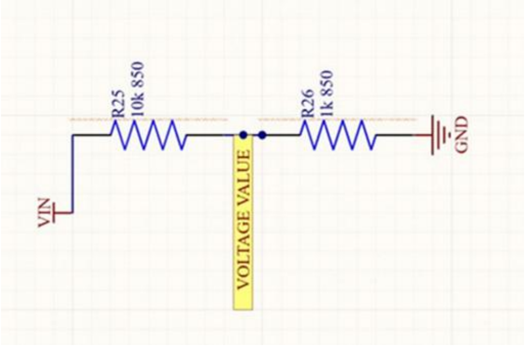
SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
Adafruit BME280	• Two in one • Small and light • Has a lot of resources • Has own regulator • Familiar with sensor • Already have in inventory

Payload Battery Voltage Sensor Trade & Selection

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	RESOLUTION (bits)	VOLTAGE RANGE (V)	COST ($)
ARD ACCES	I2C	27 x 14	4	16	0V - 25V	1.55
VOLTAGE DIVIDER	**WIRE**	**-**	**-**	**12**	**0V - 33V**	**0**
INA219	I2C OR SMBUS	20.32 X 22.85 X 1.5	2	12	0.3V - 26 V	3

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
VOLTAGE DIVIDER	• Most reliable data • Very cheap • Small and Light

VOLTAGE DIVIDER



Payload GNSS Sensor Trade & Selection

SENSOR MODEL	INTERFACES	ACCURACY (m)	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	UPDATE RATE (Hz)	RESOLUTION (m)	SENSIVITY (dBm)	COST ($)
SparkFun NEO-M9N	**UART, SPI, I2C, USB**	**Position 1.5 m** **Velocity 0.05 m/s**	**40.64 x 33.02 X 2.7**	**11.0**	**3.3 - 5**	**31**	**25 Hz**	**2**	**167**	**69.95**
Adafruit Ultimate GPS	UART or SPI or I2C	Position 1.8m Velocity 0.1 m/s	25.5 x 35 x 6.5	8.5	3.3 – 5	20	10 Hz	3	165	29.95
UBLOX MAX-M8Q	UART	Position 3 m Velocity 0.05 m/s	22 x 22 x 1.6	8.5	0.5 - 3.6	25	10 Hz	3	163	34.5

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
SparkFun NEO-M9N	• Arduino libraries available • Best resolution and accuracy rates • Distributor sales (Absolutely non-imitated chip)

Payload Auto-Gyro Rotation Rate Sensor Trade & Selection

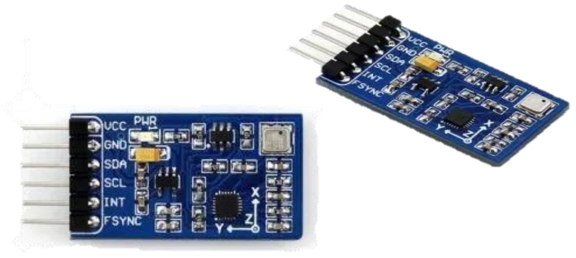
SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	RESOLUTION (position)	COUNTING FREQUENCY (kHz)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	TEMPERATURE RANGE (°C)	ACCURACY	COST ($)
Bourns EMS22A Encoder	TTL	21.2 X 15.9x 13.9	11	1024	167	3.0-5	4	-40 to 125	0.7 °m	53.8
HC-020K RPM Sensor	**TTL**	**24 X 20 X 3**	**5**	**20**	**100**	**4.5-5.5**	**20**	**-40 to 85**	0.2 °m	**2,81**
US1881 Hall Effect Sensor	TTL	4.4 x 4.3 x 3.3	1	12	10	3.5-24	5	-40 to 150	-	0.65

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
HC-020K RPM Sensor	• Low mass • Easy to mechanic integration • High RPM range

Payload Tilt Sensor Trade & Selection

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	AXIS	RESOLUTION (bits)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	RANGE (degree or v)	COST ($)
BOSCH BNO055 Shuttle Board	I2C	20 x 22 x 4.7	3	9	16	2.4 - 3.6	12.3	±16g	32
MPU9255	**I2C OR SPI**	**30 x 30 x 1**	**2**	**9**	**16**	**3.3 - 5**	**3.2**	**±16g**	**15.99**
MPU6050	I2C	21.2 x 16.4 x 3.3	2.1	6	12	3.3	3.9	±16g	2

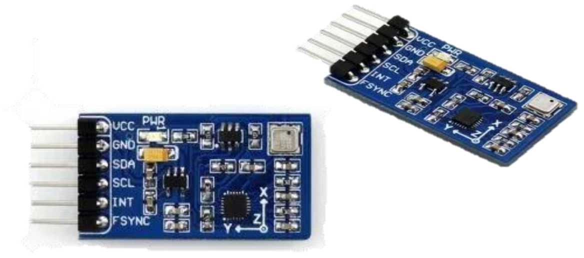
SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
MPU9255	• High accuracy • Familiarity with sensor • Already in inventory • No need to external regulation



Payload Ground Camera Orientation Sensor Trade & Selection

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	AXIS	RESOLUTION (bits)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	RANGE (degree or v)	COST ($)
BOSCH BNO055 Shuttle Board	I2C	20 x 22 x 4.7	3	9	16	2.4 - 3.6	12.3	±1000dps	32
MPU9255	**I2C OR SPI**	**30 x 30 x 1**	**2**	**9**	**16**	**3.3 - 5**	**3.2**	**±2000dps**	**15.99**
MPU6515	I2C SPI	21.2 x 16.4 x 3.3	2.1	9	16	3.3	3.9	±2000dps	5

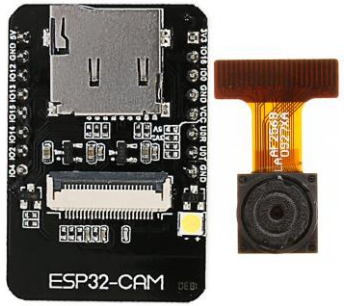
SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
MPU9255	• High accuracy • Familiarity with sensor • Already in inventory • No need to external regulation



Parachute Release Camera Trade & Selection

Model	Interface	Resolution (pixels)	Voltage (v)	Frame Rate (Hz)	Mass (g)	Size (mm)	Cost ($)
ESP32-CAM	**I2C/UART**	**1600x1200**	**5**	**60**	**10**	**40.5x27x4.5**	**11**
M5Stack ESP32 Camera Module	I2C/UART	1600x1200	5	60	12	54x25.5x13.8	12
TTGO T-Camera Plus	I2C/UART	1600x1200	5	60	16	69.3x27.4x29.2	25

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
ESP32-CAM	• Affordable • Lower mass • Smaller in size • SD Card support



Ground Camera Trade and Selection

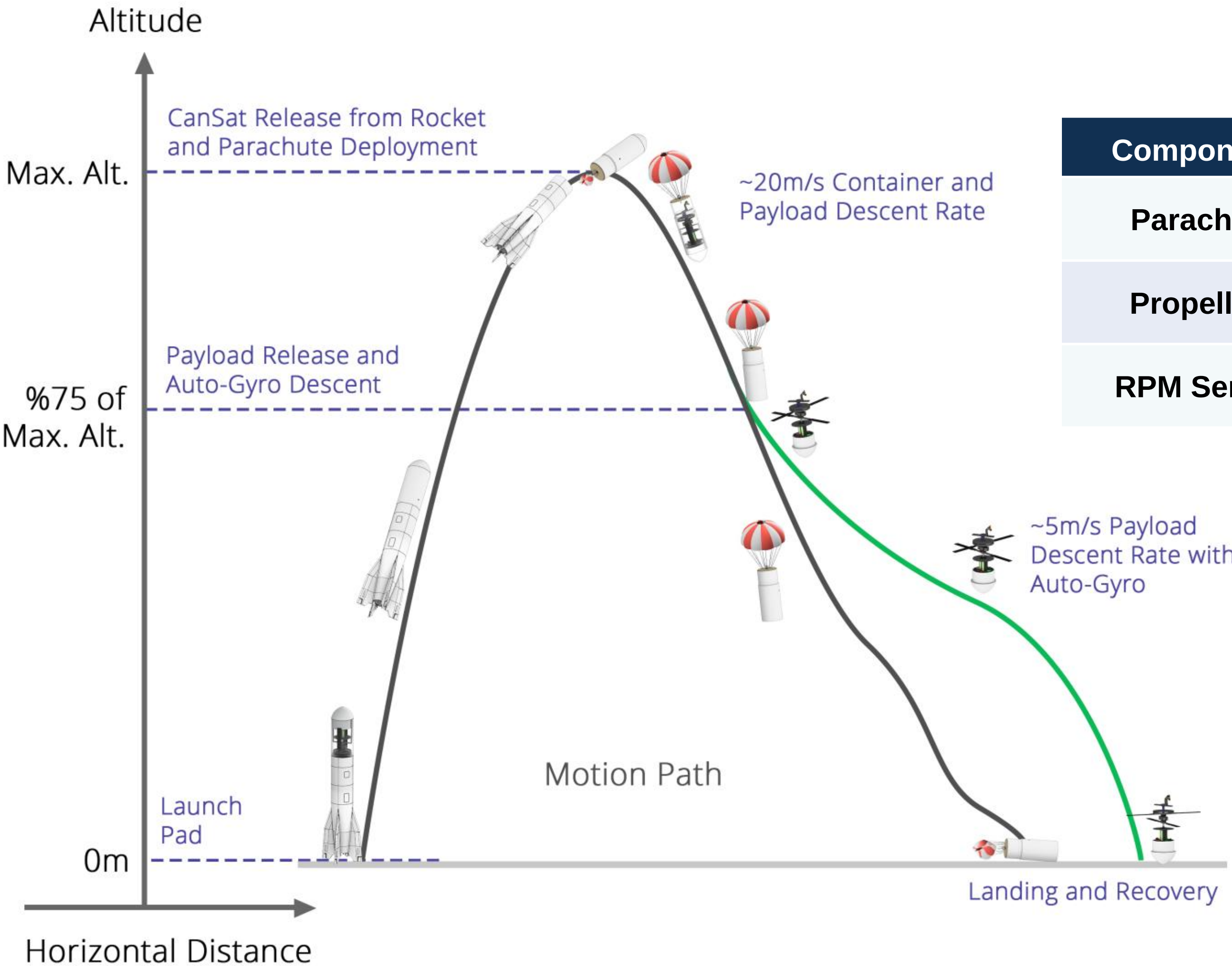
SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	FRAME RATE (Hz)	RESOLUTION (Pixels)	VIEW ANGLE	COST ($)
MOTOROBIT B19	**DIGITAL**	**19 X 19 X 19**	**6**	**5-30**	**30**	**2560 X 1920**	**130**	**37**
ADAFRUIT MiniSpy Cam	DIGITAL	28.5 X 17 X 4.2	2.8	5	30	640 X 480	120	12.5
OV7670	SCCB	30.5 X 30.5 X 18	15	3.3	30	640 X 480	110	4.8

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
MOTOROBIT B19	• High resolution and view angle • Small dimensions

Descent Control Design

Alperen Ragıp SOYLER

Descent Control Overview



Components	Materials
Parachute	40D Ripstop Nylon
Propellers	Carbon Fiber
RPM Sensor	Semi-Conductor

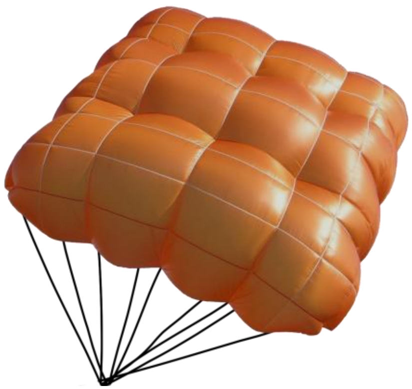
Parachute Descent Control Strategy Selection and Trade (1/3)

Design 1: Hemispherical Parachute

\+ Simple manufacturing
\+ Provides stability
\+ Easy to fold
\+ High drag coefficient

\- Larger packing volume
\- Can experience slight oscillations

Design 2: Cruciform Parachute



\+ Compact and lightweight
\+ Excellent stability

\- More complex to manufacture
\- Generates slightly less drag
\- Requires precise folding

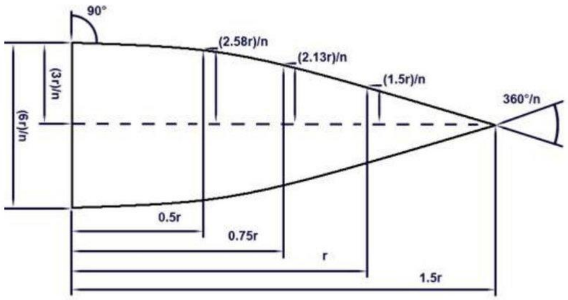
Selected Parachute Design
Design 1: Hemispherical Parachute
Reasons
The hemispherical parachute is selected due to its simplicity, cost-effectiveness, and ability to provide a controlled and stable descent. Its proven reliability in aerospace projects and compatibility with the size constraints of the system make it the ideal choice for this project.

Parachute Descent Control Strategy Selection and Trade (2/3)

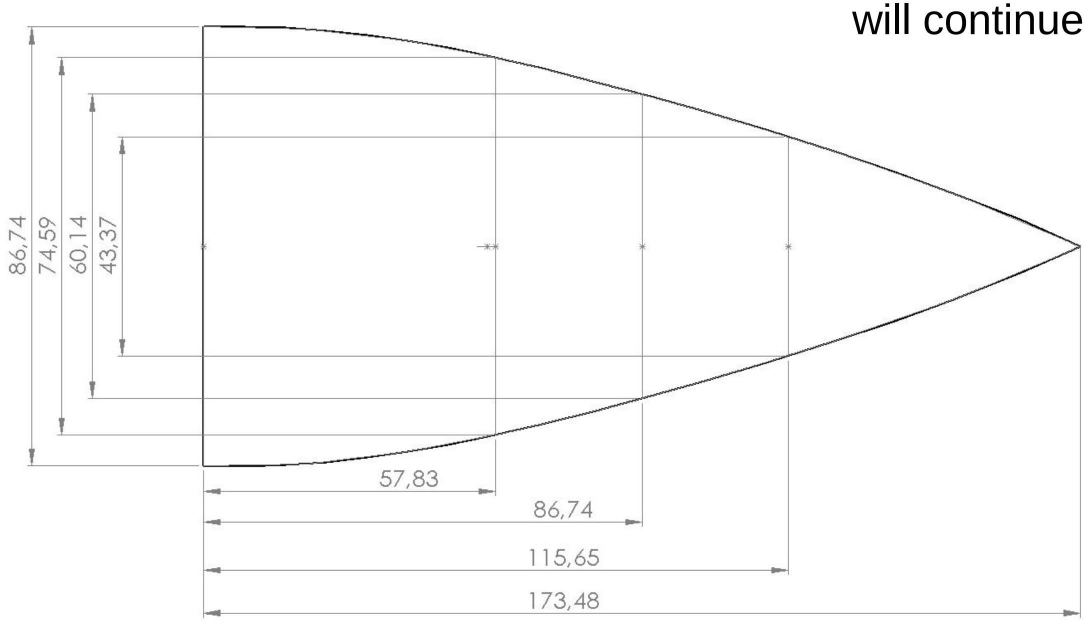
Fabric Type	Material	Weight (m²)	Features	Price
40D Ripstop Fabric 	**Ripstop Nylon**	**40 g**	• **Suitable use for in model aircraft** • **Airtight and waterproof** • **Thin and light**	**10.5$**
70D Ripstop Fabric 	Ripstop Nylon	75 g	• Same features with 40D Ripstop Fabric, but its heavier due to its high density.	8$
Parachute Fabric 	Polyester	70 g	• Suitable use for in model aircraft • Airtight and waterproof • It is much heavier than first option	2$

Selected Fabric: **40D Ripstop Fabric**

Parachute Descent Control Strategy Selection and Trade (3/3)



The parachute will consist of a total of 8 gores, with a spill hole covering 10% of the total area. The total area will be 0.05362 m², and its diameter will be 26.13 cm. In the diagram shown on the side, the dimensions of one gore of the parachute are seen. Further calculations will continue in the **Descent Rate Estimates** section.



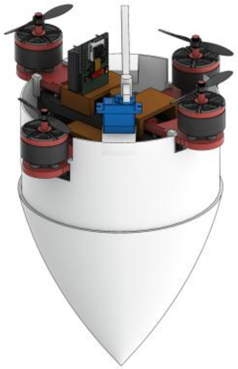
Auto-Gyro Descent Control Strategy Selection and Trade (1/2)

Design 1: Coaxial Rotor

+ Compact and space-efficient
+ Simple mechanical structure
+ High rotational stability

- More complex than design 2
- Limited redundancy

Design 2: Quadcopter



+ High maneuverability
+ Lower drag
+ Easier to balance

- Greater power consumption
- Heavier than first design

Selected Design	Reasons
Design 1: Coaxial Rotor	The **coaxial rotor design** is selected due to its compactness, simplicity, and suitability for the size constraints of the CanSat system. While the quadcopter design offers redundancy, the CanSat system prioritizes weight efficiency and reliability, making the coaxial rotor the optimal choice for this project.

The wingspan will be approximately **450 mm**, and each propeller will be **150 mm** long.

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

Design 1: NACA 0012 Airfoil

+ Symmetrical and stable structure.
+ Easy to manufacture.
+ Provides consistent performance at low speeds.

- Moderate lift generation.
- High drag at large angles of attack.
- Low lift at small angles of attack.

Design 2: Flat Plate Airfoil

+ Extremely simple and economical to manufacture.
+ Adequate lift generation at low speeds.
+ Lightweight and easy to integrate.

- High drag force compared to other profiles.
- Inefficient at higher flow speeds.
- Poor performance in terms of stability.

Selected Design	Reasons
Design 1: NACA 0012 Airfoil	The **NACA 0012 airfoil** is chosen due to its symmetrical shape, offering stability and predictable performance in auto-gyro applications. Its ease of manufacturing and reliable performance at low speeds make it a superior option. Although the flat plate airfoil is simpler to build, its high drag and lack of stability make it less suitable for the requirements of this project.

The angle of attack for the NACA 0012 propeller airfoil will be **10 degrees**.

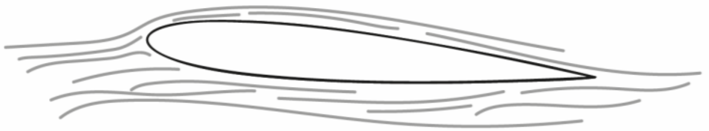
Auto-Gyro Descent Stability Control Strategy Selection and Trade (1/2)

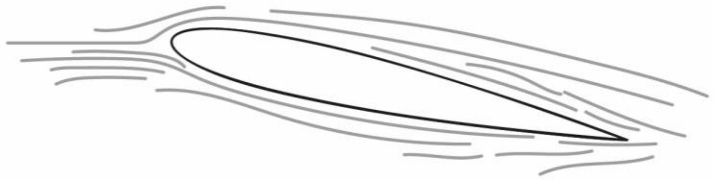
There are two different design proposals for Auto Gyro stability.
One of them is **fixed-AoA propellers**, and the other is **propellers with adjustable AoA.**

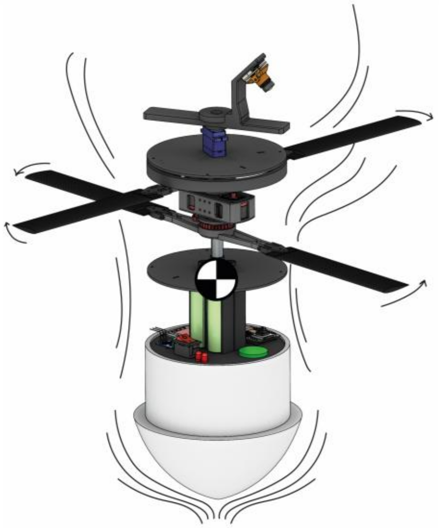
Fixed-AoA propellers provide great ease in terms of manufacturing. With a fixed angle of attack of 10 degrees, the lift coefficient of the propellers approximately can kept at its maximum. The stability by utilizing the **center of gravity** of the payload and the **aerodynamic structure of the nose cone** also can achieved. However, the inability to adjust the pitch angle might lead to some stability issues. Nevertheless, it can be overlook this.

In the other design, it can adjust the pitch angle using small motors placed inside the arms holding the propeller blades. This would minimize instantaneous stability disturbances of the payload, resulting in a much more stable descent. However, this design poses significant challenges in terms of manufacturing, weight, and power consumption.

On the next page, visuals of both designs, as well as their advantages and disadvantages can found.

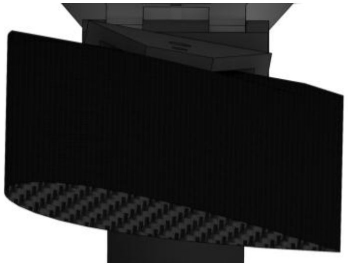






Auto-Gyro Descent Stability Control Strategy Selection and Trade (2/2)

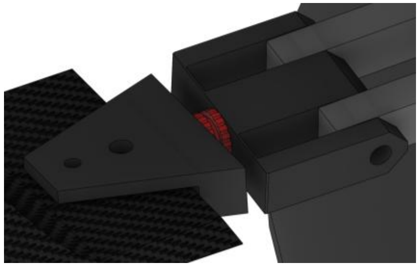
Design 1: Passive Control



+ Simple and reliable design.
+ No energy consumption.
+ Easier to manufacture.

- Fixed angle of attack.
- Limited efficiency potential.
- Not adaptable to high altitude changes.

Design 2: Active Control



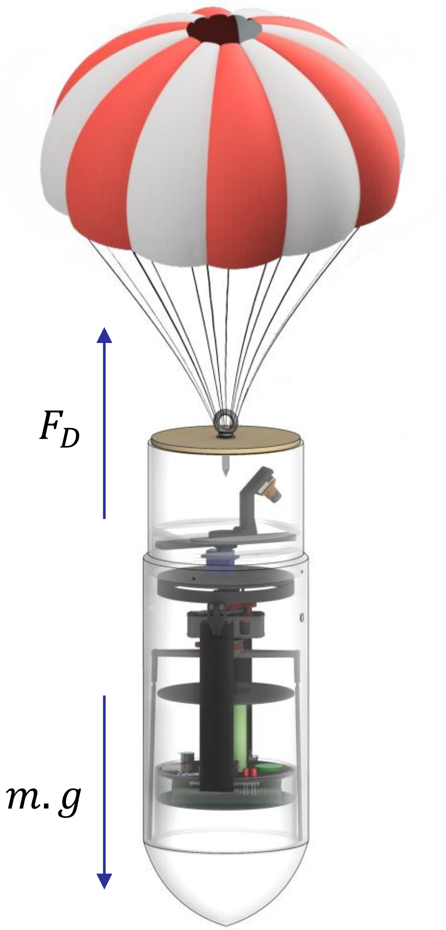
+ Provides dynamic adaptation.
+ Offers better precision.
+ Compatible with varying altitudes.

- Requires a complex mechanism.
- Consumes more energy.
- Higher maintenance and failure risk.

Selected Design	Reasons
Design 1: Passive Control	The **passive control** is chosen because it provides a simple and reliable solution for maintaining stability. The fixed 10-degree angle of attack works well with the aerodynamic design, ensuring consistent performance without requiring complex mechanisms.

Descent Rate Estimates (1/4)

Descent for Container & Payload with Parachute



$$F_{net} = m.a$$

$$F_{net} = F_D - mg$$

$$F_D = m.g$$

$$F_D = \frac{C_D.\rho.V^2.A}{2}$$

$$A = \frac{m.g.2}{C_D.\rho.V^2}$$

$$A_{effective} = 0.04826\,m^2$$

$$A_{total} = 0.05362\,m^2$$ ($A_{effective}$ divided by 0.9 due to the spill hole to calculate total area)

$$D = \sqrt{\frac{4A}{\pi}}$$

$$D = 0.2613\,m = 26.13\,cm$$

Parachute Diameter

- In order to achieve landing with constant speed, acceleration $\boldsymbol{a}$ pospulated as 0. Drag force equals $\boldsymbol{mg}$.
- The area A in the drag force formula to reach an average height and $\boldsymbol{\rho}$ value under usual circumstances are left out.
- The area of the parachute by using the necessary values are figured out .

Assumptions

$C_D = 1.3\ (with\ spill\ hole)$

$V = 20\,m/s$

$h_{avg} = 656.25\,m$

$\rho_{@656.25} = 1.09465\,kg/m^3$

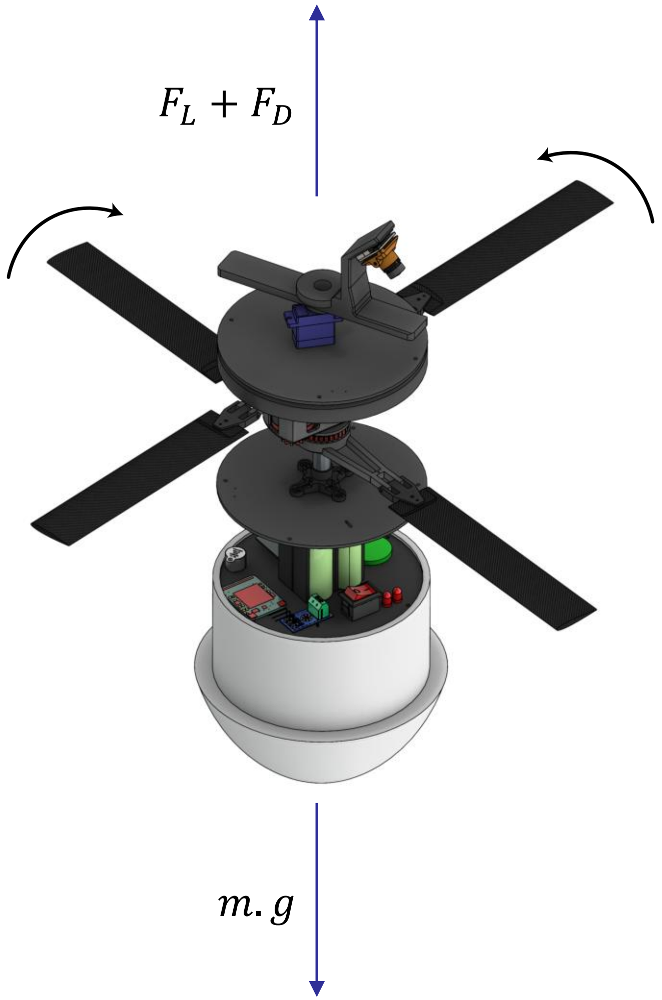
$g = 9.81\,m/s^2$

$m \approx 1.4\,kg$

C_D coefficient is assumed for hemispherical parachute with spill hole

Descent Rate Estimates (2/4)

Descent for Payload with Auto-Gyro (1/2)



$$F_L + F_D = m.g$$

$$F_L = \frac{C_L.\rho.V^2.A}{2}$$

Lifting Force

$$F_D = \frac{C_D.\rho.V^2.A}{2}$$

Drag Force

$$m.g = \frac{(C_L + C_D).\rho.V^2.A}{2}$$

$$V = \sqrt{\frac{2.m.g}{(C_L + C_D).\rho.A}}$$

$$V = 10.22\, m/s$$

This is the **airflow rate**. In other words, it includes both our landing velocity and the rotor rotation velocity produced by the propellers.

Assumptions

$C_D = 0.03$

$C_L = 1$

$V_{landing} = 5\, m/s$

$\rho = 1.2\, kg/m^3$

$g = 9.81\, m/s^2$

$m = 1\, kg$

$A = 0.152\, m^2$

C_D and C_L coefficients are assumed for NACA0012 airfoil with 10 degree AoA

Descent Rate Estimates (3/4)

Descent for Payload with Auto-Gyro (2/2)

$$V = 10.22\, m/s$$

$$V_{landing} = 5\, m/s$$

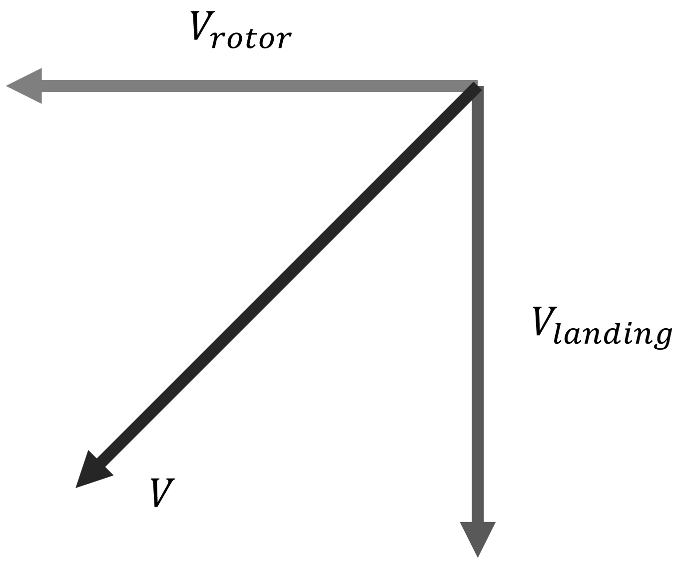
$$V_{rotor}^2 = V^2 - V_{landing}^2$$

$$V_{rotor} = 8.91\, m/s$$

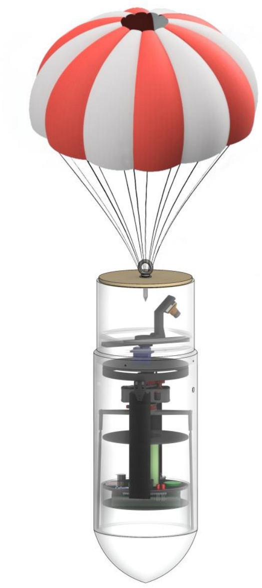
$$R_{rotor} = 0.225\, m$$

$$w_{rotor} = \frac{V_{rotor}}{R}$$

$$w_{rotor} = 39.62\, \frac{rad}{s}$$



Descent Rate Estimates (4/4)



Container & Payload with Parachute

$$Mass = 1.4kg$$

$$Descent\ Rate \approx 20\ m/s$$

$$Parachute\ Area = 0.05362\ m^2$$

$$Parachute\ Diameter = 26.13\ cm$$

Payload with Auto-Gyro

$$Mass \approx 1kg$$

$$Descent\ Rate \approx 5\ m/s$$

$$Rotor\ Area = 0.152\ m^2$$

$$Angular\ Velocity\ of\ Rotor = 39.62\ rad/s$$

Mechanical Subsystem Design

Bugrahan DEGIRMENCI & Goktug KOCCENK

Mechanical Subsystem Overview

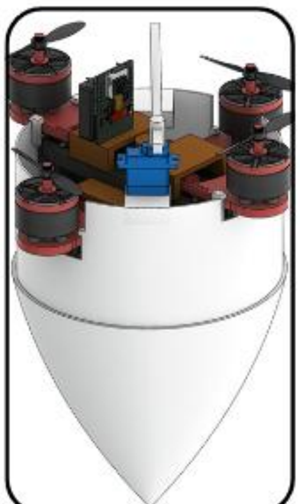
Container: **The section that houses the payload and all other components. It enables the launch along with the rocket. The container will be made of PLA.**

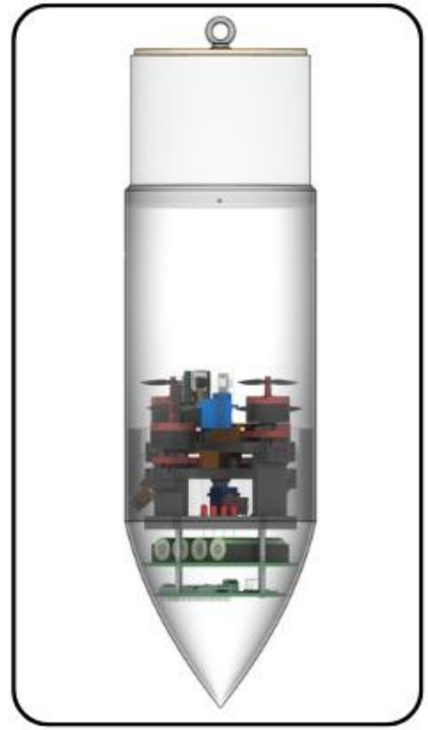
Release Mechanism: **Ensures the payload separates from the container at the desired altitude. Release mechanism will be made of ABS.**

Auto-Gyro Descent Control Mechanism: **A dual-rotor mechanism that ensures the safe descent of the payload. Auto-Gyro mechanism will be made of ABS, carbon fiber.**

Electronics: **Processor, GPS, voltage sensor, Xbee, Pressure sensor, Tilt sensor, Buzzer, Camera, Batteries, Voltage regulator, Motor Driver**

Cansat Mechanical Layout of Components Trade & Selection (1/10)



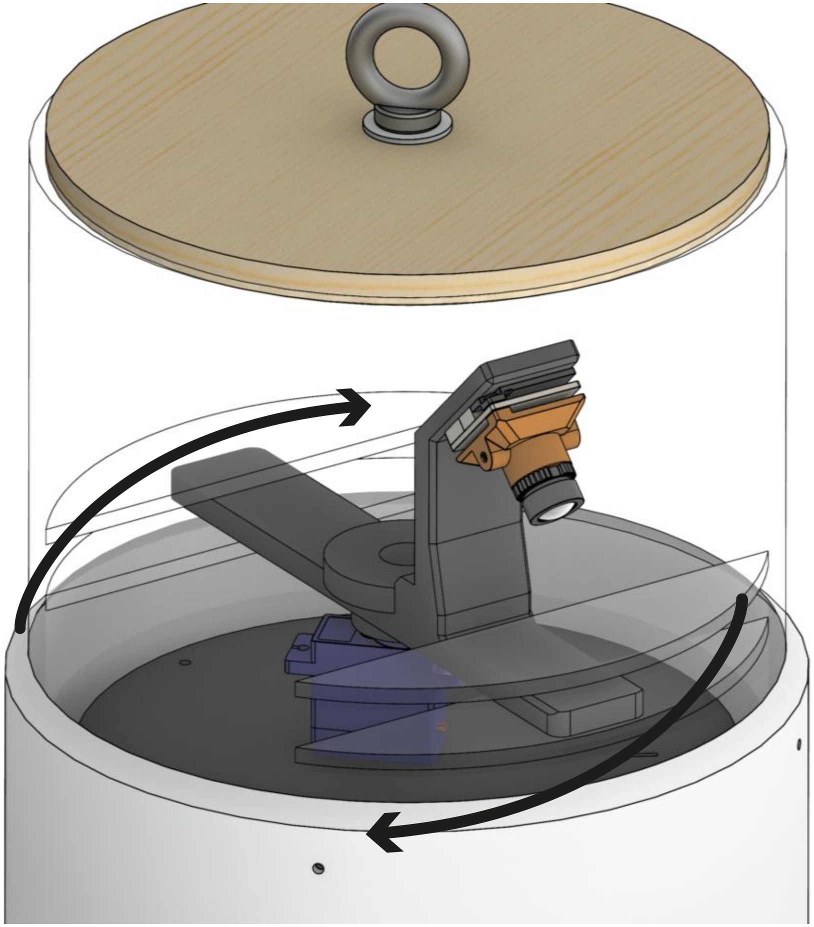


DESIGN 1: Coaxial Rotor

DESIGN 2: Quadcopter

Cansat Mechanical Layout of Components Trade & Selection (2/10)

Design 1

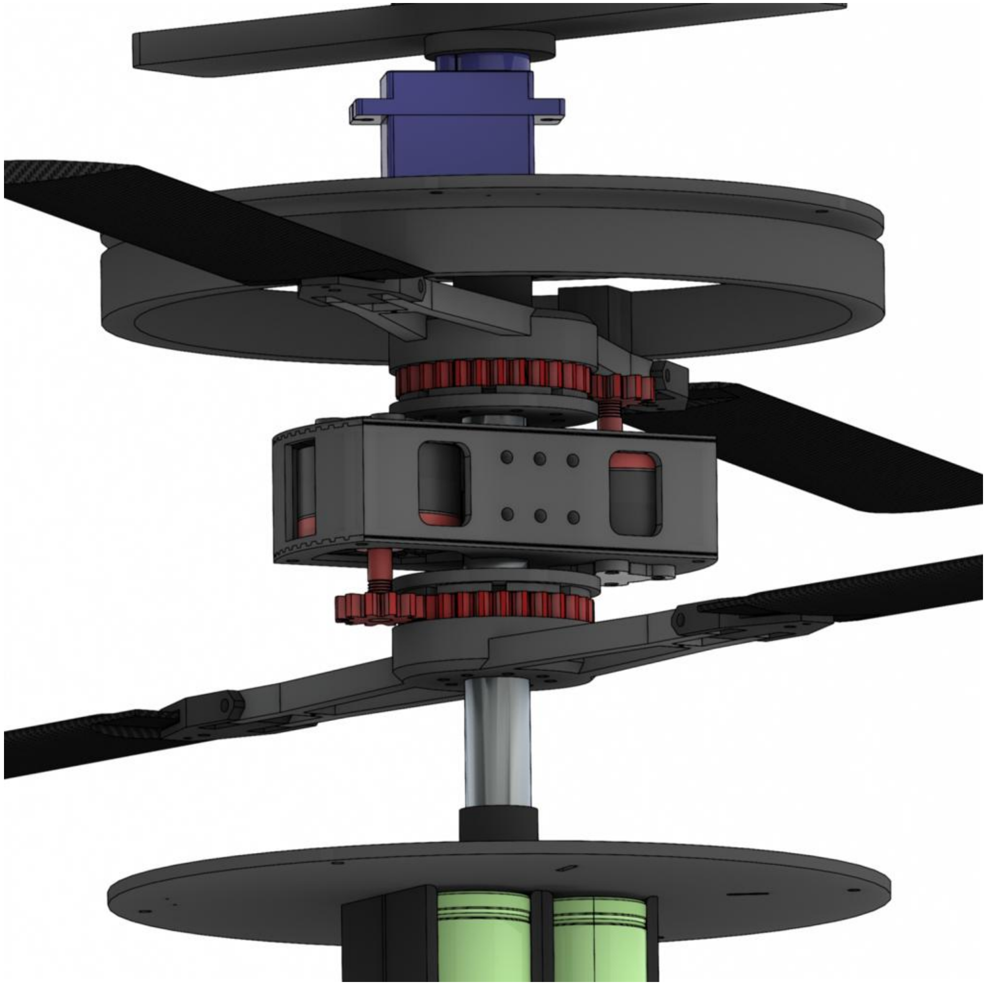


- The locking mechanism, located at the top of the payload and connected to a servo motor, remains locked by attaching to the supports on the inner surface of the container. When the servo motor operates, the lock rotates and disengages from the supports. This allows the payload to separate from the container.
- Material selection: ABS due to its low density

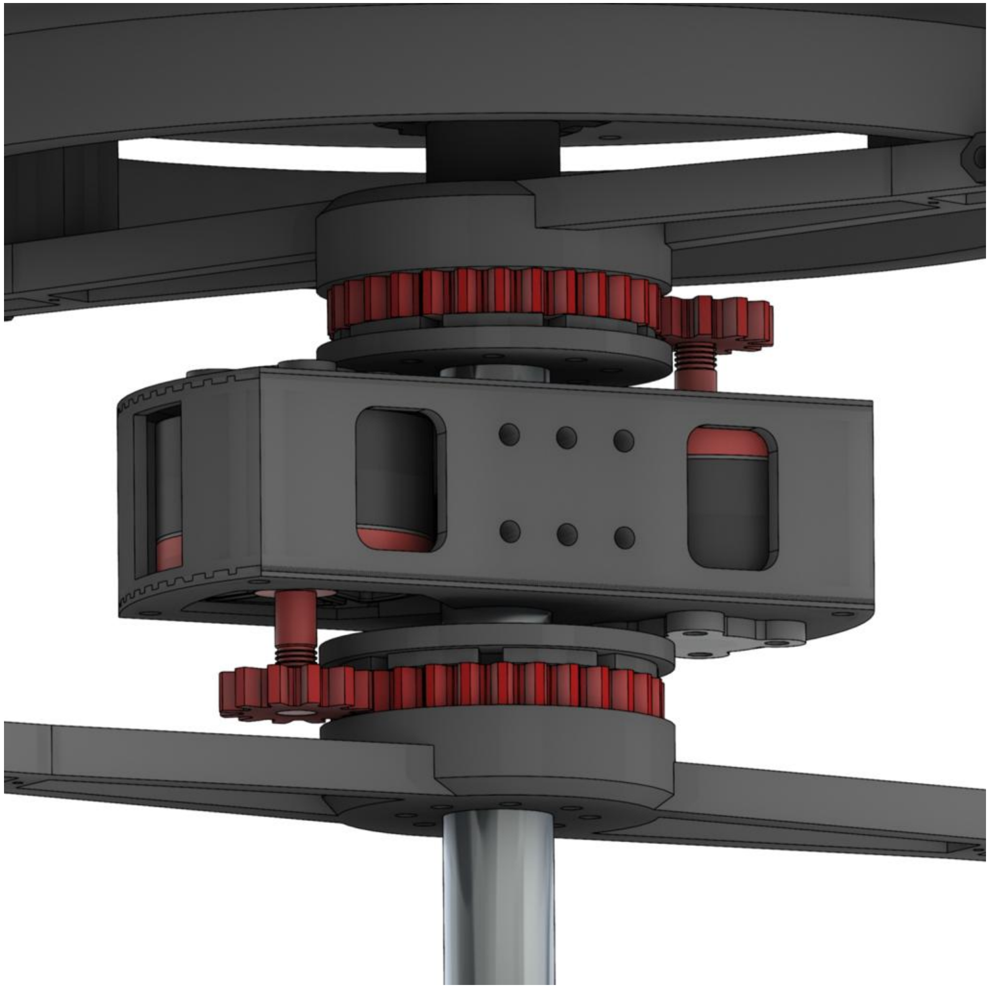
Cansat Mechanical Layout of Components Trade & Selection (3/10)

Design 1

- To prevent axial rotations caused by moment imbalance, two rotorsare used rotating in clockwise and counterclockwise directions. By using the propeller blades attached to these rotors, Its beeing planed to control the payload's descent safely and at the desired speed. The rotors are connected to two distinct main gears, which transmit the power from the motor to the propeller blades through these gears.



Design 1



- The motor block shown on the side is fixed to the skeletal shaft passing through the center of the payload and contains two motors facing opposite directions. Thanks to these two motors facing opposite directions, it's being controlled the rotation of the rotors in opposite directions. Power is transmitted to the main gears through the pinion gears located on the motor shaft.
- Material selection: ABS, Carbon fiber and Aluminum Pipe due to low density/ robustness

Cansat Mechanical Layout of Components Trade & Selection (5/10)

Design 1

- The electronic components, including the camera, servo motor, DC motor, GPS, switch and LED, will be integrated into the shoulder section of the nose cone. Other electronic components will be embedded inside the nose cone.

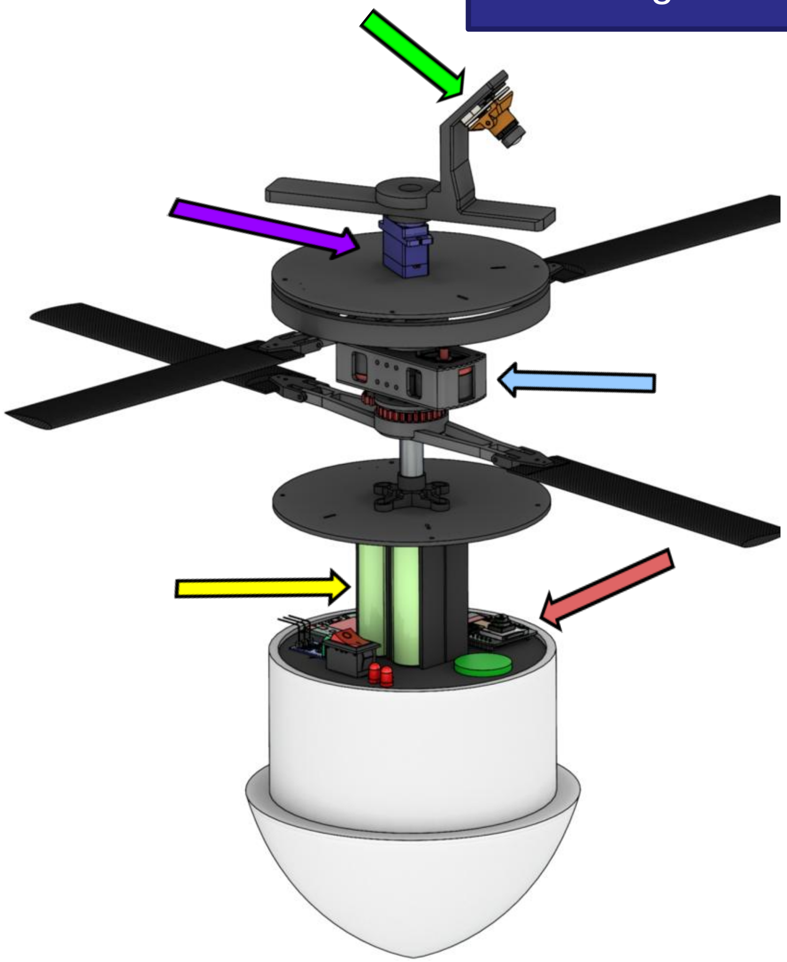
- Dc Motors location is indicated by a **blue** arrow.

- Batteries location is indicated by a **yellow** arrow.

- The camera indicated by the **red** arrow will record the deployment of the motors. Also indicated the sensors.

- The camera indicated by the **green** arrow will record the descent at an angle of 45 degrees downward from the nadir.

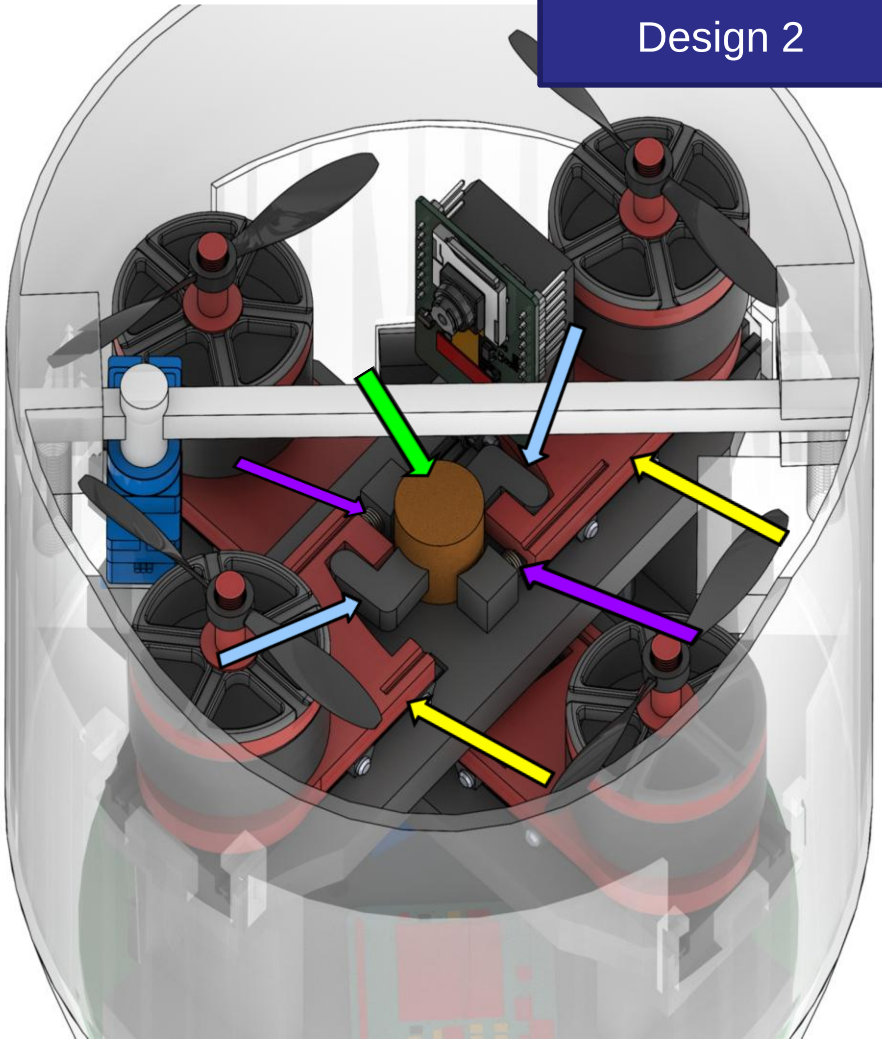
- Servo motor is indicated by a **purple** arrow.



Cansat Mechanical Layout of Components Trade & Selection (6/10)

Design 2

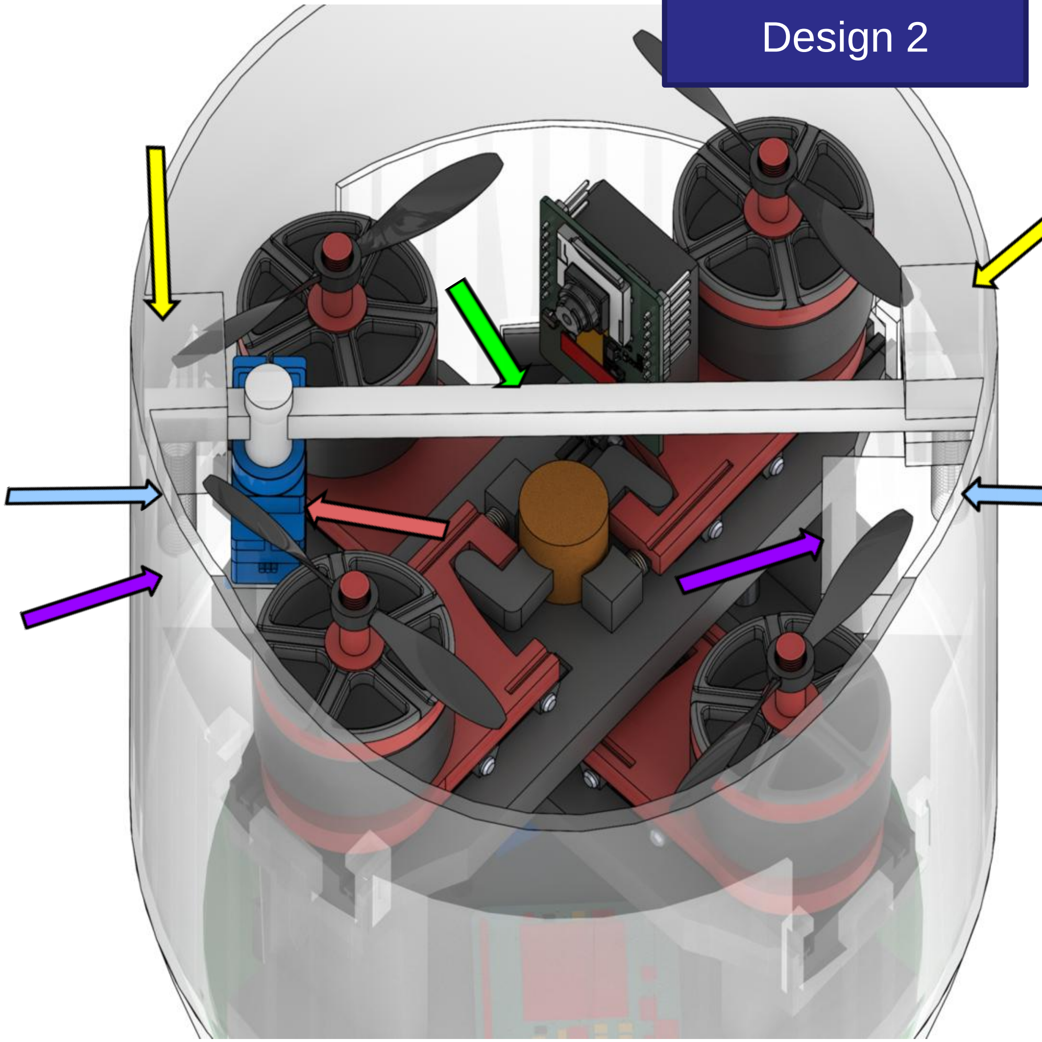
- During the initial assembly, the slides indicated by the yellow arrows are compressed by the fixed springs shown with purple arrows and locked using the mechanism indicated by the blue arrows. After the separation of the nose cone, the servo motor is activated, rotating the shaft indicated by the green arrow and releasing the locking mechanism. This allows the slides to move freely along the rail system, enabling the motors to extend outward from the shoulders of the nose cone.

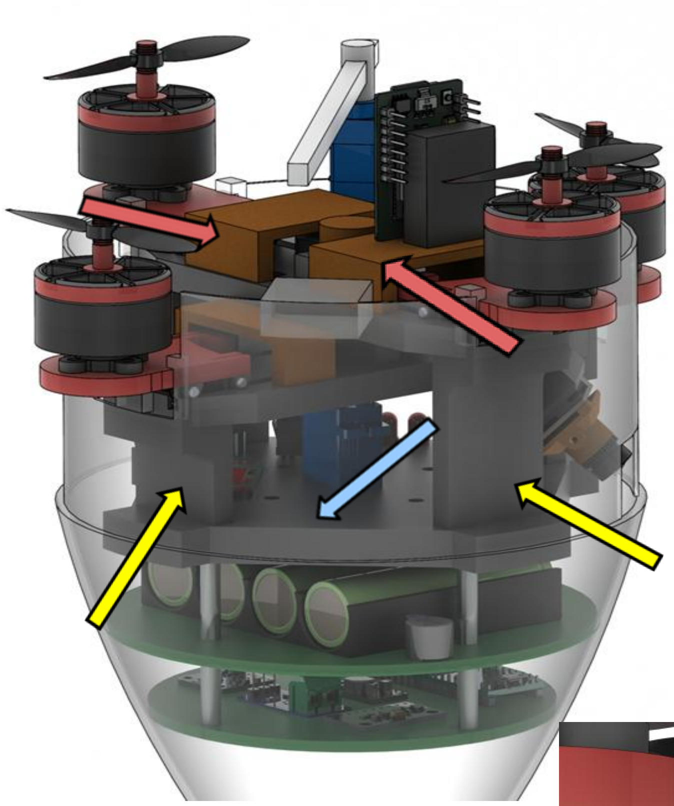


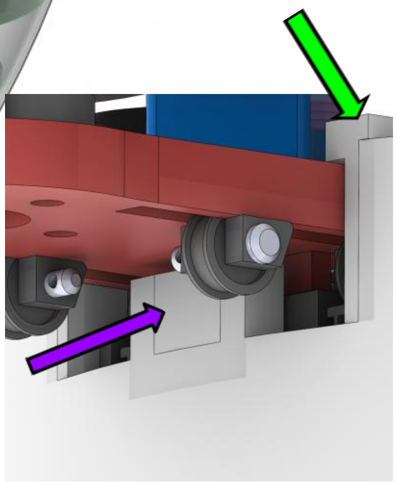
Cansat Mechanical Layout of Components Trade & Selection (7/10)

Design 2

- As the release mechanism, the spring shown by the **blue** arrow on the notched support piece indicated by the **yellow** arrow on the container is compressed during assembly with the support piece shown by the **purple** arrow on the nose cone shoulder. Afterwards, the system is locked with the servo shaft indicated by the **green** arrow. When the servo motor indicated by the **red** arrow is activated, the lock will open, and separation will occur using the spring and gravitational force.







- In the design, the rail system housing the slides is supported by columns indicated by the **yellow** arrow. Columns are fixed to the floor indicated by the **blue** arrow.
- The component indicated by the **red** arrows ensures the static stability of the motor-mounted slides and prevents them from falling during the CanSat launch phase.
- The support component indicated by the **purple** arrow prevents the slides from dropping during deployment. The parts marked by **green** arrows on the sides ensure the stabilization of the slide system while the motor is operating.

Cansat Mechanical Layout of Components Trade & Selection (9/10)

- The electronic components, including the camera, servo motor, DC motor, GPS, switch and LED, will be integrated into the shoulder section of the nose cone. Other electronic components will be embedded inside the nose cone.

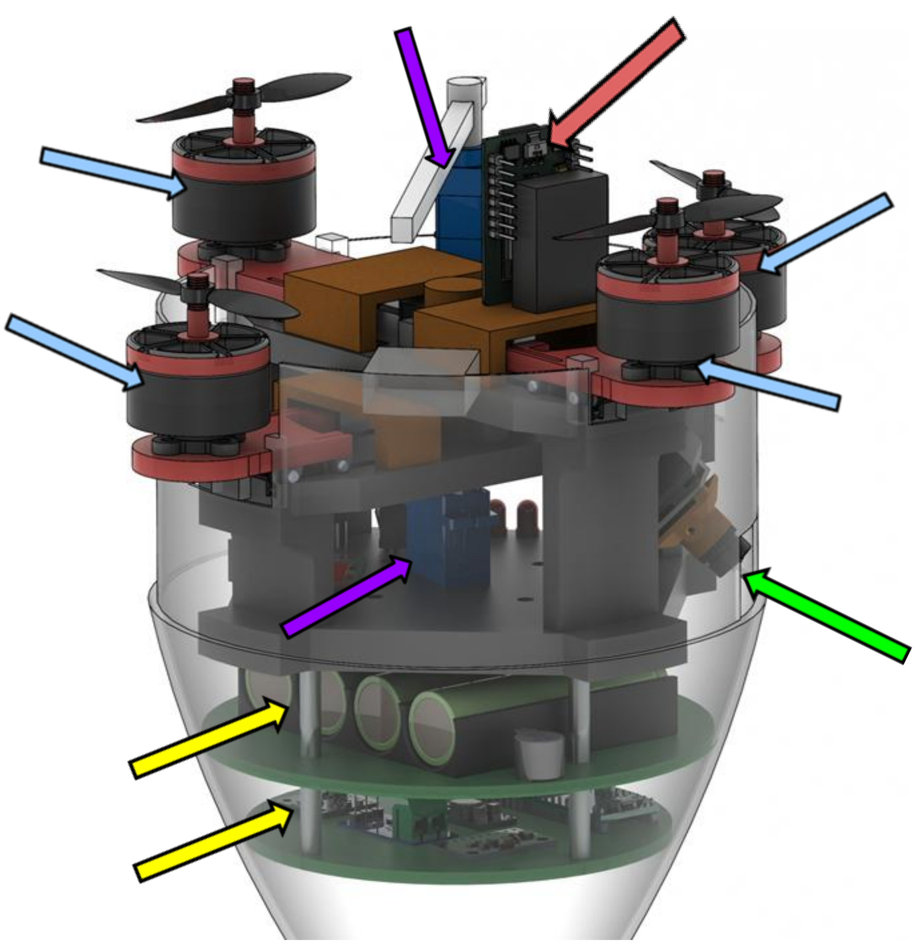
- Dc Motors location is indicated by a **blue** arrow.

- Batteries, electrical sbs. and sensors locations are indicated by a **yellow** arrow.

- The camera indicated by the **red** arrow will record the deployment of the motors.

- The camera indicated by the **green** arrow will record the descent at an angle of 45 degrees downward from the nadir.

- Servo motors is indicated by a **purple** arrow.



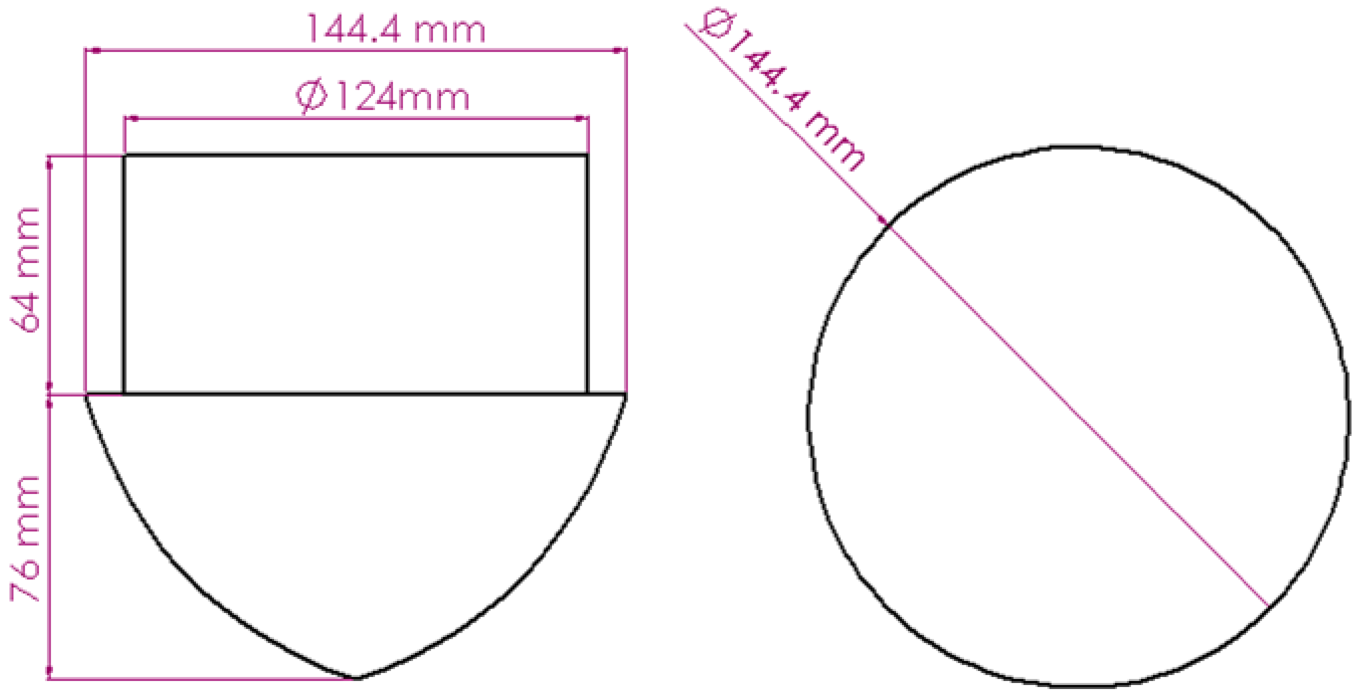
Cansat Mechanical Layout of Components Trade & Selection (10/10)

SECTION	DESIGN	RATIONALE	SELECTION
Cansat Mechanical Layout of Components	DESIGN 1	+ Easy to manufacture. + Easy to assembly. + Lighter than Design 2.(Using 2 Dc Motor and 1 Servo Motor) + Turning the camera towards the north is easier than turning the satellite itself. - Stabilization is challenging under harsh weather conditions. - The center of gravity is higher compared to the second design.	**DESIGN 1 SELECTED** Design 1 is chosed because it is lighter, easier to manufacture and assemble, and uses fewer motors, making it more efficient.
	DESIGN 2	+ Thanks to active control, it is more stable under harsh weather conditions compared to Design 1. + The center of gravity is lower compared to Design 1. - Difficult to assembly. - Heavier than Design 1.(Using 4 Dc motor and 2 Servo motor.) - With the Active Control system, turning the camera towards the north is more difficult.	

Nose Cone Design Trade & Selection (1/7)

Design 1

- The electronic components are embedded into the shoulder section of the nose cone. This ensures that the electronic components will operate smoothly, away from the vibrations and noise generated by the motors.
- The protrusions on the shoulder section of the nose cone allow for the payload to be mounted by screwing it in place.
- The nose cone is designed in a parabolic shape. In this design, the **drag coefficient ranges between 0,1 and 0,3.**

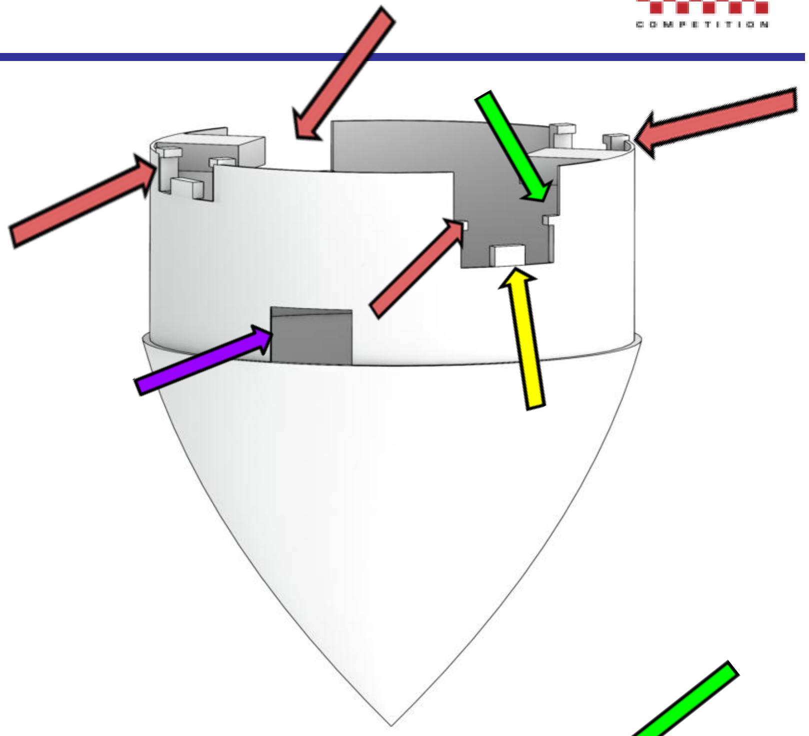


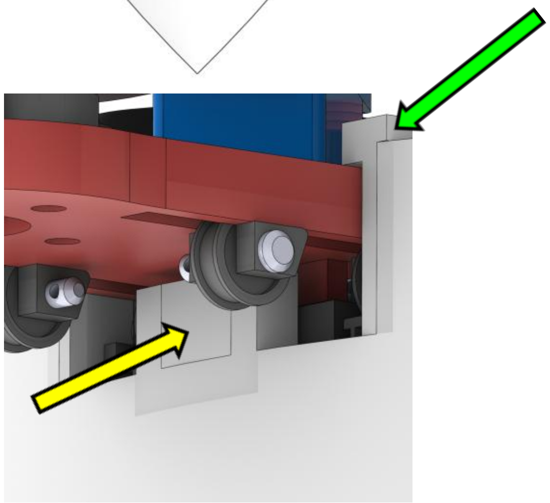
- Nose Cone technical drawing.
- Picture were drawn with CAD program
- All measure are in mm.
- Nose Cone shoulders are fit into container.

Nose Cone Design Trade & Selection (3/7)

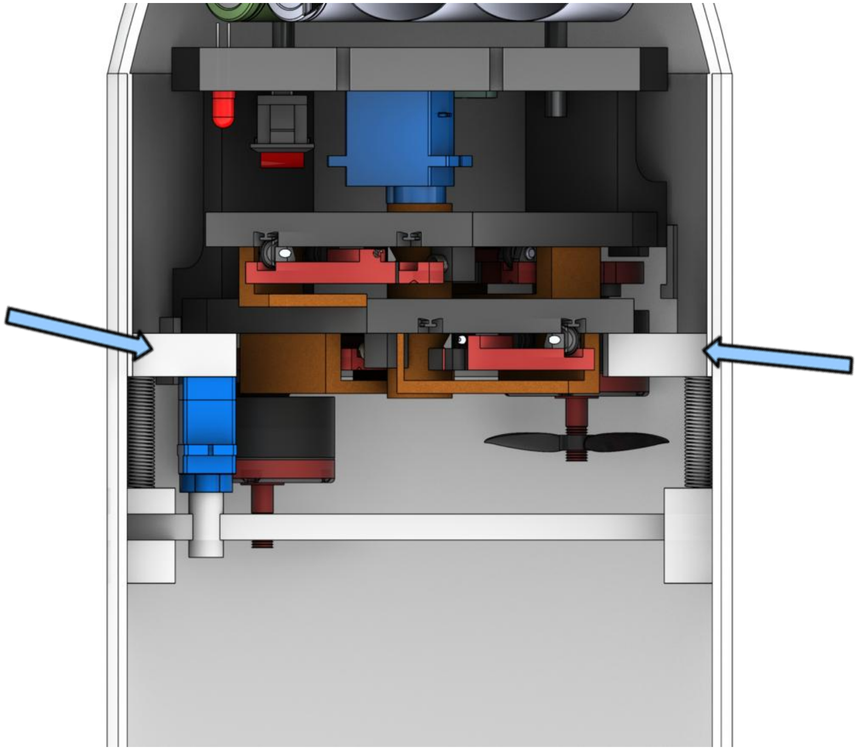
Design 2

- There are four windows on the nose cone shoulders, indicated by the **red** arrow, to allow the motor to extend outward. Additionally, a window shown with the **purple** arrow has been opened to enable the camera to capture the descent.
- At the ends of the windows, there are support components indicated by the **yellow** arrow to prevent the motors from falling during extension and support components indicated by the **green** arrow to ensure system stabilization after the motors are activated.



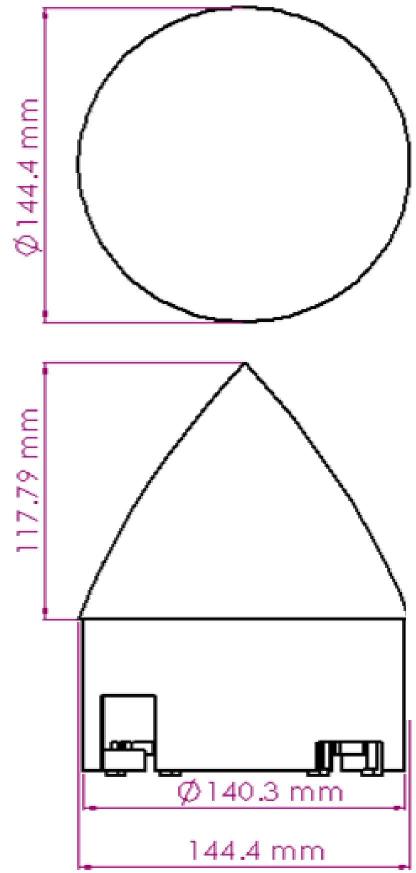


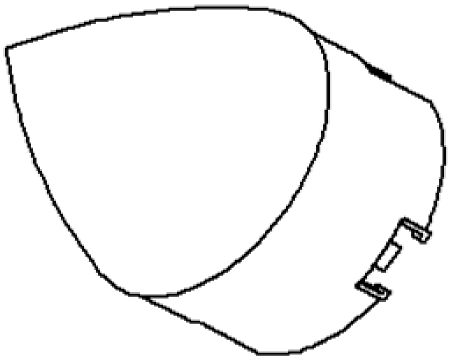
Nose Cone Design Trade & Selection (4/7)



- The support component housing the servo and servo locking system, used to compress the springs inside the container and facilitate the release of the payload, is indicated in **blue**.
- The nose cone is designed in a parabolic shape. In this design, the **drag coefficient ranges between 0.05 and 0.2.**

Nose Cone Design Trade & Selection (5/7)





- Nose Cone technical drawing.
- Picture were drawn with CAD program
- All measure are in mm.
- Nose Cone shoulders are fit into container.

Nose Cone Design Trade & Selection (6/7)

Part	Material	Density(g/cm³)	Tensile Strength (Mpa)	Resistance to temperature
Payload	PLA	1,24	110	50-60°C
	ABS	1,04	60-70	95°C

- ABS material is selected for its low density, making it suitable for our design requirements. Additionally, ABS has better heat resistance properties.

Nose Cone Design Trade & Selection (7/7)

SECTION	DESIGN	RATIONALE	SELECTION
Nose Cone Design Trade & Selection	DESIGN 1	+ Since it is smaller in volume, it is also lighter. + It's simple design makes it easier to manufacture. - The drag coefficient is higher.	**DESIGN 1 SELECTED** Design 1 is chosen because its compact design makes it lighter, easier to manufacture, and more efficient. Additionally, its simplicity ensures better practicality and reliable performance.
	DESIGN 2	+ The drag coefficient is lower. - Since the nose cone is longer, it is heavier. - Since it is more complex, it is harder to manufacture.	

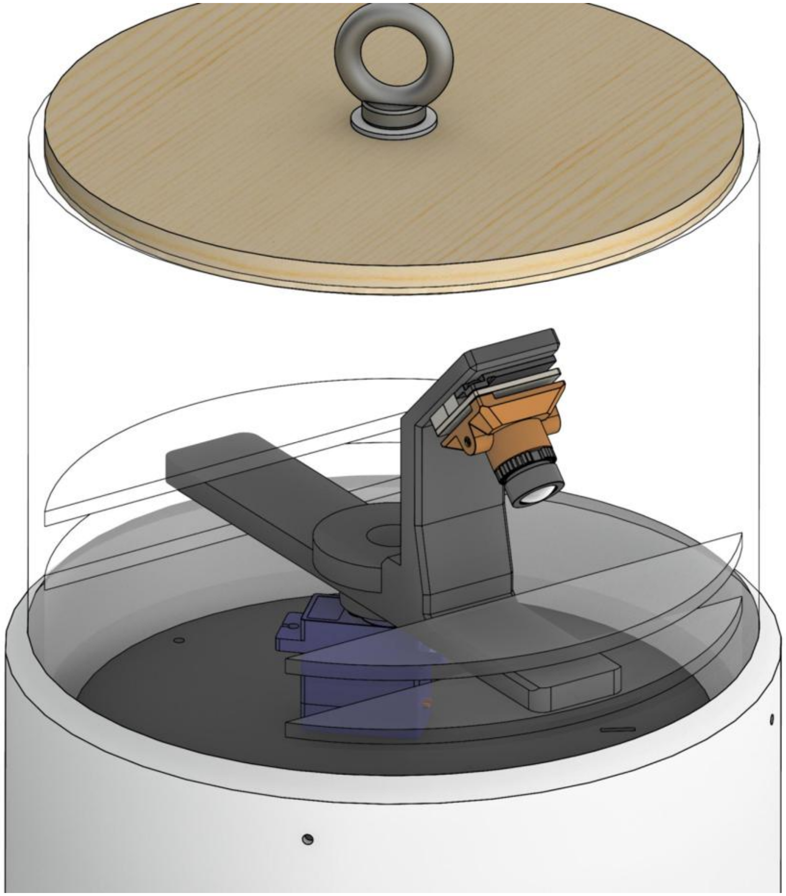
Container Design and Configuration Trade & Selection (1/7)

Design 1

- As specified in the reference container, its designed as a container and added an eyebolt. Also added support surfaces to hold the payload's locking mechanism.

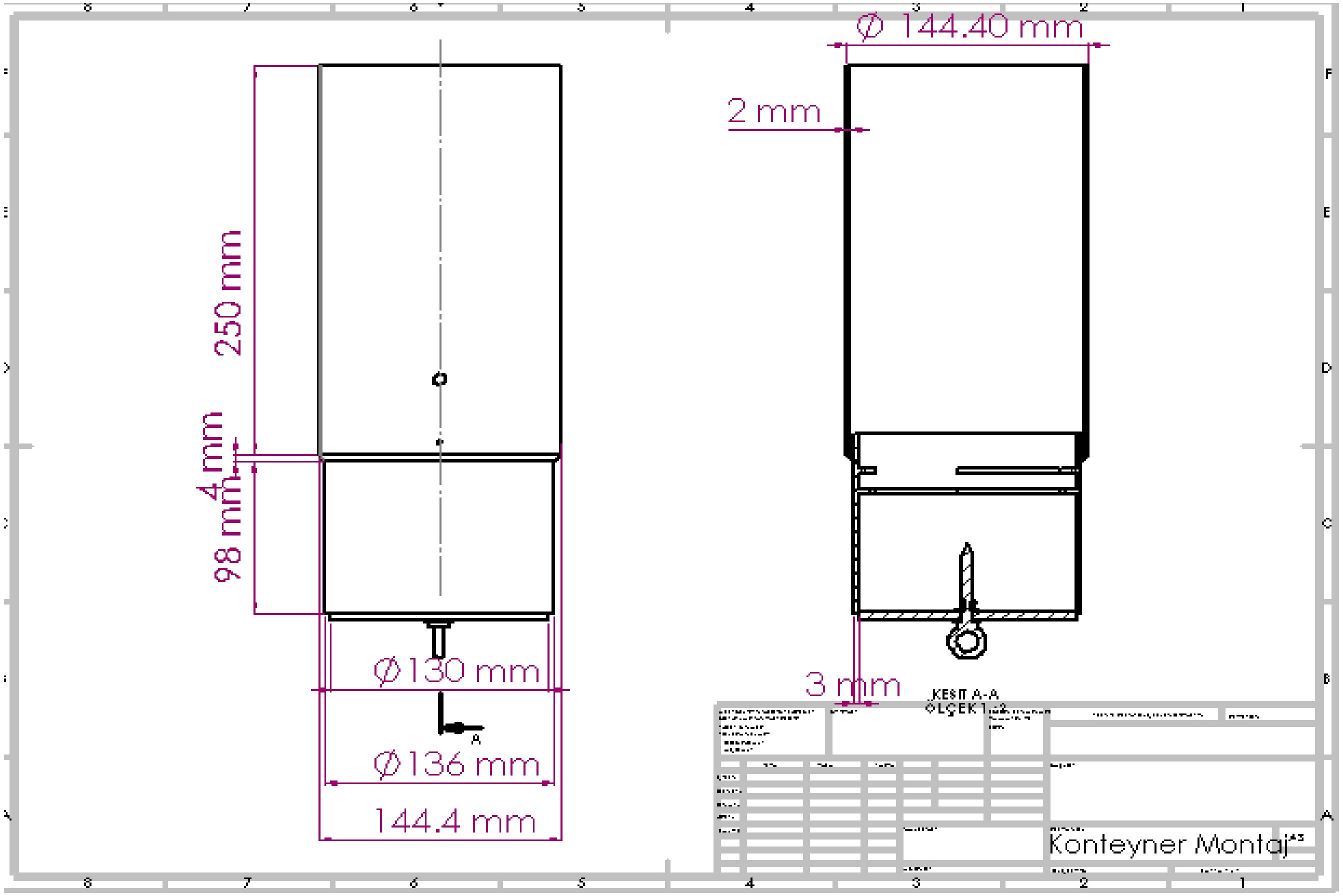
- To secure the parachute, a single eyebolt will be attached to the plywood. The assembly will include a fender washer on both the interior and exterior of the container, as well as a nylon lock nut on the inner side for enhanced stability and security.

Container Design and Configuration Trade & Selection (2/7)



- When the arms located at the top of the payload are placed into the locking slot of the container, the container will securely hold the payload.

Container Design and Configuration Trade & Selection (3/7)



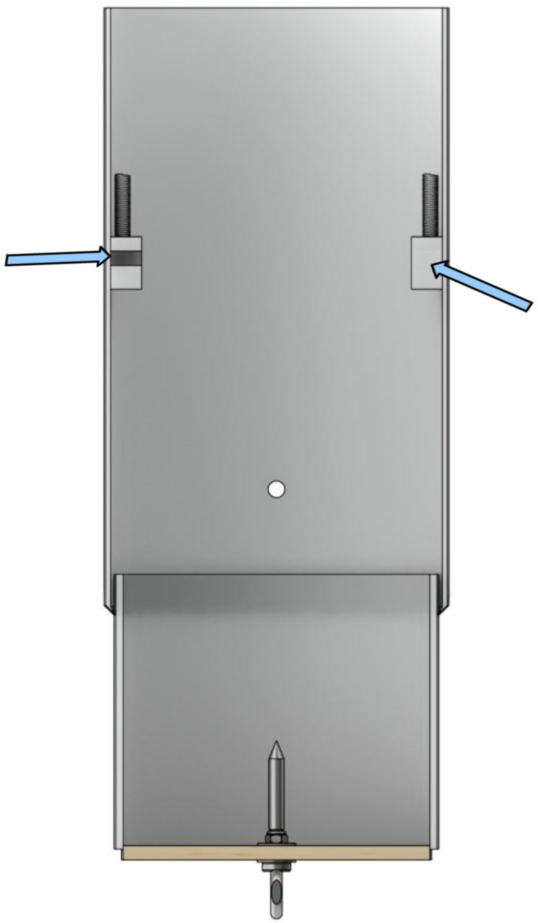
- Container technical drawing.
- Picture were drawn with CAD program
- All measure are in mm.

Container Design and Configuration Trade & Selection (4/7)

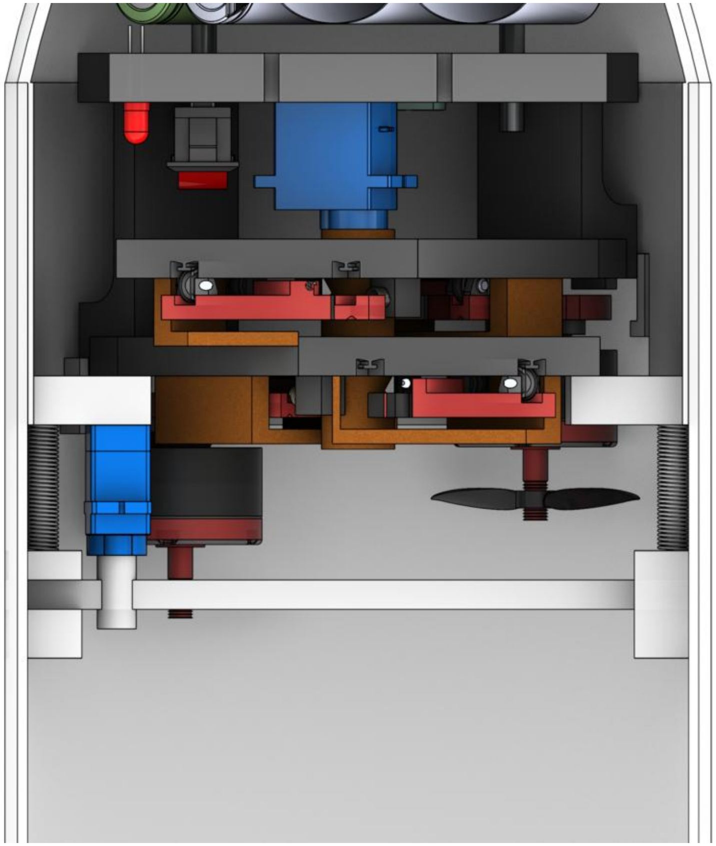
Design 2

- As specified in the reference container, its designed as a container and added an eyebolt. Also added hook-shaped support structures shown with blue arrows, with springs fixed on top, will be present.

- To secure the parachute, a single eyebolt will be attached to the plywood. The assembly will include a fender washer on both the interior and exterior of the container, as well as a nylon lock nut on the inner side for enhanced stability and security.

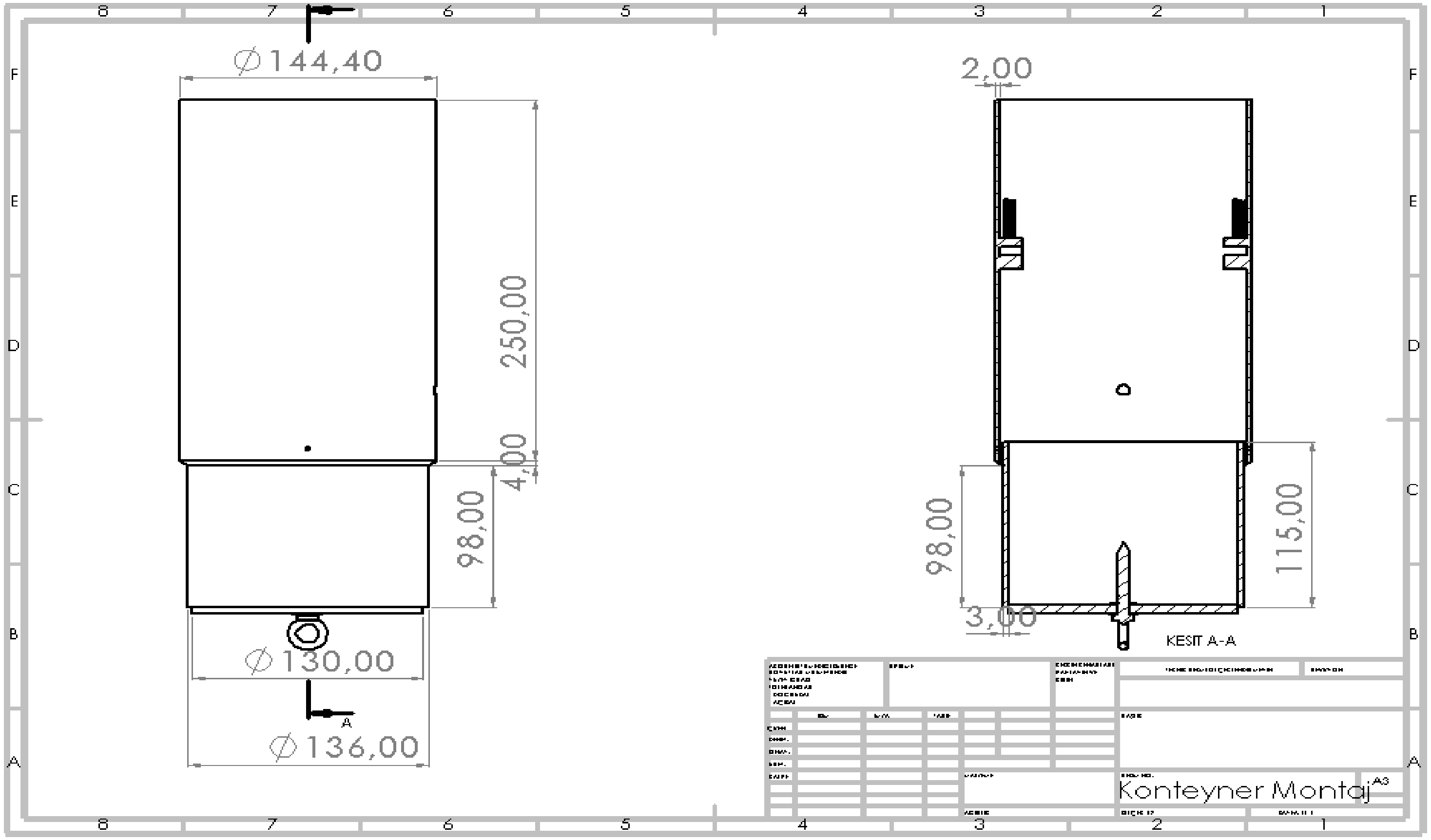


Container Design and Configuration Trade & Selection (5/7)



- During the assembly of the container and payload, the springs will be compressed, and the system will be locked by the servo-shaft located on the Nose-Cone shoulder. In this way, the container and payload will be securely locked together.

Container Design and Configuration Trade & Selection (6/7)



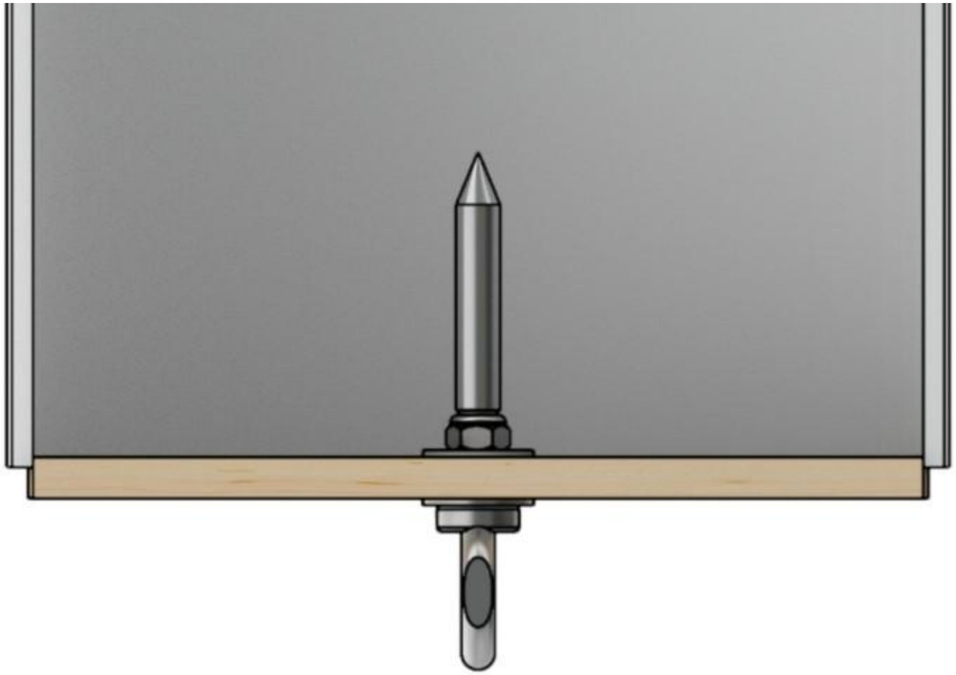
- Container technical drawing.
- Picture were drawn with CAD program
- All measure are in mm.

Container Design and Configuration Trade & Selection (7/7)

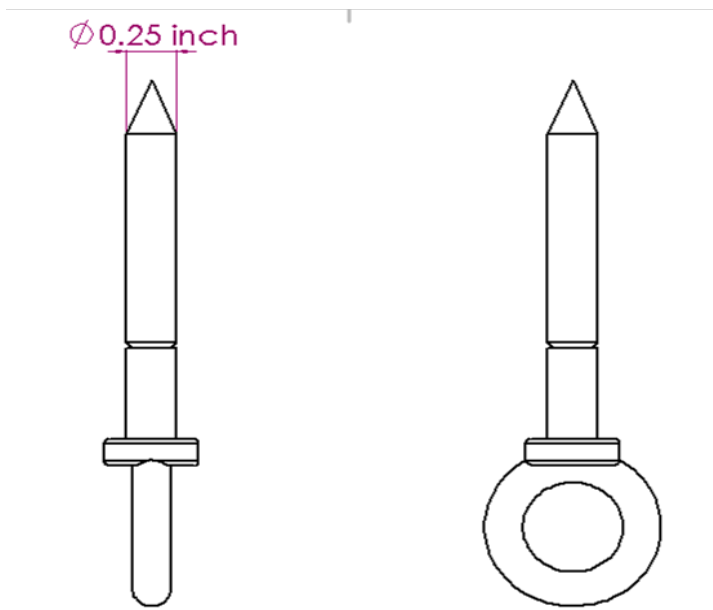
SECTION	DESIGN	RATIONALE	SELECTION
Container Design Trade & Selection	DESIGN 1	+ Easy to manufacture. + It is lighter than Design 2.	**DESIGN 1 SELECTED** It is easy to manufacture and lighter than Design 2
	DESIGN 2	+ Easy to manufacture. - It is heavier than Design 1.(Design 2 has hook-shaped supports and springs.)	

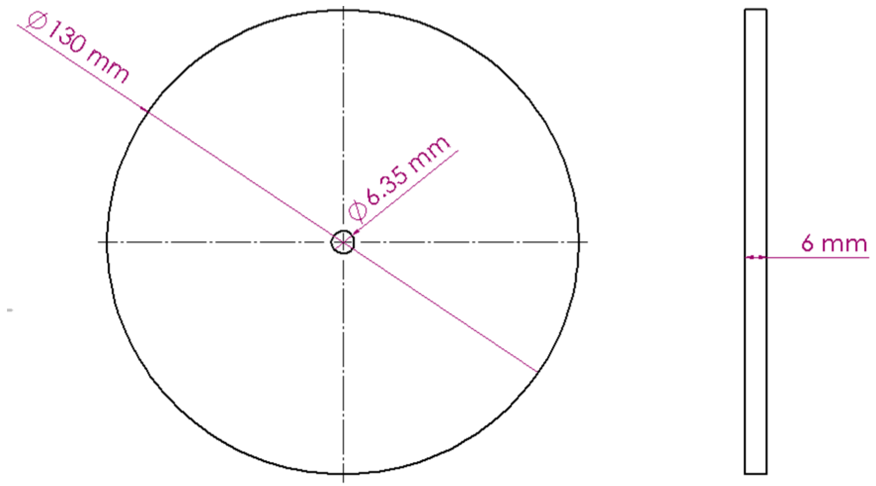
Parachute Attachment (1/2)

- To secure the parachute, a single eye bolt will be attached to the plywood. The assembly will include a fender washer on both the interior and exterior of the container, as well as a nylon lock nut on the inner side for enhanced stability and security.



Parachute Attachment (2/2)





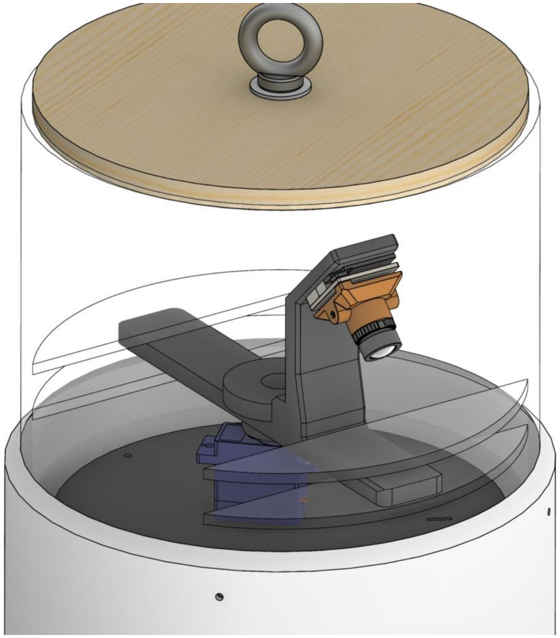
- Eyebolt technical drawing.
- Picture were drawn with CAD program.
- Measure is given inch.

- Wood Disc technical drawing.
- Picture were drawn with CAD program.
- Measure is given mm.

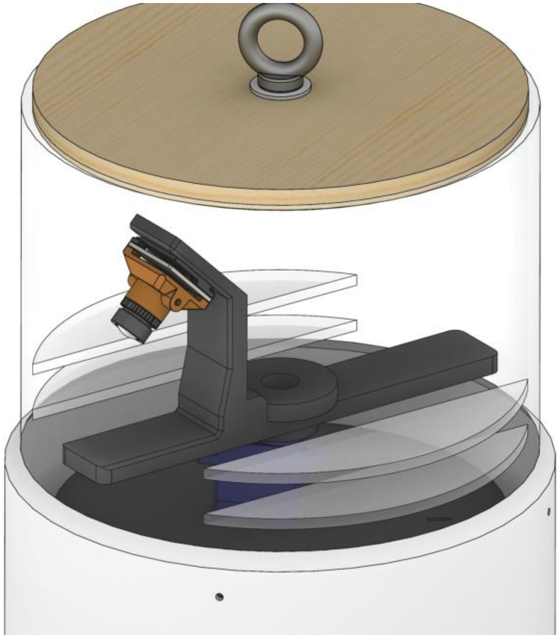
  (6.35 mm=0.25 inch)

Payload Release Trade & Selection (1/3)

Design 1



First State



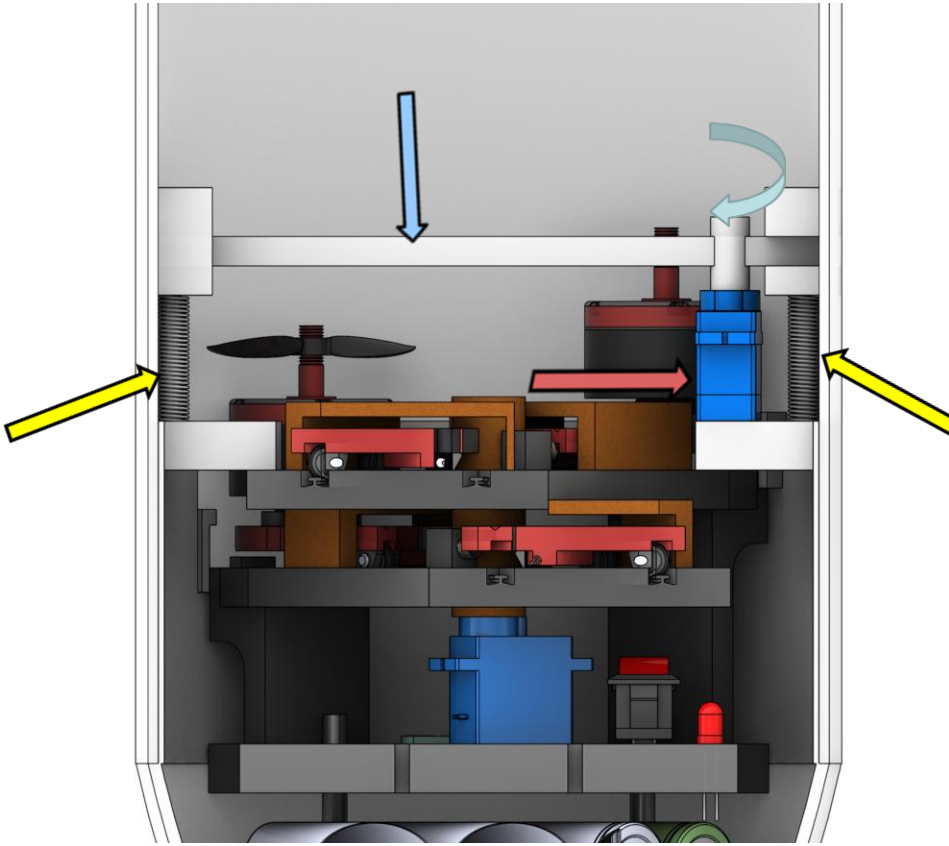
Second State

- Its designed a locking system controllable by a servo for the release mechanism. When the arms located at the top of the payload are placed into the locking slot of the container, the container will securely hold the payload.
- Once the servo operates and the arms rotate, the lock will open, allowing the payload to be released by gravity. Since the container will descend more slowly due to its parachute, the separation will occur safely.

Payload Release Trade & Selection (2/3)

Design 2

- During the assembly of the container and payload, the springs shown with the **yellow** arrow will be compressed, and the system will be locked by the servo-shaft shown with the **blue** arrow, located on the Nose-Cone shoulder. In this way, the container and payload will be securely locked together.
- When the time for release arrives, the servo motor indicated by the **red** arrows will activate, and the payload will detach from the container due to the compression force of the springs and the gravitational force.



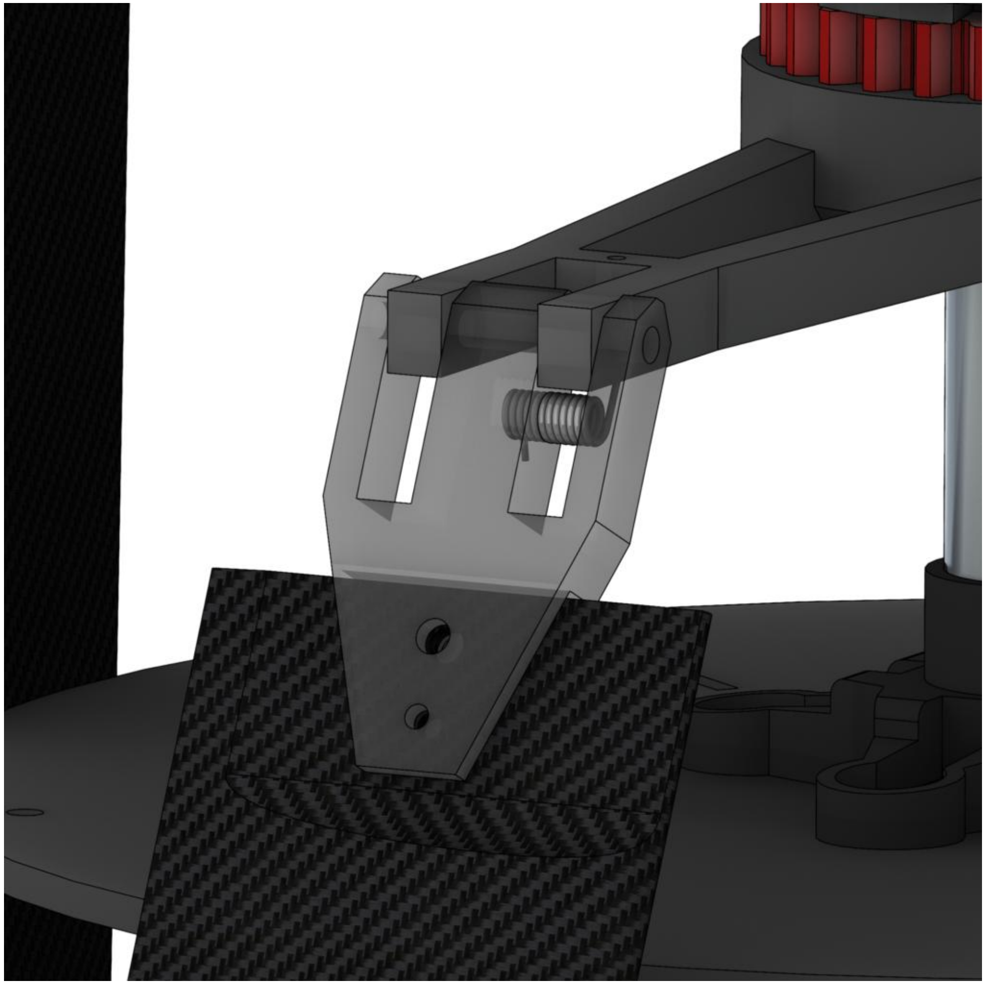
Payload Release Trade & Selection (3/3)

SECTION	DESIGN	RATIONALE	SELECTION
Payload Release Trade & Selection	DESIGN 1	+ The rod used has a greater thickness, resulting in a higher strength value. + Easy to assembly + Safer. - Since it relies solely on gravity, the release is slow.	**DESIGN 1 SELECTED** Design 1 is chosen because the thicker rod provides greater strength, making it more durable. Additionally, it is easy to assemble and offers enhanced safety.
	DESIGN 2	+ Since both spring force and gravity are used during release, the release is fast. - Since the servo motor is positioned at the edge, there is a risk of the servo shaft breaking. - Difficult to assembly.	

Auto-gyro Stow Configuration Trade & Selection (1/4)

Design 1

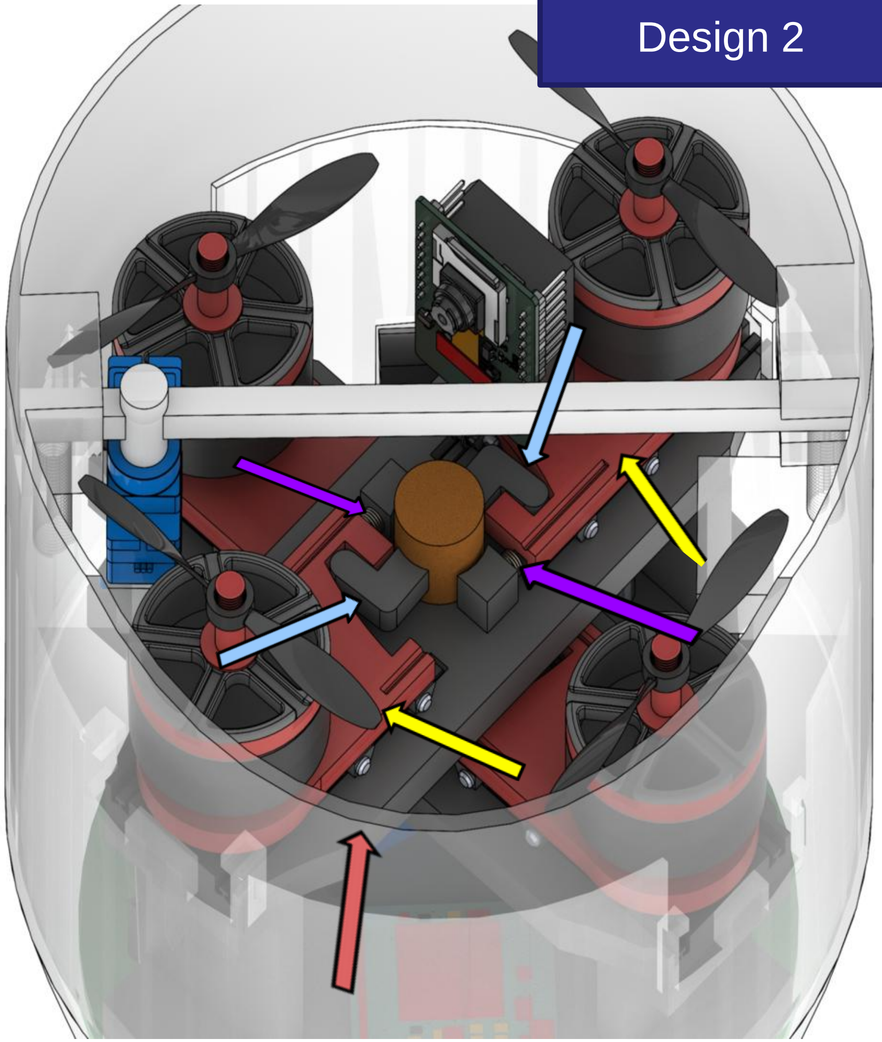
- It designed the auto-gyro blades to be foldable using springs. The container's surface will be used to keep the blades closed.
- Before placing the payload into the container, the springs will be compressed manually by closing the blades.
- The container walls will prevent the springs from opening, ensuring the blades remain closed until the payload is released.



Auto-gyro Stow Configuration Trade & Selection (2/4)

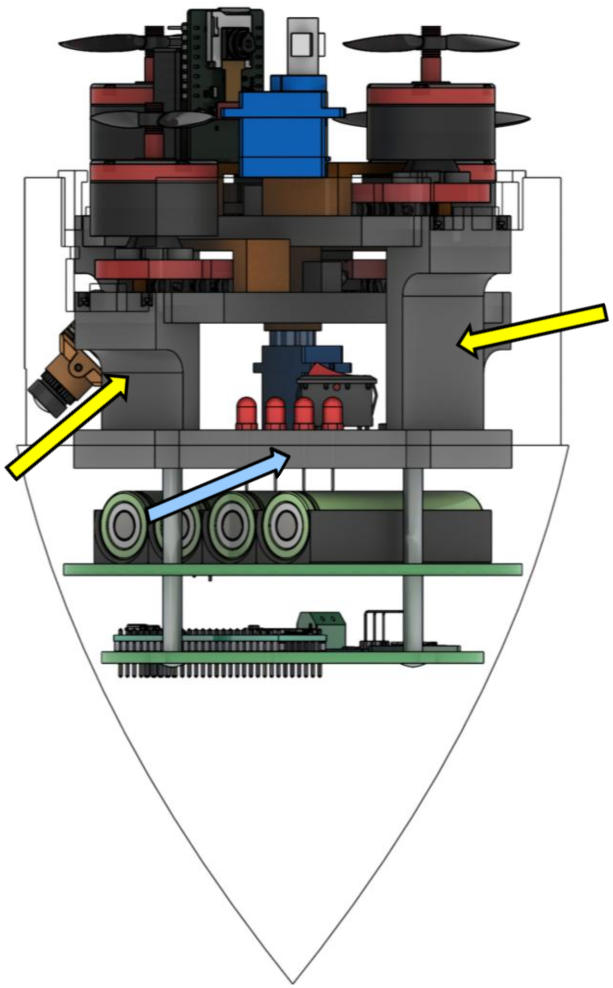
Design 2

- During the initial assembly, the slides indicated by the **yellow** arrows are compressed by the fixed springs shown with **purple** arrows and locked using the mechanism indicated by the **blue** arrows, completing the installation of the Auto-gyro system. The slides move along a rail system indicated by the **red** arrow, making their movement easier. The motor-mounted slides are arranged in a two-tier structure within the system.



Auto-gyro Stow Configuration Trade & Selection (3/4)

- In the design, the rail system housing the slides is supported by columns indicated by the **yellow** arrow. Columns are fixed to the floor indicated by the **blue** arrow.
- The floor is fixed to the Nose-Cone, ensuring the entire system remains statically balanced during flight and before payload separation.
- The motor-mounted slides are arranged in a two-tier structure within the system.



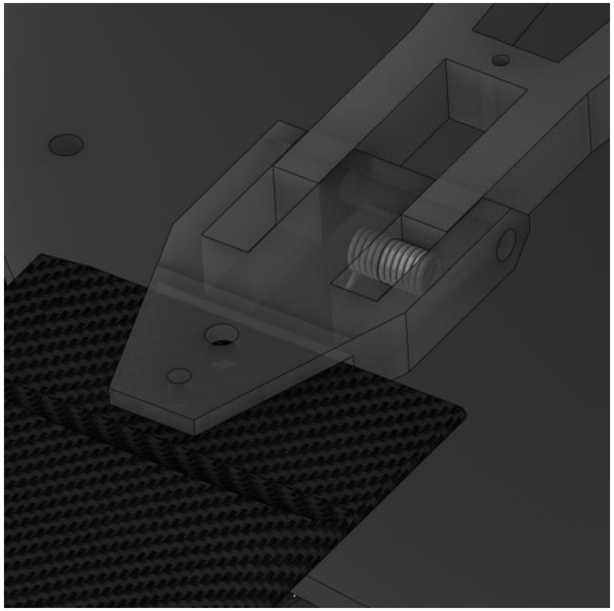
Auto-gyro Stow Configuration Trade & Selection (4/4)

SECTION	DESIGN	RATIONALE	SELECTION
Auto-gyro Stow Configuration Trade & Selection	DESIGN 1	+ The mechanism is simpler. + Easy to assembly. + It is lighter. - Since the wings rest against the container wall, there is a risk of breaking.	**DESIGN 1 SELECTED** Design 1 is chosen because it's simpler mechanism ensures ease of use, it is straightforward to assemble, and its lighter weight enhances efficiency.
	DESIGN 2	+ A more compact and secure mechanism. - A heavier and more complex system. - Difficult to assembly.	

Auto-gyro Deployment Configuration Trade & Selection (1/4)

Design 1

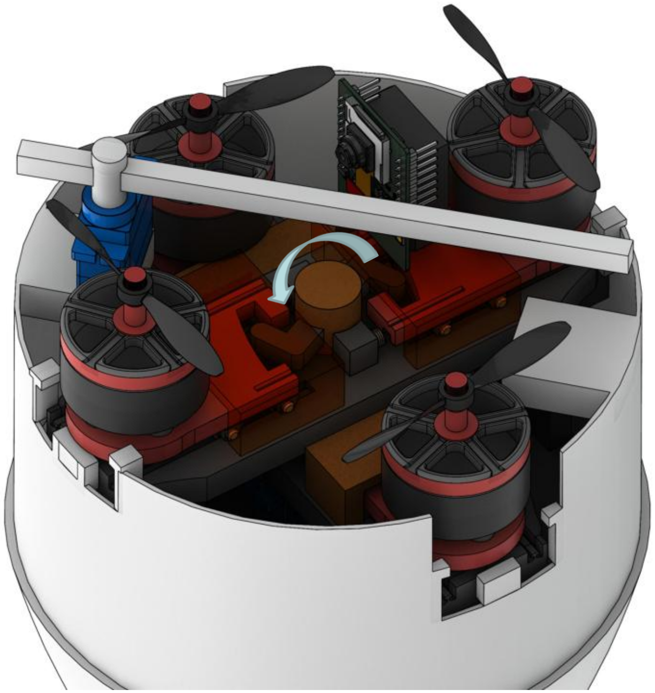
- When the container releases the payload, the auto-gyro blades will be freed and will deploy into an open position thanks to the springs.
- The limiters on the blade holders will prevent the blades from opening beyond the desired angle.



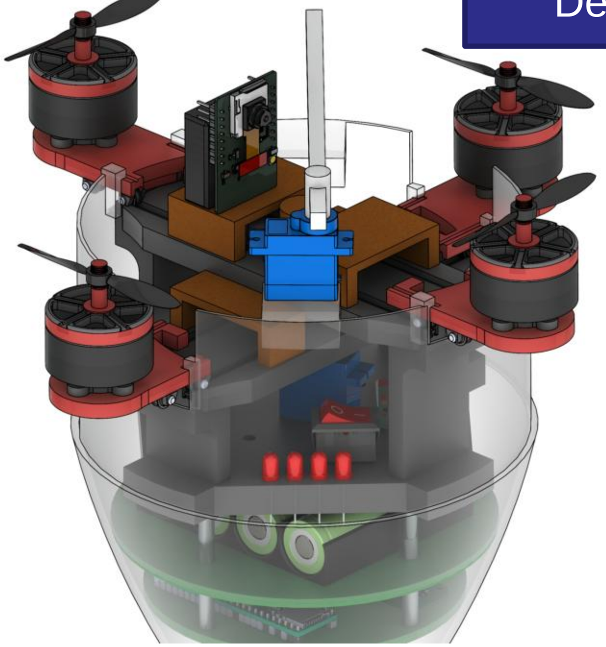
Auto-gyro Deployment Configuration Trade & Selection (2/4)

- The payload release process will occur rapidly under the influence of gravity and spring force. During this process, the servo motor located on the ground floor will be activated, and the rotational movement of the shaft connected to the servo will unlock the locking mechanism. Once the lock is released, the spring force will propel the motor-carrying slides to move along the rail system.

Design 2



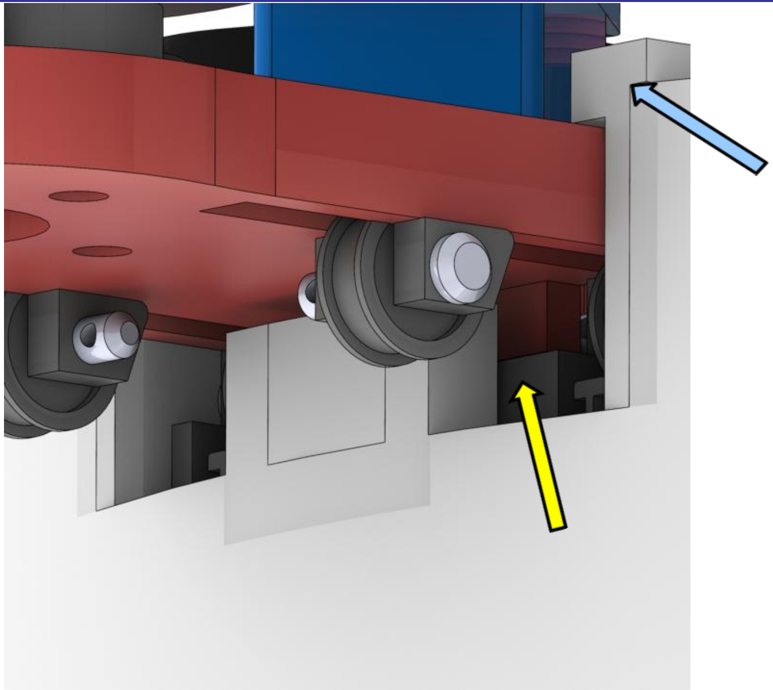
When the mechanism is opening

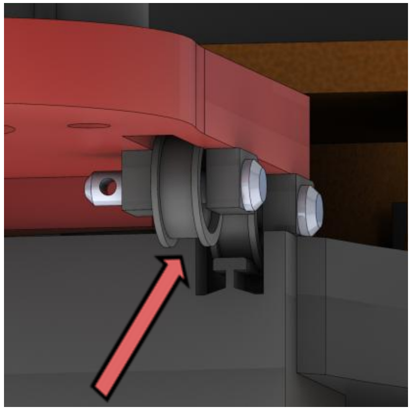


Unlocked Mechanism

Auto-gyro Deployment Configuration Trade & Selection (3/4)

- As the slides moves, it will extend outward from the shoulder of the Nose Cone, reaching the designated position. A support component integrated under the slides will contact a stop piece located at the Nose Cone's shoulder, bringing the mechanism to a halt and preventing the slides from falling downward. (Indeed **yellow** arrow)
- Additionally, components positioned at the end sections of the cuts on the Nose Cone shoulder will ensure that the slides remains stationary while the motor operates. This design ensures the system functions safely and in a controlled manner. (Indeed **blue** arrow)
- The rail system and the wheel are shown with a **red** arrow.





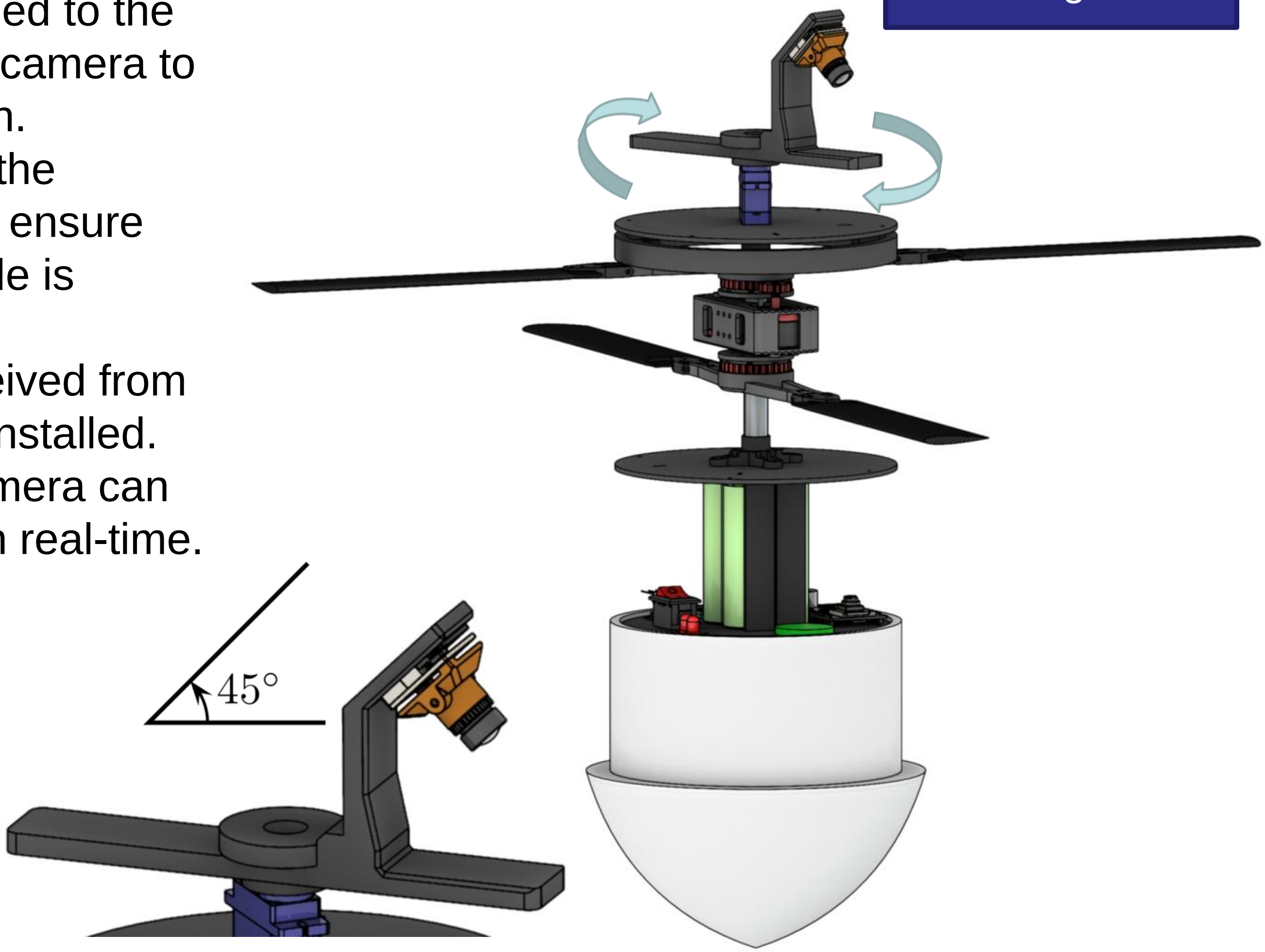
Auto-gyro Deployment Configuration Trade & Selection (4/4)

SECTION	DESIGN	RATIONALE	SELECTION
Auto-gyro Deployment Configuration Trade & Selection	DESIGN 1	+ The wings will open more quickly. + When the motor starts, there is no possibility of the wings closing again due to centrifugal force. + It is lighter than Design 2 (Design 2 uses a servo motor to deploy the auto-gyro) - Since the wings rest against the container wall, there is a risk of breaking.	**DESIGN 1 SELECTED** This design is chosen for its quicker wing deployment, prevention of retraction due to centrifugal force, and lighter design compared to Design 2.
	DESIGN 2	- A heavier and more complex system. - There is a possibility that the slides may get stuck while opening.	

Ground Pointing and Orientation Trade & Selection (1/4)

Design 1

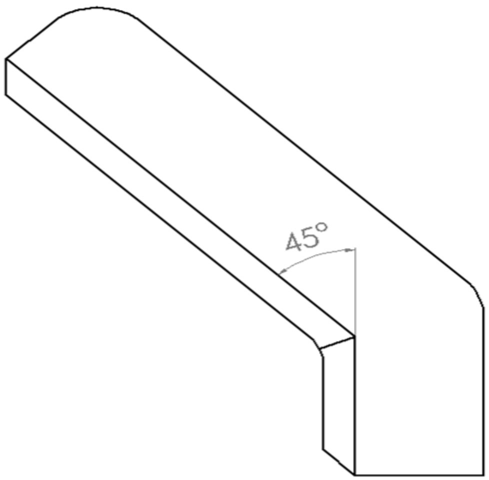
- The servo motor attached to the camera will enable the camera to rotate towards the north.
- The structure to which the camera is mounted will ensure that the 45-degree angle is maintained fixed.
- Based on the data received from the sensors that have installed. The direction of the camera can be actively controlled in real-time.

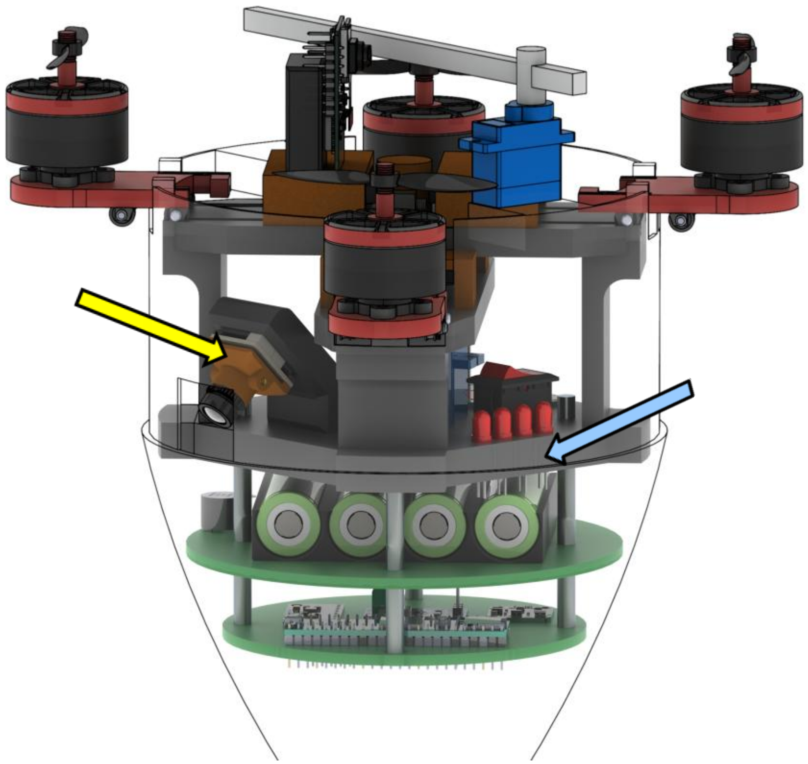


Ground Pointing and Orientation Trade & Selection (2/4)

Design 2

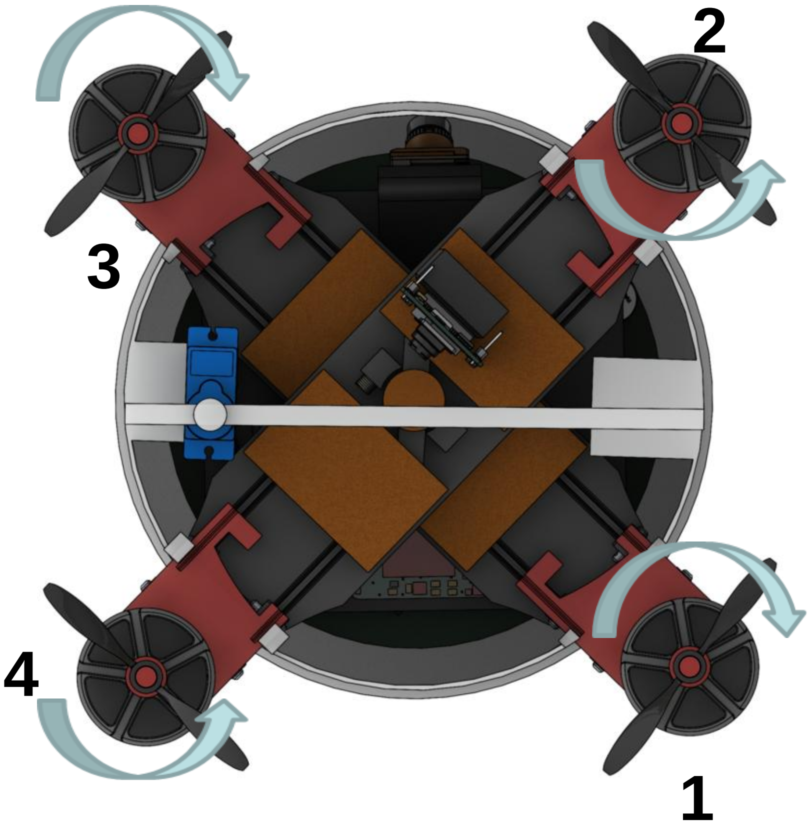
- The camera, indicated by the **yellow** arrow, will be mounted on a platform angled 45 degrees downward from the nadir. The platform will be securely fixed to the ground, as marked by the **blue** arrow.
- The camera will record the descent through a window opened at the Nose Cone shoulder.





Ground Pointing and Orientation Trade & Selection (3/4)

- When the motors are activated, motors 1 and 3 will rotate clockwise, while motors 2 and 4 will rotate counterclockwise. Based on data received from the GPS, the speeds of motors 1 and 3 will be increased to rotate the payload counterclockwise, aligning it toward the north. Once this maneuver is completed, the speeds of all motors will be equalized to restore stabilization.



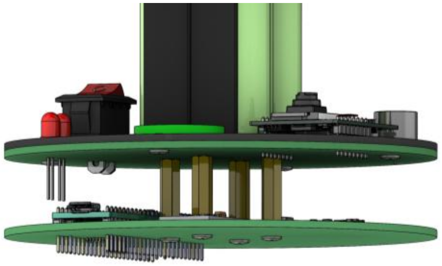
Ground Pointing and Orientation Trade & Selection (4/4)

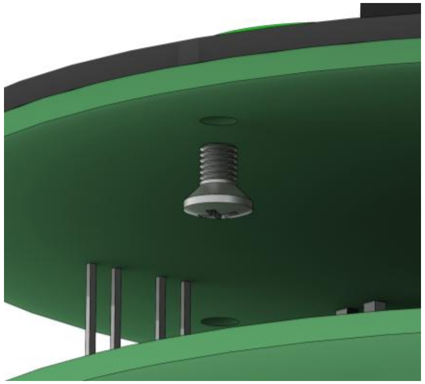
SECTION	DESIGN	RATIONALE	SELECTION
Ground Pointing and Orientation Trade & Selection	DESİGN 1	+ Rotating the camera is easier. + The camera will rotate more quickly. + It is more ergonomic as it uses the same servo motor as the separation mechanism.	**DESİGN 1 SELECTED** This design is chosen because rotating the camera is easier and faster. Additionally, it is more ergonomic, as it uses the same servo motor as the release mechanism.
	DESİGN 2	+ The footage captured is clearer compared to Design 1. - The camera will rotate is slowly.	

Electronics Structural Integrity

The designed PCB circuit board will be placed on the shoulder of the CanSat.

- All components are selected as through-hole mounting and will be soldered to the PCB board, thus ensuring the stability of the sensors and components.
- Mounting holes are added to the PCB.
- The circuit board will consist of 2 layers and will be fixed to each other with spacers and screws.
- Screws and anti-vibration elastic materials will be used for mounting the circuit board to the canSat.
- Connectors will be used for the cables coming out of the circuit board and the durability will be increased by using multi-wire cables.
- The batteries will be placed in a springless battery holder and will be attached with a zip tie.
- The battery holders will be glued with hot silicone and fixed.
- The components will be fixed with tape after they are placed.





Mass Budget (1/4)

Component	Subsystem	Location	Quantity	Mass [g]	Source	Uncertainties
Voltage Regulator	EPS	Payload	x1	2	CAD Estimation	±0.5g
Coin Cell	EPS	Payload	x2	1	CAD Estimation	±0.5 g
DC Motor	Mechanical	Payload	x2	40	Datasheet	±2 g
Motor Driver	Mechanical	Payload	x2	38	Datasheet	± 0.5
Switch	EPS	Payload	x1	2	CAD Estimation	±0.4 g
Springless Slot Battery Holder	EPS	Payload	x4	36	Datasheet	±3.6 g
Jumper cables	EPS	Payload	x20	9	Measurement	±1 g
WRL-09143	CDH	Payload	x1	16	Data Sheet	±5 g
Dvr module	Sensor	Payload	x1	3.5	Data Sheet	±0.5g
Xbee Explorer	CDH	Payload	x1	10	Data Sheet	±2 g
PCB card	EPS	Payload	x3	45	Estimation	±3 g
Servo motor	Mechanical	Payload	X1	9	Datasheet	±1 g
Buzzer	Sensor	Payload	x1	2	Measurement	±1 g
Rotor	Mechanical	Payload	x1	42	CAD estimation	±0.2 g

Mass Budget (2/4)

Component	Subsystem	Location	Quantity	Mass [g]	Source	Uncertainties
BME280	Sensor	Payload	x1	14	Measurement	±1 g
MPU9255	Sensor	Payload	x2	4	Measurement	±2 g
SparkFun NEO-M9N	Sensor	Payload	x1	11	Measurement	±1.3 g
Teensy 4.1	CDH	Payload	x1	8	Measurement	±1 g
Xbee S3B	CDH	Payload	x1	5	Data Sheet	±1 g
B19 1500 TVL 2.1mm FPV Cam	Sensor	Payload	x1	6	Data Sheet	±1.2 g
ESP32-CAM	Sensor	Payload	x1	10	Data Sheet	±2 g
Voltage Sensor	Sensor	Payload	x1	4	Data Sheet	±0.8 g
Molicel INR21700-P45B	EPS	Payload	x4	68	Measurement	±3 g
SD Card	CDH	Payload	x2	1	Measurement	±1 g
Container	Mechanical	Container	x1	270	Measurement	±0.5 g
Container plywood	Mechanical	Container	x1	30	CAD Estimation	±2 g
Eyebolt	Mechanical	Container	x1	27	Measurement	±1 g
Motor compartment	Mechanical	Payload	x1	14	CAD Estimation	±0.15 g

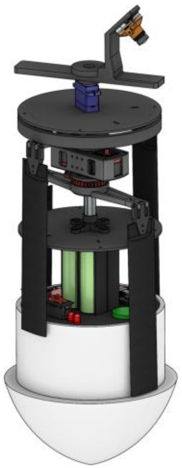
Mass Budget (3/4)

Component	Subsystem	Location	Quantity	Mass [g]	Source	Uncertainties
Blade Holder	Mechanical	Payload	x4	4	CAD Estimation	±0.1 g
Mil Holder	Mechanical	Payload	x2	4.44	CAD Estimation	±0.1 g
Aluminum Tube	Mechanical	Payload	x1	13.60	CAD Estimation	±2 g
Rotational Cam Holder	Mechanical	Payload	x1	10	CAD Estimation	±1 g
Nose Cone	Mechanical	Payload	x1	140	CAD Estimation	±2 g
Gears	Mechanical	Payload	x4	4	CAD Estimation	±0.1 g
Blades	Mechanical	Payload	x4	64	Datasheet	±1 g
Container Parachute	Mechanical	Container	x1	40	Measurement	±2 g
Assembly materials	Mechanical	Payload	-	240	Estimation	±23 g
Total Mass				1247.5		±70.5

The total weight of the CanSat is 1318 grams.

The margin of the CanSat is 82 grams.

Mass Budget (4/4)



- The weights of the assembly components will use in the manufacturing process (such as screws, nuts, bolts, solder, cables, quick adhesives, parachute cords, etc.) are uncertain.
- Due to CANSAT mission guide, our mass is below requirement. It designed this on purpose. The **remaining 82 grams of margin will be used to strenghten the satellite and for any possible uncertainty excess.**

The total weight of the CanSat is 1318 grams.

The total weight of the Payload is 951 grams.

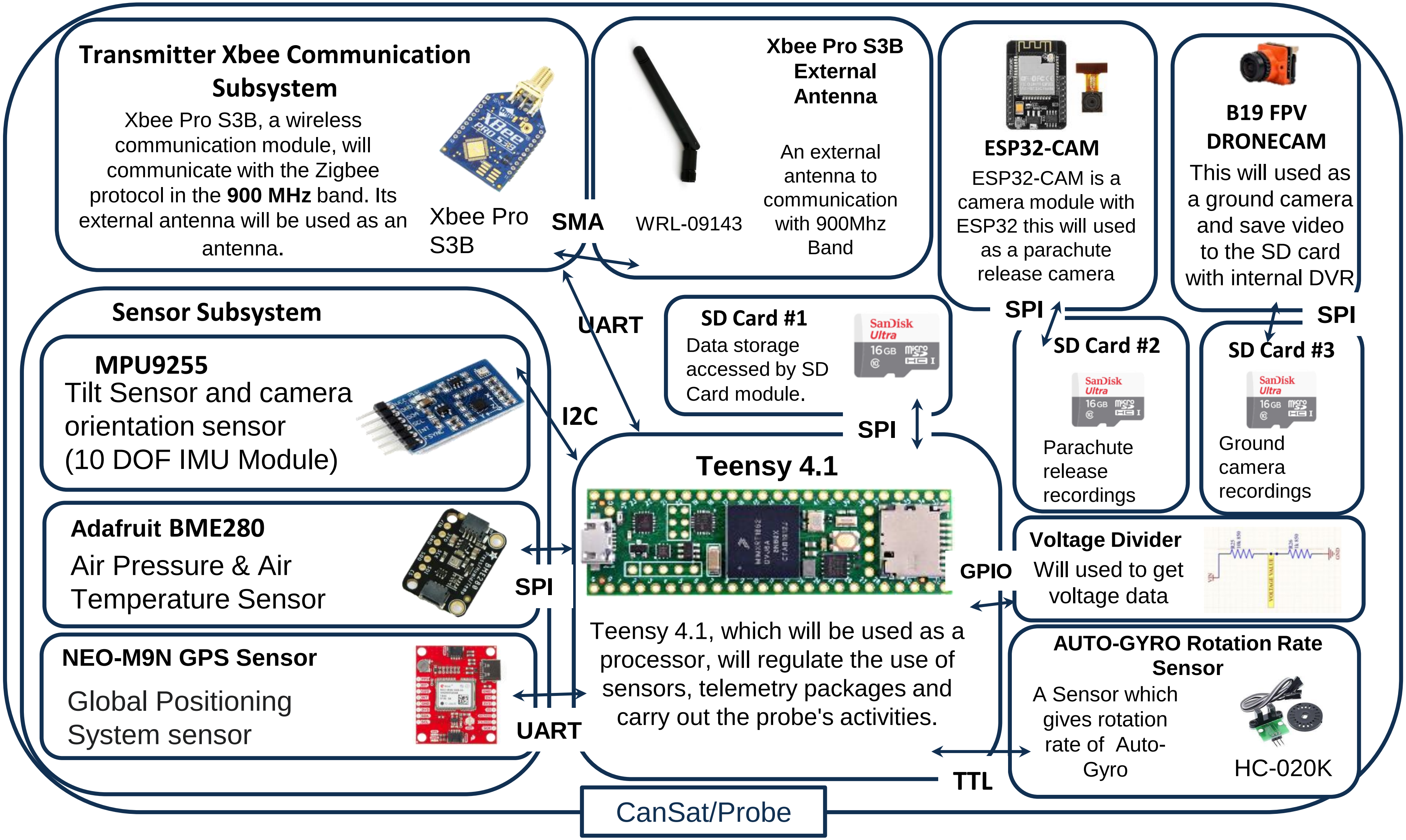
- ➢ Mass requirement: The total mass of CanSat shall be 1400 grams ±10 grams.
- ➢ Our design's estimated mass: 1318 grams
- ➢ It can be achieve the necessary weight reduction by changing the material, type, and quantity of the assembly components in case of potential weight issues.

✓ Mass budget meets the requirement.

Communication and Data Handling (CDH) Subsystem Design

Muhammet Akın OZEL

Payload Command Data Handler (CDH) Overview



Payload Processor & Memory Trade & Selection (1/2)

Model	Boot Time (s)	Processor Speed (MHz)	Operating Voltages (V)	Data Interface (Types & Number)		Memory Storage	Cost $
STM32 F103 C8T6 Blue Pill	5	72	3.3	PWM Pin (35) Digital Pin(37)	Serial Pin (8) SPI Pin (3) I2C Pin (2)	Flash 8092 Ram 1024	4.47
Teensy 4.1	**0.005**	**600**	**3.3-5**	**Digital Pin (55) PWM Pin(35)**	**Serial Pin (8) SPI Pin (3) I2C Pin (3)**	**EEPROM 4284Kb Flash 8Mb RAM 1Mb**	**31.50**
Teensy 3.6	0.005	180	3.3-5	Digital Pin(62) PWM Pin(22)	Serial Pin (6) SPI Pin (3) I2C Pin (4)	EEPROM 4Kb Flash 1Mb RAM 256Kb	29.25

Selected Processor	Selection Reasons
Teensy 4.1 	• Faster than other alternatives • Increased memory size • Total number of pins/ports meeting the need • Easy and understandable programming interface • Small footprint, not burdening the mass budget in terms of weight

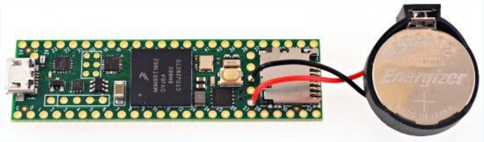
Payload Processor & Memory Trade & Selection (2/2)

Model	Memory	Interface	Data Transfer Rate		Cost $
			Write (MB/s)	Read (MB/s)	
SanDisk Ultra MicroSDHC	**16 GB**	**SPI and SD**	**98**	**98**	**4.20**
SanDisk Extreme Pro	32 GB	SPI and SD	170	90	13
Kingston MicroSDHC	16 GB	SPI and SD	10	45	8

Selected Memory Reader/Writer	Selection Reasons
SanDisk Ultra MicroSDHC 16GB 	• Cheaper, Faster Read/Write speed than alternatives • Sufficient storage for the mission

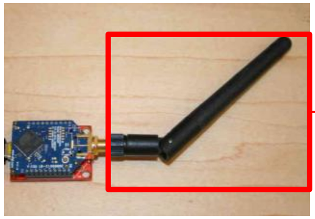
Payload Real-Time Clock

Model	Operating Voltage	Size(mm)	Weight(g)	Reset Tolerance	Interface	Cost $
Built in Teensy RTC	3.3	Included in the microcontroller		In reset conditions, software reads the last data from the EEPROM or flash	UART	0
Adafruit PCF8523 Real Time Clock	3.3-5	25.5 x 21.7 x 4.8	1.2	In reset conditions external clock continues to keep time	I2C	6.95

Selected Real–Time Clock	Selection Reasons
Built in Teensy RTC 	• Minimum area coverage • Free • Easy to use

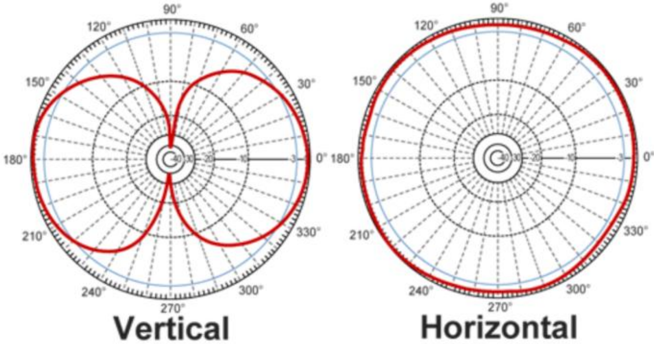
Payload Antenna Trade & Selection

Model	Connection Type	Frequency	Direction	Gain	Range (open space)	Cost $
WRL-09143	**SMA**	**900MHz**	**Omni-directional**	**2dBi**	**500m-1500m**	**9**
PYLON FXUB85	SMA	900MHz	Omni-directional	2.1 dBi	500m-1000m	10



WRL-09143 will connect here

Selected Model	Selection Reasons
WRL-09143 	• Meeting the spacing requirements needed • Saves mass and financial budget • Better range at open space



Radiation Patterns of Rubber Duck Antenna

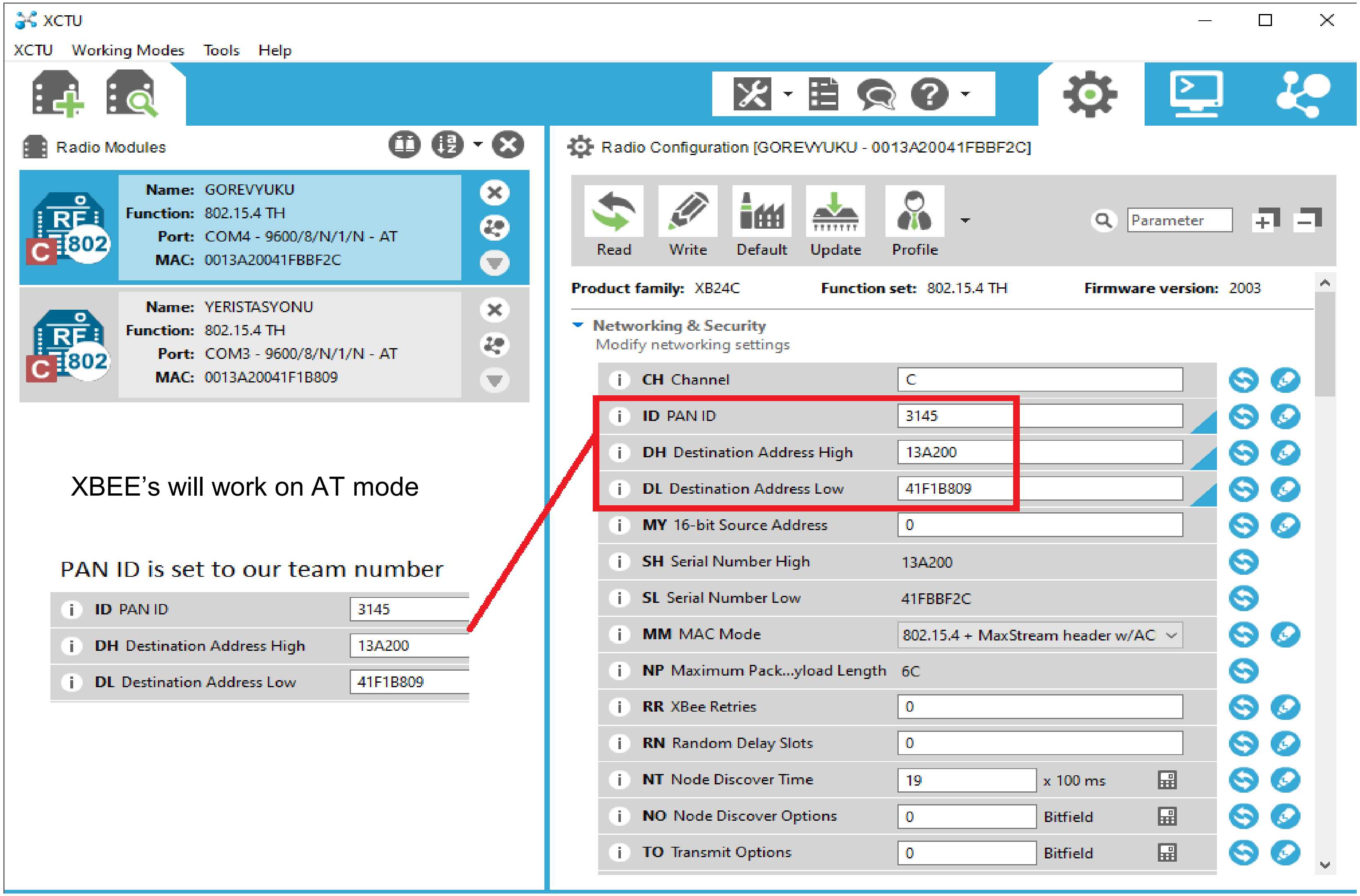
Payload Radio Configuration (1/3)

Radio Selection	Frequency	Transmit Power / Gain	Indoor Range	Outdoor Range
Xbee pro S3B	**900MHz**	**20 dBm/4dBi**	**390 ft**	**6500 ft**

Radio Configuration:

- NETID 3145
- Zigbee mesh GS as coordinator radios.
- From the payload to the ground station connection is used direct addressing.
- Data will be transmitted at 1Hz throughout the mission.
- The data will be stored locally on board to allow for the retrieval of lost packages.
- Testing and prototyping have already begun.

Payload Radio Configuration (2/3)



- **For the transmission control:**
  - XBee in AT mode utilizes an ACK mechanism to minimize transmission errors. If errors still occur, it can use a checksum method, which involves converting string telemetries into ASCII values and summing them at the end of the telemetry data. The [OPTIONAL DATA] field can be used for this purpose.

Payload Telemetry Format (1/4)

Data	Description	Resolution	Sample Data
TEAM_ID	Assigned four digit team identification number	N/A	3145
MISSION_TIME	UTC time in format hh:mm:ss	1 second	13:14:02
PACKET_COUNT	Total count of transmitted packets since turn on	integer	56
MODE	‘F’ for Flight mode; ‘S’ for Simulation Mode	‘F’ , ‘S’	F
STATE	Operating state of the software	N/A	LANDED
ALTITUDE	Altitude relative to ground level at the launch site	0.1 m	250.5
TEMPERATURE	Temperature in degrees Celsius	0.1 ◦C	20.5
PRESSURE	Air pressure of the sensor used	0.1 kPa	1013.2
VOLTAGE	Voltage of the CanSat power bus	0.1 V	4.5

Payload Telemetry Format (2/4)

Data	Description	Resolution	Sample Data
GYRO_R	Gyro’s roll data from Gyro receiver	1 degree/second	5
GYRO_P	Gyro’s pitch data from Gyro receiver	1 degree/second	2
GYRO_Y	Gyro’s yaw data from Gyro receiver	1 degree/second	1
ACCEL_R	Acceleration in roll axis from accelerometer	1 degree/second^2	10
ACCEL_P	Acceleration in pitch axis from accelerometer	1 degree/second^2	8
ACCEL_Y	Acceleration in yaw axis from accelerometer	1 degree/second^2	3
MAG_R	Magnetic field in roll axis from MPU	1 gauss	7
MAG_P	Magnetic field in pitch axis from MPU	1 gauss	126
MAG_Y	Magnetic field in yaw axis from MPU	1 gauss	48
AUTO_GYRO_ROTATION_RATE	The rotation rate of the Cansat in degrees per second	1 degree/second	68

Payload Telemetry Format (3/4)

Data	Description	Resolution	Sample Data
GPS_TIME	Time from the GPS receiver	1 second	4
GPS_ALTITUDE	Altitude from GPS receiver above mean sea level	0.1 m	85.2
GPS_LATITUDE	Latitude from GPS receiver	0.0001 ◦N	5.0000
GPS_LONGTITUDE	Longitude from GPS receiver	0.0001 ◦W	10.0000
GPS_SATS	Number of GPS satellites being tracked by GPS receiver	Integer	8
CMD_ECHO	Text of the last command received by the CanSat	N/A	CX, ON

Payload Telemetry Format (4/4)

Example frames:

..
..

3145,00:05:30,150,F,LAUNCH_PAD,1200.5,22.4,1012.3,12.6,0.02,-0.01,0.00,9.81,0.05,-0.02,30.2,45.1,60.0,0.4,00:05:30,1198.7,37.7749,-122.4194,8,CX,ON
3145,00:10:45,300,F,ASCENT,3500.8,19.8,1008.7,12.4,0.03,0.00,-0.01,9.80,0.04,0.01,29.8,44.9,59.7,0.3,00:10:45,3495.2,37.7750,-122.4195,9, CX,ON

3145,00:15:20,450,S,DESCENT,2000.3,18.5,1010.2,12.5,0.01,-0.02,0.02,9.82,0.03,-0.01,30.0,45.0,60.2,0.2,00:15:20,1998.6,37.7751,-122.4196,7, CX,ON
3145,00:25:10,750,S,LANDED,10.0,16.8,1013.5,12.8,0.00,0.00,0.00,0.00,0.00,0.00,0.0,0.0,0.0,0.0,00:25:10,10.0,37.7753,-122.4198,5,CX,ON
..
..

- Telemetry data fields are comma separated
- Telemetry frames are formatted fixed width
- Data is sent at 1Hz to the Ground Station

✓ The format matches the Competition Guide requirements

Payload Command Formats (1/2)

Command	Format	Description	Example
CX Payload Telemetry On/Off Command	CMD,<TEAM_ID>,CX,<ON_OFF>	1. CMD and CX are static text. 2. <TEAM_ID>is the assigned team identification. 3. <ON_OFF>is the string 'ON' to activate the payload telemetry transmissions and 'OFF' to turn off the transmissions.	CMD,3145,CX,ON
ST Set Time	CMD,<TEAM_ID>,ST,<UTC_TIME>|GPS	1. CMD and ST are static text. 2.<TEAM_ID> is the assigned team identification. 3. <UTC_TIME>|GPS is UTC time in the format hh:mm:ss or 'GPS' which sets the flight software time to the current time read from the GPS module.	CMD,3145,ST,13:35:59
SIM Simulation Mode Control Command	CMD,<TEAM_ID>,SIM,<MODE>	1. CMD and SIM are static text. 2.<TEAM_ID> is the assigned team identification. 3. <MODE> is the string 'ENABLE' to enable the simulation mode, 'ACTIVATE' to activate the simulation mode, or 'DISABLE' which both disables and deactivates the simulation mode.	CMD,3145,SIM,ENABLE
SIMP Simulated Pressure Data	CMD,<TEAM_ID>,SIMP,<PRESSURE>	1. CMD and SIMP are static text. 2.<TEAM_ID> is the assigned team identification. 3.<PRESSURE> is the simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.	CMD,3145,SIMP,101325
CAL Calibrate Altitude to Zero	CMD,<TEAM_ID>,CAL,	1. CMD and CAL are static text. 2.<TEAM_ID> is the assigned team identification. 3.CAL is to be sent when the CanSat is installed on the launch pad and causes the flight software to calibrate the telemetered altitude to 0 meters.	CMD,3145,CAL
MEC Mechanism actuation command	CMD,<TEAM ID>,MEC,<DEVICE>,<ON_OFF>	1. CMD and MEC are static text. 2. <TEAM ID> is the assigned team identification. 3. <DEVICE> is defined by the team to identify the specific mechanism. 4. <ON|OFF> are static strings "ON" or "OFF" that control the mechanism.	CMD,3145,MEC,ON

Payload Command Formats (2/2)

Example frame:

```
CMD,3145,CX,ON
CMD,3145,SIM,ENABLE
CMD,3145,SIMP,101325
```

- Command data fields are comma separated
- Command frames are formatted fixed width
- Data is sent at 1Hz to the Probe from Ground Station
- ✓ The format matches the Competition Guide requirements

Electrical Power Subsystem (EPS) Design

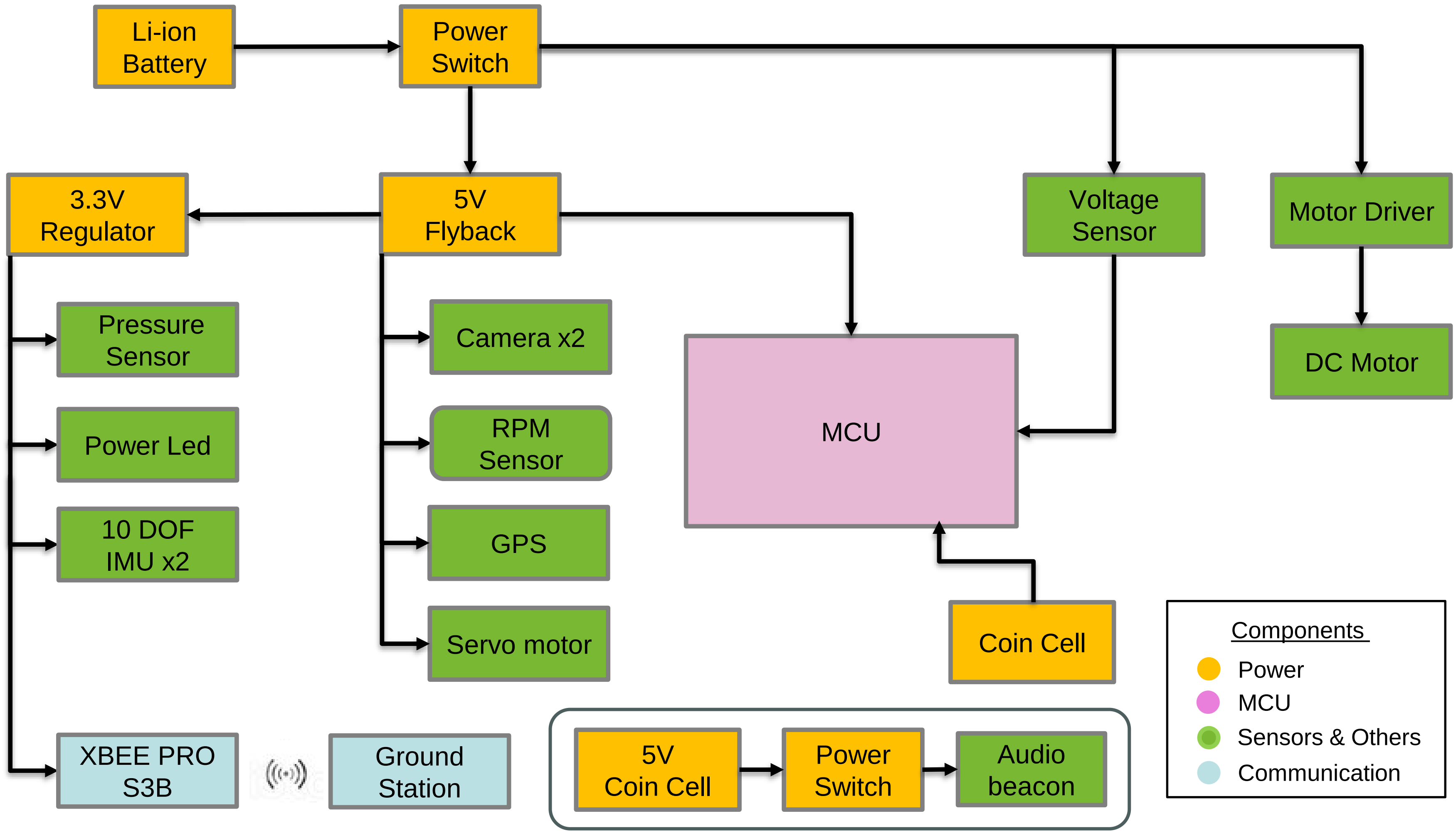
Gürkan ALKAN

EPS Overview (1/2)

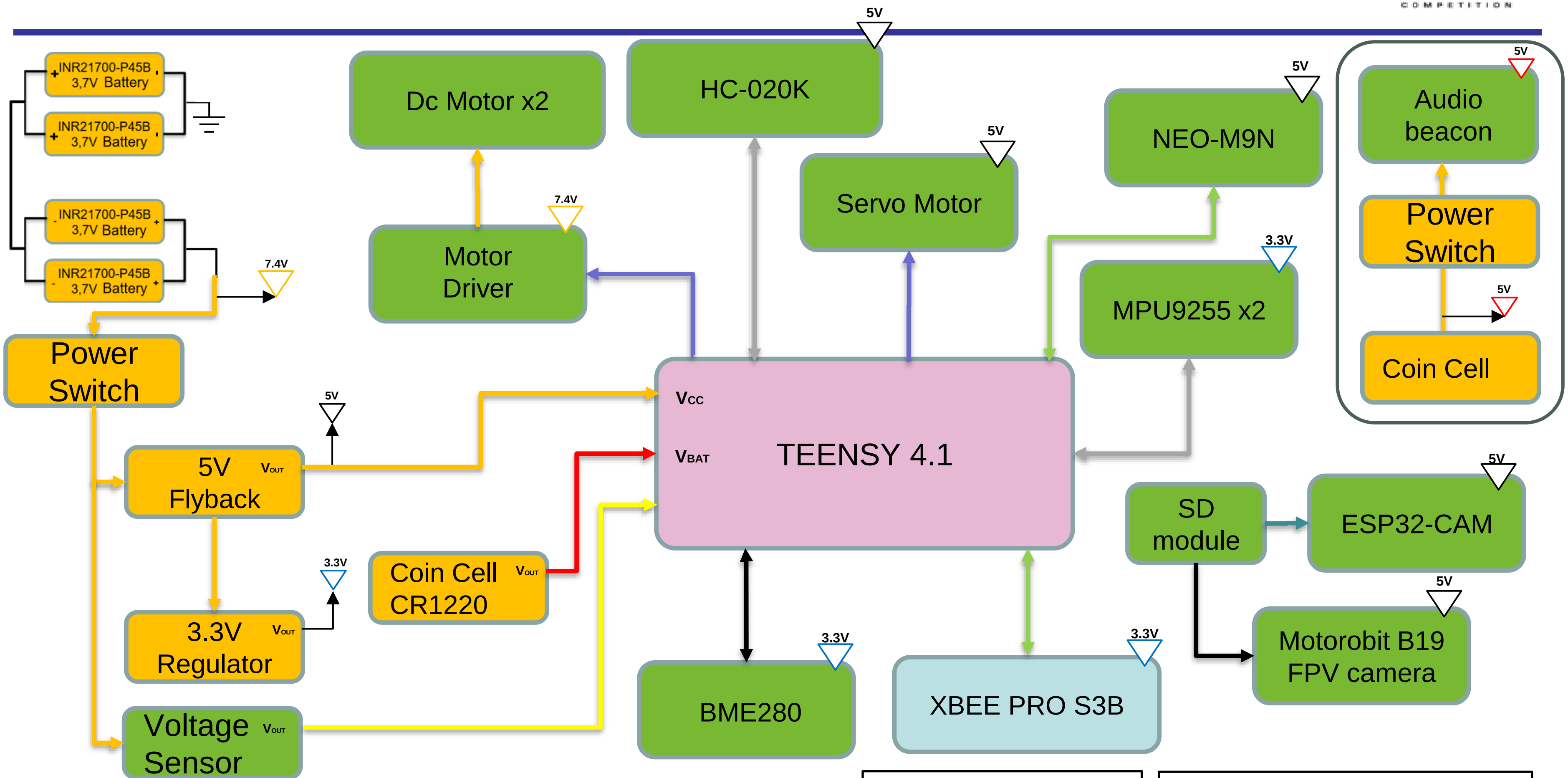
Cansat EPS Component

Component	Purpose(s)
Power	• Two Molicel INR21700-P45B 3,7V Li-ion battery will be used for supply Cansat components. • Coincell will be used for RTC module supply. • The 5V Flyback converter is used to supply MCU and some sensors in Cansat. • The 3.3V regulator is used to supply sensors and communication component in Cansat. • A power switch (external on/off switch) will be used to control the power of Cansat system. • Audio Beacon has own 5V Coin cell package and switch. İt separate from other circuits.
MCU	• Teensy 4.1 which powered by 5V will be used to collect the data and drive the all sensor components.
Sensors & Others	• SparkFun NEO-M9N will be used to find the location of Cansat. It will be supplied by 5V line. • Adafruit BME280 will be used to collect temperature and air pressure data. It will be supplied by 3.3V line. • The Motorobit B19 FPV camera record the north direction and ground. It will be supplied by 5V line. • The ESP32-Cam record the separation and deployment of the auto-gyro. It will be supplied by 5V line. • A 96 dB buzzer will be used to recovered the load after landing. It will be supplied by separate 5V line. • MPU9255 10 DOF IMU will be used to measure 9axis movement. It will be supplied by 3.3V line. • Dc Motors will be used for auto-gyro mechanism. İt will be drive by a driver motor. • HC-020K RPM Sensor will be used for measure rotation rate • Servo motor will be used for release mechanism and set camera orientation. • Battery voltage will be measured by the voltage divider.
Communications	• DIGI Xbee Pro S3 will be used to telemetry transmission. It will be supplied by 3.3V line.

Cansat Diagram



Payload Electrical Block Diagram



Components
- Power
- MCU
- Sensors & Others
- Communication

Arrows
- Digital
- VBat
- I2C
- Supply
- SPI
- PWM
- Analog
- UART

- **All components are connected to ground(GND)**
- **The payload and beacon power switch will be placed the CanSat where it can be easily reached.**

Payload Power Trade & Selection (1/2)

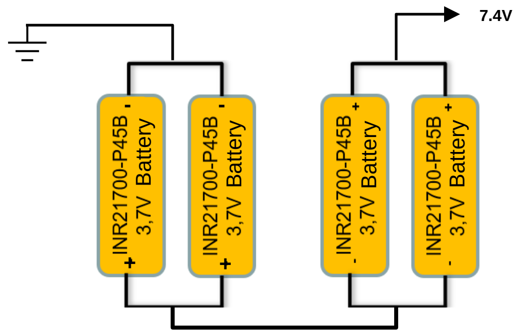
Battery Model	Voltage(V)	Capacity (mAH-WH)	Size (mm)	Max Current (A)	Weight	Type	Cost ($)
Panasonic NCR18650GA	3.7	3400mAH 12.58WH	18.6 x 65.2	10A	45.5	Li-ion	14$
SONY VTC5D	3.7	2800mAH 10.36WH	18 x 65	25A	46.5	Li-ion	7.2$
INR21700-P45B	**3.7**	**4500mAh 16.65Wh**	**21 x 70**	**45A**	**68**	**Li-ion**	**12.86$**

Selected	Reasons
Molicel INR21700-P45B	• **High Capacity** • **Rechargeable** • **High Current** • **Effective**

Payload Power Trade & Selection (2/2)

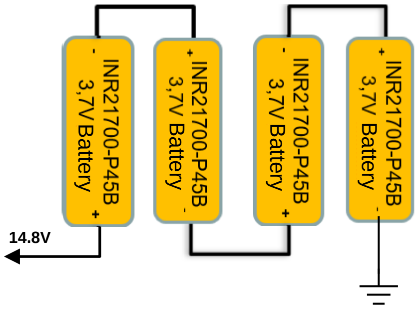
Selected

Design 1



Batteries are serial & parallel connected (2s2p)

Design 2



Batteries are serial connected (4s1p)

- Batteries will be connected to Cansat with springless battery slots. the batteries will be strengthened by soldering and using zip ties.
- The selected design is 1 because it can get more current with this design and its meets power requirements.

Payload Power Budget (1/2)

Component	Voltage(V)	Current(mA)	Duty Cycle(%)	Power Consumption (Wh)	Uncertainty (Wh)	Source
Teensy 4.1	5.0	100	100	0.5	±0.05	Datasheet
XBEE Pro S3B	3.3	150	100	0.495	±0.066	Datasheet
MPU9255	3.3	3.2	100	0.010	±0.00165	Datasheet
SparkFun NEO-M9N	5	21	100	0.105	±0.015	Datasheet
BME280	3.3	0.0036	100	$11.88x10^{-6}$	$\pm 1.2x10^{-6}$	Datasheet
Servo Motor	5	40	75	0.15	±0.018	Datasheet
DC motor(with driver) x2	7.4	9490	10(6 minutes)	14.04	±2.1	Datasheet
ESP32-Cam	5	160	100	0.8	±0.1	Datasheet
HC-020K RPM Sensor	5	25	100	0.125	±0.018	Datasheet
B19 Camera (with SD card module)	5	250	100	1.25	±0.11	Datasheet
Indicator LED	3.3	10	100	0.033	±0.001	Estimated
TOTAL				17.51	±2.48	**19.99 Wh (max)**

Payload Power Budget (2/2)

Total power consumed in 2 hour → 19.99 x 2
=39.980Wh

Total available power → Ps = Vs x Is = 4500mAh x 4 x3.7V
=66.600Wh

Margin → Available power – Power consumption
66.600 – 39.980
=26.620Wh

That calculations show that the CanSat can be powered more than two hours.

Total available power (Wh)	**66.600Wh**
Total power consumed (Wh)	**39.980Wh**
Margin	**26.620Wh**

Flight Software (FSW) Design

Aleyna YILMAZ

FSW Overview (1/3)

Overview of the CanSat FSW design:

Tasks Summary

- Check if payload is in simulation mode or flight mode.
- If payload is in **flight mode** CMD,<3145>,SIM,<DISABLE>
- MODE part in telemetry package changes to F.

1. Calibrate altitude to zero (CMD,<3145>,CAL)
2. Payload telemetry on command (CMD,<3145>,CX,<ON>)
3. Pack the sensor data in a telemetry format every 1 Hz, save it on the SD card and send it to the ground station.
4. Increment by 1 after sending each packet and save the last packet count to EEPROM.
5. Save flight time from RTC to EEPROM.
6. 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 meters/second
7. A video camera shall show the separation of the payload from the container 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.
8. The probe lands to the ground.

- If payload is in **simulation mode** CMD,<3145>,SIM,<ENABLE> CMD,<3145>,SIM,<ACTIVATE> MODE part in telemetry package changes to S.
- CMD,<3145>,SIMP,<PRESSURE> The pressure values given by the command are sent to Cansat by the ground station, Cansat calculates the altitude with these pressure values and completes the tasks with the telemetry data generated accordingly.
- For testing and demonstration purposes CMD,<3145>,MEC,<AUTOGYRO>,<ON_OFF>

LAUNCH PAD → ASCENT → APOGEE → DESCENT → PROBE RELEASE → LANDED

FSW Overview (2/3)

Programming languages:

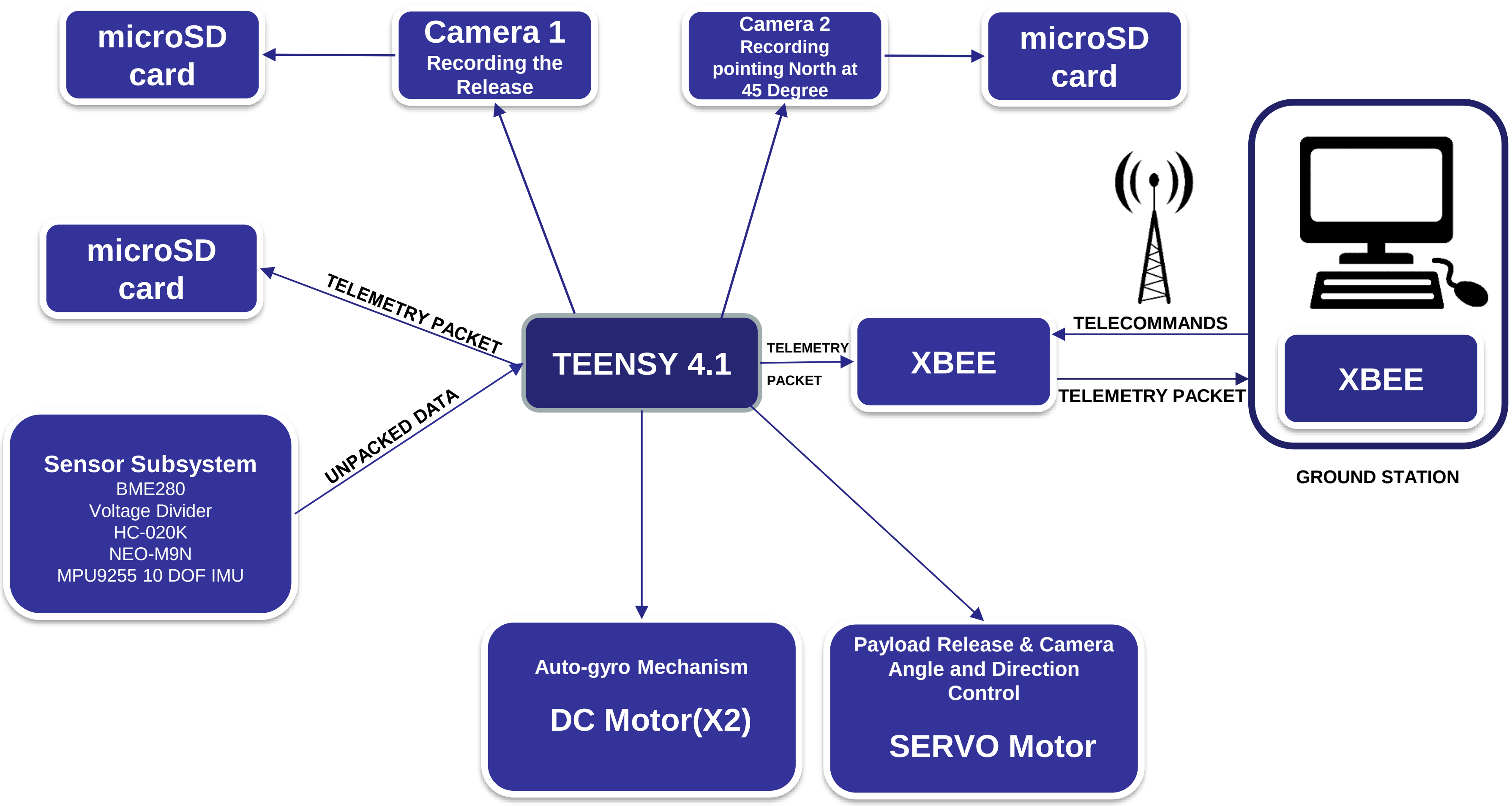
C, **C++**

Development environments-Teensyduino

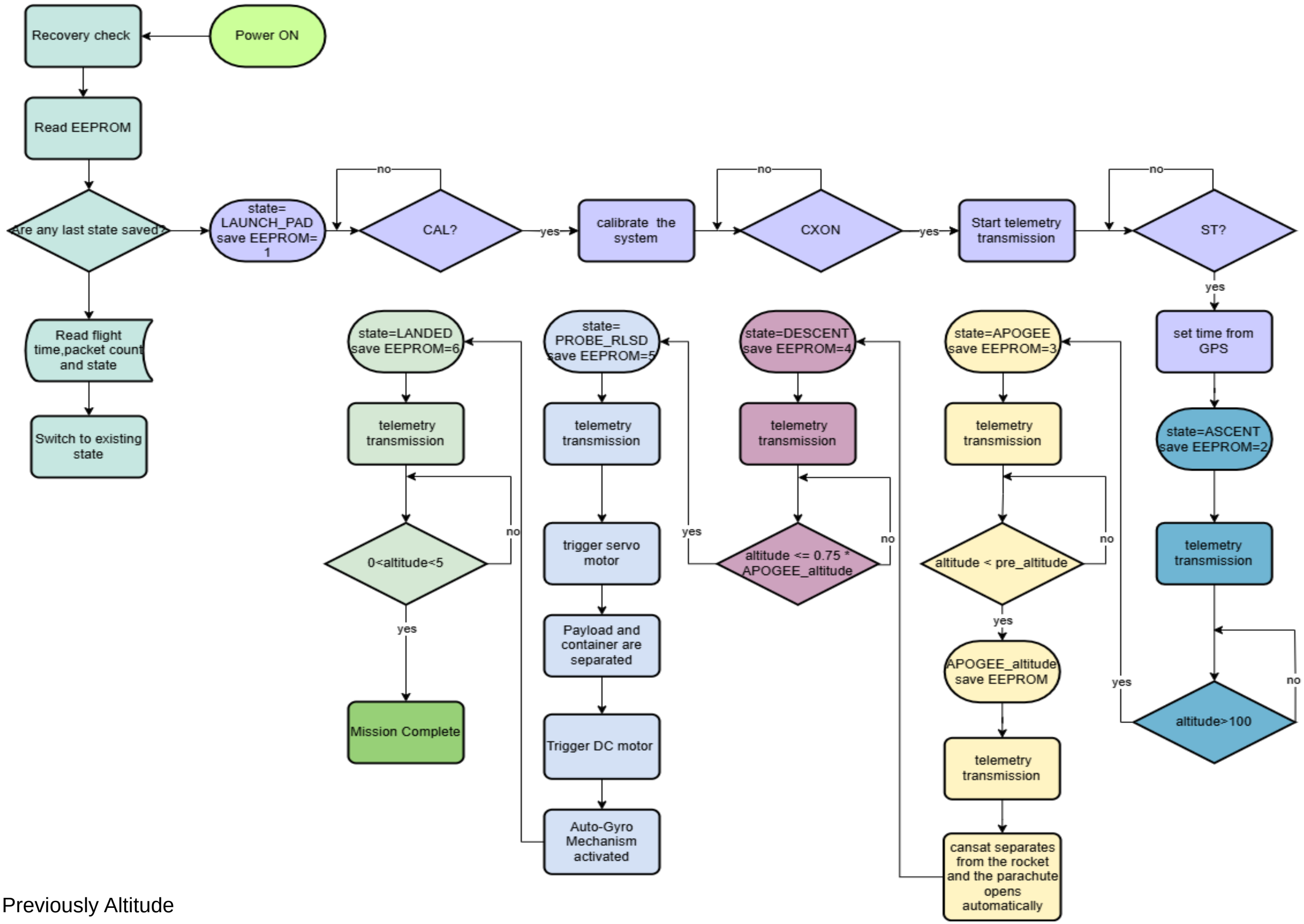
- **Teensyduino**: Teensyduino is a specialized Arduino plugin for Teensy microcontroller boards, and it used on the Arduino IDE to develop software compatible with Teensy boards. **XCTU** (Xbee Configuration and Test Utility): XCTU is a tool for Xbee wireless module configuration and testing, it used to configure and monitor Xbee module.
- **Visual Studio Code**: Visual Studio Code is using to develop our libraries, we can perform microcontroller programming operations by installing plugins such as Arduino and PlatformIO.

DIGI XCTU
Configuration & Test Utility Software

FSW Overview (3/3)



Payload FSW State Diagram (1/3)

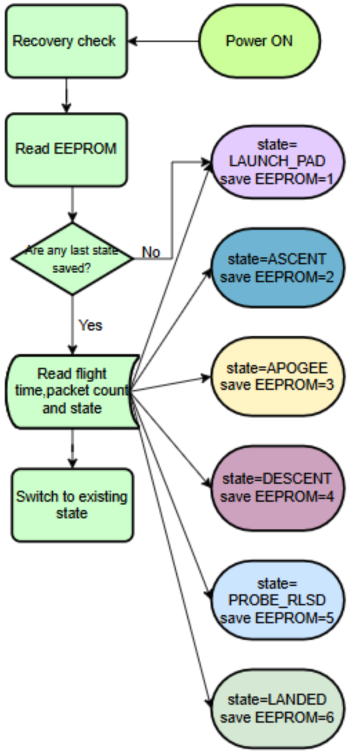


Pre_altitude: Previously Altitude

Payload FSW State Diagram (2/3)

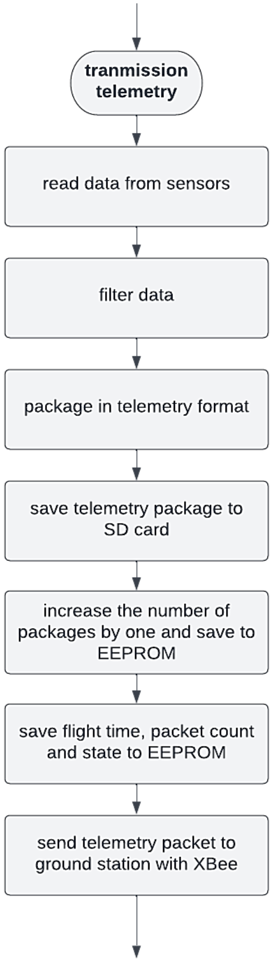
RECOVERY PLAN:

A short-term power cut due to cables that may occur during the flight, the air is not suitable for communication. In these cases, the processor can be reset, but a recovery plan has made to prevent damage from this situation. By recording the task duration, the number of packets sent and the state in EEPROM, the data will be recorded in case the processor is reset. In this way, Cansat will operate regarding what state it will be in even if it is reset during the flight and will do what it needs to do in order.



TELEMETRY TRANSMISSION:

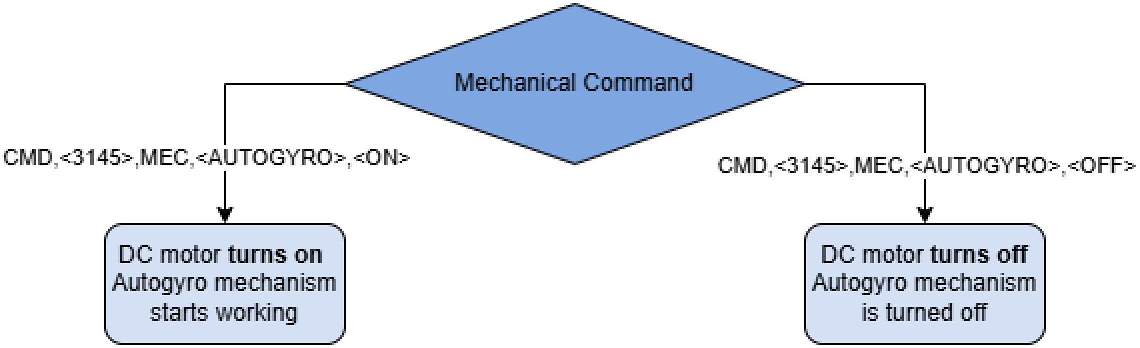
In the telemetry transmission section seen in the FSW diagram above, the following operations are performed respectively.



Payload FSW State Diagram (3/3)

MEC Command

The MEC command is to be sent to activate a specific mechanism. DEVICE is defined by the team to identify the specific mechanism. Auto-gyro mechanism is chosen as device, for command



- ***NOTE: The MEC Command is not to be used during flight unless something did not work as expected. It is for testing and demonstration***

Simulation Mode Software

GROUND STATION

With the **ENABLE** and **ACTIVAVE** commands sent from the ground station, the simulation mode is opened, and the MODE part of the telemetry package becomes S. Then the **SIMP** command is sent along with the fake pressure data.
Stay in simulation mode until DISABLE command is selected.

CMD,<3145>,SIM,<ENABLE>

CMD,<3145>,SIM,<ACTIVATE>

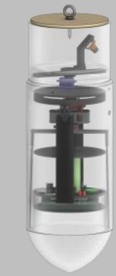
CMD,<3145>,SIMP,<PRESSURE>

Pressure data

Altitude data

CMD,<3145>,SIMP,<DISABLE>

CANSAT



In simulation mode, CanSat will operate as it is at launch, but it is actually on the ground. It substitutes the sample sim data from the **SIMP** command as pressure data and the altitude is calculated and added into the telemetry package. Other sensors are not affected by this situation. When the **DISABLE** command comes, the simulation mode is exited.

Software Development Plan (1/2)

Prototyping and prototyping environments

- A breadboard is used for the prototype, each sensor are tested one by one and then try the prototype on the breadboard, and a PCB will be design according to this prototype. The mechanisms using are generally auto-gyro and dc motor, it also tested it in the laboratory of the university.

Software subsystem development sequence

- Create a general algorithm
- Try to improve the software
- Test and assemble in each component
- Bug fixing

Test methodology

- It was tested whether each sensor gave correct data.
- Calibrations were made.
- Data recovery algorithm tested.
- Xbee’s range tested.

Development team

- Aleyna YILMAZ
- Muhammed Said GONUL

Software Development Plan (2/2)

Task Name	Start	End	Duration	November	December	January	January	February	February	February	March	March	March	March	April	May	May	June	June	June
Creation of sensor libraries	01/11/2024	10/11/2024	10 days																	
Receiving data from sensors	01/11/2024	21/11/2024	20 days				P							C			T			P
Use of all sensors together	21/11/2024	11/12/2024	20 days				D							D			E			F
Create a simple flight diagram	11/12/2024	16/12/2024	5 days				R							R			S			R
Creation of telemetry package	16/12/2024	26/12/2024	10 days														T			
Save data to SD card and EEPROM	01/01/2025	06/01/2025	5 days														S			
Trial of triggers for release and Auto-Gyro mechanism	01/01/2025	05/02/2025	1 months																	
Sending the telemetry packet to the ground station	01/01/2025	11/02/2025	30 days																	
Trying simulation mode	01/01/2025	20/03/2025	2.5 months																	
Find bugs and improve	01/02/2025	20/03/2025	1.5 months																	
Develop control algorithms	15/02/2025	25/03/2025	1 months																	
Flight software testing	05/02/2025	20/05/2025	3 months																	

As seen in our calendar, we do not leave the flight software to the last minute and aim to finish it early.

%100 done

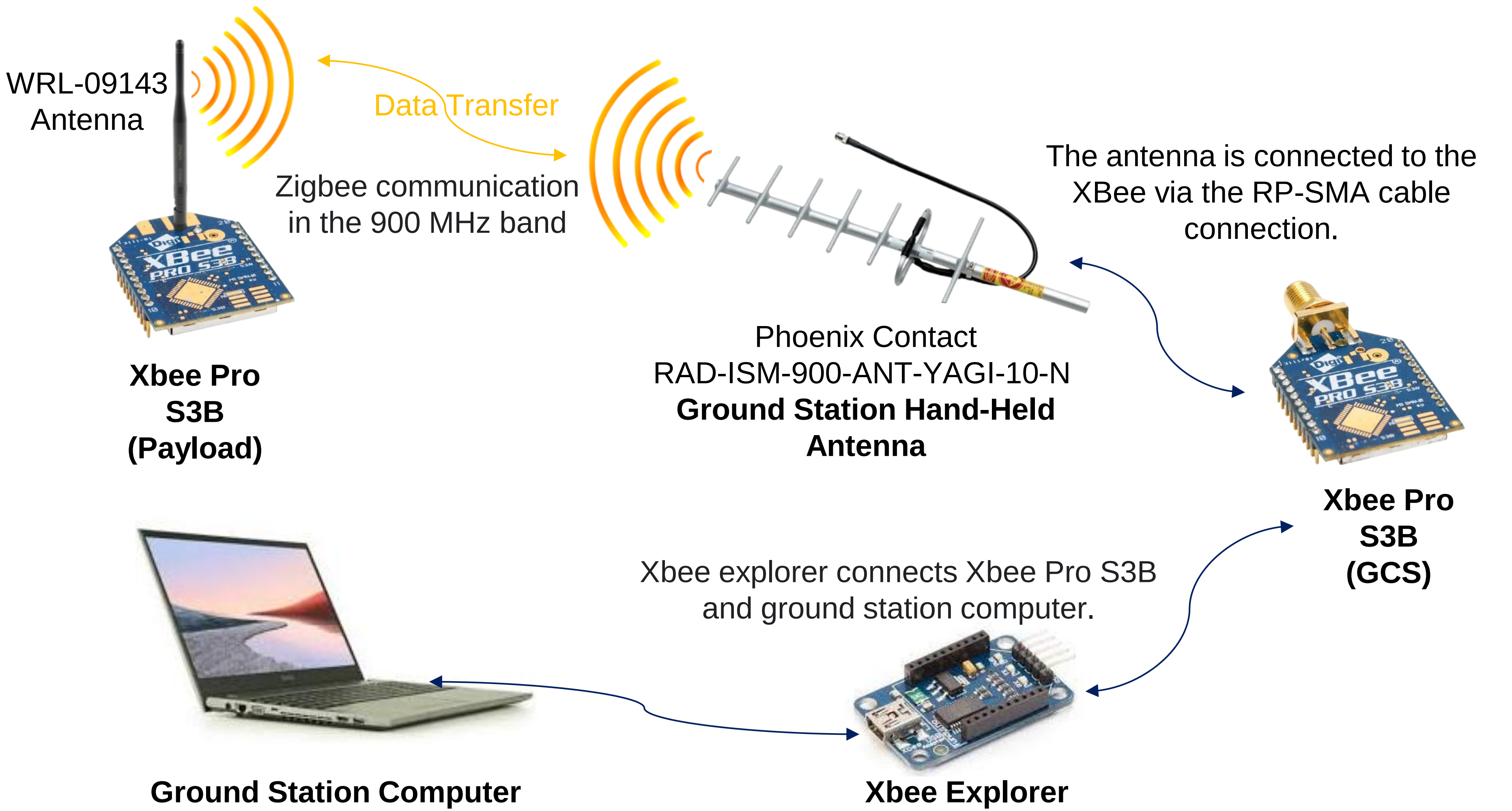
%75 done

%50 done

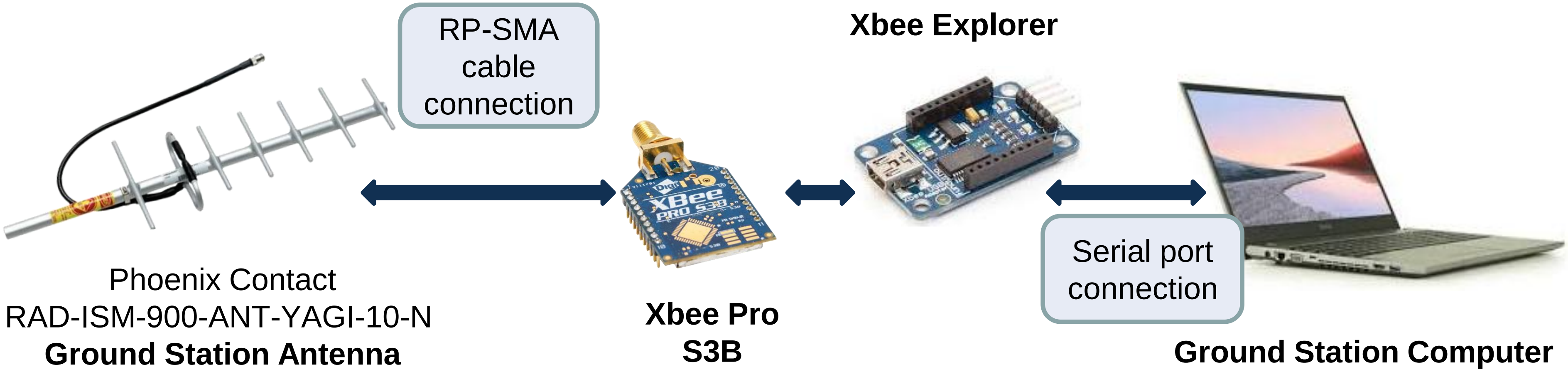
Ground Control System (GCS) Design

Muhammed Said GÖNÜL

GCS Overview



GCS Design



- The ground station will be able to work actively for two hours with the battery.
- Computer fans will be used to prevent the computer from overheating.
- Umbrellas will be used to protect the ground station from the sun.
- Windows updates will be disabled.

GCS Antenna Trade & Selection (1/2)

	Model	Connection Type	Frequency	Direction	Gain	Cost ($)
✓	RAD-ISM-900-ANT-YAGI-10-N	N-Type	900 MHz	Directional	12 dBi	325
	BGYD890G	N-Type	900 MHz	Directional	8.7 dBi	210

Selected Antenna	Reasons
RAD-ISM-900-ANT-YAGI-10-N 	• Better signal transmission than alter natives, • Easier to position and steer, • High availability in the market, • To be lightweight, • Being resistant to weather conditions is one of our preferred reasons.

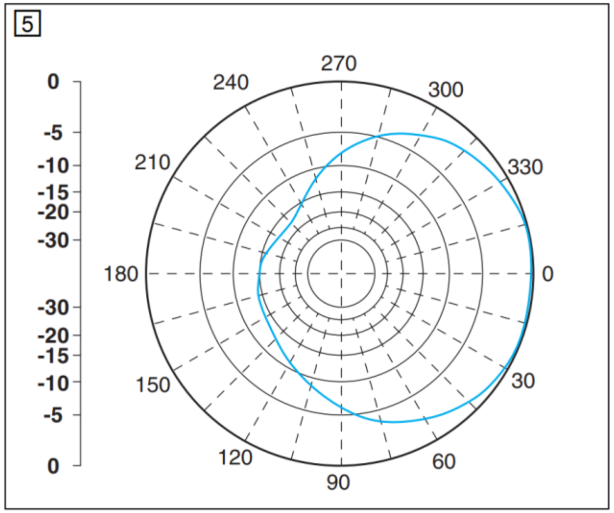
GCS Antenna Trade & Selection (2/2)

As RAD-ISM-900-ANT-YAGI-10-N is a **hand-held** antenna, it will be held in the hand by a team member and directed to the CanSat throughout the flight.

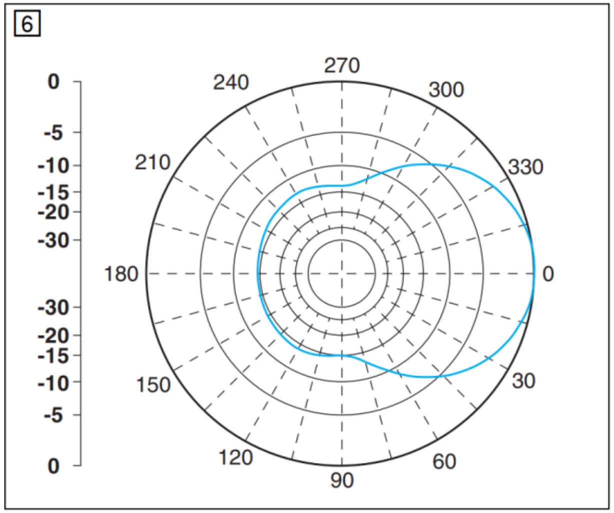
The extension cable of the antenna will be kept short for a healthier communication and to prevent the people around.

A possible negative situation will be avoided by surrounding the area where the antenna is located with a safety strip.

Horizontal



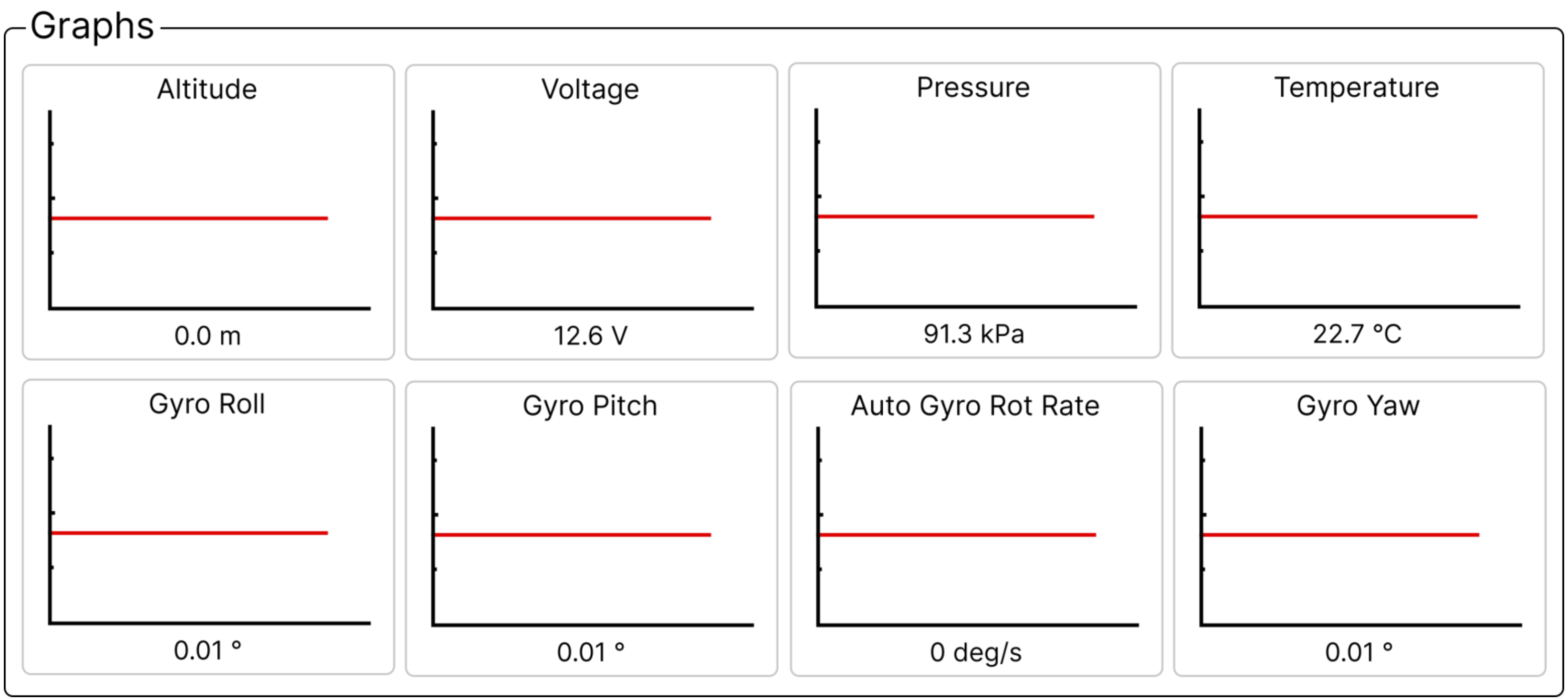
Vertical



Radiation Patterns of *RAD-ISM-900-ANT-YAGI-10-N*

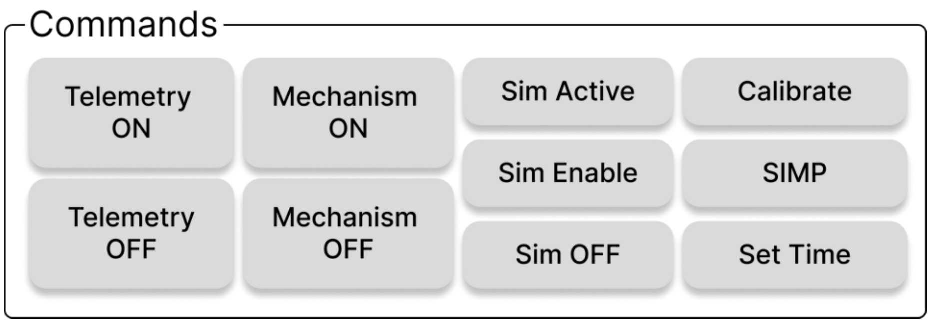
GCS Software (1/6)

Ground Station Interface Prototype



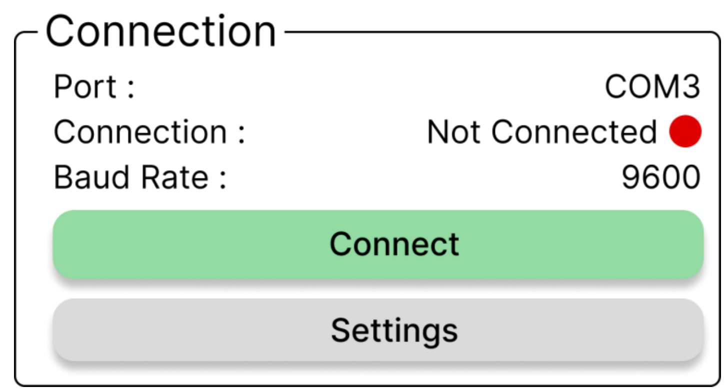
The interface will display graphs of instantaneous altitude, voltage, pressure, temperature, gyro pitch, roll, and yaw, as well as auto-gyro rotation rate, using accurate time-dependent engineering units, as seen in the prototype.

GCS Software (3/6)

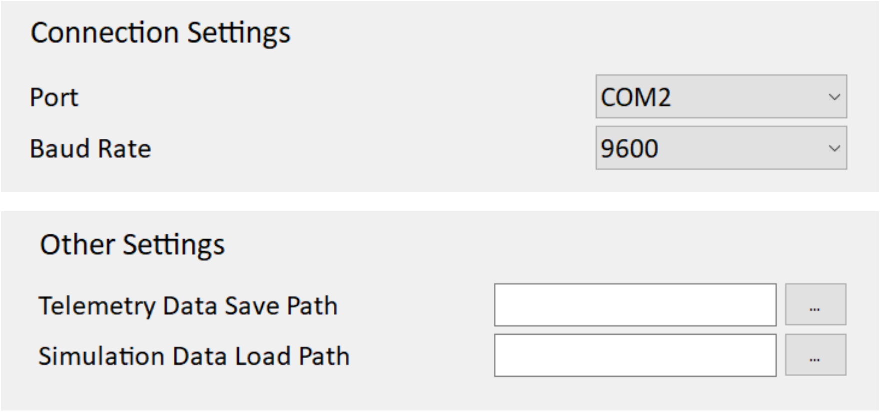


The *Commands* panel enables the transmission of calibration commands for the barometric sensor and roll/tilt angles, which are verified by receiving single-bit responses from the payload. Successful transmission of commands will be confirmed on the ground control station's real-time telemetry display. The simulation mode will be activated by the SIMULATION ENABLE and SIMULATION ACTIVE commands via the buttons on the panel. In addition, all mechanisms will also be realized via these buttons.

The *Connection* panel displays the connection status with the CanSat, as well as the selected port and baud rate. The panel also includes connect, disconnect, and settings buttons. Connection settings, the directory for the simulation file, and the directory for saving flight data are located in the settings page.

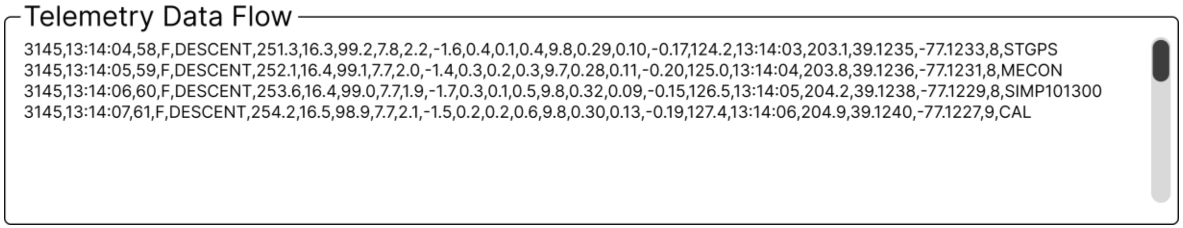


GCS Software (4/6)



On the *Settings* page, there are fields for port selection and baud rate configuration. Additionally, there are fields to select the directory for the simulation file and the directory for saving flight data.

Real-time incoming telemetry lines will appear here. The most recent one will be listed at the top, and the desired telemetry line can be seen by moving up and down in this list.



GCS Software (5/6)

Telemetry

Team ID	1234	Mission Time	T+ 00:00:00
Packet Count	0	Mode	Flight
Voltage	12.6 V	State	Launch Wait
Altitude	0.0 m	Temperature	22.7 °C
Pressure	91.3 kPa	Gyro Roll	0.01 °
Gyro Pitch	0.01 °	Gyro Yaw	0.01 °
Acceleration Roll	0.01 °	Acceleration Pitch	0.01 °
Acceleration Yaw	0.01 °	Magneto Roll	0 Gs
Magneto Pitch	0 Gs	Magneto Yaw	0 Gs
Auto Gyro Rot Rate	0 deg/s	GPS Time	14:50:21
GPS Sats	20	GPS Altitude	0.0 m
GPS Longitude	0.0001	GPS Latitude	0.0001
CMD Echo			

In the *Telemetry* panel, incoming sensor data will be displayed instantly on the ground station interface and updated with each new data package. The Telemetry panel will include mission time with a resolution of 1 second or better and the count of successfully received packets. The raw telemetry data will first be parsed in the background, and then each parsed data point will be written into its respective field using engineering units. In this way, all sensor data will be accurately processed and presented to the user.

GCS Software (6/6)

Software Packages to be Used

- Qt C++ Application

  In addition to the Qt framework, the following modules/libraries will be used:;

  - QtCore
  - QtSerialPort
  - QtCharts
  - QtWidgets
  - QtGui
  - A CSV parsing/writing library (e.g., fast-cpp-csv-parser) or custom CSV handler

- XTCU Digi Xbee Software

Archiving and Displaying Data in the Interface

- The data will be saved to the ground station created using Qt application.
- The data will be recorded in real time in the Qt application and will be converted into graphics live with the help of QtCharts.

Delivery of Data to Contest Officials

- Information will be saved to the computer as .csv extension.
- The name of the CSV file will be set to «Flight_3145.csv»
- All recorded information will be put into the USB memory stick and handed over to the jury.

Simulation Mode

The ground station interface user will start the simulation mode with the command sent from the command line in the interface. The file containing the simulation data will be uploaded from the Select file section. Then the ground station will start sending data consecutively from the csv file with a frequency of 1Hz. Telecommand sending will occur via XBee via serial port, just like telemetry is read.

CanSat Integration and Test

Metin SATI

CanSat Integration and Test Overview (1/4)

Subsystem Level

- -Sensors
- -CDH
- -EPS
- -Radio communications
- -FSW
- -Mechanical
- -Descent Control

Integrated Level

- -Descent Test
- -Communications
- -Mechanisms
- -Deployment

Environmental Test

- -Drop test
- -Thermal test
- -Vibration test
- -Fit Check
- -VACUUM test

Simulation

- -GCS to CanSat
- - CanSat to GCS

Planning the tests → Testing components of Subsystems → Testing subsystems → Integration process and system tests → Environmental tests

CanSat Integration and Test Overview (2/4)

Subsystem Level	
Sensors	• Calibration of sensors. • Reliability test. • Sensor Durability tests
CDH	• Accuracy and timing of data sent by Xbee. • Correct processing and storage of data.
EPS	• Power budget calculation and power adequacy test. • Current leakage detection.
Radio communications	• XBEE Communication Test. • Antenna Range test.
FSW	• Data protection in case of failure or shutdown. • Parachute, release mechanism, auto-gyro system tests.
Mechanical	• Mechanism tests.(separation mechanism etc.) • Parachute ejection test. • Mass and dimension test. • Endurance tests.
Descent Control	• Parachute area calculations. • release mechanism and auto-gyro system tests • Descent speed test in parachute and auto-gyro control stages

CanSat Integration and Test Overview (3/4)

Integrated Level	
Descent Test	• Parachute and auto-gyro landing speeds test.
Communications	• XBees' communication tests in different conditions.
Mechanisms	• Testing the ability of all components to maintain their configurations under some forces. • Testing the weight and size compatibility of the manufactured and used components.
Deployment	• Deployment moments tests.

Simulation	
GCS to CanSat	• Sending the data in the given sample file to the CanSat.
CanSat to GCS	• Sending the new telemetry packet, which is obtained by changing and processing the new data with the sensor data, to the ground station.

CanSat Integration and Test Overview (4/4)

Enviromental Test	
Drop test	• 30 Gs shock durability test of the system. • Durability of component and battery mounting points.
Thermal test	• Testing whether the CanSat deforms and performs its functions under high temperature.
Vibration test	• Testing the integrity of ports, battery connections and the overall system.
Fit Check	• Measurement of CanSat dimensions and weight.
Vacuum test	• Verify the deployment of payloads.

Subsystem Level Testing Plan (1/4)

SENSORS	
GPS	• Sending NMEA sentences to the ground station and parsing the sentences are tested.
AIR PRESSURE & AIR TEMPERATURE	• After taking the altitude and temperature values, the accuracy is checked.
IMU SENSOR	• The magnetic field, rotation rate, and acceleration data obtained from the sensor were tested using the simulation image created at the ground station.
CAMERA	• The images from both cameras are checked to ensure they are as expected (for example, the first camera is positioned to monitor the parachute deployment and the auto-gyro system deployment, and the second camera is positioned at a 45-degree angle facing north from the CanSat's vertical (nadir) direction). It is also tested to confirm that the video recording is done in the specified quality.
VOLTAGE SENSOR MODULE	• The sensor's data is checked with a voltmeter.
RPM Sensor	• The accuracy of the auto-gyro rotation rate data is checked.

Subsystem Level Testing Plan (2/4)

CDH	
MCU	• It is tested that the data from the sensors are transmitted and processed to the ground station.
XBEE	• The communication between XBEEs is checked and the distance between them is tested.
CAMERA	• It is tested that both cameras record the video on the SD card without any issues.
SD CARD	• It is checked that the telemetry packets coming to the ground station are recorded on the SD card.
RTC MODULE	• The accuracy of the timing of the data is checked with the RTC module.

Subsystem Level Testing Plan (3/4)

- The tests are made by establishing the circuit of each component on the breadboard.

EPS	FSW
• During the mission, the current values at different stages are measured. • It is checked that the system is working during the 2-hour task. • It is tested short circuit faults. • Voltage values on voltage dividers are measured. • The functionality of the power switches of the CanSat and the audio beacon, as well as the audio beacon, is checked. • The separate battery connections and voltage values of the audio beacon are checked. • It will be testing that during the start-up and landing phases of the auto-gyro system, the motors did not experience power interruptions, and the batteries were sufficient to provide the required power.	• The accuracy of the data received from the sensors is checked. • The correctness of the order of data transmission is checked. • In case of microprocessors reset, data recovery algorithms tests is performed. • Flight algorithm tests are carried out (separation mechanism and auto-gyro system etc.). • The command sent from the ground station in the event of a mishap is tested to work correctly. • The functionality of the commands used to activate all mechanisms is tested.

Subsystem Level Testing Plan (4/4)

DESCENT CONTROL

- The payload and container will be attached to a drone and released from a sufficient height. At this stage, the automatic deployment of the parachute, the descent of the payload and container at a speed of 20 m/s with the parachute, the activation of the release mechanism at 75% of the altitude to detach the payload from the container, and the controlled descent of the payload at a speed of 5 m/s using the auto-gyro system will be tested.

RADIO COMMUNİCATION

- Communication of XBees is tested in various distance and environmental conditions.
- It is tested whether there is any data loss during communication (telemetry transmission frequency and compliance with the specified telemetry data format).

MECHANICAL

- Total mass is checked.
- The container has been checked to ensure it meets the desired size and structure.
- The separation and second camera mechanisms, controlled by a single servo motor, will be tested.
- The durability of CANSAT and its subsystems is tested.
- The parachute and auto-gyro system (including the operation of the motors and their ability to generate sufficient torque, etc.) will be tested for the container and load's descent at the specified speeds
- The compliance of structural parts with the specified rules (The nose cone being a single piece and ensuring it is airtight etc.) is checked.
- To prevent fire risks, it is checked that the heat-using mechanisms do not come into contact with the outside environment.
- Factors such as the area of the parachute and the structural adequacy of the selected material have been tested.

Integrated Level Functional Test Plan

Integrated Level Functional Test Plan	
DESCENT TESTING	• The descent speeds of the container and payload are tested with a parachute and auto-gyro system. For this, the container and payload is dropped from a certain height.
COMMUNICATIONS	• XBEEs' communication is tested at different distances and conditions. • By using the drone, it will be taken to the mission height , and the accuracy of the data, its arrival at the ground station, and the 1 Hz update frequency will be checked.
DEPLOYMENT	• Its durability against large shock forces will be tested. • release tests will be carried out at different altitudes. • Parachute distribution systems will be tested. • Compliance of the components with their planned placement will be tested.
MECHANISMS	• The separation mechanism, auto-gyro mechanism, parachute, and the designed and integrated components(The nose cone being a single piece etc.)are being tested.

Environmental Test Plan (1/2)

DROP TEST	VACUUM TEST
The purpose of the test is to test the durability of component mounts, battery slots and connection points against the about 30 Gs shock force produced on the system. CanSat, which is fixed from the ceiling, does not hit the ground and a pillow is placed on the base. CanSat, which is connected with a rope that does not flex, is left at a height of 61 cm without holding the test structure. and after the test, the following are expected: • No loss of power, • No damage did not occur, • The structure must not flex, • Telemetry data were received without any problems.	The purpose of this test is to verify the deployment process. As described in the mission guide, a vacuum chamber will be built and test start: • The CanSat will be vacuumed while inside. • According to telemetry data, the vacuum will be stopped and air entry will be allowed. • At this stage of the test, the CanSat should be observe. • Telemetry data and the activation of all mechanisms based on altitude changes are checked.

Environmental Test Plan (2/2)

FIT CHECK	VIBRATION TEST	THERMAL TEST
• The CanSat will be placed into the rocket. At this stage, the suitability of the weight and dimensions of the payload and container will be checked using a test rocket.	The purpose of this test is to test mounting strength and structural integrity. Using orbital sander, CanSat continues to collect accelerometer data against 0-233 hz vibration and is evaluated by damage-functionality at the end of the test. The amount of shaking generated by the sander is around 20 to 29 Gs.	• The purpose of this test is to demonstrate the temperature resistance of the CanSat. During launch, the payload may heat up to the mid-30s degrees. The CanSat must remain in a thermal chamber set to 60 degrees for 2 hours without undergoing any deformation, loss of functionality, or failure during this period. This test will be carried out using an industrial oven provided by Gazi University. Safety measures, such as gloves and other necessary equipment, will be used during the test. 

Simulation Test Plan

GCS TO CANSAT	CANSAT TO GCS
• The values in the sample file given to us are read. values are transmitted to the ground station and processed. • The data is sent to the Xbee in the CanSat with a frequency of 1 Hz. • The data processed by the processor in the CanSat is added to the telemetry packet.	• The data sent with the data received from the sensors are changed and saved and CanSat is enabled to read the incoming data values. • Finally, sending it back to the ground station is tested. • In this way, the simulation is completed.

Mission Operations & Analysis

Gürkan ALKAN

Overview of Mission Sequence of Events (1/4)

Arrival at Launch Site

- Check for any damages that could appear during the travel **(Whole Team)**
- Score sheet review and checklist **(MCO)**
- Set up GCS and antenna **(GSC)**

Pre-Launch Prep

- Communication and sensors test **(CC+GSC)**
- Battery charge control **(CC)**
- Mechanism inspection **(CC)**
- Buzzer activation
- Auto-gyro system control
- Payload is stowed into rocket **(CC)**
- CanSat dimension and weight check **(CC)**
- Mounting CanSat to the rocket **(CC)**
- Sensors Calibration **(GCS+CC)**
- Safety Check **(Whole Team)**

Overview of Mission Sequence of Events (2/4)

Launch

- CanSat is released and starts its mission
- CanSat is released from rocket
- Parachute deploy automatically
- Payload is released from Container
- Auto-gyro system activate
- Data received periodically by ground station **(GSC)**
- Data is plotted on GCS interface simultaneously **(GSC)**

Recovery and Data Retrieve Process

- Crew tracs payload by GPS **(RC)**
- Crew searches audio Beacon **(RC)**
- CanSat is recovered and returned to launch site **(RC)**
- Flight data is retrieved from SD card on payload and video is retrieved from SD card on container **(GSC+RC)**

Overview of Mission Sequence of Events (3/4)

Post Flight

- Received telemetry data will be analyzed **(Whole Team)**
- Damage Inspection will be done **(CC+RC)**
- Clearing Ground Station area **(Whole Team)**
- Flight Data files will be delivered to judges **(MCO)**
- PFR

Overview of Mission Sequence of Events (4/4)

	Team Member(s)	Responsibilities
Mission Control Officer (MCO)	Gürkan ALKAN	Coordinating all efforts and interacting with the flight coordinator as needed.
Ground Station Crew (GSC)	Muhamed Said GONUL, Muhammet Akın OZEL, Aleyna YILMAZ	Monitoring the ground station for telemetry reception and issuing commands to the CanSat.
Recovery Crew (RC)	Bugrahan DEGIRMENCI, Göktuğ KOCCENK	Tracking the CanSat and going out into the field for recovery and interacting with the field judges. This crew is responsible for making sure all field scores are filled in.
CanSat Crew (CC)	Enes KALENDER, Atakan SAYDAM	Preparing the CanSat, integrating it into the rocket and verifying its status.

Mission Operations Manual Development Plan

- Mission operations manual will be developed for successful CanSat pre-launch, launch, recovery and post-flight operations using the checklist and instructions.
- The mission operations manual will be reviewed and approved by all team members.
- The content of the manual will be developed in accordance with the events disscussed in Mission Sequence of Events.

CanSat Assembly (Pre-Launch Prep)	• Battery charge control • Mechanism inspection
CanSat Testing (Pre-Launch Prep)	• Communication and sensors test • Auto-gyro mechanism test • CanSat dimension and weight check • Sensors Calibration • Safety Check
Ground Station (Pre-Launch & Launch)	• Set up GCS and antenna • Communication and sensors test
Integration (Pre-Launch)	• Payload is stowed into rocket • CanSat dimension and weight check • Mounting CanSat to the rocket
Recovery & Data Analysis (Post Flight)	• CanSat is found • Flight data is retrieved from SD cards • Damage Inspection is done • Ground Station area is cleared • Flight Data files delivered to judges

CanSat Location and Recovery

CanSat recovery

- CanSat is going to be searched by audio beacon.
- Landing zone will be determined by: observing the descent and GPS location data.

Container recovery

- The container will be made of in fluorescent orange color.

apastron

Team #3145 Apastron

E-mail: apastron.modeluydu@gmail.com

Team Leader contact: Gürkan ALKAN

+90 5xx-xxx-xx-xx

Labeling

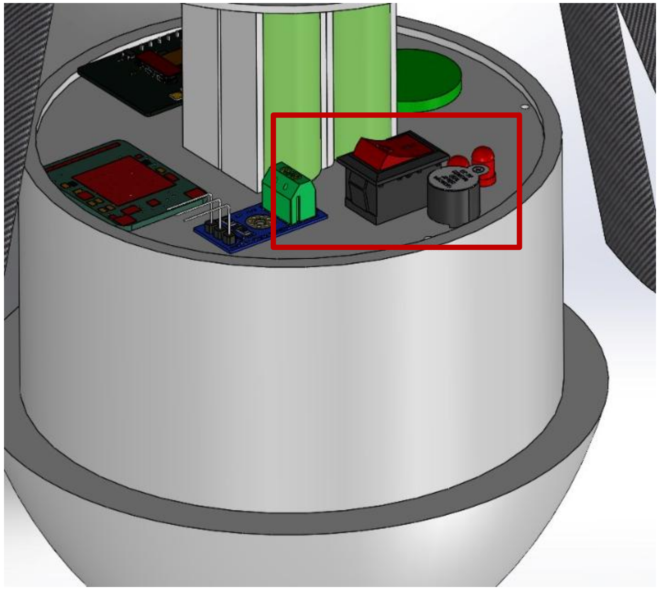
- There will be a label with the team's email address, contact information and phone number on the CanSat.

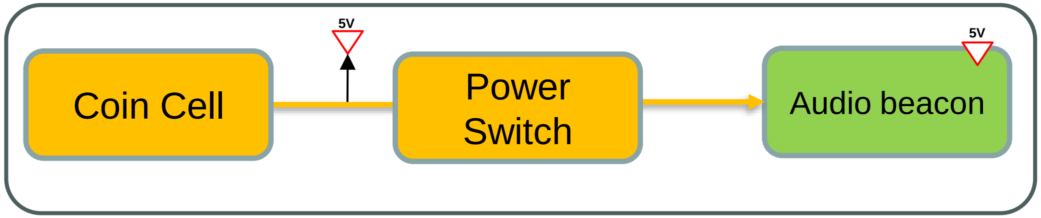
CanSat Beacon Design

- The audio beacon have an easily accessible power switch.
- The audio Beacon is operate on a separate battery.
- Audible beacon that is turned on with power switch separately from Cansat electronics.
- Audio beacon tested for recovery mission.

– Features of audio beacon:
  - Working Voltage: 4-8 V
  - Sound Output: 85 Db

– Coin cell battery pack used to supply power the audio beacon.

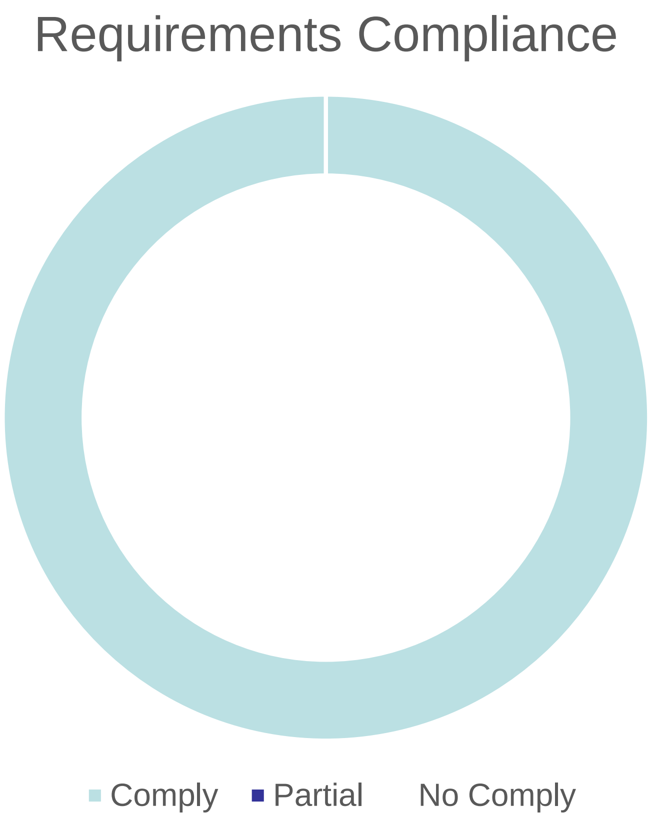




Requirements Compliance

Gürkan ALKAN

Requirements Compliance Overview



- The requirements are fully **complied**.

There are no major problems for compliance of the requirements.

The design will be updated if there is an incompliance in the future.

Requirements Compliance (1/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
Operational Requirements				
C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	64, 68	
C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	71, 73	
C3	The Cansat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	23, 24	
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	23, 25	
C5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	23, 25, 80	
C6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	23, 25	
C7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Comply	23, 25	
C8	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	141, 143	
C9	The payload shall record video of the release of the payload from the container and the operation of the auto-gyro descent control system.	Comply	15, 37	
C10	A second video camera shall point in the north direction during descent.	Comply	15, 38	
C11	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	Comply	91	

Requirements Compliance (2/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
C12	The second video camera shall be spin stabilized so the ground view is not rotating in the video.	Comply	36, 91	
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat electronics.	Comply	117, 118	
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	177, 179	
Structural Requirements				
S1	The CanSat mass shall be 1400 grams +/- 10 grams.	Comply	98, 99	
S2	Nose cone shall be symmetrical along the thrust axis.	Comply	45, 46, 47	
S3	Nose cone radius shall be exactly 72.2 mm	Comply	65	
S4	Nose cone shoulder length shall be a minimum of 50 mm	Comply	65	
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	64 , 68	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	64	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	65	
S8	Cansat structure must survive 15 Gs vibration.	Comply	55, 57, 64	
S9	Cansat shall survive 30 G shock.	Comply	55, 57, 64	

Requirements Compliance (3/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
S10	The container shoulder length shall be 90 to 120 mm.	Comply	73	
S11	The container shoulder diameter shall be 136 mm.	Comply	73	
S12	Above the shoulder, the container diameter shall be 144.4 mm	Comply	73	
S13	The container wall thickness shall be at least 2 mm.	Comply	73	
S14	The container length above the shoulder shall be 250 mm +/- 5%.	Comply	73	
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	64, 68	
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	83	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	64, 95, 120	
S18	The Cansat container shall meet all dimensions in section F.	Comply	73	
S19	The Cansat container materials shall meet all requirements in section F	Comply	71	
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	N/A	We will not separate nose cone
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 15 Gs acceleration.	Comply	N/A	We will not separate nose cone

Requirements Compliance (4/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
Mechanism Requirements				
M1	No pyrotechnical or chemical actuators are allowed.	Comply	55, 57	
M2	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	Comply	152	
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	55, 57, 64	
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	120	
Electrical Requirements				
E1	Lithium polymer batteries are not allowed.	Comply	119	
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	119	
E3	Easily accessible power switch is required	Comply	120	
E4	Power indicator is required	Comply	120	

Requirements Compliance (5/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
E5	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Comply	122	
E6	The audio beacon shall operate on a separate battery.	Comply	117, 118	
E7	The audio beacon shall have an easily accessible power switch.	Comply	118	
Communications Requirements				
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	106	
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	107	
X3	XBEE radios shall not use broadcast mode.	Comply	107	
X4	The probe shall transmit telemetry once per second.	Comply	106	
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	109, 110, 111, 112	
Sensor Requirements				
SN1	Cansat payload shall measure its altitude using air pressure.	Comply	29, 30	
SN2	Cansat payload shall measure its internal temperature.	Comply	29, 31	
SN3	Cansat payload shall measure its battery voltage.	Comply	29, 32	
SN4	Cansat payload shall track its position using GPS.	Comply	29, 33	
SN5	Cansat payload shall measure its acceleration and rotation rates.	Comply	29, 35	

Requirements Compliance (6/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
SN6	Cansat payload shall measure auto-gyro rotation rate.	Comply	29, 34	
SN7	Cansat payload shall video record the release of the parachute and deployment of the auto-gyro at 75% peak altitude.	Comply	29, 37	
SN8	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	Comply	29, 38, 91	
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 in either direction.	Comply	29, 36, 38, 91	
SN10	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	37, 38	
SN11	The Cansat shall measure the magnetic field.	Comply	36	
Ground Station Requirements				
G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Comply	140	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	143	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	142, 143	
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	124	
G5	Each team shall develop their own ground station.	Comply	138, 143	
G6	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	138, 139, 140, 141, 142	

Requirements Compliance (7/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
G7	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	138	
G8	Teams shall plot each telemetry data field in real time during flight.	Comply	138, 139	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	134, 135, 136	
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	135	
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	140	
G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the Cansat.	Comply	141, 143	
G13	The ground station shall use a table top or handheld antenna.	Comply	136, 137	
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	135, 138	
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	138, 142	
G16	The ground station shall be able to activate all mechanisms on command.	Comply	140	

Requirements Compliance (8/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
Flight Software Requirements				
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	127	
F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	124 ,127	
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	124, 127	
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	130	
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	130	
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	124, 130	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	129	

Management

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CanSat Budget – Hardware (1/2)

Component	Quantity	Subsystem	Status	Unit Cost	Total Cost	Type
Teensy 4.1 Development Board	x1	Electronics	Re-use	31.50 $	31.50 $	Actual
XBee-PRO S3B RF Module	x2	Electronics	New	57 $	114 $	Actual
Camera Module Motorobit B19 1500 Tvl 2.1mm Fpv Camera Module	x1	Electronics	Re-use	37 $	37 $	Actual
Adafruit BME280 Temperature Humidity Pressure Sensor	x1	Electronics	Re-use	14.95 $	14.95 $	Actual
SparkFun NEO-M9N	x1	Electronics	New	69.95 $	69.95 $	Actual
MPU9255	x1	Electronics	Re-use	15.99 $	15.99 $	Actual
Runcam mini Fpv DVR Module	x1	Electronics	Re-use	17.99 $	17.99 $	Actual
SanDisk Ultra 16GB microSD Card	x1	Electronics	Re-use	8.46 $	8.46 $	Actual
Buzzer	x1	Electronics	New	1.90 $	1.90 $	Actual
ESP 32CAM	x1	Electronics	Re-use	11 $	11 $	Actual
Voltage sensor module	x1	Electronics	Re-use	1.55 $	1.55 $	Actual
3V Lithium Coin Cell Battery - CR1220	x1	Electronics	New	0.95 $	0.95 $	Actual
Molicel INR-21700-P45B- Li-Ion Battery	x4	Electronics	New	12.86 $	51.44 $	Actual
Xbee Explorer USB Adaptor	x2	Electronics	Re-use	4.2 $	8.4 $	Actual

CanSat Budget – Hardware (2/2)

Component	Quantity	Subsystem	Status	Unit Cost	Total Cost	Type
3mm Green LED	x1	Electronics	New	0.2 $	0.2 $	Actual
Xbee WRL 09143 antenna	x1	GS Antenna	New	9 $	9 $	Actual
SanDisk Ultra 16GB microSD Card	x3	Electronics	Re-use	4.20$	12.60 $	Actual
PLA+ Filament	x1	Mechanics	New	23.42 $	23.42 $	Actual
40D Ripstop Parachute Fabric	x2 m	Mechanics	Re-use	5.05 $	11.10 $	Actual
Rolling Swivel package	x1 pkg	Mechanics	Re-use	1.22 $	1.22 $	Actual
HC-020K RPM Sensor	x1	Electonics	New	2.85 $	2.85 $	Actual
Voltgae regulator	x2	Electronics	New	10 $	10 $	Actual
R2304 F3P Airplane Brushless Motors	X2	Mechanics	New	24 $	48 $	Actual
SunSky X 18A ESC	X2	Mechanics	New	18 $	36 $	Actual
Servo motor	x1	Mechanics	New	8.75 $	8.75 $	Actual
Hardware tools (screws, springs, etc.)	>2	Mechanics	N/A	-	40 $	Estimated
Passive electronis components	>2	Electronics	N/A	-	12 $	Estimated

Total Hardware Cost = 694,20 $

CanSat Budget – Other Costs (1/2)

Component	Quantity	Subsystem/Aim of use	Total Cost	Currency	Status
PC	1	Ground Station	0	$	Personal computer ✓
Phoenix Contact RAD-ISM-900-ANT-YAGI-10-N	1	Ground Station	325	$	Purchased last year (Re-use)
3D Printer	1	Prototyping	7500	₺	Purchased by our sponsor ✓
Test equipment's	>1	Lab tests	-	$	Purchased by our sponsor ✓
Environmental test facilities		The laboratories of our school are going to be used.			
Flights + Visas	7		8900	$	Estimated
Rentals	-	-	-	$	No projected rentals yet

	Source	Type of support
Sources of Income	**ULAK COMMUNICATIONS INC.**	**Financial (1000 $)**
	İHAMER Aerospace & Defense Technologies	**Test Equipment's**

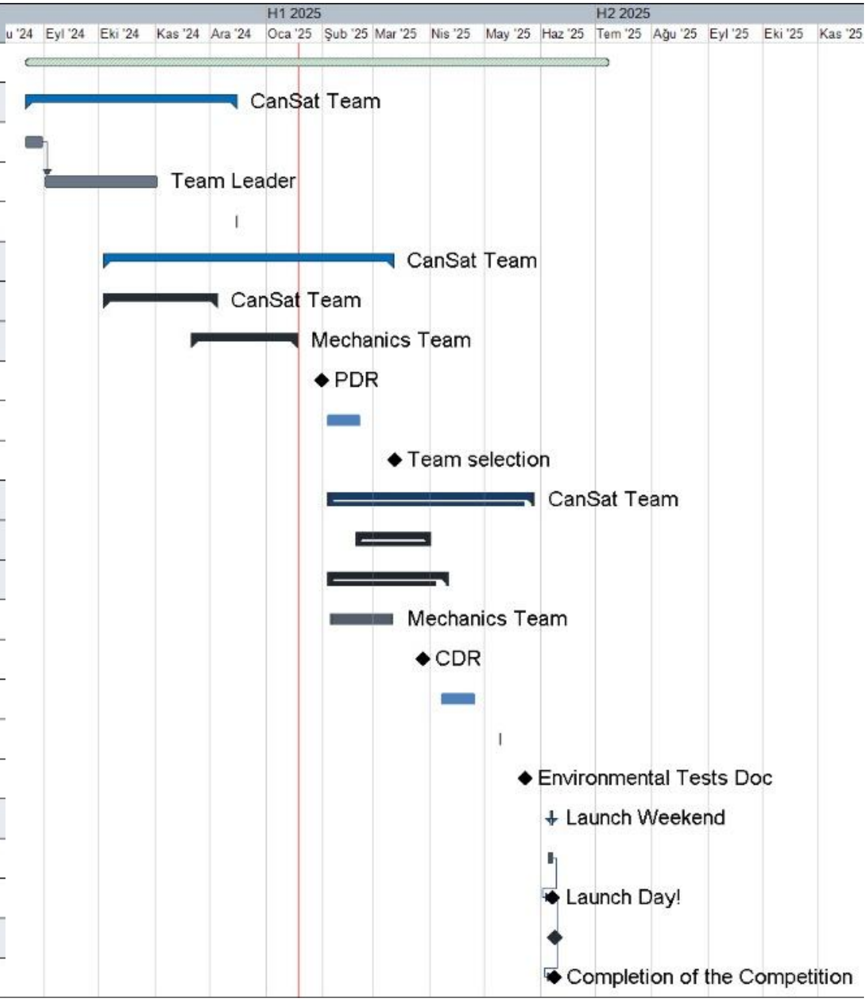
CanSat Budget – Other Costs (2/2)

TOTAL COSTS	
Cost Type	Total
Hardware	694.20 $
Other	9430 $
TOTAL	**10121.20 $**

- ✓ Development of the CanSat is under 1000$
- Funding is currently being sought for travel and accommodation expenses.

Program Schedule Overview

		Task Name	Start	End	Duration
1		TEAM APASTRON - CANSAT PROJECT	21.08.2024	8.07.2025	233 days
2		**PHASE 1- Application**	**21.08.2024**	**15.12.2024**	**85 days**
3		Examination of the Competition Guide by the te...	21.08.2024	30.08.2024	8 days
4		Application	1.09.2024	1.11.2024	46 days
5		Last day of Application payment	15.12.2024	15.12.2024	1 day
6		**PHASE 2- PDR**	**3.10.2024**	**12.03.2025**	**116 days**
7		**Development of the Design**	**3.10.2024**	**4.12.2024**	**45 days**
9		**Development of the Prototype**	**20.11.2024**	**17.01.2025**	**45 days**
11		Deadline for uploading the PDR Documents to ...	31.01.2025	31.01.2025	0 days
12		PDR Presentations	3.02.2025	21.02.2025	15 days
13		Top 40 teams selected. Invitation letters to be r...	12.03.2025	12.03.2025	0 days
14		**PHASE 3- CDR**	**3.02.2025**	**28.05.2025**	**83 days**
15		**Finalizing the Design**	**19.02.2025**	**1.04.2025**	**30 days**
17		**Subsystem Tests**	**3.02.2025**	**11.04.2025**	**50 days**
19		Manufacturing the parts	5.02.2025	11.03.2025	25 days
20		Deadline for uploading the CDR Documents to ...	28.03.2025	28.03.2025	0 days
21		CDR Presentations	7.04.2025	25.04.2025	15 days
22		CDR results posted	9.05.2025	9.05.2025	1 day
23		Environmental Test Documents	23.05.2025	23.05.2025	0 days
24		**PHASE 4- LAUNCH WEEKEND**	**6.06.2025**	**7.06.2025**	**1 day**
25		Flight Readiness Review (FRR)	6.06.2025	6.06.2025	1 day
26		Launch Day	7.06.2025	7.06.2025	0 days
27		**PHASE 5- Post Flight**	**8.06.2025**	**8.06.2025**	**0 days**
28		Post Flight Review (PFR) , Awards	8.06.2025	8.06.2025	0 days



Detailed Program Schedule (1/3)

One of the most important factors in the success of a project is, undoubtedly, project planning.

- A detailed program schedule was prepared, taking into account the important details of the project.
- This plan is important for each team member to benefit from future events while working and to make their own planning accordingly.
- The CanSat Project consists of 5-phases.

Indicators:

: Academic milestones (exam)

: Academic holiday

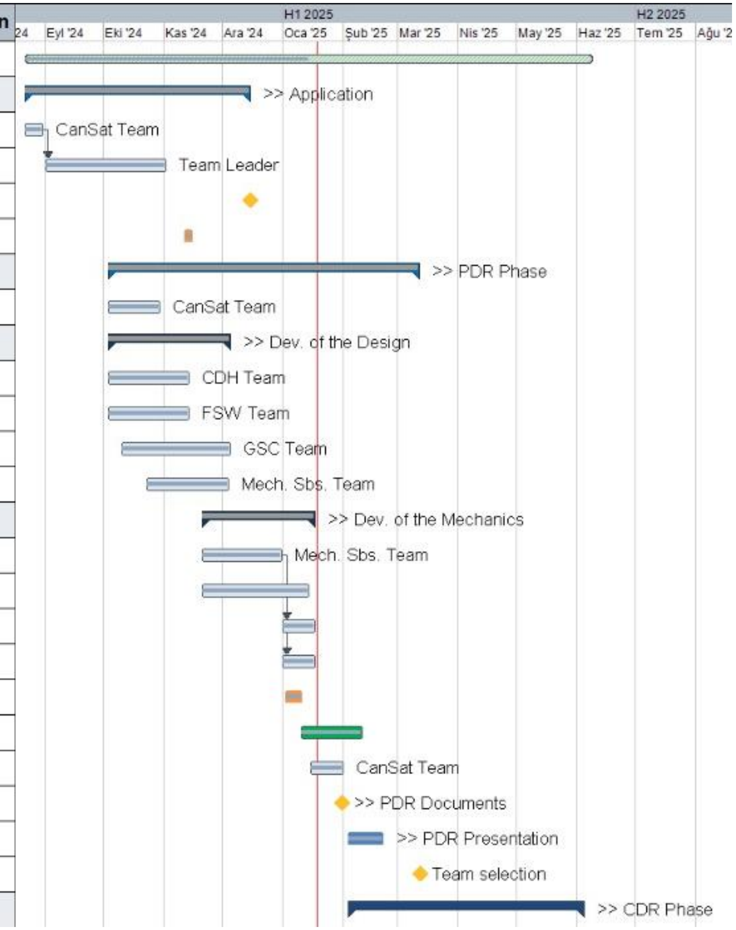
: Competition milestones

: Current date

: Major integration and test activities

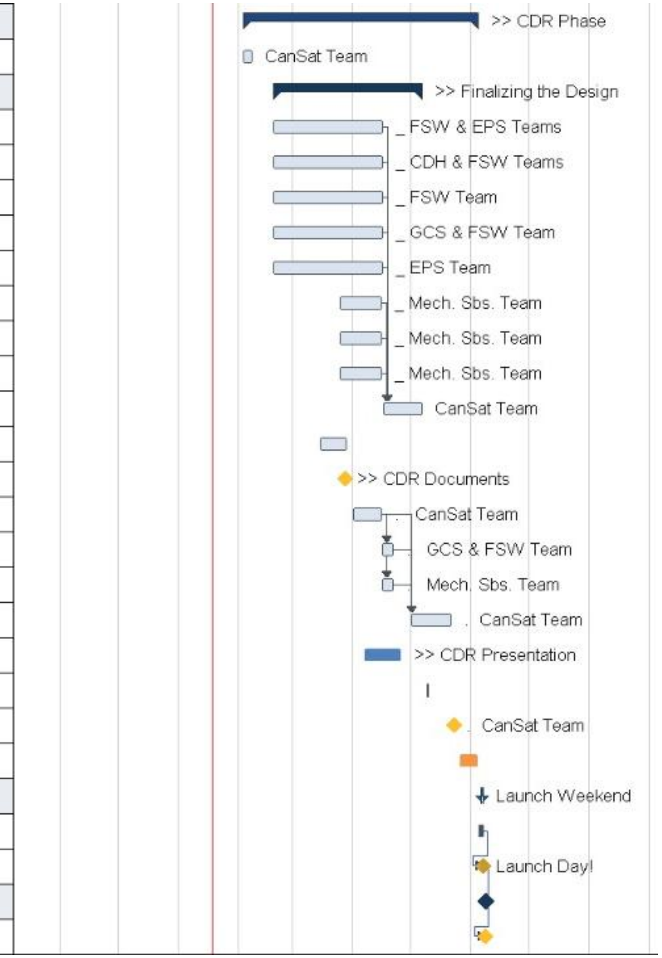
Detailed Program Schedule (2/3)

		Task Name	Start	End	Duration	Completion
1		TEAM APASTRON - CANSAT PROJECT	21.08.2024	9.06.2025	210 days	50%
2		**PHASE 1- Application**	**21.08.2024**	**15.12.2024**	**84 days**	**100%**
3		Examination of the Mission Guide	21.08.2024	30.08.2024	8 days	100%
4		Application	1.09.2024	1.11.2024	46 days	100%
5		Last day of Application payment	15.12.2024	15.12.2024	0 days	100%
6		Mid-term exams	11.11.2024	15.11.2024	5 days	100%
7		**PHASE 2- PDR**	**3.10.2024**	**12.03.2025**	**114,81 da...**	**100%**
8		Examining the PDR template and distributing tasks to team ...	3.10.2024	29.10.2024	19 days	100%
9		**Development of the Design**	**3.10.2024**	**4.12.2024**	**45 days**	**100%**
10		Preliminary Communication Tests	3.10.2024	13.11.2024	30 days	100%
11		Development of Flight Software (Theoretical)	3.10.2024	13.11.2024	30 days	100%
12		Prototyping the GSC Software	10.10.2024	4.12.2024	40 days	100%
13		Determination of Mechanical components as a draft	23.10.2024	3.12.2024	30 days	100%
14		**Development of the Mechanics**	**20.11.2024**	**17.01.2025**	**43 days**	**100%**
15		Design of the CanSat prototype #1 and #2	20.11.2024	31.12.2024	30 days	100%
16		Design of the Auto-Gyro Mechanism	20.11.2024	14.01.2025	40 days	100%
17		Descent Control Design	31.12.2024	17.01.2025	13 days	100%
18		Updating and Optimizing the Mechanical Designs	31.12.2024	17.01.2025	13 days	100%
19		Final exams	2.01.2025	10.01.2025	7 days	100%
20		Semester Break	10.01.2025	10.02.2025	22 days	100%
21		PDR Time Slot selection	15.01.2025	31.01.2025	13 days	100%
22		Deadline for uploading the PDR Documents to the system	31.01.2025	31.01.2025	0 days	100%
23		PDR Presentations	3.02.2025	21.02.2025	15 days	100%
24		Top 40 teams selected. Invitation letters to be requested	12.03.2025	12.03.2025	0 days	0%
25		**PHASE 3- CDR**	**3.02.2025**	**4.06.2025**	**88,03 days**	**0%**



Detailed Program Schedule (3/3)

25	**PHASE 3- CDR**	**3.02.2025**	**4.06.2025**	**88,03 days**	**0%**
26	Examining the CDR template and distributing tasks to team ...	3.02.2025	7.02.2025	5 days	0%
27	**Finalizing the Design**	**19.02.2025**	**6.05.2025**	**55 days**	**0%**
28	Subsystem level tests of Sensors and the Processor	19.02.2025	16.04.2025	41 days	0%
29	Communication Tests	19.02.2025	16.04.2025	41 days	0%
30	Development and Tests of Flight Software	19.02.2025	16.04.2025	41 days	0%
31	Testing the GSC Software	19.02.2025	16.04.2025	41 days	0%
32	EPS Tests	19.02.2025	16.04.2025	41 days	0%
33	Descent Control Subsystem tests	25.03.2025	15.04.2025	16 days	0%
34	Auto-Gyro Mechanism tests	25.03.2025	15.04.2025	16 days	0%
35	Parachute deployment tests	25.03.2025	15.04.2025	16 days	0%
36	Updating the design according to the test results and/or in...	16.04.2025	6.05.2025	14 days	0%
37	CDR Time slot selection	15.03.2025	28.03.2025	10 days	0%
38	Deadline for uploading the CDR Documents to the system	28.03.2025	28.03.2025	0 days	0%
39	Production and Integration Process	1.04.2025	15.04.2025	11 days	0%
40	System Level Communication Tests	16.04.2025	21.04.2025	4 days	0%
41	System Level Mechanism Tests	16.04.2025	21.04.2025	4 days	0%
42	Environmental Tests	1.05.2025	21.05.2025	15 days	0%
43	CDR Presentations	7.04.2025	25.04.2025	15 days	0%
44	CDR results posted	9.05.2025	9.05.2025	1 day	0%
45	Environmental Test Documents	23.05.2025	23.05.2025	0 days	0%
46	Final Exams	26.05.2025	4.06.2025	8 days	0%
47	**PHASE 4- LAUNCH WEEKEND**	**6.06.2025**	**7.06.2025**	**1 day**	**0%**
48	Flight Readiness Review (FRR)	6.06.2025	6.06.2025	1 day	0%
49	Launch Day	7.06.2025	7.06.2025	0 days	0%
50	**PHASE 5- Post Flight**	**8.06.2025**	**8.06.2025**	**0 days**	**0%**
51	Post Flight Review (PFR) , Awards	8.06.2025	8.06.2025	0 days	0%



Conclusions

Subsystem planning and designs, mechanical, software and electrical designs of the CanSat according to technical requirements are presented in the PDR.

Major Accomplishments

- 90% of the components ordered & received.
- Mechanical design completed.
- All sensors has been tested.
- Radio protocol and communications prototyped.
- Ground Station Interface design is completed.
- All requirements are compliant.
- Project is on schedule.

Major Unfinished Work

- System-level tests
- Sponsor interviews for funding for the travel costs is proceeding

Our team is ready to proceed to the next stage as; major design work has been completed, we already started to prepare for the CDR, and the Project is in the prototyping and test phase.

We are ready!!