CanSat 2025
Critical Design Review (CDR)

#3145
Apastron

Presentation Outline

Contents

Team Organization

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	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver/Transmitter (Serial)
XCTU	Next Generation Configuration Platform for XBEE/RF Solutions

System 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.**

Summary of Changes Since PDR

Subsystem	Change	PDR	CDR	Reasoning
Sensor	Ground Camera Sensor	B19 sensor is selected as Ground Camera sensor	ESP32-CAM sensor is selected as Ground Camera sensor	Video losses caused by momentary power outages in the B19 sensor have been prevented with the ESP32-CAM. With our specially designed software for the ESP32-CAM, videos have been recorded without any frame loss.
CDH	Payload Radio Module	Xbee PRO S3B with external antenna WRL-09143 is selected as Radio module	Xbee PRO S3B with Wire antenna is selected as Radio module	lighter and more compact structure providing long-distance data communication

apastron

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

Pre-Launch Activities

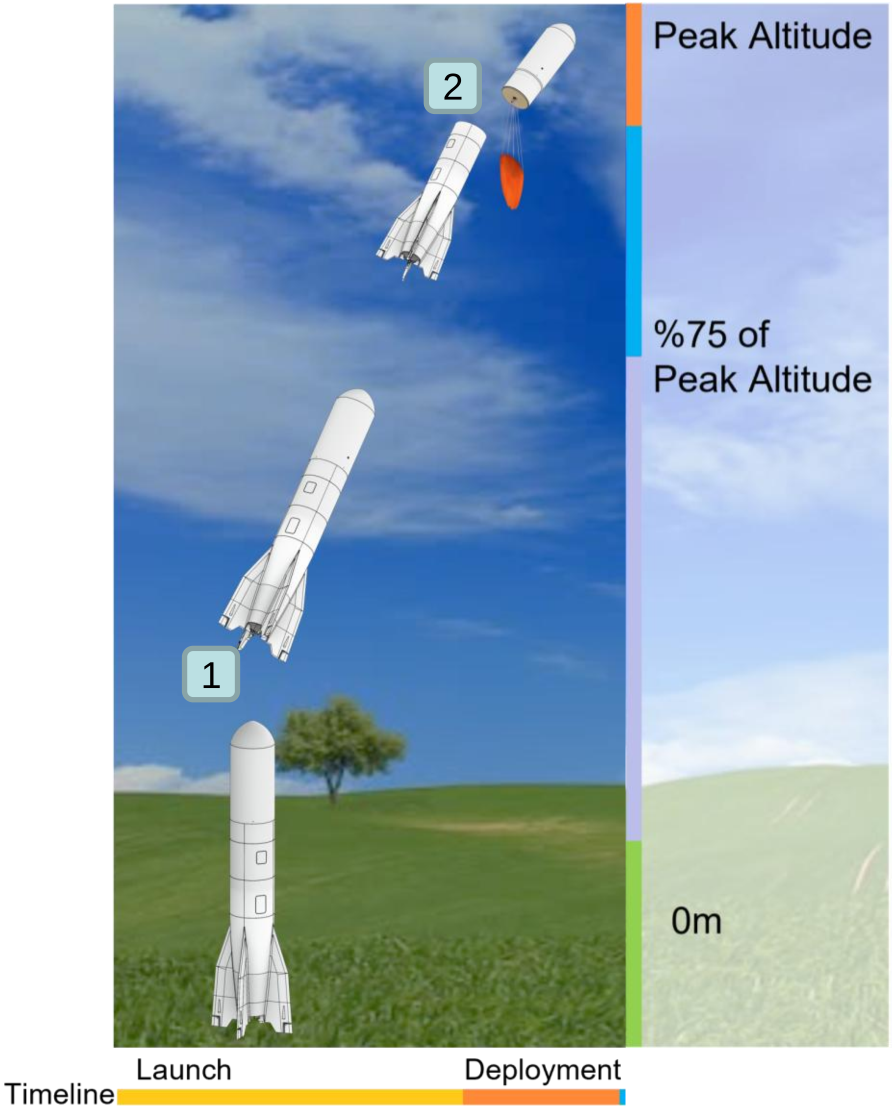
Title	Team Member(s)
Mission Control Officer (MCO)	Gürkan ALKAN
Ground Station Crew (GSC)	Muhamed Said GONUL, Muhammet Akın OZEL, Aleyna YILMAZ, Metin SATI
Recovery Crew (RC)	Bugrahan DEGIRMENCI, Göktuğ KOCCENK
CanSat Crew (CC)	Enes KALENDER, Atakan SAYDAM, Alperen Ragıp SOYLER

Ground Station Setup → CanSat Final Preparations → CanSat Check-In → Launch Preparation Procedures

- Each team member will follow the Launch Preparation Procedures listed in the Mission Operations Manual and assigned to the roles shown above in the table.
- The responsibilities of each team member are discussed in detail in *Mission Sequence of Events* section.

System Concept of Operations (CONOPS) (2/5)

System Concept of Operations (CONOPS) (3/5)



Launch 1

Corresponding States:
LAUNCH_PAD & ASCENT

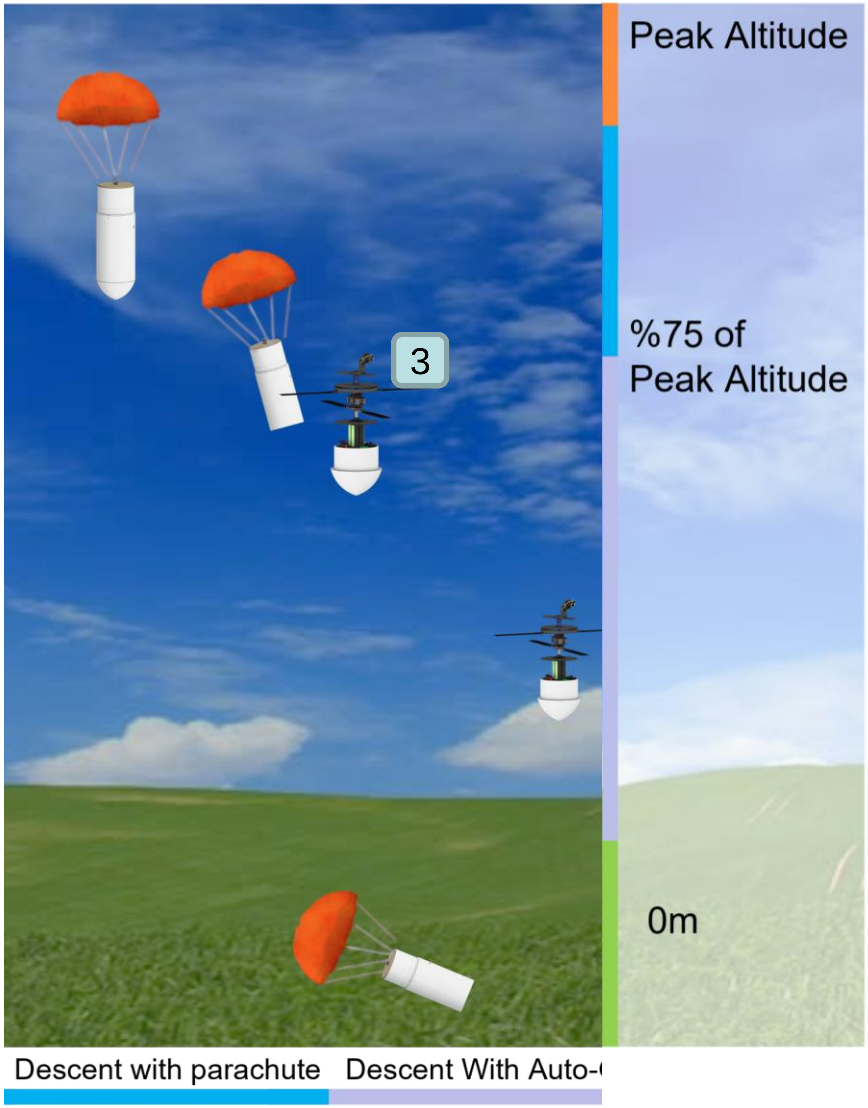
The CanSat (container and payload) will take the place and function of the nose cone and some part of rocket during ascent. Cansat shall ascent the peak altitude with rocket. The cansat transmits telemetry once per second (1Hz) to the ground station, from launch to landing.

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 automatically.

System Concept of Operations (CONOPS) (4/5)



Descent 3

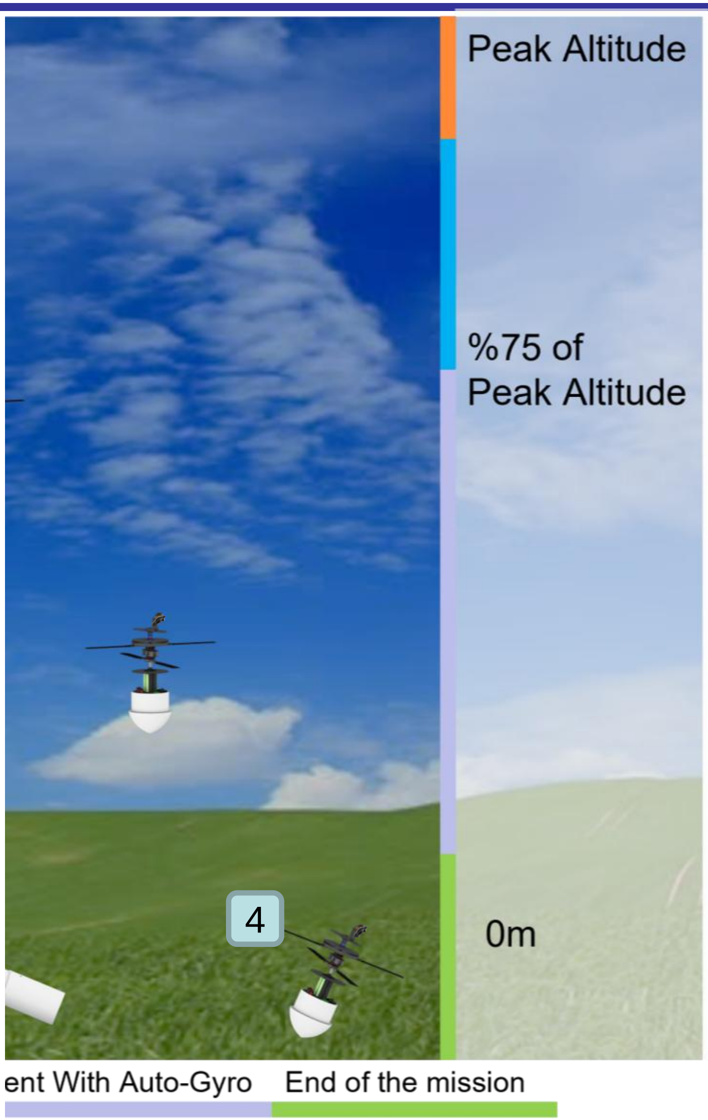
Corresponding States:
DESCENT & PROBE_RELEASE

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.



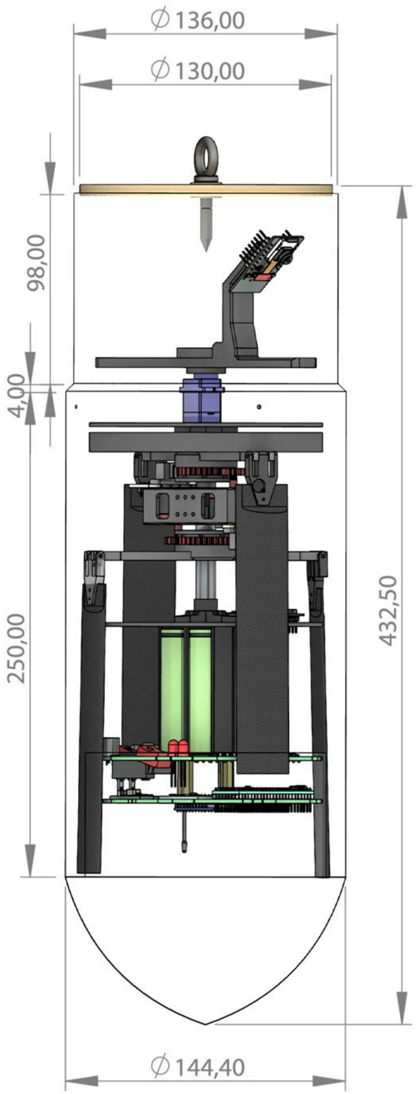
Landing 4

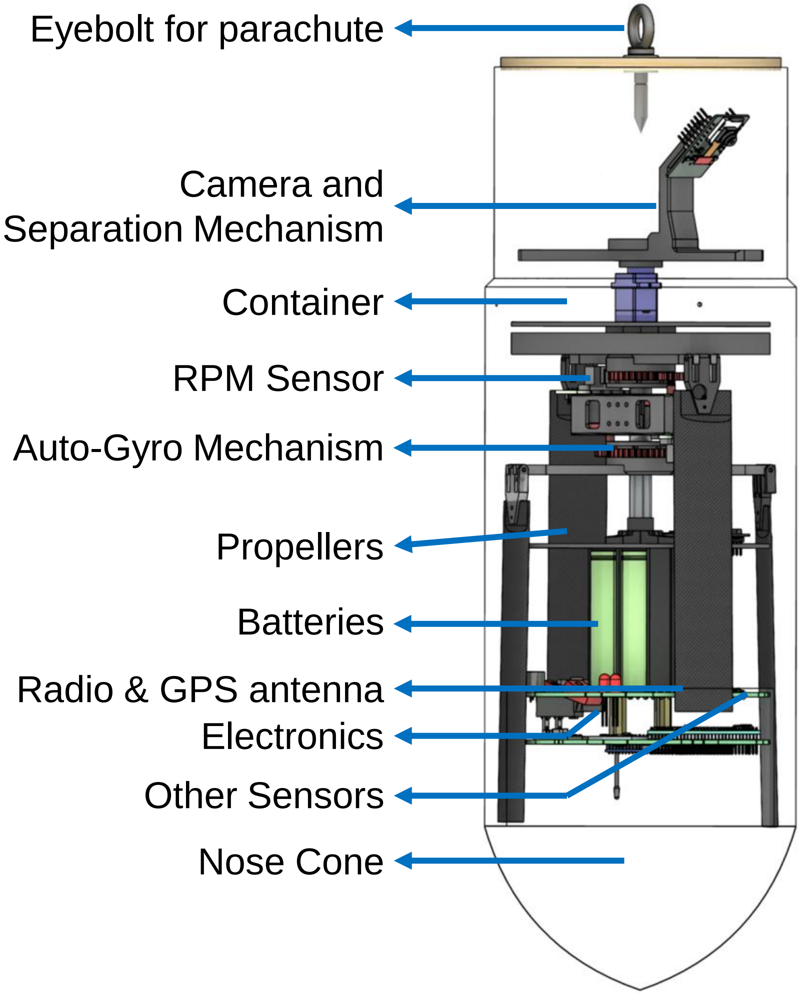
Corresponding State:
LANDED

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.

CanSat Physical Layout (1/3)

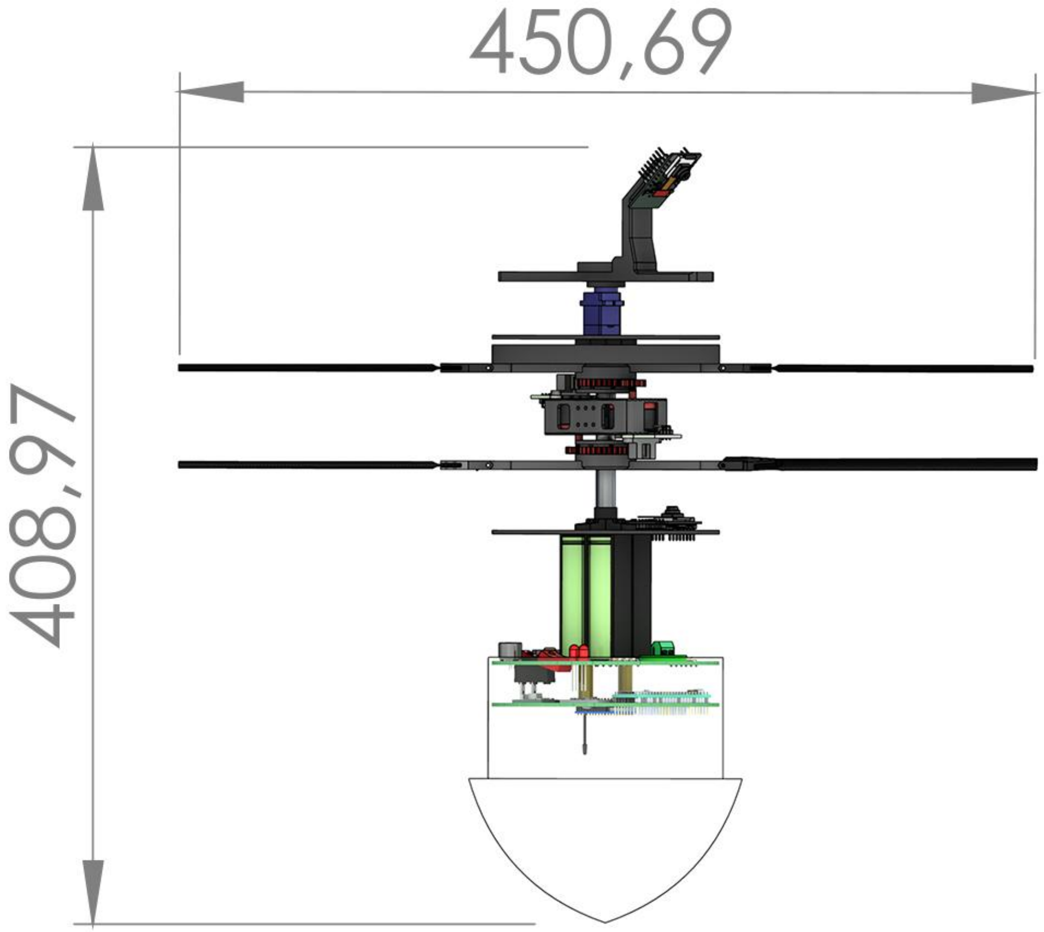




All dimensions are in mm

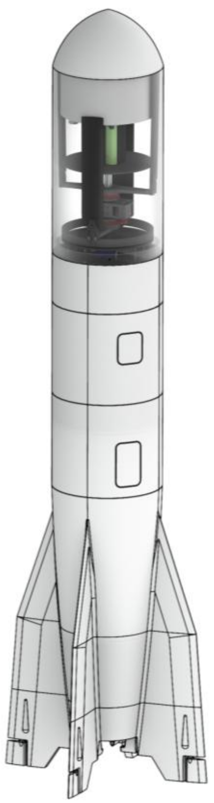
CanSat Physical Layout (2/3)

Deployed configuration

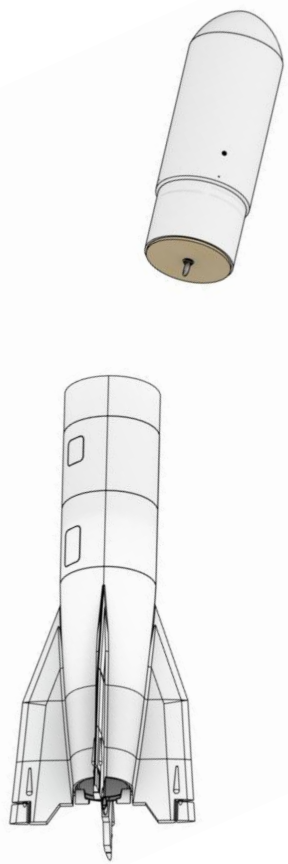


CanSat Physical Layout (3/3)

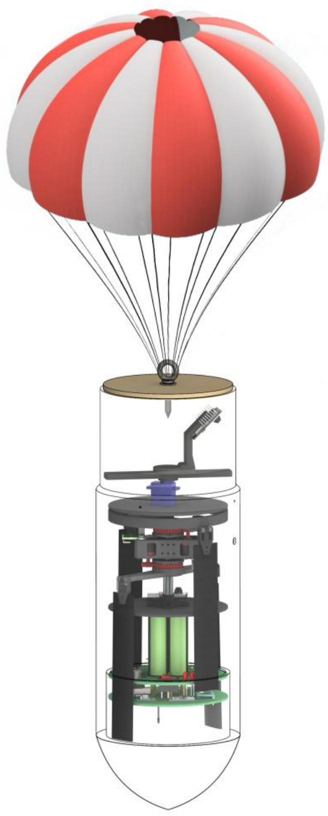
Launch



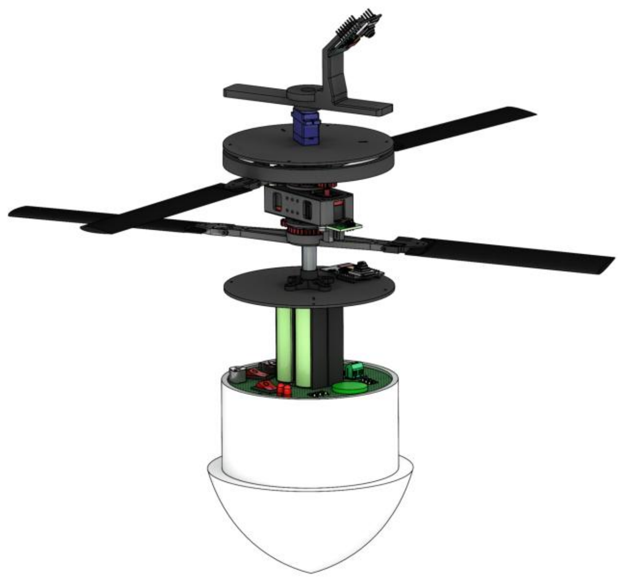
Deployment



Container + Payload Parachute Descent



Auto-Gyro Descent



Launch Vehicle Compatibility

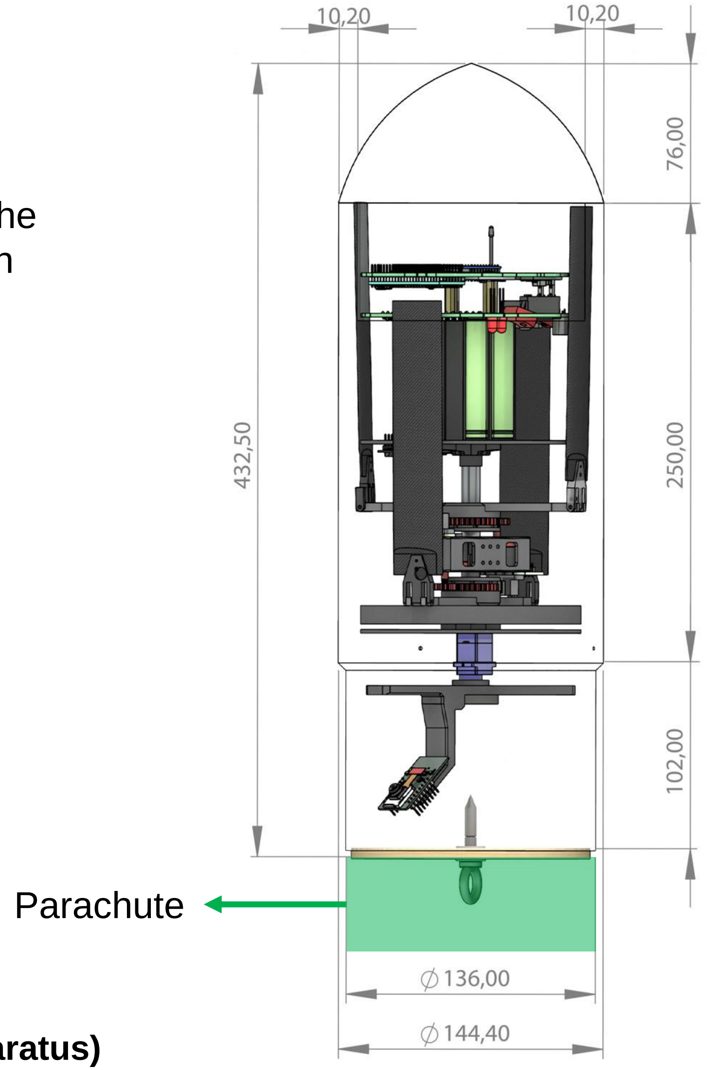
On the side is a diagram with the necessary dimensions. All dimensions are in mm.

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

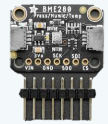
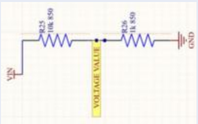
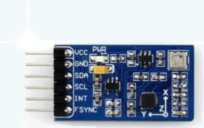


(There are no sharp protrusions at any control apparatus)

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 (x2) 	High precision 9 axes gyro acceleration magnetometer measurement, stability will be verified
AUTO-GYRO DEPLOY CAMERA GROUND CAMERA	ESP32-CAM (x2) 	Provides SD card support , easy to integrate and small size

Sensor Changes Since PDR

Changed Sensor	PDR	CDR	Rationale
Ground Camera Sensor	**B19 sensor is selected as Ground Camera sensor**	**ESP32-CAM sensor is selected as Ground Camera sensor**	**Video losses caused by momentary power outages in the B19 sensor have been prevented with the ESP32-CAM. With our specially designed software for the ESP32-CAM, videos have been recorded without any frame loss.**

Payload Air Pressure Sensor Summary

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	0.18	25.2 x 18.0 x 4.6	1	3V-5V	0.0036	300 – 1100	14.95

Equation

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

$\boldsymbol{P} = Measure\ level\ at\ current\ altitude$

$\boldsymbol{P_0} = Given\ pressure\ at\ sea\ level$

$\boldsymbol{Altitude} = Calculated\ Altitude$

Sensor Accuracy

Pressure = ±1.00 hPa
Altimeter = ±1.00 m

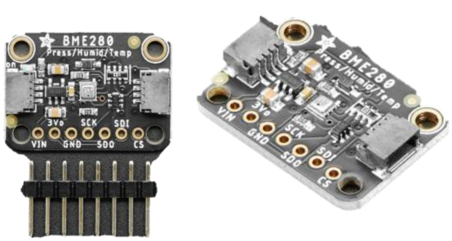
Data Format

Pressure = **PRESSURE** hPa
Altimeter = **ALTITUDE** m

Data Processing

Using libraries:
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>
This line of code gives the pressure value;
Adafruit_BME280 bme;
float altitude =bme.readAltitude(SEALEVELPRESSURE_HPA);

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



Payload Air Temperature Sensor Summary

SENSOR MODEL	INTERFACES	ACCURACY (hPa)	RESOLUTION (°C)	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	PRESSURE RANGE (hPa)	COST ($)
Adafruit BME280	**I2C OR SPI**	**±1.00**	**0.01**	**25.2 x 18.0 x 4.6**	**1**	**3V-5V**	**0.0036**	**300 – 1100**	**14.95**

Sensor Accuracy

Temperature = ±1.0 ℃

Data Processing

Using libraries:

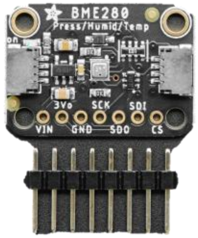
```
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>
```

This line of code gives the temperature value;

```
Adafruit_BME280 bme;
 float altitude =bme.readTemperature();
```

Data Format

Temperature = **TEMPERATURE** ℃



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

Payload Voltage Sensor Summary

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	RESOLUTION (bits)	VOLTAGE RANGE (V)	COST ($)
VOLTAGE DIVIDER	WIRE	-	-	12	0V - 33V	0

Equation

$$V_{out} = V_{in} \times \left[\frac{R_2}{R_1+R_2}\right]$$
$$\boldsymbol{R_1} = First\ resistor$$
$$\boldsymbol{R_2} = Second\ resistor$$
$$\boldsymbol{V_{in}} = Input\ voltage\ for\ circuit$$
$$\boldsymbol{V_{out}} = Measured\ output\ voltage$$

Data Format

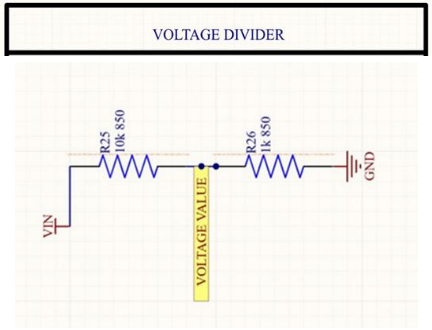
Voltage = **VOLTAGE** V

Data Processing

This line of code gives the Voltage values;

voltageSensorVal = analogRead(voltageSensorPin);

vIN = (voltageSensorVal / 4095) * 3.3*11;



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

Payload GNSS Sensor Summary

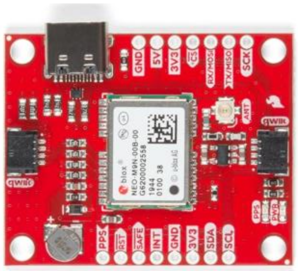
SENSOR MODEL	INTERFACES	ACCURACY (m)	SİZE (mm)	WEIGHT (g)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	UPDATE RATE (Hz)	RESOLUTION (m)	SENSIVITY (dBm)	COST ($)
SparkFun NEO-M9N	**UART, SPI, I2C, USB**	**Position 1.5 m** **Velocity 0.05 m/s**	**40.64 x 33.02 X 2.7**	**11.0**	**3.3 - 5**	**31**	**25 Hz**	**2**	**167**	**69.95**

Sensor Accuracy
Position = 1.5 m
Velocity = 0.05 m/s

Data Format
GPS Time = **GPS_TIME** hh:mm:ss
GPS Latitude = **GPS_LATITUDE** °
GPS Longitude = **GPS_LONGITUDE** °
GPS Altitude = **GPS_ALTITUDE** °
GPS Satellite = **GPS_SATS** int

Data Processing
Using library:
#include <SparkFun_u-blox_GNSS_Arduino_Library.h>
This line of code gives the GPS parameters;
day = myGNSS.getDay(); **month** = myGNSS.getMonth()
year = myGNSS.getYear(); **angle** = myGNSS.getHeading();
latitude = myGNSS.getLatitude(); **satellites** = myGNSS.getSIV();
longitude = myGNSS.getLongitude();

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
Adafruit Ultimate GPS	• Arduino libraries available • High sensivity • High accuracy • Including RTC



Auto-gyro Rotation Rate Sensor Summary

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	RESOLUTION (position)	COUNTING FREQUENCY (kHz)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	TEMPERATURE RANGE (°C)	ACCURACY	COST ($)
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**

Equation

$$\boldsymbol{RPM} = \frac{T}{N} \times 60$$

$$\boldsymbol{RPM} = Revolutions\ Per\ Minute$$

$$\boldsymbol{N} = Pulse\ in\ sample$$

$$\boldsymbol{T} = Sample\ time$$

Data Format

RPM =**AUTO_GYRO_ROTATION_RATE**

Data Processing

This line of code gives the Rotation Rate values;

```
volatile int pulseCount = 0;
pulseCount++;
const int PPR = 20;
float rpm = (pulseCount * 60.0) / PPR;//(Pulses per revolution)
pulseCount = 0;
```

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

Payload Tilt Sensor Summary

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	AXIS	RESOLUTION (bits)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	RANGE (degree or v)	COST ($)
MPU9255	**I2C OR SPI**	**30 x 30 x 1**	**2**	**9**	**16**	**3.3 - 5**	**3.2**	**±16g**	**15.99**

Data Processing

Using library:

#include <MPU9255.h>

This line of code gives the position parameters;

mpu.read_gyro(); **MPU_GYROX** = mpu.gx; **MPU_GYROY** = mpu.gy; **MPU_GYROY** = mpu.gz;
mpu.read_acc(); **MPU_ACCX** = mpu.ax; **MPU_ACCY** = mpu.ay; **MPU_ACCY** = mpu.az;

Sensor Accuracy

Position = 1.8 m *Velocity = 0.1 m/s*

Data Format

MPUa_X =**ACCEL_R°** MPUg_X=**GYRO_R**
MPUa_Y =**ACCEL_P°** MPUg_Y=**GYRO_P**
MPUa_Z =**ACCEL_Y°** MPUg_Z=**GYRO_Z**

SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
MPU9255	• High accuracy • Familiar with sensor • Most efficient working values

Payload Ground Camera Orientation Sensor

SENSOR MODEL	INTERFACES	SİZE (mm)	WEIGHT (g)	AXIS	RESOLUTION (bits)	SUPPLY VOLTAGE (V)	SUPPLY CURRENT (mA)	RANGE (degree or v)	COST ($)
MPU9255	**I2C OR SPI**	**30 x 30 x 1**	**2**	**9**	**16**	**3.3 - 5**	**3.2**	**±2000dps**	**15.99**

Data Processing

Using library:

#include <MPU9255.h>

This line of code gives the position parameters;

mpu.read_mag(); **MPU_MAGX** = mpu.mx; **MPU_MAGY** = mpu.my; **MPU_MAGY** = mpu.mz;

Sensor Accuracy

Position = 1.8 m *Velocity = 0.1 m/s*

Data Format

MPUm_X =**MAG_R**◦

MPUm_Y =**MAG_P**◦

MPUm_Z =**MAG_Y**◦

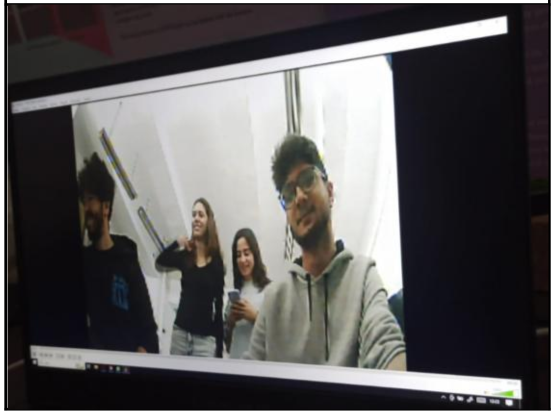
SELECTED SENSOR	REASONS FOR SELECTING THE SENSOR
MPU9255	• High accuracy • Familiar with sensor • Most efficient working values

Ground Camera Sensor Summary

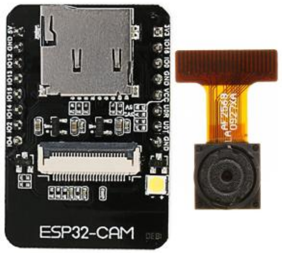
Model	Interface	Resolution (pixels)	SUPPLY CURRENT (mA)	Voltage (v)	Frame Rate (Hz)	Mass (g)	Size (mm)	Cost ($)
ESP32-CAM	I2C/UART	1600x1200	205	5	60	8	40.5x27x4.5	11

- Has internal SD card module.
- Supporting up to 1600x1200 pixels also meet the requirements of minimum 640x480 pixels.

OUTPUT



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



Auto-Gyro Deploy Camera Summary

Model	Interface	Resolution (pixels)	SUPPLY CURRENT (mA)	Voltage (v)	Frame Rate (Hz)	Mass (g)	Size (mm)	Cost ($)
ESP32-CAM	I2C/UART	1600x1200	205	5	60	8	40.5x27x4.5	11

- Has internal SD card module.
- Supporting up to 1600x1200 pixels also meet the requirements of minimum 640x480 pixels.

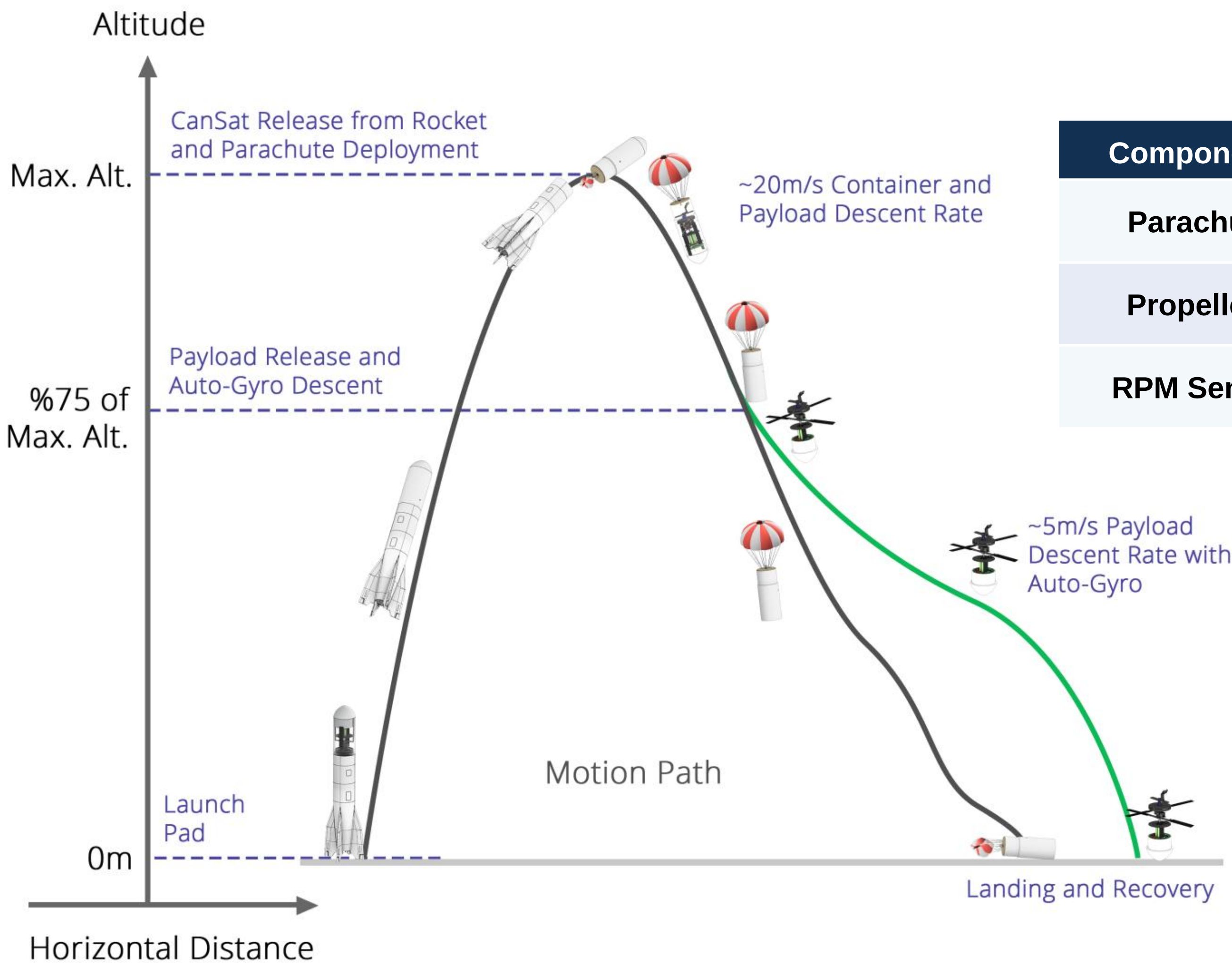
OUTPUT

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

Descent Control Design

Alperen Ragıp SOYLER

Descent Control Overview

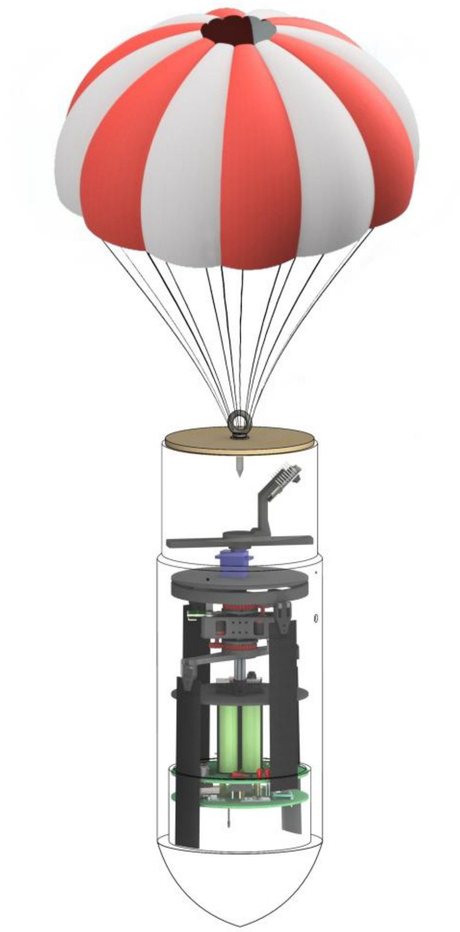


Components	Materials
Parachute	40D Ripstop Nylon
Propellers	Carbon Fiber
RPM Sensor	Semi-Conductor

Descent Control Changes Since PDR

No changes have been made to the Descent Control Design since PDR.

Container Parachute Descent Control Summary (1/2)



In our design, after the rocket separates from the container, the parachute, which is connected to the eyebolt with ropes, will open with the air flow and provide a stable descent to 75% of the maximum altitude.

Descending with the parachute at a speed of approximately 20 meters/second to 75% of the maximum altitude, CanSat will then hand over the descent to the Auto-Gyro mechanism after the parachute phase.

Container Parachute Descent Control Summary (2/2)

- **Parachute Shape:** Hemispherical
- **Area of the parachute:** $0.05362\ m^2$
- **Diameter of the parachute:** $0.2613\ m = 26.13\ cm$
- **Total gores:** 8 gores
- **Spill hole area:** 10% of the total area

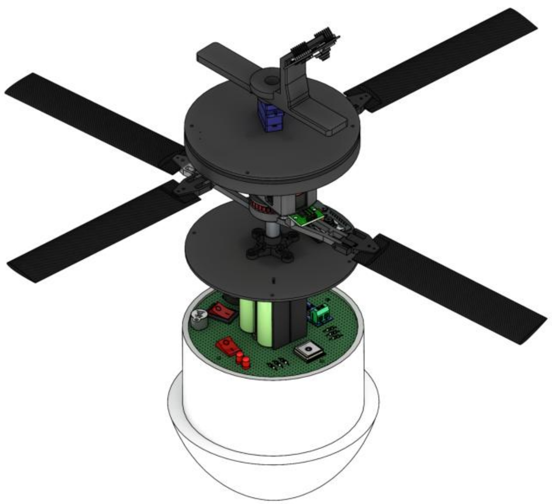
- **Color Selection:** Fluorescent Orange
- **Material:** 40D Ripstop Nylon

40D Ripstop Nylon

Please see the <u>Descent Rate Estimates parachute section</u> for calculations.

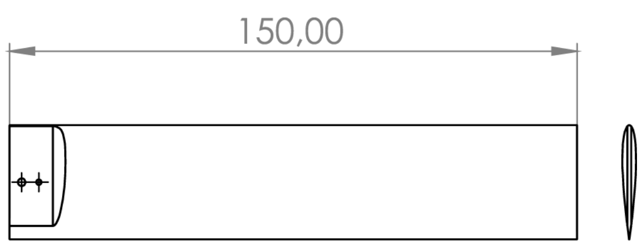
Auto-gyro Descent Control Summary (1/2)

Coaxial Rotor Auto-Gyro Mechanism



- **Propeller Airfoil:** NACA0012
- **Propeller Size:** $150\ mm$
- **Material:** Carbon Fiber
- **AoA Degree:** $10\ °$
- **Lift Coefficient:** 1
- **Drag Coefficient:** 0.03

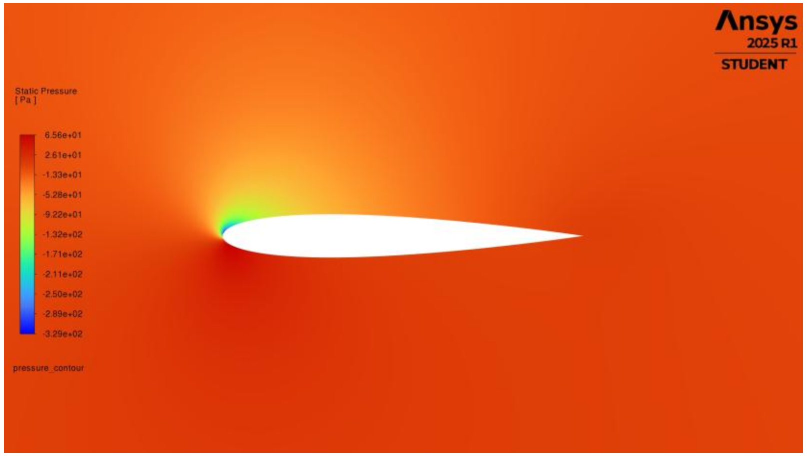
- **Rotor Area:** $0.152\ m^2$
- **Angular Velocity of Rotor:** $39.62 \frac{rad}{s}$
- **Expected Rotation Rate:** $378.34\ RPM$



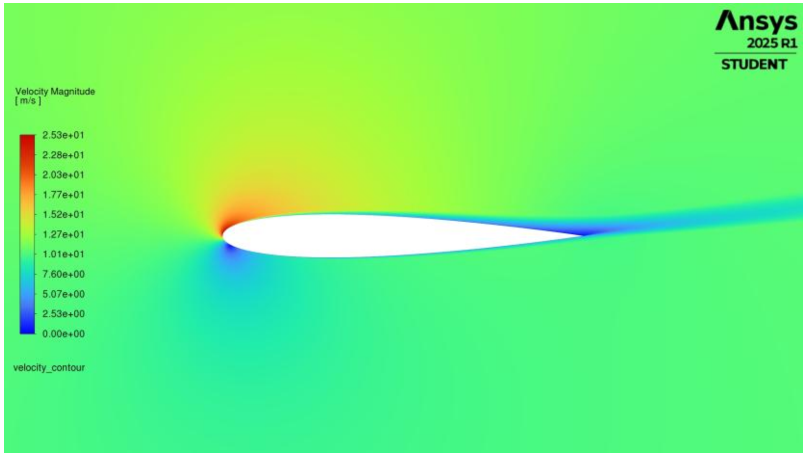
Please see the Descent Rate Estimates auto-gyro section for calculations.

Auto-gyro Descent Control Summary (2/2)

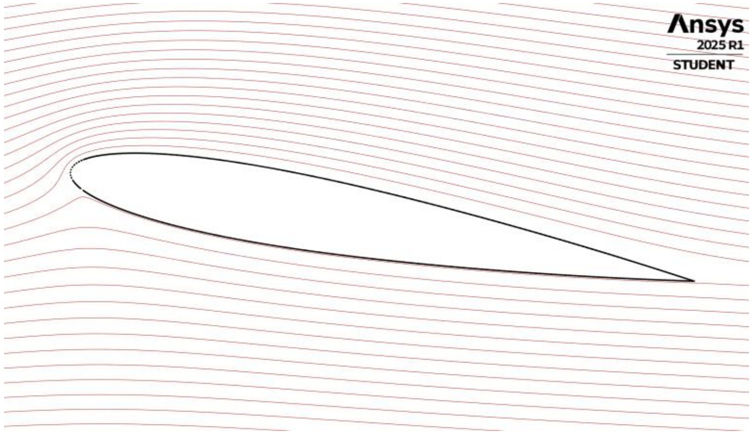
Ansys Analysis for NACA0012 Airfoil



Pressure Analysis

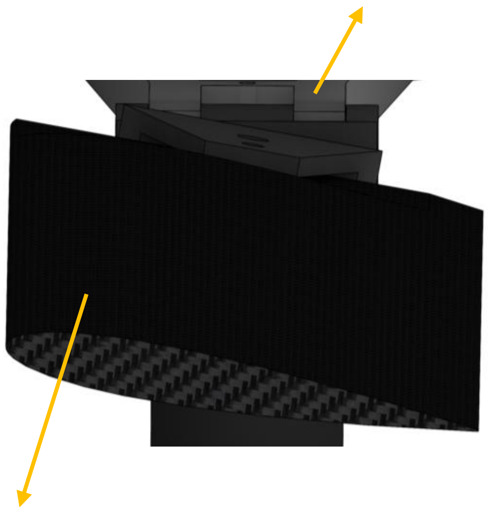


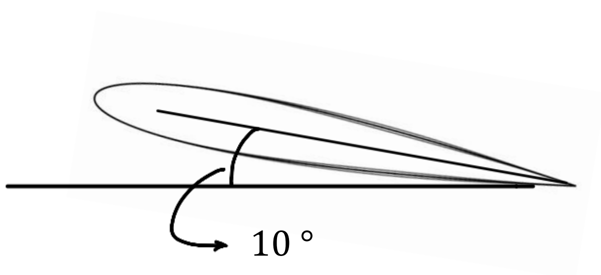
Velocity Analysis



Aerodynamic Analysis

Auto-gyro Descent Stability Control Design





Passive Control Auto-Gyro Stability

A passive stability control system will be used in the Auto-Gyro mechanism. The wings will be attached to the rotor arms at a 10-degree angle of attack. This will both make the lift coefficient more effective and reduce potential stability problems.

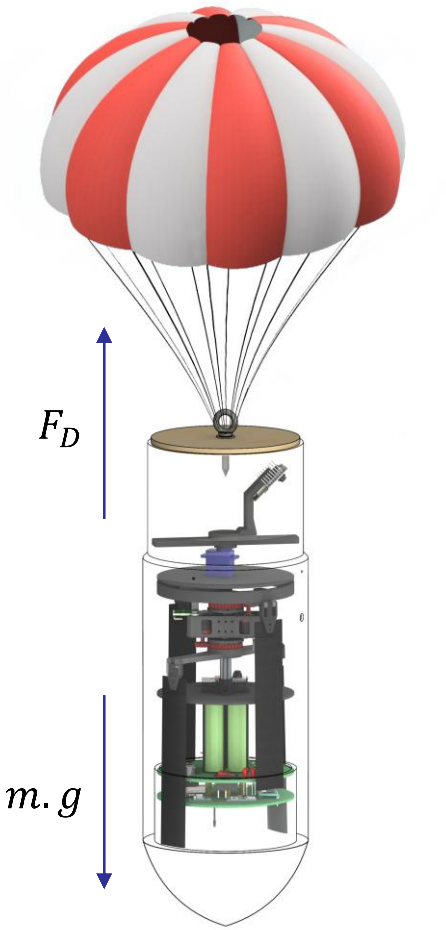
To prevent the CanSat from tumbling, both the stability of the wings attached at a specific angle of attack and the aerodynamic structure of the nose cone and the CanSat's center of mass will play an important role.

In addition, to prevent the CanSat from rotating on its own axis, a software will be added to detect rotation and adjust the rotors to create a momentum opposite to the direction of rotation to stabilize it. This adjustment will happen very quickly, so it will have no effect on the landing speed.

In this way, the nadir point can be continuously maintained.

Descent Rate Estimates (1/4)

Descent for Parachute Phase



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

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

$$F_D = m.g$$

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

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

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

$$A_{total} = 0.05362\, m^2$$ ($A_{effective}$ 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*)

$V = 20\, m/s$

$h_{avg} = 656.25\, m$

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

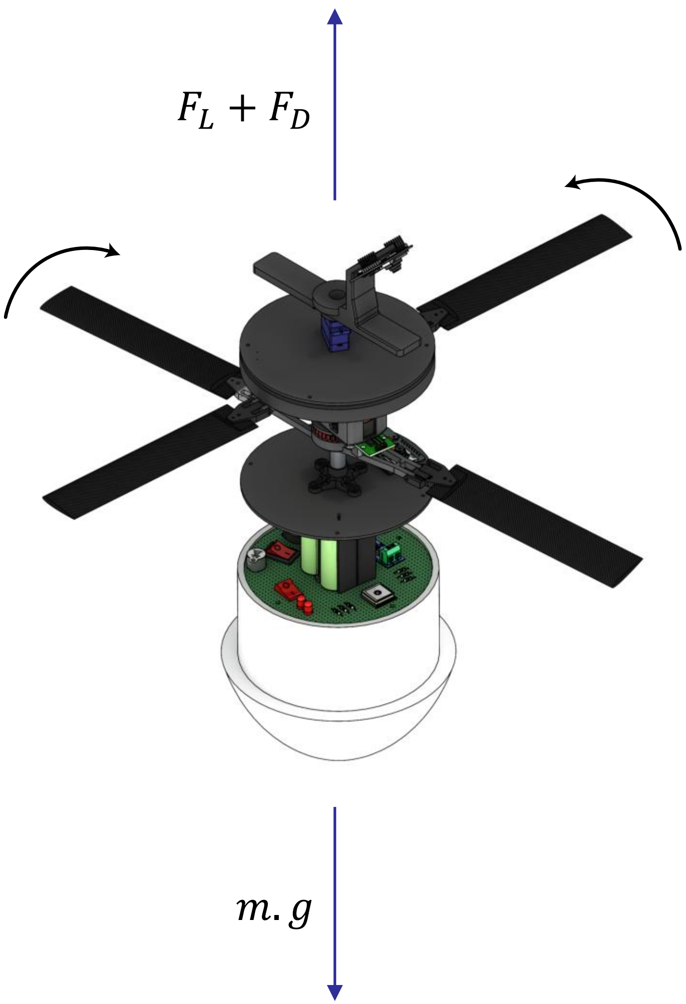
$g = 9.81\, m/s^2$

$m \approx 1.4\, kg$

C_D coefficient is assumed for hemispherical parachute with spill hole

Descent Rate Estimates (2/4)

Descent for Auto-Gyro Phase (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 Auto-Gyro Phase (2/2)

$$V = 10.22\ m/s$$

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

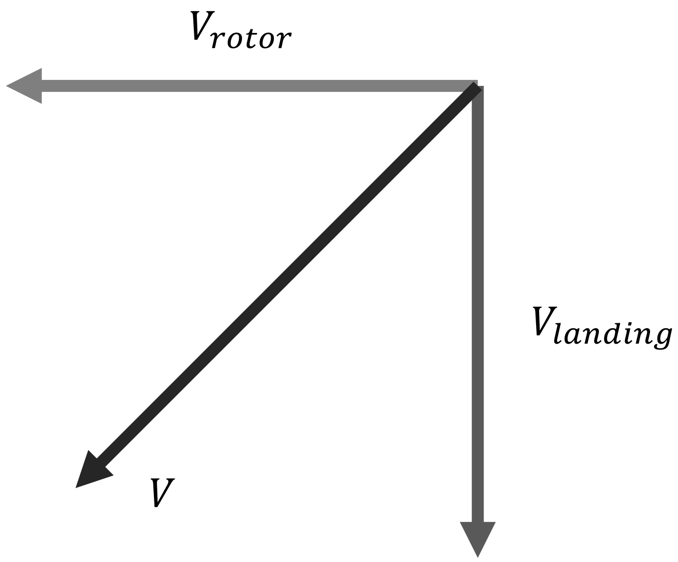
$$V_{rotor}^2 = V^2 - V_{landing}^2$$

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

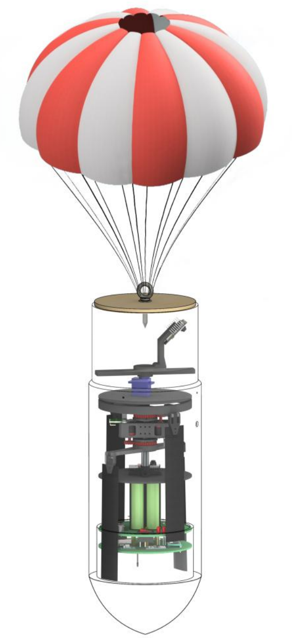
$$R_{rotor} = 0.225\ m$$

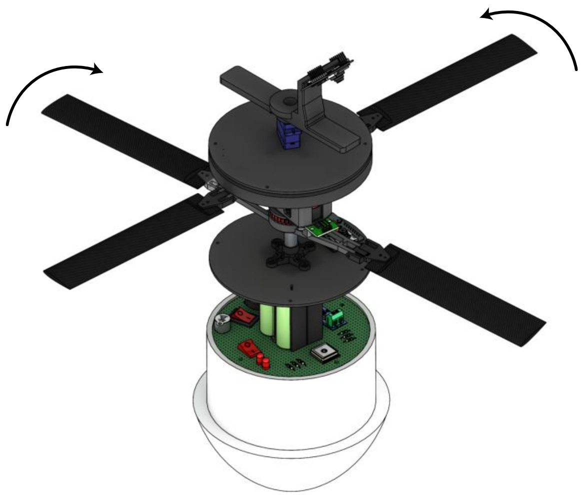
$$w_{rotor} = \frac{V_{rotor}}{R}$$

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



Descent Rate Estimates (4/4)





Parachute Phase

$$Mass = 1.4kg$$

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

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

$$Parachute\ Diameter = 26.13\ cm$$

Auto-Gyro Phase

$$Mass \approx 1kg$$

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

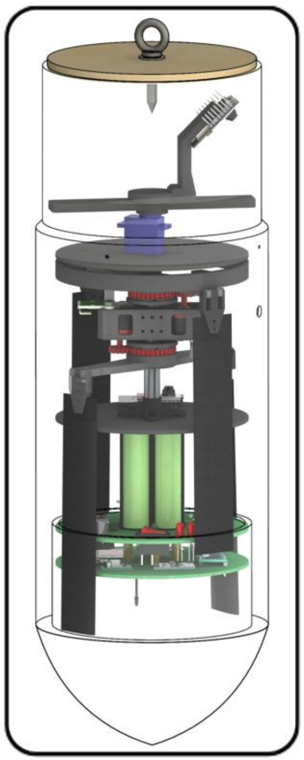
$$Rotor\ Area = 0.152\ m^2$$

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

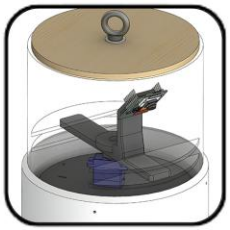
Mechanical Subsystem Design

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.

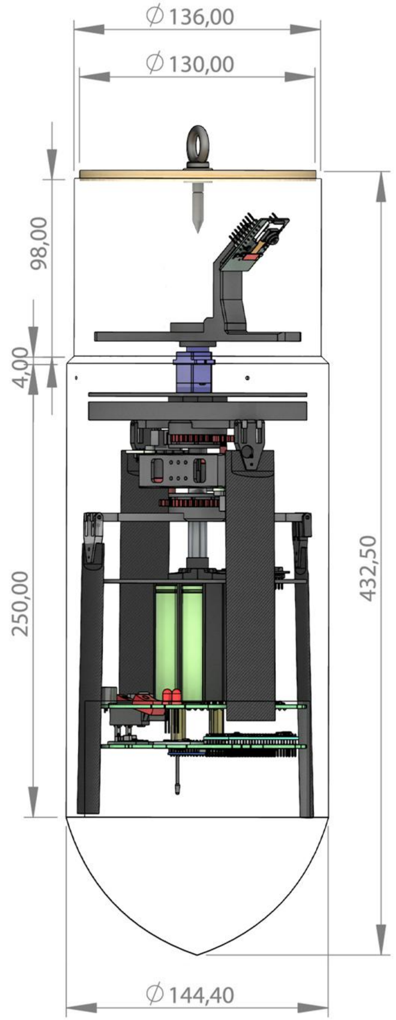
Auto-Gyro Descent Control Mechanism: A dual-rotor mechanism that ensures the safe descent of the payload. Auto-Gyro mechanism will be made of ABS, carbon fiber.

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

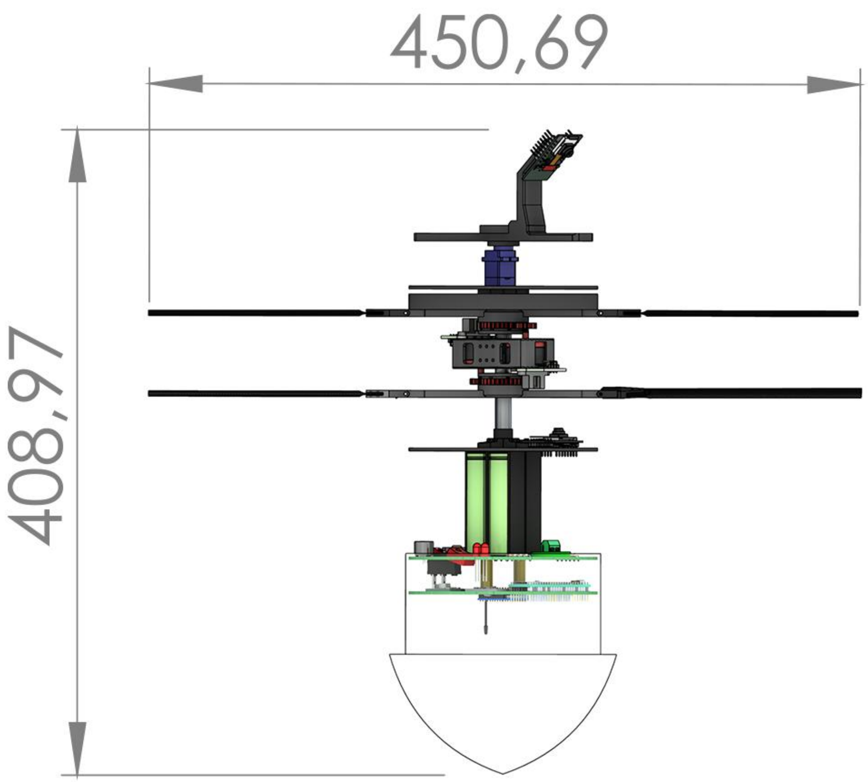
Mechanical Subsystem Changes Since PDR

No changes have been made to the Mechanical Subsystem Design since PDR.

Cansat Mechanical Layout of Components (1/9)



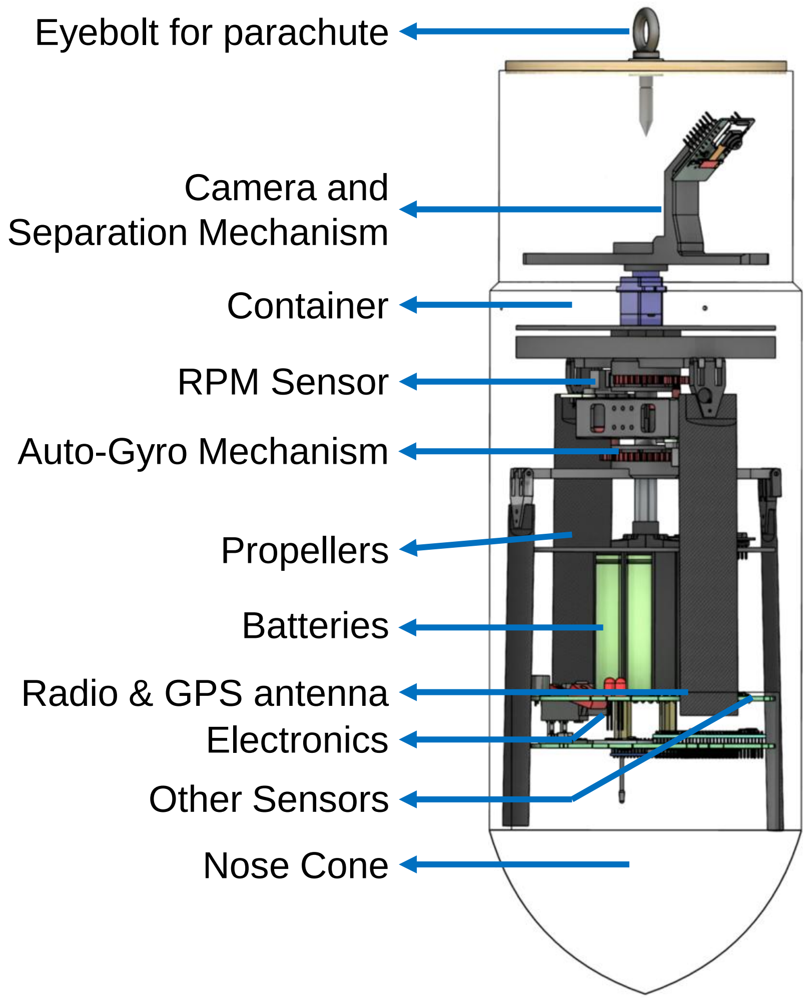
Dimensions of Payload with Container



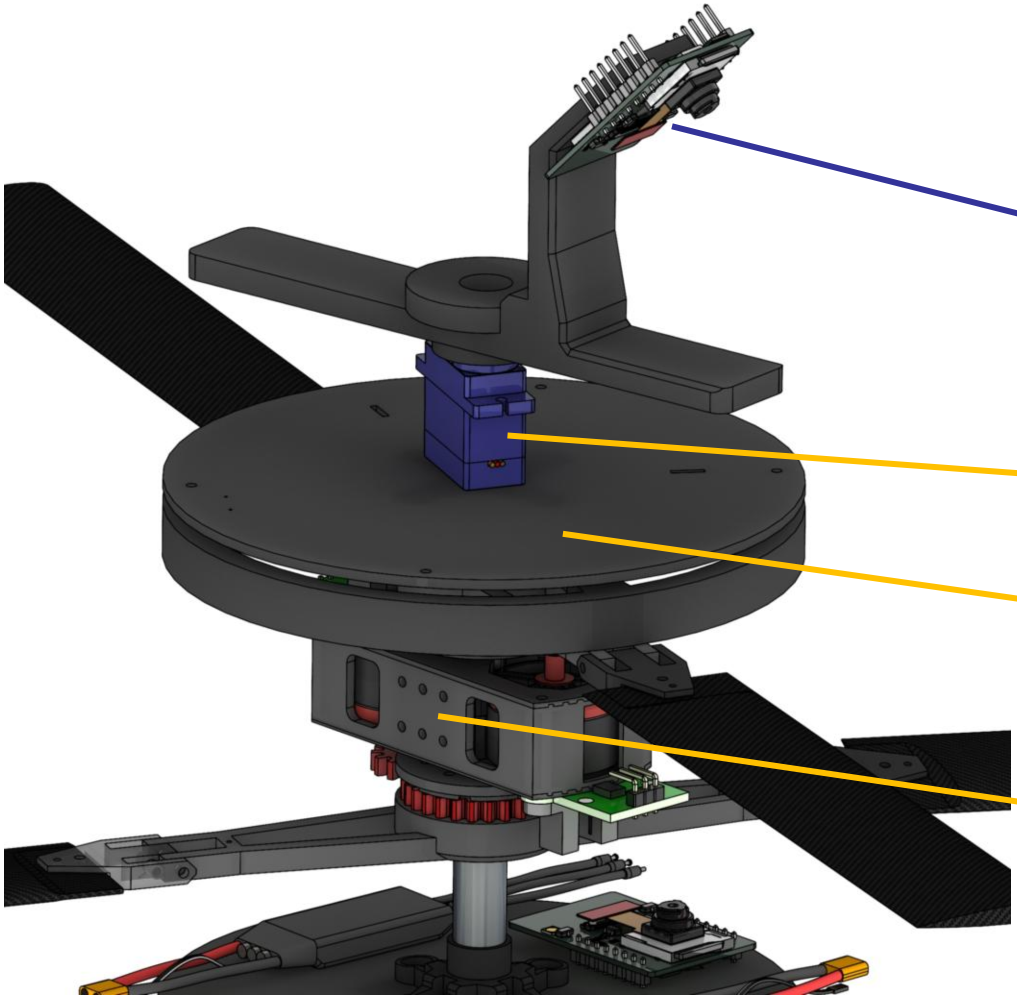
Dimensions of Deployed Payload

Cansat Mechanical Layout of Components (2/9)

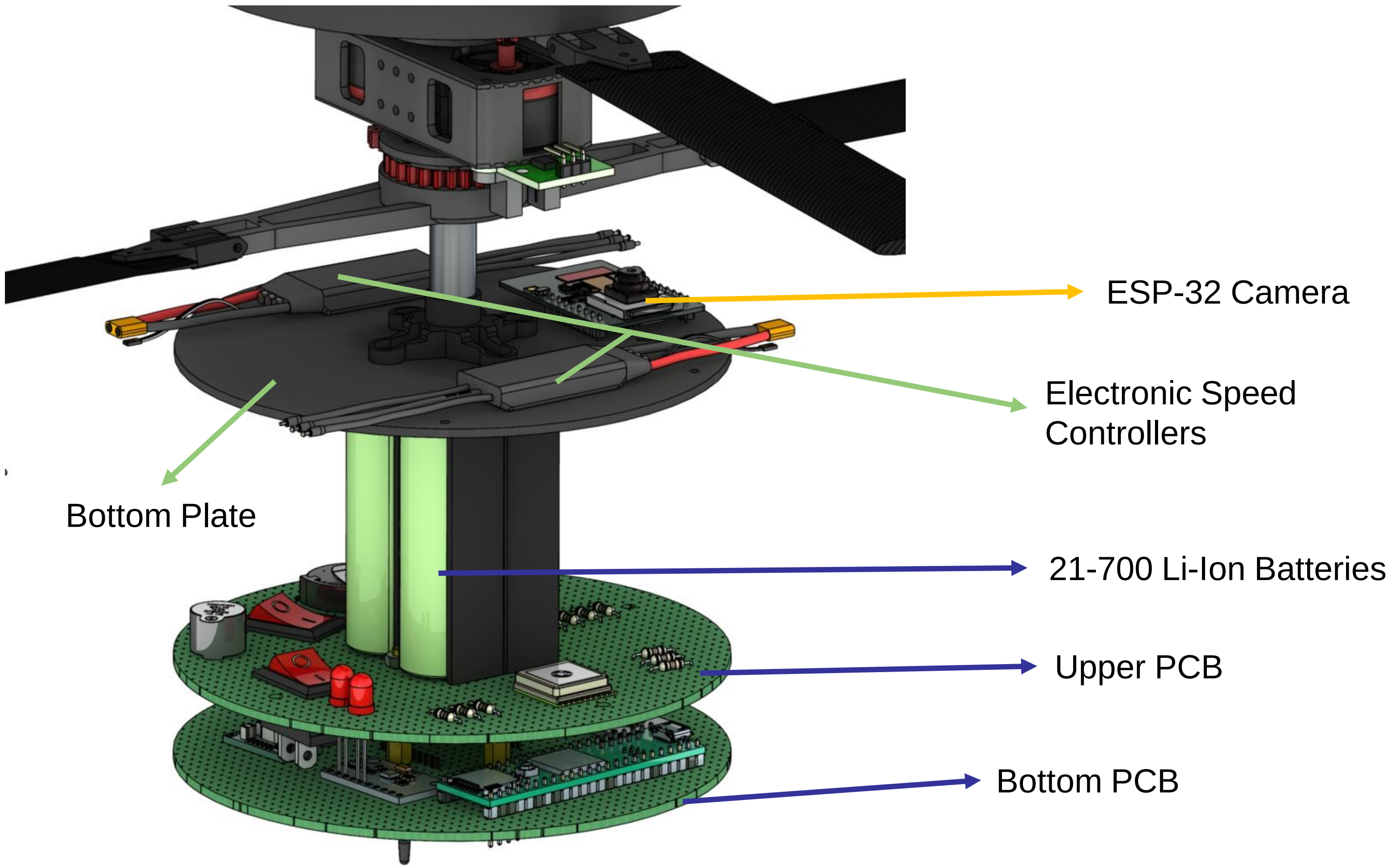
General View of the Components



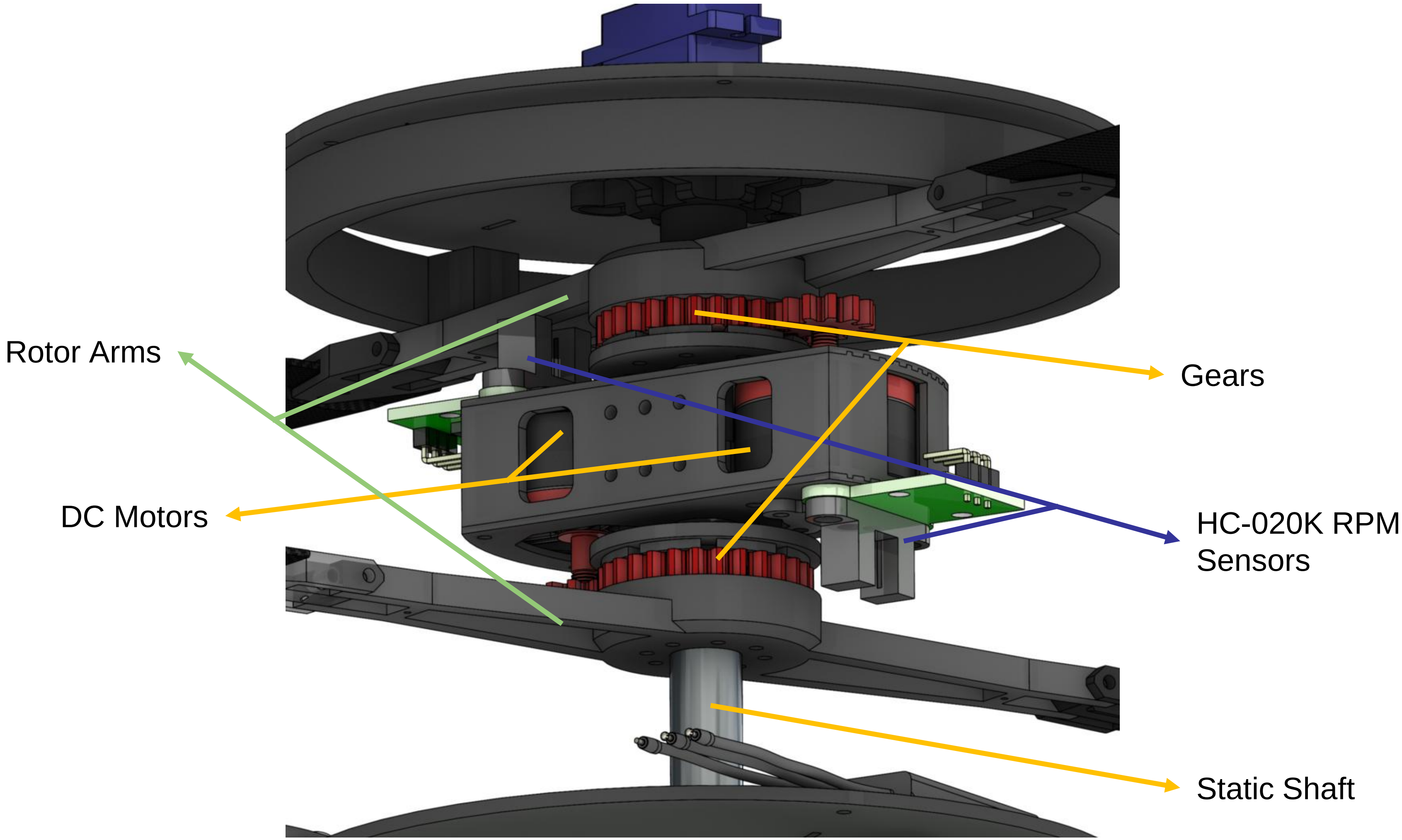
Cansat Mechanical Layout of Components (3/9)

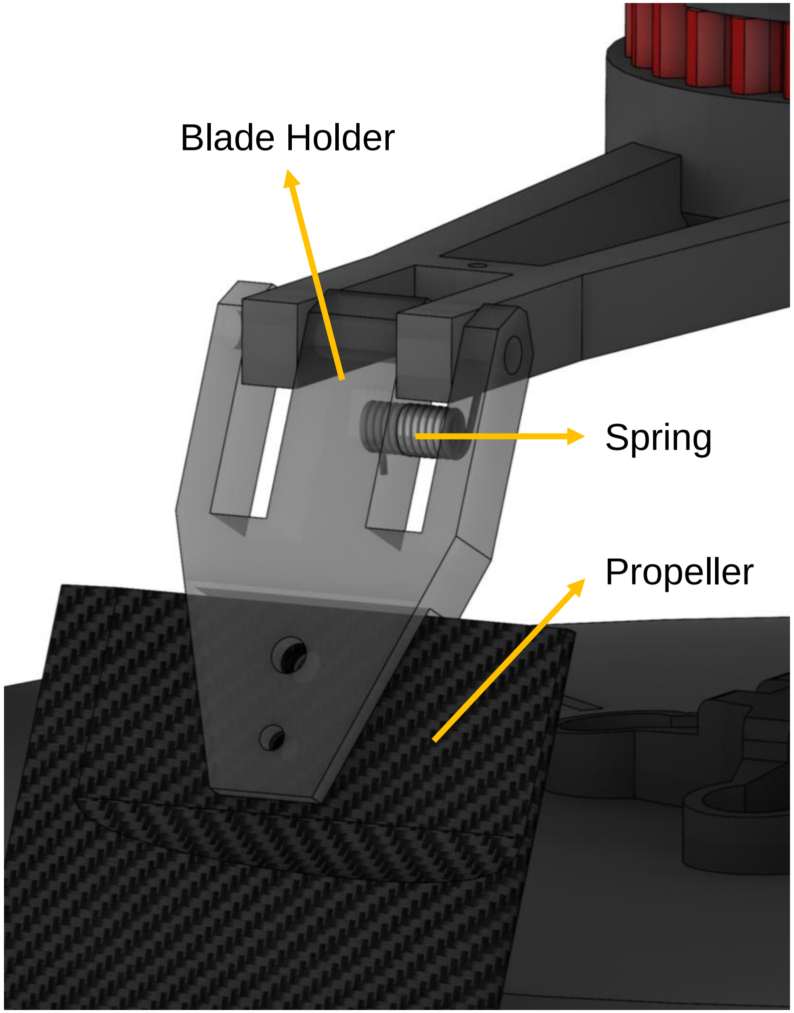


Cansat Mechanical Layout of Components (4/9)



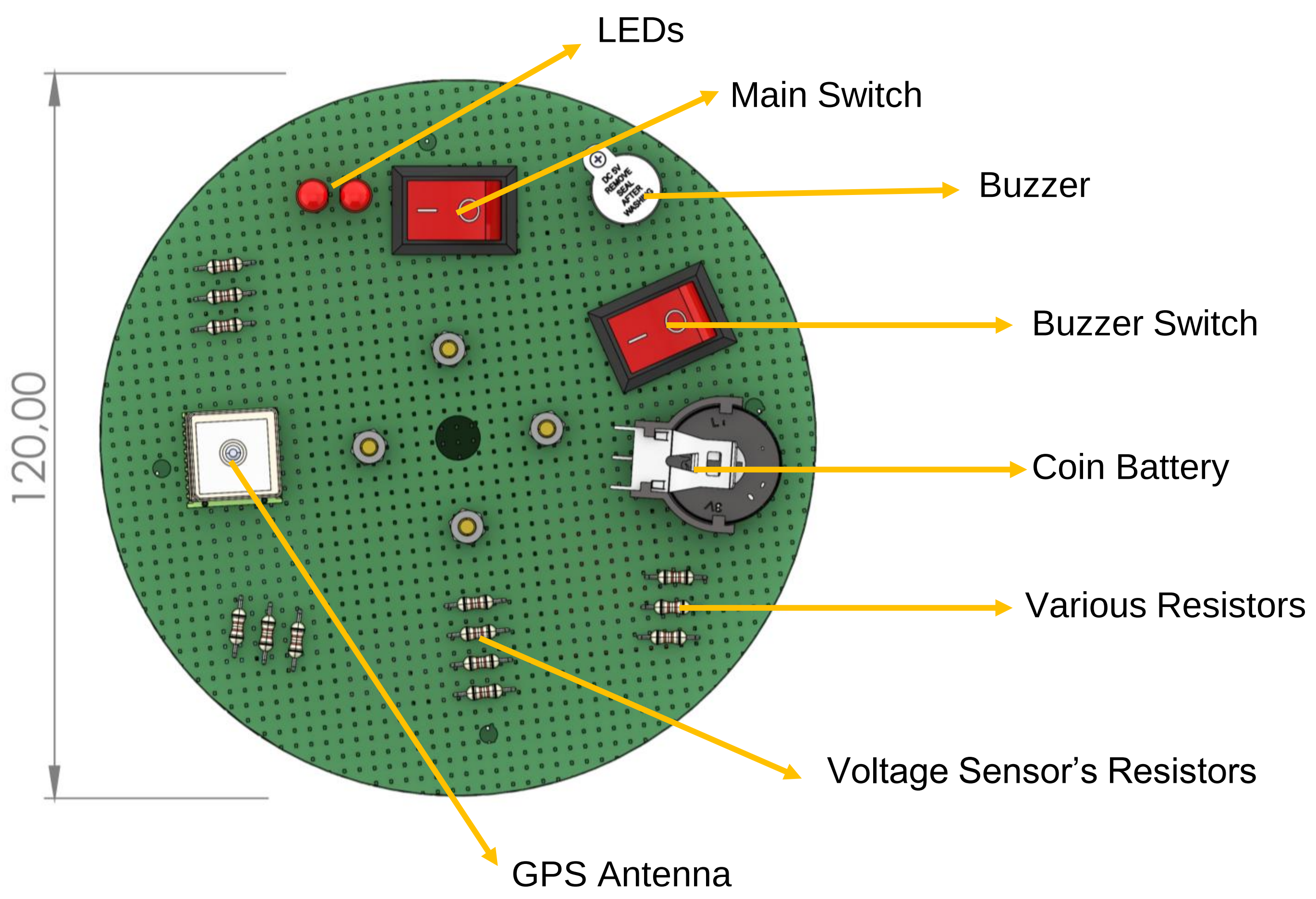
Cansat Mechanical Layout of Components (5/9)





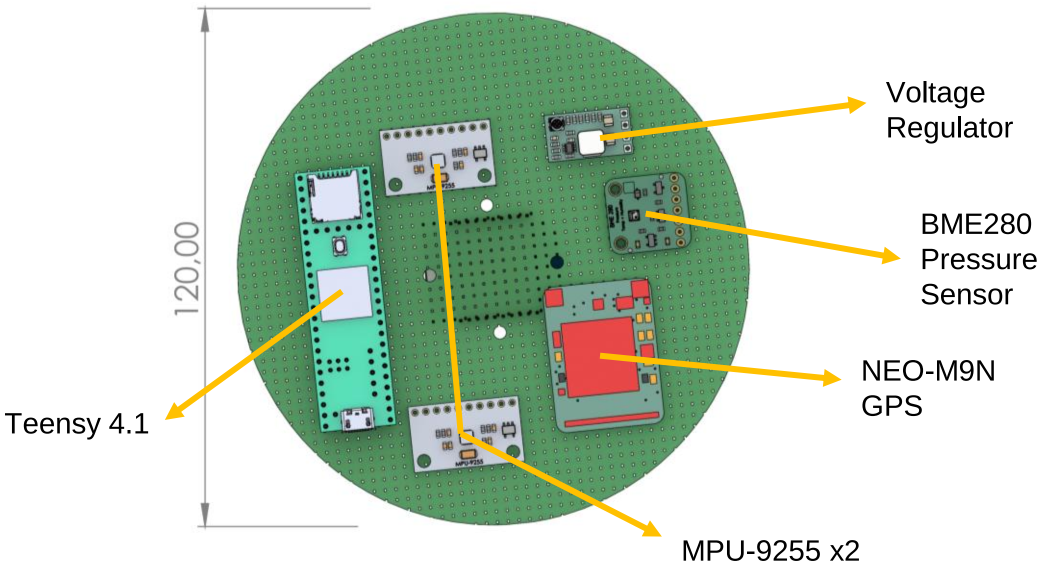
Each blade holder has springs inside it, allowing the propeller to open easily after separation.

Upper PCB Components



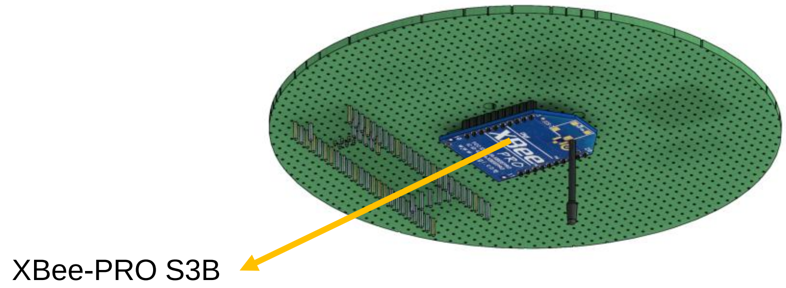
Cansat Mechanical Layout of Components (8/9)

Bottom PCB Components



Top

Bottom



Cansat Mechanical Layout of Components (9/9)

Material Selections

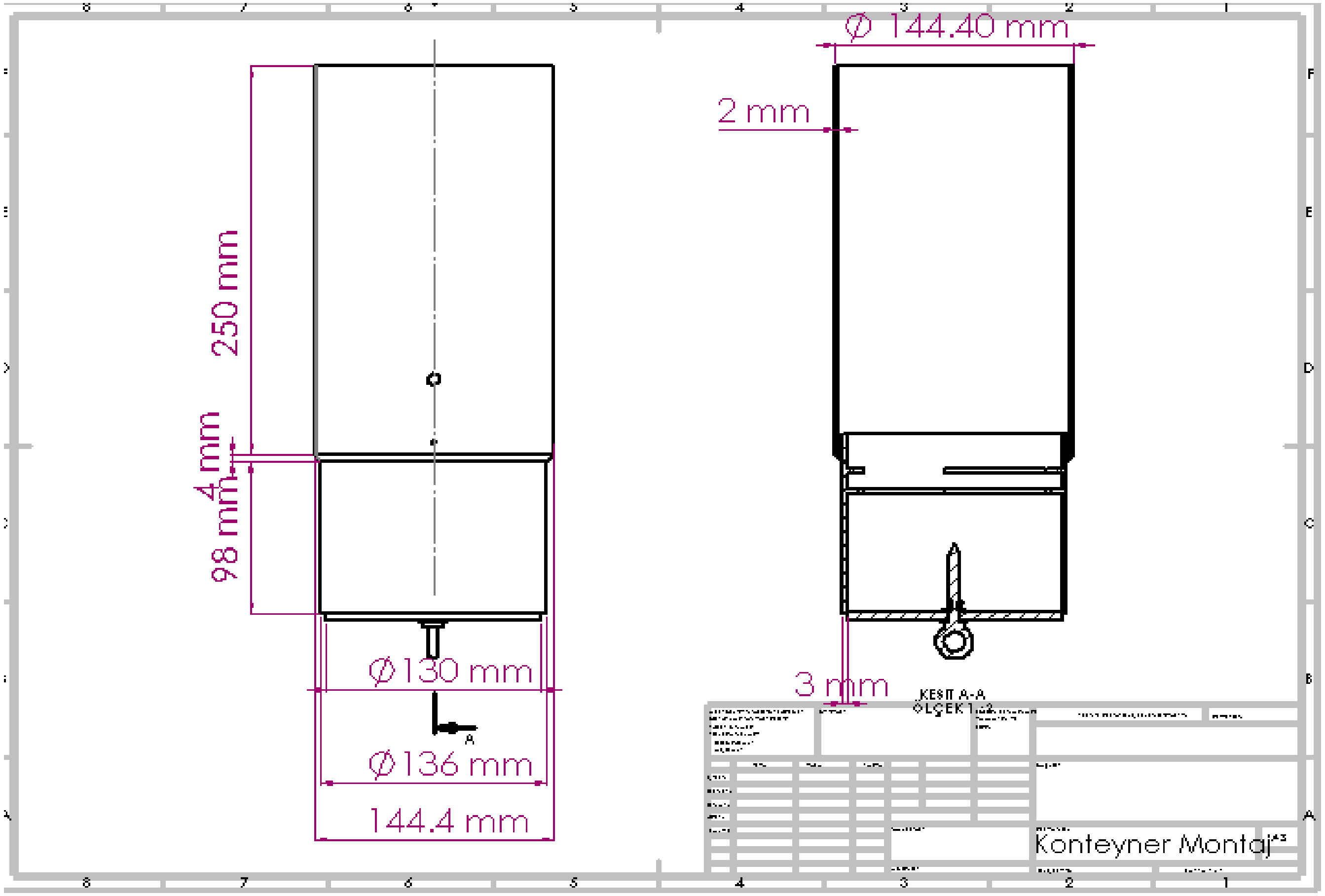
Parts	Materials
Nose Cone	PLA
Container	PLA
Propellers	Carbon Fiber
Top Plate	PLA
Bottom Plate	PLA
Box for Motors	PLA
Static Shaft	Aliminum
Rotor Arms	PLA
Blade Holders	PLA
Spring	Steel
PCB	FR4

Container Design (1/2)

- 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.

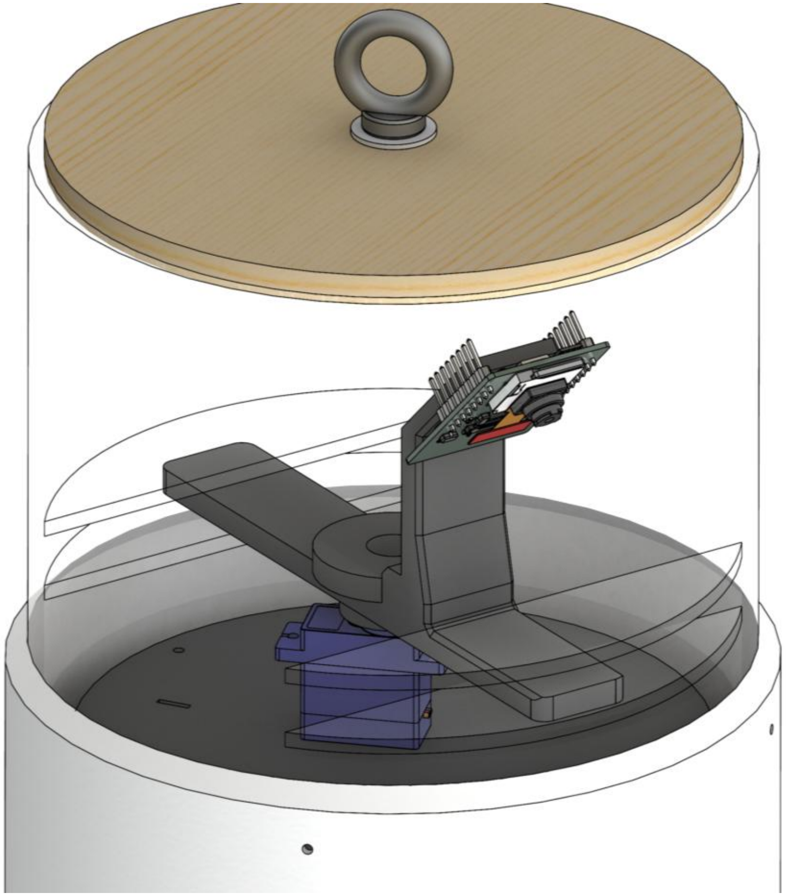
Container Design (2/2)



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

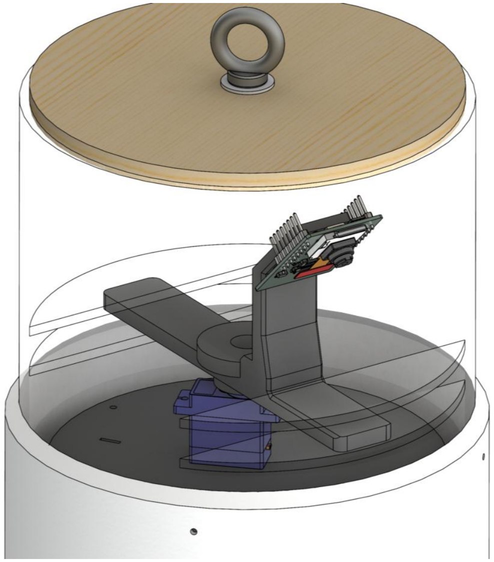
- **The dimensions of the produced container will be verified by measuring with calipers and micrometers.**

Payload Pre-Deployment Configuration

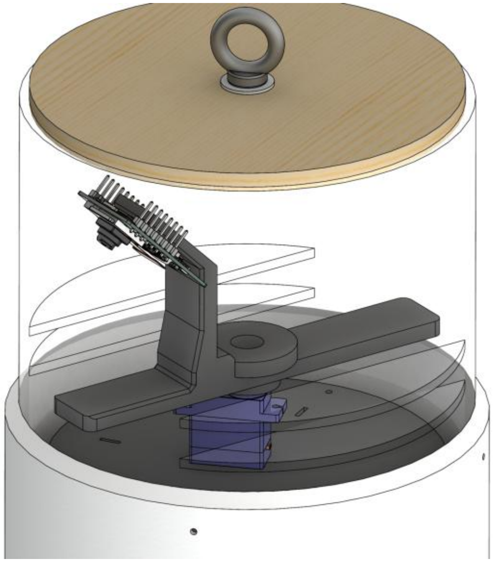


- When the arms located at the top of the payload are placed into the locking slot of the container, the container will **securely and stowed hold the payload**.

Payload Release



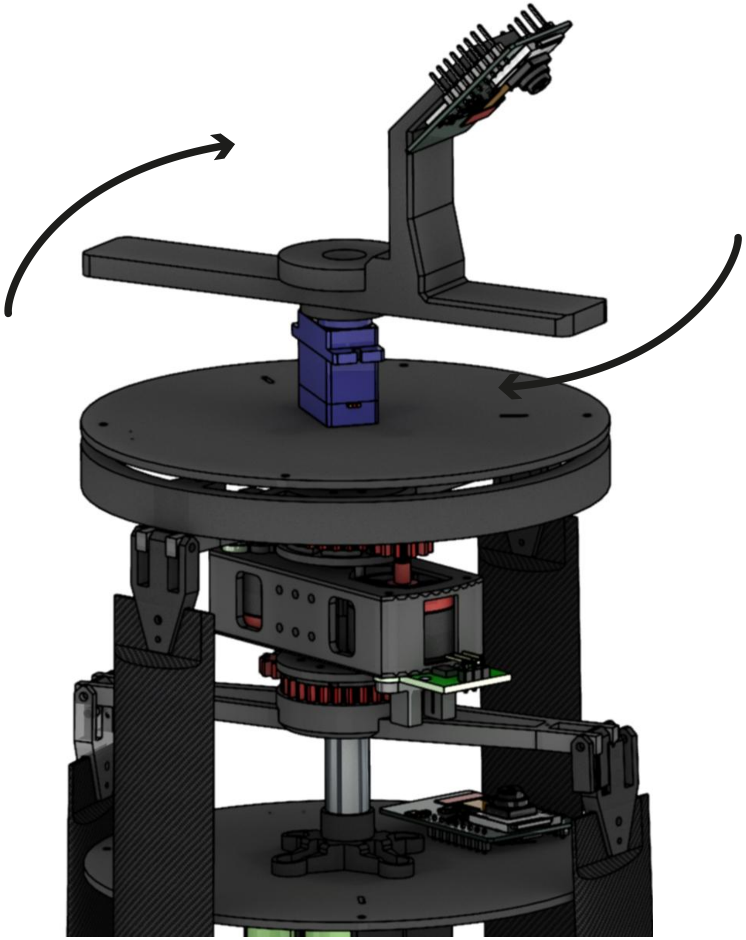
First State



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 Deployment Configuration

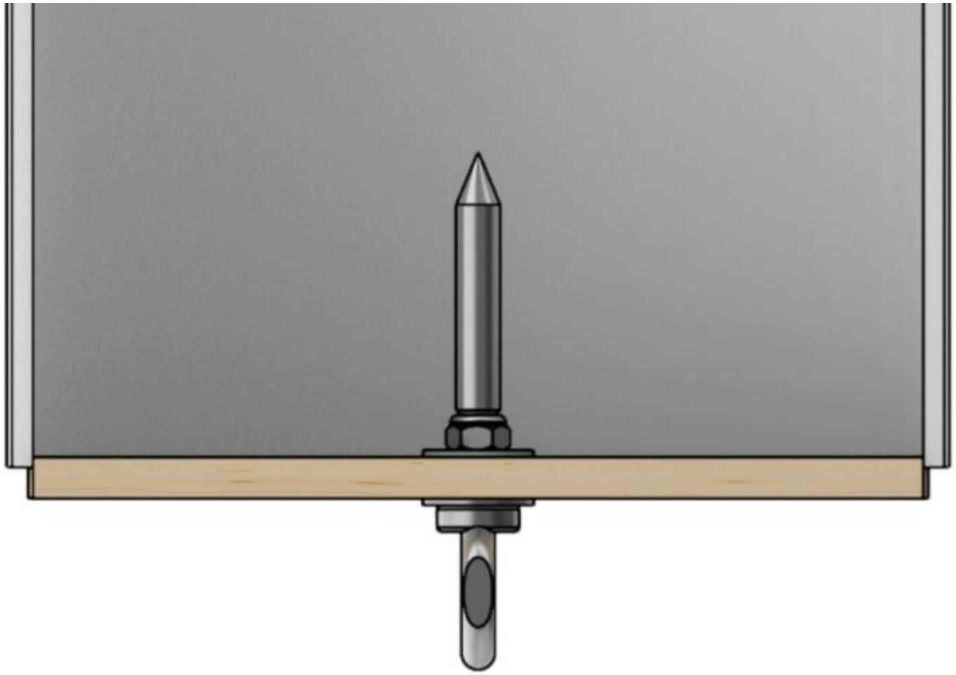


After separation, the only mechanism that will change, except than Auto-Gyro Deployment, is the ground camera that connected to the separation mechanism.

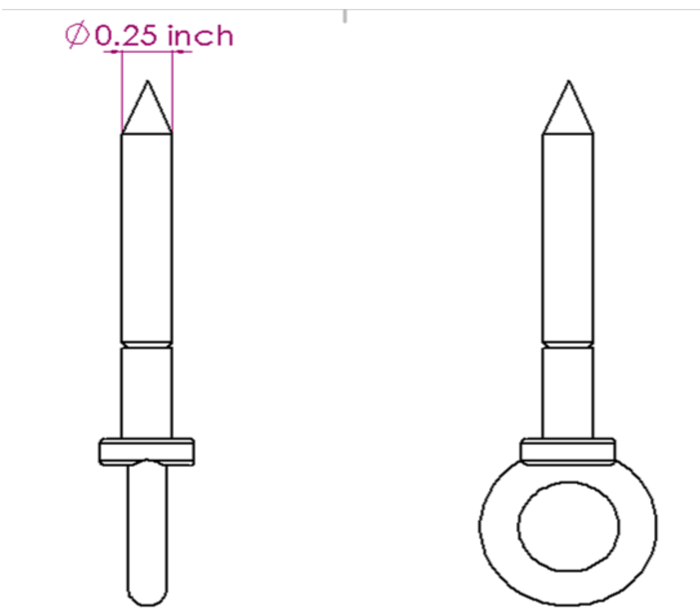
Immediately after separation, the same mechanism will turn the camera North direction with the servo by using the data it receives from the sensors.

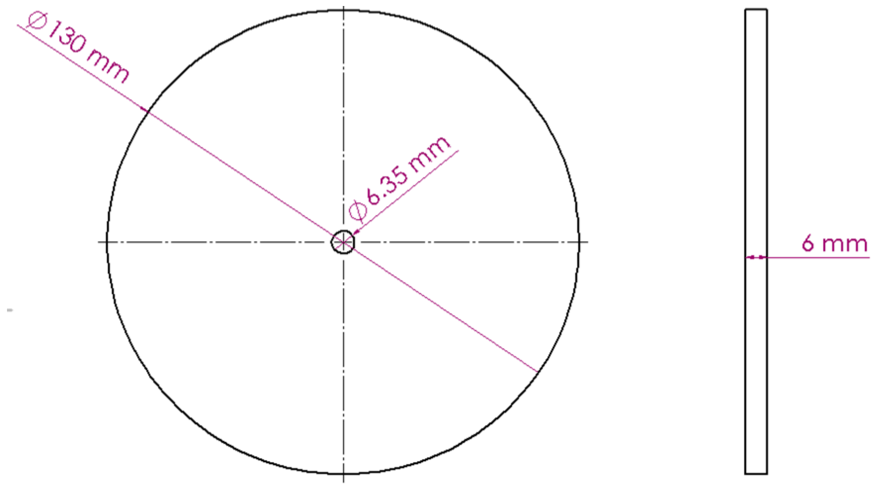
Parachute Attachment to Container (1/2)

- 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 to Container (2/2)





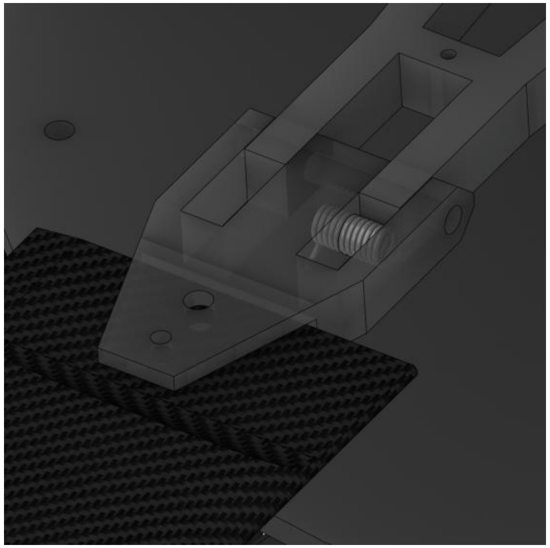
- Eyebolt technical drawing.
- Picture were drawn with CAD program.
- Measure is given inch.

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

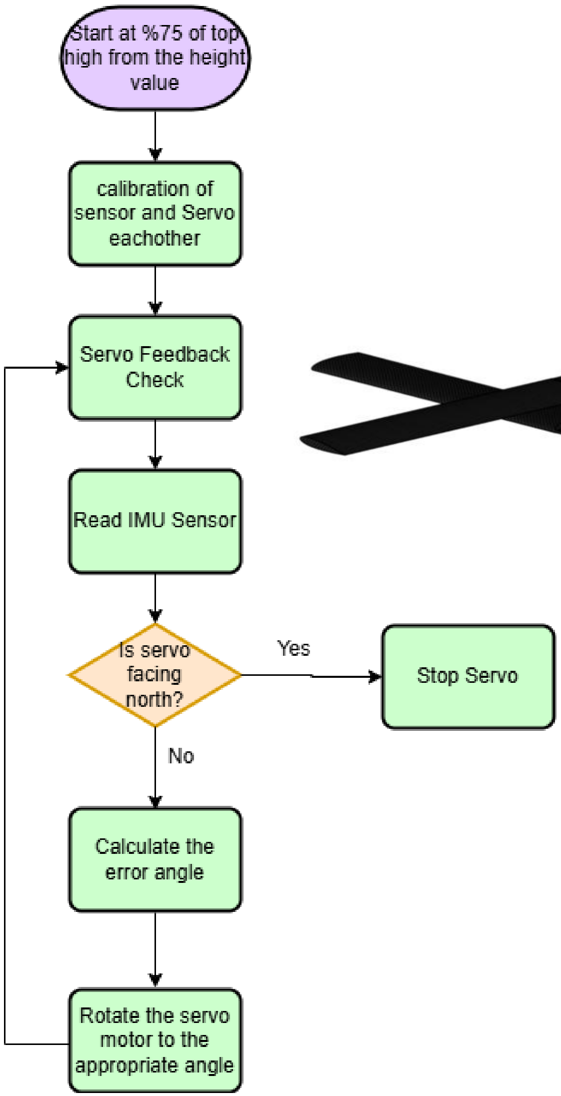
  (6.35 mm=0.25 inch)

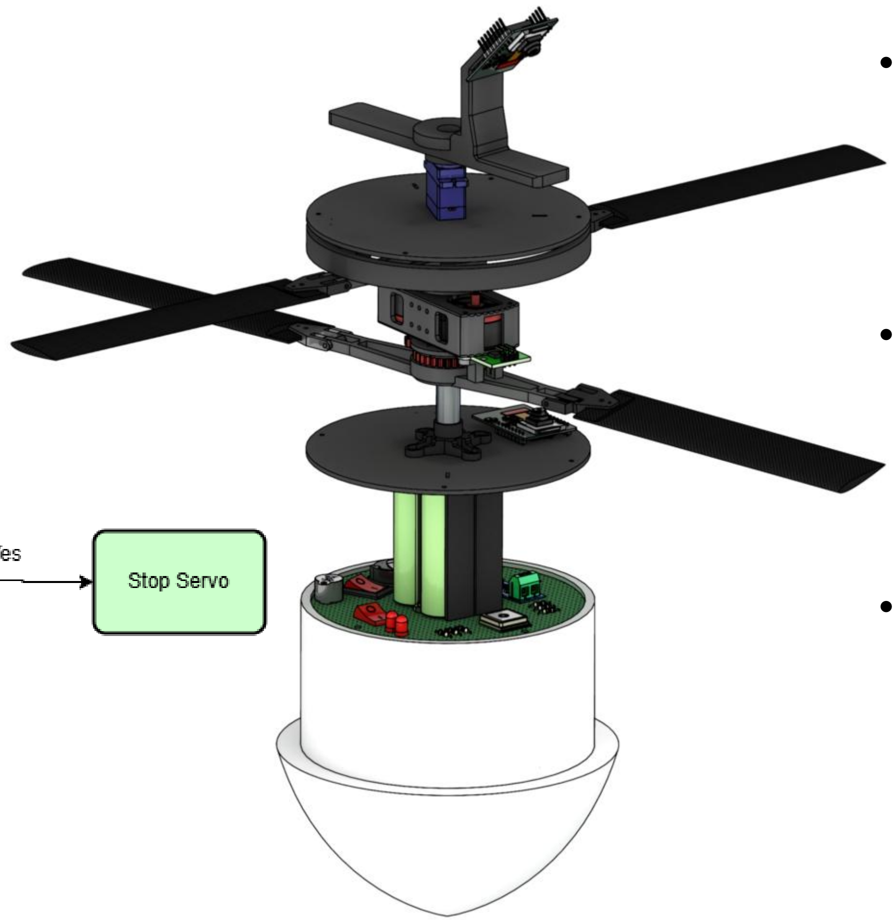
Auto-gyro deployment

- 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.



Ground Camera Pointing



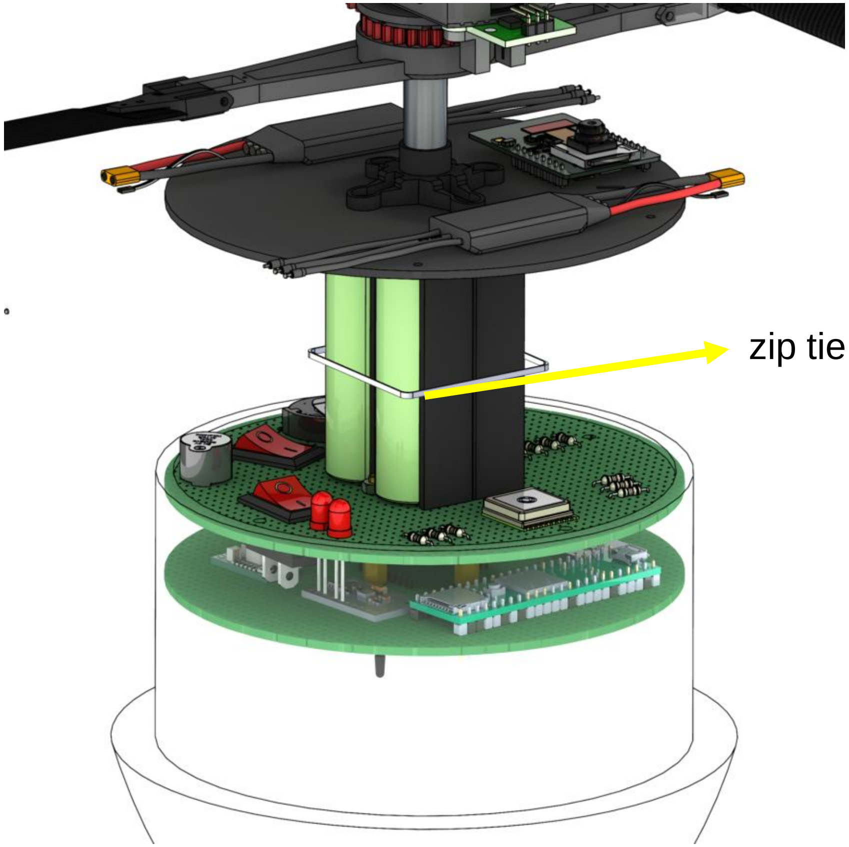


- The servo motor attached to the camera will enable the camera to rotate towards the north.
- The structure to which the camera is mounted will ensure that the 45-degree angle is maintained fixed.
- Based on the data received from the sensors that have installed. The direction of the camera can be actively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

Structure Survivability

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.
- All reinforcements to be made above will be tested to see if they remain intact against sudden **accelerations and shock forces**.
  - This will be ensured through **environmental tests and subsystem test plans.**



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)

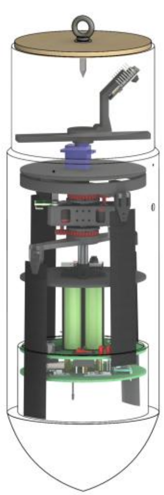
Component	Subsystem	Location	Quantity	Mass [g]	Source	Uncertainties
BME280	Sensor	Payload	x1	14	Measurement	±1 g
MPU9255	Sensor	Payload	x2	4	Measurement	±2 g
SparkFun NEO-M9N	Sensor	Payload	x1	11	Measurement	±1.3 g
Teensy 4.1	CDH	Payload	x1	8	Measurement	±1 g
Xbee S3B	CDH	Payload	x1	5	Data Sheet	±1 g
ESP32-CAM	Sensor	Payload	x2	8	Data Sheet	±1.6 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.



- 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 strengthen the satellite and for any possible uncertainty excess.**

The total weight of the CanSat is 1318 grams.

The total weight of the Payload is 998 grams.

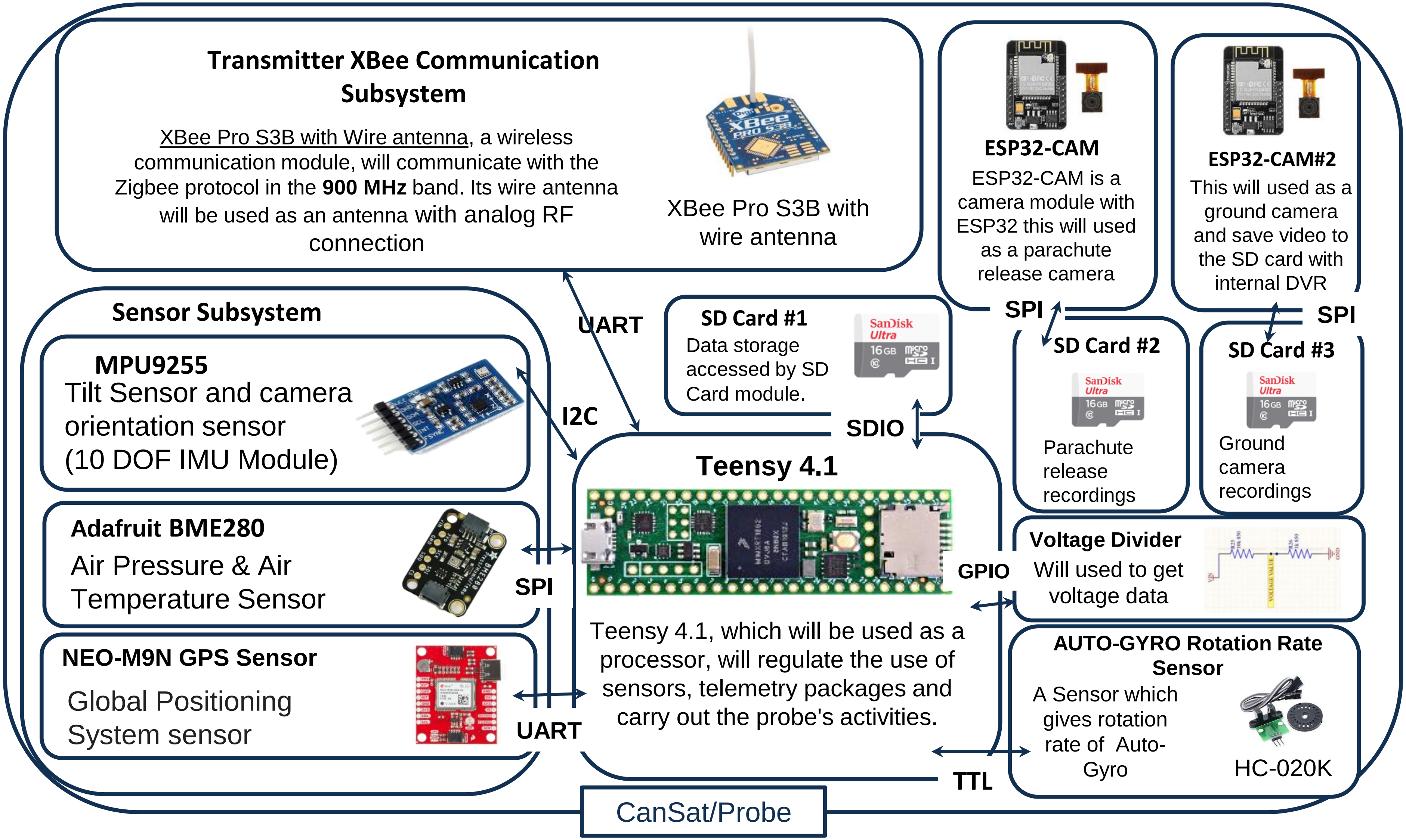
➢ Mass requirement: The total mass of CanSat shall be 1400 grams ±10 grams.
➢ Our design's estimated mass: 1318 grams
➢ It can be achieve the necessary weight reduction by changing the material, type, and quantity of the assembly components in case of potential weight issues.

✓ Mass budget meets the requirement.

Communication and Data Handling (CDH) Subsystem Design

Muhammet Akın OZEL

CDH Overview



CDH Changes Since PDR

Changed Module	PDR	CDR	Rationale
Payload Radio Module	Xbee PRO S3B with external antenna WRL-09143 is selected as Radio module	Xbee PRO S3B with Wire antenna is selected as Radio module	lighter and more compact structure providing long-distance data communication

Payload Processor & Memory Selection (1/2)

Model	Boot Time (s)	Processor Speed (MHz)	Power Consumption at 600Mhz (mA)	Operating Voltages (V)	Data Interface (Types & Number)		Memory Storage	Cost $
Teensy 4.1	**0.005**	**600**	**100**	**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**

- **The boot time is approximately 5ms**

ITCM (Instruction Tightly Coupled Memory)	DTCM (Data Tightly Coupled Memory)
64 bit	32 bit

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

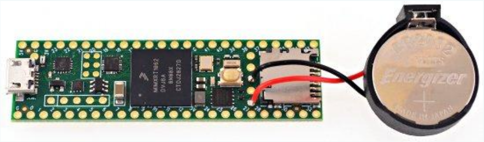
Payload Processor & Memory Selection (2/2)

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**

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

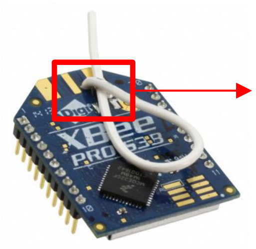
Payload Real-Time Clock

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

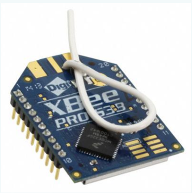
Selected Real–Time Clock	Selection Reasons
Built in Teensy RTC 	• Minimum area coverage • Free • Easy to use

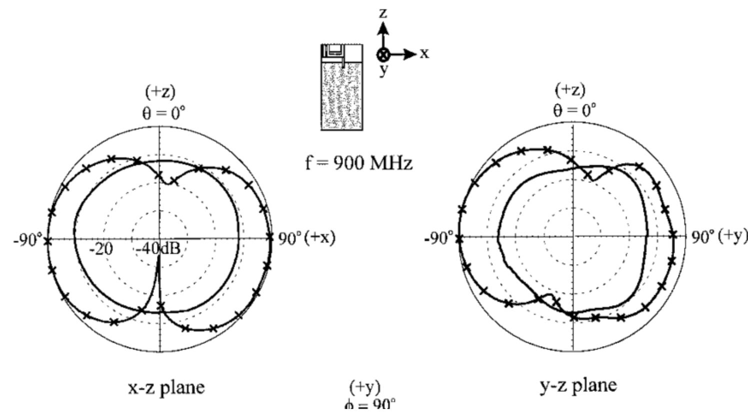
Payload Antenna Selection

Model	Connection Type	Frequency	Direction	Gain (dBi)	Range (open space)	Cost $
Integrated Wire Antenna	Fixed (Integrated)	900MHz	Omni-directional	1.5-1.8	To the 14km	0 (included in xbee)



Performance	Mass
• Frequency is 900Mhz. • Gain is 1.5-1.8. • Empedance is 50Ω.	• Length is 83 mm. • Weight is under 1g.

Selected Model	Selection Reasons
XBEE Pro S3B's Wire antenna 	• Meeting the spacing requirements needed • Saves mass and financial budget • Better range at open space



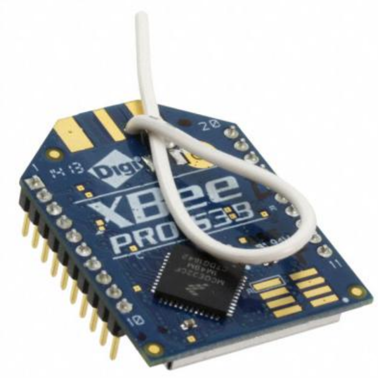
Radiation Patterns of Antenna

Payload Radio Configuration (1/3)

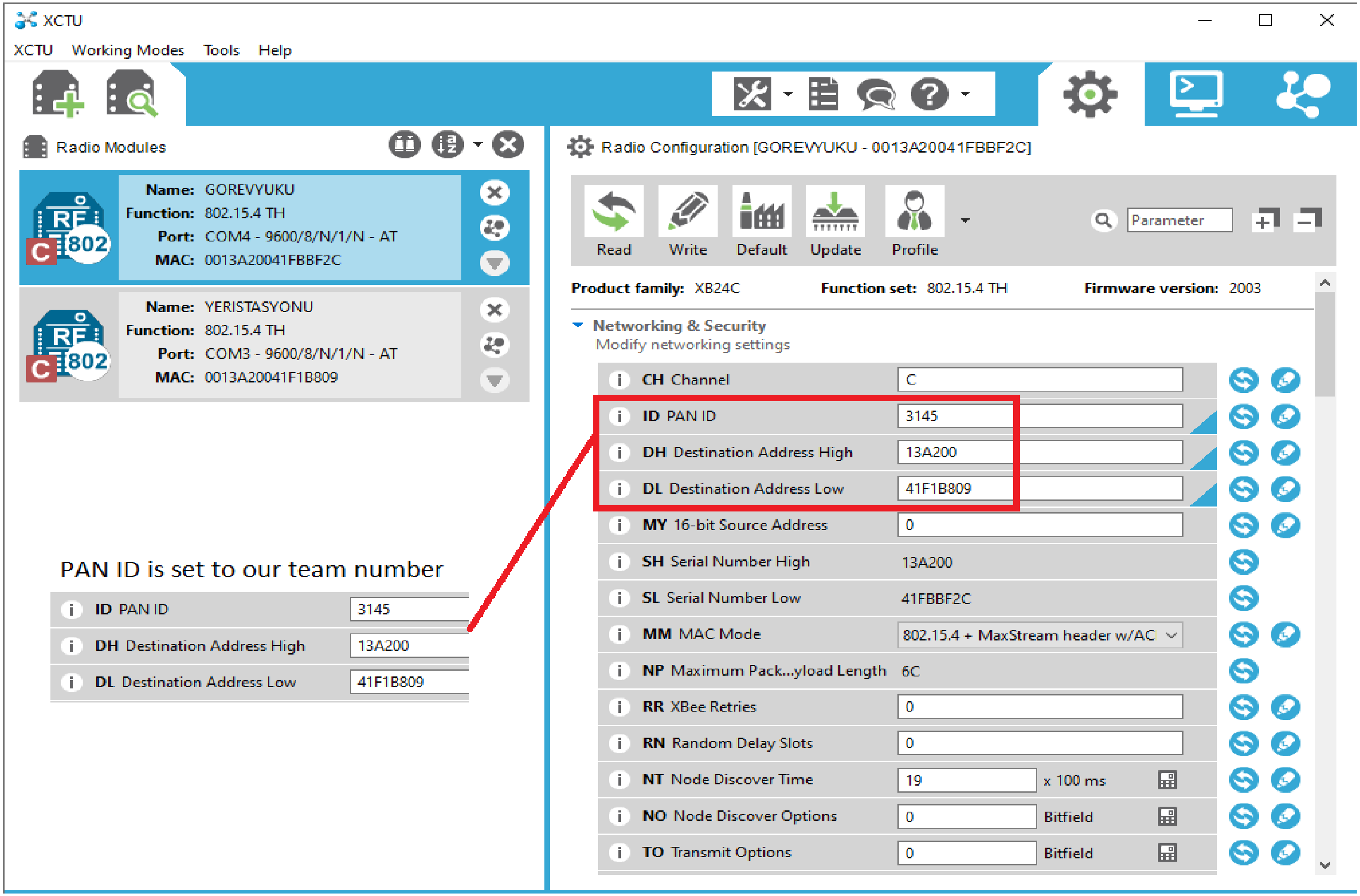
Radio Selection	Frequency	Transmit Power / Gain	Indoor Range	Outdoor Range	Cost
Xbee pro S3B with Wire antenna	**900MHz**	**20 dBm/4dBi**	**390 ft**	**6500 ft**	**53.85$**

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)



Payload Radio Configuration (3/3)

- **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.
  - At last tests there is no problems.

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

-The data rate of packets is 1 telemetry transmission per second, which complies with the mission guide.

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 Design

Gürkan ALKAN

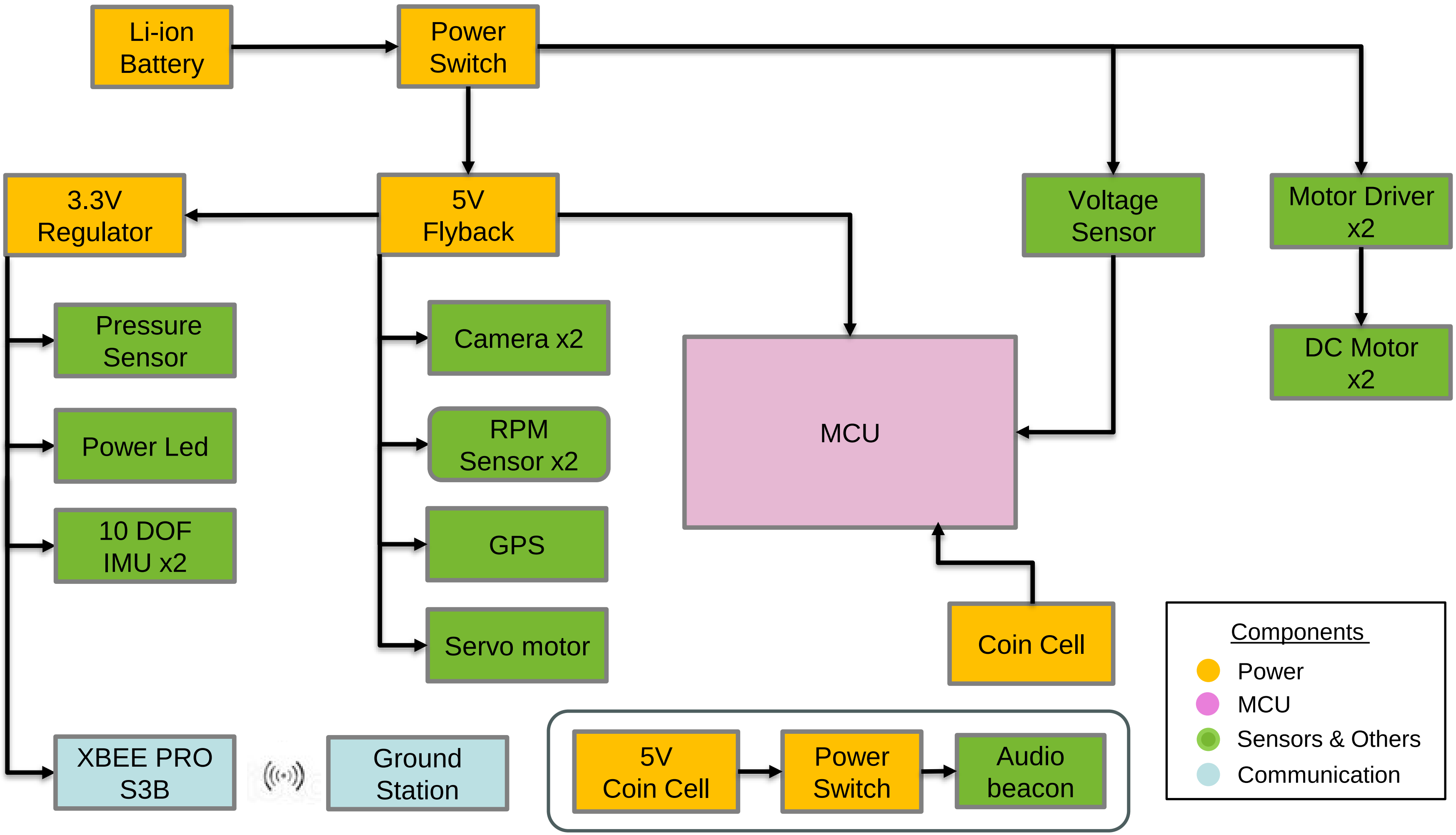
EPS Overview (1/2)

Cansat EPS Component

Component	Purpose(s)
Power	• Four 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 ESP32-Cam 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.

EPS Overview (2/2)

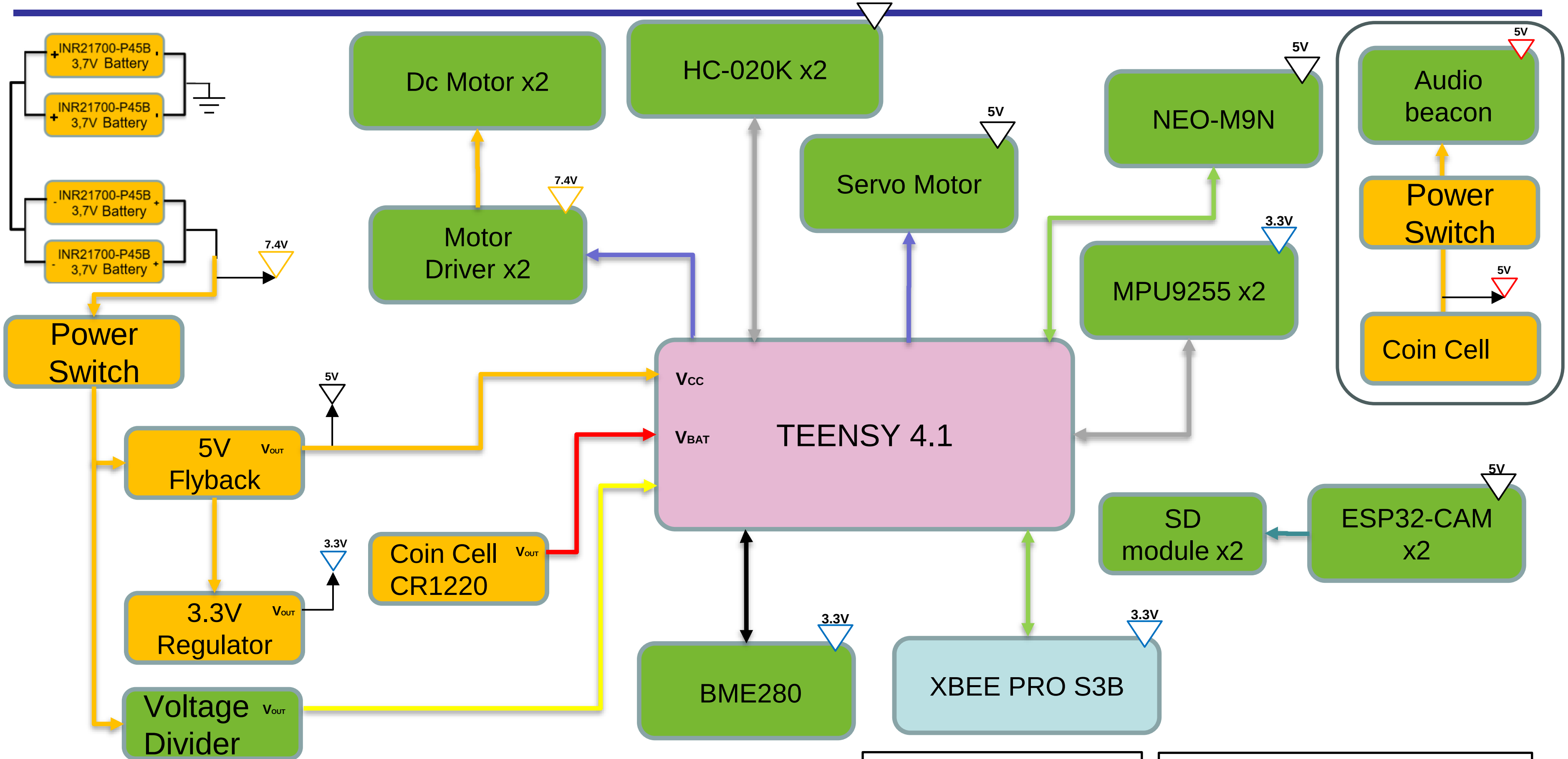
Cansat Diagram



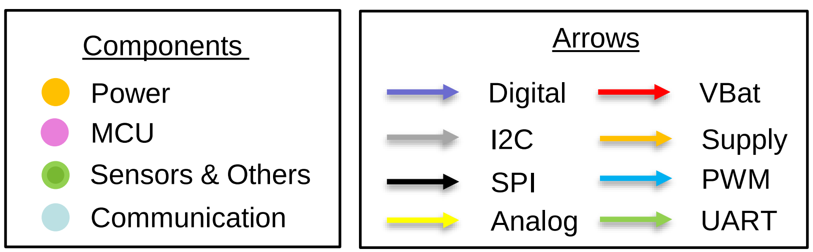
EPS Changes Since PDR

No changes have been made to the EPS since PDR.

Payload Electrical Block Diagram



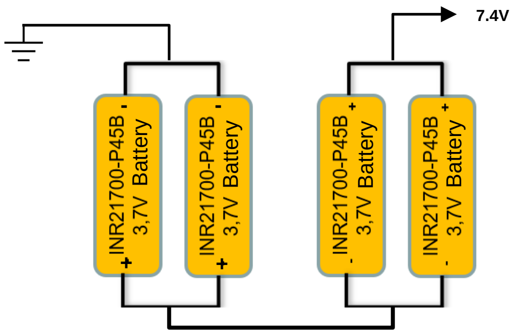
- **All components are connected to ground(GND)**
- **The payload and beacon power switch will be placed the CanSat where it can be easily reached.**



Payload Power Source

Battery	Voltage (V)	Capacity (mAh-WH)	Energy Density (Wh/g)	Instant Current (mA)	Size (mm)	Weight	Type	Cost ($)
INR21700-P45B	3.7	4500mAh 16.65Wh	0.242	45A	21 x 70	68	Li-ion	12.86$

Design 1



- **Batteries are serial & parallel connected (2s2p)**
- **There will be 4 cells**
- Batteries will be connected to Cansat with **springless battery slots**. the batteries will be strengthened by soldering and using **zip ties**.

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

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 x2	5	205	100	2.05	±0.21	Datasheet
HC-020K RPM Sensor	5	25	100	0.125	±0.018	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**
Margin Percentage	**38%**

Flight Software (FSW) Design

Aleyna YILMAZ

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

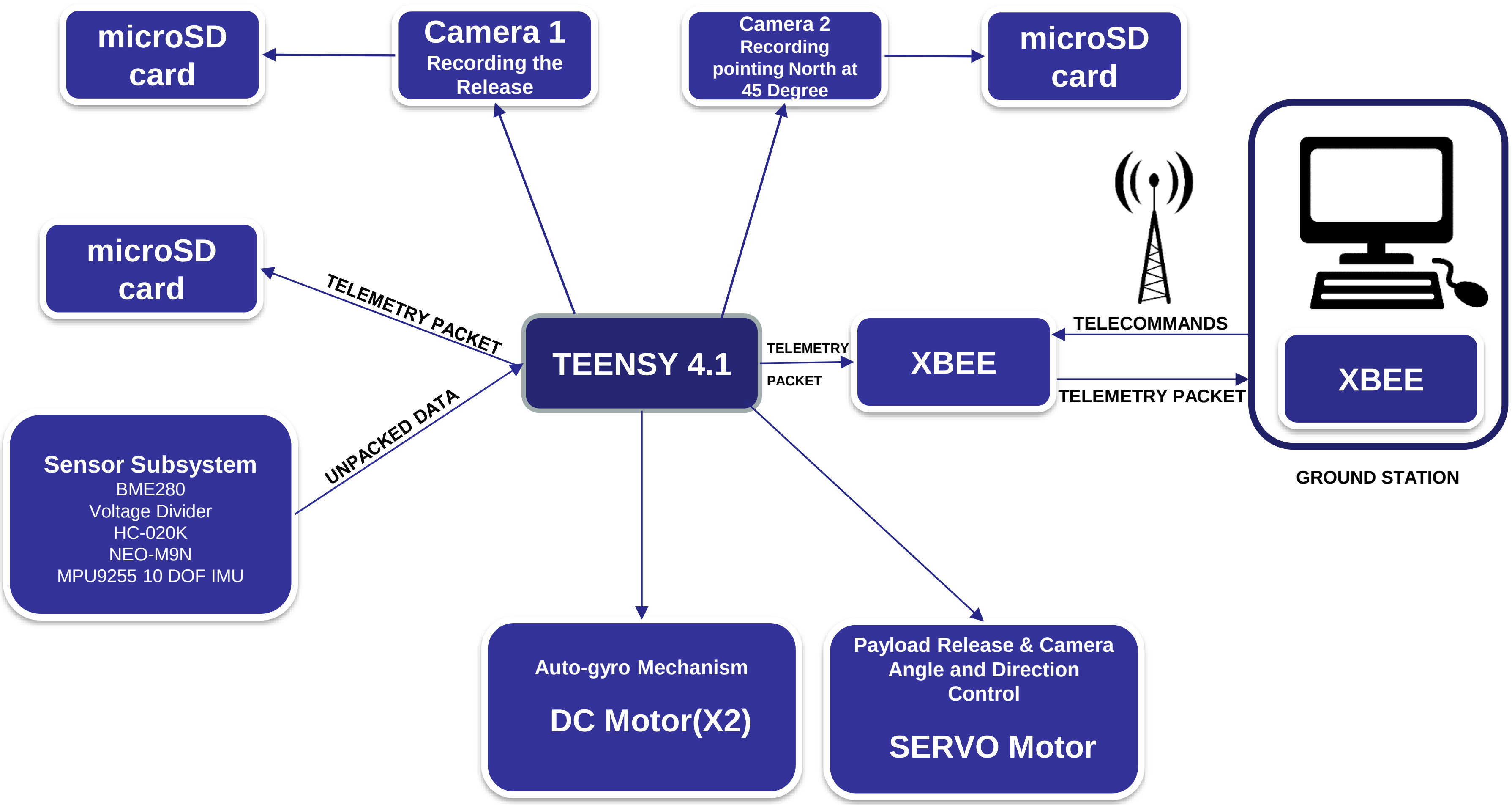
FSW Overview (2/3)

Programming languages:

C, **C++**

Development environments-Teensyduino

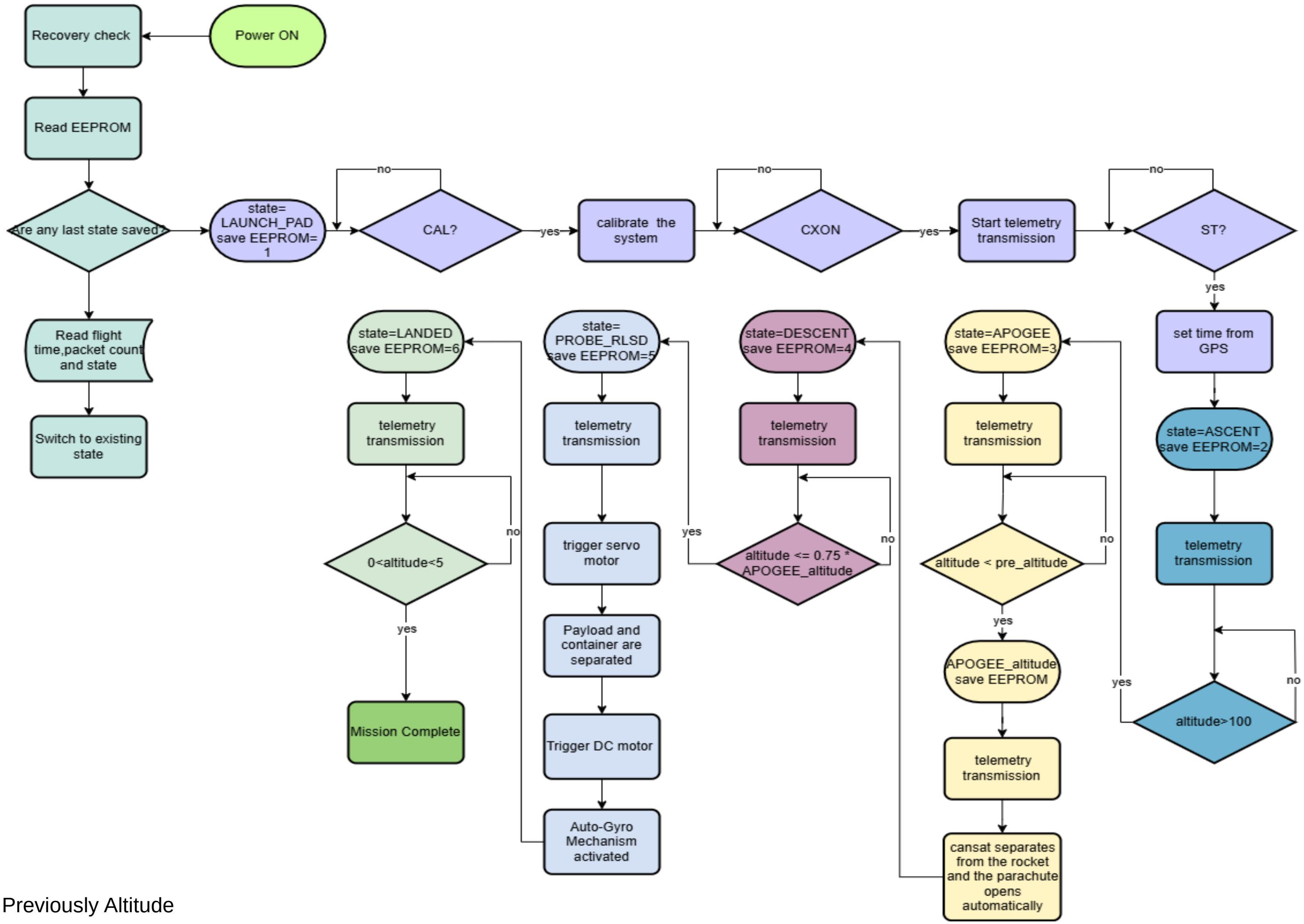
- **Teensyduino**: Teensyduino is a specialized Arduino plugin for Teensy microcontroller boards, and it used on the Arduino IDE to develop software compatible with Teensy boards. **XCTU** (Xbee Configuration and Test Utility): XCTU is a tool for Xbee wireless module configuration and testing, it used 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.


microSD card
Camera 1
Recording the Release
Camera 2
Recording pointing North at 45 Degree
microSD card
microSD card
TELEMETRY PACKET
TEENSY 4.1
TELEMETRY
PACKET
XBEE
TELECOMMANDS
TELEMETRY PACKET
XBEE
GROUND STATION
UNPACKED DATA
Sensor Subsystem
BME280
Voltage Divider
HC-020K
NEO-M9N
MPU9255 10 DOF IMU
Auto-gyro Mechanism
DC Motor(X2)
Payload Release & Camera Angle and Direction Control
SERVO Motor

FSW Changes Since PDR

No changes have been made to the FSW subsystem since PDR.

Payload CanSat FSW State Diagram (1/3)

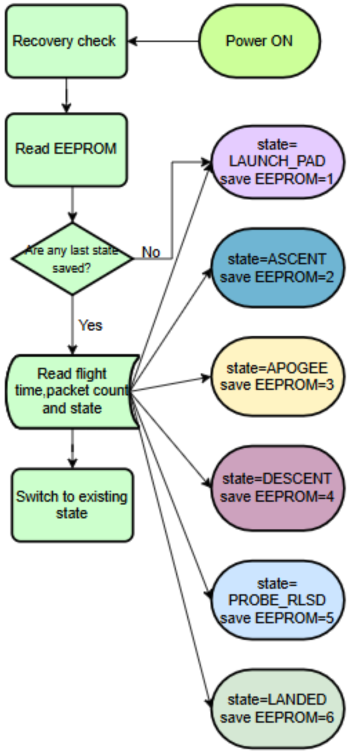


Pre_altitude: Previously Altitude

Payload CanSat FSW State Diagram (2/3)

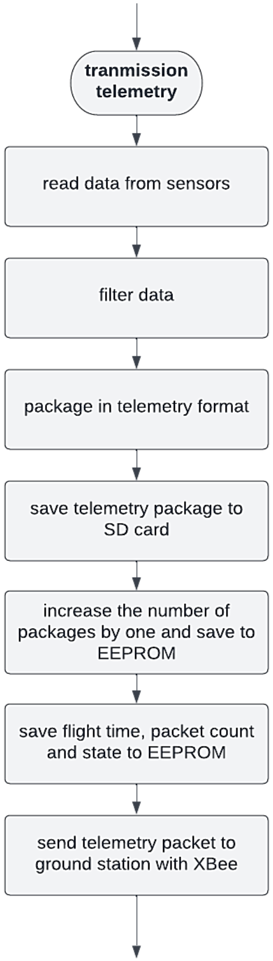
RECOVERY PLAN:

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.



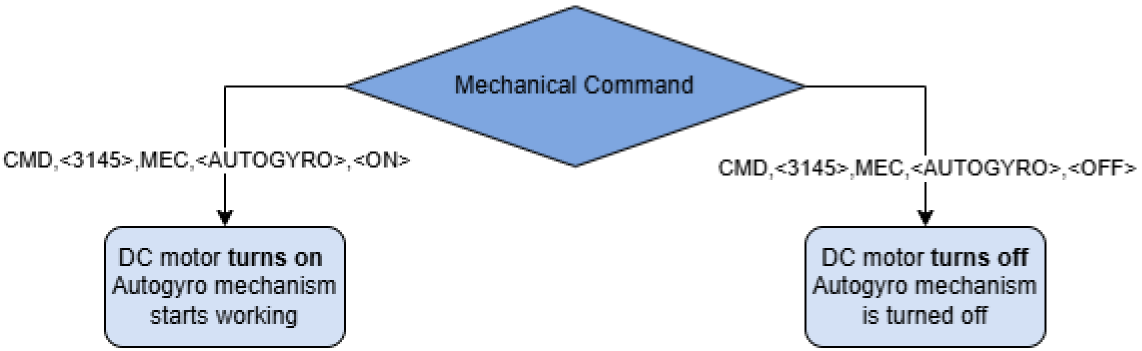
TELEMETRY TRANSMISSION:

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



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 **ACTIVATE** 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>

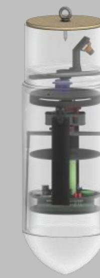
CMD,<3145>,SIMP,<PRESSURE>

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

We have made significant progress since the PDR. Range tests have been conducted with XBees, and the simulation mode has been tested successfully. Overall, we are now in the testing phase.

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

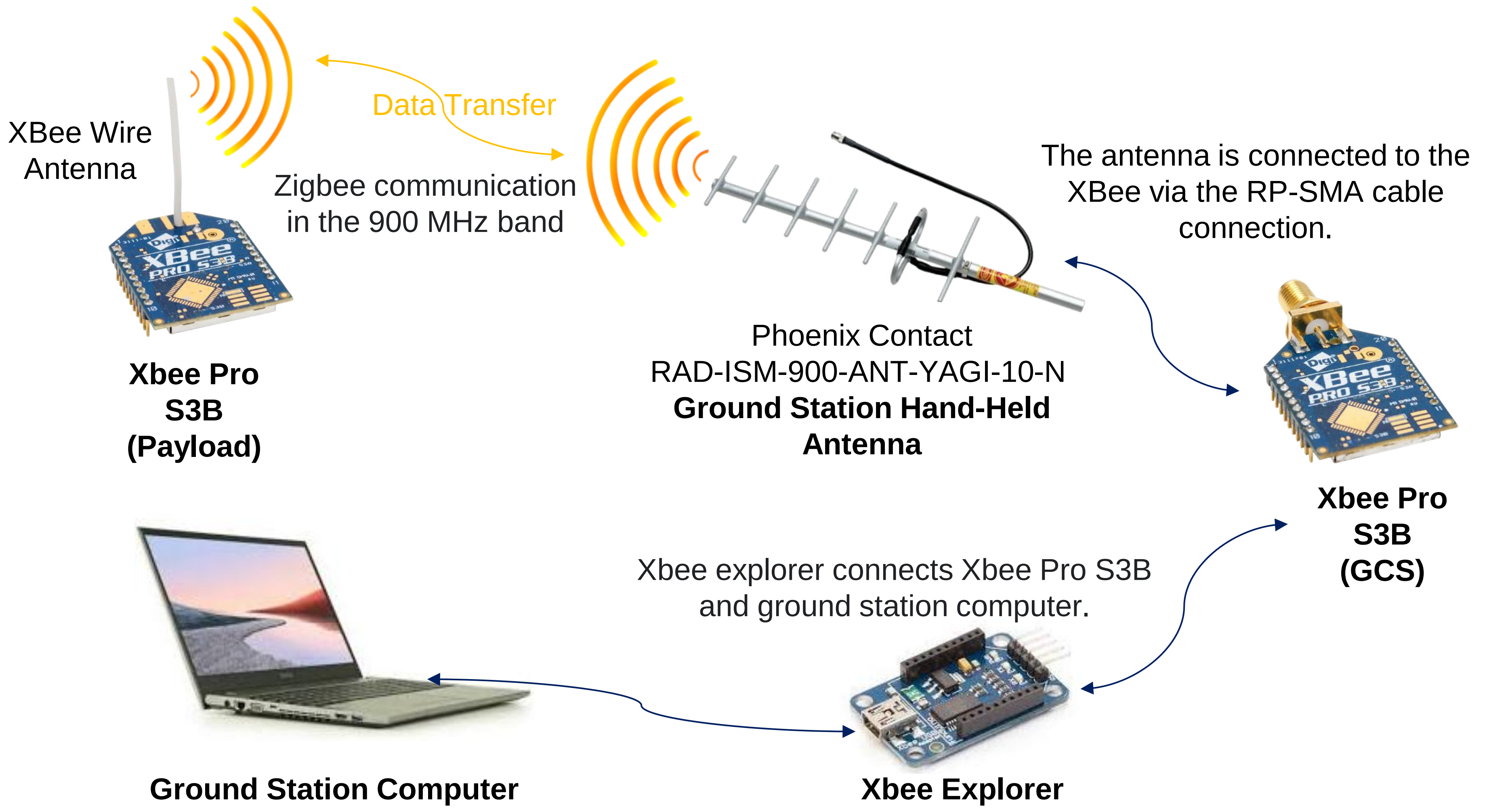
%75 done

%50 done

Ground Control System (GCS) Design

Muhammed Said GÖNÜL

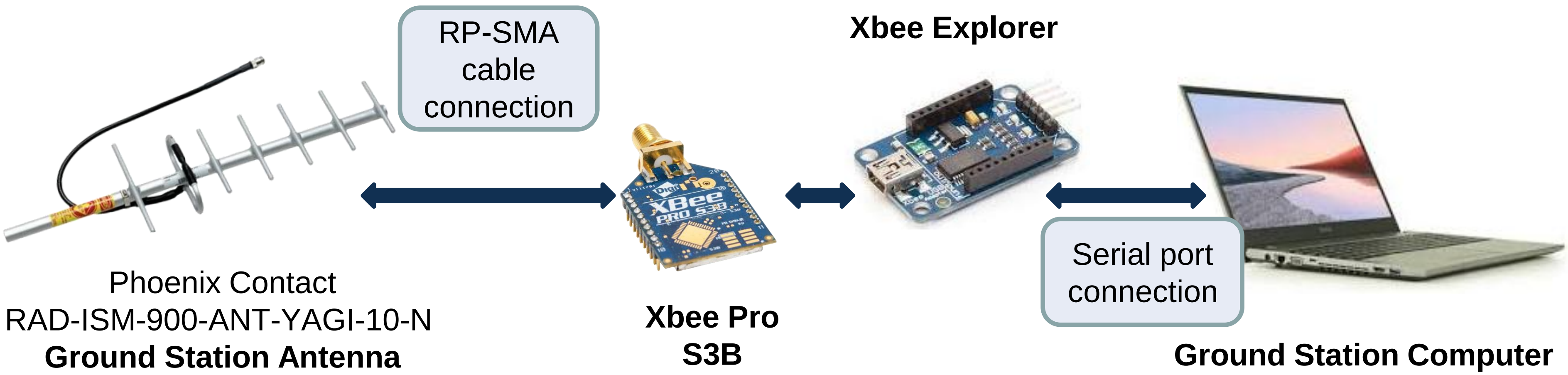
GCS Overview



GCS Changes Since PDR

<u>No changes</u> have been made to the GCS since PDR.

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.

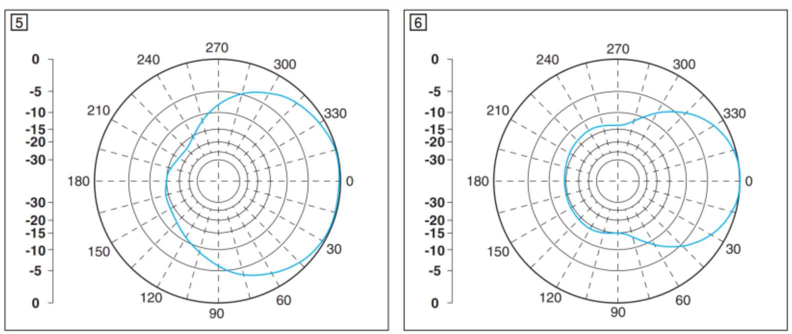
GCS Antenna (1/2)

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 model satellite 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.

Model	Connection Type	Frequency	Direction	Gain
RAD-ISM-900-ANT-YAGI-10-N	N-Type	900 MHz	Directional	12 dBi



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

Phoenix Contact
RAD-ISM-900-ANT-YAGI-10-N

GCS Antenna (2/2)

Variables	Values
P_{TX}	24 dBm
G_{TX}	1.9 dBi
G_{RX}	12 dBi
L_{TX}	0.3 dB
L_{RX}	0.3 dB
L_M	0 dB
f	915 MHz
d	3 km

1. Free Space Path Loss (FSPL)

L_{FS} (dB) = 20·log10(d) + 20·log10(f) + 32.45

L_{FS} ≈ 9.54 + 59.22 + 32.45 ≈ 101.21dB

2. Received Power Calculation

P_{RX} (dBm) = $P_{TX} + G_{TX} - L_{TX} - L_{RX} - L_{FS} - L_M + G_{RX}$

24dBm + 1.9dBi + 12dBi = 37.9dB

0.3dB + 101.21dB + 0dB + 0.3dB = 101.81dB

P_{RX} = 37.9 − 101.81 ≈ −63.91dBm

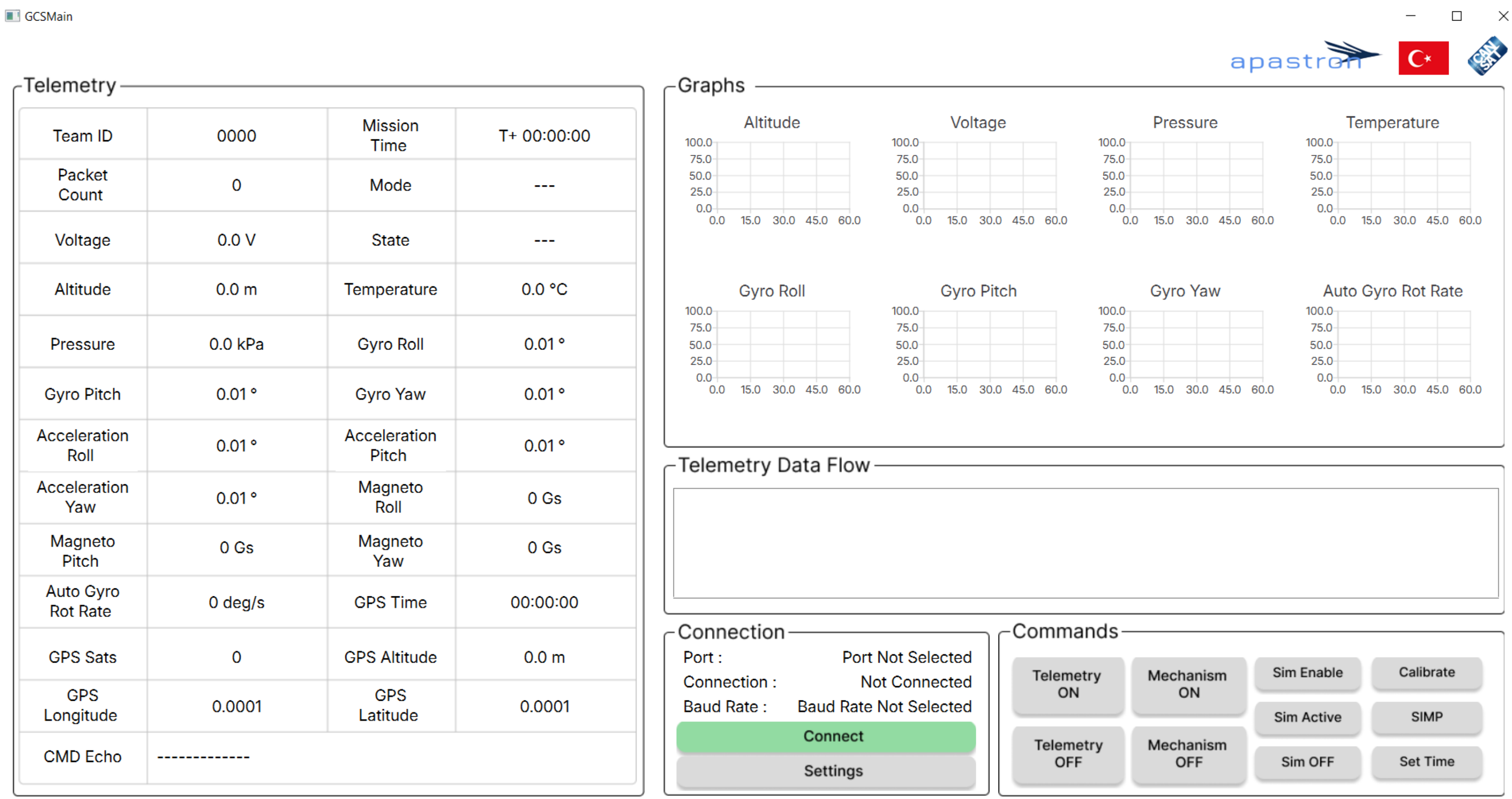
Variables	Calculated Values
L_{FS}	101.21dB
P_{RX}	−63.91dBm

3. Link Budget

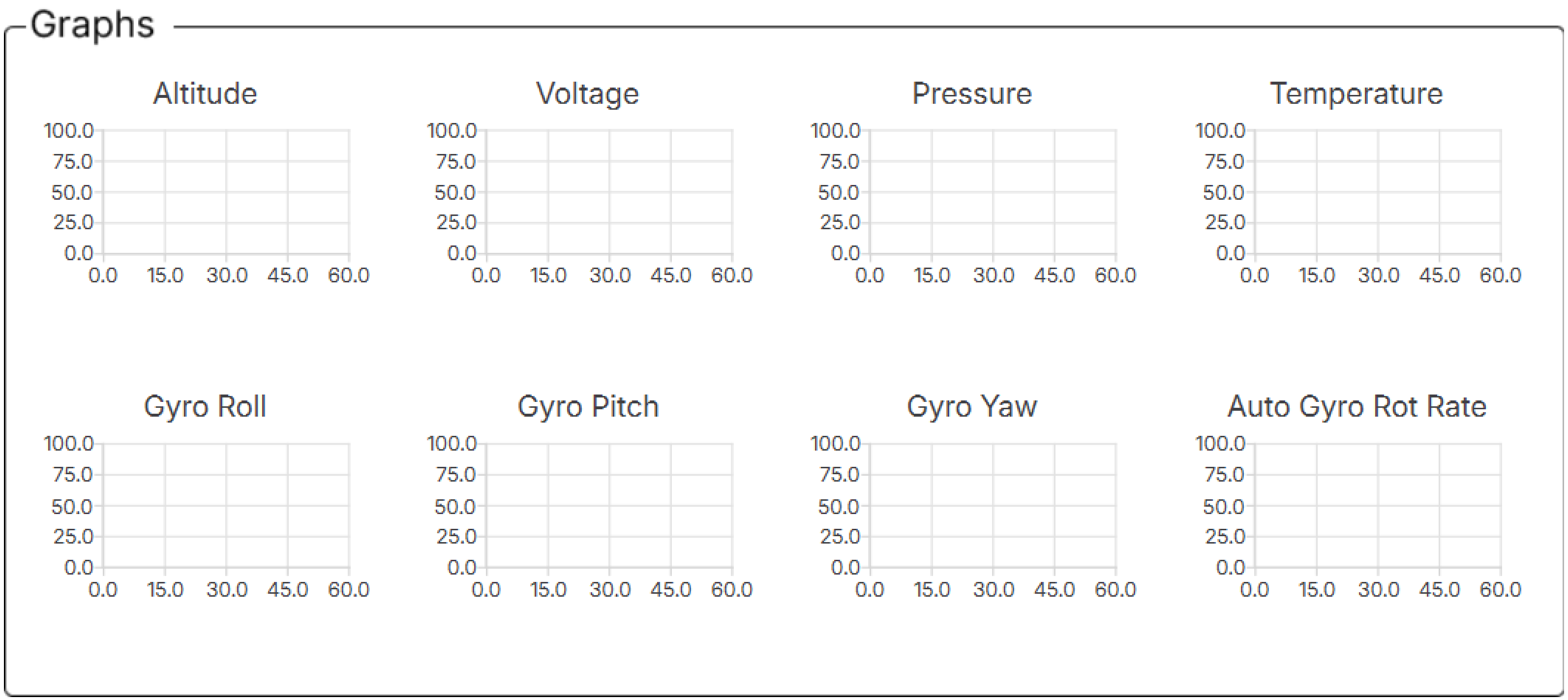
−63.91dBm > -101.21dBm

According to the calculations, at a distance of 3 km, the received signal strength provides a reliable connection with an adequate power margin. However, these results need to be tested under real-world conditions.

GCS Software (1/6)

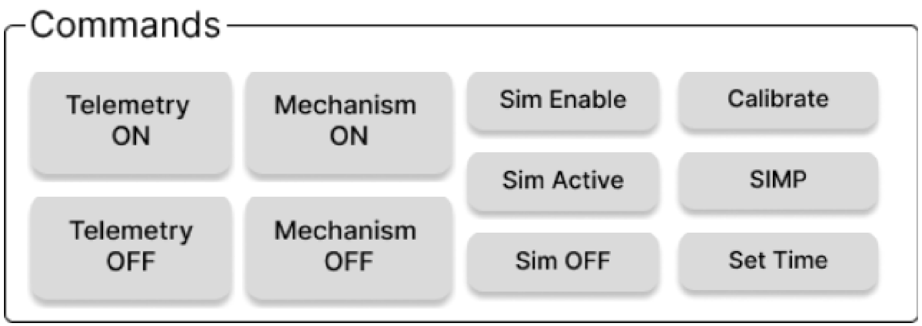


Ground Station Interface – Final Implementation



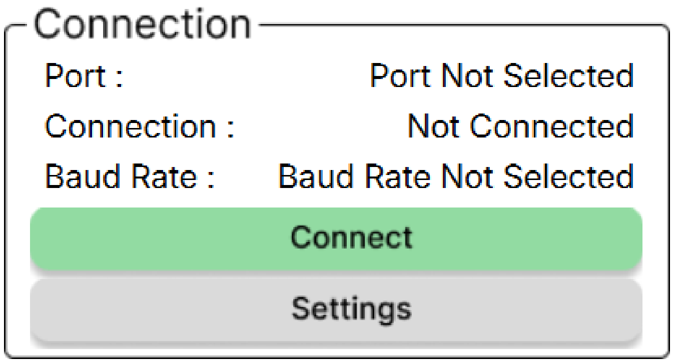
The interface is now finalized and displays graphs of instantaneous altitude, voltage, pressure, temperature, and the gyroscope's pitch, roll, and yaw values, along with the auto-gyro rotation rate, using accurate time-dependent engineering units.

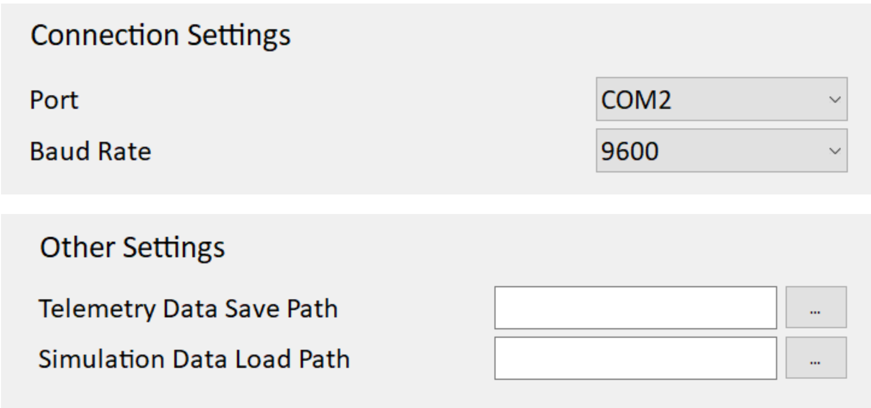
GCS Software (3/6)



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.

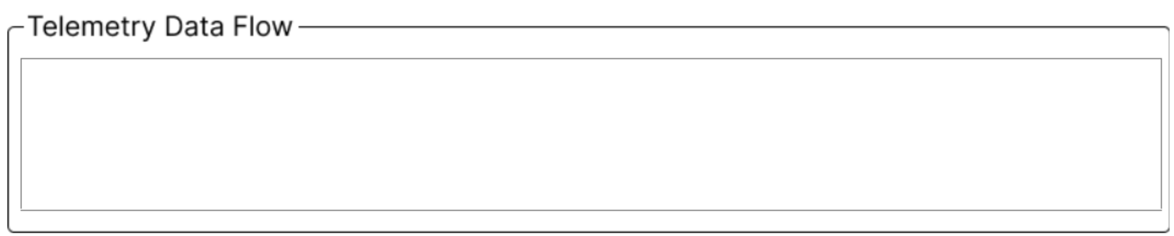
The *Connection* panel displays the connection status with the CanSat, as well as the selected port and baud rate. The panel also includes connect, disconnect, and settings buttons. Connection settings, the directory for the simulation file, and the directory for saving flight data are located in the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





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	0000	Mission Time	T+ 00:00:00
Packet Count	0	Mode	---
Voltage	0.0 V	State	---
Altitude	0.0 m	Temperature	0.0 °C
Pressure	0.0 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	00:00:00
GPS Sats	0	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.

Since the PDR, the ground station interface has been completely developed and optimized. All modules have been integrated to ensure that telemetry data is processed in real time and accurately, delivering a seamless and reliable data stream 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)

- The accuracy of all sensors has been tested in environments where the actual values of the received data are known.

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)

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

CDH		EPS
MCU	• It is tested that the data from the sensors are transmitted and processed to the ground station.	•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 with a multimeter. •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 with a multimeter. •This will test whether the motors did not experience power interruptions during the start-up and landing phases of the auto-gyro system, and whether the batteries were sufficient to provide the required power, by running the motors for a period of time and checking the thrust power.
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)

RADIO COMMUNICATION	FSW
•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). •The distance, communication, and transmission power tests of the antennas on the payload and the ground station are conducted by going to suitable terrains. •The interface of the ground station, reception of telemetry packets and their display on the screen, command sending operations, etc., will be tested through trials at all stages.	• The accuracy of the data received from the sensors is checked in environments with known values. • The correctness of the data transmission order is checked by referring to the mission guide. • In case of microprocessor reset, data recovery algorithm tests are performed. • Flight algorithm tests are conducted by releasing the payload and container from a certain height (separation mechanism, 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 both individually and together. • The accuracy of telemetry packets and transmission stages is tested in environments where the real values of the data in the packets (time, location, etc.) are known.

Subsystem Level Testing Plan (4/4)

DESCENT CONTROL	MECHANICAL
•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.	• The total mass is checked with a precision scale. • The container has been checked with precision measuring instruments to ensure it meets the desired size and structure. • The separation and second camera mechanisms, controlled by a servo motor, will be tested by releasing the CanSat from a certain height. • The durability of the CanSat and its subsystems is tested by simulating all possible situations it might encounter, such as drop tests, applying a certain amount of force, etc. • 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 descent of the container and payload at specified speeds by releasing the CanSat from a certain height. • The compliance of structural parts with the specified rules (such as the nose cone being a single piece and ensuring it is airtight) is checked. • To prevent fire risks, it is checked that heat-using mechanisms do not come into contact with the outside environment. • Factors such as the container release mechanism and the structural adequacy of the materials selected for the parachute (e.g., the parachute must stay intact under expected forces) will be tested by releasing the CanSat from a certain height.

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. • The distance, communication, and transmission power tests of the antennas on the payload and the ground station are conducted by going to suitable terrains. • By inserting an SD card into the MCU, a verification will be provided between the processed telemetry packet and the sent telemetry packet.
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 structural and dimensional suitability of the container and other components will be checked at all stages, from production to assembly, using precise measuring instruments. •The CanSat will be placed into the rocket, and the suitability of the payload and container in terms of weight and dimensions 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. 

Test Procedures Descriptions (1/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
1	Calibration and trouble-free operation of the BME280 sensor	SN1, SN2	The pressure sensor must give the correct pressure and temperature values
2	Calibration and trouble-free operation of the Voltage Sensor	SN3	The voltage sensor must give the correct voltage value of the source.
3	Trouble-free operation of the ESP32-CAMs	C9,C10, C11,SN7, SN8,SN9, SN10	One of the CanSat payload cameras shall record the deployment of the parachute and auto-gyro, while a second camera shall record a nadir-direction video at a 45° angle during descent, with rotation stabilization and no more than ±10° deviation. The videos shall have a minimum resolution of 640x480 and be in color.
4	Calibration and trouble-free operation of the MPU9255 sensor	SN5,SN11	The IMU sensor must give the correct values of the payload acceleration, rotation rates and magnetic field.
5	Calibration and trouble-free operation of the HC-020K RPM Sensor	SN6	The RPM sensor must give the correct value of auto-gyro rotation rate.
6	Calibration and trouble-free operation of the NEO-M9N sensor	SN4	The GPS sensor must give the correct values like latitude longitude etc of the environment.
7	All sensors work smoothly together	-	All sensors must work without any problem

Test Procedures Descriptions (2/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
8	Connecting XBee modules to each other with PANID and provide data receiving and transmitting	X1,X2, X3, G1,G16	Two Xbee module should be able to connect and send/receive data each other
9	Observing changes in data by performing a range test	G13	Telemetry package must be taken smoothly when the distance is between with 750-1000 meters without loss.
10	Testing of data transfer	X5	Transmission of the telemetry package must be lossless.
11	Telemetry format test	X5, G2, G7,G8	The telemetry format should be the same as given in the mission guide, and data transmission should occur once per second.
12	SD card data processing and video recording test	G2	After mission SD card should be able to save all telemetry packages and video records.
13	Testing data rate with RTC module	C8,X4, G3, G12,F3	Cansat should send telemetry package with range of 1 seconds

Test Procedures Descriptions (3/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
14	Measuring Voltage values in batteries and regulators	-	Values must be same with given in *EPS* part
15	Measuring battery current and controlling of power switches	E3,E7	The battery should not provide a current value that could cause problems, and the power switches should be checked.
16	Testing the separate battery and power switch of the audio beacon	C13, E6, E7	Audio beacon must work without any problem
17	Two-hour power consumption monitoring with the entire system installed	E5	The probe must work over than two hours
18	Strength of battery and cable connections	S17, M4	Shouldn't be any disconnection with vibration or shock force
19	Electric leakage and short circuit control	-	The EPS system should have no leakage current or short circuit at any point.
20	Motor power continuity and battery sufficiency Power indicator test	E4	The motors should not experience power interruptions during the start-up and landing phases of the auto-gyro system, and the batteries should always provide the required power.

Test Procedures Descriptions (4/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
21	Testing of the separation and second camera mechanisms controlled by a single servo motor.	C5,C10, C11,C12, S16,SN8, SN9	Both the separation mechanism and the servo motor controlling the direction of the second camera must operate smoothly.
22	Correct operation of auto-gyro system and parachute mechanism.	C3,C4,C6, C7	Separation, the start of the auto-gyro system, and the parachute mechanisms must operate smoothly, and the parachute must remain attached under the expected forces.
23	Total weight, size and structural strength tests	S1,S2,S3, S4,S7, S10,S11, S12,S13, S14	Cansat must meet the weight, size and structural strength requirements specified in the mission guide.
24	Testing the compliance of structural parts with the specified rules.	C1,C2,S5, S6,S15,M1	The compliance of structural parts with the specified rules should be tested (e.g., the nose cone being a single piece and ensuring it is airtight).
25	Performing durability tests of Cansat and its subsystems	S8,S9, S17,M3	The CanSat should be resistant to various shocks and impacts.
26	Fire risk test	M2	Heat-using mechanisms should not come into contact with the outside environment.

Test Procedures Descriptions (5/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
27	Processing data and creating telemetry correctly Testing of data transfer, data count tracking, and mission time tracking.	X5,F1,F2	The telemetry packet must be in the correct format, FSW must keep the number of transmitted packets, and CanSat must keep the mission duration.
28	The probe's data reception test during power on/off and under unexpected conditions.	G4, F1,F2	The probe should continue to receive data correctly even when turned off and on, during processor resets, or in case of brief power loss.
29	Correct execution of commands from the ground station	F7	All mechanisms and processes should be initiated with the commands sent from the Ground Station (GS).
30	Correct operation for the command to switch to simulation mode and the transfer of data	-	Probe shall complete the simulation mode correctly
31	Flight algorithm tests (separation mechanism and auto-gyro system, etc.).	F7	The flight algorithm should perform the operations (parachute deployment, separation mechanism, and activation of the auto-gyro system, etc.).

Test Procedures Descriptions (6/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
32	Correct operation of ground station commands	G1,G4, G6, G12,G16	Sending commands, activating mechanisms, configuring, and similar actions should work correctly and complete the process.
33	Ground station PC charging time and design features test	G5,G9, G10,G14	The ground station must remain open for 2-3 hours during operation and meet the specifications outlined in the mission guide (large font, team-specific requirements,etc.).
34	Interface data acquisition, data processing and storage testing	G2,G3, G15	During mission, dataset must be taken without loss. And after mission all data must storage
35	Antenna testing.	G9,G13	The antennas must have sufficient transmission power and communicate correctly under various distances and weather conditions.
36	Telemetry display test on the ground station.	G6,G7, G8	All telemetry must be displayed in real-time on the ground station during launch and landing. Telemetry should be in SI units with units shown on the screens. Teams must plot each telemetry data field in real-time during flight.

Test Procedures Descriptions (7/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
37	Correct operation of the transition to simulation command	G11, F6	When the simulation enable and simulation active commands send from GS, probe must be work in simulation mode
38	Accurate transmission of simulation data and execution of operations	G12, F4	The transmission of pressure datas and telemetry package must be trouble-free
39	Simulation mode payload altitude determination test.	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.
40	Correct operation of mechanisms according to altitudes sent via simulation mode	C5,C6,C7	The mechanisms shall work at correctly at a time
41	Control of the specified speeds at the specified altitudes for the CanSat and payload	C4, C6, C7	The CanSat must descend at 20 m/s with the automatic deployment of the parachute, the release mechanism must activate at 75% altitude, and the payload must descend at 5 m/s in a controlled manner using the auto-gyro

Test Procedures Descriptions (8/8)

Test Proc	Test Description	Rqmts	Pass/ Fail Criteria
42	Cost and Foreign Matter Control	C14,E1,E2	The Cansat cost must not exceed $1000. Lithium polymer batteries must not be used etc.
43	Drop Test	S9, S17,M3, M4	CanSat should withstand 30 Gs of shock
44	Thermal Test	-	CanSat should withstand 60C over 2 hours
45	Vibration Test	S8	CanSat should withstand 200 233 Hz of vibration
46	Fit Check	C1, C2, S1,S2, S3, S4 S5, S6,S7,S10, S11,S12,S13, S14,S18,S19	The CanSat must meet all the physical measurements provided in the mission guide (e.g., CanSat must be 1400 (+- 10) grams, etc.).
47	Vacuum Test	-	CanSat should keep working under vacuum condition.

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)

	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 Metin SATI 	Monitoring the ground station for telemetry reception and issuing commands to the CanSat.
Recovery Crew (RC)	Bugrahan DEGIRMENCI, Göktuğ KOCCENK, Metin SATI 	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, Alperen Ragıp SOYLER 	Preparing the CanSat, integrating it into the rocket and verifying its status.

Overview of Mission Sequence of Events (2/4)

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)**
- Umbrella is installed to protect the Ground Station from sun **(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)**
- CanSat is mounted to the rocket **(CC)**
- Sensors Calibration **(GCS+CC)**
- Safety Check **(Whole Team)**

Overview of Mission Sequence of Events (3/4)

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 tracks 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 (4/4)

Post Flight

- Received telemetry data will be analyzed **(Whole Team)**
- Damage Inspection will be done and logged (to be used in the prep of PFR) **(CC+RC)**
- Clearing Ground Station area **(Whole Team)**
- Telemetry data file will be delivered in a USB drive to judges for review **(MCO)**
- PFR

Field Safety Rules Compliance

- 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 manual will be assembled in a three ring binder.
- The content of the manual will be developed in accordance with the events disscussed in Mission Sequence of Events.
- Manual Preparation Status: the base is ready, new tasks will be added. The final version of the manual will be ready after the tests and rehearsals.

CanSat Assembly (Pre-Launch Prep)	• Battery charge control • Mechanism inspection
CanSat Testing (Pre-Launch Prep)	• Communication and sensors test • Auto-Gyro is checked whether it is in the correct configuration • 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)	• Damage Inspection is done • CanSat is found • Flight data is retrieved from SD cards • 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

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Team Leader contact: Gürkan ALKAN

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Labeling

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

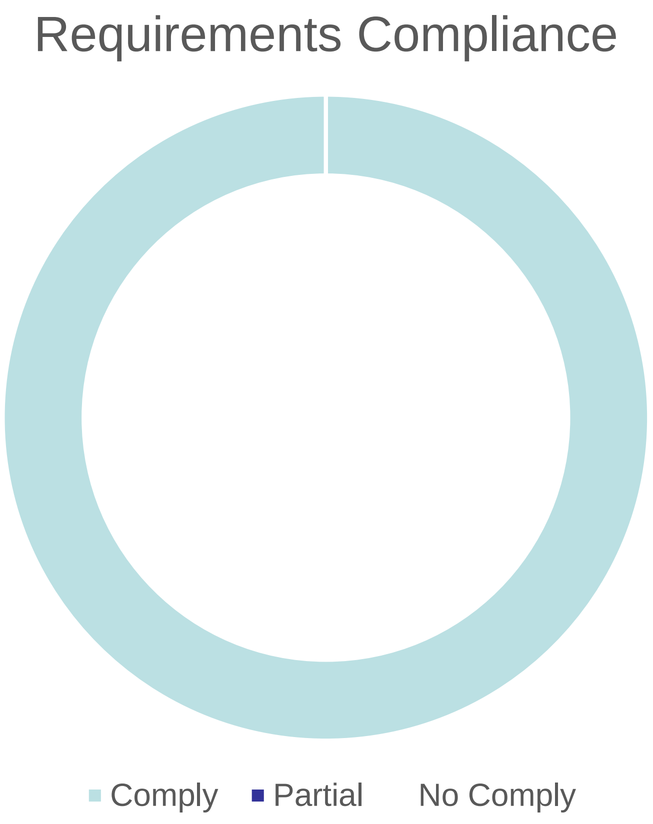
Mission Rehearsal Activities

CanSat Assembly, Launch Configuration Check (Pre-Launch Prep)	• Final assembly of the CanSat • Battery charge control • Mechanism inspection • Stowing appendages	• Will be rehearsed on May 4th, 2025
CanSat Testing, Powering On/Off (Pre-Launch Prep)	• Communication and sensors test • Auto-Gyro is checked whether it is in the correct configuration • CanSat dimension and weight check • Sensors Calibration • Safety Check	• Will be rehearsed on April 20th & May 4th, 2025
Ground Station Radio Link Check (Pre-Launch & Launch)	• Set up GCS and antenna • Communication and sensors test • Ground station interface and data logging processes check	• Will be rehearsed on April 20th & May 4th, 2025
Integration to the launch vehicle (Pre-Launch)	• CanSat dimension and weight check • Fold and attach the parachute • Autogyro is stowed into the container • Mounting CanSat to the rocket	• Will be rehearsed on May 4th, 2025
Recovery & Telemetry Data Analysis (Post Flight)	• Flight data is retrieved from SD cards • Telemetry processing, archiving, and analysis • Damage Inspection is done • Ground Station area is cleared	• Will be rehearsed on May 4th, 2025

Requirements Compliance

Gürkan ALKAN

Requirements Compliance Overview



- The requirements are fully **complied**.

There are no major problems for compliance of the requirements.

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	18, 21	
C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	61, 62	
C3	The Cansat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	17, 18	
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	17, 19	
C5	At 75% flight peak altitude, the payload shall be released from the container.	Comply	17, 19, 64	
C6	At 75% peak altitude, the payload shall deploy an auto-gyro descent control system.	Comply	17, 19	
C7	The payload shall descend at 5 meters/second with the auto-gyro descent control system.	Comply	17, 19	
C8	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	119, 121	
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	36	
C10	A second video camera shall point in the north direction during descent.	Comply	35	
C11	The second camera shall be pointed 45 degrees from the Cansat nadir direction during descent.	Comply	69	

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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	69	
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat electronics.	Comply	93, 95	
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	164, 166	
Structural Requirements				
S1	The CanSat mass shall be 1400 grams +/- 10 grams.	Comply	73, 74	
S2	Nose cone shall be symmetrical along the thrust axis.	Comply	42, 43	
S3	Nose cone radius shall be exactly 72.2 mm	Comply	24, 52	
S4	Nose cone shoulder length shall be a minimum of 50 mm	Comply	24, 52	
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	130	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	130	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	24	
S8	Cansat structure must survive 15 Gs vibration.	Comply	70, 133	
S9	Cansat shall survive 30 G shock.	Comply	70, 132	

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	62	
S11	The container shoulder diameter shall be 136 mm.	Comply	62	
S12	Above the shoulder, the container diameter shall be 144.4 mm	Comply	62	
S13	The container wall thickness shall be at least 2 mm.	Comply	62	
S14	The container length above the shoulder shall be 250 mm +/- 5%.	Comply	62	
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	18, 21	
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	68	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	55, 58, 59, 70	
S18	The Cansat container shall meet all dimensions in section F.	Comply	62	
S19	The Cansat container materials shall meet all requirements in section F	Comply	61	
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	60, 61	
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	130	
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	63,	
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	96	
Electrical Requirements				
E1	Lithium polymer batteries are not allowed.	Comply	96	
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	96	
E3	Easily accessible power switch is required	Comply	95	
E4	Power indicator is required	Comply	95	

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	98	
E6	The audio beacon shall operate on a separate battery.	Comply	93, 95	
E7	The audio beacon shall have an easily accessible power switch.	Comply	95	
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	82	
X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	83	
X3	XBEE radios shall not use broadcast mode.	Comply	83	
X4	The probe shall transmit telemetry once per second.	Comply	82	
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	85, 86, 87, 88	
Sensor Requirements				
SN1	Cansat payload shall measure its altitude using air pressure.	Comply	26, 28	
SN2	Cansat payload shall measure its internal temperature.	Comply	26, 29	
SN3	Cansat payload shall measure its battery voltage.	Comply	26, 30	
SN4	Cansat payload shall track its position using GPS.	Comply	26, 31	
SN5	Cansat payload shall measure its acceleration and rotation rates.	Comply	26, 32	

Requirements Compliance (6/8)

Rqmt Num	Requirement	Compliance	Reference Slides	Team Comments or Notes
SN6	Cansat payload shall measure auto-gyro rotation rate.	Comply	26, 33	
SN7	Cansat payload shall video record the release of the parachute and deployment of the auto-gyro at 75% peak altitude.	Comply	26, 36	
SN8	Cansat payload shall video record the ground at 45 degrees from nadir direction during descent.	Comply	26, 35, 69	
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	26, 34, 35	
SN10	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	35, 36	
SN11	The Cansat shall measure the magnetic field.	Comply	34	
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	118	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	121	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	120, 121	
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	100	
G5	Each team shall develop their own ground station.	Comply	116, 121	
G6	All telemetry shall be displayed in real time during ascent and descent on the ground station.	Comply	116, 117, 118, 119, 120	

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	116	
G8	Teams shall plot each telemetry data field in real time during flight.	Comply	116, 117	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	111, 113, 114	
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	113	
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	118	
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	119, 121	
G13	The ground station shall use a table top or handheld antenna.	Comply	114, 115	
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	113, 116	
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	116, 120	
G16	The ground station shall be able to activate all mechanisms on command.	Comply	118	

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	104	
F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	100, 104	
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	100, 104	
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	107	
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	107	
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	100, 107	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	106	

Management

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Status of Procurements

Component	Quantity	Status	Component	Quantity	Status
Teensy 4.1 Development Board	x2	Received	**Molicel INR-21700-P45B- Li-Ion Battery**	x4	Received
XBee-PRO S3B RF Module	x3	Received	**Xbee Explorer USB Adaptor**	x3	Received
Adafruit BME280 Temperature Humidity Pressure Sensor	x1	Received	**R2304 F3P Airplane Brushless Motors**	x2	To be ordered
SparkFun NEO-M9N	x1	Received	**3mm Green LED**	x1	Received
MPU9255	x1	Received	**HC-020K RPM Sensor**	x1	Received
Runcam mini Fpv DVR Module	x1	Received	**Voltgae regulator**	x2	Received
SanDisk Ultra 16GB microSD Card	x3	Received	**Servo motor**	x1	Received
Buzzer	x1	Received	**SunSky X 18A ESC**	X2	Received
ESP 32CAM	x2	Received	**PLA+ Filament**	x3	Received
Voltage sensor module	x1	Received	**40D Ripstop Parachute Fabric**	x2 m	Received
3V Lithium Coin Cell Battery - CR1220	x3	Received	**Rolling Swivel package**	x1 pkg	Received
Yagi Antenna	x1	Received	**Hardware tools (screws, springs, etc.)**	>2	Received
Passive electronis components	>2	Received			

- All received components are received before the CDR presentations (April 2024), which is highly compatible with our Project Plan Detailed Schedule.

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
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	x2	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 = 668,20 $

✓ Development of the CanSat is under 1000$

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)
Train Tickets	7		476	$	
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	-	Car rental & accommodation	2400	$	No projected rentals yet

	Source	Type of support
Sources of Income	**ULAK COMMUNICATIONS INC.**	**Financial (1000 $)**

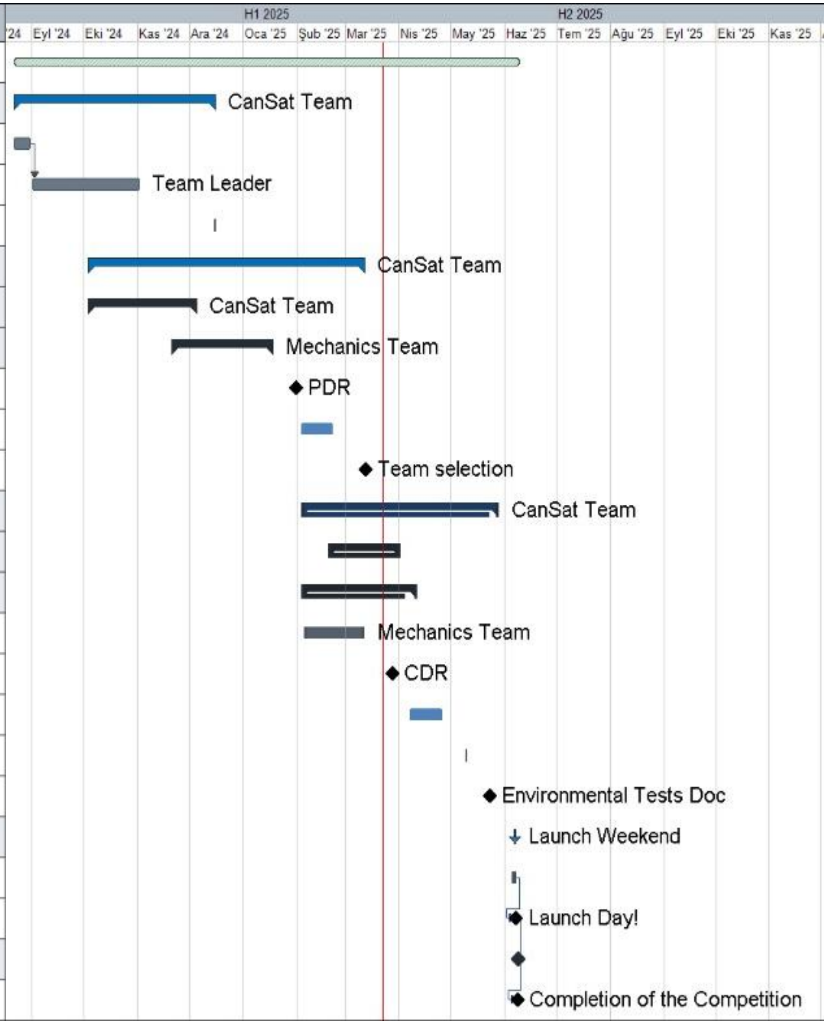
CanSat Budget – Other Costs (2/2)

TOTAL COSTS	
Cost Type	**Total**
Hardware	668.20 $
Other	12101 $
TOTAL	**12769.20 $**

- ✓ 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	9.06.2025	212 days
2		**PHASE 1- Application**	**21.08.2024**	**15.12.2024**	**85 days**
3		Examination of the Competition Guide by the team	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 the system	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 requested	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 the system	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

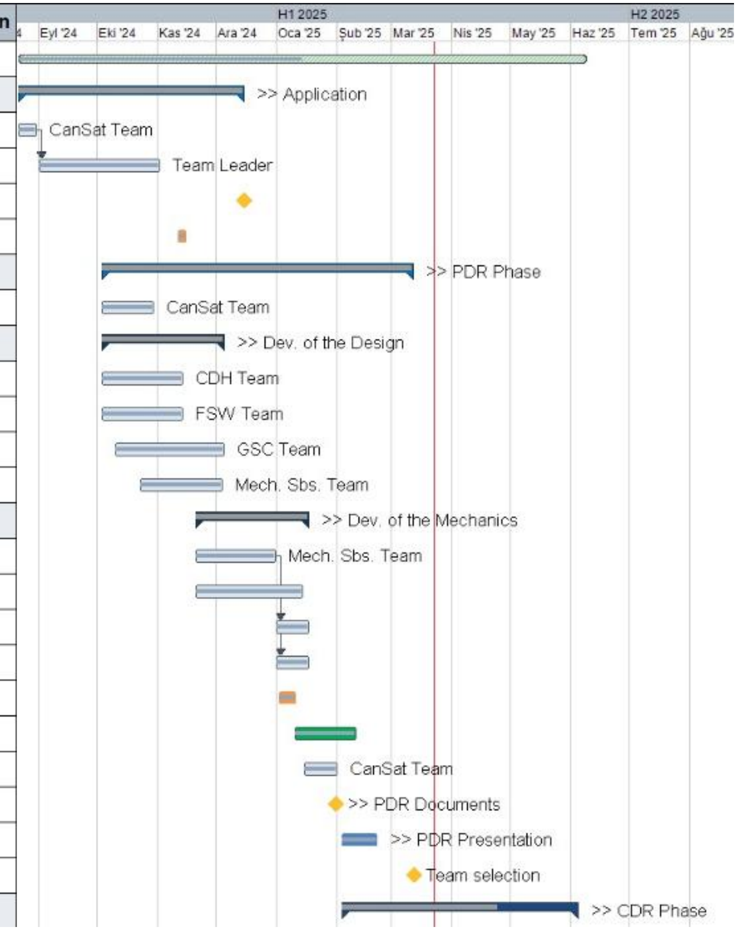
◆ : Competition milestones

— : Current date

▬ : Major integration and test activities

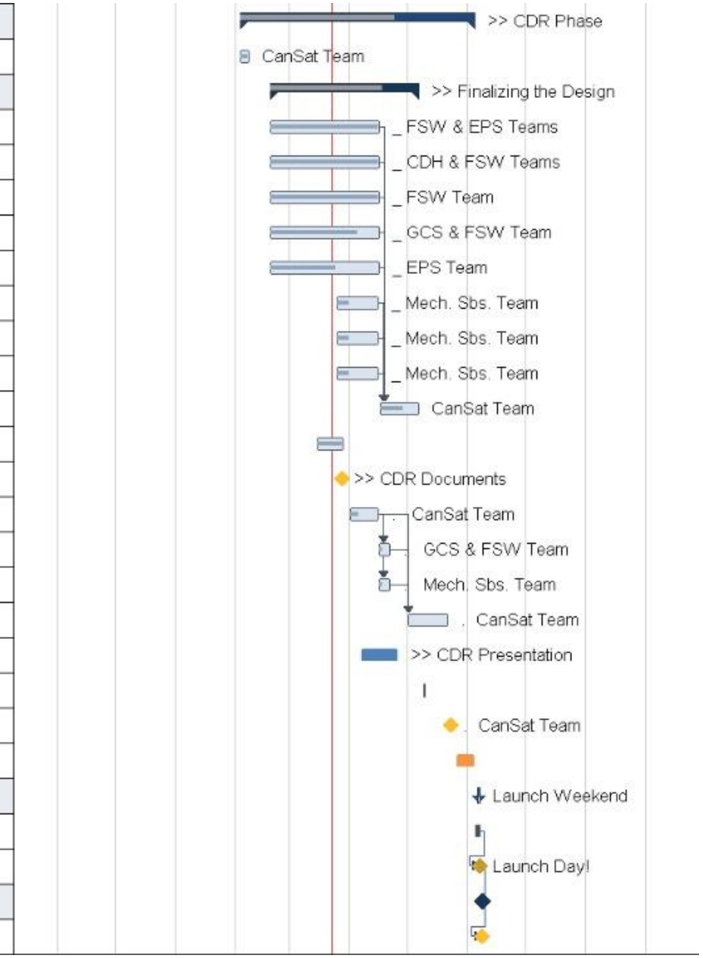
Detailed Program Schedule (2/3)

		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	100%
25		**PHASE 3- CDR**	**3.02.2025**	**4.06.2025**	**88,03 days**	**66%**



Detailed Program Schedule (3/3)

25	**PHASE 3- CDR**	**3.02.2025**	**4.06.2025**	**88,03 days**	**66%**
26	Examining the CDR template and distributing tasks to team ...	3.02.2025	7.02.2025	5 days	100%
27	**Finalizing the Design**	**19.02.2025**	**6.05.2025**	**55 days**	**76%**
28	Subsystem level tests of Sensors and the Processor	19.02.2025	16.04.2025	41 days	100%
29	Communication Tests	19.02.2025	16.04.2025	41 days	100%
30	Development and Tests of Flight Software	19.02.2025	16.04.2025	41 days	100%
31	Testing the GSC Software	19.02.2025	16.04.2025	41 days	80%
32	EPS Tests	19.02.2025	16.04.2025	41 days	60%
33	Descent Control Subsystem tests	25.03.2025	15.04.2025	16 days	30%
34	Auto-Gyro Mechanism tests	25.03.2025	15.04.2025	16 days	30%
35	Parachute deployment tests	25.03.2025	15.04.2025	16 days	30%
36	Updating the design according to the test results and/or in...	16.04.2025	6.05.2025	14 days	60%
37	CDR Time slot selection	15.03.2025	28.03.2025	10 days	100%
38	Deadline for uploading the CDR Documents to the system	28.03.2025	28.03.2025	0 days	100%
39	Production and Integration Process	1.04.2025	15.04.2025	11 days	30%
40	System Level Communication Tests	16.04.2025	21.04.2025	4 days	30%
41	System Level Mechanism Tests	16.04.2025	21.04.2025	4 days	30%
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%



Shipping and Transportation

- We are planning to transport CanSat and all components/tools/ equipments in our carry-on bags in order to make sure nothing gets lost on the way.
- We are also planning to produce spare parts and take them with our hand luggages too.

Conclusions (1/4)

- Major Accomplishments
- Major Unfinished Work
- Testing to Complete
- Flight Software Status

✓ Development of the design
  - Auto-Gyro mechanism
  - Release Mechanism
  - Ground Camera Controlling

✓ Development of the mechanics
  - Design of the CanSat prototype
  - Prototype 3D print

✓ Electronic Subsystems Designs

✓ Ground Control Station Design

✓ GCS Software Design

✓ Subsystem Level Tests
  - 4/7 of subsystems are tested

✓ Parts Procurements
  - %92 of the components are received

✓ Selected for top 41 teams

✓ Proceeding to the competition

Conclusions (2/4)

Major Accomplishments

Major Unfinished Work

Testing to Complete

Flight Software Status

- ❑ Integration of the subsystems
- ❑ Manufacturing the mechanical parts
- ❑ Testing the mechanical parts
- ❑ Subsystem Level Tests
  - 4/7 of subsystems are tested
- ❑ Ground Station Integrated Level Tests
- ❑ Simulation Mode Tests
- ❑ Descent Control Tests
  - Parachute Deployment Tests
  - Auto-Gyro Deployment Tests
- ❑ Environmental Tests
- ❑ Finding funds for travel & accommodation expenses
  - Discussions are ongoing
- ❑ Clarifying the shipping/transportation method

Conclusions (3/4)

- Major Accomplishments
- Major Unfinished Work
- **Testing to Complete**
- Flight Software Status

- Integration of the subsystems
- Manufacturing the mechanical parts
- Testing the mechanical parts
- Subsystem Level Tests
  - 4/7 of subsystems are tested
- Ground Station Integrated Level Tests
- Simulation Mode Tests
- System Level Communication Tests
- Descent Control Tests
  - Parachute Deployment Tests
  - Auto-Gyro Deployment Tests
- Environmental Tests

Conclusions (4/4)

- Major Accomplishments
- Major Unfinished Work
- Testing to Complete
- **Flight Software Status**

- All the sensor libraries are complete and confirmed to be working.
- Flight Software developed.
- Simulation Mode is going to be tested.
- Integration with the Sensor & EPS subsystems is proceeding.