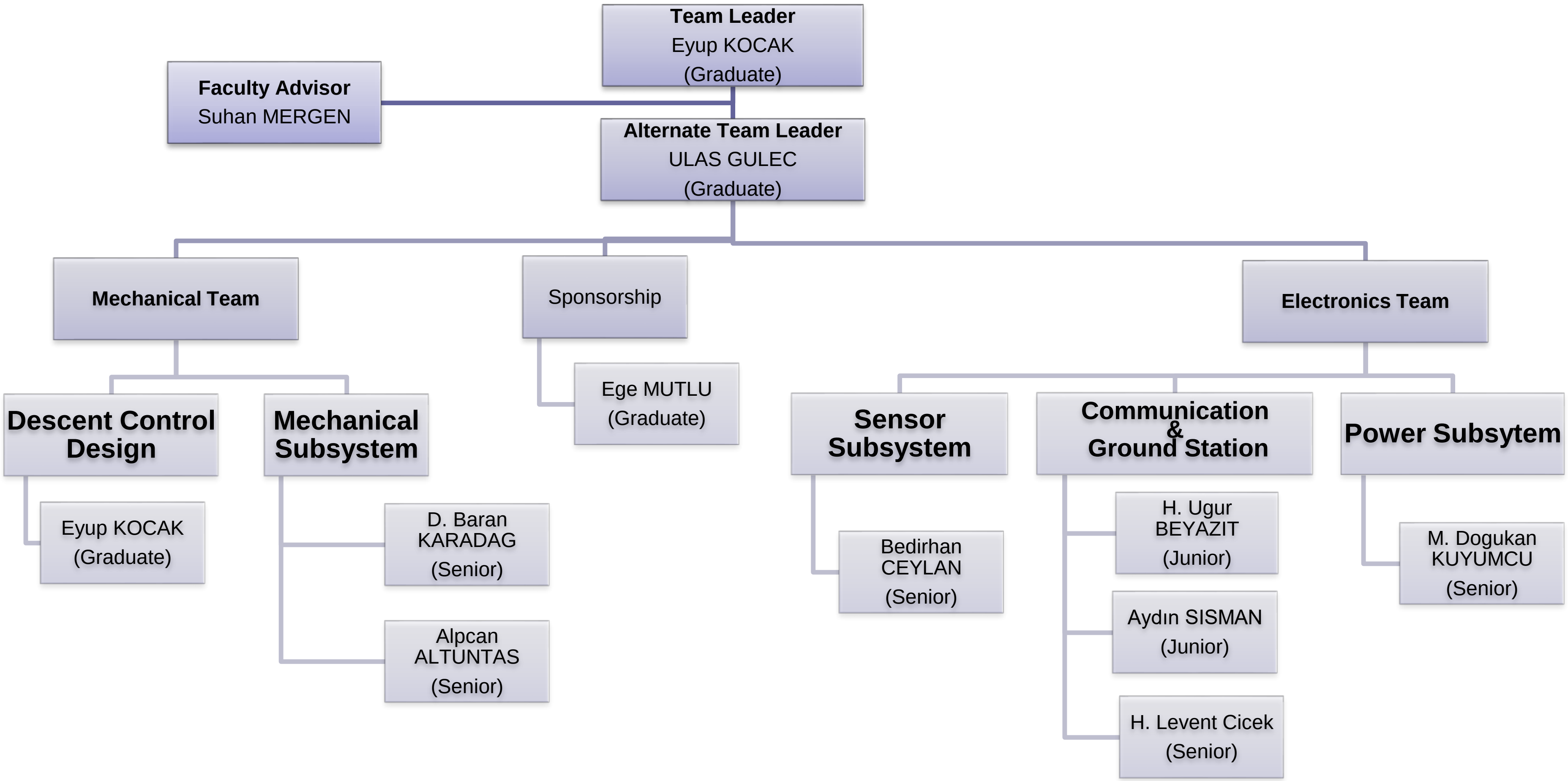
CanSat 2019
Critical Design Review (CDR)

2806

CanBee

Presentation Outline

Team Organization



Acronyms

A	Analysis
CDH	Communication and Data Handling
CR	Competition Requirement (Mission Guide PDF)
D	Demonstration
DCS	Descent Control System
EPS	Electrical Power Subsystem
FSW	Flight Software
GCS	Ground Control System
GPS	Global Positioning System
GUI	Graphical User Interface
HLR	High Level Requirement
I	Inspection
I²C	Inter-Integrated Circuit
ISM	Industrial Scientific Medical
MS	Mechanical Subsystem
PCB	Printed Circuit Board
RC	Radio Communication

Acronyms

RTC	Real Time Clock
SD Card	Secure Digital Card
SMA RF	SubMiniature version A Radio frequency
SMB RF	SubMiniature version B Radio frequency
SPI	Serial Peripheral Interface
SR	System Requirement
SSD	Sensor Subsystem Design
T	Test
UART	Universal Asynchronous Receiver-Transmitter
VM	Verification Method

System Overview

Suhan Mergen

Mission Summary

Mission Objectives

1. Designing and constructing a CanSat that contains a passive propelled payload and a parachute deployable container.
2. Total mass of the CanSat (*science payload and container*) shall be **500 g ±10 g**.
3. The descent rate of the CanSat (*container and science payload*) shall be **20 m/s ±5m/s**.
4. The science payload shall descend using an **auto-gyro/passive helicopter** recovery descent control system.
5. The probe shall transmit all sensor data in the telemetry**.**

Bonus Mission Objectives

Using a camera to capture the release of the science probe and the ground during passive descent

External Objectives

Sponsorship activities

Summary of Changes Since PDR

PDR phase payload design

Component	PDR	CDR	Rationale
Propeller system	Two mill (one-in-another) design	Single aluminium mill and two bearing design	Better functionality, lighter weight
Duralit plates	Hexagonal lates	Circular plates with symmetrical gaps	Lighter weight, possibility to add other components
Electronic component holders	Duralit plate under the pcb's and battery	Custom 3D printed case	Better structural integrity

CDR phase payload design

There have been major design changes for the payload since the PDR phase such as the propeller system, Duralit plates and the 3D printed electronics supporters.

Summary of Changes Since PDR

PDR phase payload design

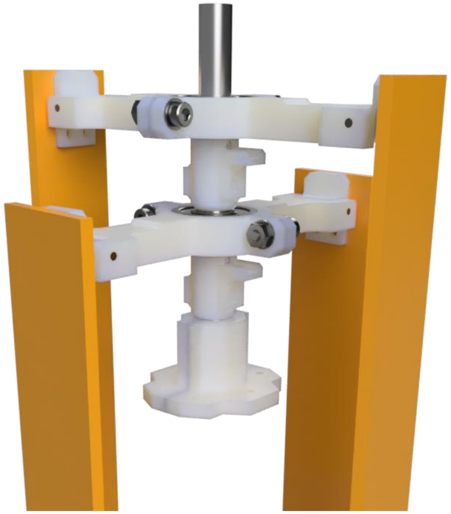
Component	PDR	CDR	Rationale
Encoder	Optocupler - Semiconductor	Hall Effect Sensor	Mechanical constrains are prevented
LED	There is no LED	Additional LED is attached	Power sign can be observed with the help of LED
Antennas	Duck Antenna Outdoor omni-direcitonal antenna	2.4 GHz Antenna Adhesive(U.F.L) TL-ANT2415D	High gain value, small size, longer distance communications , flexible, small dimensions

CDR phase payload design

There is no significant changes since PDR in electrical components except the encoder sensor and the antenna.

Changes at the Propeller System

PDR

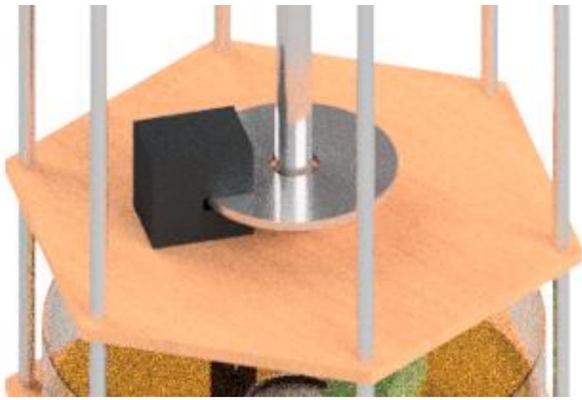


CDR

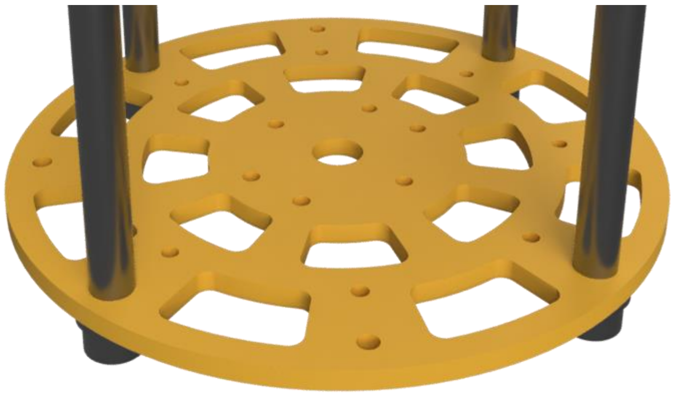
The previous (PDR) design had carbon fiber propeller wings as well as a ‘two mill’ design which only used one bearing in order to mount the mill on to the duralit plate. However we changed this design to a ‘two bearing’ design that is supported by 3D printed spacers and mill cases. This design enables the propeller system to function more smoothly and stable as well as being lighter than the previous design.

Summary of Changes Since PDR

Changes at the Duralit Plates



PDR

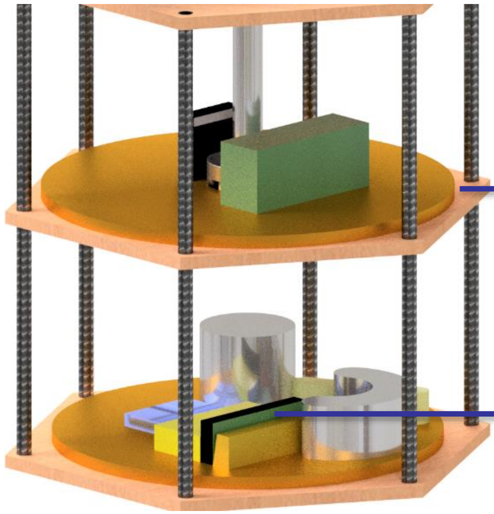


CDR

Instead of using hexagonal plates which enabled the propellers to fold easily, we decided to use circular plates that have symmetrical holes which enable us to fix new components if necessary. These gaps also helped us to conserve in weight. Due to the changes at the propeller system, the propeller wings dont have any problem folding down the payload.

Summary of Changes Since PDR

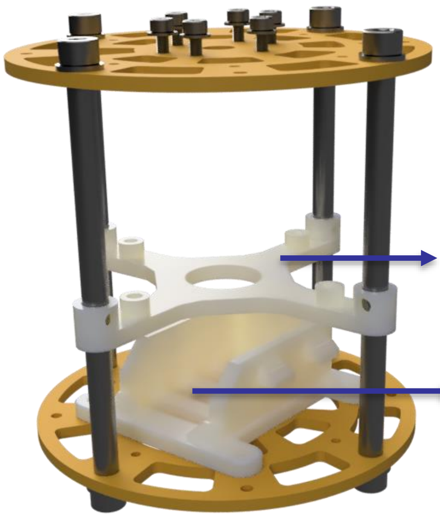
Electronic Component Holders



Duralite under the PCB's

No case or holder for the battery

PDR



PCB Holder

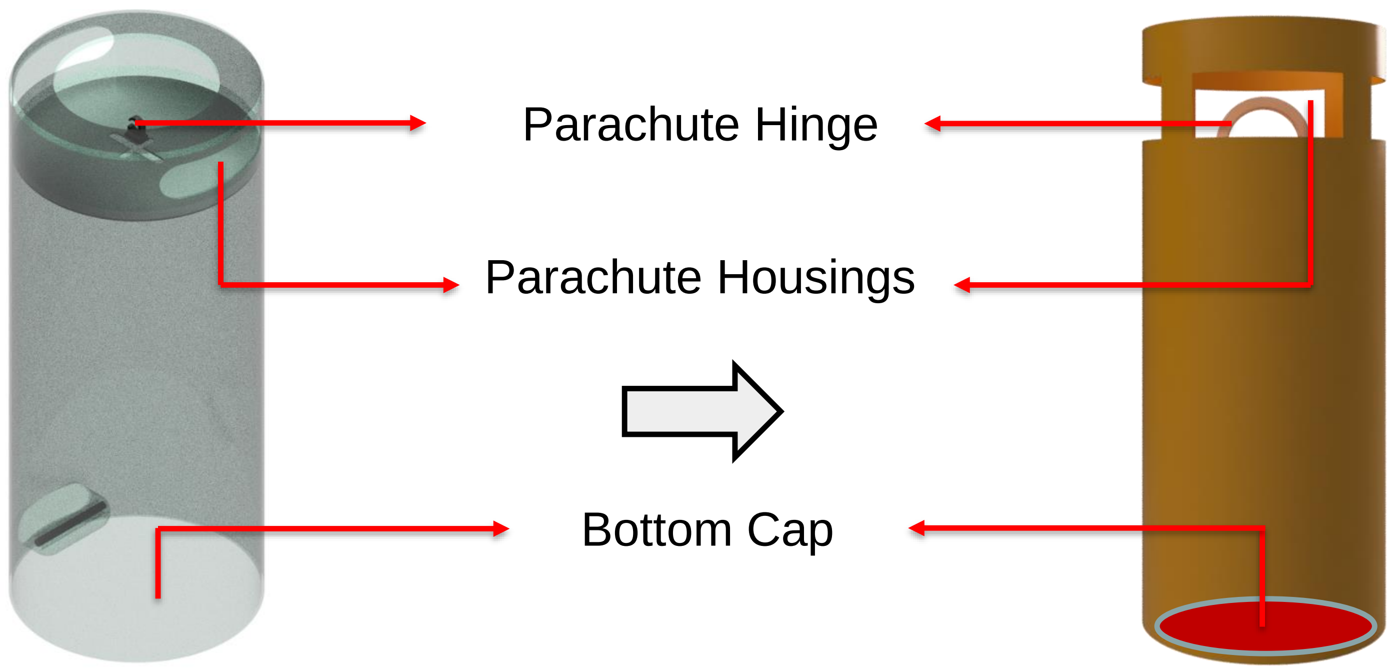
Battery Case

CDR

Duralit was not a safe material to use under the PCB. It has possibility of crack or loosen from the PCB. Therefore, we 3D printed a custom holder and case for the PCB and the battery. The battery case replaced the transparent polyethylene case which could cause the battery to overheat easily. The 3D printed battery case surrounds the battery perfectly preventing it from snapping.

Summary of Changes Since PDR

Container



There is no major change for the container design

Electrical Power Subsytem

PDR

CDR

An additional LED is attached to the science probe to understand the power status of electrical components easily.

PDR

CDR

Encoder sensor is changed from a consept of ultrasonic sensor to magnetic hall sensor due to mechanical constrains.

Summary of Changes Since PDR

Communication Data Handling

PDR

We changed it because it was better in terms of flexibility and ease of use.

Ground Control System

PDR

CDR

We changed it because it was better in terms of flexibility and ease of use and gain.

System Requirement Summary

RQ#	Description	Rationale	A	I	T	D
1	Total mass of the CanSat (science payload and container) shall be 500 g ±10 g.	CR-HLR	✓	✓		
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	CR-HLR	✓			✓
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	CR				✓
4	The container shall be a fluorescent color; pink, red or orange.	CR				✓
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	CR				✓
6	The rocket airframe shall not be used as part of the CanSat operations.	CR				✓
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	CR	✓			✓
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	CR-HLR	✓	✓		

System Requirement Summary

RE#	Description	Rationale	A	I	T	D
9	The container shall release the payload at 450 meters +/- 10 meters.	CR-HLR	✓			✓
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	CR-HLR	✓	✓		✓
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	CR-HLR	✓			✓
12	All descent control device attachment components shall survive 30 Gs of shock.	CR-HLR	✓			✓
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	CR	✓			
14	All structures shall be built to survive 15 Gs of launch acceleration.	CR	✓			✓
15	All structures shall be built to survive 30 Gs of shock.	CR	✓			✓
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	CR	✓			

System Requirement Summary

RE#	Description	Rationale	A	I	T	D
17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	CR	✓			✓
18	Mechanisms shall not use pyrotechnics or chemicals.	CR				✓
19	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	CR				✓
20	The science payload shall measure altitude using an air pressure sensor.	CR-HLR	✓	✓	✓	
21	The science payload shall provide position using GPS.	CR-HLR	✓	✓	✓	
22	The science payload shall measure its battery voltage.	CR-HLR	✓	✓	✓	
23	The science payload shall measure outside temperature.	CR-HLR	✓	✓	✓	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	CR-HLR	✓	✓	✓	

System Requirement Summary

RE#	Description	Rationale	A	I	T	D
25	The science payload shall measure pitch and roll.	CR-HLR	✓	✓		
26	The probe shall transmit all sensor data in the telemetry	CR	✓	✓		
27	The Parachute shall be fluorescent Pink or Orange	CR		✓		
28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	CR	✓	✓		✓
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	CR	✓			✓
30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	CR	✓	✓		
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	CR		✓		✓
32	XBEE radios shall have their NETID/PANID set to their team number.	CR			✓	

System Requirement Summary

RE#	Description	Rationale	A	I	T	D
33	XBEE radios shall not use broadcast mode.	CR		✓		✓
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	CR-HLR	✓	✓		
35	Each team shall develop their own ground station.	CR	✓			✓
36	All telemetry shall be displayed in real time during descent.	CR-HLR	✓			
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	CR	✓			
38	Teams shall plot each telemetry data field in real time during flight.	CR	✓			✓
39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	CR		✓		
40	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.	CR		✓		

System Requirement Summary

RE#	Description	Rationale	A	I	T	D
41	Both the container and probe shall be labeled with team contact information including email address.	CR				✓
42	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.	CR	✓			
44	No lasers allowed.	CR				✓
45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	CR	✓			✓
46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	CR	✓			
47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	CR	✓			✓

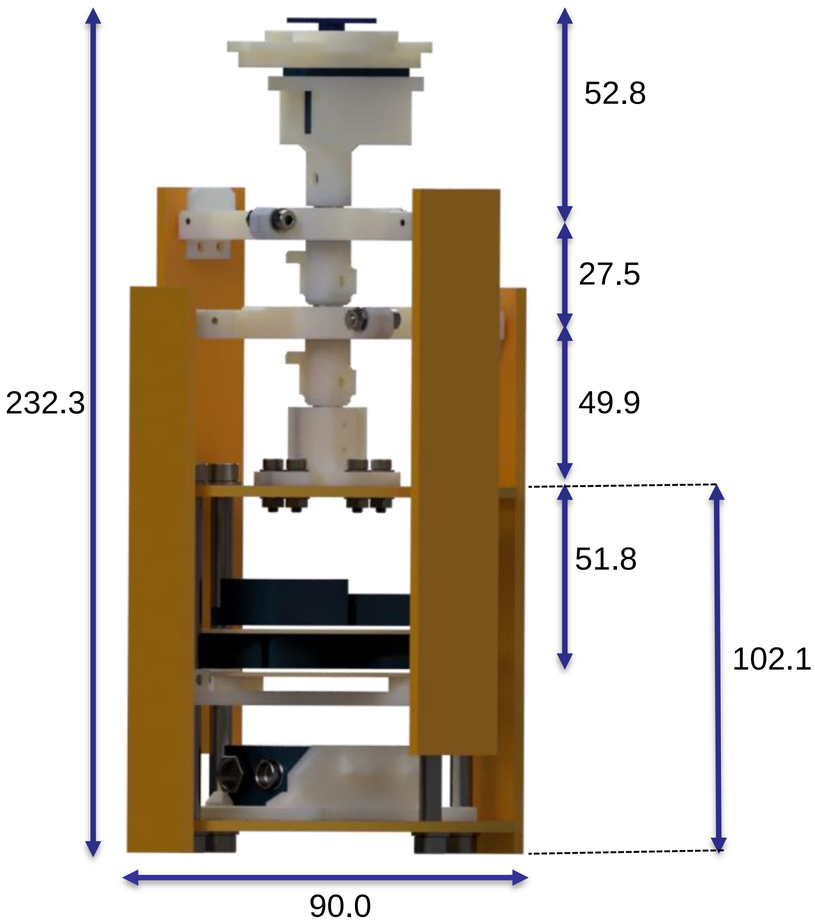
System Requirement Summary

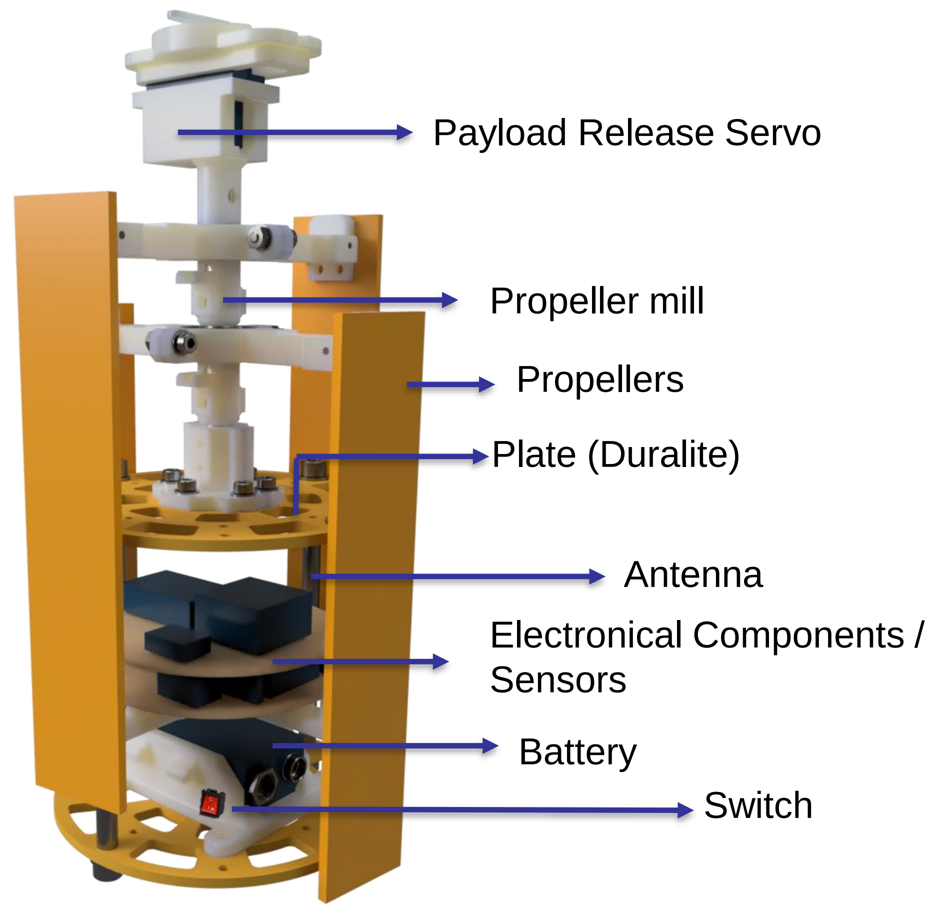
RE#	Description	Rationale	A	I	T	D
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	CR	✓	✓		
49	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.	CR		✓		
50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	CR	✓	✓		
51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	CR	✓			✓
52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	CR	✓			✓
53	The GPS receiver must use the NMEA 0183 GGA message format.	CR	✓			✓
54	The CANSAT must operate during the environmental tests laid out in Section 3.5.	CR		✓		
55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	CR	✓	✓		

System Requirement Summary

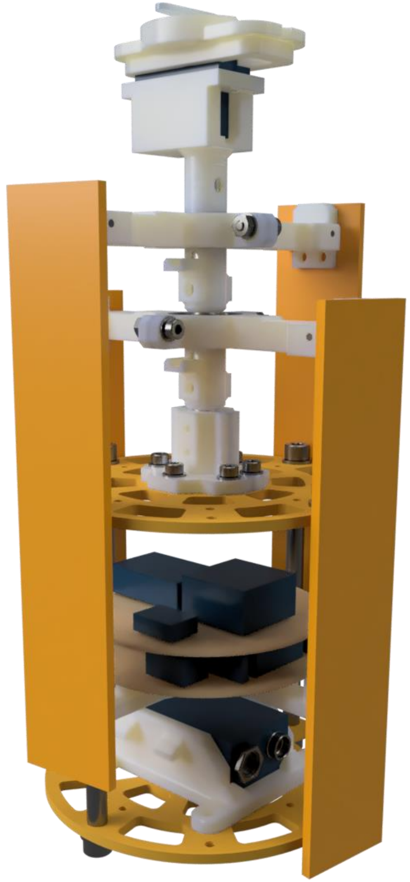
RE#	Description	Rationale	A	I	T	D
Bonus 1	The camera shall point in one direction relative to the earth's magnetic field with a stability of +/- 10 degrees in all directions during descent. Direction does not matter as long as it is in one direction.	CR	✓			✓
Bonus 2	Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The direction the camera is pointed relative to earth's magnetic north shall be included in the telemetry.	CR	✓	✓		
Can Bee 1	When the reset and recovery state occurs, flight software should stop and at the end of this state, it should record data again.				✓	✓

Payload Physical Layout

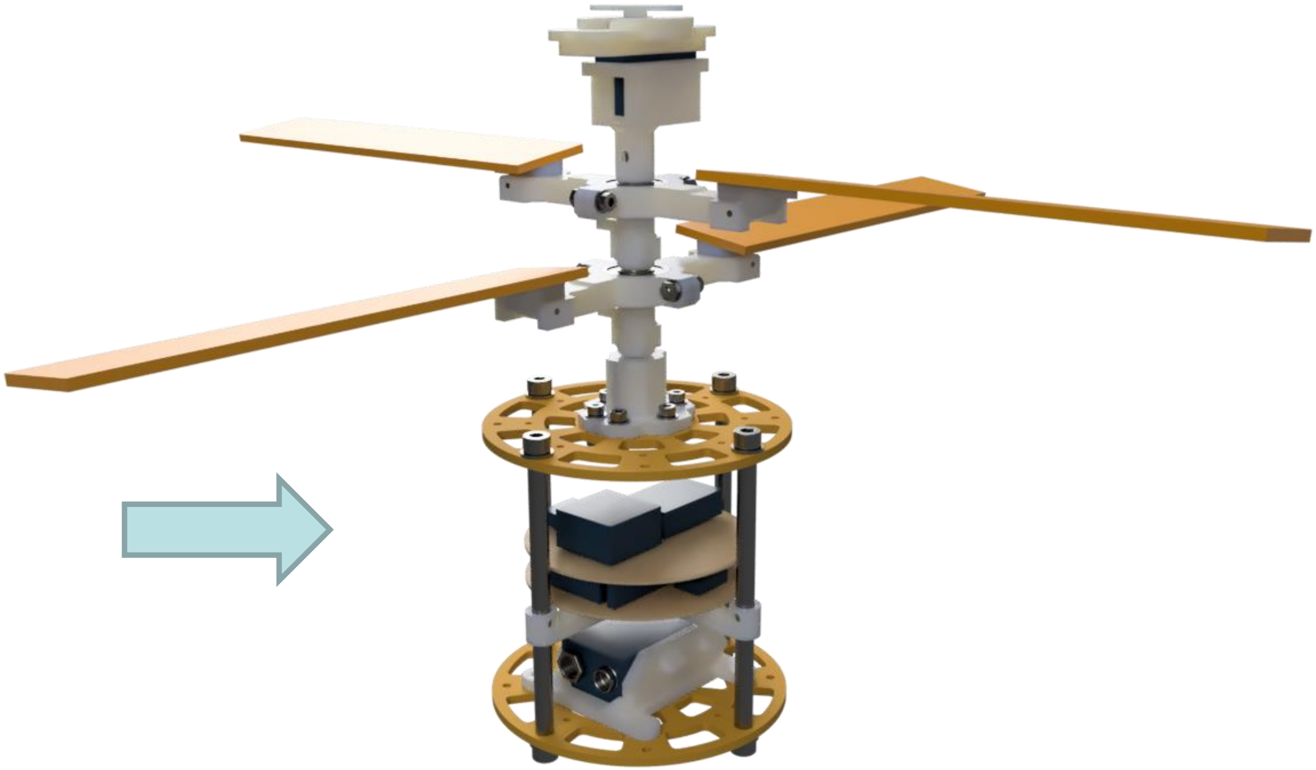




Payload Physical Layout

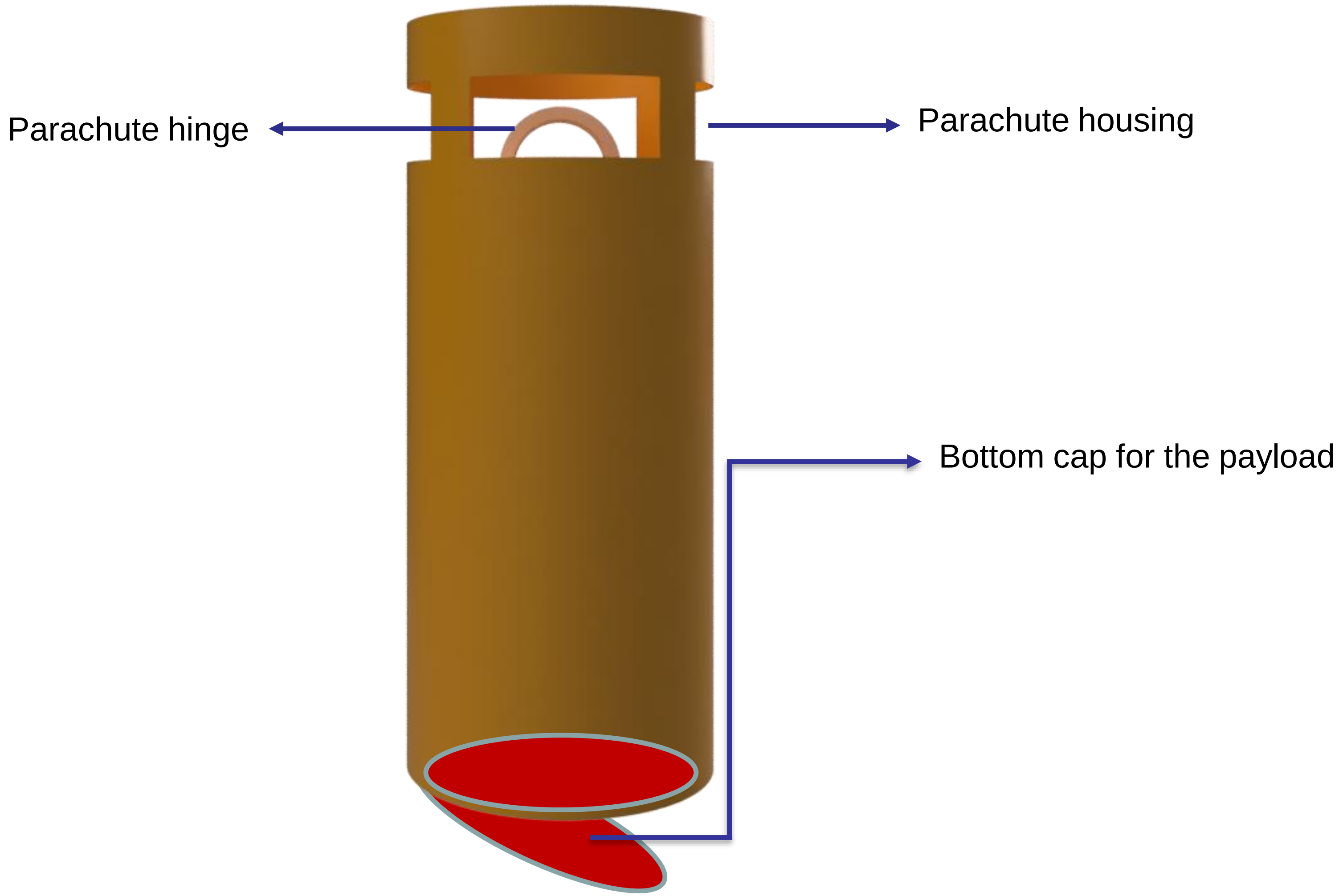


Stowed configuration



Deployed configuration

Payload Physical Layout



System Concept of Operations

PRE LAUNCH	LAUNCH & DESCENT	POST LAUNCH
Prelaunch Briefing	Rocket launch	Locate and retrieve
Mechanic and Electronic Controls	Continue collecting data and telemetry	Retrieve GCS data and SD Card data
Locate the CanSat into the Rocket	The deployment of the CanSat from the rocket	Analysis of the data and reduce wrong values.
Calibration of Barometric Altitude and Roll-Pitch Angles	The deployment of the parachute	Prepare and present PFR
CanSat begins collecting data and Telemetry at 1 Hz	Releasing the Payload from the Container	
	Landing	
	Stop the transmission, sound the buzzer.	

System Concept of Operations

Team Member Roles and Responsibilities on Launch Day

Mission Control Officer

- Eyup Kocak (EK)

Ground Station Crew

- Ugur Bayezıt (UB)
- Haluk Levent Cicek (HLC)

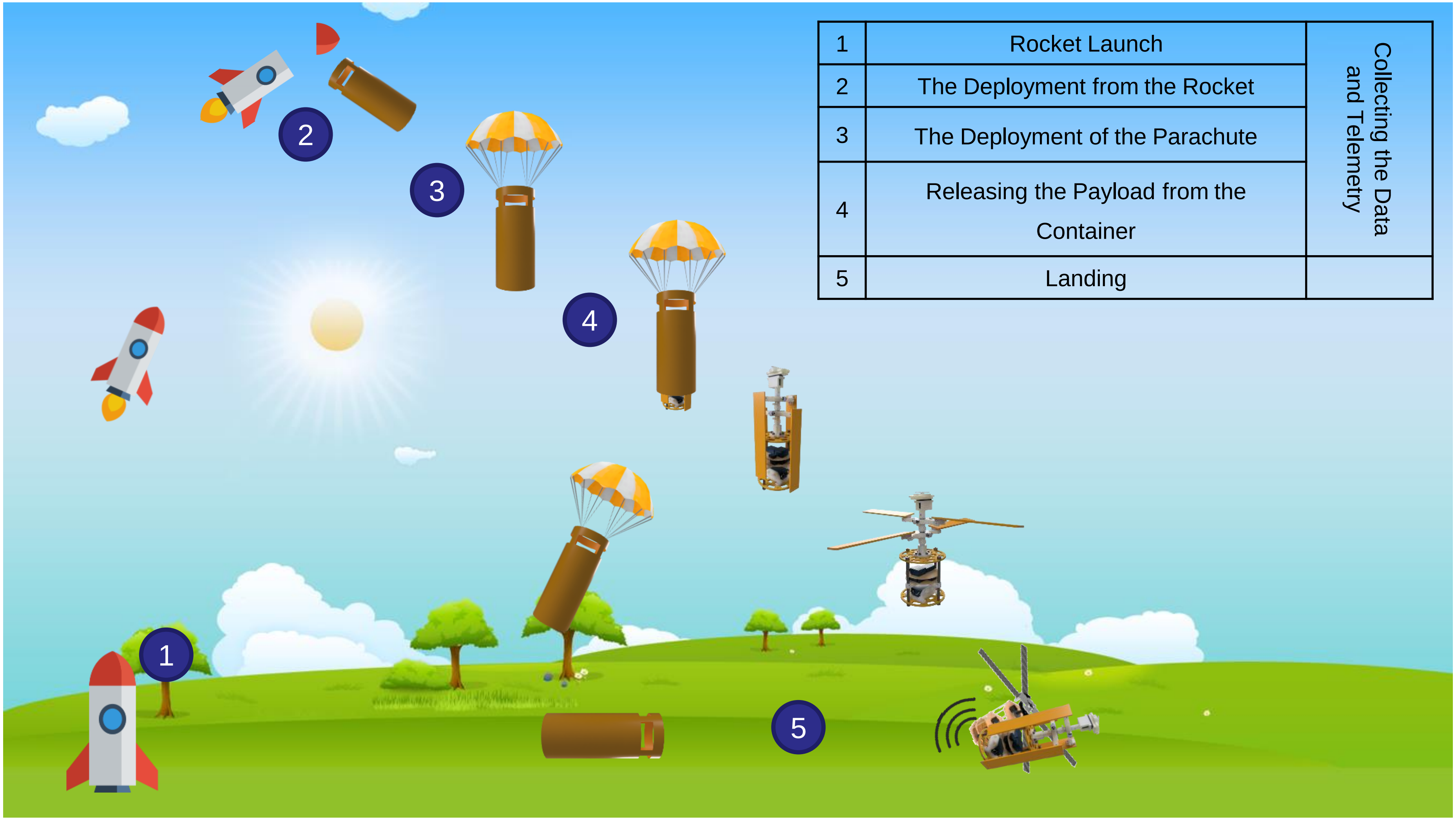
Recovery Crew

- Aydın Sisman (AS)
- Dogus Baran Karadag (DBK)

CanSat Crew

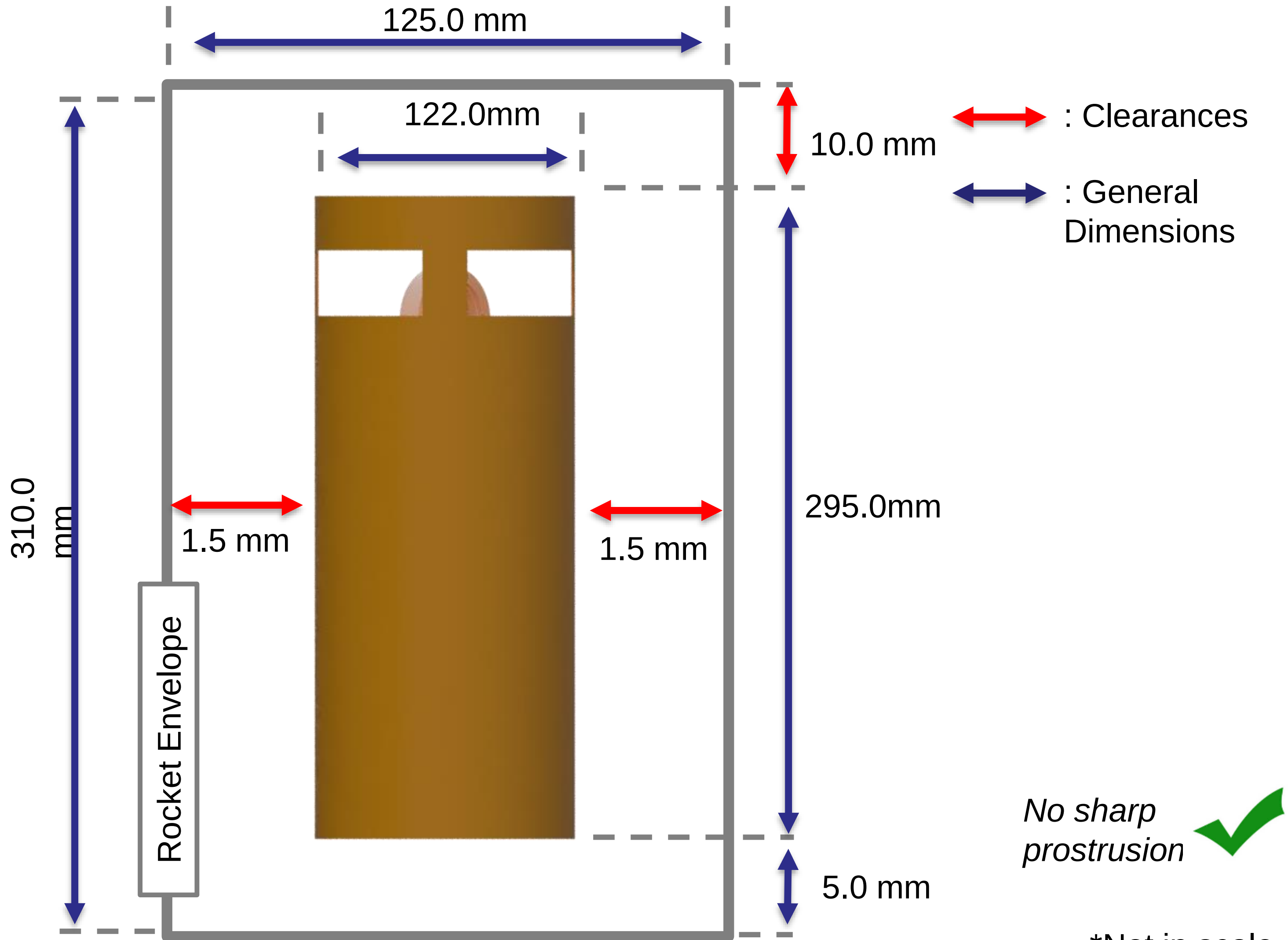
- Dogukan Kuyumcu (DK)
- Bedirhan Ceylan (BC)
- Suhan Mergen (SM)
- Alpcan Altuntas (AA)

System Concept of Operations



1	Rocket Launch	Collecting the Data and Telemetry
2	The Deployment from the Rocket	
3	The Deployment of the Parachute	
4	Releasing the Payload from the Container	
5	Landing	

Launch Vehicle Compatibility



No sharp prostrusion

*Not in scale.

Sensor Subsystem Design

Bedirhan Ceylan

Sensor Subsystem Overview

Selected Sensor	Function of Sensor
Adafruit BMP 180	Measures pressure and temperature
Adafruit Ultimate GPS Breakout	Detects the position
MPU 6050	Will be used as pitch and roll sensor
Camera(AdafruitMini Spy Camera)	As a bonus mission,camera will record video
Analog Voltage Measurment with Teensy	Measures the voltage level of battery
US 1881 Hall Effect Sensor	To detect blade spin
Adafruit BMP 180	Sensor measures pressure of container

Sensor Changes Since PDR

Name	PDR Selection	CDR Selection
Auto-Gyro Blade Spin Rate Sensor	ON SEMICONDUCTOR QRD 114	US1881

Rationale

The reasons for changing this sensor from QRD 114 to US1881 are;
There were some limitations on using QRD 114. Due to vibration, the disk which passes from the gap of QRD 114 circuit, trembles and hits the edges. So, We have changed the sensor to US1881 due to mechanical limitations.

Sensor Subsystem Requirements

	Sensor SubsystemRequirments		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
SSD-1	1	Total massof theCanSat (science payload and container) shall be 500 grams ±10g.	√	√	√	
SSD-2	7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	√			√
SSD-3	9	The container shall release the payload at 450 meters ±10meters.	√			√
SSD-4	13	All electronic components shall been closed and shielded from the environment with the exception of sensors.	√		√	
SSD-4	16	All electronics shall be hard mounted using proper mounts such as standoffs,screws, or high performance adhesives.	√		√	
SSD-5	20	The science payload shall measure altitude using an air pressure sensor.	√	√	√	

Sensor Subsystem Requirements

	Sensor Subsystem Requirments		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
SSD-6	22	The science payload shall measure its battery voltage.	✓	✓	✓	
SSD-7	23	The science payload shall measure outside temperature.	✓	✓	✓	
SSD-8	24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	✓	✓	✓	
SSD-9	25	The science payload shall measure pitch and roll.	✓	✓	✓	
SSD-10	34	Cost of the CanSat shall be under $1000. Ground support a nd analysis tools are not included in the cost.	✓	✓		
SSD-11	44	No lasers allowed.				✓
SSD-12	49	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.		✓		

Payload Air Pressure Sensor Summary

Name	Weight(g)/ Dimensions (mm)	Power(μW)	Working Conditions	Accuracy /Error(Pa)	Interface	Other Parameters	Cost($)
Adafruit BMP180	4 / 21 x 18	1mAx3.6V 3-32μAx3.6V	From30kPa to 110kPa	3 Pa	I2C	Temperature Measurement is included	9.95

$$z(in\ meters) = 4430 \times \left(1 - \left(\frac{P_z}{P_0}\right)^{\frac{1}{5.255}}\right)$$

Where, P_z is the pressure value at altitude z and P_0 is the pressure at reference altitude. In this way, we can get altitude values.

•Adafruit BMP 180

•Compact Size
•Enough resolution
•Cheap
•Both for pressure and temperature

Payload Air Temperature Sensor Summary

Name	Weight(g)/ Dimensions (mm)	Power/ Operating Current	Working Conditions	Accuracy/Error (degC)	Interface	Cost($)
AdafruitBMP 180	4 / 21 x 18	1mAx3.6V 3-32 μAx3.6V	From -40to 85 degC	-/±1 degC	I2C	9.95

Temperature will be measured with BMP180 in **Celcius**. We will directly get the value with getTemperature command which exists in SFE_BMP180.h library.

•Adafruit BMP 180

•Compact Size
•Enough resolution
•Cheap
•Both for pressure and temperature

GPS Sensor Summary

Name	Weight(g)/ Dimensions (mm)	Power (mW)	Working Conditions (Velocity)	Sensivity (Acquisiton/ Tracking) (dBm)	Accuracy /Error(m)	Interface	Warm/ ColdStart (second)	Cost($)
Adafruit Ultimate GPS Breakout	8.5 / 25.5 x35 x6.5	20mA x (3.3/5) V	515 m/s	-145 dBm/ -165 dBm	±1.8m	Serial	Warm/ ColdStart: 34seconds	40.95

We are collecting **longitude and lattitude values** from Adafruit_GPS.h library with GPS.latitude and GPS.longitude.

•Adafruit Ultimate GPS Breakout

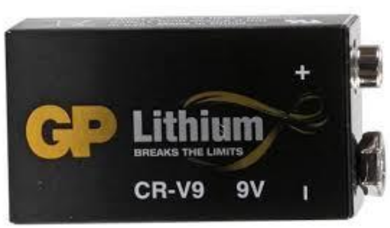
•Knowledge about velocity
•Know both about warm and cold start
•Less power consumption

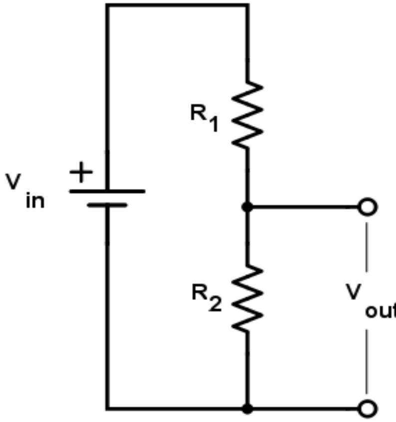
Payload Voltage Sensor Summary

Name	Dimensions(mm) / Weight(g)	Power Consumption (mW)	Accuracy/Error(V)	Interface	Cost$)
Voltage Divider Circuit	4 x 5/1	Negligible	Less than 0.01V	Analog	1

- We will measure voltage level of battery with Teensy 3.5. Due to limitation of voltage reading at Teensy, We will use a voltage divider which has R1 and R2 resistances. R1 must be twice bigger than R2 to measure 3V.

$$V_{battery} = Measurement\ at\ analog\ pin \times \frac{3.3}{1023} \times \frac{3R_2}{R_2}$$





Pitch/Roll Sensor Summary

Name	Dimensions(mm)/ Weight(g)	Operating Temperature	Power (mW)	Accuracy/Error (Degree)	Interface	Cost($)
Adafruit MPU6050	20.3 x 15.6/2.1	-40°C -85°C (TA)	(2.38V-3.46V) x0.11mA	±2	I2C	8.31

- We get gyrosope raw values here;

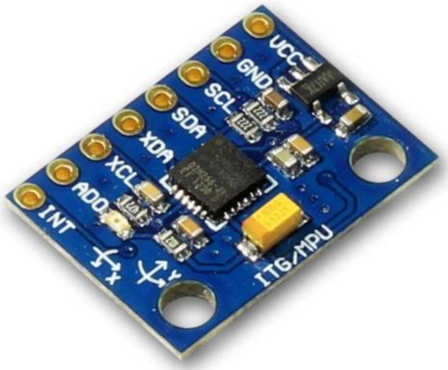
GyX=(Wire.read()<<8|Wire.read()) + GyXoff;
GyY=(Wire.read()<<8|Wire.read()) + GyYoff;
GyZ=(Wire.read()<<8|Wire.read()) + GyZoff;

- Here we interpret raw values to pitch/roll values in radians.

pitch = atan(x/sqrt((y*y) + (z*z)));
roll = atan(y/sqrt((x*x) + (z*z)));

Adafruit MPU6050

•Simple and light
•Less power consumption
•Cheaper than rivals



Auto-Gyro Blade Spin Rate Sensor Summary

Name	Dimensions (mm)/ Weight(g)	Operating Temperature	Power (mW)	Operating Point(mT)	Accuracy/ Error	Interface	Cost ($)
US1881	4.10x 1.5/2.1	-40°C to 85°C (TA)	(3.5V-24V) x5mA (max)	0.5-9.5	±2 µsec	Analog	8.31

- Hall effect sensor detects change in magnetic field and gives the data 0 or 1. We count the numbers of changes from 1 to 0. Changes of 1 to 0 is summed for each second. In this way, we evaluate the spin rate of blades.

•US1881 Hall Effect Sensor

•So small and light
•Simple to design
•Has enough for the purpose

Bonus Objective Camera Summary

Camera	Dimensions (mm)/ weight(g)	Operating Voltage(V)	Operating Current(mA)	Quality of Image/Video (Pixel/fps)	Cost($)
Adafruit Mini Spy Camera	6.2 x6.2 x4.4/2.8	3.7-5	Standby:80 Operating:110	Static Image:1280 x720/ Video:640 x 480 for 30 fps	12.50

After the deployment from container, camera will be triggered for more than one second and it will start to record 480p video and store the video in a MicroSD card. Camera will be powered with Teensy 3.5.

•Adafruit Mini Spy Camera

•So small and light
•Enough Resolution
•Low operating Current
•Cheaper than rivals

Container Air Pressure Sensor Summary

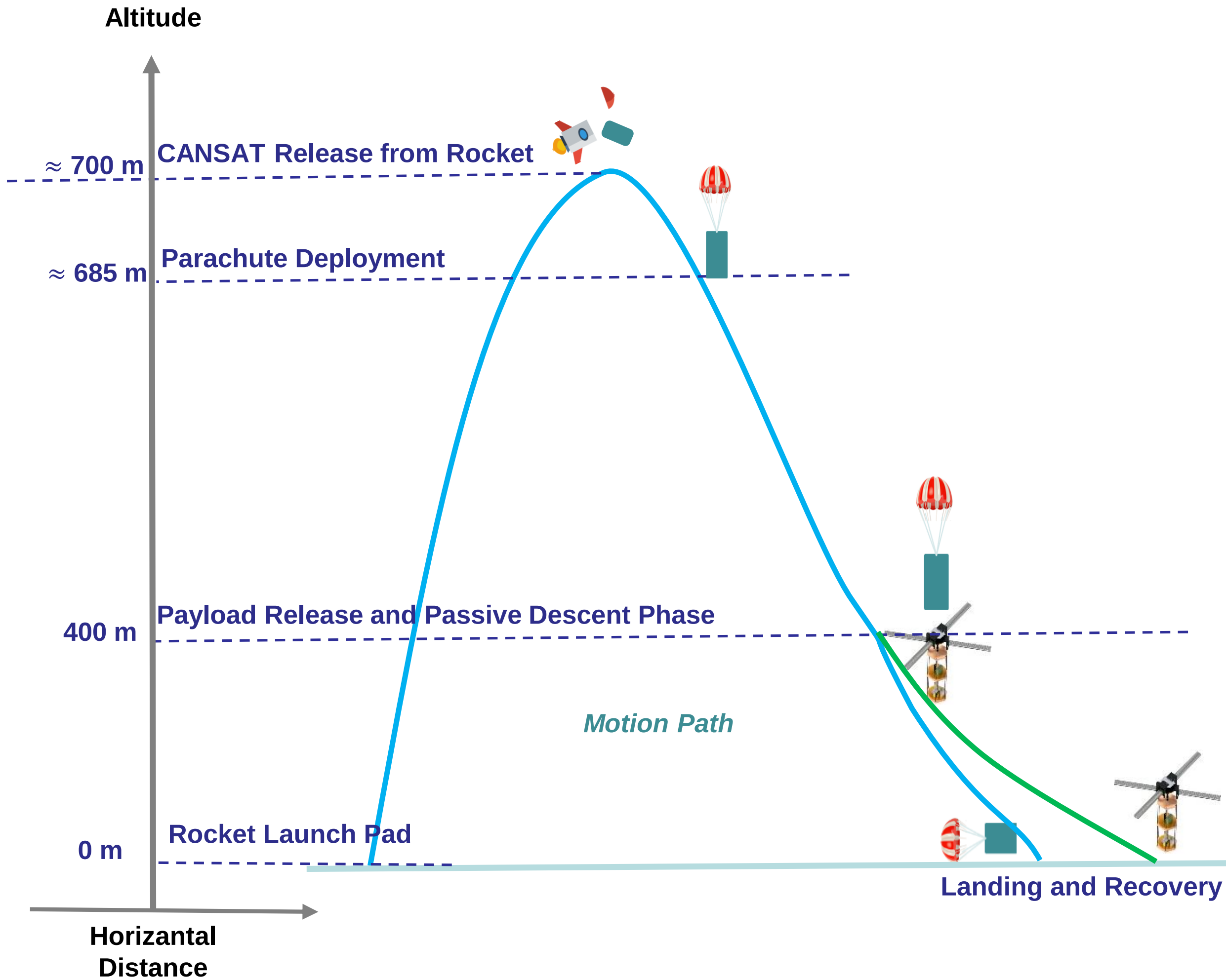
The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

Descent Control Design

Eyup Kocak

Descent Control Overview

COMPONENTS	MATERIALS
Propeller	Polycarbonate
Parachute	Umbrella Fabric
Encoder	Hall Effect Sensor
Propeller Shaft	Aluminium
Servo Motor	-

Descent Control Changes Since PDR

COMPONENTS	PDR	CDR	RATIONALE
Encoder	ON Semiconductor QRD 114	Hall Effect Encoder	Precise Measurement and Easy Attachment
Propeller	Carbon Fiber Wings	Polycarbonate Propeller Wings	Lighter, Cheaper and Waxier

Prototype Testing

- Container release mechanism tested many times to see consistency.
- Propeller design will be tested under drone test.

Descent Control Requirements

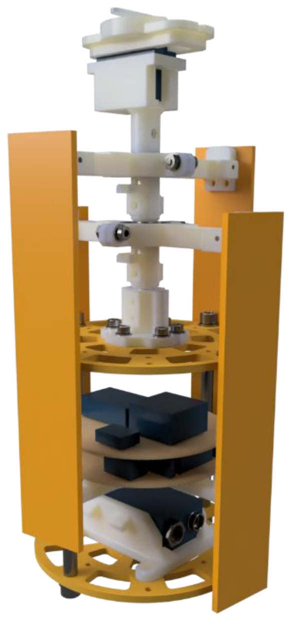
Descent Control Requirements						
ID	**# of CR**	**Description**	**Verification**			
			A	**I**	**T**	**D**
DCS-1	7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	✓			✓
DCS-2	8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	✓	✓		
DCS-3	9	The container shall release the payload at 450 meters +/- 10 meters.	✓			✓
DCS-4	10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	✓	✓		✓
DCS-5	11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	✓			✓

Descent Control Requirements

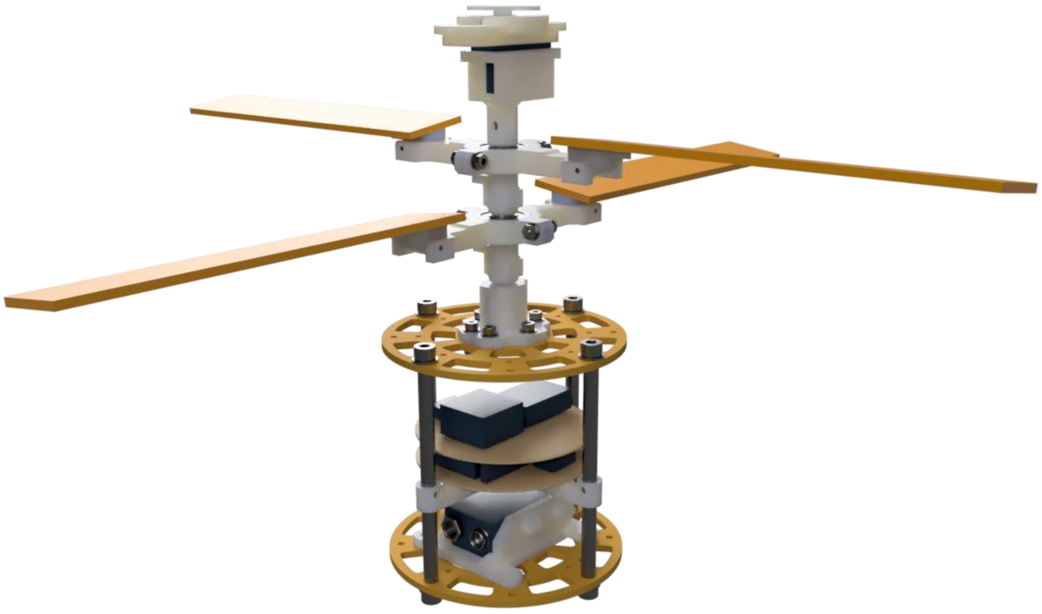
	Descent Control Requirements						
ID	# of CR	Description	Verification			
			A	I	T	D
DCS-6	12	All descent control device attachment components shall survive 30 Gs of shock.	✓			✓
DCS-7	14	All structures shall be built to survive 15 Gs of launch acceleration.	✓			✓
DCS-8	34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	✓	✓		
DCS-9	52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	✓			✓

Payload Descent Control Hardware Summary

Coaxial Propeller Mechanism will be used since a realistic model and it will prevent to the whirl around. Propellers will be deployed passively after the release phases from the container.



Stowed Position



Deployed Position

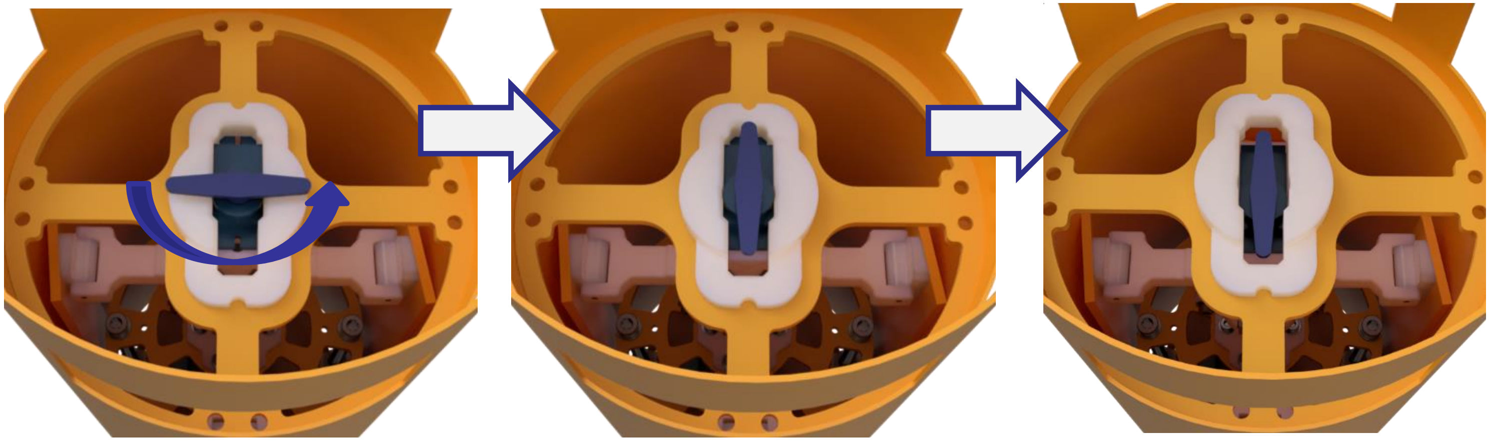
Payload Descent Control Hardware Summary

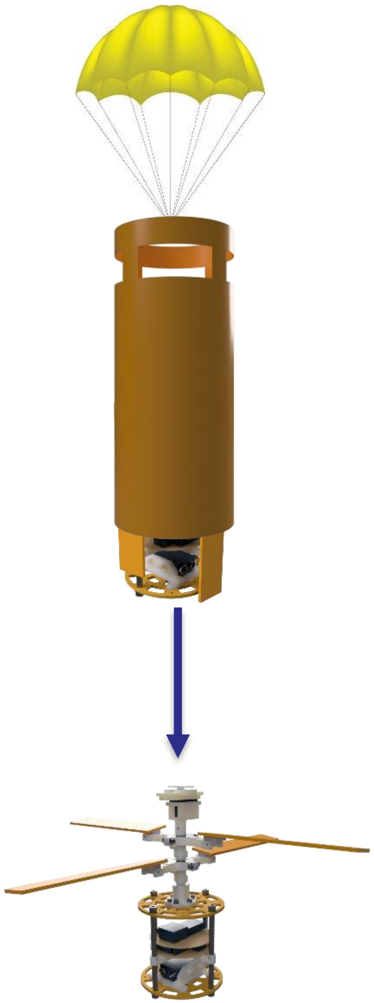
Spinning Servo Mechanism

Stowed Position:
Servo arm locks the prob.

Release Movement:
Servo arm starts turning.

Release:
Servo arm position matched with the gap geometry.





Deployment Method

Payload Descent Control Hardware Summary

Component Sizing:

- Propeller angle of attach is 8 degrees with vertical axis.
- All propeller wing sizes are 30 mm x 157.5 mm.
- Polycarbonate is selected as 3 mm to provide enough drag force and less weight.

Key Design Considerations:

- Spinning Servo Release Mechanism is selected due to high stability.
- Coaxial propellers are connected onto the single mill using to separate bearings.
- Propellers will be deployed passively after the release from container.

Color Selection:

- Propeller wings will be fluorescent orange or pink.

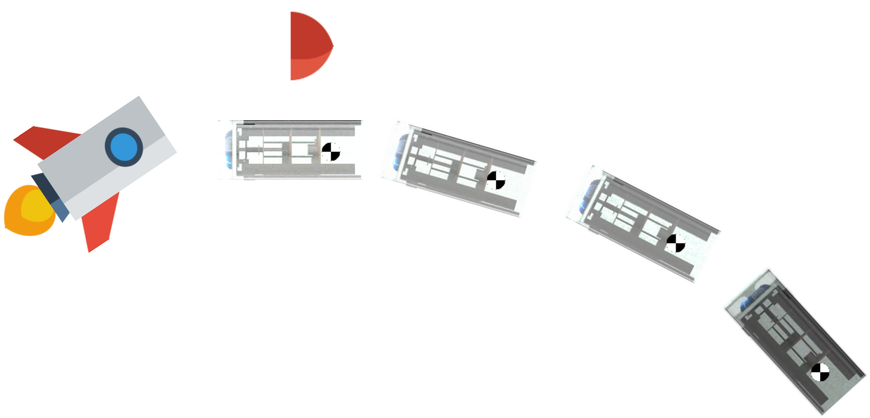
Active controls:

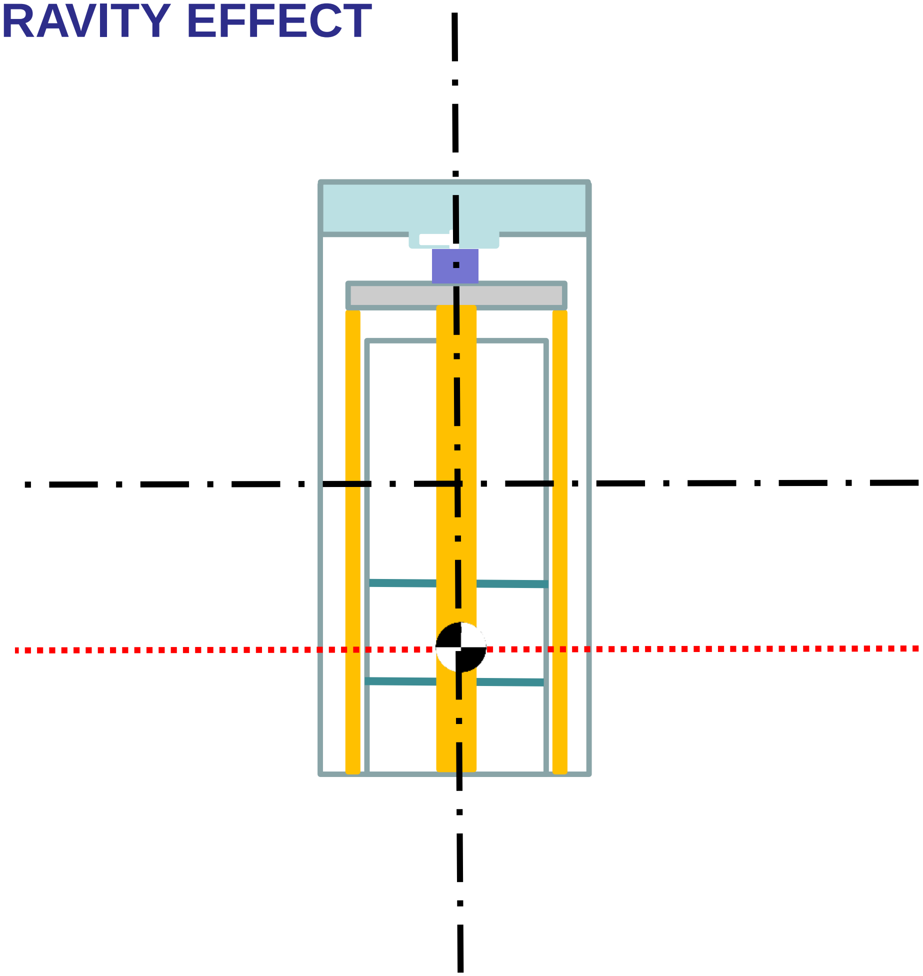
- Active control mechanism is not used. But servo motor is using to trigger to the container release mechanism.

Descent Stability Control Design

CENTER OF GRAVITY EFFECT

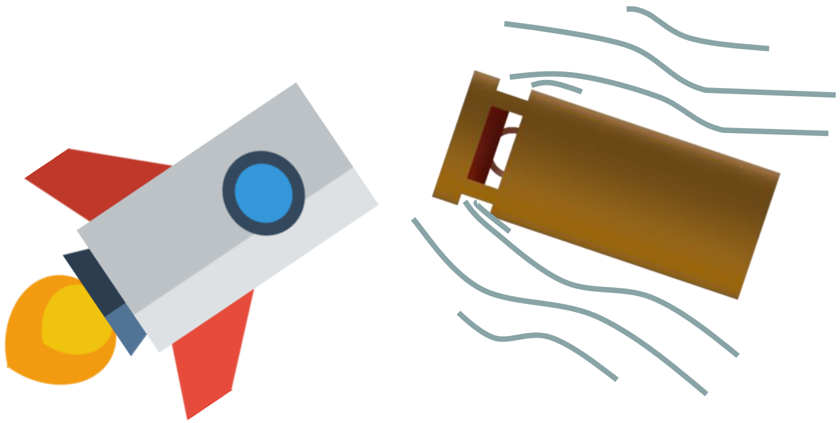
Center of gravity is the point in the body at which it balances. The center of gravity of the CANSAT is designed to be close to the bottom. By providing the center of gravity, nadir direction will be maintained.



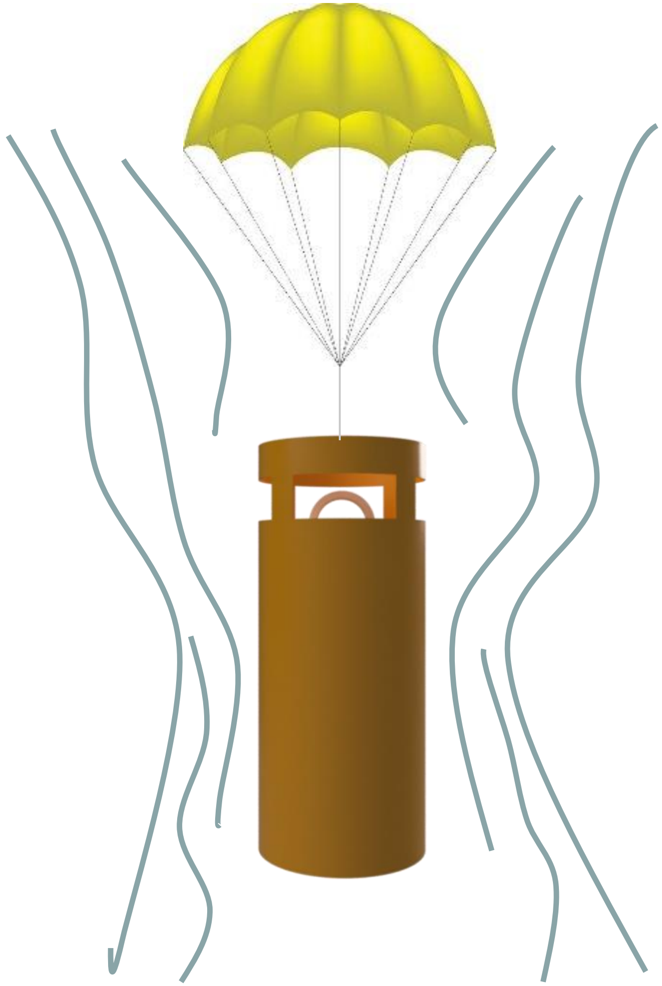


Schematic View Of CANSAT

Container Descent Control Hardware Summary



Parachute Stowed Position



Parachute Deployed Position

- Parachute compartment has a openings to help parachute to deploy swiftly.

Container Descent Control Hardware Summary

Component Sizing:

- Parachute cross-sectional area is 0.136 m^2 and parachute rope is 50 cm.
- Parachute openings are 70 mm x 30 mm.
- Polycarbonate cover is selected as 3 mm to provide enough drag force and less weight.

Key Design Considerations:

- Spinning Servo Release Mechanism is selected due to high stability.
- Parachute has a spill hole to reduce sway.
- Parachute compartment has a openings to help parachute to deploy swiftly.
- Parachute fabric is umbrella fabric as it is quite foldable and can take high tensions.

Color Selection:

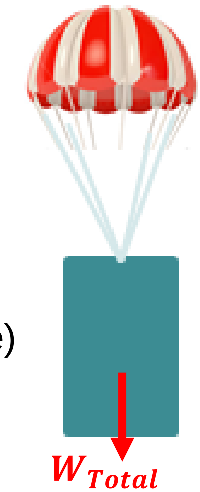
- Parachute fabric and container cover color will be fluorescent orange or pink.

Active controls:

- Active control mechanism is not used. But servo motor is using to trigger to the container release mechanism.

Descent Rate Estimates

Container & Payload Post Rocket-Separation Velocity Estimates

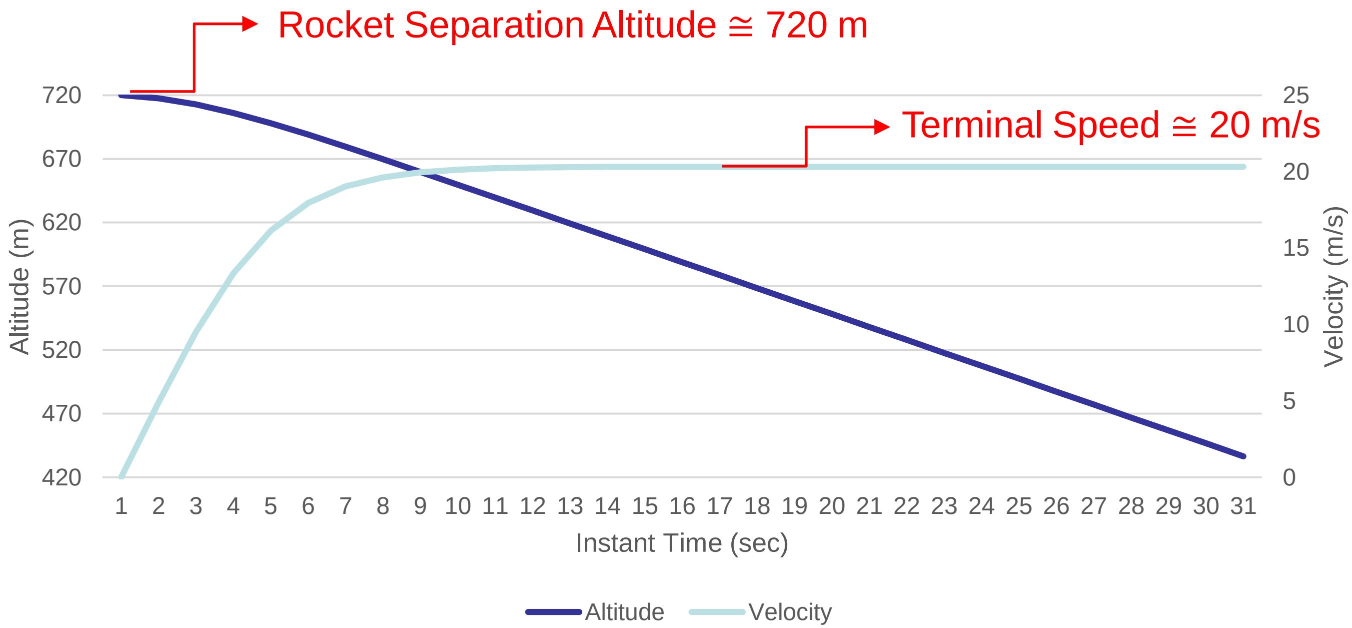


Vertical Speed of Parachute should be 20 m/s;

$$R_p = \sqrt{\frac{2\,F_D}{\pi\,\rho\,V^2\,C_D}} = 0{,}0675\,m$$

$$A_p = 0{,}95\,\pi\,{R_p}^2 = 0{,}0136\,m^2$$

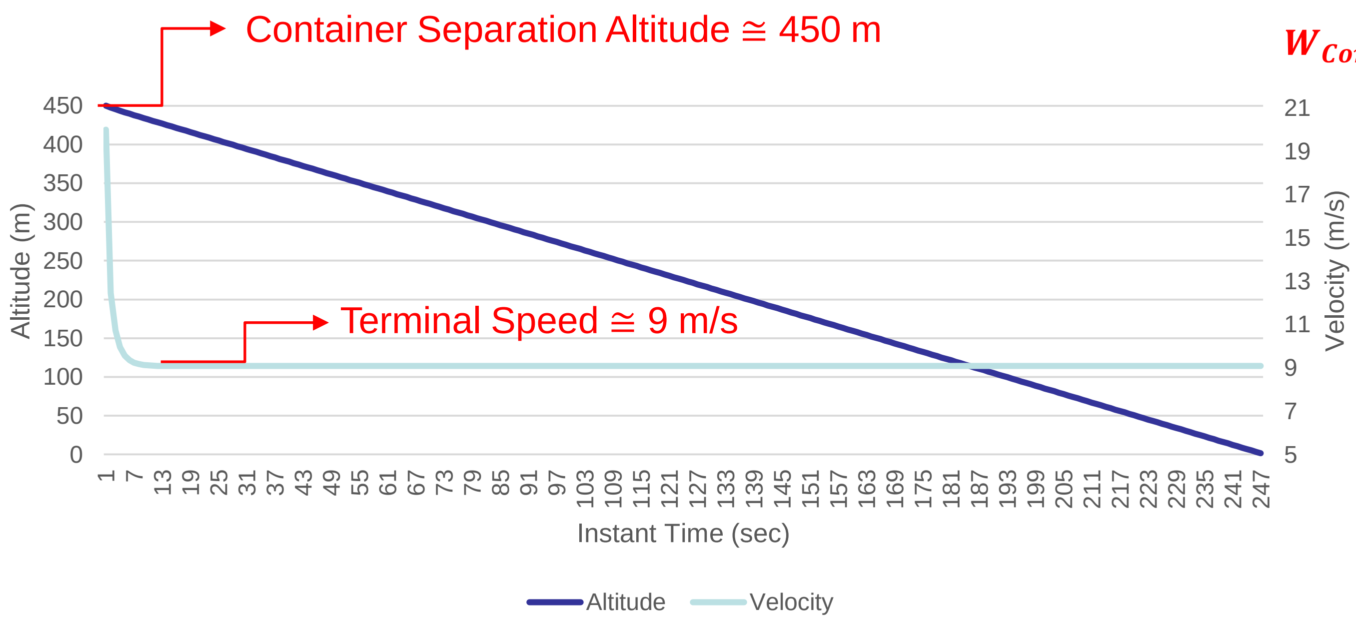
C_d = 1.5 for dome type parachute
R_p: Radius of the Parachute (m)
ρ = 1.225 (kg/m³)
A_p = Reference Area
V = 20 m/s (Calculated Vertical Speed of Parachute)
F_D = $W_{container} + W_{Payload}$ = 4.94 N



Container After Release Velocity Estimates

Vertical Speed of Parachute should be 20 m/s;

C_d = 1.5 for dome type parachute
ρ = 1.225 (kg/m³)
A_p = Reference Area
F_D = $W_{container}$ = 1.35 N



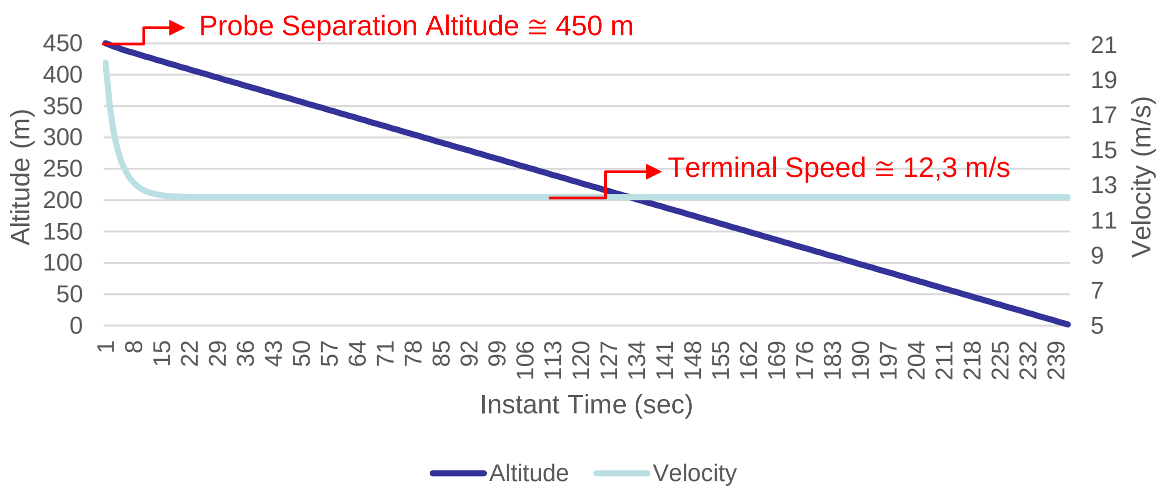
Descent Rate Estimates

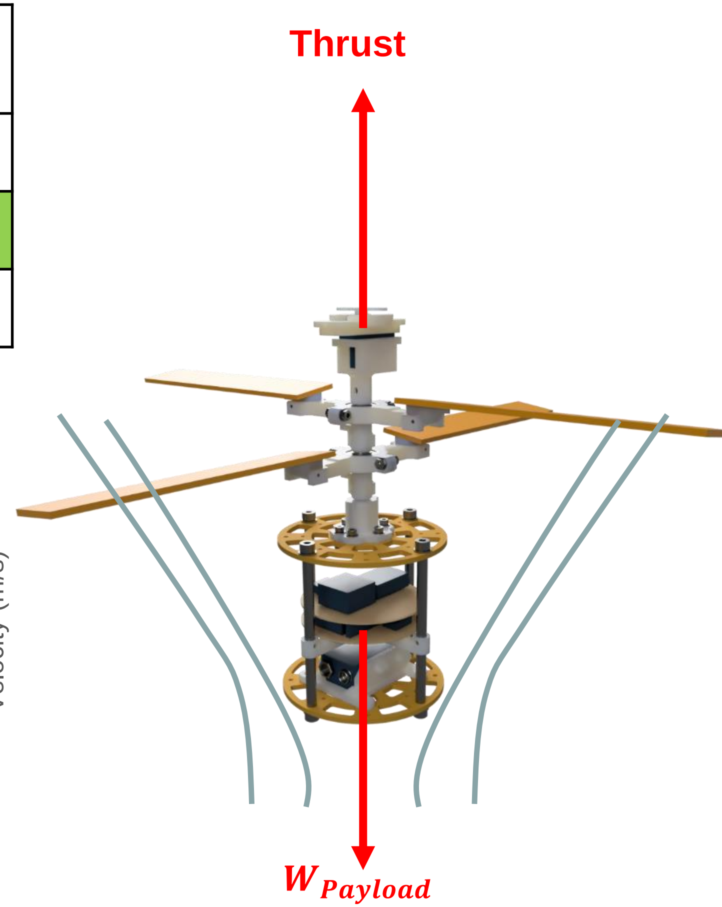
Container & Payload Post Rocket-Separation Velocity Estimates

In order to keep terminal velocity approx. at 12,5 m/s, the thrust should be equal to the payload weight.

Propeller Radius (m)	Total Area (m²)	Terminal Velocity (m/s)
0,1	0,03	24,63
0,2	0,12566	12,31
0,3	0,28274	8,21

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





Descent Rate Estimates

SUMMARY

Estimated Descent Rate of **the Container + Payload** is approximately 20.0 m/s.

Estimated Descent Rate of **the Container** is approximately 9.0 m/s.

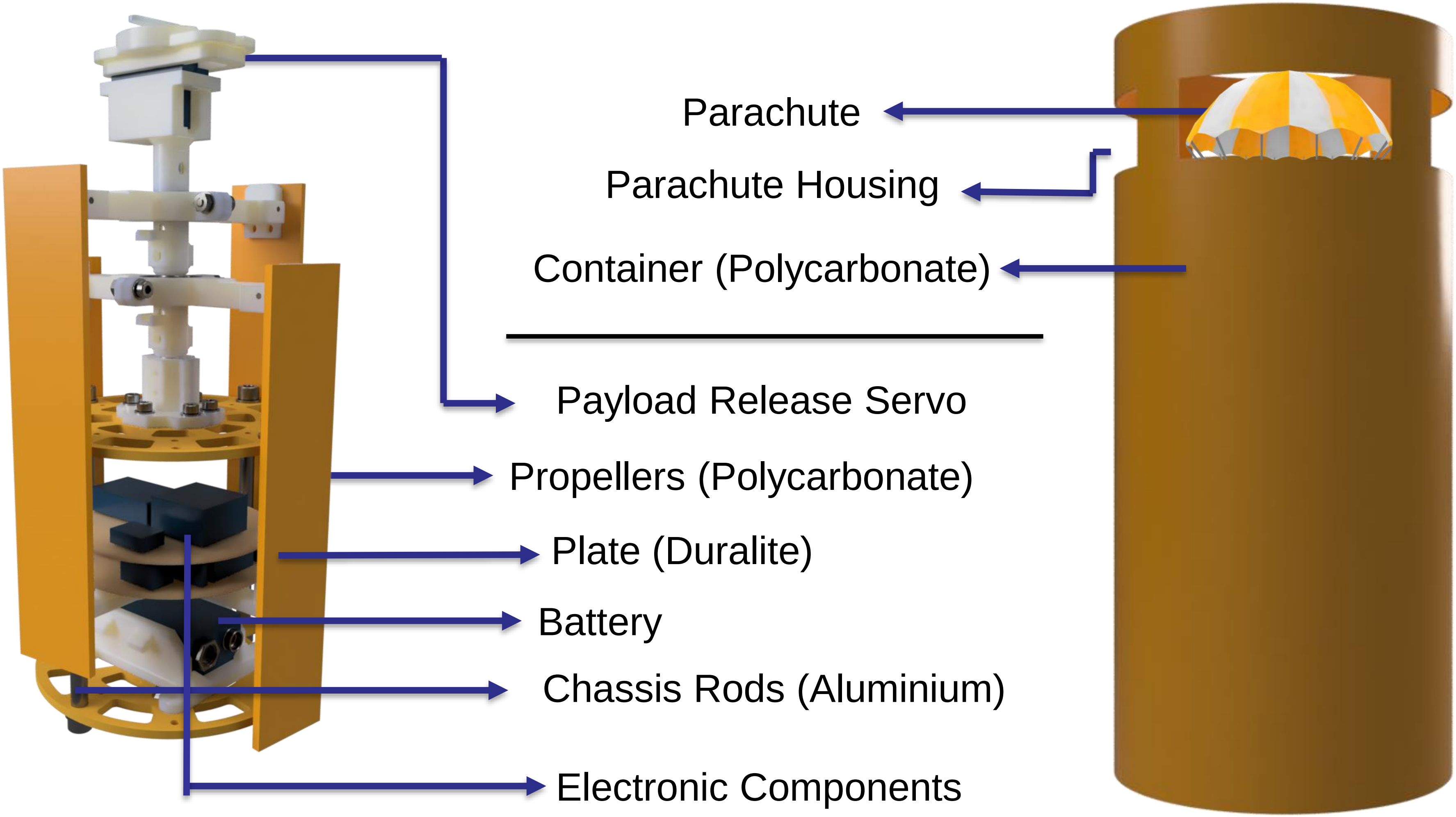
Estimated Descent Rate of **the Payload** is approximately 12.5 m/s.

Configuration	Mass (g)	Descent Rate (m/s)
Container + Payload	504	~20.00
Container	138	~9.00
Payload	366	~12.31

Mechanical Subsystem Design

Alpcan Altuntas

Mechanical Subsystem Overview



Mechanical Subsystem Changes Since PDR

There have been major design changes when compared to the PDR design. These changes were made in order to reduce weight and increase the structural integrity of both the payload and the container.

Components	PDR	CDR	Rationale
Propeller mill	Two separate mills as a propeller shaft	Two bearings attached to the propellers	More realistic, consistent and stable
Plates	Hexagonal plates	Weight reduced circular plates	We opened gaps inside the duralite plates in order to conserve weight and open up possible attachment points
Chassis rods	4 mm diameter rods	8 mm diameter rods	4 mm rods were too weak to outstand the outer impacts. 8 mm is sufficient for this specific mission.
PCB holder	Duralite plates under the PCB’s	3D printed platform under the PCB’s	The duralite plates could not prevent and outer impact. 3D prınted platform surrounds the PCB’s perfectly preventing any possible outer blow.
Battery case	Transparent polyethylene case for protection and integrity	3D printed custom case which has a better structural integrity and protection	The polyethylene case was very open to outer damage. In order to protect it from the impacts and the sun, we designed a 3D printed case.
Propeller wings	Carbon fiber propeller wings	Polycarbonate propeller wings	Lighter, cheaper and waxier
Propeller spacers	Since there were two propeller mills, we used no spacers	Spacers are added after two bearing design is selected	After changing the ‘’two mill’’ design we added spacers in order to maintain a operational wing position.

Mechanical Subsystem Changes Since PDR

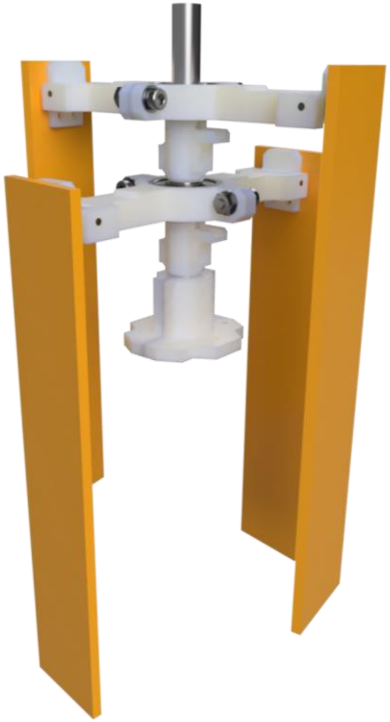
We made a few changes since the PDR;

1. Propeller Mechanism
2. Electronic Component Cases
3. Duralit Plate Designs

1. Propeller mechanism

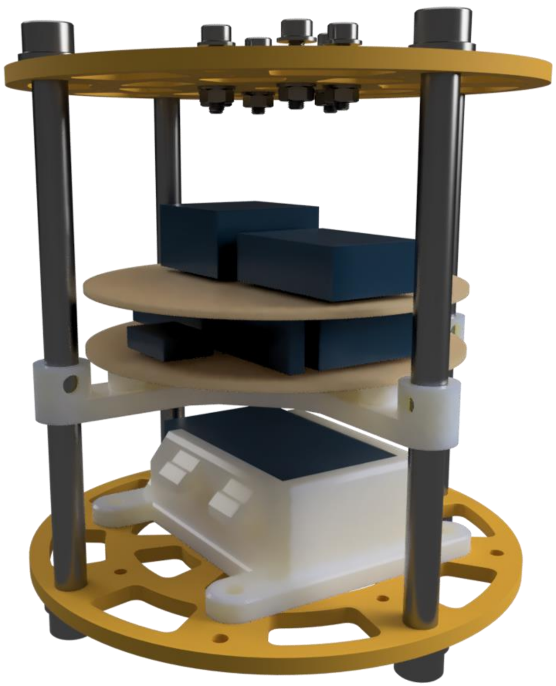
We switched from two separate propeller mills to only one mill (which is supported by 2 separate bearings on top of each other).

The propeller mills and stops have been attached on to this custom 3D printed structure.



Mechanical Subsystem Changes Since PDR

2. Electronical Component Cases



We 3D printed custom cases for the battery and the electronical components.

3. Duralit Plate Designs

We changed the hexagonal plates to circular plates. However the weight of the plate has been reduced significantly due to the symmetrical gaps on the plates (these gaps and holes also enable us to attach new Components easily).

Mechanical Sub-System Requirements

		Mechanical Sub-System Requirements	Verification			
ID	# of CR	Description	A	I	T	D
MSS-1	1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	✓	✓		
MSS-2	2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	✓	✓		
MSS-3	3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.				✓
MSS-4	4	The container shall be a fluorescent color; pink, red or orange.				✓
MSS-5	5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.				✓
MSS-6	6	The rocket airframe shall not be used as part of the CanSat operations.	✓	✓		
MSS-7	7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	✓			✓
MSS-8	10	The science payload shall descend using an auto-gyro/passive helicopter recovery descent control system.				✓
MSS-9	12	All descent control device attachment components shall survive 30 Gs of shock.	✓			✓

Mechanical Sub-System Requirements

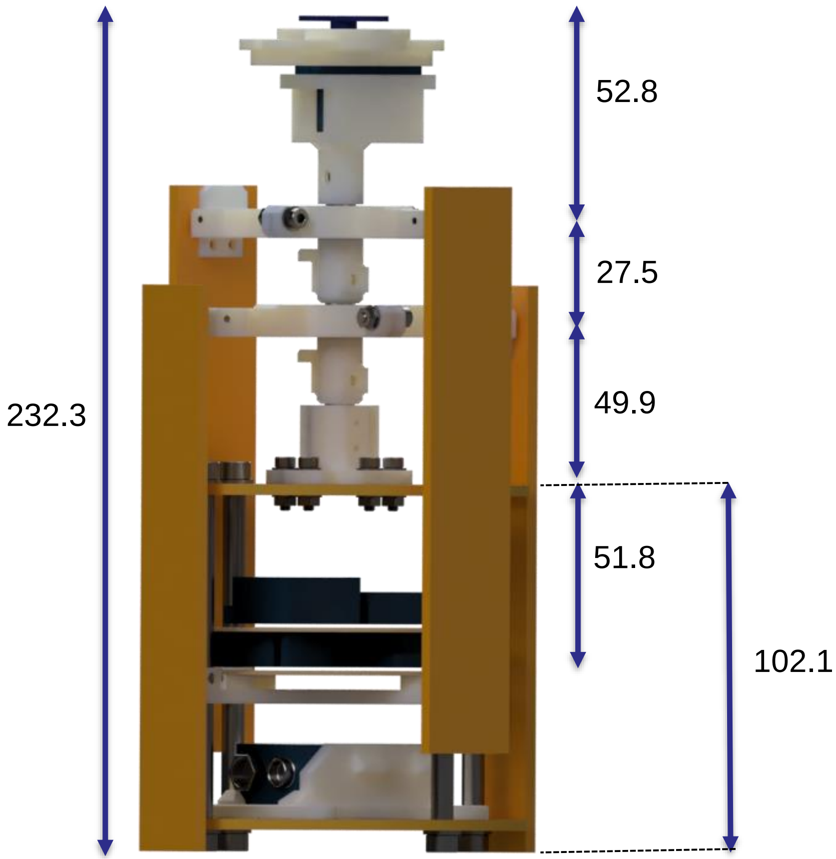
		Mechanical Sub-System Requirements	Verification			
ID	# of CR	Description	A	I	T	D
MSS-10	13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	✓			
MSS-11	14	All structures shall be built to survive 15 Gs of launch acceleration.	✓			✓
MSS-12	15	All structures shall be built to survive 30 Gs of shock.	✓			✓
MSS-13	16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	✓			
MSS-14	17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	✓			✓
MSS-15	18	Mechanisms shall not use pyrotechnics or chemicals.				✓
MSS-16	19	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.				✓
MSS-17	27	The Parachute shall be fluorescent Pink or Orange		✓		
MSS-18	45	The probe must include an easily accessible power switch that can be accessed without disassembling the Cansat and in the stowed configuration.	✓			✓

Mechanical Sub-System Requirements

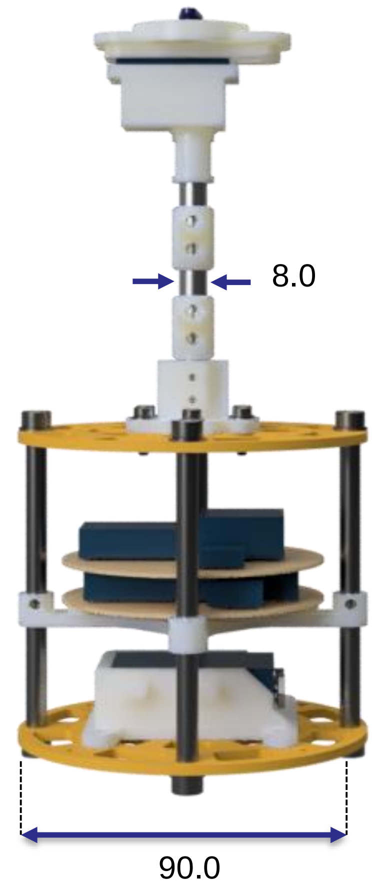
		Mechanical Sub-System Requirements	Verification			
ID	# of CR	Description	A	I	T	D
MSS-19	45	The probe must include an easily accessible power switch that can be accessed without disassembling the Cansat and in the stowed configuration.	✓			✓
MSS-20	46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	✓			
MSS-21	50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	✓	✓		
MSS-22	51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	✓			✓
MSS-23	52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	✓			✓

Payload Mechanical Layout of Components

Structure of the Payload



Payload Structure

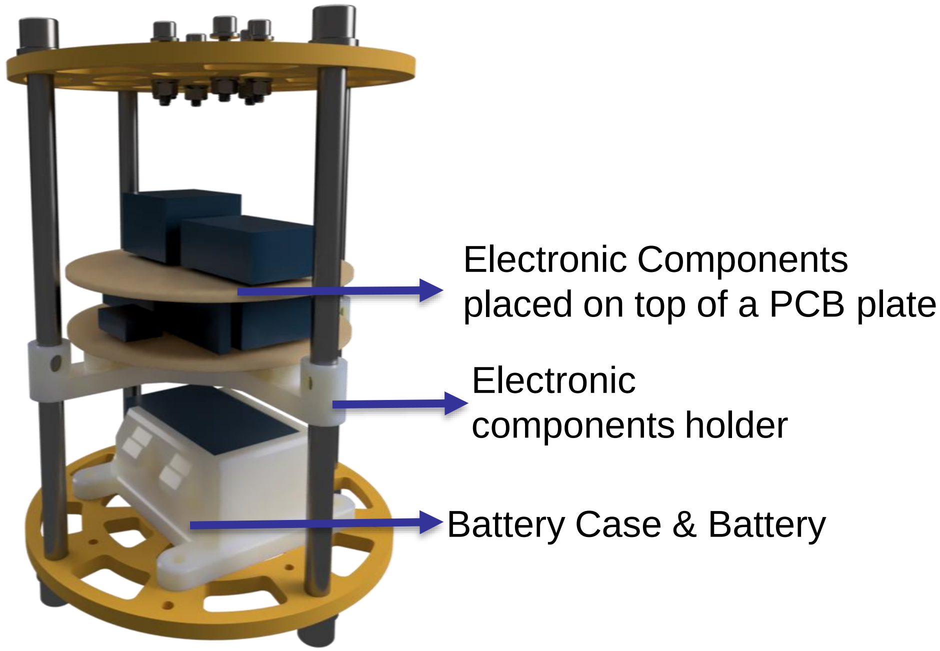


Chassis Structure

- All measurements are in millimeters.

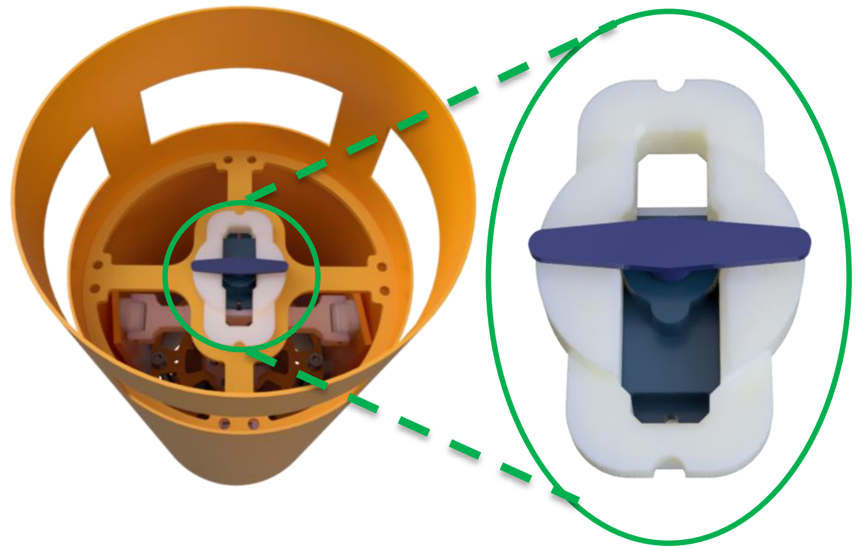
Payload Mechanical Layout of Components

Electrical Components



The electronic components are placed on top of a custom 3D printed plate which stands at a lower part of the payload which creates a low point of central gravity.

Container Attachment Point

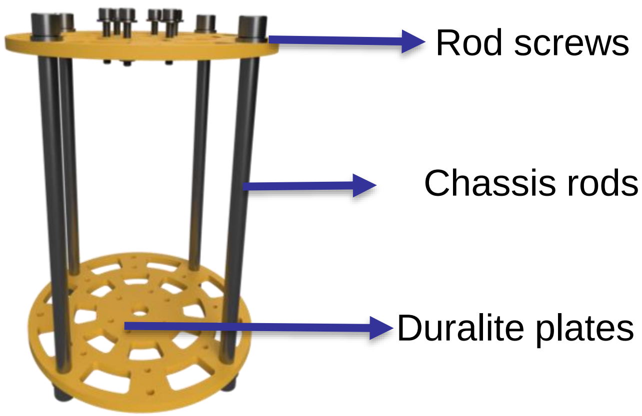


The payload is attached to the container with a release mechanism.

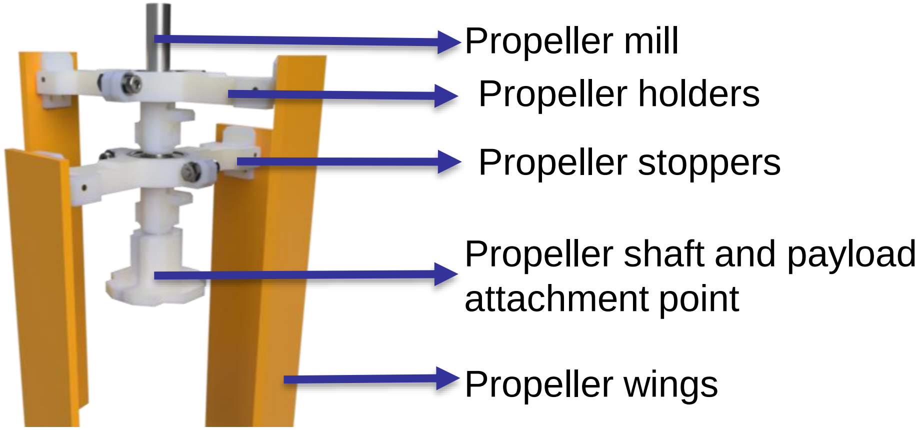
We are using a tail that rotates and slips down the container gap. This is the only attachment point we use that connects the payload and container.

Payload Mechanical Layout of Components

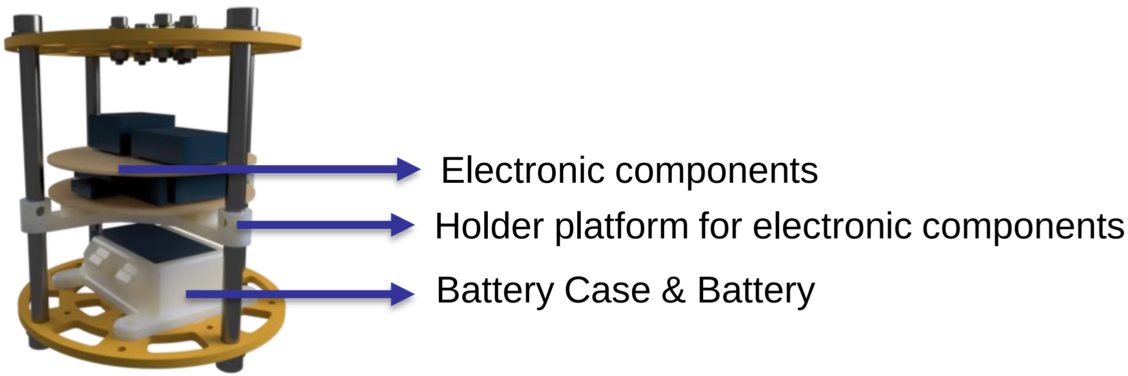
Chassis



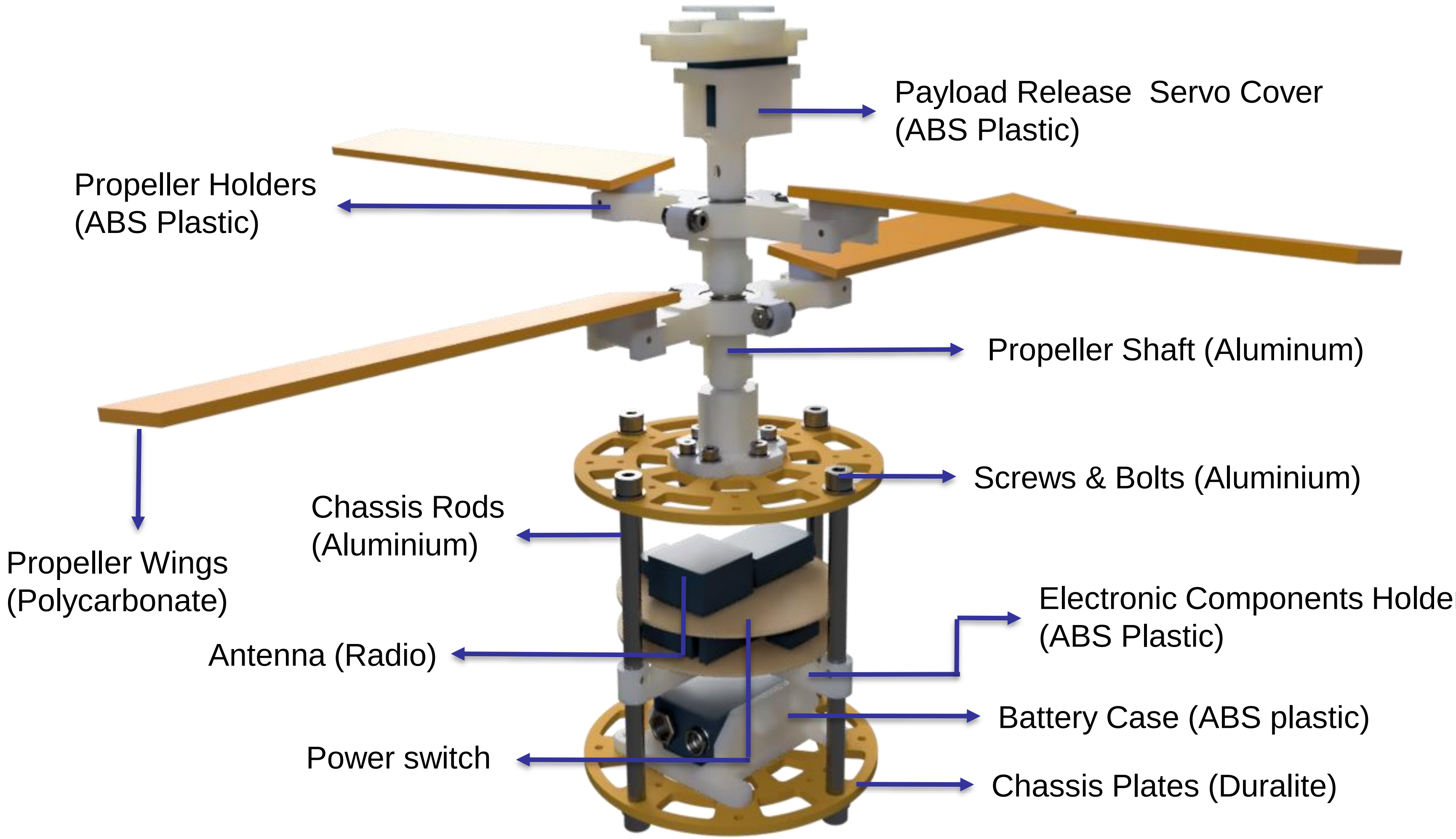
Propeller System



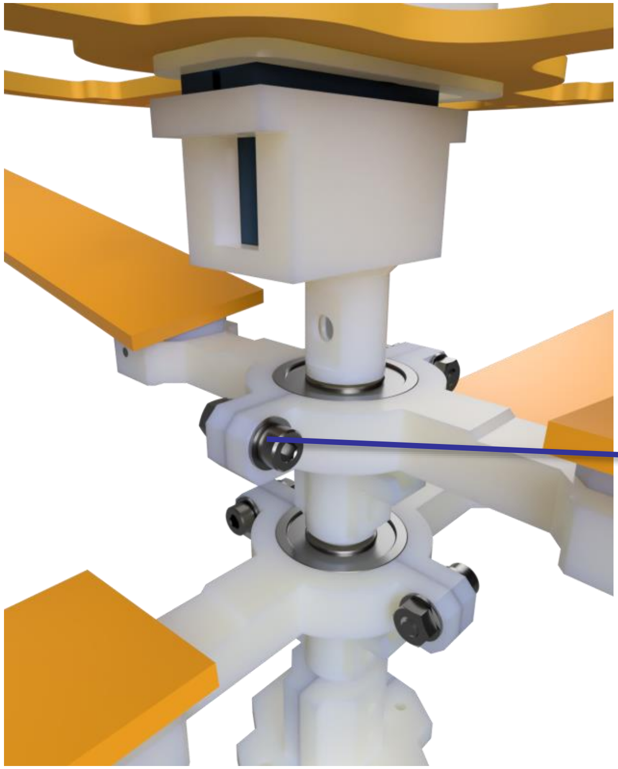
Electronic Components

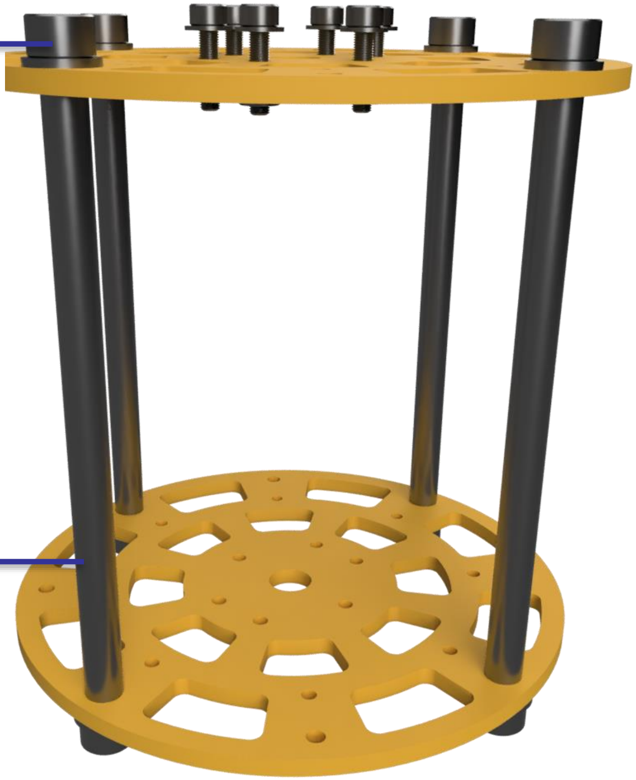


Payload Mechanical Layout of Components



Payload Mechanical Layout of Components



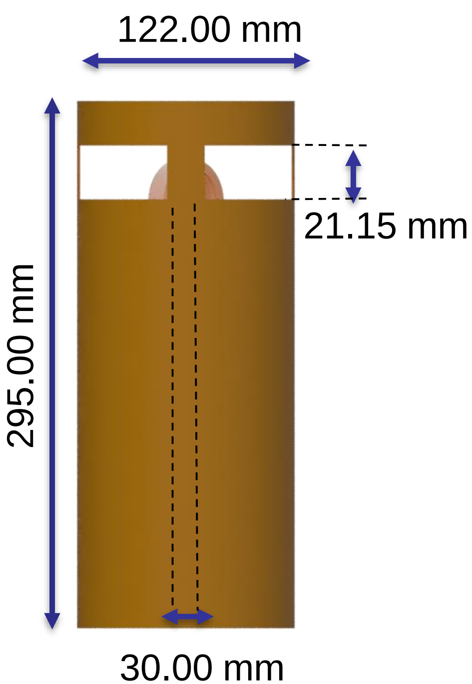


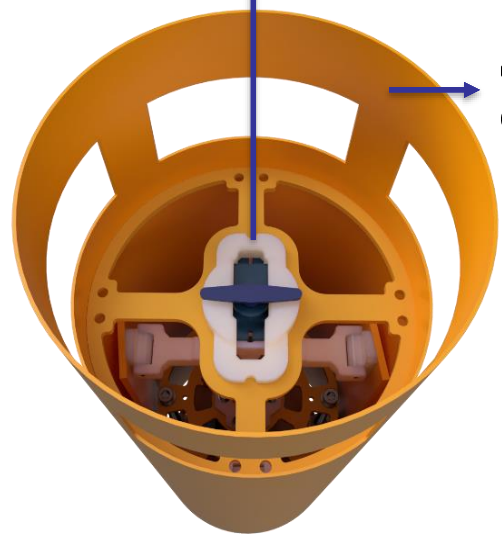
8 piece of M5 screws and nuts

18 piece of M3 screws and nuts

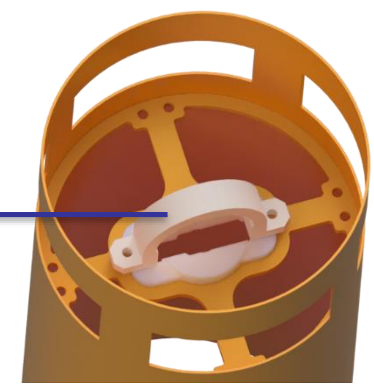
4 piece of chassis rods

Container Mechanical Layout of Components

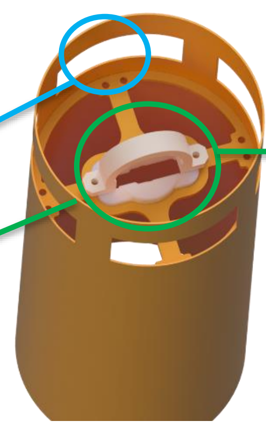




We decided to use polycarbonate as our container material due to its lightweight, durability and flexibility.



The container consists of two major parts;

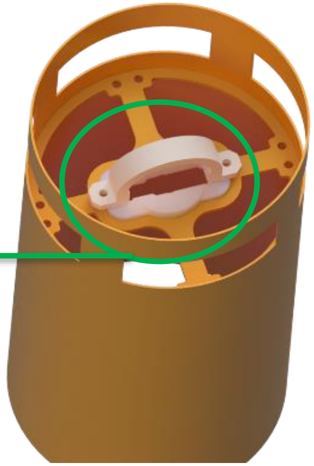


Note: We do not have any electronic component in the container.

Container Mechanical Layout of Components

Parachute Housings

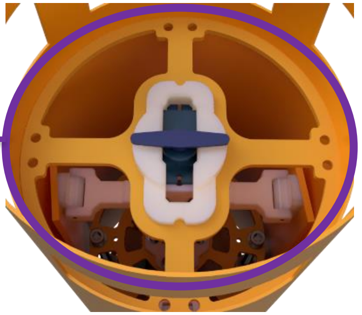
There are a total of 4 parachute housings in order to benefit from the high-pressure air flow while the container and payload start the descending phase. As soon as the housings vacuum the air, the parachute is triggered for deployment.



Parachute Hinge

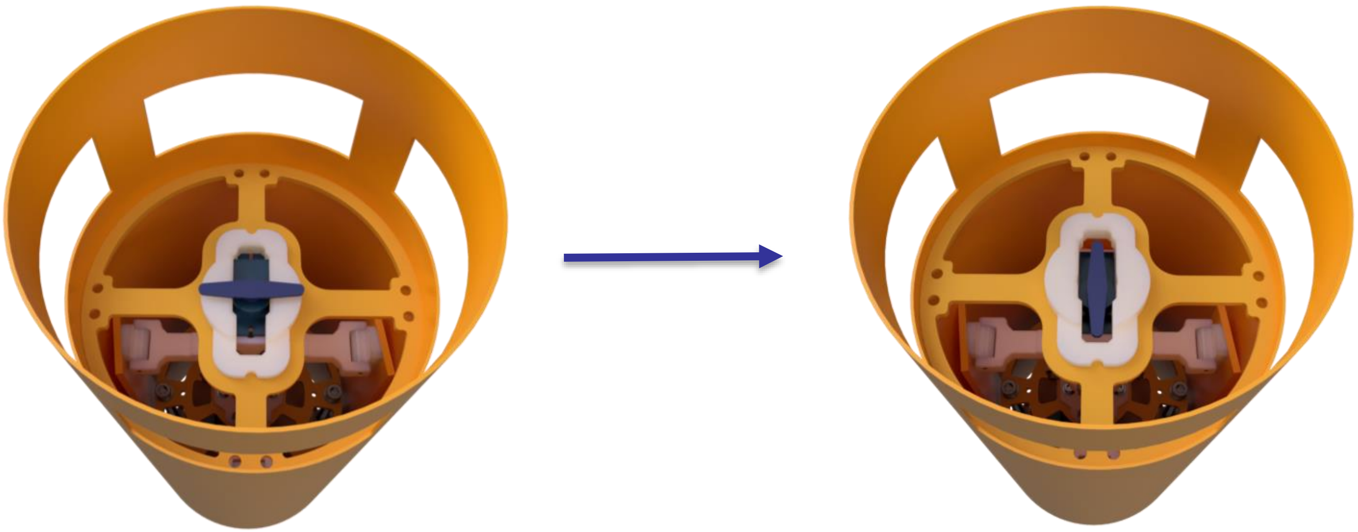
We 3D printed a hinge that holds the parachute intact when it is deployed. It is placed right over the release mechanism

Payload Attachment Points



We designed a platform that both supports the container and holds the release mechanism that enables the deployment of the payload.

Payload Release Mechanism



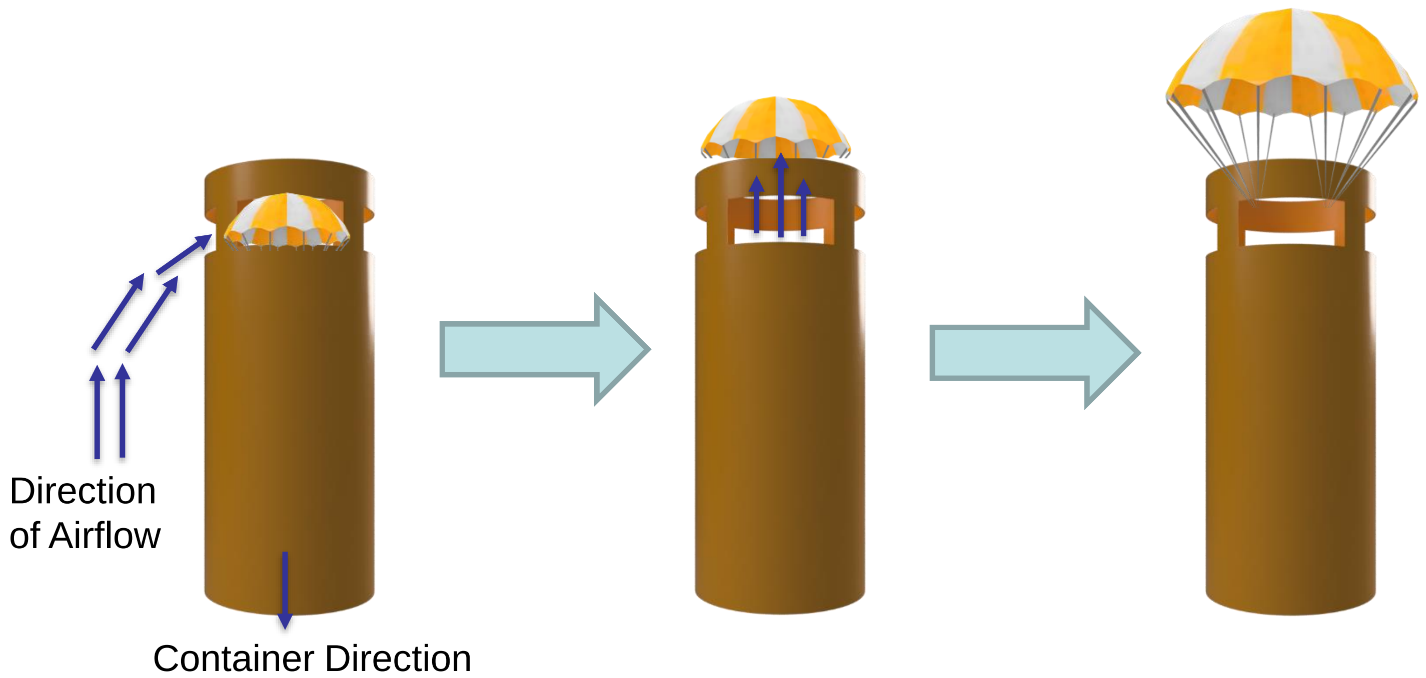
Servo Locked

Servo Free

The payload has a release mechanism at the top which rotates and slips down from the container. The tails are mounted on a servo which controls this rotational movement. There are also two stopper pins that limit the movement of the tail in order to prevent them from malfunctioning.

The container has an identical shaped gap under the parachute housing for this specific movement.

Container Parachute Release Mechanism



The parachute is being triggered passively by the air openings around the container. When the container and payload slips from the rocket, the container will be exposed to an immediate high-pressure air flow. The openings around the parachute housing vacuum the air inside and trigger the deployment of the parachute.

Structure Survivability

Criteria	PDR	CDR	Rationale
Electronic Component Mounting Methods	Electronic components are glued on to the plate as well as being mounted with 4 screws	Electronic components sit on top of a custom 3D printed plate which holds the PCB's firmly.	We will cover the electronical components with silicon which is a more suitable material.
Electronic Component Enclosures	Electronic components are surrounded by a transparent polyethylene case	Electronic components are surrounde d by a transparent polyethyl ene case as well as a 3D printed protective structure	The method we used at the pdr phase was very simple and sufficient however we decided to use a more dura ble solution.
Acceleration and Shock Force Requirements and Testing	Not tested	The payload and container has been dropped from a 100m height. Apart from a minor concussion, the payload and container remained fully functional.	The test phase is not limited with the 100m freefall. We will do another test which will be from an altitude of 750m that give us a better understanding.

Structure Survivability

Criteria	PDR	CDR	Rationale
Securing Electrical Connections	Electronic components are soldered on to the PCB's and covered by glue in order to prevent them from being deattached.	Electronic components are soldered on to the PCB's and coverd by silicon (the use of jumpers canceled due to the risk of deattchement at the launching phase)	We will cover the electro nical components with sil icon which is a more suitable material.
Descent Control Attachments	A servo-powered release mechanism is used for the descent phase.	Alongside with the payload release mechanism, a cap underneath the container enables the payload to slip down while also preventing it from vacuuming high-pressure air	We added the container bottom cap in order to prevent the payload from being harmed due to the high-pressure air flow.

Mass Budget

Mass of Electronic Components		
Component	**Mass (grams)**	**Source**
Adafruit BMP180	4	Datasheet
Adafruit Ultimate GPS Breakout	8.5	Datasheet
Voltage Divider Circuit	1	Datasheet
Adafruit MPU6050	2.1	Datasheet
US1881 Hall Effect Sensor	2.1	Datasheet
Adafruit Mini Spy Camera	2.8	Datasheet
Teensy 3.5	4.8	Datasheet
Sandisk Ultra Mini SD 16GB	1	Datasheet
Arduino DS1307	2.3	Datasheet
2.4GHz Antenna Adhesive	2.2	Datasheet
Xbee Pro s1	2.5	Datasheet
Total	33.3 g	

Mass Budget

Mass of the Propeller System Components		
Component	**Mass (grams)**	**Source**
Propeller Mill	5	Measured
Encoder Housing	4(x2) = 8	Measured
Bearing Clips	20(x2) = 40	Measured
Propeller Shaft	5	Measured
Bearings	45(x2) = 90	Measured
Propeller Shaft Fix	15	Measured
Servo Housing	22	Measured
Total	185 g	

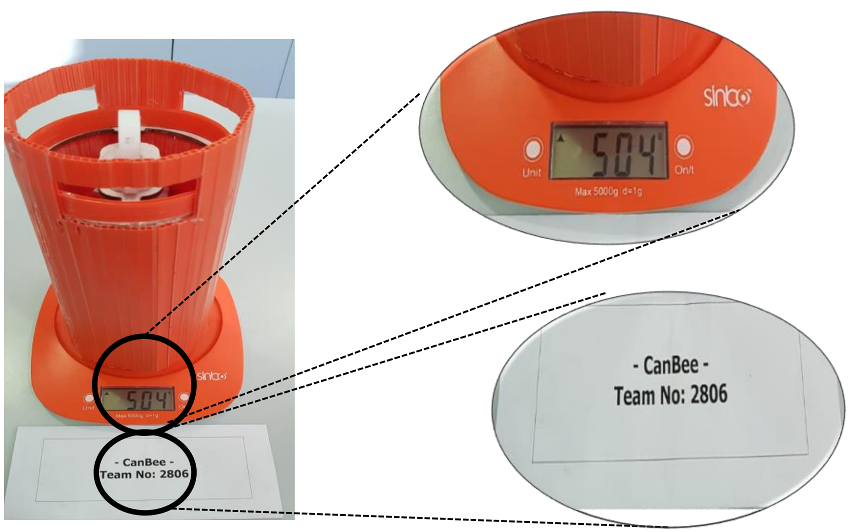
Mass Budget

Mass of the Structural Components (Chassis)		
Component	**Mass (grams)**	**Source**
Chassis Rods	4(x6) = 24	Measured
Duralit Plates	14(x2) = 28	Measured
Electronics Platform	12	Measured
Battery Case	17	Measured
M3-M5 Bolts&Nuts	100	Measured
Total	181 g	

Mass of the Container components		
Component	**Mass (grams)**	**Source**
Container	113	Measured
Parachute Hinge	25	Measured
Total	138	

Mass Budget

	Minimum CR Mass	Total Base Mass	Maximum CR Mass
Requirement	490 g	500 g	510 g
CanSat		504 g	
Margin	-14 g		+6 g



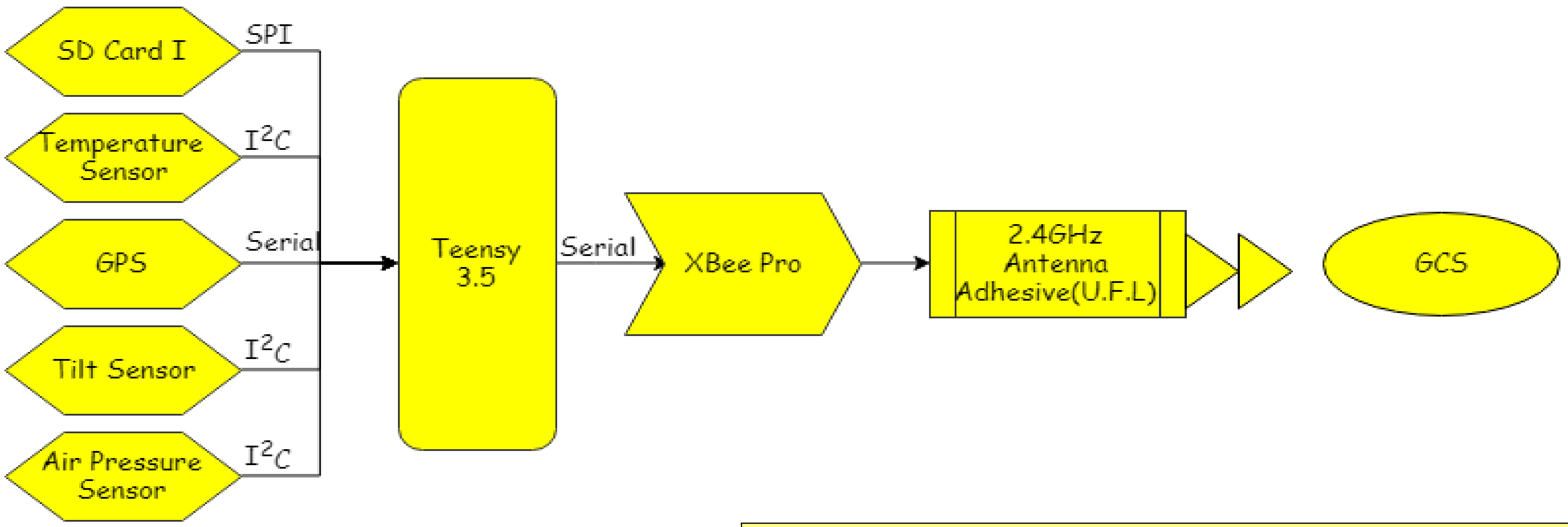
*In case of staying under the required mass, we could add equally pieces into the container.

- Weight limit is indicated in requirements as $\pm$10 gram.
- Total mass is equal to 504g. Total mass margin is +6 g or -14 g.

Communication and Data Handling (CDH) Subsystem Design

Haluk Levent Cicek

CDH Overview



CDH Component	
Component	**Function**
Teensy 3.5	Payload Microprocessor
Xbee Pro	Payload Radio
DS1307 RTC	RTC for the System

CDH Changes Since PDR

COMPONENTS	PDR	CDR	Reasons
Antenna	Duck Antenna	2.4GHz Antenna Adhesive(U.F.L)	High gain value, small size, longer distance communications, flexible, small dimensions

CDH Requirements

	Communication and Data Handling Requirements		Verification			
ID	# of CR	Description	A	I	T	D
CDH-1	13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	✓			
CDH-2	16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	✓			
CDH-3	20	The science payload shall measure altitude using an air pressure sensor.	✓	✓	✓	
CDH-4	21	The science payload shall provide position using GPS.	✓	✓	✓	
CDH-5	22	The science payload shall measure its battery voltage.	✓	✓	✓	
CDH-6	23	The science payload shall measure outside temperature.	✓	✓	✓	
CDH-7	26	The probe shall transmit all sensor data in the telemetry	✓	✓		
CDH-8	30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	✓	✓		

CDH Requirements

	Communication and Data Handling Requirements		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
CDH-9	31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		✓		✓
CDH-10	32	XBEE radios shall have their NETID/PANID set to their team number.			✓	
CDH-11	33	XBEE radios shall not use broadcast mode.				✓
CDH-12	36	All telemetry shall be displayed in real time during descent.	✓			
CDH-13	37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	✓			
CDH-14	38	Teams shall plot each telemetry data field in real time during flight.	✓			✓
CDH-15	42	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.	✓			
CDH-16	46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	✓			
CDH-17	49	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.		✓		

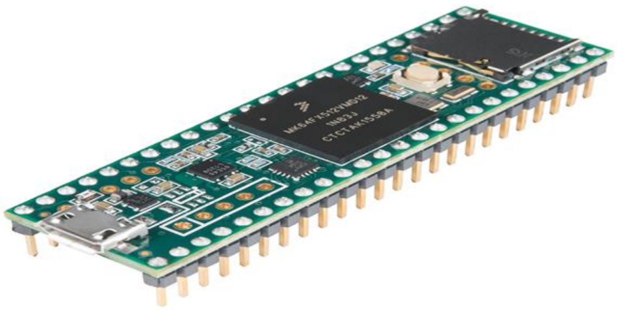
Payload Processor & Memory Selection

Microcontroller Board	Speed (MHz)	Boot Time(ms)	Interfaces		Form Factor(mm)	Cost ($)	Weight (g)	Power Consumption (mA)	Non-Volatile Memory options(Kb)		Volatile memory options(Kb)
Teensy 3.5 Micro Controller	120	0.3	I²C	3	62,3 x 18.0	24.95	4.8	0.020	EEPROM (4)	Flash(512)	SRAM (256)
			SPI	3							
			UART	6							
Arduino Uno	16	3.7	I²C	1	68.66 x 53.4	22.00	25	0.020	EEPROM (1)	Flash(32)	SRAM (2)
			SPI	1							
			UART	1							
Arduino Mega	16	3.3	I²C	1	101.52 x 53.3	38.5	37	0.020	EEPROM (4)	Flash(256)	SRAM (8)
			SPI	1							
			UART	1							

SELECTED

- Teensy 3.5

- Lightest weight
- Smallest form factor
- Programmable with Arduino IDE
- Larger size of non-volatile andvolatile memory options



Payload Processor & Memory Selection

Model	Capacity (GB)	Transfer Speed(MB/s)	Cost($)
Samsung EVO	16	48	7.5
Sandisk Ultra	16	48	6.4
Syrox	16	45	5.9

There are several SD card alternatives for the storage according to technical specifications like transfer speed but it’s important that the SD card shall be capable of some conditions like shock and vibration.

SELECTED

- SanDisk Ultra

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

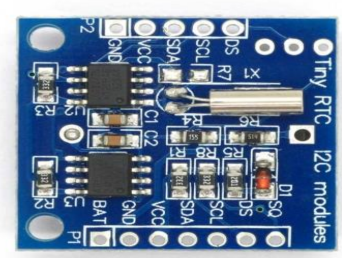
Payload Real-Time Clock

Model	Voltage (V)	Power Consumption (mA)	Accuracy (ppm)	Interface	Weight and Size(mm/g)	Hardware/ Software
DS1302	2	0.015	∓ 40	I2CI^2C	16.5x26.3x 1.6 / 9	Hardware
DS1307	5	0.015	∓ 23	I2CI^2C	26x22x 5/ 2.3	Hardware
DS3231	5.5	0.084	29$\mp$2	I2CI^2C	38x22x 14 / 2.3	Hardware

SELECTED

- Arduino DS1307

- 56-Byte non-volatile RAM
- Automatic power-fail Detect and switch circuitry
- Simple serial port interfaces

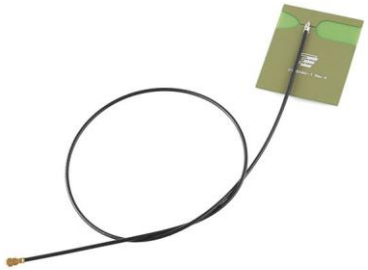


Reset Control: Each phases and packet countings are stored in EEPROM. If reset operation is done, microcontroller gets values from EEPROM.

Payload Antenna Selection

Antenna Model	Gain	Dimensions	Connector Type	Frequency	Mass
2.4GHz Antenna Adhesive(U.F.L)	2 dBi	41 x 30mm, 350mm cable	SMA	2.4 GHz	2.2g

Final Selection for Antenna : 2.4GHz Antenna Adhesive(U.F.L)



Performance Specifications:

- High gain value
- Small size
- Required for longer distance communication

Using the directional antenna with 2dBi provides us advantage in data transmission with harmonically working with Xbee. Sma connector is adaptable with XBee. Also,the weight of out antenna is 2.2 g.

Payload Radio Configuration

Device	Voltage (V)	Transmit Current (mA)	Receive Current (mA)	Operating Frequency (GHz)	Outdoor Line Of Sight Range (ft)	Transmit Power (mW/dBm)	RF Data Rate (Kbps)	Cost ($)
Xbee Pro S1	2.1-3.6	200	55	2.4	8.200	63/(+18)	250	37.95
Xbee Pro S2B	2.7-3.6	205	47	2.4	5280	63/(+17)	250	58.5
Xbee Pro 900 Hp	2.4V-3.6	229	44	0.87	21.120	250/(+24)	200	97.50

SELECTED

- Xbee Pro S1

- Low TX currents
- Low cost
- Better range
- Team member experience

NETID will be set to 2806

Transmission control will be done at the each mission phase, we will have error message if any error occurs.

Payload Telemetry Format

<Team ID>	Team identification
<Mission Time>	The elapsed time from the moment of departure
<Packet Count>	The count of transmitted packets, which is to be maintained through processor reset.
<Altitude>	Altitude with one meter resolution
<Pressure>	Measured atmospheric pressure
<Temp>	Tempature in degrees
<Voltage>	Voltage of the CanBee
<GPS Time>	Time generated by the GPS receiver
<GPS Latitude>	Latitude generated by the GPS receiver
<GPS Longitude>	Longitude generated by the GPS receiver
<GPS Altitude>	Altitude generated by the GPS receiver
<GPS Sats>	The number of GPS satellites being tracked by the GPS receiver.
<Tilt X>	Tilt sensor X axis value
<Tilt Y>	Tilt sensor Y axis value
<Tilt Z>	Tilt sensor Z axis value
<Software State>	Software availability
<Camera State>	The power state of the camera.

The telemetry data shall be transmitted with ASCII comma separated fields like below:
<Team ID> , <MISSION TIME> , <PACKET COUNT> , <ALTITUDE> , <PRESSURE> , <TEMP> , <VOLTAGE> , <GPS TIME > , <GPS LATITUDE> , <GPS LONGITUDE> , <GPS ALTITUDE> , <GPS SATS> , <TILT X > , <TILT Y> , <TILT Z > , <SOFTWARE STATE>,<CAMERA STATE>

Example Frame:
2803 , 27 , 105 , 298.56 , 815.24 , 20.18 , 9.12 , 080563 , +42.236 , -41.359 , 302.12 , 8 , 3 , 92 , -91 , 2 , 0

Data rate of packets will be sent in **continuous mode**. ***Our telemetry frame matches the requirement.***

MATCH

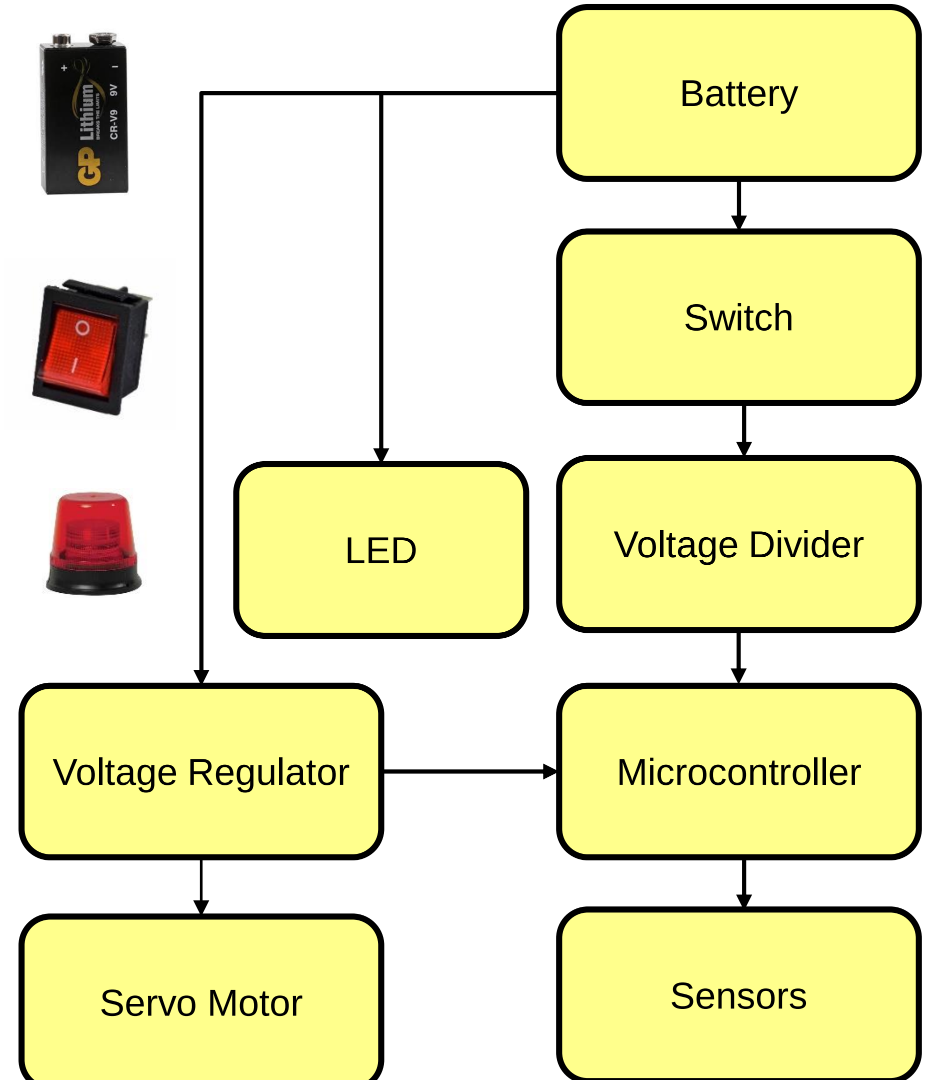
Container Processor & Memory Selection

The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

Electrical Power Subsystem Design

Dogukan Kuyumcu

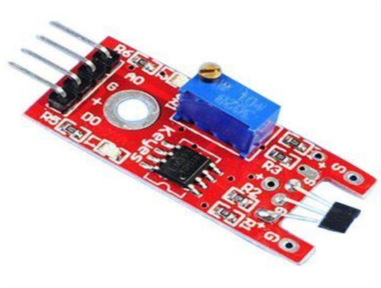
EPS Overview



- **Battery**: Voltage source of the system.
- **Switch:** Electrical component used for the voltage on/off control.
- **Voltage Divider:** Provides measurement of voltage level.
- **Voltage Regulator:** To regulate voltage in order to supply system.
- **Microcontroller:** Teensy 3.5 microcontroller unit for data handling.
- **Sensors:** Ensure data measurement like temperature, pressure and etc.
- **Servo Motor:** Used for seperation of science probe from container.

EPS Changes Since PDR

SUBJECT	PDR	CDR	CHANGING DETAIL
Encoder	Optocoupler	Hall Effect Sensor	Optocoupler sensor has a limited gap between it’s transmitters. There could be some damage in optocoupler sensor during rotary motion.So, hall effect sensor is more practical instead of optocoupler.
Power Sign	-	LED	LED indicator is used in CDR process to show if power is implemented or not.



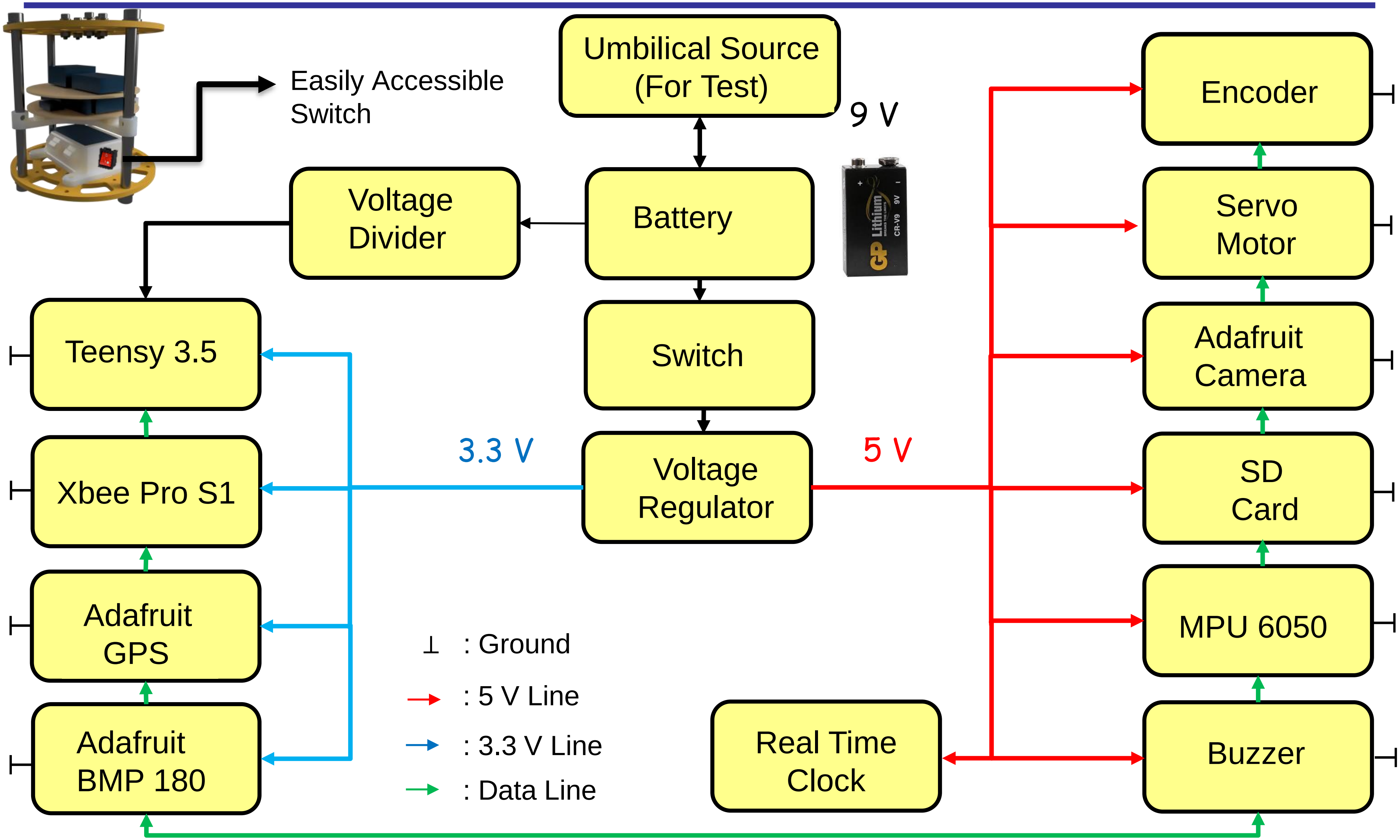
EPS Requirements

	Electrical Power Subsystem Requirements		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
EPS-1	1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	✓	✓		
EPS-2	13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	✓			
EPS-3	34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	✓	✓		
EPS-4	40	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.		✓		
EPS-5	45	The probe must include an easily accessible power switch that can be accessed without disassembling the CANSAT and in the stowed configuration.	✓			✓
EPS-6	46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CANSAT and in the stowed state.	✓			

EPS Requirements

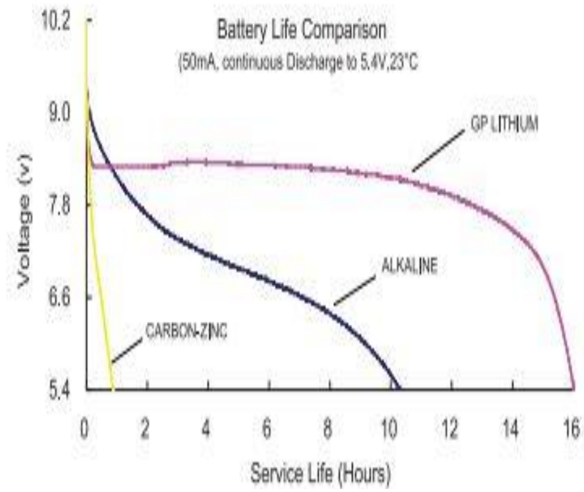
	Electrical Power Subsystem Requirements		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
EPS-7	47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	✓			✓
EPS-8	49	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.		✓		
EPS-9	50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	✓	✓		
EPS-10	51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	✓			✓
EPS-11	54	The CANSAT must operate during the environmental tests laid out in Section 3.5.		✓		
EPS-12	55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	✓	✓		

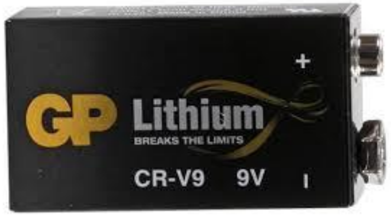
Payload Electircal Block Diagram



Payload Power Source

Model	GP CR-V9
Nominal Voltage	9 V
Current Capacity	800mAh @ 10mA to 5.4V at 23°C
Weight	34g
Size	Height : 48.0mm Length : 26.0mm Thickness : 16.5mm
Operating Tempature	Min.: -40°C Max.: 60°C
Generated Current	Up to 812 mA





- **Battery Chosen:** Lithium Primary Manganese Dioxide - GP GPCR-V9
- Only one battery cell is used as an electrical power source in payload system.

Payload Power Budget

NO	Electronic Components	Duty Cycle (%)	Operational Current (mA)	Operational Voltage (V)	Source	Power Consumption (Wh)
1	Teensy 3.5	100	50	3.3	Datasheet	0.66
3	MPU6050	100	3.9	5	Datasheet	0.002
4	Xbee Pro S1	100	200	3.3	Datasheet	0.792
5	Encoder	100	5(x2)	5(x2)	Datasheet	0.002(x2)
6	Servo Motor	0.033	100	5	Measurement	0.003
7	Buzzer	25	30	5	Datasheet	0.075
8	Camera	100	100	5	Datasheet	0.041
9	SD Card	100	100	5	Estimated	0.041
10	BMP180	100	$5x10^{-3}$	5	Measurment	0.002
11	Adafruit GPS	100	20	3.3	Datasheet	0.005
12	Real Time Clock	100	0.015	5	Datasheet	$0.075x10^{-3}$
TOTAL						**1.622**

Payload Power Budget

Power Source	Total Power Consumed (mWh)	Margin (Wh %)	Total Power Available (mWh)
GP GPCR-V9 Lithium Battery	1622 mWh	76.45 % 5.505 Wh	7200 mWh

Only 1 battery is used as an electrical power source in payload system.

So there is no battery configuration.

- All components operation times are considered with respect to descent time which is approximately 300 second except Xbee,Teensy and Buzzer.
- There is a differance considered in calculations for both capacity and power consuption indicated as margin above.

Payload Power Budget

- Total power consumption is calculated related with selected parts.
- Selected voltage source is sufficient for total power consumption.
- Xbee pro S1 and Teensy 3.5 must be worked stable at least 2 hours. However, they operate during descent process actively. Their operation currents vary depending on stable or active condition. So, power budget calculation is done with the consideration of these values indicated below.

Components	Stable Time(s)	Stable Current (mA)	Active Time(s)	Operation Current (mA)
Teensy 3.5	6920 s	20 mA	280 s	50 mA
Xbee Pro S1	6920 s	50 mA	280 s	200 mA
Buzzer	5400 s	30 mA	1800 s	30 mA

Container Electrical Block Diagram

The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

Container Power Source

The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

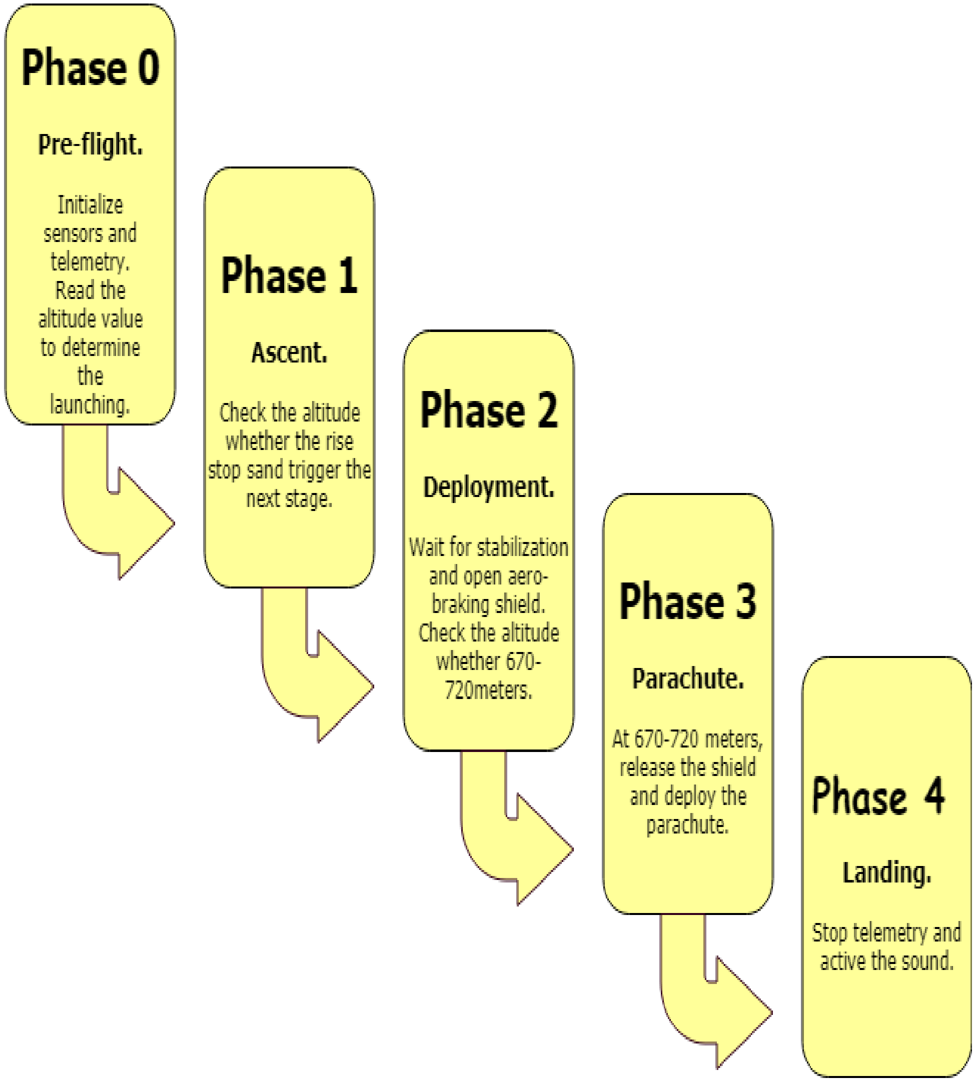
Container Power Budget

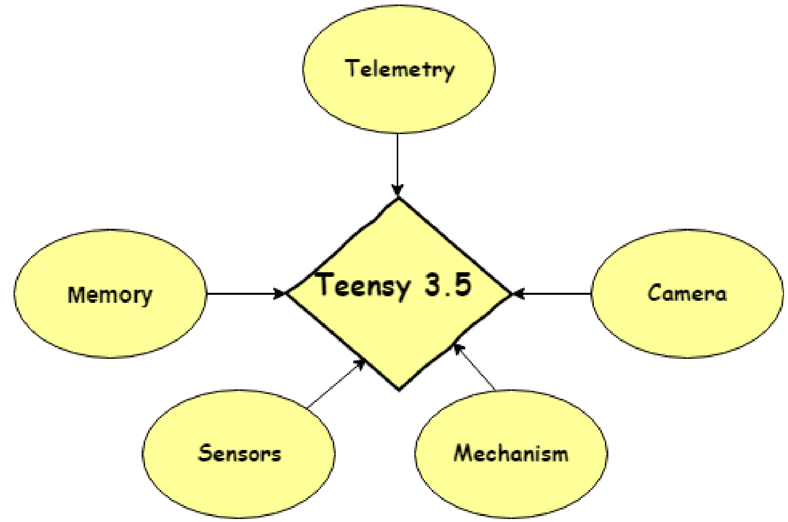
The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

Flight Software (FSW) Design

Haluk Levent ÇİÇEK

FSW Overview





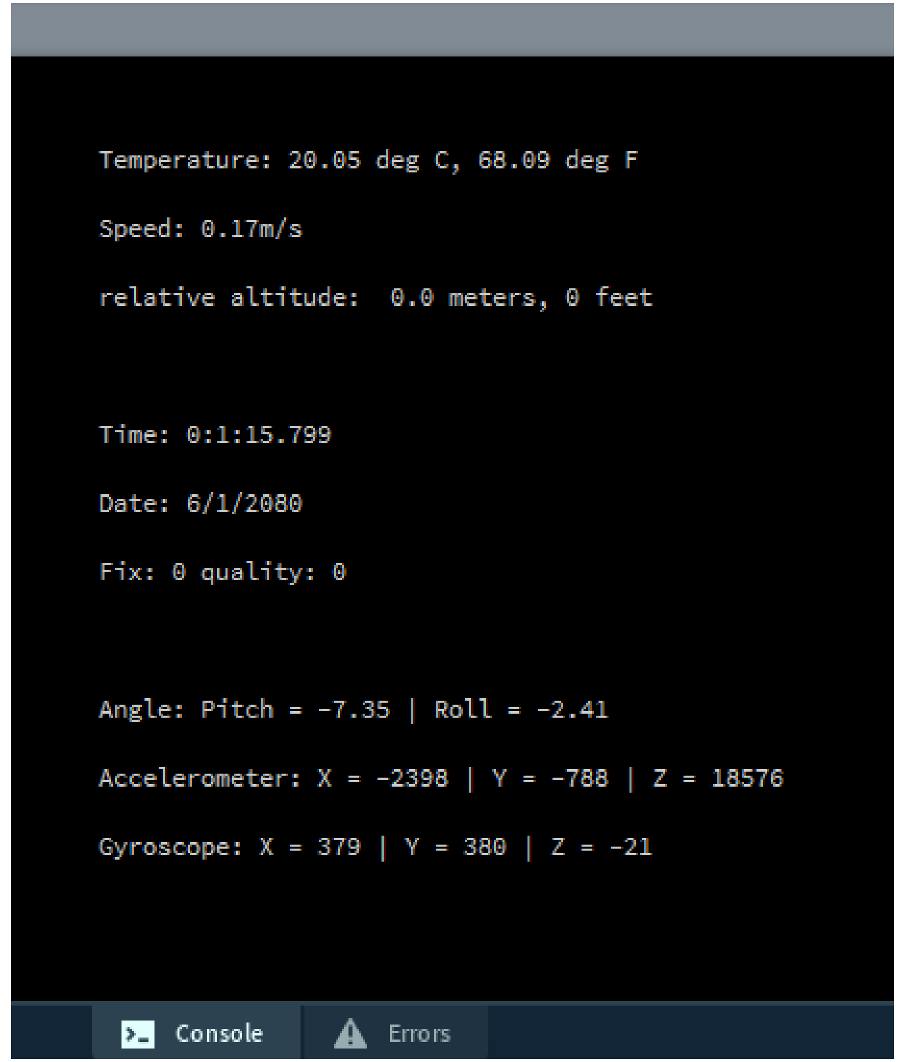
Program Language	Development Environment
Processing	Arduino IDE

Brief Summary Of FSW Tasks:

FSW get values from the sensors to send GCS and trigger the release and deployment. Also, it follows the stages of the flight and actives the sound after landing.

FSW Changes Since PDR

Programming Language
C/C++ and C# To Processing
Reasons
One of our friends have experience on Processing language and it is easier for using. Thus we are using Processing language for successful communications. Following figure shows the taken data with Processing language.



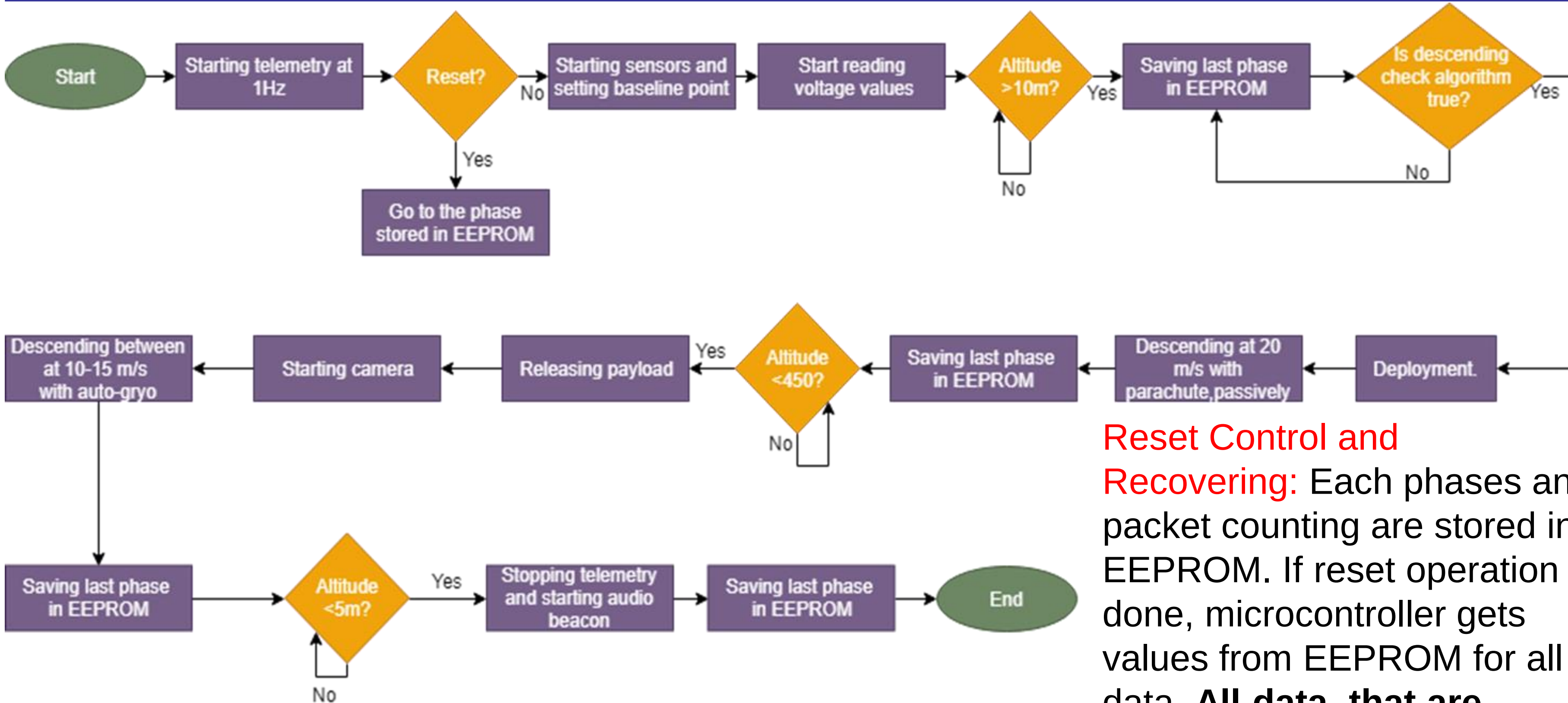
FSW Requirements(1/2)

	Flight Sofware Requirements		Verification			
ID	# of CR	Description	A	I	T	D
FSW-1	9	The container shall release the payload at 450 meters +/- 10 meters.	✓			✓
FSW-2	11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	✓			✓
FSW-3	30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	✓	✓		
FSW-4	38	Teams shall plot each telemetry data field in real time during flight.	✓			✓
FSW-5	42	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.	✓			
FSW-6	46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	✓			
FSW-7	47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	✓			✓
FSW-8	48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	✓	✓		

FSW Requirements(2/2)

Flight Software Requirements			Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
FSW-9	CanBee-1	When the reset and recovery state occurs, flight software should stop and at the end of the this state, it should record data again.			✓	✓

There is no requirement for that description. However, for identifying for reset and methods for recovery, we should add this requirement.



Reset Control and Recovering: Each phases and packet counting are stored in EEPROM. If reset operation is done, microcontroller gets values from EEPROM for all data. **All data, that are saved, are used for recovering.**

The main purpose of reset and recovery is that if we have faced any problems we can save previous data.

All data is get from sensors with 4 Hz rate. Data is saved to SD Card. Data is sent to GCS with telemetry. Sending packets are counted and saved to EEPROM.

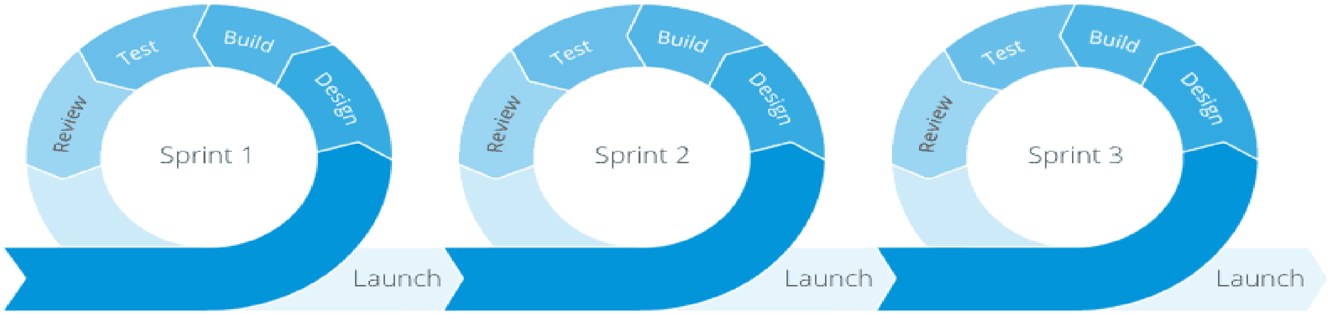
Container CanSat FSW State Diagram

The separation of the science probe from the container is carried out by the servo attached to the science probe. The bottom lid of the container will be opened by the aid of air flow. Therefore, no electro-mechanical equipment was attached to the container.

Software Development Plan

- **Avoiding Late Software Development:**
  We are using Agile development methodology. We are dividing the project into the sprints such as testing the drawing temperature graph and taking sensor values correctly. Each sprint are testing and verifying at the end other development phase. Therefore, risk of late software development will be eliminated.

- **Software Subsystem Development Sequence:**



Software Development Plan

- **Prototyping and Prototyping Environments:**

Breadboard will be used for prototyping. After that, the circuit board will be printed on PCB. Then, software will be run with temporary values.

- **Test Methodology:**

Each component are testing separately. When iteration of any integration is done, tests will be done again such as; free-fall drop test, communication test, debugging, power test.

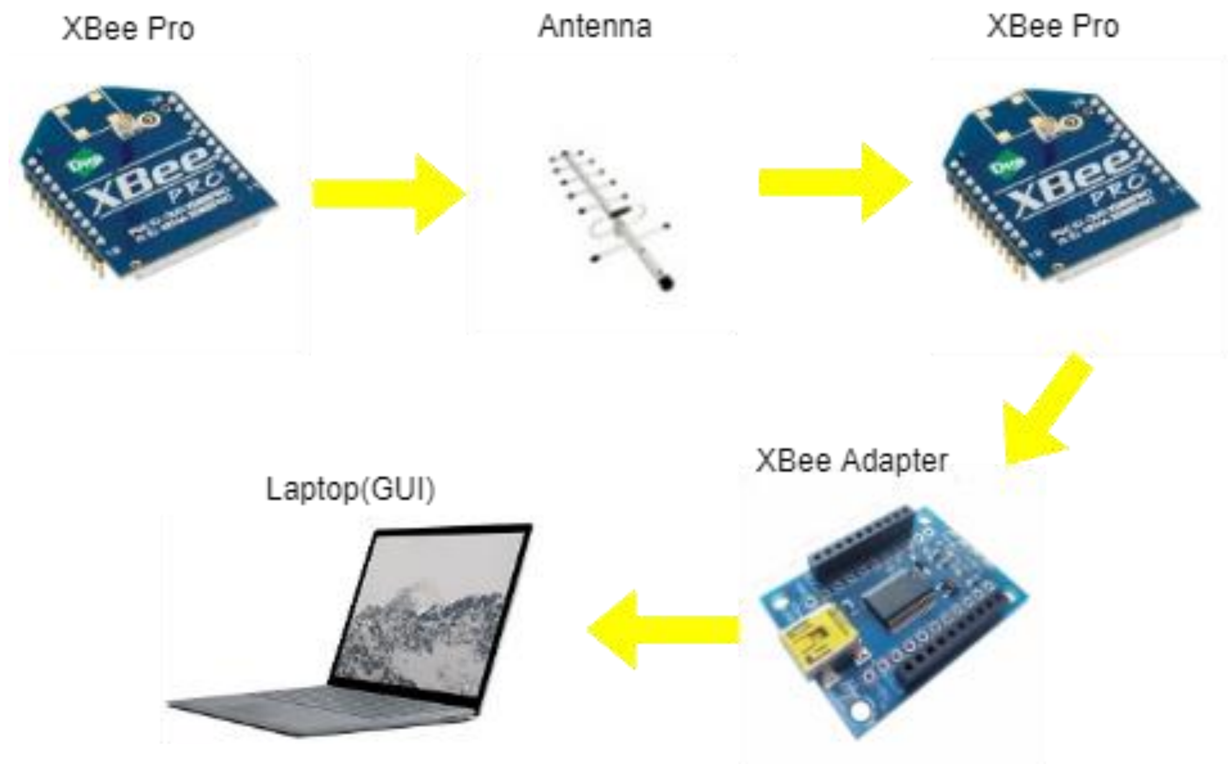
- **Development Team:**
  - Haluk Levent ÇİÇEK

- **Progress since PDR:** We have changed our programming language as a Processing instead of C/C++. Currently, we can take data with Processing successfully. Also, real time graphs for speed, temperature,altitude,pitch and roll values are drawn successfully as shown in the figures in the ground control system part of the presentation.

Ground Control System (GCS) Design

Haluk Levent Cicek

GCS Overview



GCS Changes Since PDR

COMPONENTS	PDR	CDR	Reasons
Antenna	Duck Antenna	2.4GHz Antenna Adhesive(U.F.L)	Better gain, easy to use, better range
Software	C/C++ and C#	Processing	Our friend have an experince on processing language

GCS Requirements

	Ground Control System Requirements		Verification			
ID	# of CR	Description	A	I	T	D
GCS-1	31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		✓		✓
GCS-2	32	XBEE radios shall have their NETID/PANID set to their team number			✓	
GCS-3	33	XBEE radios shall not use broadcast mode.		✓		✓
GCS-4	34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	✓	✓		
GCS-5	35	Each team shall develop their own ground station..	✓			✓

GCS Requirements

	Ground Control System Requirements		Verification			
ID	# of CR	Description	A	I	T	D
GCS-6	36	All telemetry shall be displayed in real time during descent	✓			
GCS-7	37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	✓			
GCS-8	38	Teams shall plot each telemetry data field in real time during flight.	✓			✓
GCS-9	39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.		✓		
GCS-10	40	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.		✓		
GCS-11	42	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	✓			

GCS Design

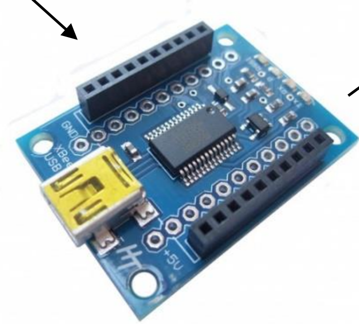
Specifications	
Battery	Can operate 4 hours
Overheating Mitigation	External cooler under the laptop Sun shielding umbrella
Auto Update Mitigation	Auto update will be disabled Internet connection will be disabled

SMA to SMA cable and connector

XBee Module

XBee module is connected to XBee adapter with slot.

Outdoor omni-direcitonal antenna

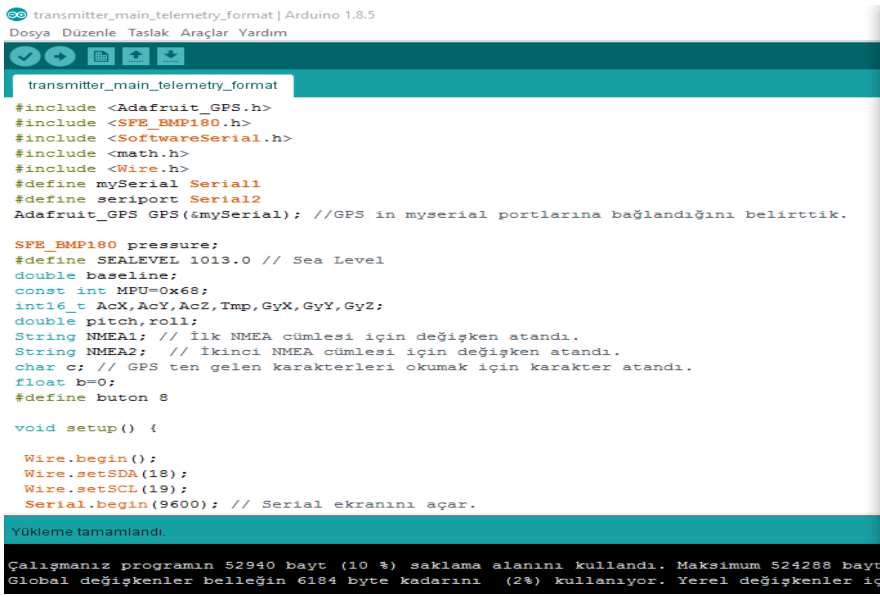


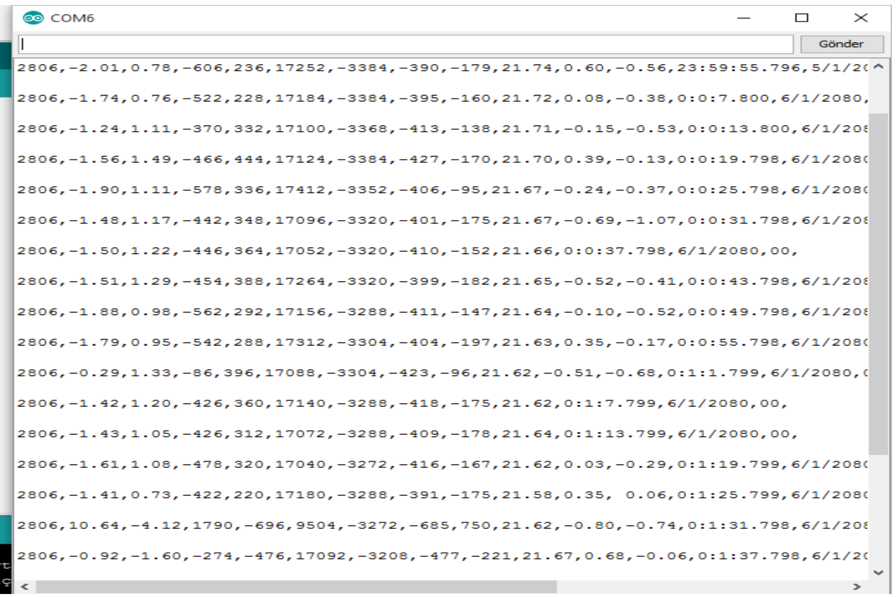
XBee Adapter

USB Converter

GCS Software

- **Telemetry display screen shots:** Telemetry data are taken and recorded on text file.





- **Progress since PDR:**

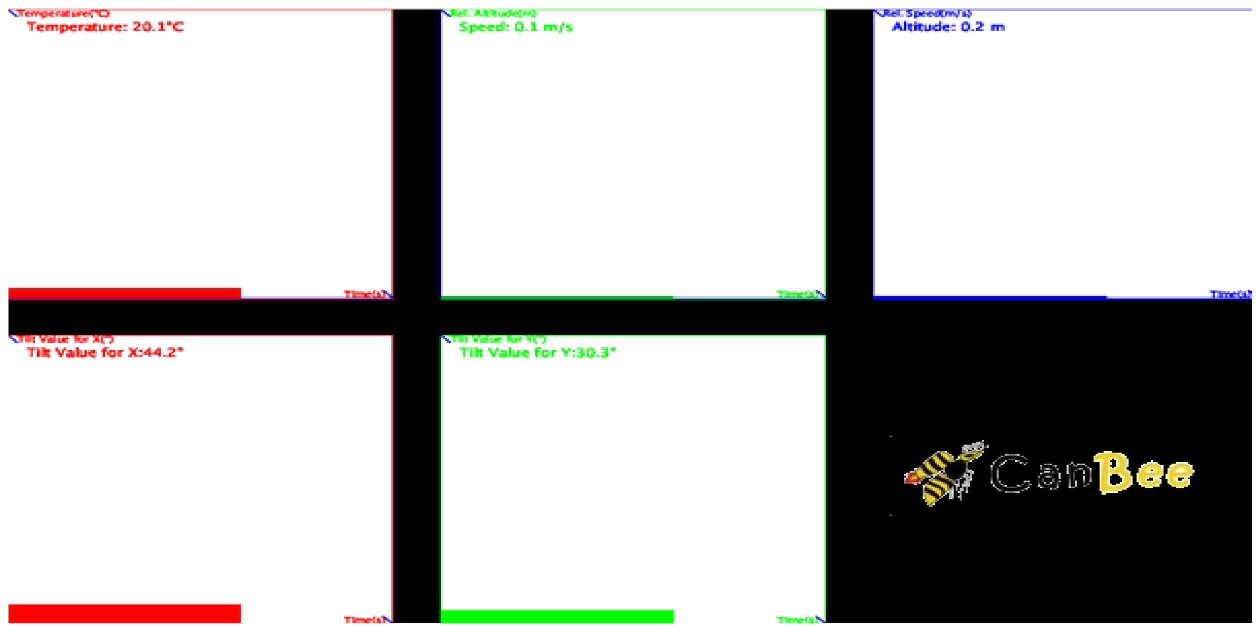
At the end of the PDR, we had no data communication and plotting real time graphs. We can not take sensor values with C/C++ for this reason, we are using Processing language. Currently, we can take sensor values from the Xbee and we can draw real time graphs according to these values.

GCS Software

- **Commercial off the shelf (COTS) software packages used:**

Processing language is used for drawing graph with real time values that is taken with Xbee. Also, Arduino is used for taking data from Xbee. In Arduino, there are some different libraries such as; Adafruit_GPS and BMP180 for taking sensor values. Following figure shows us the real time graphs for temperature, speed, altitude, pitch and roll.

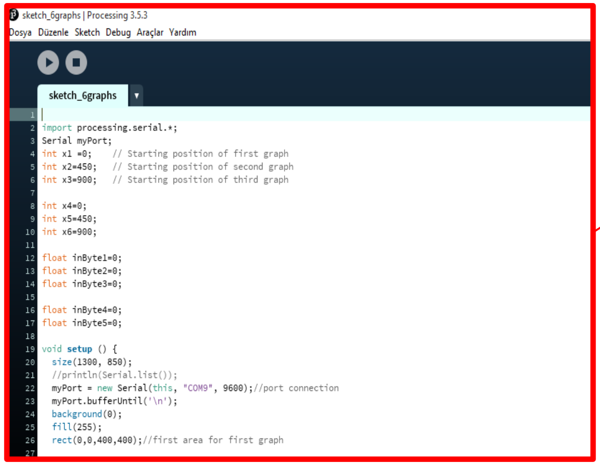
To calibrate angle and barometric sensor, there will be button on the flight software. Clicking the button will send the local altitude and the initial angle to the payload. The initial values will be entered into a text box.



GCS Software

- **Command software and interface:**

Processing is using for command software. Processing interface and sample code for real time graph are shown in the following figure:



sketch_6graphs

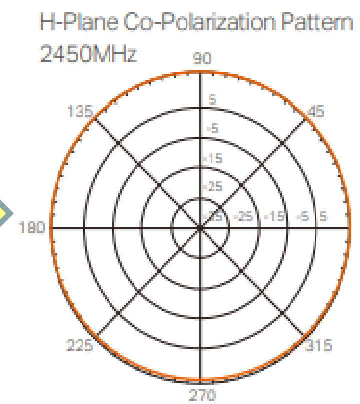
```

import processing.serial.*;
Serial myPort;
int x1 =0;    // Starting position of first graph
int x2=450;   // Starting position of second graph
int x3=900;   // Starting position of third graph

int x4=0;
int x5=450;
int x6=900;

float inByte1=0;
float inByte2=0;
float inByte3=0;

float inByte4=0;
float inByte5=0;

void setup () {
  size(1300, 850);
  //println(Serial.list());
  myPort = new Serial(this, "COM9", 9600);//port connection
  myPort.bufferUntil('\n');
  background(0);
  fill(255);
  rect(0,0,400,400);//first area for first graph

```

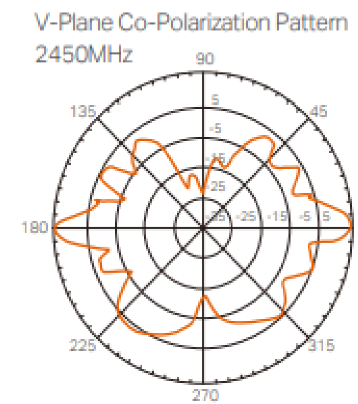
GCS Antenna

Model	Type(andconnector)	Gain (dBi)	Dimensions (mm)	Radiation Pattern	Frequency Range (GHz)
DuckAntenna	Dipole (SMA RF Connector)	2	106x13	Omnidirectional	2.4-2.5
Magnetic Mount Antenna	Dipole (SMA RF Connector)	7	200x10	Omnidirectional	2.4 ISMBand
TL-ANT2415D	N Female Connector	15	1500x12	Omnidirectional	2.4-2.5

•TL-ANT2415D

•Enough gain
•High dBi
•Suitable with Xbee
•Small dimension





New antenna selection criteria is easy availability.

Supplied mounting kits allow easy installation for a variety of environments

CanSat Integration and Test

Suhan Mergen

General View of Integration & Test

- System is tested with several different methods to examine all subsytems and components within the scope of integrity.
- System is integrated with all subsystems make together with using bolts, electrical connections with pcb and etc.
- Environmental tests are operated in accordance with stated requirement list and test procedure in mission guide

CanSat Probe System

- Sensors
- EPS
- FSW
- Mechanical
- Descent Control
- Mechanisms Test
- Deployment Test
- Descent Test

Environmental Tests

- Drop Test
- Vibration Test
- Thermal Test
- Fit Check

SYSTEM

Ground Control System

- Communication Test
- Radio communications
- CDH

CanSat Integration and Test Overview

Integrated Level Test & Subsytem Level Test

- Integrated test operation is performed to observe if whole system can operate in common or not.
- Each subsystem is tested separately to check integrated subsystems can operate all together without any failure.

(yellow box) : Subsystem Level Test

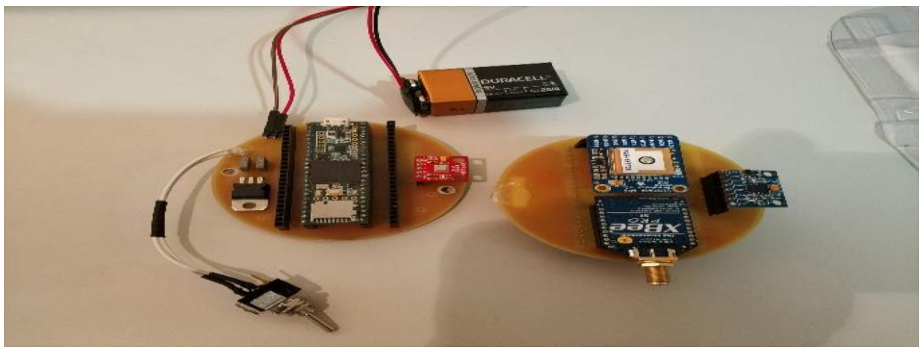
(white box) : Integrated Level Test

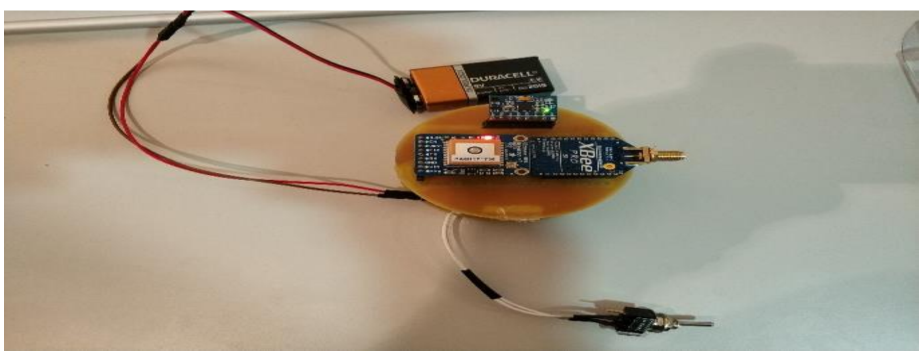
CanSat Probe System

Descent Testing	Communication	Mechanism	Deployment
FSW	**CDH**	**MS**	**SENSOR**
• Real Time Demonstration Data Test	• Accurate Data Transfer Test • XBee Data Transfer in Range	• Weight Control Test • Servo Motor Adjustment	• Sensor Calibrations • Operatable Sensors Test
DCS	**RC**	**EPS**	**DCS**
• Acceleration Test • Seperation of Probe Test	• Configuration of Antenna Test	• Voltage and Current Measurment Test	• Propeler Motion Test

Subsystem Level Testing Plan

Subsystem Level Testing	
Sensors	**CDH**
Each sensor was calibrates and tested seperately.	All interfaces were checked such as SPI , Serial Interfaces.
All sensors were tested together on a PCB. All requirments are achieved.	Data communications were checked for each component with XBEE, all requirments achieved



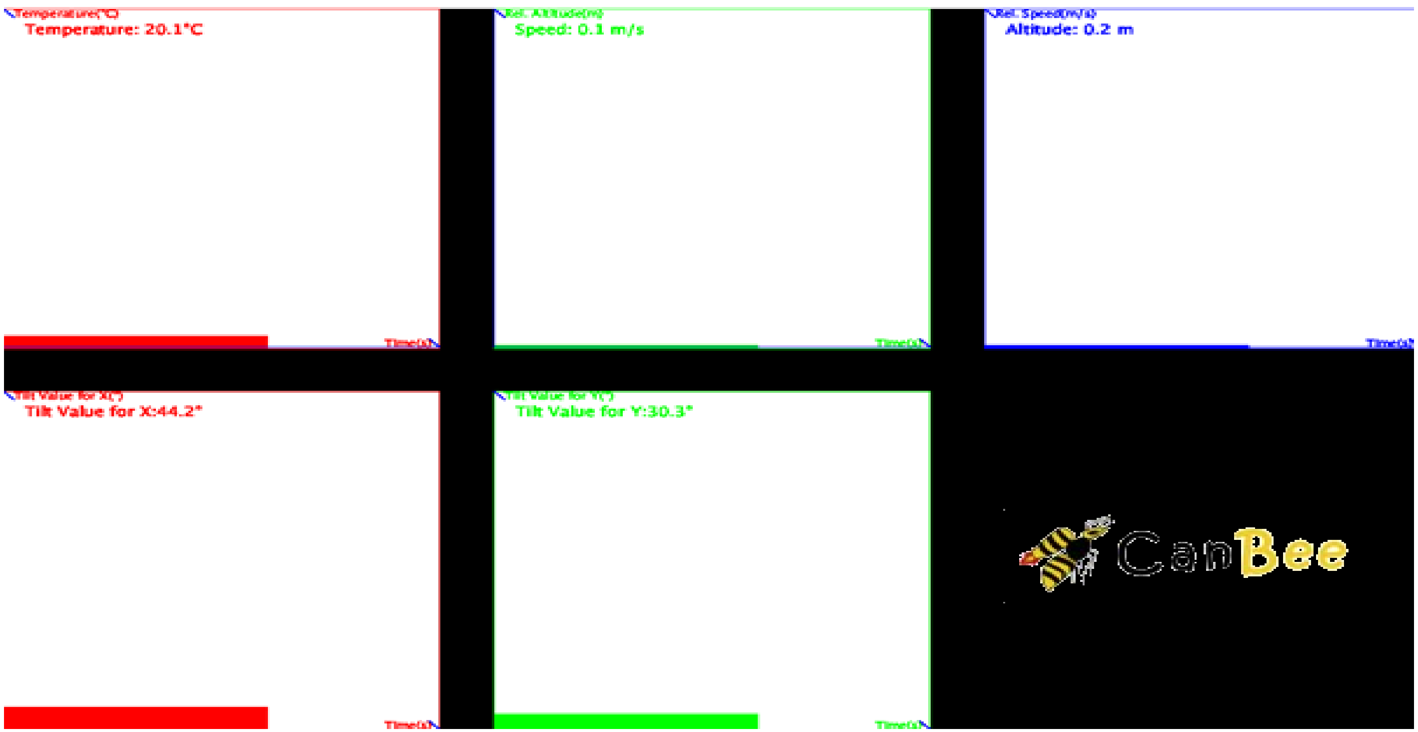



```
2806,-2.01,0.78,-606,236,17252,-3384,-390,-179,21.74,0.60,-0.56,23:59:55.796,5/1/20
2806,-1.74,0.76,-522,228,17184,-3384,-395,-160,21.72,0.08,-0.38,0:0:7.800,6/1/2080,
2806,-1.24,1.11,-370,332,17100,-3368,-413,-138,21.71,-0.15,-0.53,0:0:13.800,6/1/208
2806,-1.56,1.49,-466,444,17124,-3384,-427,-170,21.70,0.39,-0.13,0:0:19.798,6/1/2080
2806,-1.90,1.11,-578,336,17412,-3352,-406,-95,21.67,-0.24,-0.37,0:0:25.798,6/1/2080
2806,-1.48,1.17,-442,348,17096,-3320,-401,-175,21.67,-0.69,-1.07,0:0:31.798,6/1/208
2806,-1.50,1.22,-446,364,17052,-3320,-410,-152,21.66,0:0:37.798,6/1/2080,00,
2806,-1.51,1.29,-454,388,17264,-3320,-399,-182,21.65,-0.52,-0.41,0:0:43.798,6/1/208
2806,-1.88,0.98,-562,292,17156,-3288,-411,-147,21.64,-0.10,-0.52,0:0:49.798,6/1/208
2806,-1.79,0.95,-542,288,17312,-3304,-404,-197,21.63,0.35,-0.17,0:0:55.798,6/1/2080
2806,-0.29,1.33,-86,396,17088,-3304,-423,-96,21.62,-0.51,-0.68,0:1:1.799,6/1/2080,
2806,-1.42,1.20,-426,360,17140,-3288,-418,-175,21.62,0:1:7.799,6/1/2080,00,
2806,-1.43,1.05,-426,312,17072,-3288,-409,-178,21.64,0:1:13.799,6/1/2080,00,
2806,-1.61,1.08,-478,320,17040,-3272,-416,-167,21.62,0.03,-0.29,0:1:19.799,6/1/2080
2806,-1.41,0.73,-422,220,17180,-3288,-391,-175,21.58,0.35, 0.06,0:1:25.799,6/1/2080
2806,10.64,-4.12,1790,-696,9504,-3272,-685,750,21.62,-0.80,-0.74,0:1:31.798,6/1/208
2806,-0.92,-1.60,-274,-476,17092,-3208,-477,-221,21.67,0.68,-0.06,0:1:37.798,6/1/20
```

Subsystem Level Testing Plan

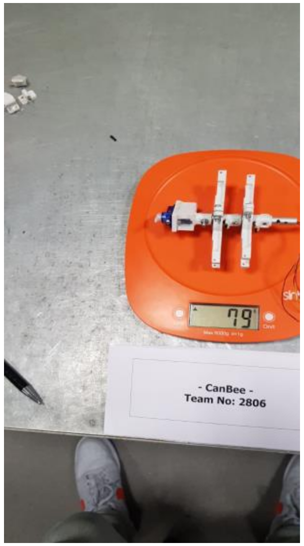
Subsystem Level Testing	
EPS	**Communications**
Lithium batteries are analyzed.	XBee devices were configured with antennas.
Batteries were tested with a representation circuit and the real system.	XBee devices were tested in line of sight and indoor to see communication range.
Lithium battery were tested under the load see maximum current available and service life.	Data communications tests were done in different range for Xbee.

Subsystem Level Testing
FSW
In our FSW, there are 5 real time plotting graphs that is drawn according to the data comes from the telemetry. Between all datas, we are using «,» as a token and data are seperated with the help of this token. Following figure shows us the correctly drawn real time plotting graphs.

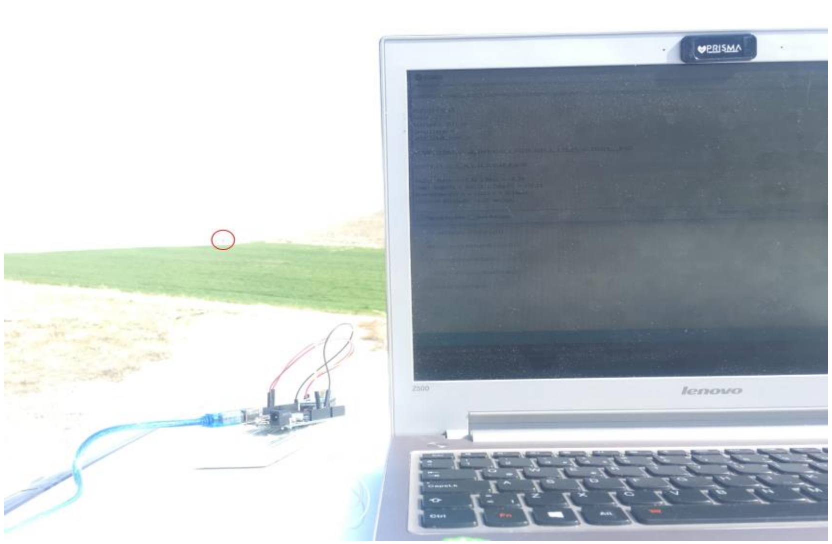


Subsystem Level Testing Plan

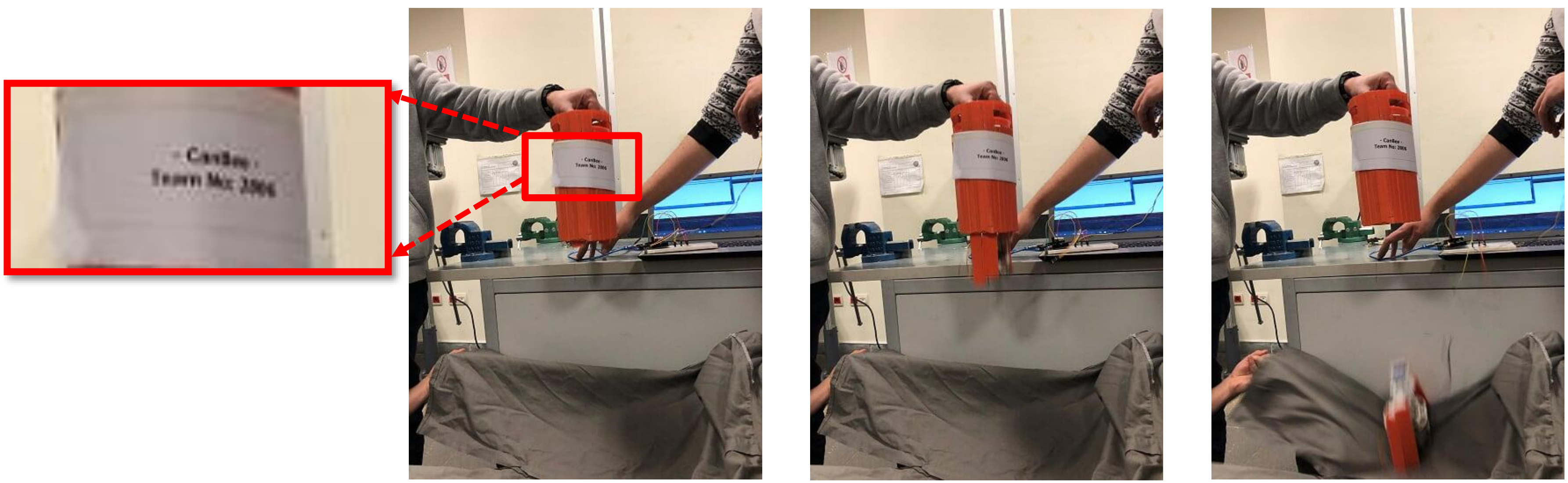
Subsystem Level Testing	
Mechanical Tests	**Descent Control**
Also all mechanical connections strength and endurance are checked with several test procedures. Each component's weight in the system is measured with a precision scales	Descent test will be done in May.



Integrated Level Functional Testing	
Descent Test	**Communication Test**
Descent test will be done in May.	Data communications tests were done in different range for Xbee. All sensor data transfer and communication through telemetry is tested without any failure.

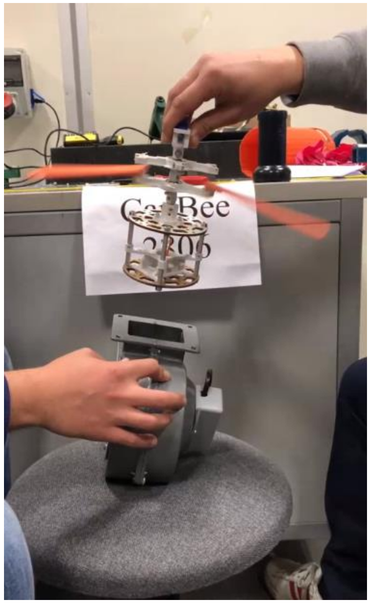


Integrated Level Functional Testing	
Mechanism Test	**Deployment Test**
Mechanical connections between science probe and container and endurance are checked after mechanism test. Payload is released with a servo motor mechanism and the process is operated without any failure.	Descent control test is done with the purpose of inspection of motion of propellers and CanSat. This test is operated in faculty laboratory with a blow dryer to inspect if propellers react against wind accurately.

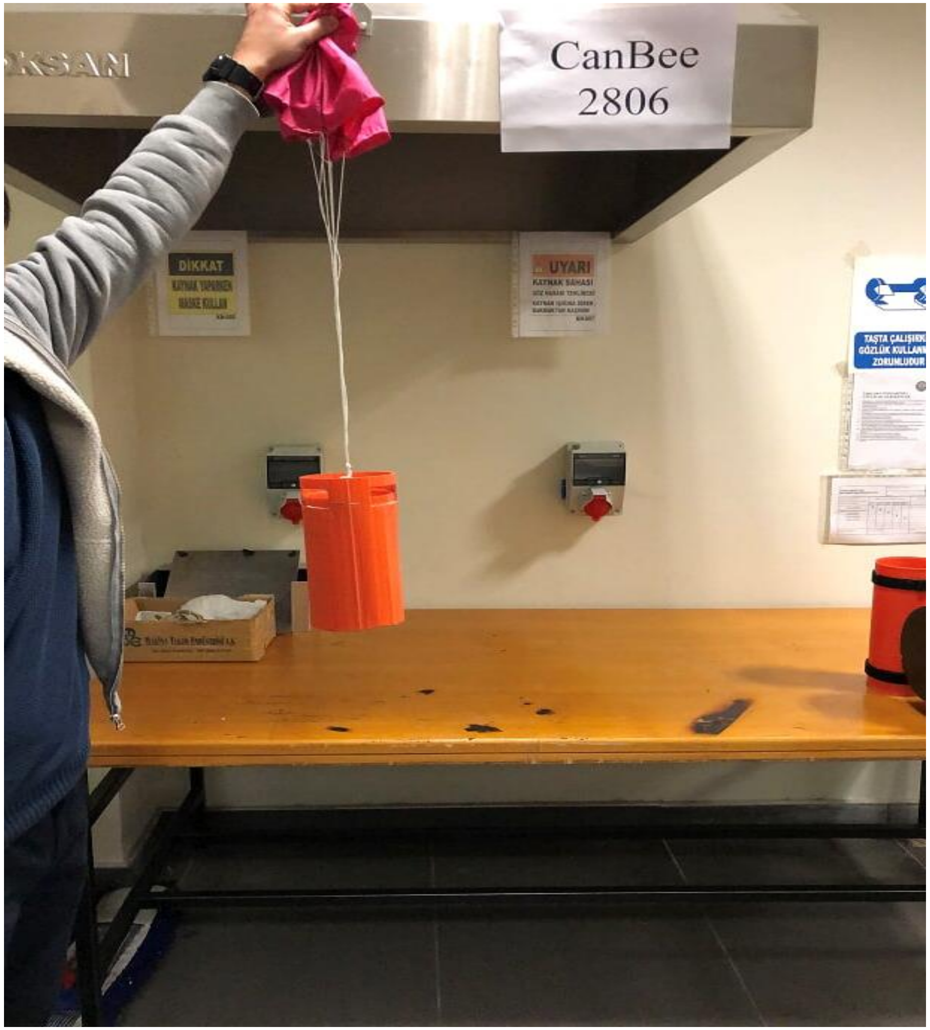


Integrated Level Functional Test Plan

Integrated Level Functional Testing	
Mechanism Test	Deployment Test
Mechanical connections between science probe and container and endurance are checked after mechanism test. Payload is released with a servo motor mechanism and the process is operated without any failure.	Descent control test is done with the purpose of inspection of motion of propellers and CanSat. This test is operated in faculty laboratory with a blow dryer to inspect if propellers react against wind accurately.

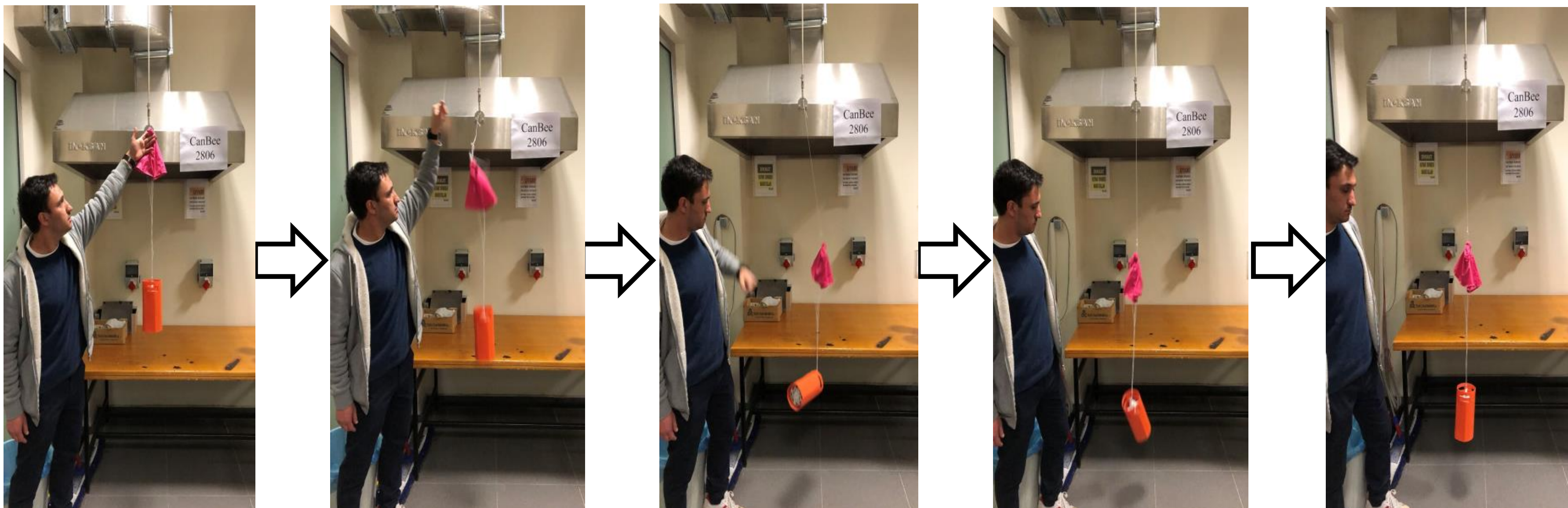


Drop Test

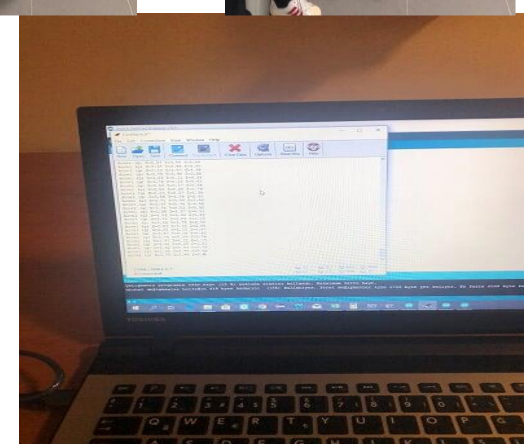


- Cord is attached to the parachute and attachment points are observed against any damage during test process.
- CanSat dropped from a certain altitude with a 61 cm kevlar cord.
- Team tag is attached to the ventilation as shown.

Drop Test

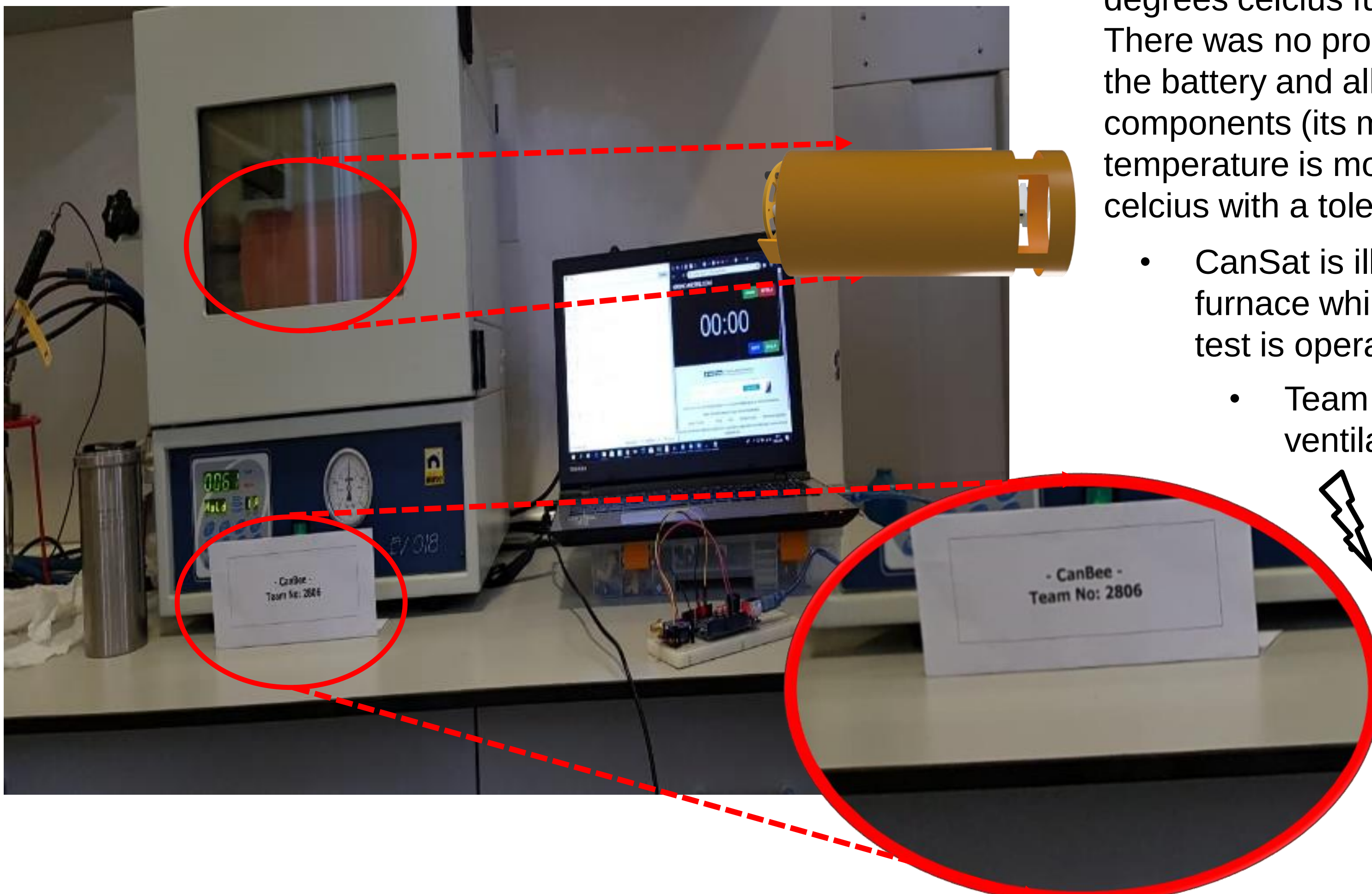


- The payload withstanded this test without any malfunctioning parts. A minor crack was observed at the bottom duralit plate which was predictable. A couple of payloads are manufactured in order to replace the tested one.



Environmental Test Plan

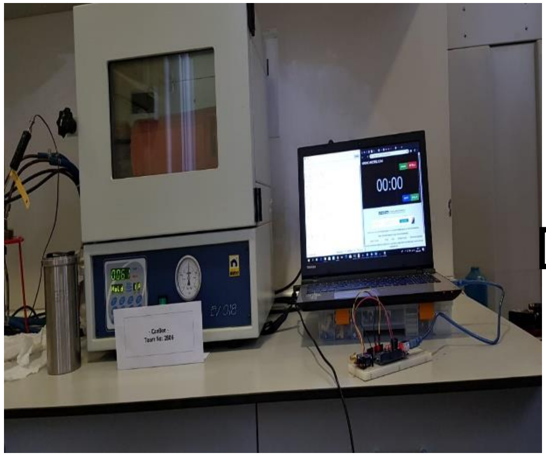
Thermal Test

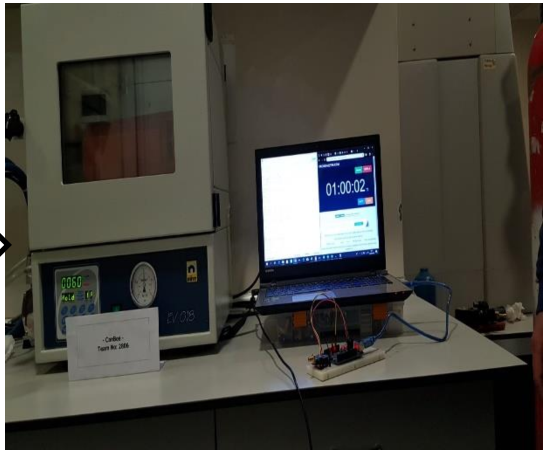


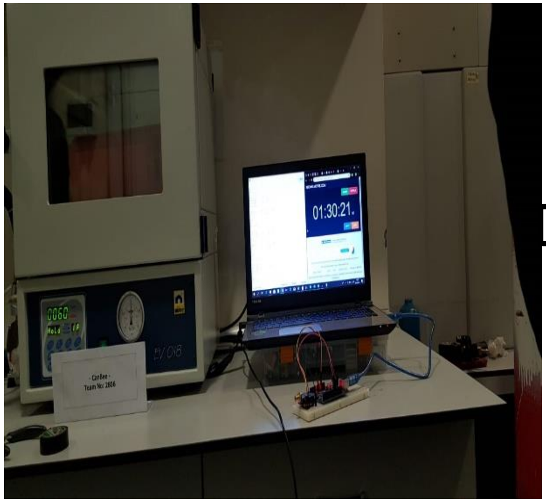
- We kept the payload inside a 60 degrees celcius furnace for 2 hours. There was no problem at all including the battery and all electrical components (its maximum working temperature is more than 60 degrees celcius with a tolerance).
  - CanSat is illustrated in the furnace while the thermal test is operating
    - Team tag is attached to the ventilation as shown.

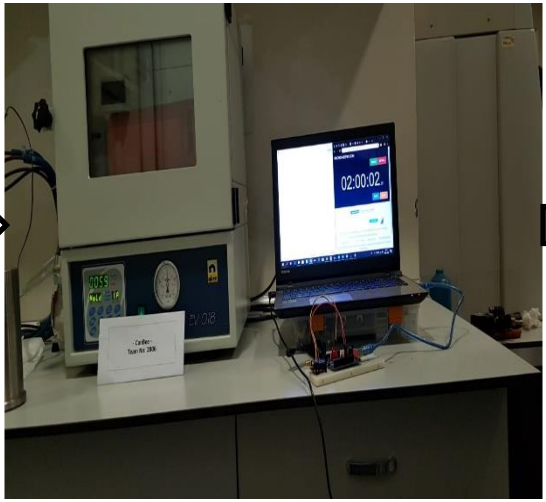
GPS values are deteriorated because test process is operated in inclosed area where GPS sensor can’t execute data transfer properly.

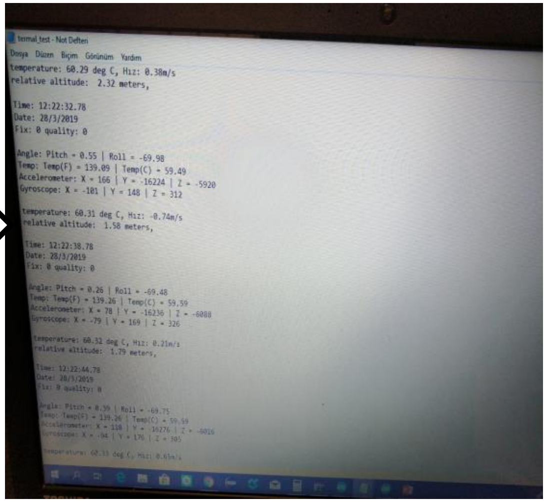
Thermal Test







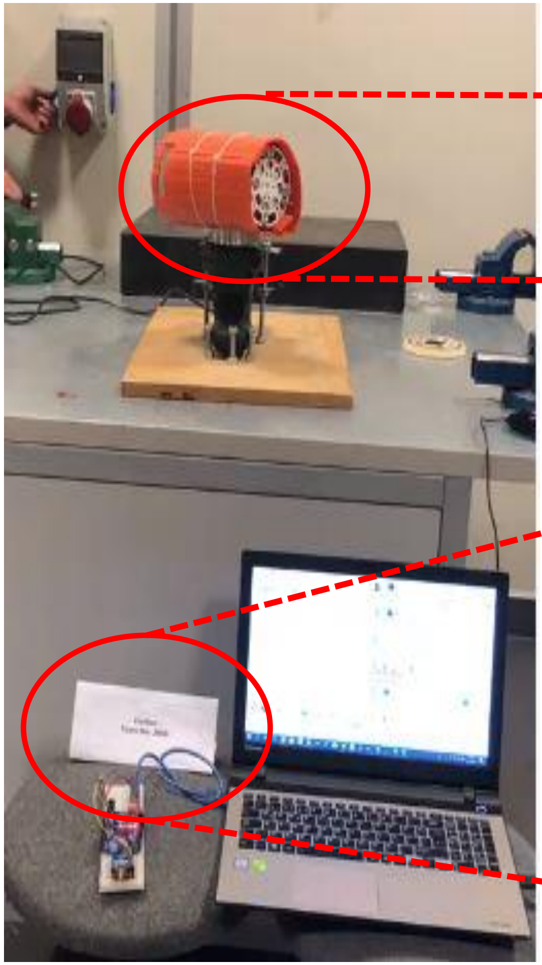




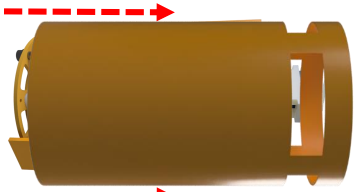
Environmental Test Plan

Vibration Test

- CanSat is placed on the surface of the orbit sander with plastic clamp and to secure silicon.
- All required frequency and speed level is set up that values mentioned in next page.
- Team tag is showed in figure.
- Data is collect properly during vibration test process.



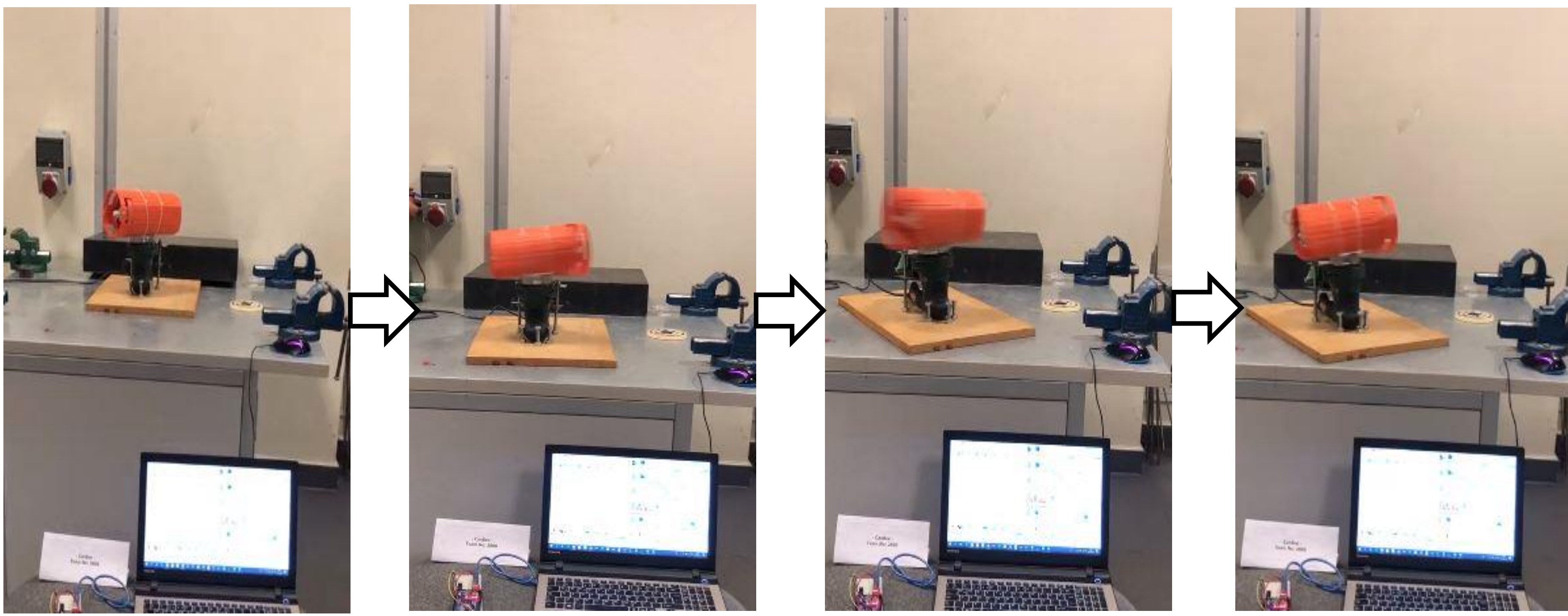
CanSat



Team Tag

Environmental Test Plan

Vibration Test



We have completed the vibration test using an orbit sander set to 200Hz and confirmed the ability of our payload to withstand an impact force more than the value of 20G’s. Orbit sander is fixed to the table to prevent any accident.

Environmental Test Plan

Fit Check

We have slipped a cylinder (124.68mm diameter) over the payload and confirmed the suitability of the payload regarding the diameter.

Fit Check

Cansat is dropped from inside of the pipe with outer diameter of 124.68mm. Operation is succesfully completed.

Test Procedures Descriptions

Test Proc	Test Description	Requirements	Pass Fail Criteria
1	**Sensor Subsystem Test:** Tests are done on PCB for each sensors. Correct data collection were verified after tests.	16,20,21,22,23,25	PASS
2	**Mechanical Test:** Mechanical parts like bearings, bolts, shaft and other parts are tested individually.	1,2,3,4,17,18,19,51	PASS
3	**Communication and Data Handling Subsystem Test:** Communication between sensors and Xbee were verified. XCTU is used for checking Xbee modules.	20,21,22,23,24,25, 26, 30,53	PASS
4	**Electrical Power Subsystem Test:** The battery was connected to the setup for measuring the battery voltage.	13,16,45,46,49,50	PASS
5	**Communication Test:** Communication between sensors and Xbee were checked. GCS sotware were tested for plotting real time graphs. Communication tests were done for different ranges.	31,32,33,36,37,38, 39	PASS

Test Procedures Descriptions

Test Proc	Test Description	Requirements	Pass Fail Criteria
6	**Flight SoftwareTest:** Tests are done on PCB for each sensors. Correct data collection were verified after tests.	9, 11, 30, 38 42, 46, 47, 48	PASS
7	**Mechanism Test:** Servo motors trigger is tested.	7	PASS
8	**Descent Test:** Decent Test will performed in May.	7, 8, 9, 10, 11 12, 14, 34, 52	Not Tested Yet
9	**Deployment Test:** Tests of blade openings when they face with air.	1, 2, 7	PASS
10	**Drop Test:** We dropped the payload from an altitude of 61 cm. We tested the the strength of materials and observed the failures.	12, 14, 15	PASS
11	**Thermal Test:** Cansat waited in furnice for 60 minutes. We observed if we can still get datas from sensors.	19	PASS
12	**Vibration Test:** Payload is tested for more than 20G at 200Hz on a orbit sender. We tried to observe if Cansat can resist at 20G.	14, 15, 16	PASS
13	**Fit Check Test:** Cansat is dropped from inside of a pipe with outer diameter 124.49mm.	2, 3	PASS

Mission Operations & Analysis

Suhan Mergen

Overview of Mission Sequence of Events

1. Arrival Full Team
2. Setting Up GCS and Antenna
3. Calibrate Sensors
4. Offical Control Mass&Dimension
5. CanSat Integrated to Rocket
6. Power On
7. Check Telemetry
8. Launch
9. Collecting Data
10. Flight Software Save Data
11. Descent Finish
12. Buzzer ON Telemetry OFF
13. Recovery
14. Data Analyses
15. Handing Over the SD Card
16. Preparing to PFR

Overview of Mission Sequence of Events

Misson Control Officer

- Eyup Kocak(EK)

Ground Station Crew

- Ugur Bayezit(UB), Haluk Levent Cicek(HLC)

Recovery Crew

- Aydin Sisman(AS), D. Baran Karadag(DBK)

CanSat Crew

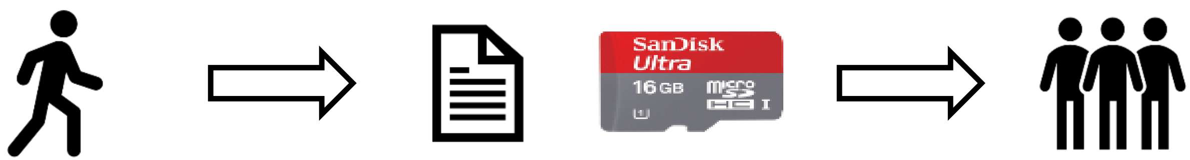
- Bedirhan Ceylan(BC), Alpcan Altuntas(AA), Dogukan Kuyumcu(DK), Suhan Mergen(SM)

Overview of Mission Sequence of Events

Ground Control System setup consist of 4 main item:

- Computer with 2 hours battery
- Arduino microprocessor
- Xbee telemetry sensor
- Antenna

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



Assembly and Test of the science probe is proceed with container and science probe.

Field Safety Rules Compliance

- Mission operation manual will be compiled and printed into a three ring binder against any weather condition. Mission operation manual will be used for accurate integration and detail of procedures.

MISSION OPERATION MANUAL				
CONFIGURATION OF GROUND CONTROL	**PREPERATION OF CANSAT**	**INTEGRATION OF CANSAT**	**PREPERATION PROCEDURE**	**REMOVAL PROCEDURE**
Test the connection between payload and receiver antenna.	Check if electronic components are work properly. Check all mechanical components.	Placement of CanSat into the rocket.	Inspection of data on gorund control station	Deliveration of telemetry data from ground control to judges for inspection.

- **Development Status:** Mission operation manual procedures will be update in progress of time. Checklists of mission operation manual are complied according to test processes.

CanSat Location and Recovery

- **Selected Color:** Fluorescent Orange

- The recovery crew will be minimum 2 people in order to get back probe and heat shield.
- Parachute fabric and probe body will be painted easily detectable color such as orange.
- Container cover will be selected easily detectable color such as orange.
- Science probe will have buzzer that sounds loud.
- A sticker that indicates team leader name, team number, contact details and e-mail address will be placed <u>on the probe and the container.</u>

Return Address Labeling

Mission Rehearsal Activities

		Rehearsal Time	Description
•Ground system radio link check procedures	• Xbee and antenna connection is tested. • Accuracy of telemetry in a certain range is ensured with this procedure.	04.01.2019	Requirement
•Powering on/off the CanSat	• Power is activated with a switch.	04.01.2019	Requirement
Launch configuration preparations	• All electrical components are placed into their own locations. • All mechanical parts are integrated and checked	04.01.2019	Requirement

Mission Rehearsal Activities

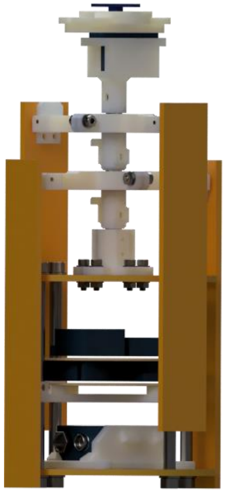
Activity	Details	Rehearsal Time	Description
•Loading the CanSat in the Launch Vehicle	• CanSat science probe and container will be placed into the rocket before launch operation.	04.29.2019	Developed
•Telemetry Processing, Archiving, and Analysis	• Telemetry data analysis will be operated in the ground station without any loses. Received data will be saved on SD card to deliver judges.	04.29.2019	Developed
Recovery	• CanSat science probe will be recovered with the help of buzzer and recovery crew. • GPS also can be helpful for recovery.	04.29.2019	Developed

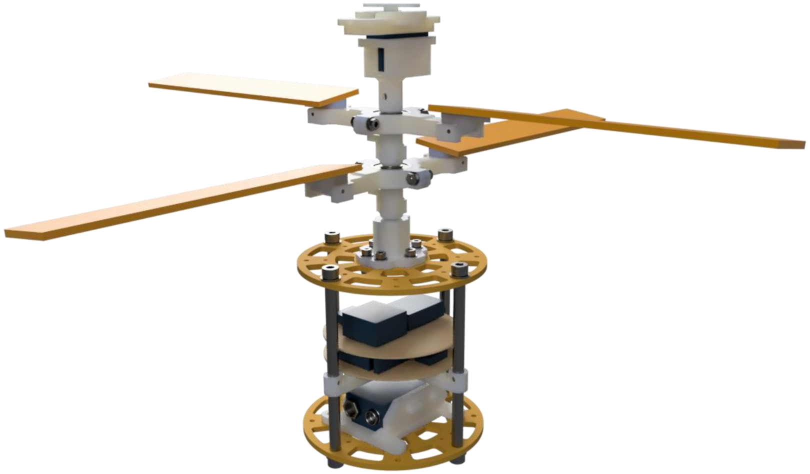
Requirements Compliance

Suhan Mergen

Requirements Compliance Overview

- The CanSat currently meets the general requirements that are laid out in the following slides.
- Overall, the CanSat shows great results, but will continue to be developed and perfected through future tests.





Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Comply	81	
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	142, 143	
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Comply	30	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	151	
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	142, 143	
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply	67	
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Partial	75	Tests are on proceed

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Partial	55	Tests are on proceed
9	The container shall release the payload at 450 meters +/- 10 meters.	Partial	45	Tests are on proceed
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Comply	69, 70	
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Partial	58	Tests are on proceed
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	140, 141	
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	63	
14	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	140, 141	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
15	All structures shall be built to survive 30 Gs of shock.	Partial	140, 141	Tests are on proceed
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	71	
17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial	140, 141	Tests are on proceed
18	Mechanisms shall not use pyrotechnics or chemicals.	Comply	-	
19	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	138, 139	
20	The science payload shall measure altitude using an air pressure sensor.	Comply	36	
21	The science payload shall provide position using GPS.	Comply	38	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
22	The science payload shall measure its battery voltage.	Comply	39	
23	The science payload shall measure outside temperature.	Comply	37	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	41	
25	The science payload shall measure pitch and roll.	Comply	40	
26	The probe shall transmit all sensor data in the telemetry	Comply	122	
27	The Parachute shall be fluorescent Pink or Orange	Comply	151	
28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	Partial	109	Not for all sensors.

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Partial	-	Sensor datas are collected but not created in a file.
30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	92	
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	91	
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	91, 136	
33	XBEE radios shall not use broadcast mode.	Comply	91, 92	
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	169	
35	Each team shall develop their own ground station.	Comply	148	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
36	All telemetry shall be displayed in real time during descent.	Comply	89	
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	122	
38	Teams shall plot each telemetry data field in real time during flight.	Comply	123	
39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Comply	121	
40	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	121	
41	Both the container and probe shall be labeled with team contact information including email address.	Comply	151	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
42	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	114	
44	No lasers allowed.	Comply	-	
45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Comply	70	
46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Comply	70, 95	
47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Comply	99	
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	99	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
49	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.	Comply	100	
50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Comply	63, 69, 70	
51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	136, 140	
52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Comply	69	
53	The GPS receiver must use the NMEA 0183 GGA message format.	Comply	38	
54	The CANSAT must operate during the environmental tests laid out in Section 3.5.	Comply	136, 143	

Requirements Compliance

# of CR	Requirement	Compliance	Reference Slide #	Comments
55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	103	
Bonus 1	The camera shall point in one direction relative to the earth's magnetic field with a stability of +/- 10 degrees in all directions during descent. Direction does not matter as long as it is in one direction.	Partial	70	Tests are on proceed.
Bonus 2	Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The direction of the camera is pointed relative to earth's magnetic north shall be included in the telemetry.	Partial	42	Direction of camera will be assembled.

Management

Suhan Mergen

Status of Procurements

No	Part	Model	Order Status	Arrived Date
1	Microcontroller	Teensy 3.5	Ordered	12.20.2018
2	Telemetry	Xbee Pro S1	Ordered	01.02.2019
3	Hall Effect	Sparkfun AH1815	Ordered	01.02.2019
4	GPS	AdafruitUltimate GPSBreakout	Ordered	12.20.2018
5	Air presurre	AdafruitBMP180	Ordered	12.20.2018
6	Air temperature	AdafruitBMP180	Ordered	12.20.2018
7	Pitch and Roll	AdafruitMPU6050	Ordered	12.20.2018
8	Camera	Adafruit MiniSpy Camera	Ordered	01.02.2019
9	Memory	SanDisk Ultra	Ordered	01.02.2019
10	Buzzer	YT12095	Ordered	12.24.2018
11	Amplifier (Telemetry)	Own Design	Ordered	01.02.2019
12	Probe Antenna	Sparkfun 2.4GHz Adhesive	Ordered	12.24.2018
13	GCS Antenna	TP LINK TL-ANT2415D	Ordered	12.24.2018
14	Payload Release	Servo Motor	Ordered	01.02.2019
15	Battery	GP GPCR-V9	Ordered	12.15.2018
16	Voltage Regulator	LD1117,LM7805	Ordered	01.02.2019
17	Switch	Sible Dip Switch	Ordered	01.02.2019
18	Umbilical PowerSource	USB Socketand Cable	Ordered	01.02.2019
19	Real - Time Clock	ArduinoDS1307	Ordered	01.02.2019

CanSat Budget – Hardware

ELECTRONICS

No	Part	Model	Quantity	Cost($)	Procurement
1	Microcontroller	Teensy 3.5	1	24,95	Actual
2	Telemetry	Xbee Pro S1	2	49,00	Actual
3	Hall Effect	Sparkfun AH1815	1	0,95	Actual
4	GPS	AdafruitUltimate GPSBreakout	1	40,95	Actual
5	Air presurre	AdafruitBMP180	1	9,95	Actual
6	Air temperature	AdafruitBMP180	1	9,95	Actual
7	Pitch and Roll	AdafruitMPU6050	1	8,31	Actual
8	Camera	Adafruit MiniSpy Camera	1	12,50	Actual
9	Memory	SanDisk Ultra	1	6,4	Budgeted
10	Buzzer	YT12095	1	0,43	Budgeted
11	Amplifier (Telemetry)	Own Design	2	30,0	Estimated
12	Probe Antenna	Sparkfun 2.4GHz Adhesive	1	4,95	Budgeted
13	GCS Antenna	TP LINK TL-ANT2415D	1	68,69	Budgeted
14	Payload Release	Servo Motor	1	1,82	Actual
15	Battery	GP GPCR-V9	1	3,5	Actual
16	Voltage Regulator	LD1117,LM7805	1	1,25	Budgeted
17	Switch	Sible Dip Switch	1	0,25	Actual
18	Umbilical PowerSource	USB Socketand Cable	1	2,5	Actual
19	Real - Time Clock	ArduinoDS1307	1	5,57	Budgeted

CanSat Budget – Hardware

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No	Part	Model	Quantity	Cost($)	Procurement
1	Construction	Aluminium Rod 6mm x 125mm	3	3.3	Actual
2	Construction	Aluminium Rod 6mm x 100mm	1	0,7	Actual
3	Construction	Duralite Disc 100mm x 3mm	3	2,7	Actual
4	Construction	3D Printed parts	13	16,25	Actual
5	Ball Bearing	688 ZZ	2	1,9	Actual
6	Fasteners	Bolt M5	8	2,1	Actual
7	Fasteners	Bolt M3	26	2,6	Actual
8	Fasteners	Nut M3	26	2,6	Actual
9	Fasteners	Washer	14	0.7	Actual
10	Releasing	Servo Motor	1	1,82	Actual
11	Container	Polycarbonate Sheet 400mm x 295mm	3	7	Actual
12	Paddle	Polycarbonate Sheet 200mm x 30mm	4	6	Actual
13	Container	Magnets	4	4,8	Actual

CanSat Budget – Hardware

Total Electronics Cost	281,92$
Total Mechanics Cost	52,47$
Total Cost of All Components	334,39$

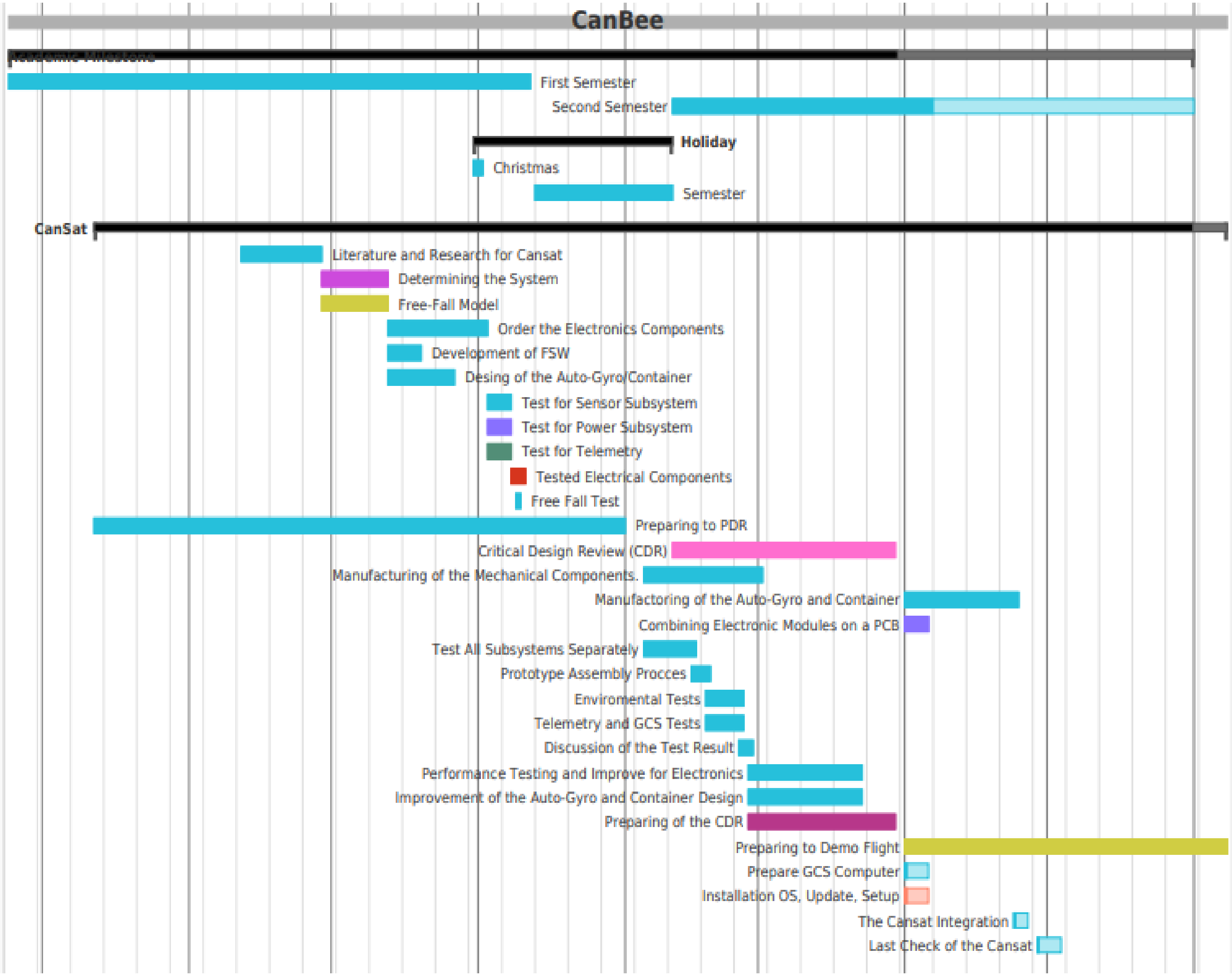
CanSat Budget – Other Costs

OtherCosts	Quantity	Cost($)	TotalCost($)	Determination
Travel	11	788	8668	Estimated
Hotel	11(5 days)	104,5	1150	Estimated
Rental Cars	1(5 days)	208	1860	Estimated
Computer	1	0	0	Owned
Umbrella and coolerfor GCS	1	52	52	Estimated
Food	11(5 days)	140	1540	Estimated
Prototyping	2	334,39	668,78	Estimated
Test Facilities and Equipment	4	0	0	Owned*
Grand Total			13938,78	

! Tests were operated under favour of Cankaya University. Test were done in laboratories in the university. So there is no cost for test facilities and equipments.

Program Schedule Overview

CanBee	start	end	91%
Academic Milestone	**09/24/18**	**05/31/19**	**75%**
First Semester	09/24	01/11	100%
Second Semester	02/11	05/31	50%
Holiday	**12/31/18**	**02/10/19**	**100%**
Christmas	12/31	01/01	100%
Semester	01/13	02/10	100%
CanSat	**10/12/18**	**06/07/19**	**97%**
Literature and Research f...	11/12	11/28	100%
Determining the System	11/29	12/12	100%
Free-Fall Model	11/29	12/12	100%
Order the Electronics Co...	12/13	01/02	100%
Development of FSW	12/13	12/19	100%
Desing of the Auto-Gyro/...	12/13	12/26	100%
Test for Sensor Subsystem	01/03	01/07	100%
Test for Power Subsystem	01/03	01/07	100%
Test for Telemetry	01/03	01/07	100%
Tested Electrical Compon...	01/08	01/10	100%
Free Fall Test	01/09	01/09	100%
Preparing to PDR	10/12	01/31	100%
Critical Design Review (C...	02/11	03/29	100%
Manufacturing of the Mec...	02/05	03/01	100%
Manufactoring of the Auto...	04/01	04/24	100%
Combining Electronic Mo...	04/01	04/05	100%
Test All Subsystems Sepa...	02/05	02/15	100%
Prototype Assembly Proc...	02/15	02/18	100%
Enviromental Tests	02/18	02/25	100%
Telemetry and GCS Tests	02/18	02/25	100%
Discussion of the Test Re...	02/25	02/27	100%
Performance Testing and ...	02/27	03/22	100%
Improvement of the Auto...	02/27	03/22	100%
Preparing of the CDR	02/27	03/29	100%
Preparing to Demo Flight	04/01	06/07	100%
Prepare GCS Computer	04/01	04/05	10%
Installation OS, Update, S...	04/01	04/05	10%
The Cansat Integration	04/24	04/26	15%
Last Check of the Cansat	04/29	05/03	5%

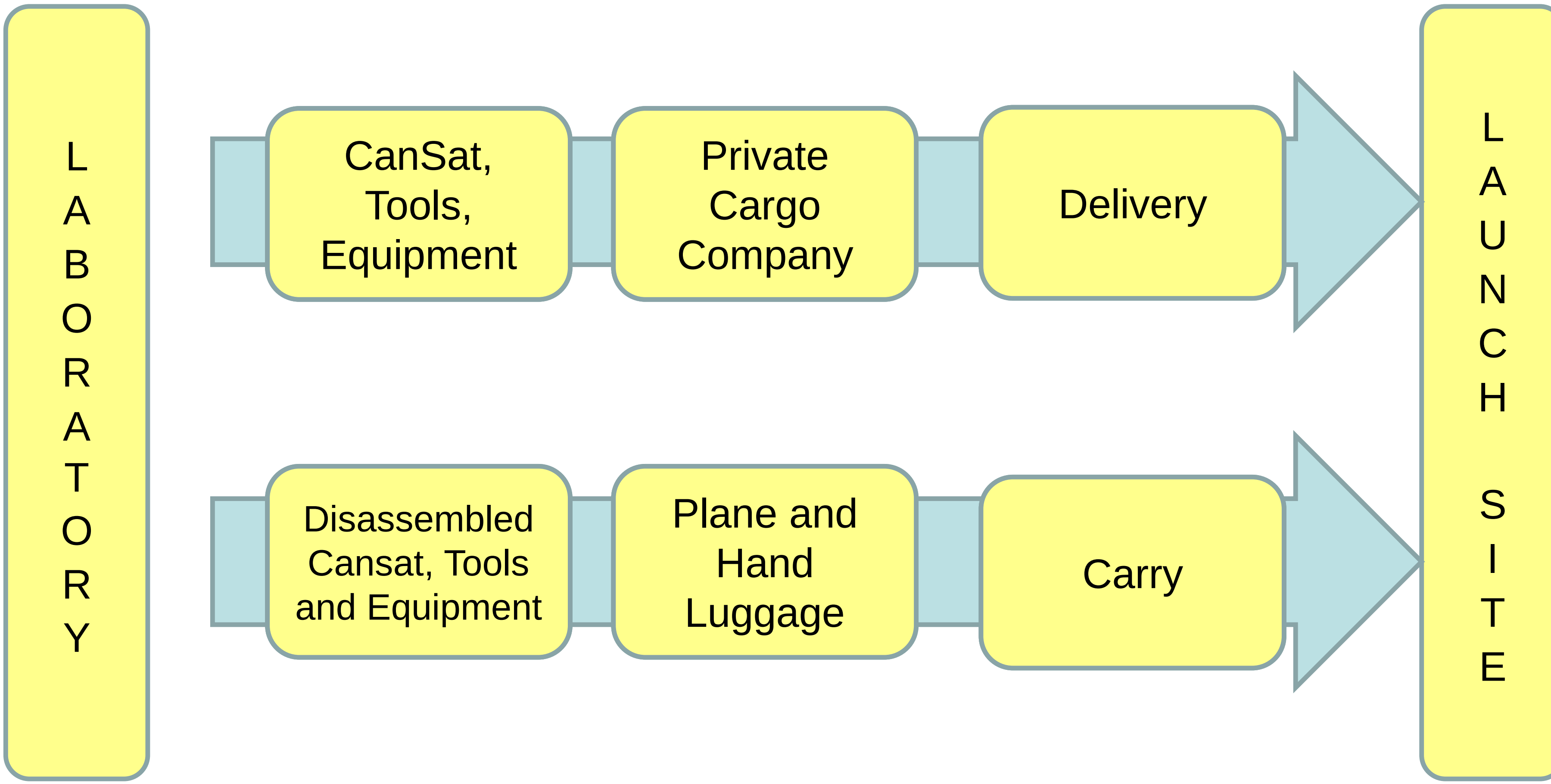


Detailed Program Schedule

		Begin Date	End Date	Duration (Day)
Academic Schedule		09.24.18	05.31.19	240
Holiday	Christmas	1.01.2019	1.01.2019	1 ✓
	Semester	1.14.19	01.14.19	20
Exam	First semester midterm	11.05.2018	11.30.2018	25 ✓
	First semester final	1.02.2019	1.13.2019	11 ✓
	Second semester midterm	4.01.2019	4.26.2019	22
	Second semester final	5.20.2019	5.31.2019	11
Flight Software Design		12.13.18	02.25.19	5
Development of FSW		12.13.18	12.18.18	4 ✓
Checking the Interface		12.18.18	12.19.18	1 ✓
Telemetry and GCS Tests		02.18.19	02.25.19	6 ✓
Electronic Subsystem		12.13.18	4.05.2019	113
Selecting Electronic Components		12.13.18	1.02.2019	15 ✓
Testing of Electronic Components		1.03.2019	1.09.2019	7 ✓
Performance Testing and Improving for Electronics		02.27.19	03.22.19	18 ✓
Combining Electronic Modules on a PCB		4.01.2019	4.05.2019	5
Mechanical Subsystem		11.29.18	04.24.19	147
Determining the System		11.29.18	12.12.2018	10 ✓
Design of the Auto-Gyro/Container		12.13.18	12.26.18	10 ✓
Manufactoring of the Mechanical Components		2.05.2019	3.01.2019	19 ✓
Improvement of the Auto-Gyro and Container Design		02.27.19	03.22.19	18 ✓
Manufacturing of the Auto-Gyro and Container		4.01.2019	04.24.19	18

Shipping and Transportation

Transportation: Team members will fly to Houston.
Shipment: We have different processes simultaneously for shipment.



MAJOR ACCOMPLISHMENTS

ELECTRONICS

- PCB was designed and tested.
- Telemetry was tested.
- Flight software was developed and was tested with fake transition values.
- GCS software was developed and tested.
- Now, improvements are being made.
- Descent tests with quadcopter will be made.

MECHANICS

- First prototype was integrated for tests.
- Environmental tests were done except vibration test.
- Now, improvements are being made.
- Drone tests and vibration test will be done.

All requirements were supplied with our system. According to tests and calculations, we are ready to next stage. Summarize, **CanBee** team is ready to next stage of development.