CanSat 2019
Preliminary Design Review (PDR)

2806
CanBee

Presentation Outline

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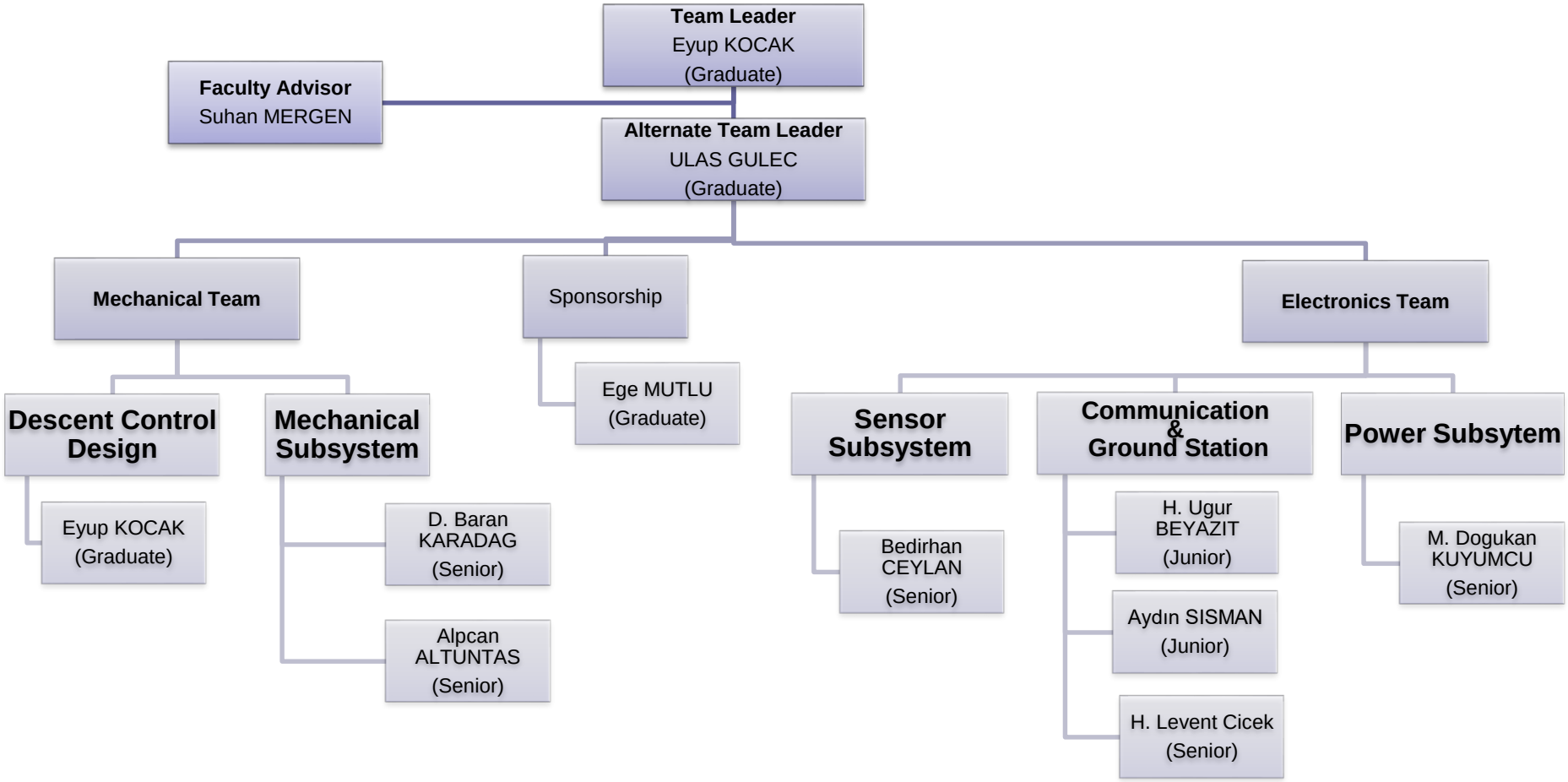
Team Organization



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

Systems 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

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

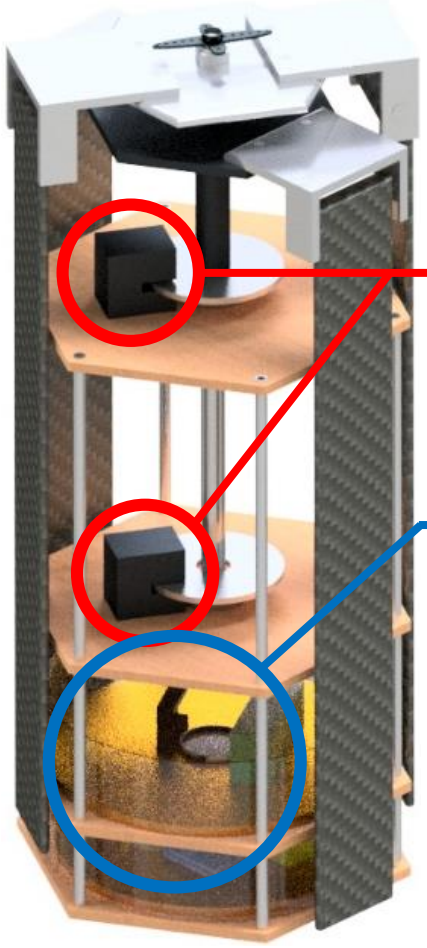
RE#	Description	Rationale	A	I	T	D
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	CR	✓	✓		
49	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 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	✓	✓		

System Level CanSat Configuration Trade & Selection

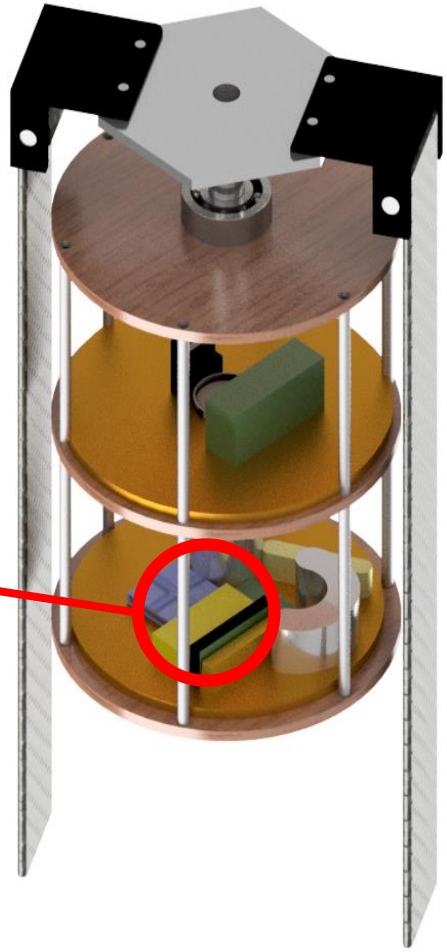
Coaxial Double-Propeller Design



Encoders

Electronics

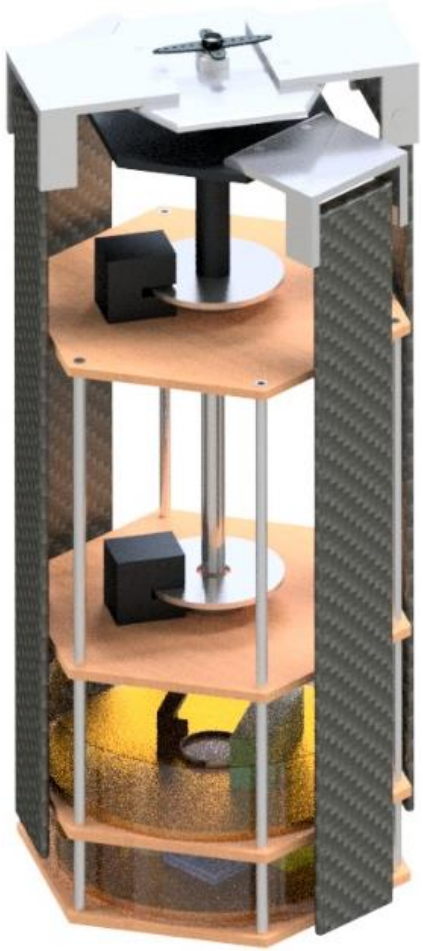
Single Propeller Design



Angular rotation will be measured with a compass sensor.

System Level CanSat Configuration Trade & Selection

Coaxial Double-Propeller Design



CONOPS 1

Propellers open up with air filled inside the payload.

During the decent, each propeller turn in the opposite direction.

Payload stays stationary.

CONOPS 2

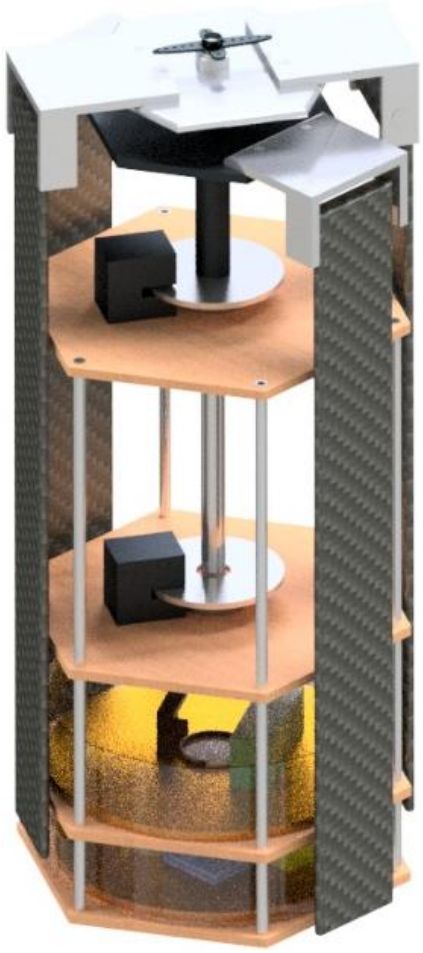
Propellers open up with air filled inside the payload.

The propeller and the payload turn together in the same direction.

Single Propeller Design

System Level CanSat Configuration Trade & Selection

Coaxial Double-Propeller Design



Pros

PayLoad stays stationary.

Allows measuring the angular velocity of the propellers

Cons

Complex mechanical design

Increased total weight

Extra layer of mechanical joints.

Single Propeller Design

Pros

Simple mechanical design.

Reduced total weight.

Cons

Extra sensor to measure the propeller velocity

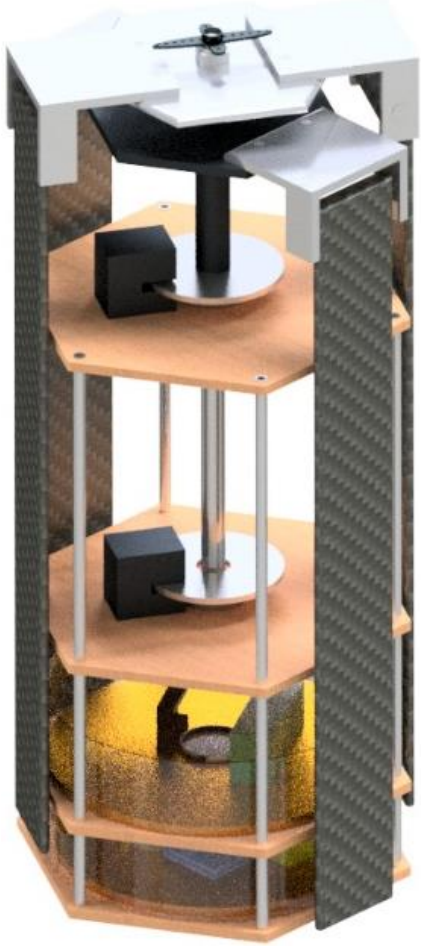
Payload turns with the propellers.

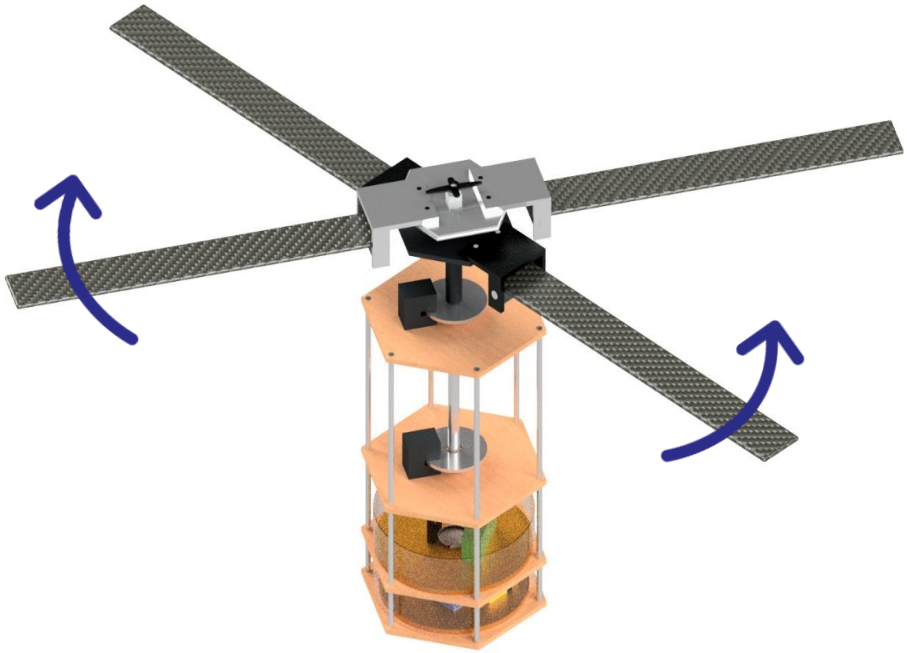
Almost impossible to record a proper video with the camera attached.

Components should be placed to keep COG on the rotation axis.

System Level Configuration Selection

Coaxial Double-Propeller Design





Rationale

Pevents the angular rotation of the payload

Lowered gravitational center

No need to consider position of the COG with respect to rotation axis.

Single Propeller Design

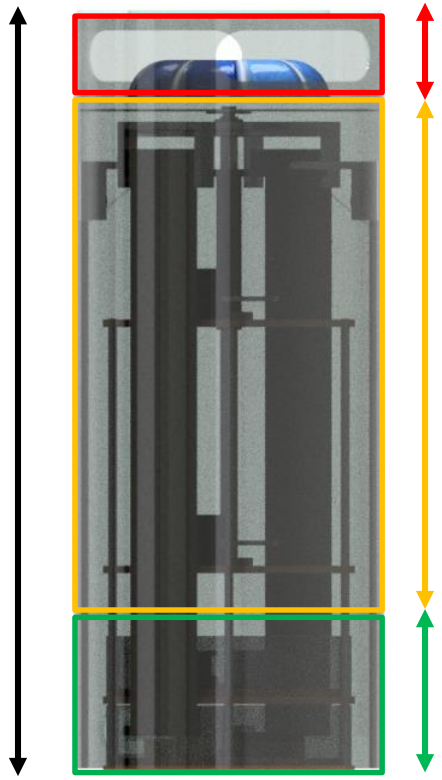
Physical Layout

Parachute Section
- Parachute
- Hinge

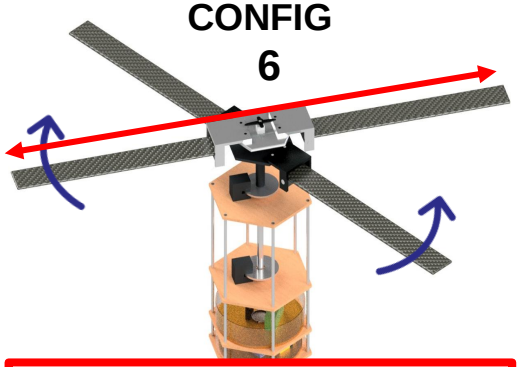
Mechanism Section
- Propeller Conn.
- Bearings
- Encoder-Prop. Shaft. Conn.

Electronics Section
- Sensors
- Micro Contr.
- RF Comm. Mod.
- Power

CONTAINER & PAYLOAD (LAUNCH CONFIG)



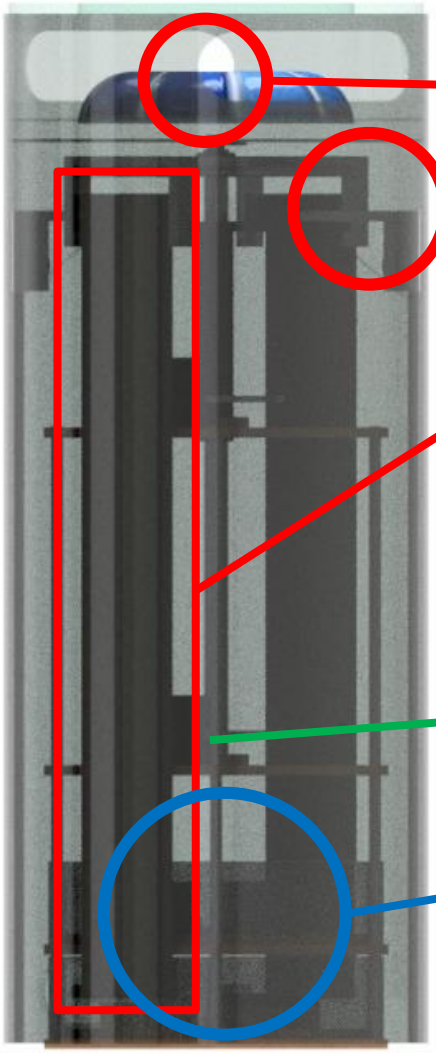
DEPLOYED CONFIG



Smaller than the envelope.

No	Size (mm)
1	298
2	120
3	33
4	210
5	50
6	520

Physical Layout



Parachute

Hinge

Propeller

Camera (Lens will be placed at the bottom.)

Battery

Sensor

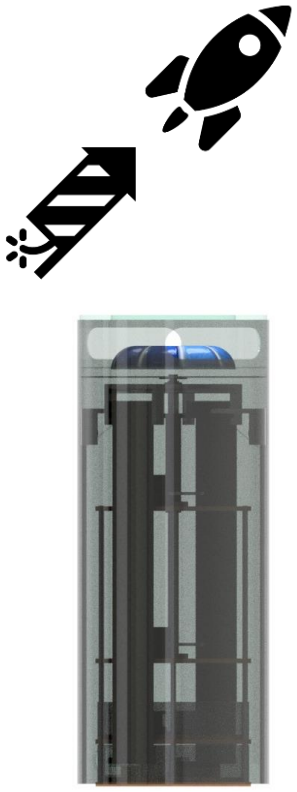
Propeller Release Servo

Electronics

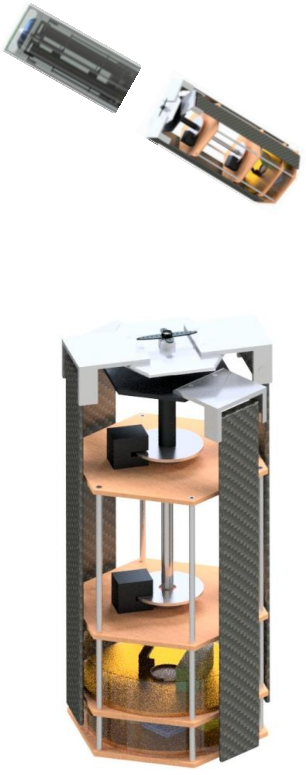
Radio

Physical Layout

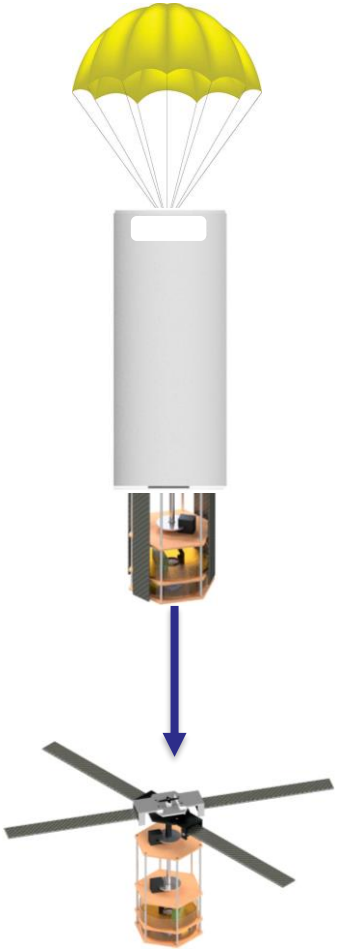
LAUNCH



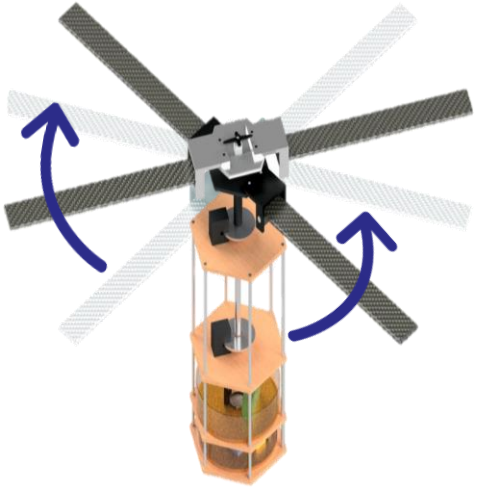
DEPLOYED



PARACHTUE PAYLOAD



PASSIVE DESCENT



System Concept of Operations

PRE LAUNCH

Prelaunch Briefing

Mechanic and Electronic Controls

Locate the CanSat into the Rocket

Calibration of Barometric Altitude and Roll-Pitch Angles

CanSat begins collecting data and Telemetry at 1 Hz

LAUNCH

Rocket launch

Continue collecting data and telemetry

The deployment of the CanSat from the rocket

The deployment of the parachute

Releasing the Payload from the Container

Landing

Stop the transmission, sound the buzzer.

POST LAUNCH

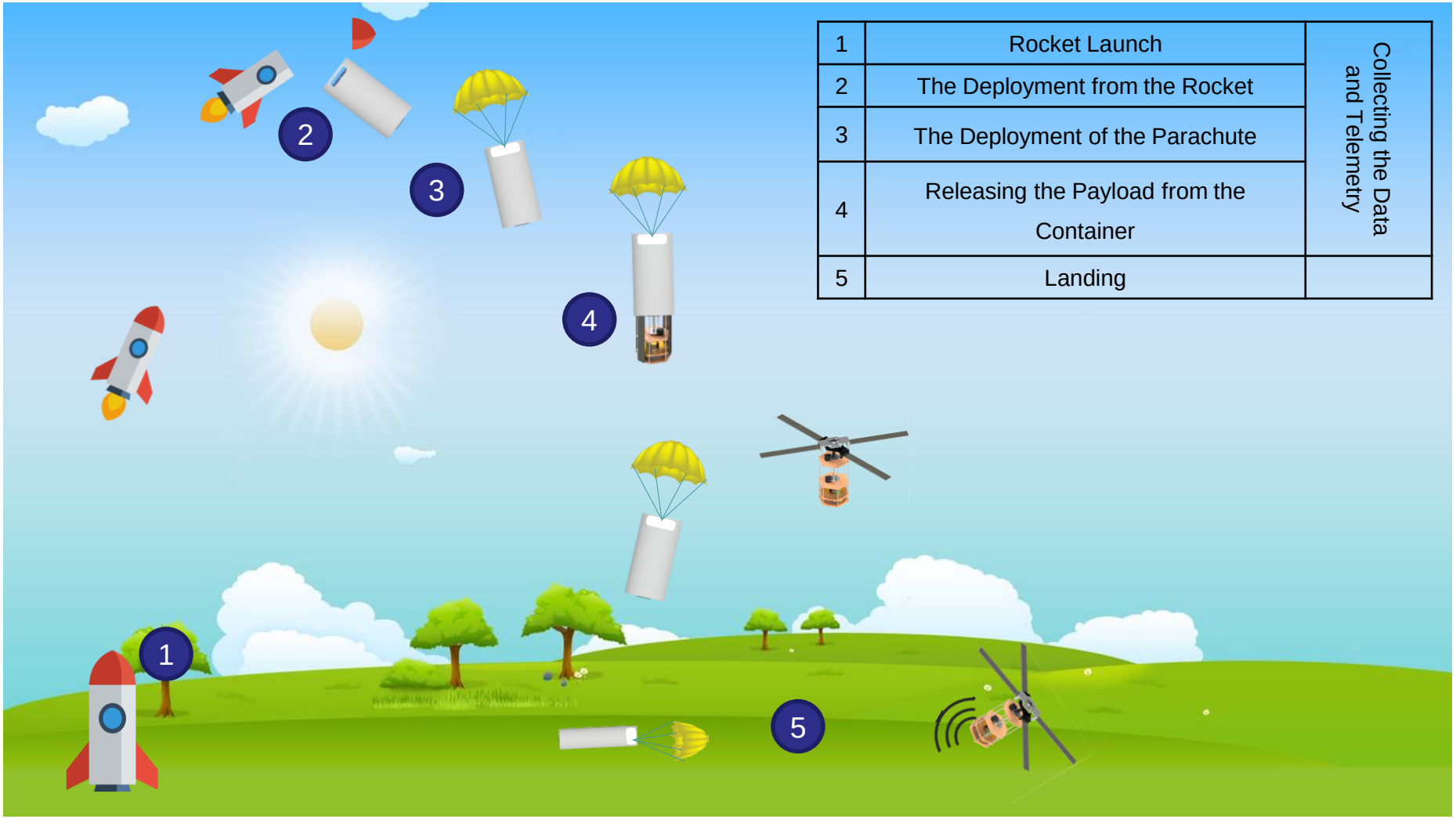
Locate and retrieve

Retrieve GCS data and SD Card data

Analysis of the data and reduce wrong values.

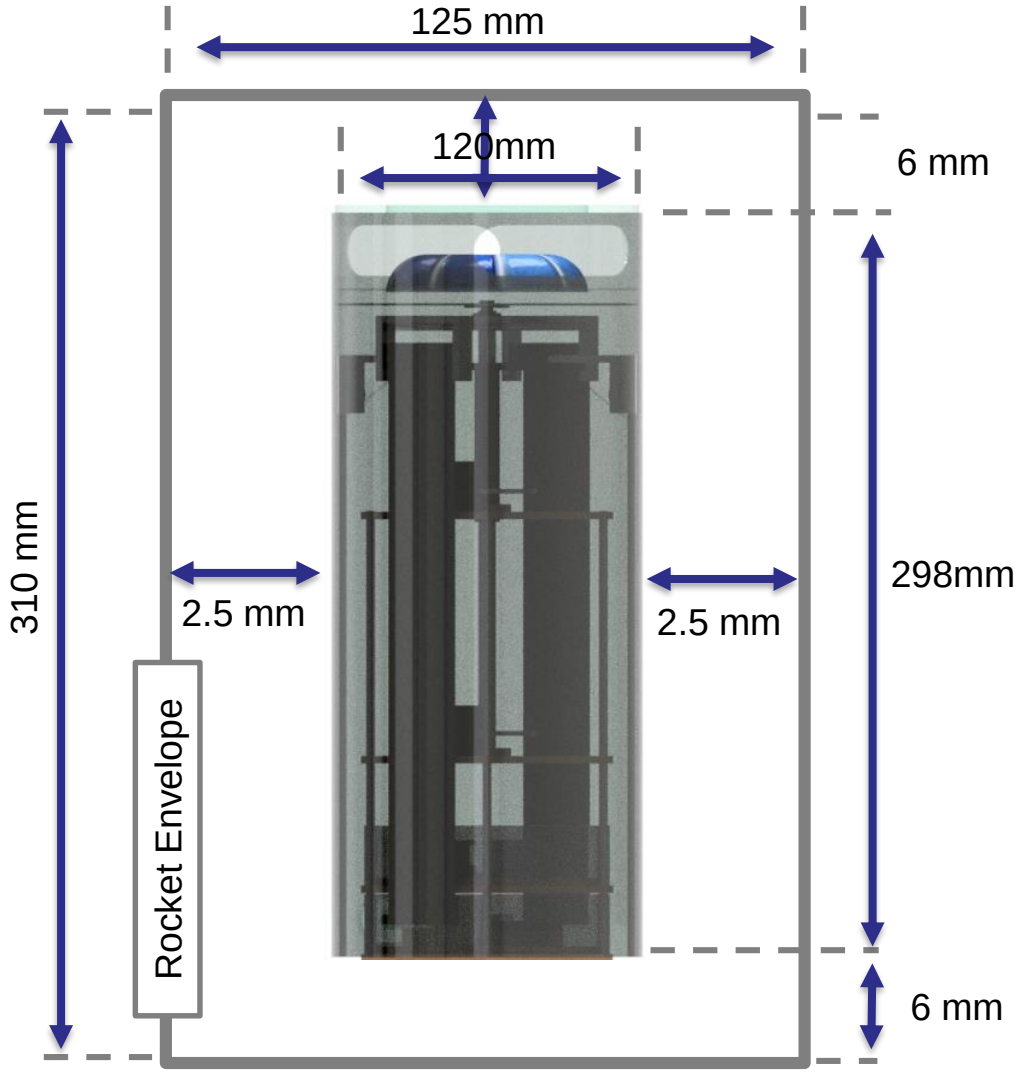
Prepare and present PFR

System Concept of Operations



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 prostrusions.

*Not in scale.

Sensor Subsystem Design

Bedirhan Ceylan

Sensor Subsystem Overview

Selected Sensor	Function of Sensors
Adafruit BMP 180	Measures pressure and temperature for altitude measurement
Adafruit Ultimate GPS Breakout	Detects the position
MPU 6050	Will be used as pitch and roll sensor
Camera(Adafruit Mini Spy Camera)	As a bonus mission, Camera will record video
Voltage Regulator	Regulates voltage at required levels.
Encoder (Original Design)	To detect blade spin
Adafruit BMP 180	Sensor measures pressure of container

Sensor Subsystem Requirements

	Sensor Subsystem Requirments		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
SSD-1	1	Total mass of the CanSat (science payload and container) shall be 500 grams ±10 g.	✓	✓		
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 ±10 meters.	✓			✓
SSD-4	13	All electronic components shall be enclosed 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 and 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 b e manufactured with a metal package similar to 18650 cells.		✓		

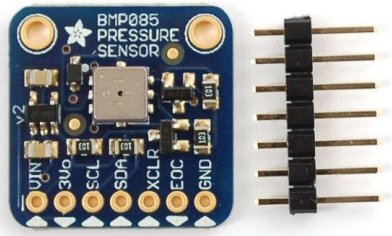
Payload Air Pressure Sensor Trade & Selection

Name	Weight(g)/ Dimensions (mm)	Power (µW)	Working Conditions	Resolution	Interface	Other Parameters	Cost($)
Adafruit BMP 280	1.3g/17.7 x 19.0 x 2	2.7µA -	From 30kPa to 110kPa	1.6Pa	I2C,SPI	Temperature Measurement included	9.95
Adafruit MPL 3115 A2	1.2g/18 x 19 x 2	50 µA x5.5V 8.5-265 µA x3.6V	From 50 kPa to 110 kPa(up to 10 km)	1.5Pa	I2C	Temperature Measurement included	9.95
Adafruit BMP 180	4g/-	1mA x3.6V 3-32 µA x3.6V	From 30kPa to 110kPa	3 Pa	I2C	Temperature Measurement included	9.95
Adafruit 10 DOF IMU	2.8g/38x23 x3	1mA x3.6V 3-32µA x3.6V	From 30kPa to 110kPa	3 Pa	I2C	Temperature, Pressure, Tilt Measurement included	29.95

SELECTED

•Adafruit BMP 180

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



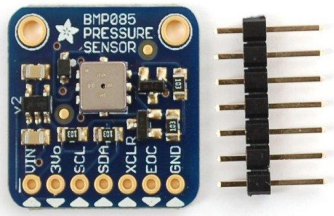
Payload Air Temperature Sensor Trade & Selection

Name	Weight(g)/ Dimensions (mm)	Power/ Operating Current	Working Conditions	Resolution/ Accuracy	Interface	Cost($)
Adafruit MCP 9808	1.3/17.7 x 19.0 x 2	-/200 µA	From -40 to 125 degC	0.0625 degC/ ±0.25 degC	I2C	9.95
Texas Instruments LM35DZ	1/5.21 x 5.34 x4.19	-/60 µA	From -55 to 150 degC	-/±0.5 degC	Analog	2,03
Adafruit MPL 3115 A2	1.2/18 x 19 x 2	50 µA x5.5V 8.5-265 µA x3.6V	From -40 to 85 degC	- /±1 degC(Max ±3)	I2C	9.95
Adafruit BMP 180	4/-	1mA x3.6V 3-32 µA x3.6V	From -40 to 85 degC	-/±2 degC	I2C	9.95
Adafruit 10 DOF IMU	2.8/38x23 x3	1mA x3.6V 3-32µA x3.6V	From -40 to 85 degC	-/±2 degC	I2C	29.95

SELECTED

•Adafruit BMP 180

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



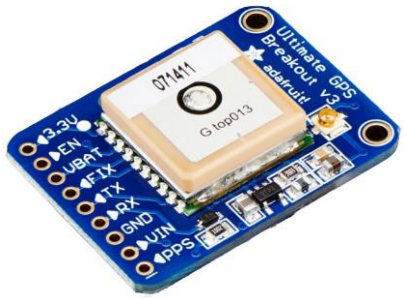
GPS Sensor Trade & Selection

Name	Weight(g)/ Dimensions (mm)	Power (mW)	Working Conditions (Velocity)	Sensivity (Acquisiton/ Tracking) (dBm)	Accuracy	Interface	Warm/Cold Start(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	<3 meters	Serial	Warm/Cold Start:34 seconds	40.95
MT3329	9.45/38 x 38 x7.8	53mA x (3.2/5.0)	-	-165 dBm / -	<3 meters	USB/Uart	Warm Start:1 Cold Start:35	22.77
U-blox Neo-M8	-/12.2 x16 x2.4	21mA x 3V	-	-167 dBm / -	2 meters	UART, USB, SPI, DDC	Cold Start:26	19.99

SELECTED

•Adafruit Ultimate GPS Breakout

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



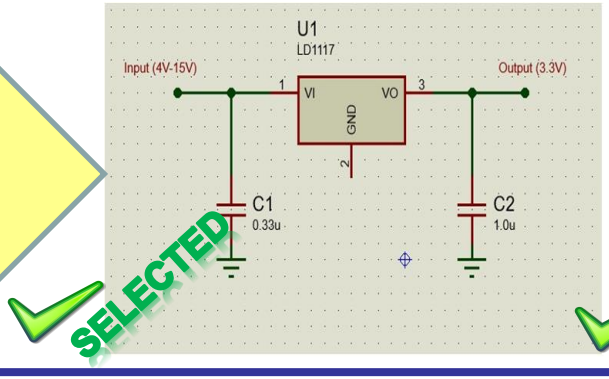
Payload Power Voltage Sensor Trade & Selection

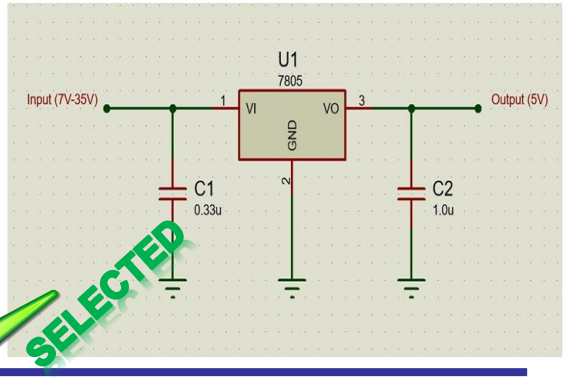
Name	Dimensions(mm)/Weight(g)	Operating Temperature	Power(W)	Presicion	Interface	Cost$)
Adafruit INA219 High Side DC Current Sensor Breakout	22.86x20.32/1.9	-	(3-5)Vx	1%	I2C	9.95
Adafruit Linear Voltage Regulator-LD1117	29x 10x 4/-	-40°C -150°C	800mA x (1.2-5)V	1%	Analog	1.25
Adafruit Linear Voltage Regulator-LM7805	29x 10x 4/-	-40°C -150°C	1.5A x (5-24)V	%2	Analog	0.75

- We will measure voltage level of battery with Teensy, we will not use a special voltage sensor like Adafruit INA219. We will also use voltage regulators LD1117 and LM7805 to lower the voltage.

Voltage Regulators LD1117, LM7805

•Original Design
•Cheap





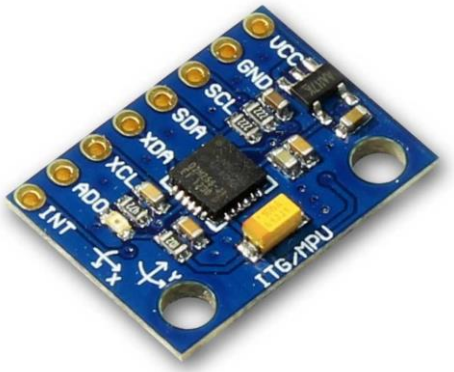
Pitch and Roll Sensor Trade & Selection

Name	Dimensions(mm)/Weight(g)	Operating Temperature	Power(mW)	Full scale of gyroscope/ accelerometer	Interface	Cost$)
Adafruit MPU 6050	20.3 x 15.6/2.1	-40°C -85°C (TA)	(2.38V-3.46V) x 0.11mA	±250, ±500, ±1000, ±2000°/sec(dps) ±2g, ±4g, ±8g, ±16g	I2C	8.31
Bosch BNO055	5.20 x 3.80 x 1.13/-	-40°C -85°C (TA	(2.5V-3.0V) x 12.3mA	±125,±250, ±500, ±1000, ±2000°/sec(dps) ±2g, ±4g, ±8g, ±16g	I2C,UART	12.07

SELECTED

Adafruit MPU6050

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



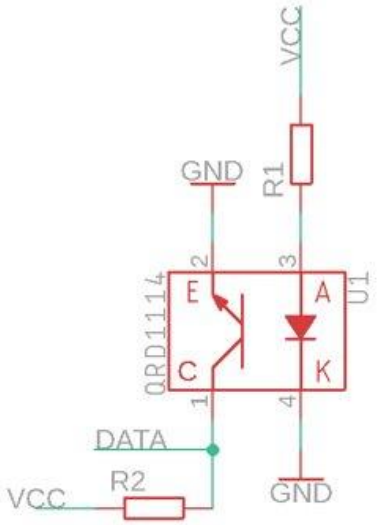
Auto-gyro Blade Spin Rate Sensor Trade & Selection

Name	Dimensions(mm)/Weight(g)	Operating Temperature	Power(mW)	Response Time(µs)/Resolution	Interface	Cost$)
ON Semiconductor QRD 1114	4.39x 6.10x.4.65/-	-40°C -85°C	100mW	10, 50/-	Analog	1.65
Pololu 19:1 Metal Gearmotor 37Dx52L mm with 64 CPR Encoder	38x 38x80.1x /92	-	12V x 300mA	-/64,1200(with gear) counts per revolution	Analog	12.07

SELECTED

ON Semiconductor QRD 114

- So small and light
- Less power consumption
- Cheaper and our own product



Bonus Camera Trade & Selection

Camera	Dimensions(mm)/weight(g)	Operating Voltage(V)	Operating Current(mA)	Response Time	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
Eachine 2503	Camera:8 x 8 SD Card:12 x12	3.8-5	Standby:165 Operating:200	1920 x 1080 for 30fps/ 1280 x 720 for 60 fps	30.98
Turboving Cyclops V3	18 x18/7.2	4.2	-	720 x 480/-	16.28

SELECTED

•Adafruit Mini Spy Camera

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

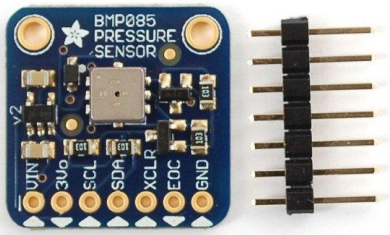
Container Air Pressure Sensor Trade & Selection

Name	Weight(g)/ Dimensions (mm)	Power (µW)	Working Conditions	Resolution	Interface	Other Parameters	Cost($)
Adafruit BMP 280	1.3g/17.7 x 19.0 x 2	2.7µA -	From 30kPa to 110kPa	1.6Pa	I2C,SPI	Temperature Measurement included	9.95
Adafruit MPL 3115 A2	1.2g/18 x 19 x 2	50 µA x5.5V 8.5-265 µA x3.6V	From 50 kPa to 110 kPa(up to 10 km)	1.5Pa	I2C	Temperature Measurement included	9.95
Adafruit BMP 180	4g/-	1mA x3.6V 3-32 µA x3.6V	From 30kPa to 110kPa	3 Pa	I2C	Temperature Measurement included	9.95
Adafruit 10 DOF IMU	2.8g/38x23 x3	1mA x3.6V 3-32µA x3.6V	From 30kPa to 110kPa	3 Pa	I2C	Temperature, Pressure, Tilt Measurement included	29.95

Currently there will be no sensing device to monitor the container pressure. If we face any problem during the CDR environment testing, we may use BMP180 to monitor the container pressure.

•Adafruit BMP 180

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

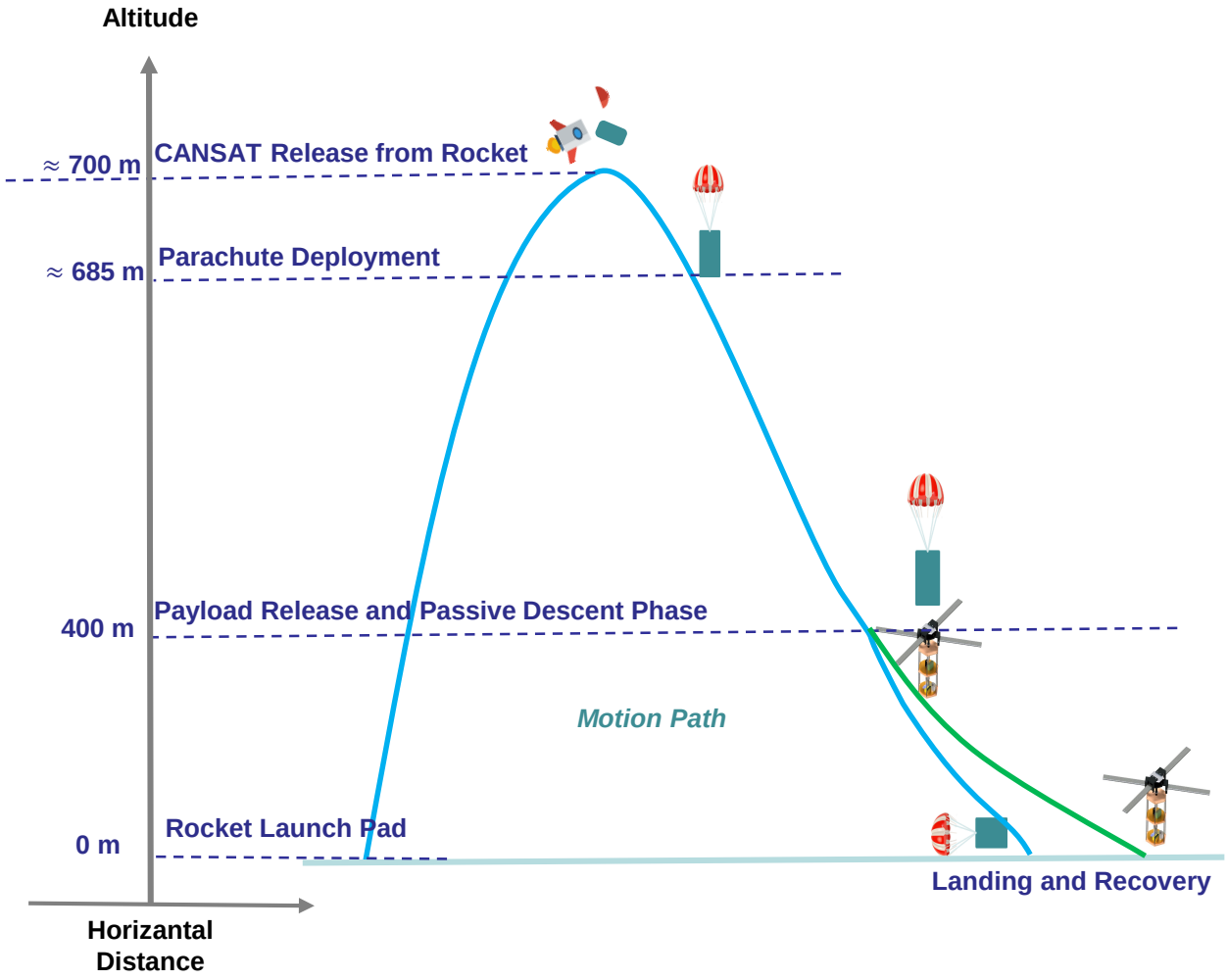


Descent Control Design

Eyup Kocak

Descent Control Overview

COMPONENTS	MATERIALS
Propeller	Carbon Fiber
Parachute	Rip Stop Nylon
Encoder	Semi-conductor
Propeller Shaft	Aluminum
Servo Motor	-



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 Strategy Selection and Trade

CANSAT descent control is related with parachute design. Hence, parachute alternatives discussed at first.

PARACHUTE CONFIGURATION

X-Type Parachute

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

Dome Type Parachute

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

Para Foil Type Parachute

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

Payload Descent Control Strategy Selection and Trade

PARACHUTE CONFIGURATION

Type	Material	Cd	Mass (g)	Appx. Price [$]
X-Type	Nylon	1.35	18	2.0
Dome	Nylon	1.5	18	2.0
Para Foil	Nylon	0.75	21	2.5

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

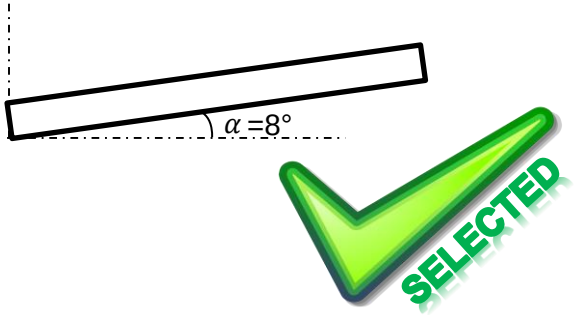
$$A_p = \frac{2\,F_D}{\rho\,V^2\,C_d} \qquad A_p = 0{,}95\,\pi\,{R_p}^2$$

R_p: Radius of the Parachute (m)
C_d: Drag Coefficient (Assumed 1,5 for dome type)
ρ : Air Density at 15˚C
A_p: Reference Area of the Parachute when Spill Hole is extracted (m²)
V : Velocity (Limited 20 m/s by competition requirements)
F_D: Drag Force (Should be equal to the weight)

Payload Descent Control Strategy Selection and Trade

AUTOGYRO OPERATION

AIRFOIL TRADE SELECTION

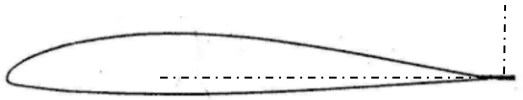


Flat Plate

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

NACA 0012 Airfoil

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



Boeing VR-7 Airfoil

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

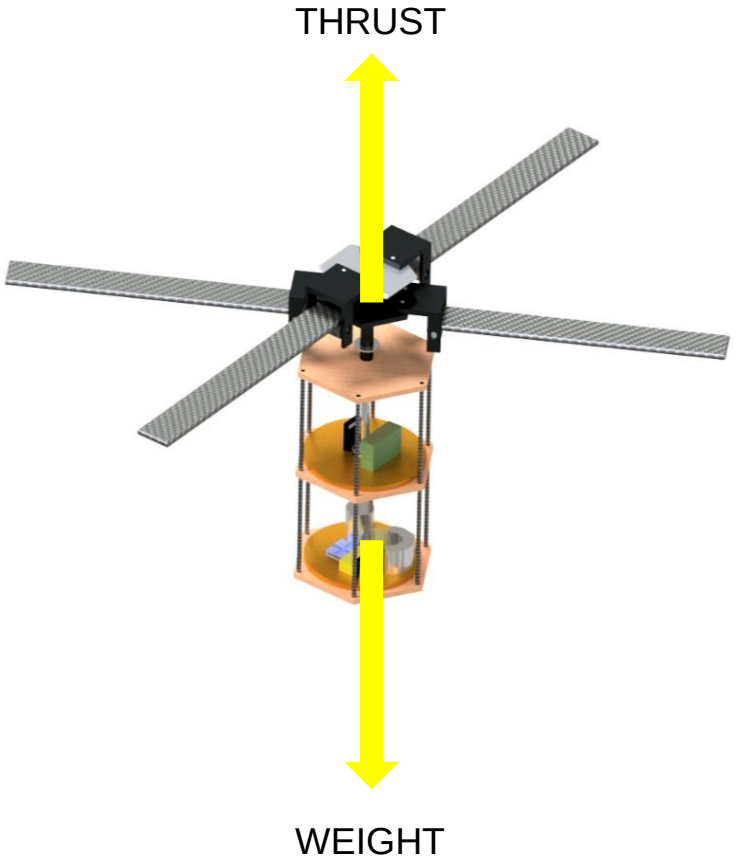
Payload Descent Control Strategy Selection and Trade

AUTOGYRO OPERATION

Type	Material	Cd	Cl
Flat Plate	Carbon Fiber	1,28	0,58
Naca0012	PLA	0,009	1,0
Boeing VR-7	PLA	0,03	1,4

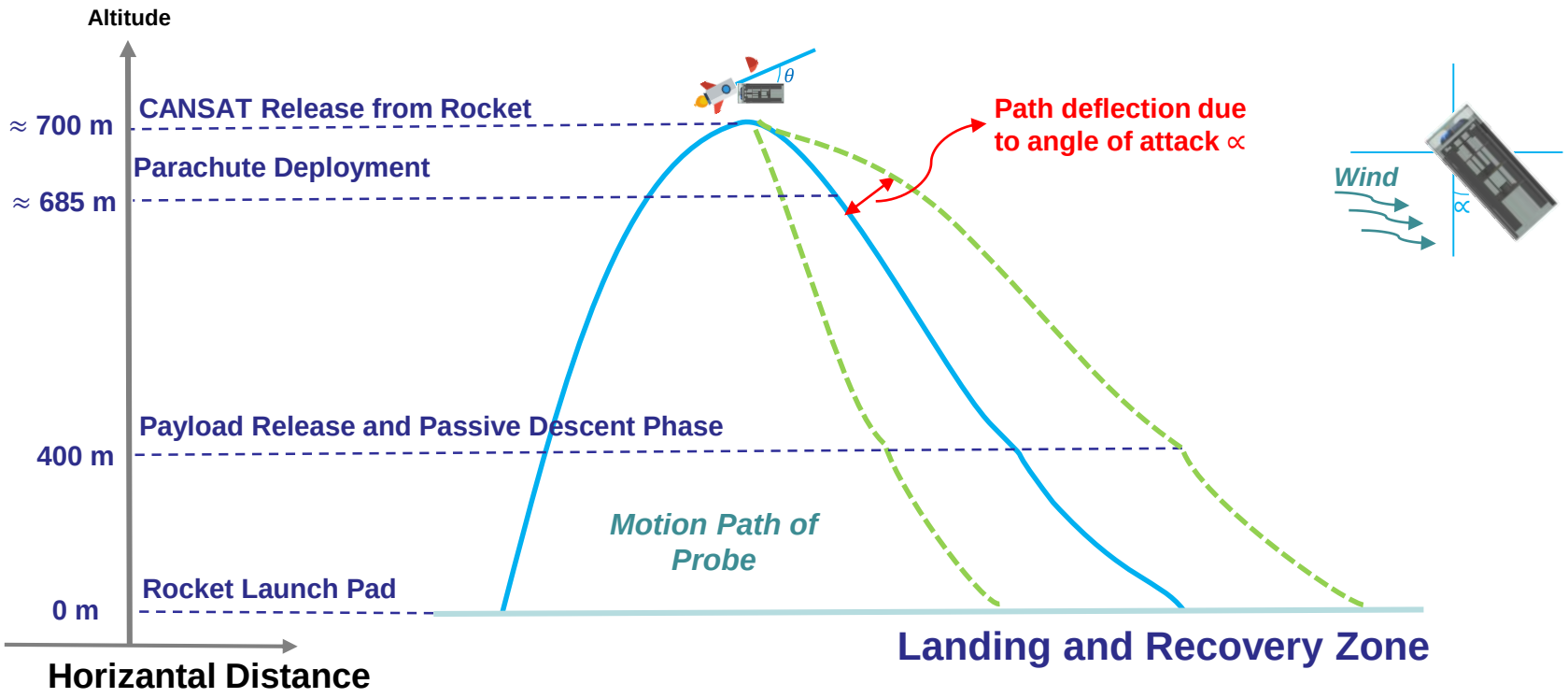
$$F_L = \frac{A\,\rho\,V^2\,C_l}{2} \qquad F_D = \frac{A\,\rho\,V^2\,C_d}{2} \qquad T = F_D + F_L$$

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



Payload Descent Stability Control Strategy Selection and Trade

Descent of Passive Helicopter Recovery

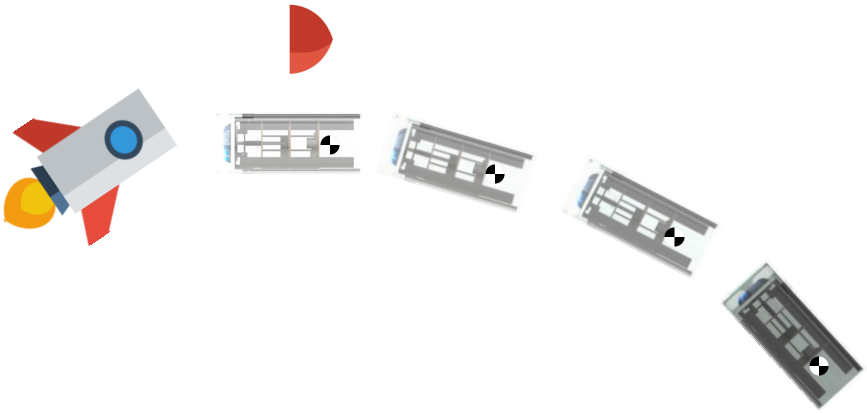


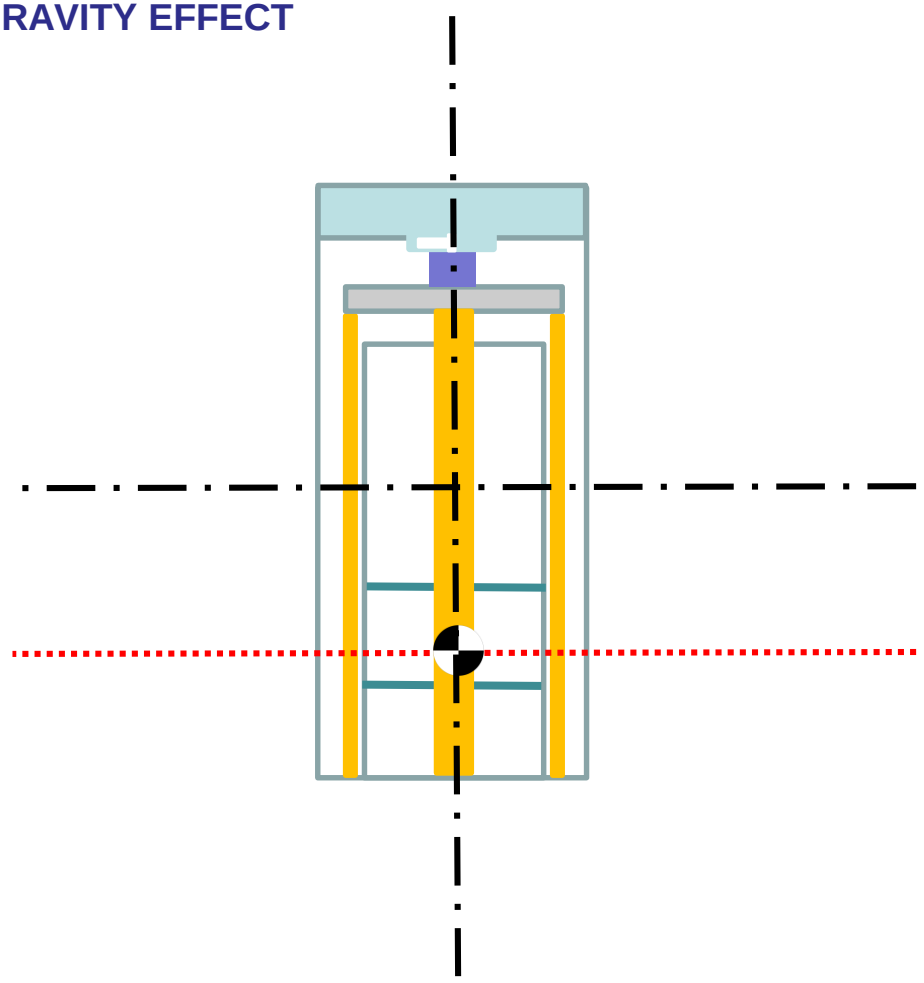
- CANSAT release angle θ from the rocket determines first stage of probe motion path .
- Wind situation affects the horizontal speed component of payload and angle of attack $\propto$.
- Seperation angle θ and wind situation affects the tumbling of probe.

Payload Descent Stability Control Strategy Selection and Trade

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.





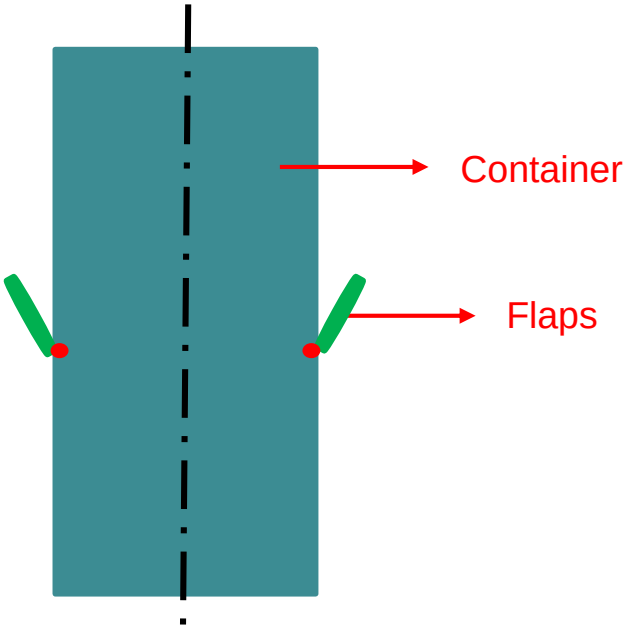
Schematic View Of CANSAT

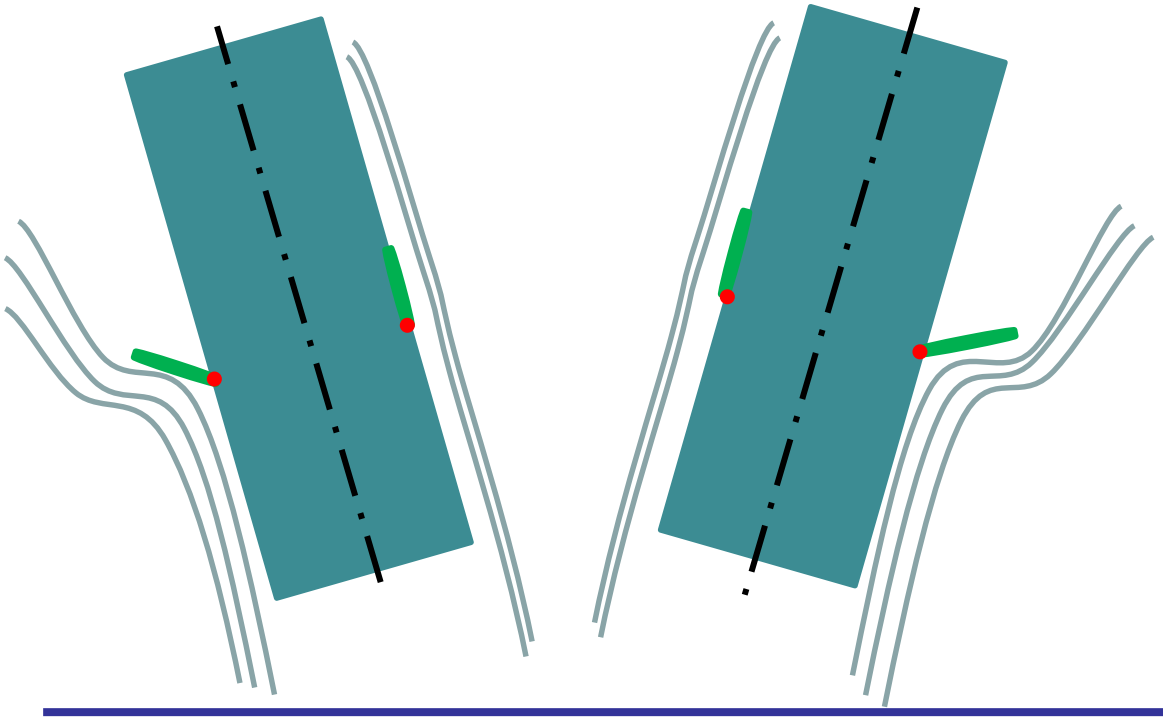
Payload Descent Stability Control Strategy Selection and Trade

Flap Like Effect

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

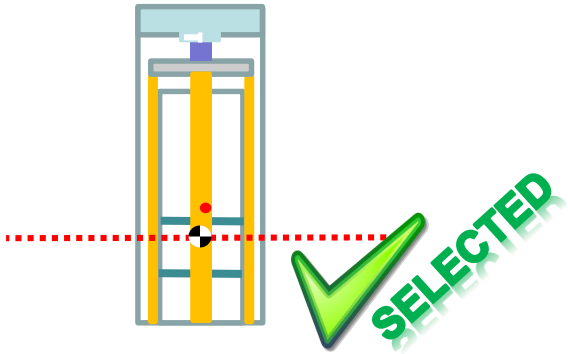
Flaps will produce lift, while descending with an angle of attack and the wing will exert a force on the air to change probe direction.





Payload Descent Stability Control Strategy Selection and Trade

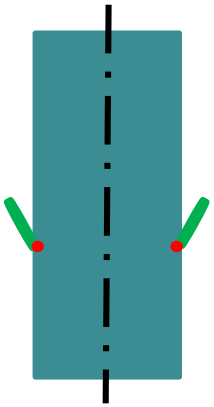
Tumbling Control Trade & Selection



Center of Gravity Effect

Pros
- Passive Control
- Efficient

Cons
- Assembly process is complex
- All component have to be placed near to front side.



Flaps

Pros
- Effective tumbling control
- Lift force generation

Cons
- Active Control
- Needs Extra Energy and Mechanism

Descent Rate Estimates

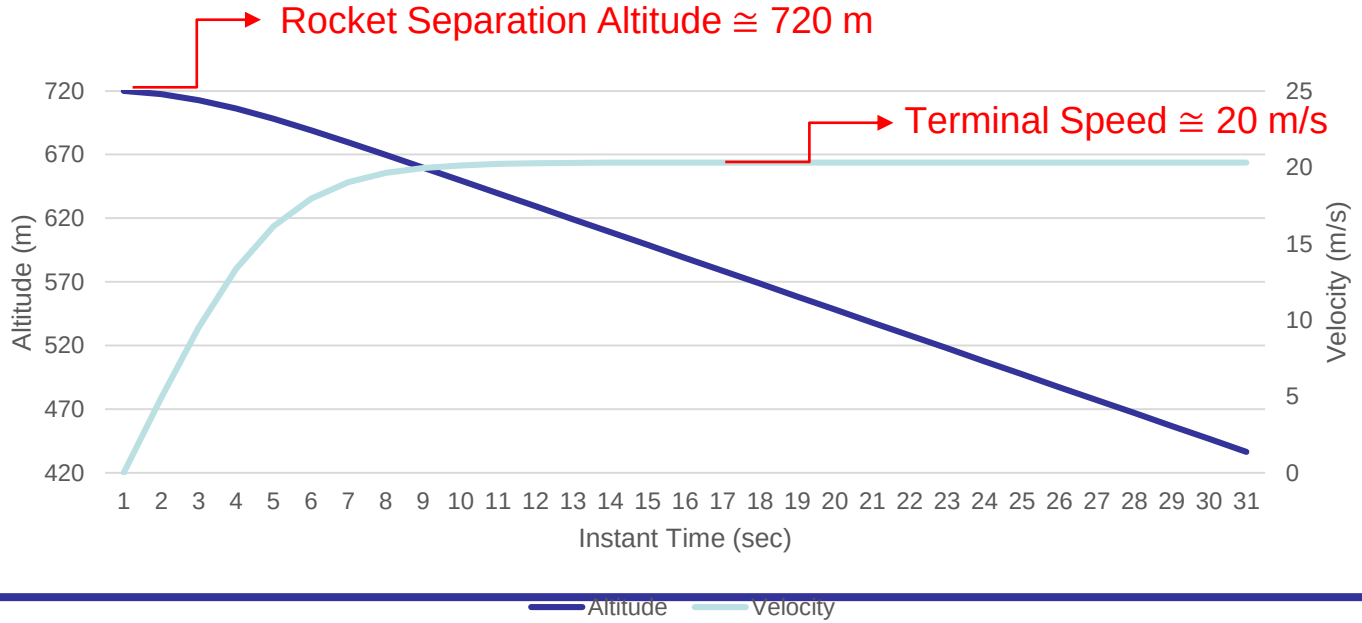
Container & Payload Post Rocket-Separation Velocity Estimates

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 = $W_{container} + W_{Payload}$ = 4,87 N

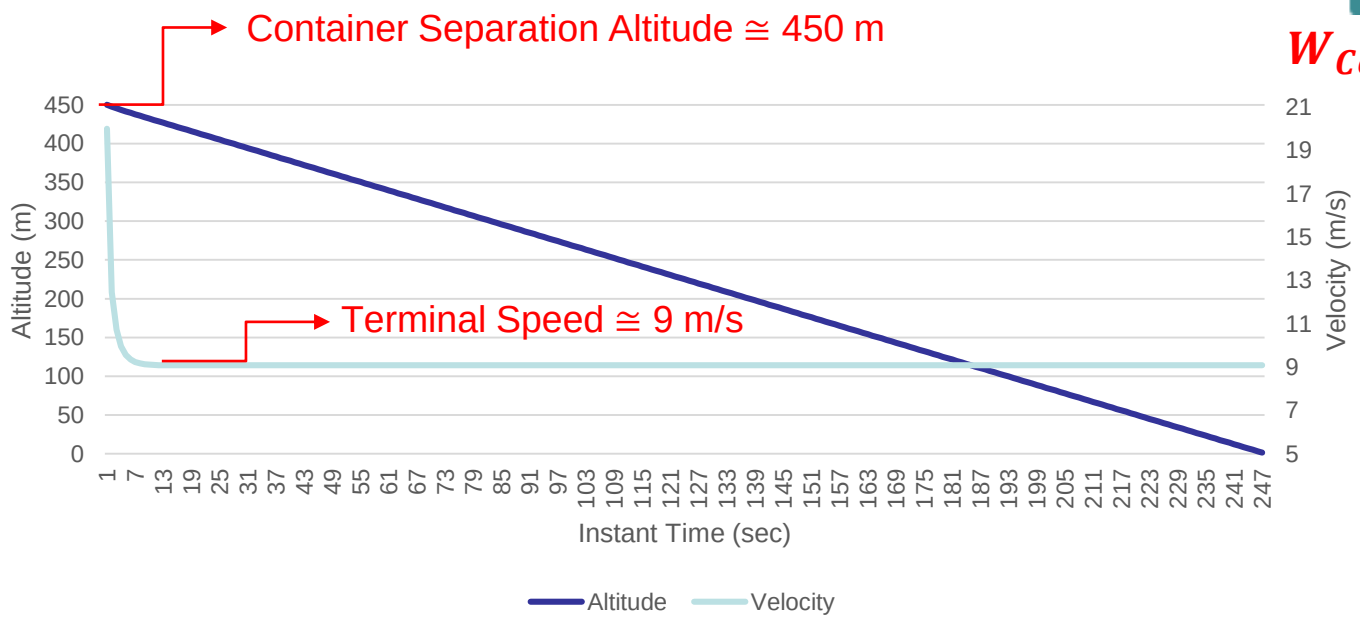


Descent Rate Estimates

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 = $W_{container}$ = 1,44 N



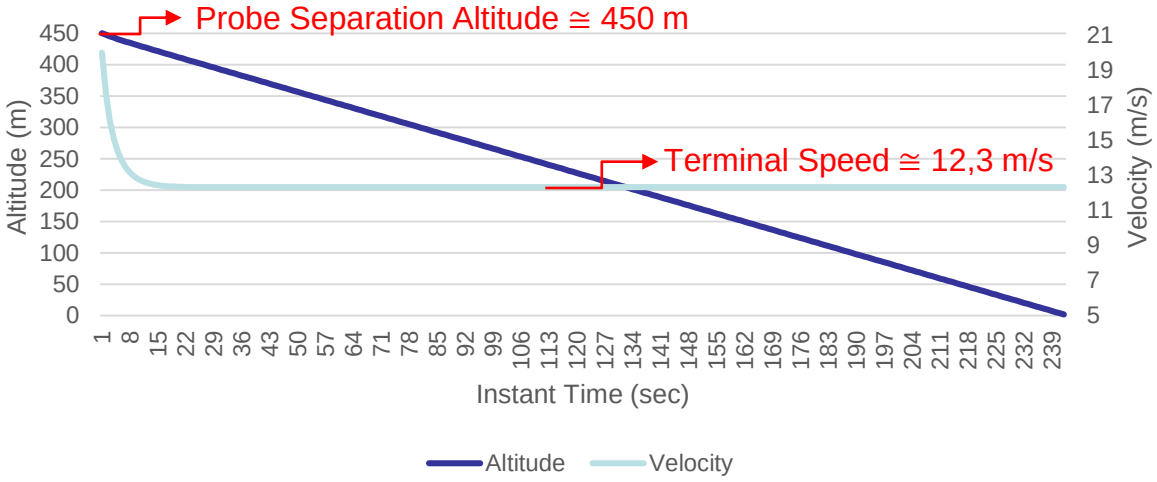
Descent Rate Estimates

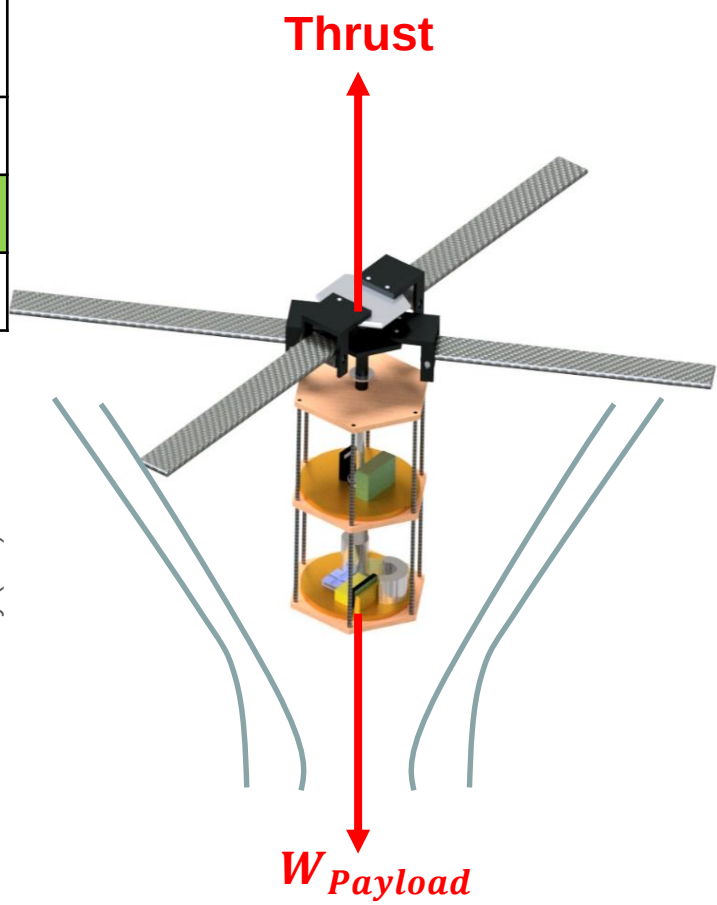
Container & Payload Post Rocket-Separation Velocity Estimates

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 (m^2)	Terminal Velocity (m/s)
0,1	0,03	24,63
0,2	0,12566	12,31
0,3	0,28274	8,21

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



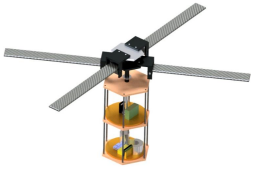


Descent Rate Estimates

SUMMARY

Estimated Descent Rate of **the Container + Payload** is approximately 20 m/s.

Estimated Descent Rate of **the Container** is approximately 9 m/s.



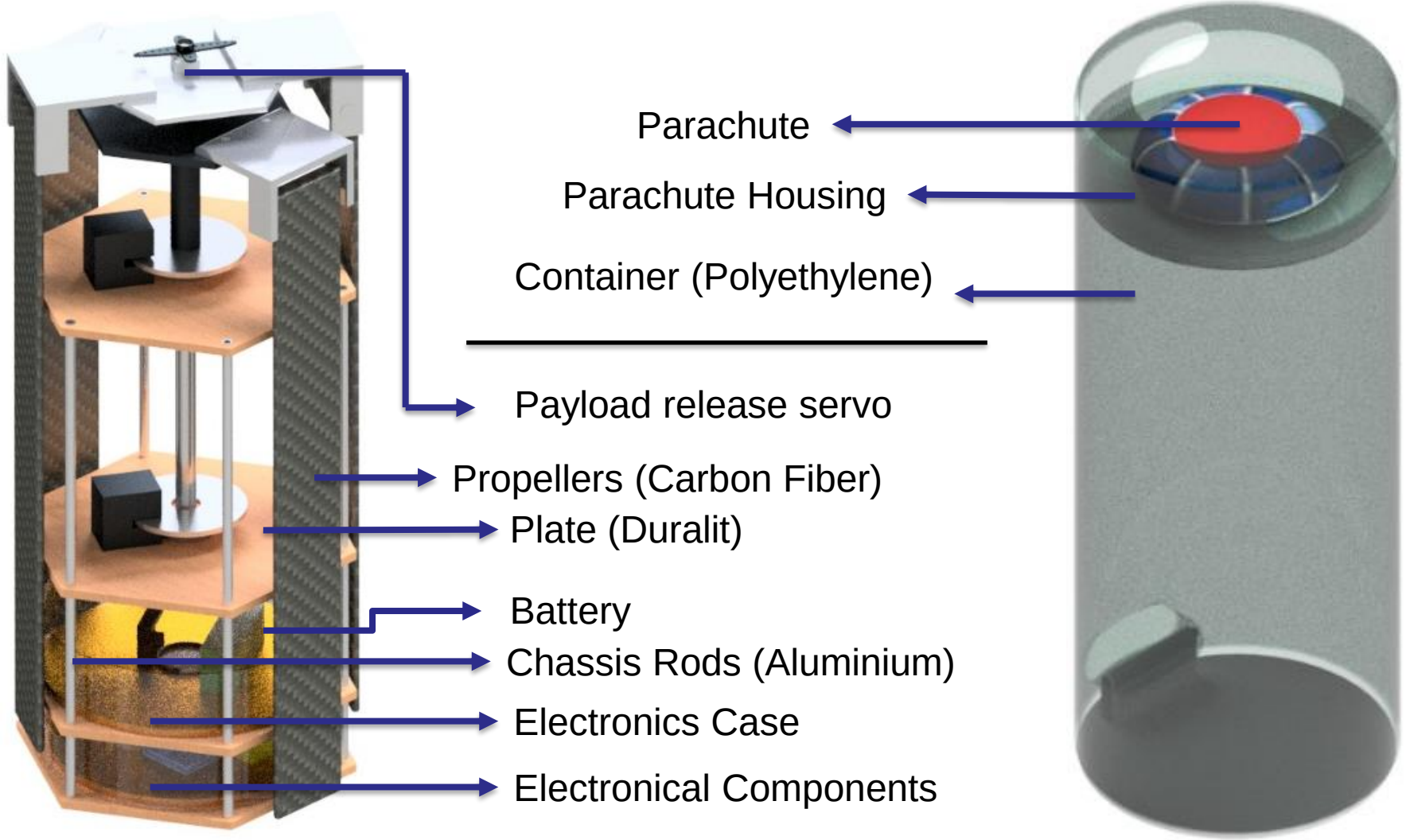
Estimated Descent Rate of **the Payload** is approximately 12,5 m/s.

Configuration	Mass (g)	Descent Rate (m/s)
Container + Payload	497,7	~20
Container	140,70	~9
Payload	357,0	~12.31

Mechanical Subsystem Design

Alpcan Altuntas

Mechanical Subsystem Overview



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

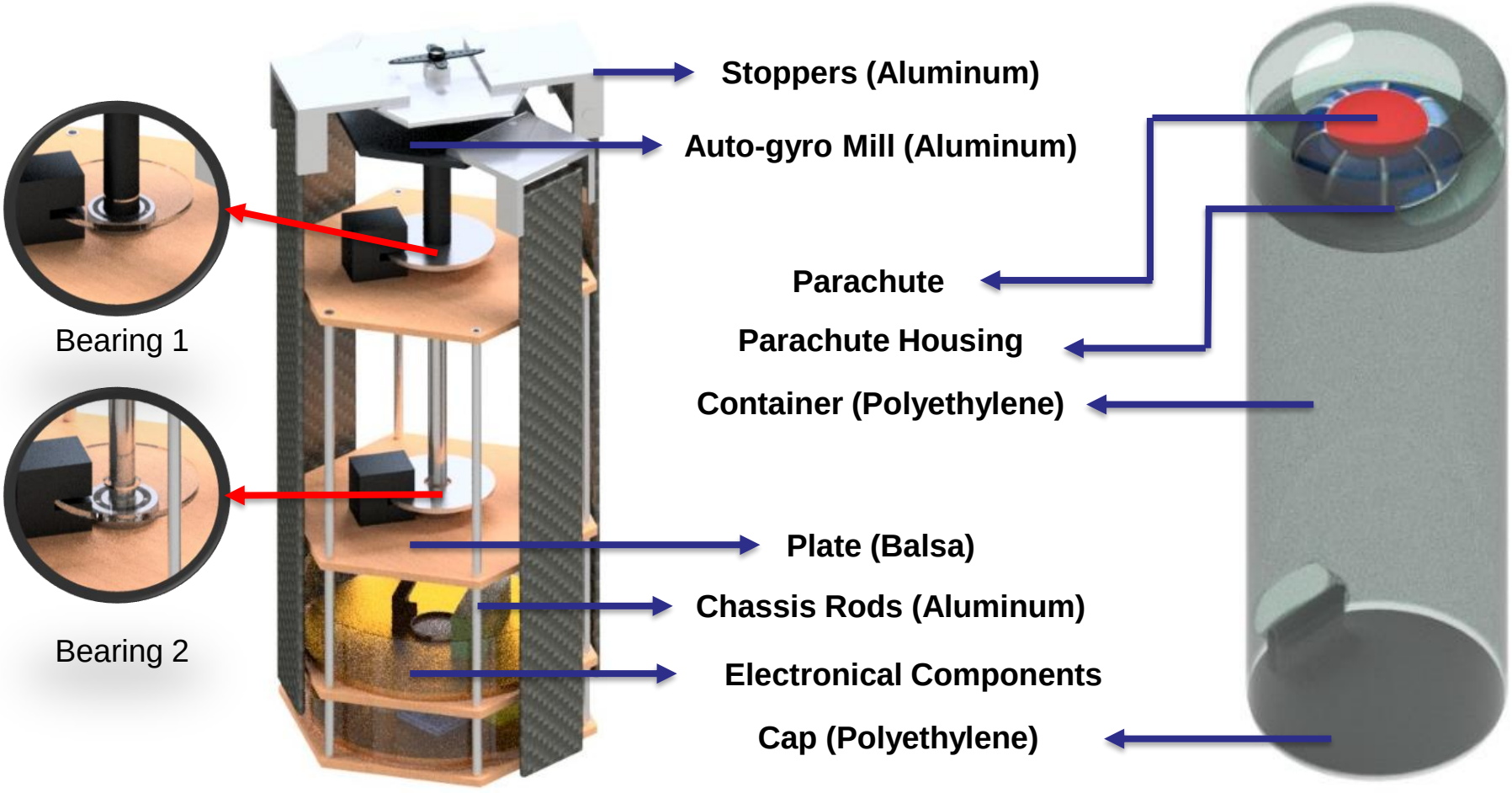
		Mechanical Sub-System Requirements	Verification			
ID	# of CR	Description	A	I	T	D
MSS-10	13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	✓			
MSS-11	14	All structures shall be built to survive 15 Gs of launch acceleration.	✓			✓
MSS-12	15	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-18	45	The probe must include an easily accessible power switch that can be accessed without disassembling the Cansat and in the stowed configuration.	✓			✓
MSS-19	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-20	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-21	51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	✓			✓
MSS-22	52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	✓			✓

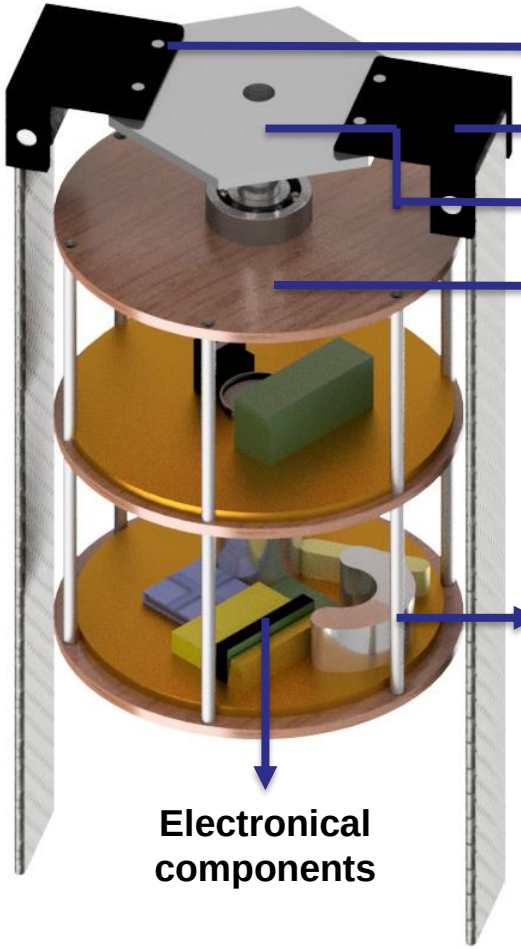
Payload Mechanical Layout of Components Trade & Selection

LAYOUT 1



Payload Mechanical Layout of Components Trade & Selection

LAYOUT 2



Nut and Bolt

Stoppers (Aluminum)

Auto-gyro mill (Aluminum)

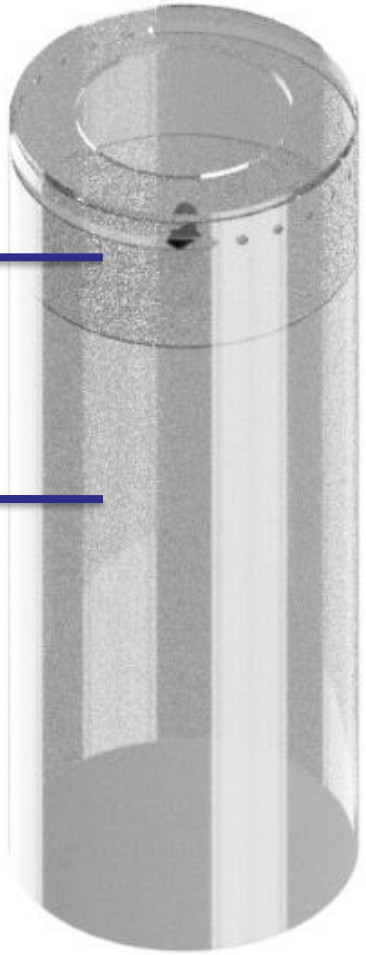
Plates (Balsa)

Parachute Housing

Container (Polyethylene)

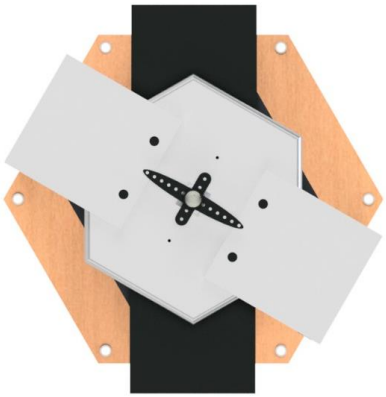
Chassis rods (Aluminum)

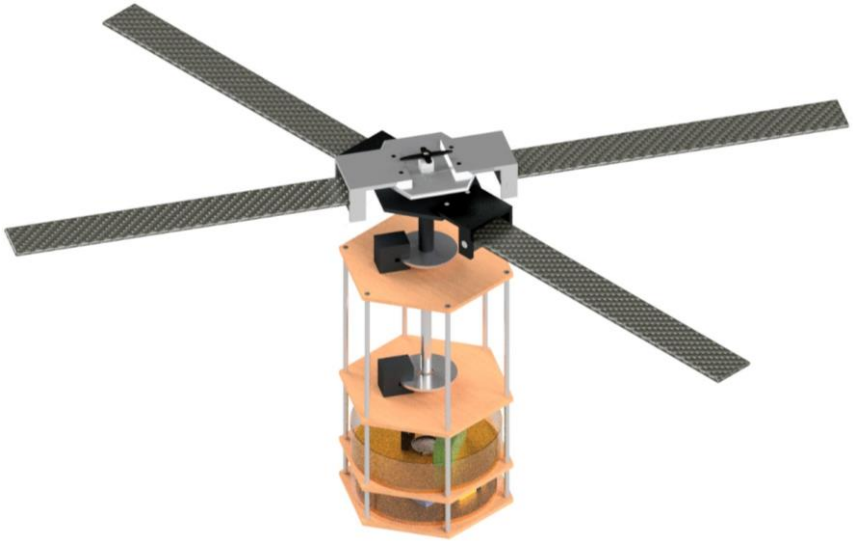
Electronical components



Payload Mechanical Layout of Components Trade & Selection

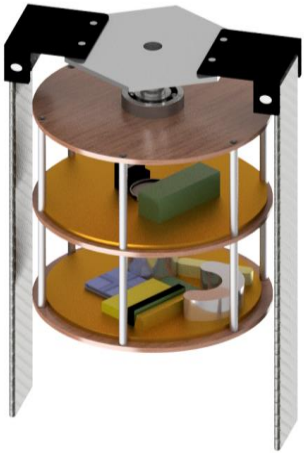
LAYOUT 1





- Higher lift due to the coaxial propellers .
- The hexagon shape enables it to become a more compact design.
- Center of gravity position is lower than the Layout 2.

LAYOUT 2



- Lower lifting power due to its singular propellers.
- Payload turns with the propellers.
- Center of gravity position is at a higher point which causes stability issues.

Payload Mechanical Layout of Components Trade & Selection

PAYLOAD CHASSIS MATERIAL TRADE & SELECTION			
	ALUMINUM	BALSA WOOD	PLA
Weight	LIGHT	LIGHT	MODERATE
Strength	MODERATE	LOW	LOW
Cost	MODERATE	LOW	MODERATE
Shock Absorbtion on Impact	MODERATE	LOW	LOW

Even though Balsa Wood and PLA has its own distinct advantages

ALUMINUM is selected due to its better compatibility (Higher Strength and Shock Absorption) with our **payload.**

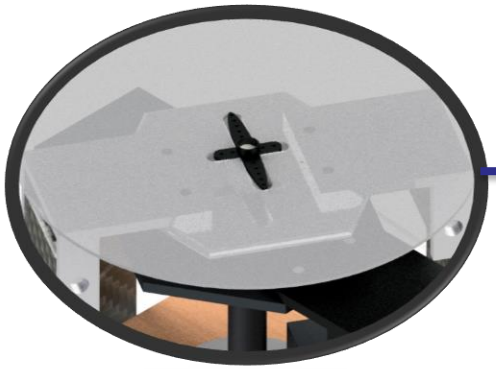
Payload Mechanical Layout of Components Trade & Selection

PROPELLER MATERIAL TRADE & SELECTION			
	CARBON FIBER	BALSA WOOD	PLA
Weight	LIGHT	LIGHT	MODERATE
Strength	HIGH	LOW	LOW
Cost	**VERY HIGH**	LOW	MODERATE
Shock Absorbtion on Impact	HIGH	LOW	LOW

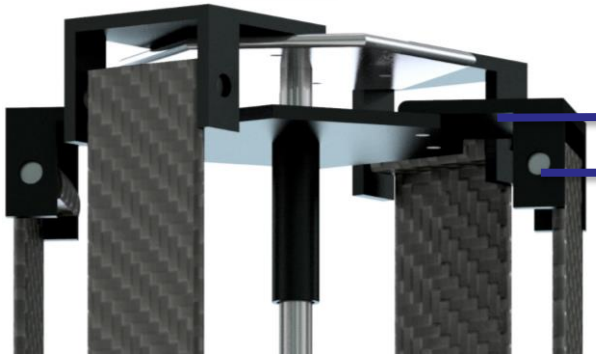
Even though Balsa Wood and PLA has its own distinct advanteges,

CARBON FIBER is selected due to its better compatibility (Higher Strength and Shock Absortion) with our **propellers.**

Payload Pre Deployment Configuration Trade & Selection



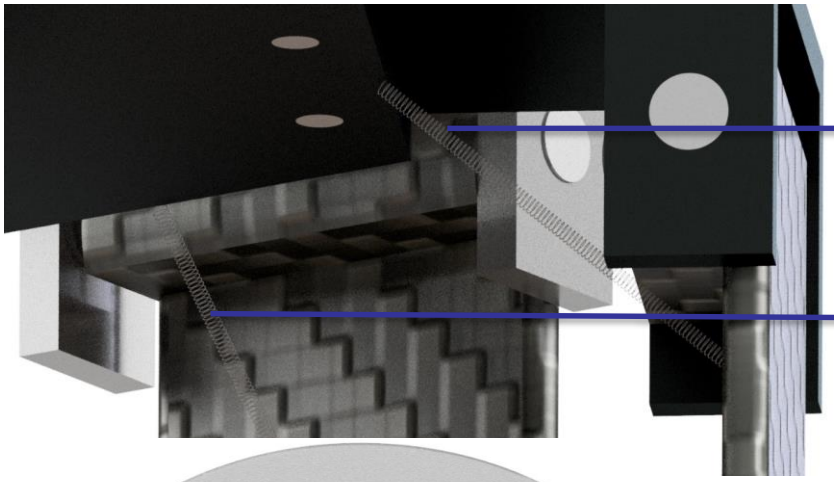
A servo motor with two hinges hold the payload intact with the container.



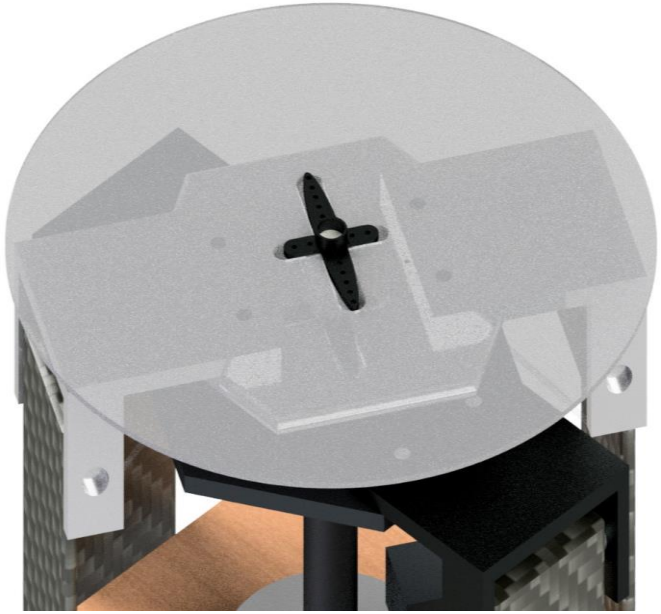
Springs that placed between the propeller and the chassis

Pins that enable the propellers to achieve a folded state

Payload Deployment Configuration Trade & Selection



Springs that have very low tensile strength are located between the mill and the propellers in order to stabilize the deployment of payload

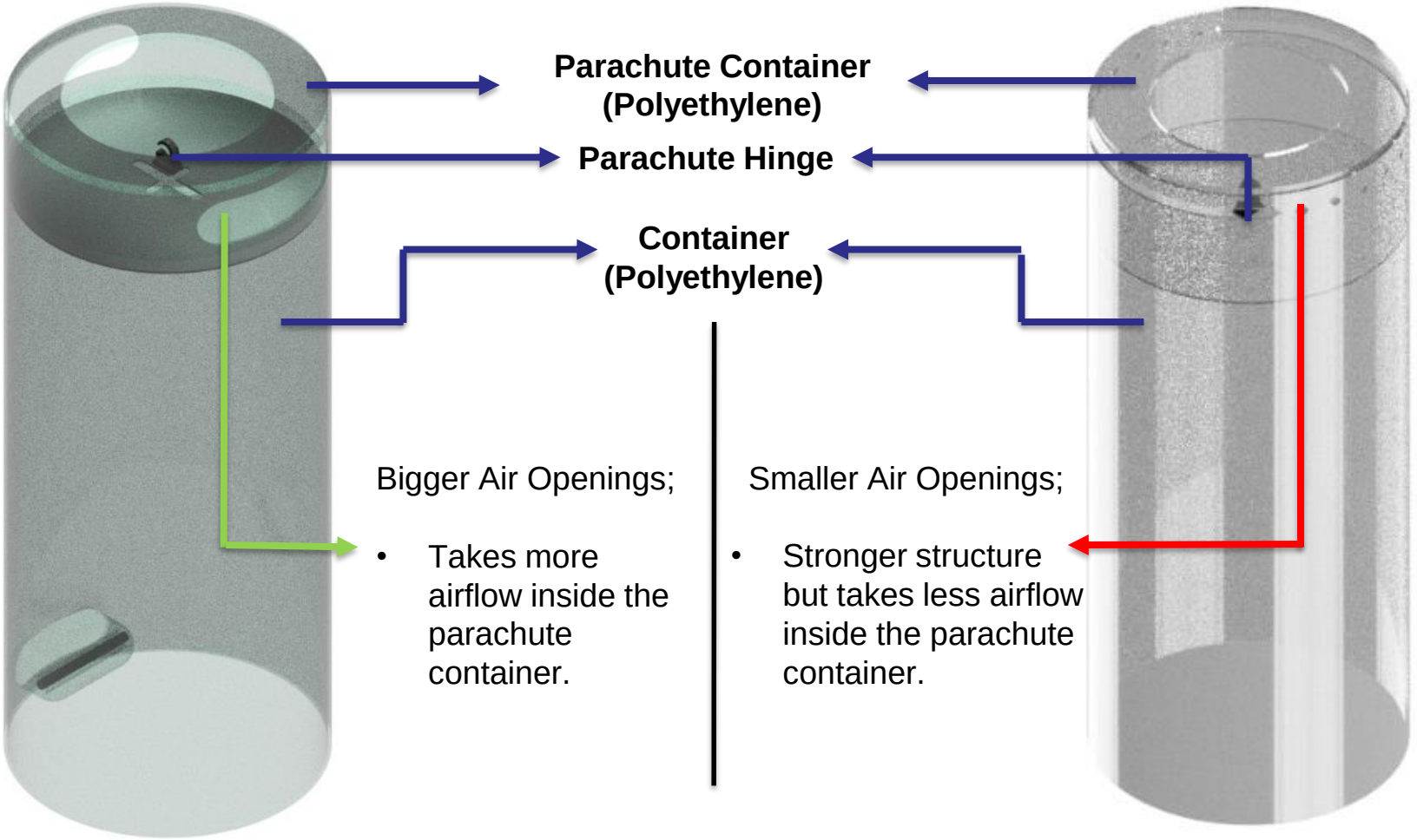


The tails rotate, the payload starts descending while the springs prevent the propellers from contacting the container (after deployment, the springs will not effect the activation of the gyro due to the low tensile strength).

Container Mechanical Layout of Components Trade & Selection

LAYOUT 1

LAYOUT 2



Parachute Container (Polyethylene)

Parachute Hinge

Container (Polyethylene)

Bigger Air Openings;

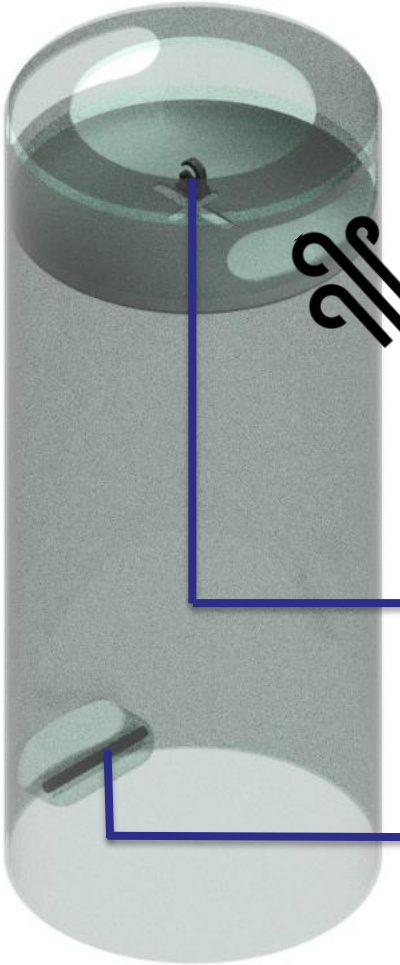
- Takes more airflow inside the parachute container.

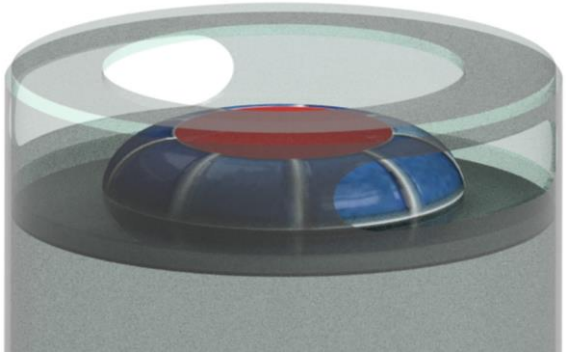
Smaller Air Openings;

- Stronger structure but takes less airflow inside the parachute container.

Container Mechanical Layout of Components Trade & Selection

LAYOUT 1





- The container is made out of polyethylene which is a very light and durable material for this task.

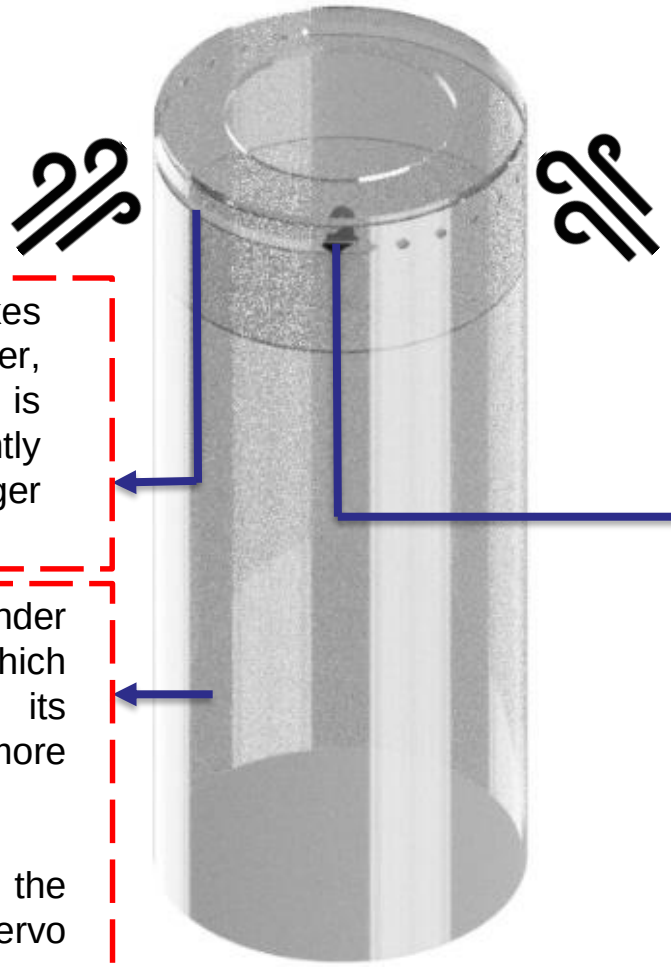
- The openings on the parachute housing takes the air inside and creates a pressure which triggers the deployment of the parachute

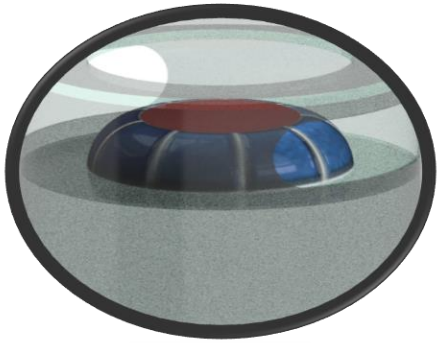
- There is **a hinge** that is hooked gently beneath the parachute.

- A cap is located at the bottom of the container that opens up (without any major pressure) as soon as the payload begins falling

Container Mechanical Layout of Components Trade & Selection

LAYOUT 2



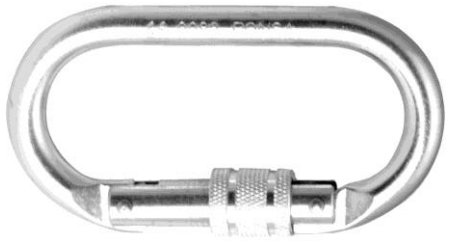


- Smaller air holes makes the structure stronger, however the airflow is decreased significantly (which causes a longer airflow).

- There isn't any cap under the container which reduces weight but its mechanism weighs more than itself.

- It may be a risk if the payload release servo malfunctions.

- A carabiner is located inside the parachute housing that is gently mounted on to the parachute (Heavy and risky)



Container Mechanical Layout of Components Trade & Selection

CONTAINER MATERIAL TRADE & SELECTION			
	Polyethylene	ABS Plastic	PLA Plastic
Weight	LIGHT	MODERATE	HIGH
Strength	MODERATE	MODERATE	MODERATE
Cost	**VERY LOW**	LOW	LOW
Shock Absorbtion on Impact	HIGH	LOW	MODERATE

Even though ABS and PLA plastic has its own distinct advantages,

Polyethylene is selected due to its better compatibility with our payload.

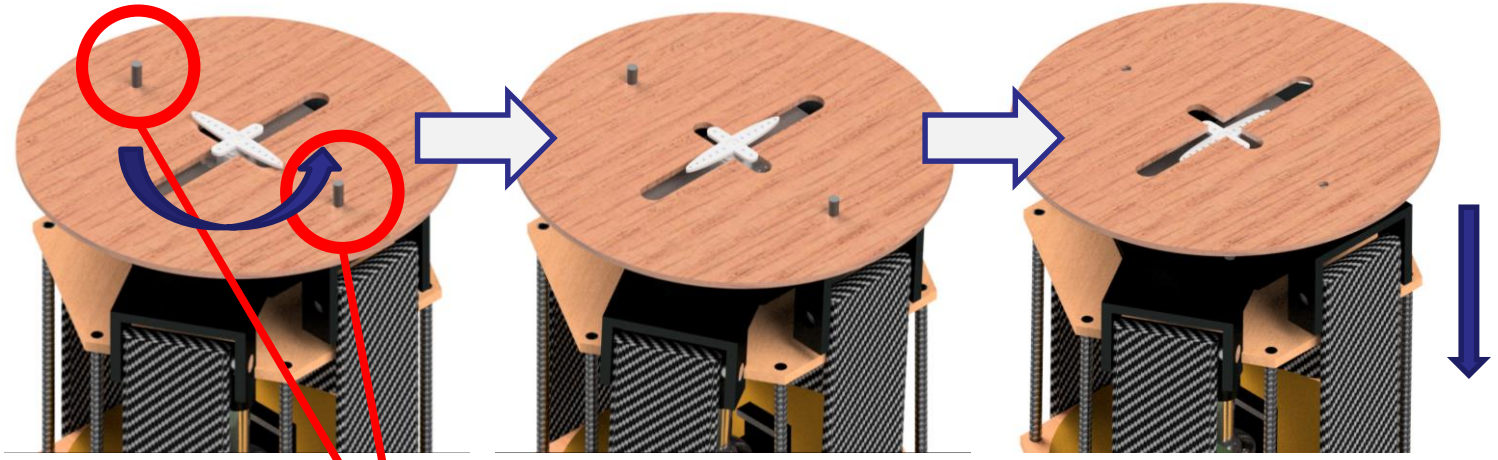
Payload Release Mechanism

Spinning Servo Mechanism

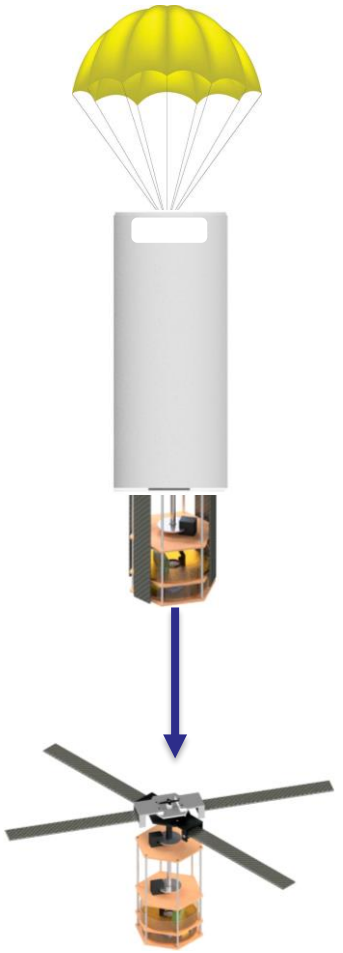
Stowed Position:
Servo arm locks the prob.

Release Movement:
Servo arm starts turning.

Release:
Servo arm position matched with the gap geometry.

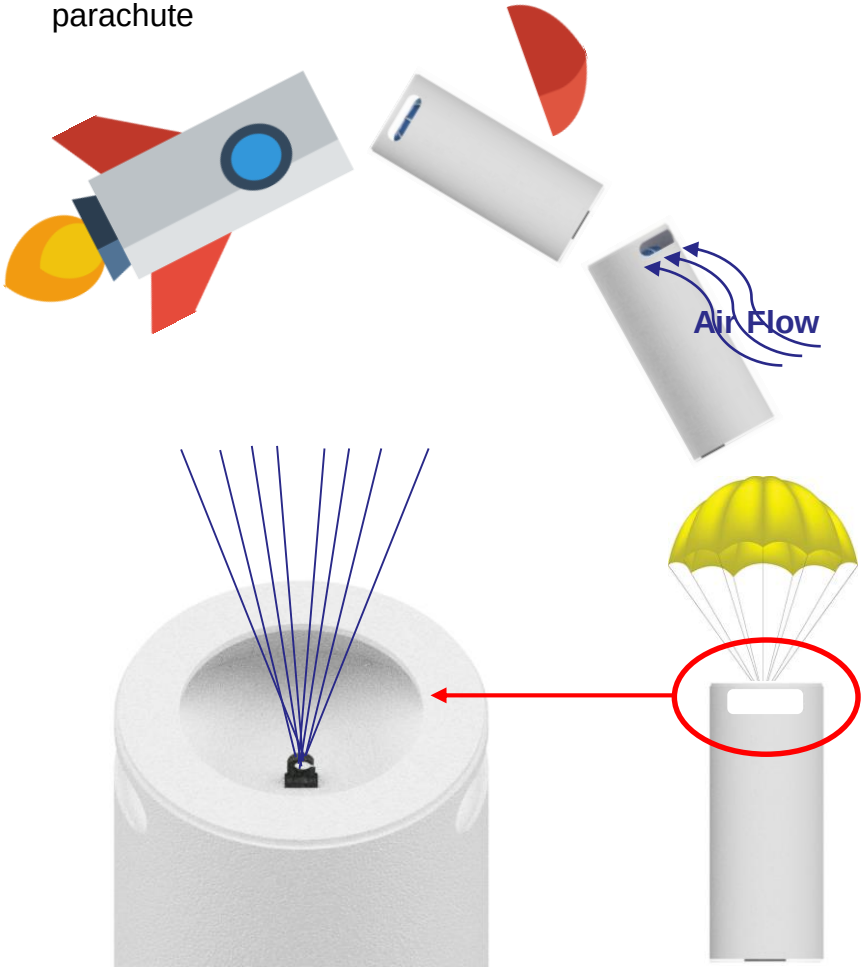


Stop pins: To prevent uncontrolled rotation of the science prob.

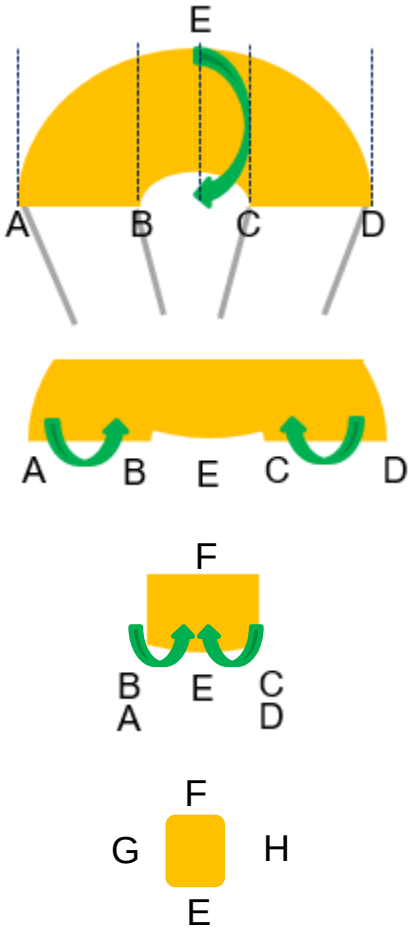


Container Parachute Release Mechanism

The openings on the parachute housing takes the air inside and creates a pressure which triggers the deployment of the parachute

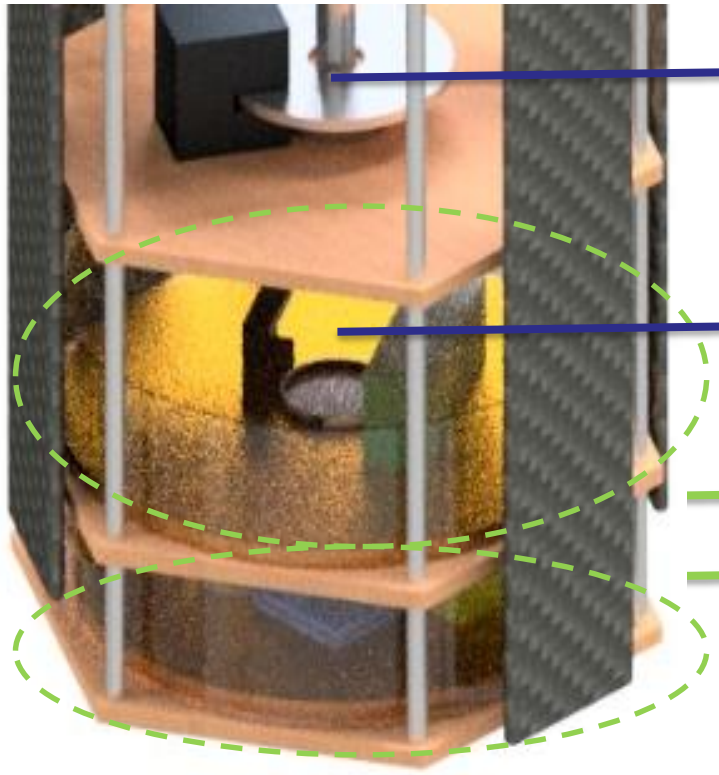


Parachute Stowe Method



1. Canopy is flaked on its side. Nose (E) is folded under B-C line.
2. D line is stacked on C line then A line is stacked on B line.
3. AB and CD lines are stacked on E line.
4. If necessary G side is stack on H side.

Electronics Structural Integrity



Shaft will have one DOF: rotation about the vertical axis.
Bearings will be clamped using bolts and nuts.

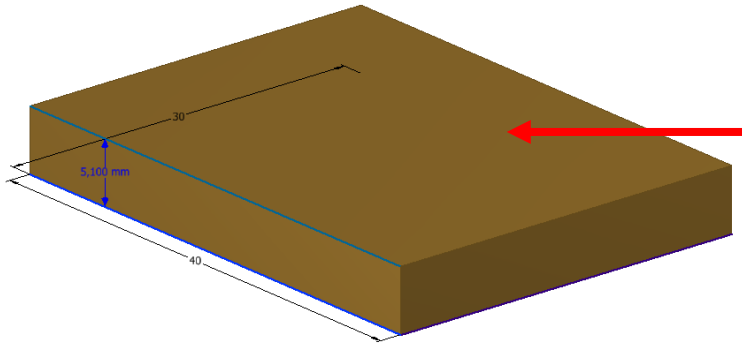
The electronic components are mounted onto the Printed Circuit Boards (PCB) which are also pinned on to the balsa plates.

The surface of the electronic components are surrounded by transparent cases in order to prevent any risk.

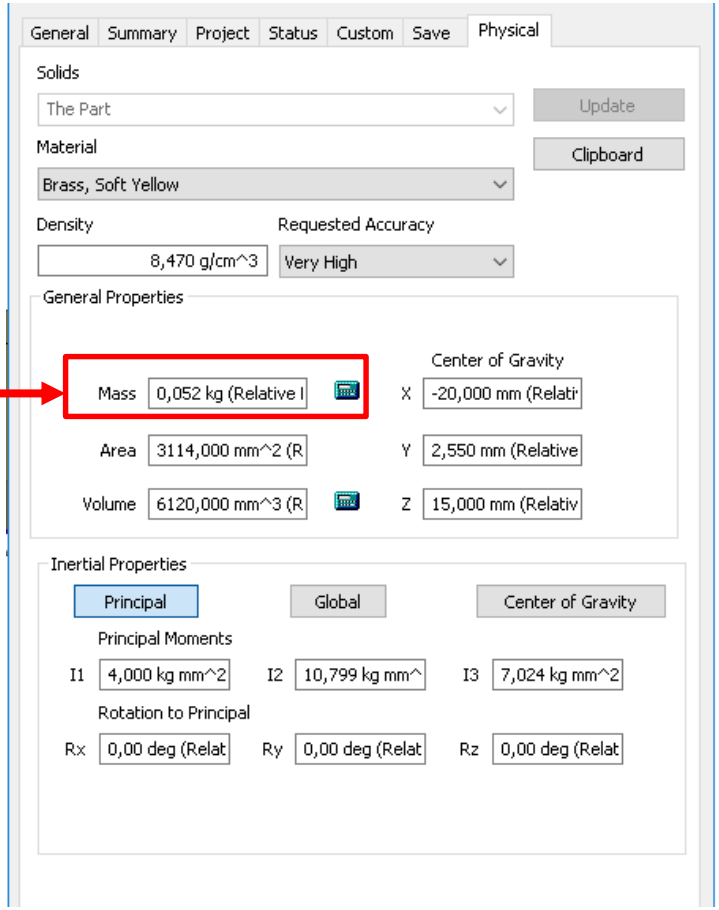
Mass Budget

Method of Correction

Autodesk Inventor CAD program was used to determine mechanic component weights. In order to determine the accuracy of the CAD program, a simple correction methodology was applied.



CAD Model of an Brass Work piece



- A simple brass workpiece is modeled on Autodesk Inventor and the mass of workpiece was obtained using CAD Properties Interfaces.

- On the other hand, the mass of real brass piece was measured on precision scales.

Error is 1,54%

A safety margin can be determined as **3%** that is bigger than error 1,54%.

Mass Budget

System	Subsystem	Mass (g)	Percent (%)	Verification Method
Science Probe	Body and Chassis	123	34,45	Estimate
	Electronics	39	10,92	Data Sheet
	Batteries and Servo Motor	77	21,57	Data Sheet
	Propeller Breaker	64	17,93	Estimate
	Propeller Holder	38	10,64	Estimate
	Large Propeller Mills	8	2,24	Estimate
	Small Propeller Mills	8	2,24	Estimate
	TOTAL	**357,00**	**100,00**	
	Margin	7,23	3% of the Estimated Components	

System	Subsystem	Mass (g)	Percent (%)	Verification Method
Container	Container Case	99,70	70,86	Estimate
	Container Cap	18,00	12,79	Estimate
	Parachute Hook	5,00	3,55	Estimate
	Parachute	18,00	12,79	Estimate
	TOTAL	**140,70**	**100**	
	Margin	4,221	%3 of the Estimated Components	

Mass Budget

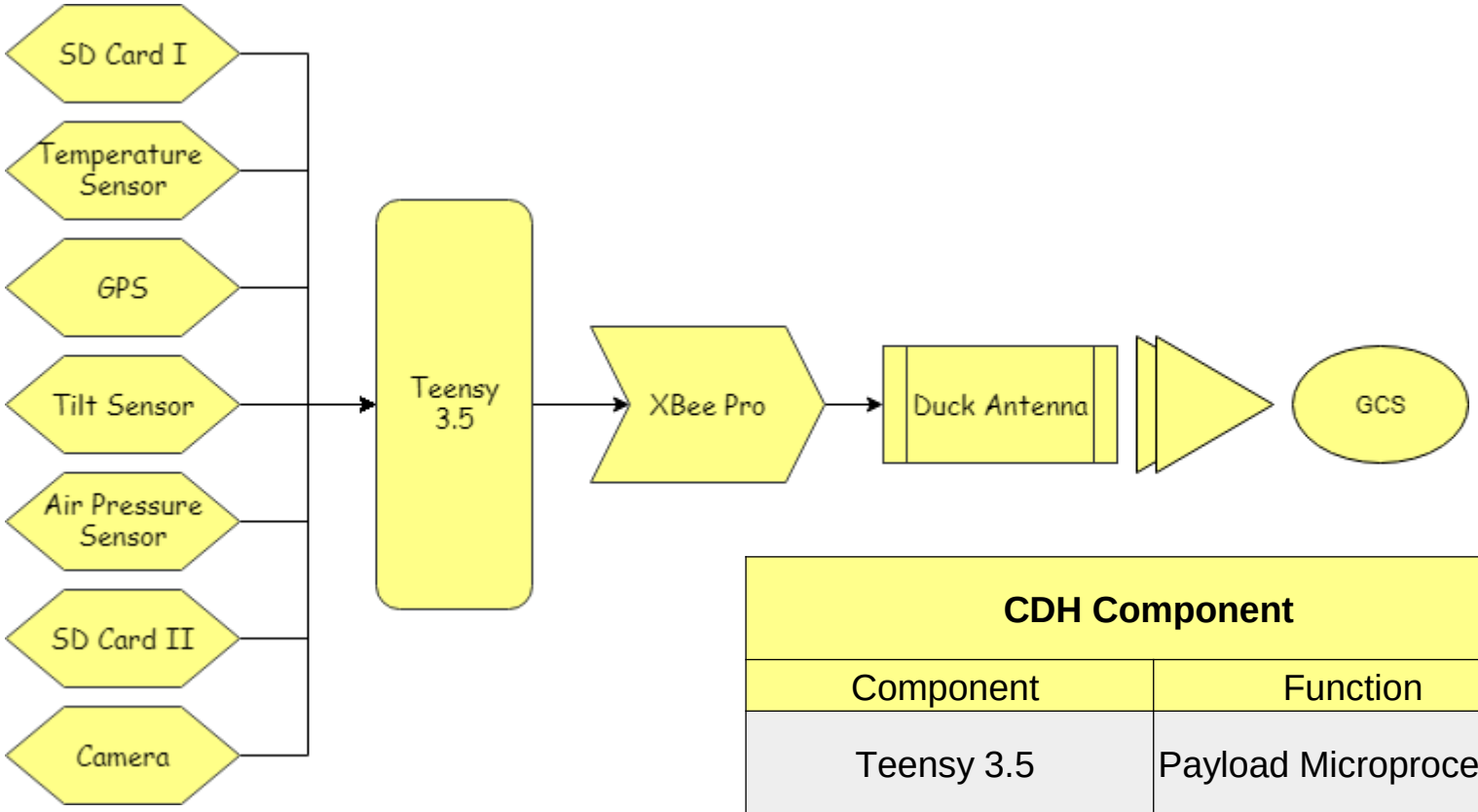
	Minimum CR Mass	Base mass	Maximum CR Mass
Requirement	490g	500g	510g
CanSat	486,25g*	497,7g	509,15g
	With Margin (-3%)		With Margin (+3%)

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

Communication and Data Handling (CDH) Subsystem Design

Ulas Gulec

Payload CDH Overview



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

Payload 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.	✓	✓		

Payload CDH Requirements

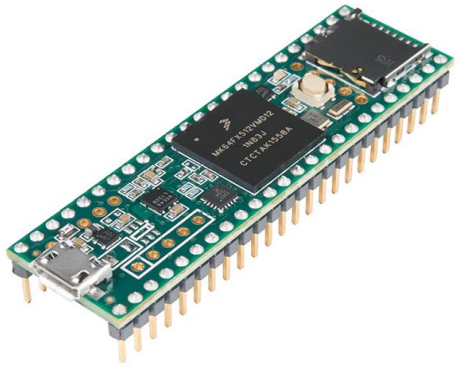
	Communication and Data Handling Requirements		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
CDH-9	31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		✓		✓
CDH-10	32	XBEE radios shall have their NETID/PANID 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 Trade & 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							

•Teensy 3.5

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



Payload Processor & Memory Trade & 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

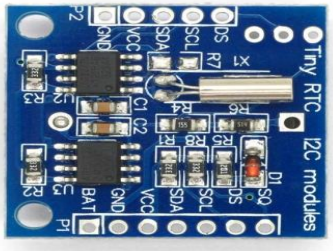
Payload Real-Time Clock

Model	Voltage (V)	Power Consumption (mA)	Accuracy (ppm)	Interface	Weight and Size(mm/g)	Hardware/ Software
DS1302	2	0.015	∓40	I^2C	16.5x26.3x 1.6 / 9	Hardware
DS1307	5	0.015	∓23	I^2C	26x22x 5/ 2.3	Hardware
DS3231	5.5	0.084	∓2	I^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 Trade & Selection

Model	Type(and connector)	Gain (dBi)	Dimensions (mm)	Radiation Pattern	Frequency Range (GHz)
Duck Antenna	Dipole (SMA RF Connector)	2	106x13	Omni directional	2.4-2.5
Magnetic Mount Antenna	Dipole (SMA RF Connector)	7	200x10	Omni directional	2.4 ISM Band
Buccaneer Antenna PX0407	Connector Supplied with SMB plug	2	105x19	Omni directional	2.4-2.5

Criteria : Frequency range is suitable for us. Also, Xbee is working on 2.4 GHz

SELECTED

•Duck Antenna

•Easily available
•Less size
•Less Weight

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

Telemetry will be start before the rocket launch and will be active during all phases. After landing, telemetry will be stopped.

SELECTED

•Xbee Pro S1

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

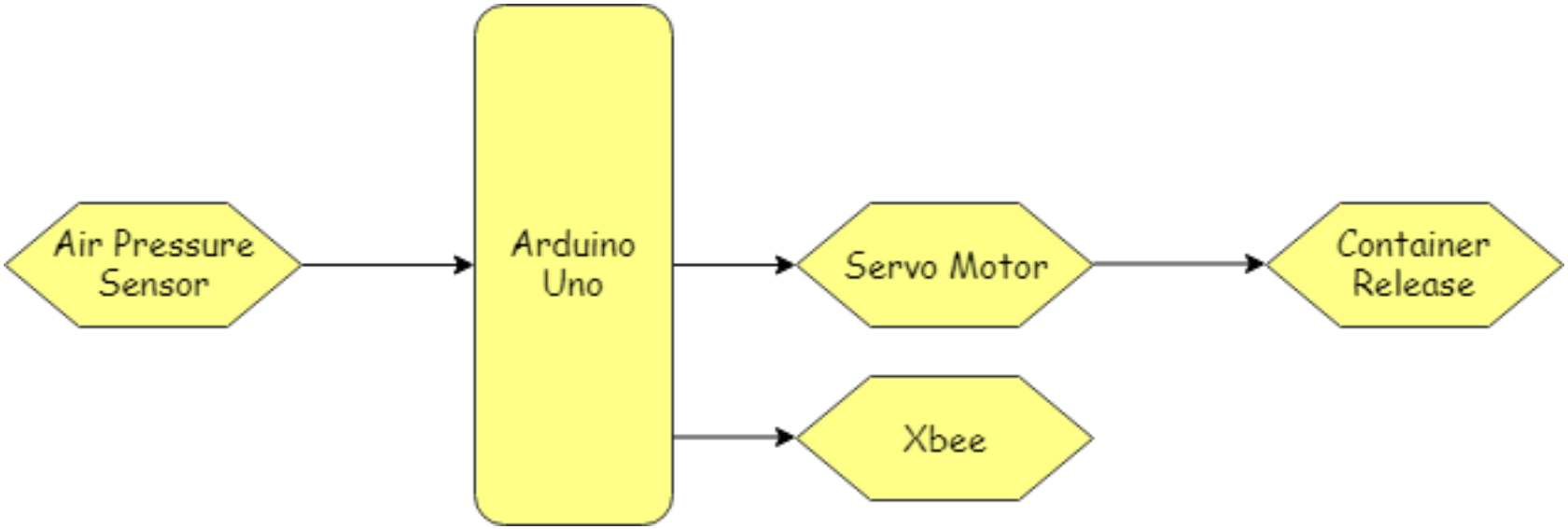
NETID will be set to 2806

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.***

Container CDH Overview



Currently there will be no electronic sensing device to monitor the container. If we face any problem during the CDR environment testing, we may use this structure to monitor pressure.

Container CDH Requirements

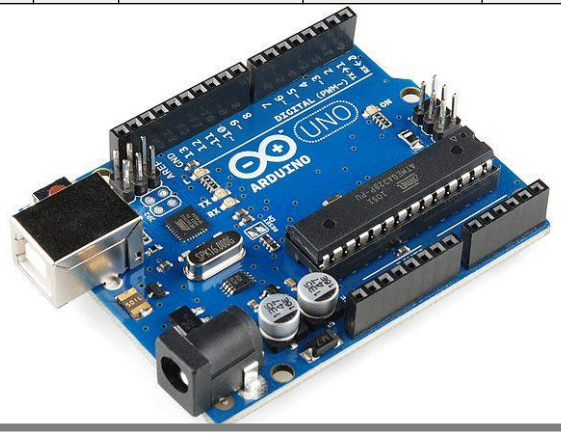
	Communication and Data Handling Requirements		Verification			
ID	**# of CR**	**Description**	**A**	**I**	**T**	**D**
CDH-1	13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.		✓		
CDH-2	16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	✓	✓		✓
CDH-3	20	The science payload shall measure altitude using an air pressure sensor.		✓	✓	
CDH-4	31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		✓		✓
CDH-5	32	XBEE radios shall have their NETID/PANID set to their team number.				✓
CDH-6	33	XBEE radios shall not use broadcast mode.				✓
CDH-7	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.	✓			✓

Container Processor & Memory Trade & Selection

Microcontroller Board	Speed (MHz)	Boot Time(ms)	Interfaces		Form Factor(mm)	Cost ($)	Weight(g)	Power(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							

•Arduino Uno

- Lightest weight
- 5V output need to camer
- Low cost
- Smaller size

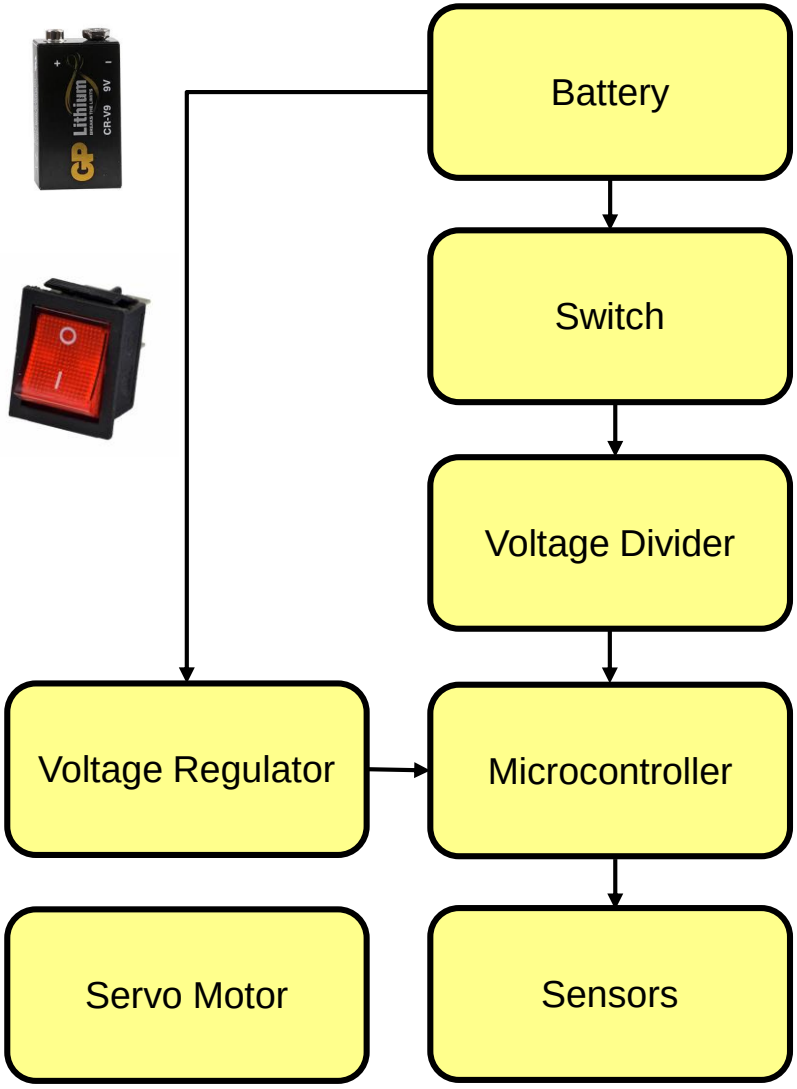


Currently there will be no electronic sensing device to monitor the container. If we face any problem during the CDR environment testing, we may use this structure to monitor pressure and trigger the servo.

Electrical Power Subsystem (EPS) 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.

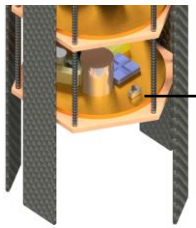
Electrical Power Subsystem Requirements

	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.	✓			

Electrical Power Subsystem 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 ELECTRICAL BLOCK DIAGRAM



Easily Accessible Switch

Umbilical Source

9 V

Voltage Divider

Battery

Switch

Voltage Regulator

3.3 V

5 V

Teensy 3.5

Xbee Pro S1

Adafruit GPS

Adafruit BMP 180

Encoder

Servo Motor

Adafruit Camera

SD Card

MPU 6050

Buzzer

⊥ : Ground

: 5 V Line

: 3.3 V Line

: Data Line

Payload Power Trade & Selection

Design 1: Solar Panel

Solar Panel Model	Voltage (V)	Ampere (mA)	Size (mm)	Cost ($)
AIYIMA	4	140	70x70x0.3	5
GSPV-Mini-G	6	90	70x70x0.3	5

Advantages:
- Peaceful with nature.
- Produce its own energy.

Disadvantages:
- Needs extra electronic equiment.
- Expensive.
- Low ampere capacity

Payload Power Trade & Selection

Design 2: Battery

Battery	Type	Voltage (V)	Capacity (mAh)	Weight (g)	Size (mm)	Cost($)
Duracell	Alkaline	9	560	45	17.50x26.5x48.50	2.5
Duracell Ultra Power	Alkaline	9	600	45	17.50x26.5x48.50	2.9
GP GPCR-V9	Lithium Primary	9	800	34	16.5x26x48	3.5

SELECTED

Chosen Design: 2
GP GPCR-V9

Advantages:
- Provides constant power.
- Easy to use.
- Efficient.
- High ampere capacity.

PAYLOAD POWER BUDGET

NO	Electronic Components	Duty Cycle (%)	Operational Current (mA)	Operational Voltage (V)	Total Capacity (mAh)	Power Consumption (Wh)	Source
1	Teensy 3.5	100	50	3.3	133.27	0.66	Datasheet
3	MCU6050	100	3.9	5	0.325	0.0016	Datasheet
4	Xbee Pro S1	100	200	3.3	317.16	0.792	Datasheet
5	Encoder	100	200	5	16.66	0.083	Estimated
6	Servo Motor	0.033	100	5	0.27	1.38×10^{-3}	Datasheet
7	Buzzer	25	30	5	15	0.075	Datasheet
8	Camera	100	100	5	8.33	0.041	Datasheet
9	SD Card	100	100	5	8.333	0.041	Estimated
10	Real Time Clock	100	1.5	5	0.125	0.62×10^{-3}	Datasheet
				TOTAL	**499.5 mAh**	**1.695 Wh**	

PAYLOAD POWER BUDGET

Required Power (Wh)	Required Capacity (mAh)	Margin (%)	Total Capacity (mAh)	Total Power Consumed (Wh)
1.695 Wh	499.5 mAh	20% (0.339 Wh & 99.9 mAh)	599.4 mAh	2.034 Wh

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 tolerance considered in calculations for both capacity and power consuption indicated as margin above.

PAYLOAD POWER BUDGET

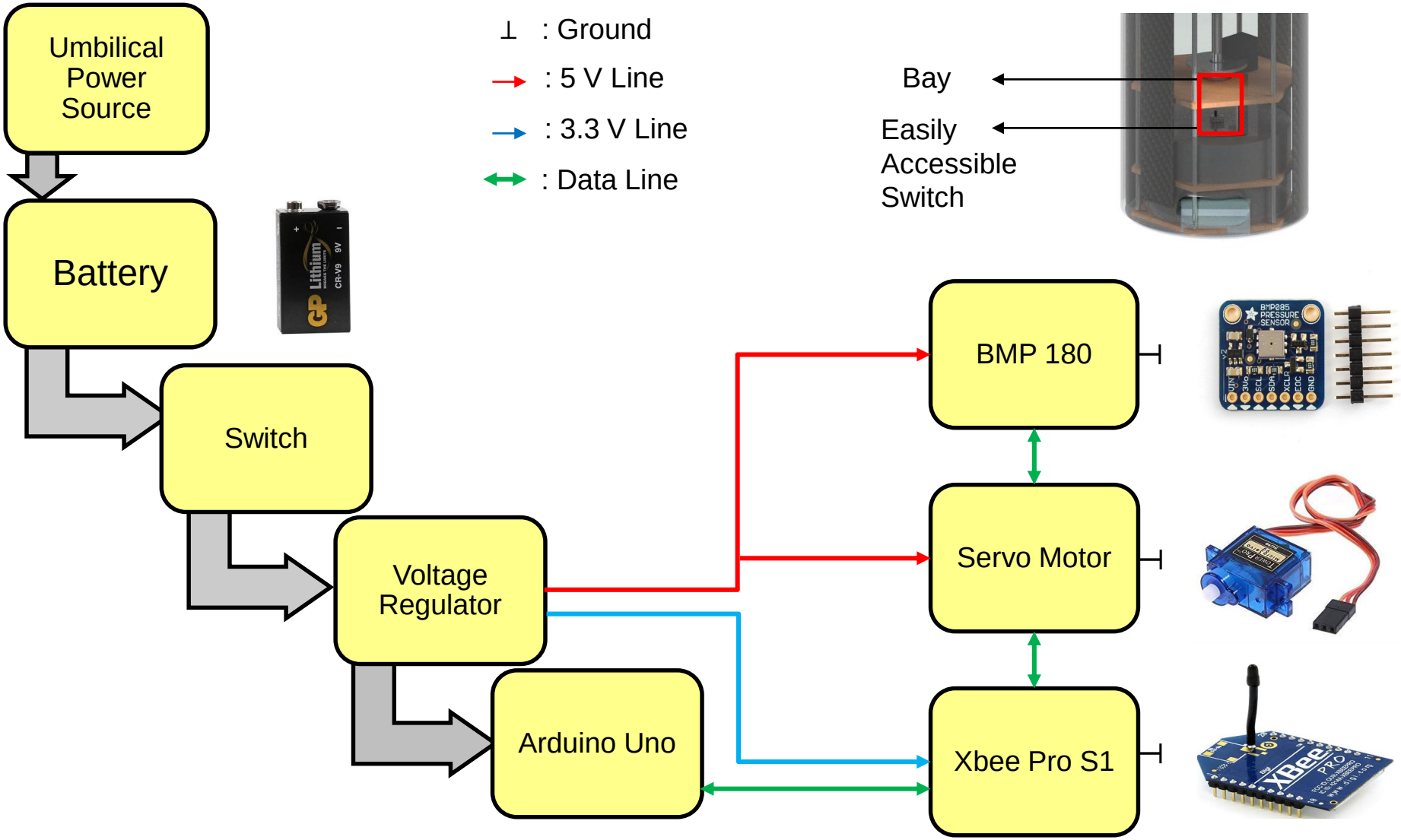
Total Power Consumption(Wh)	Total Available Power(Wh)
2.034 Wh	7.2

Total Capacity Consumption(mAh)	Total Available Capacity(mAh)
599.4 mAh	800 mAh

- Total power consumption and capacity 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 along 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



Container Power Trade & Selection

Design 1: Solar Panel

Solar Panel Model	Voltage (V)	Ampere (mA)	Size (mm)	Cost ($)
AIYIMA	4	140	70x70x0.3	5
GSPV-Mini-G	6	90	70x70x0.3	5

Advantages:
- Peaceful with nature.
- Produce its own energy.

Disadvantages:
- Needs extra electronic equiment.
- Expensive.
- Low ampere capacity

Container Power Trade & Selection

Design 2: Battery

Battery	Type	Voltage (V)	Capacity (mAh)	Weight (g)	Size (mm)	Cost($)
Duracell	Alkaline	9	560	45	17.50x26.50x48.50	2.5
Duracell Ultra Power	Alkaline	9	600	45	17.50x26.50x48.50	2.9
GP GPCR-V9	Lithium Primary	9	800	34	16.5x26x48	3.5

SELECTED

Chosen Design: 2

GP GPCR-V9

Advantages:

- Provides constant power.
- Easy to use.
- Efficient.
- High ampere capacity.

Container Power Budget

NO	Electronic Components	Duty Cycle (%)	Operational Current (mA)	Operational Voltage (V)	Total Capacity (mAh)	Power Consumption (Wh)	Source
1	Arduino Uno	100	20	5	1.66	0.0083	Datashee
2	Adafruit BMP180	100	0.65	3.3	0.0541	$0.178x10^{-3}$	Datasheet
3	Servo Motor	0.033	100	5	0.27	$1.38x10^{-3}$	Datasheet
4	Xbee Pro S1	100	200	3.3	317.16	0.792	Datasheet
				TOTAL	**319.14 mAh**	**0.793 Wh**	

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

So there is no battery configuration.

Container Power Budget

Required Power (Wh)	Required Capacity (mAh)	Margin (%)	Total Capacity (mAh)	Total Power Consumed (Wh)
0.793 Wh	319.14 mAh	20% (0.1586 Wh & 63.828 mAh)	382.96 mAh	0.9516 Wh

- Total power consumption and capacity is calculated related with selected parts.
- There is a margin considered in calculations for both capacity and power consumption indicated as margin above.

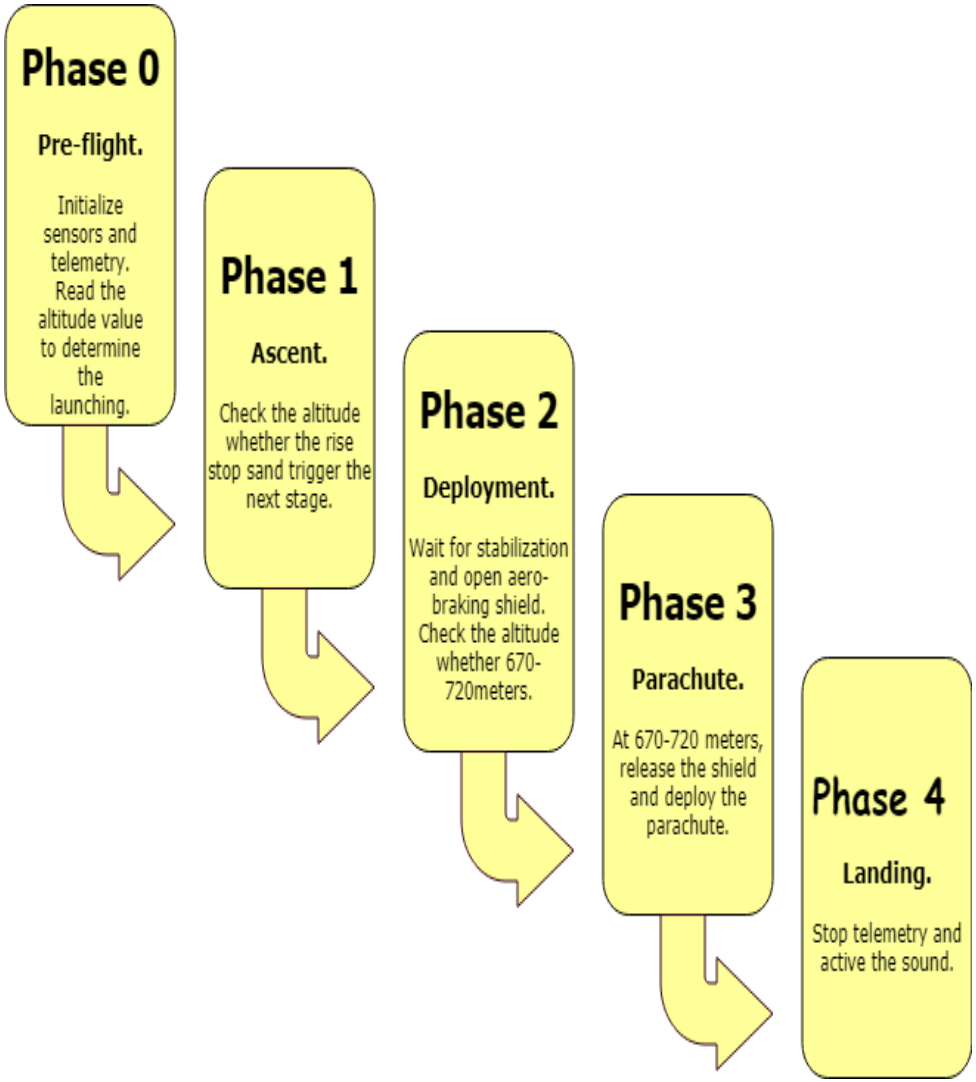
Total Power Consumption(Wh)	Total Available Power(Wh)
0.9516 Wh	7.2

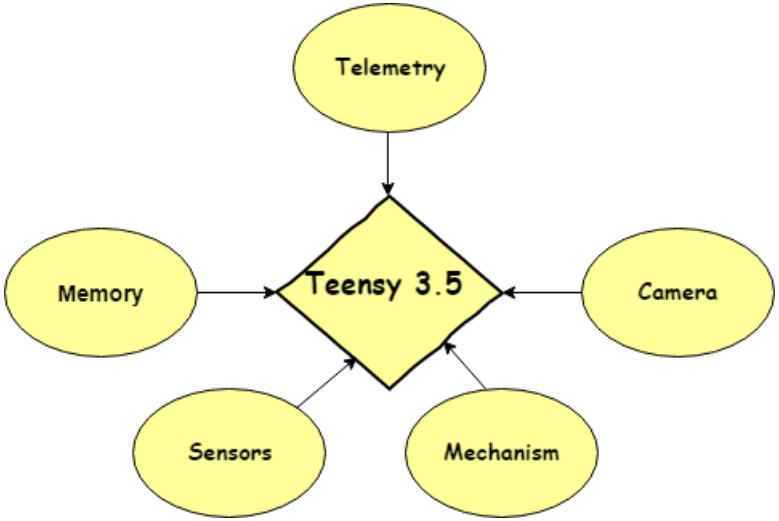
Total Capacity Consumption(mAh)	Total Available Capacity(mAh)
382.96 mAh	800 mAh

Flight Software (FSW) Design

Ulas Gulec

FSW Overview





Program Language	Development Enviroment
C\C++	Arduino IDE

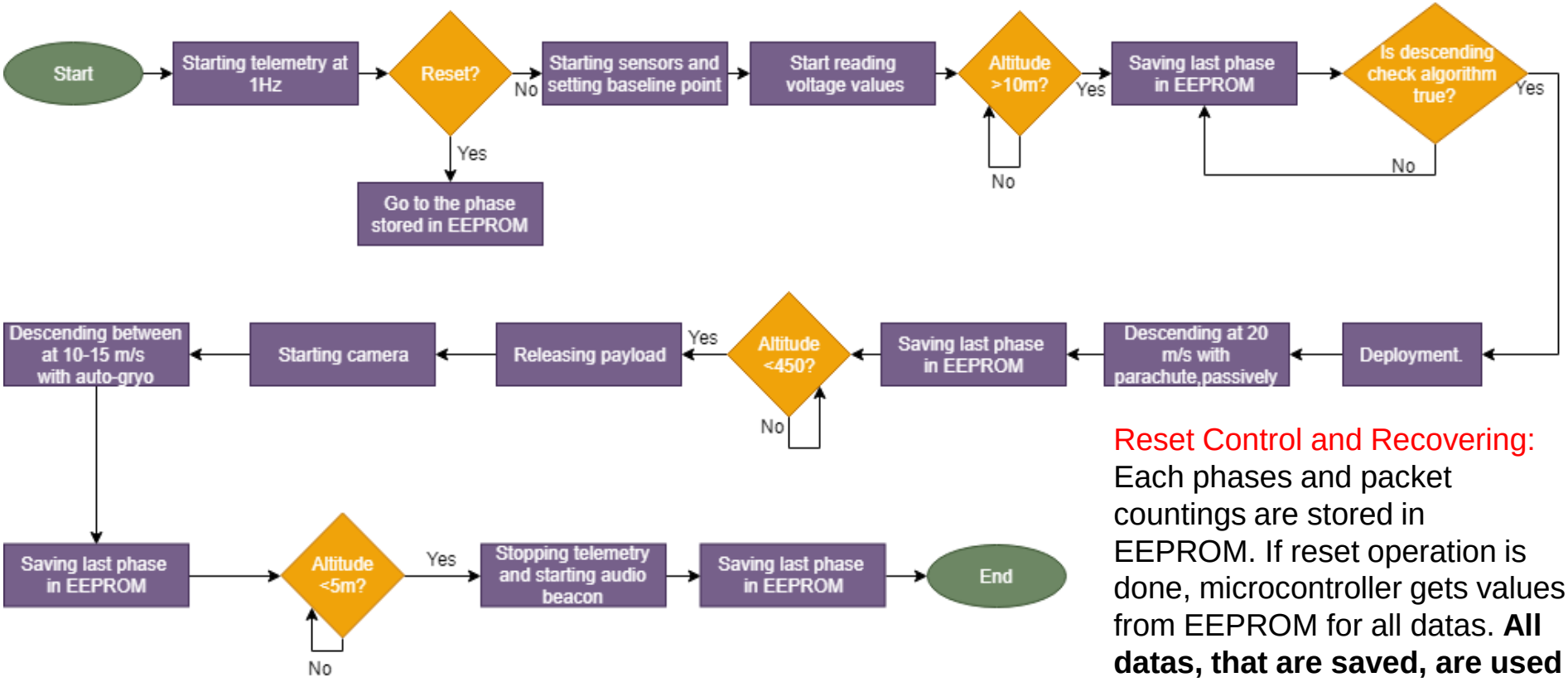
Brief Summary Of FSW Tasks:

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 Requirements

	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.	✓	✓		

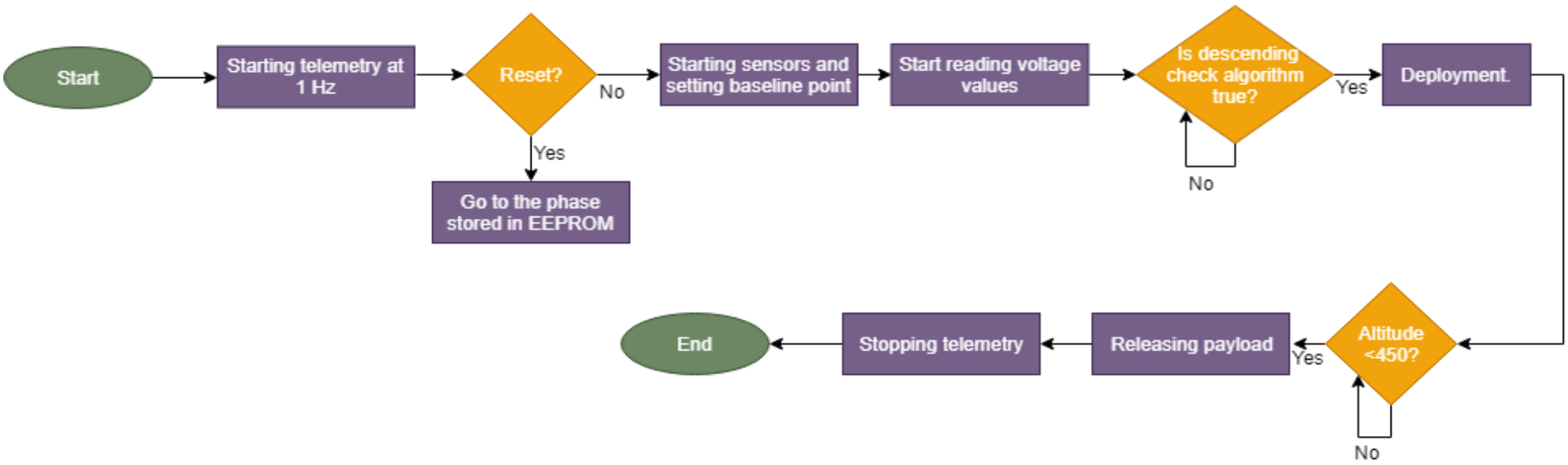
Payload FSW State Diagram



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

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 FSW State Diagram



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. **Pressure and voltage data, that are saved, are used for recovering.**

Pressure and voltage 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.

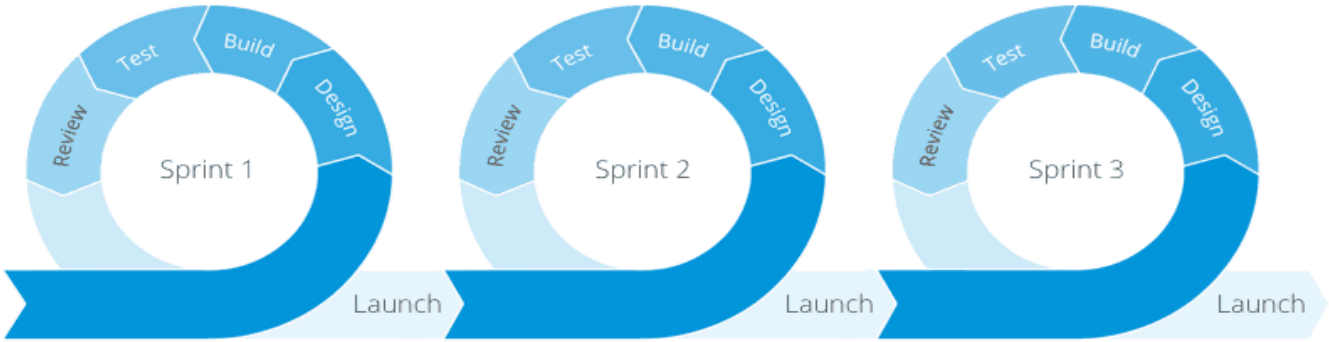
Note : We do not aim to use flight software diagram for container. If we will face any problem during our tests, we would use this flight software diagram for container.

Software Development Plan

- **Avoiding Late Software Development:**

  We will use Agile development methodology. We will divide the project into the sprints. Each sprint will be tested and verified 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 circiut board will be printed on PCB. Then, software will be run with temporary values.

- **Test Methodology:**

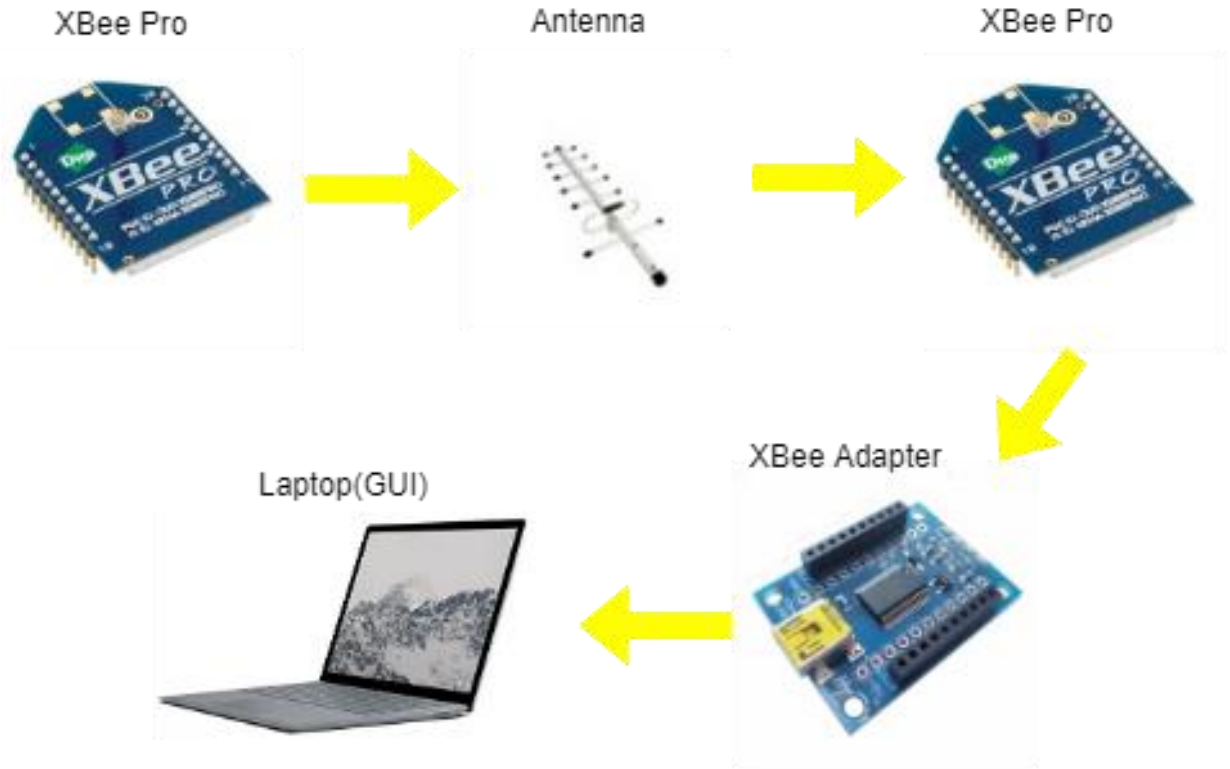
Each component will be tested seperately. When iteration of any integration is done, tests will be done again such as; free-fall drop test, communication test, debugging, power test.

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

Ground Control System (GCS) Design

Ulas Gulec

GCS Overview



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

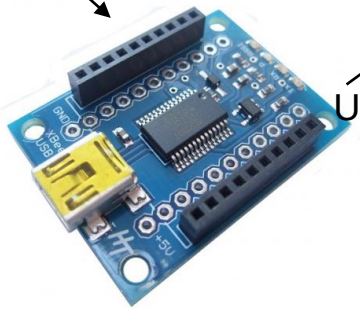
Spesifications	
Battery	Can operate 4 hours
Overheating Mitigation	External cooler under the laptop Sun shielding umbrella
Auto Update Mitigation	Auto update will be disabled Internet connection will be disabled

SMA to SMA cable and connector

Rubber Duck Antenna

XBee Module

XBee module is connected to XBee adapter with slot.

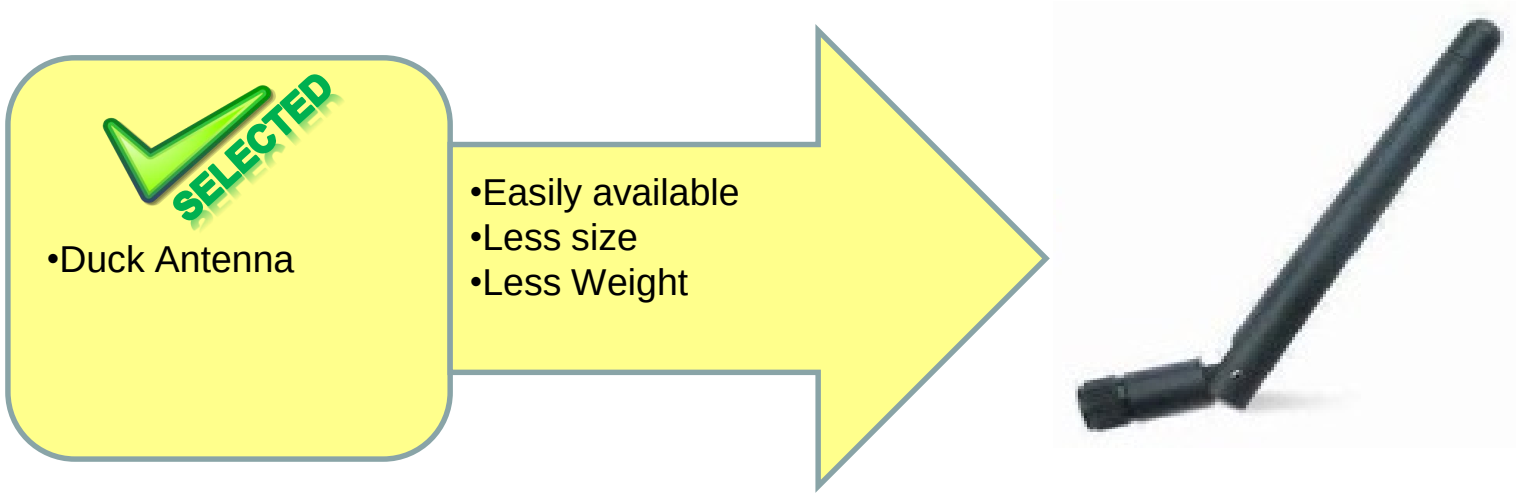


XBee Adapter

USB Converter

GCS Antenna Trade & Selection

Model	Type(and connector)	Gain (dBi)	Dimensions (mm)	Radiation Pattern	Frequency Range (GHz)
Duck Antenna	Dipole (SMA RF Connector)	2	106x13	Omni directional	2.4-2.5
Magnetic Mount Antenna	Dipole (SMA RF Connector)	7	200x10	Omni directional	2.4 ISM Band
Buccaneer Antenna PX0407	Connector Supplied with SMB plug	2	105x19	Omni directional	2.4-2.5



GCS Software

Software Packages: GUI Design will be done in C#.

Timer

00.00.00

Real Time Graphs

Altitude

Pressure

Voltage

Temperature

CanBee

Real Time Camera

Telemetry

Receiving Packets Counter

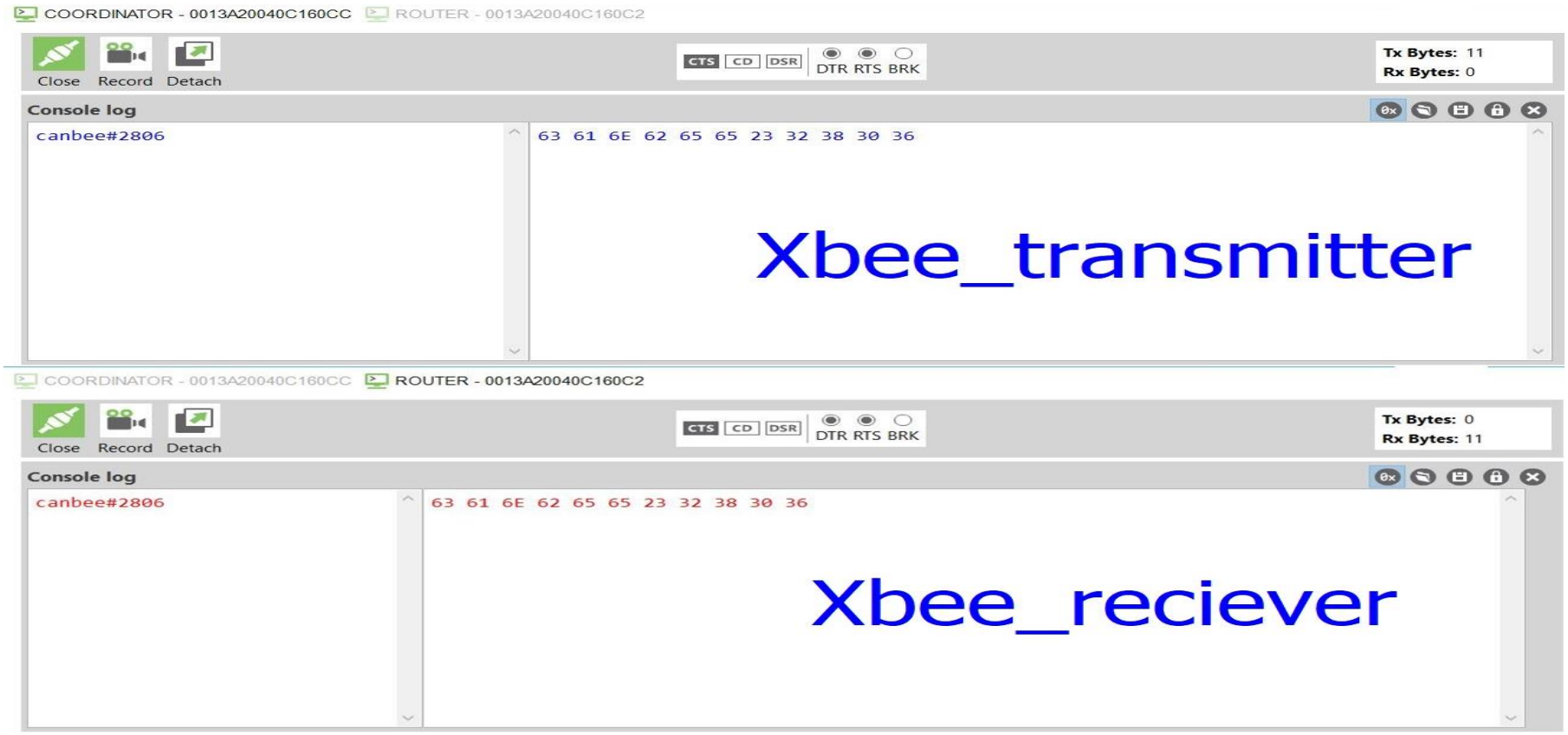
1

Command Window

Command

Send

GCS Software



Calibration: Initial values of barometric and row/pitch angles will be set to zero value. After that, we will send with Xbee transmitter and will recieve from Xbee receiver.

GCS Software

1.TELEMETRY RAW DATA RECEIVED

Raw data will be recieved from Xbee adapter.

<TEAM ID >,<MISSIONTIME>,<PACKET COUNT>,<ALTITUDE>,<PRESSURE>,<TEMP>, <VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>,<X>,<Y>,<Z>,<SOFTWARE STATE>,<CAMERA STATE>

2.PARSING TELEMETRY DATA

Raw data will be parsed using an algorithm to create CSV file easily.

{[0]:TEAM ID, [1]:MISSION TIME,[2]:PACKET COUNT,[3]:ALTITUDE, [4]:PRESSURE,[5]:TEMP,[6]:VOLTAGE,[7]:GPS TIME, [8]:GPSLATITUDE,[9]:GPS LONGITUDE,[10]:GPS ALTITUDE,[11]:GPS SATS,[12]:X, [13]:Y,[14]:Z,[15]:SOFTWARE STATE,[16]:CAMERA STATE}

3.SAVE DATA IN CSV FILE TYPE

Data parsed will be saved to bottom of the CSV file.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Team ID	Mission Time	Packet Count	Altitude	Pressure	Temp	Voltage	GPS Time	GPS Latitude	GPS Longitude	GPS Altitude	GPS Sats	X	Y	Z	Software State	Camera State

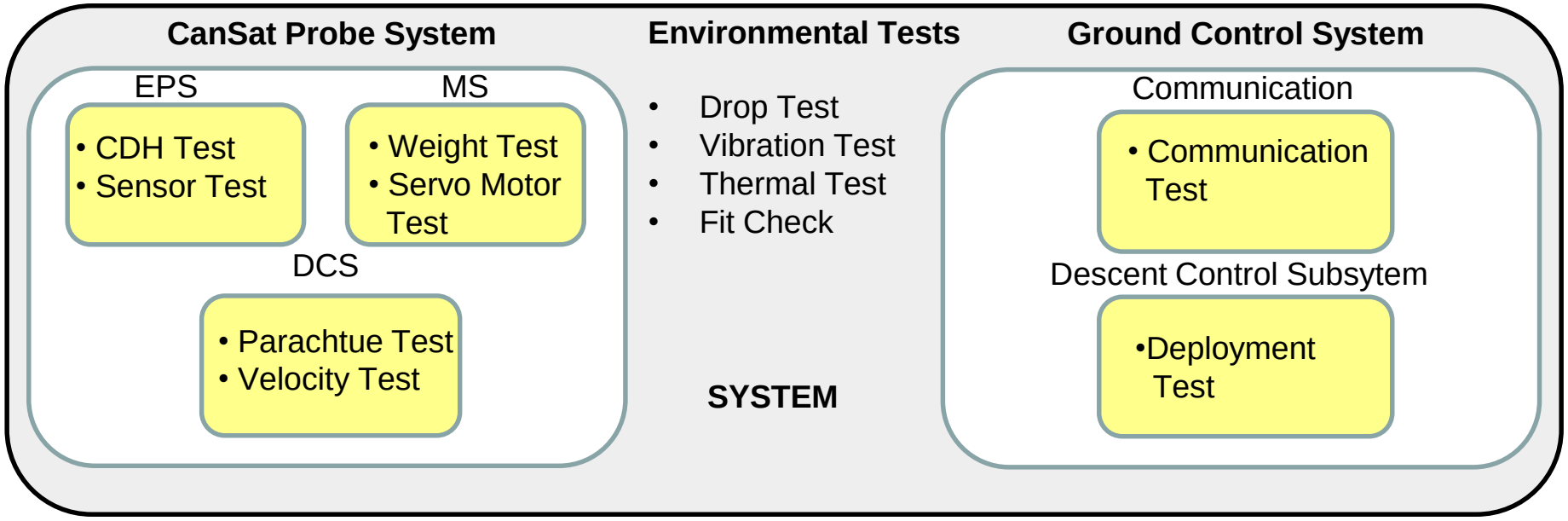
CanSat Integration and Test

Suhan Mergen

CanSat Integration and Test Overview

General View of Integration & Test

- System will be tested with several different methods to examine all subsytems and components within the scope of integrity.
- If any problem arise during test process, other selections will be reserved the right to change as an alternative or backup option.
- System will be integrated with all subsystems make together with using bolts, electric connections with pcb and etc.



CanSat Integration and Test Overview

Subsystem Level Test

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

OPERATION	
CanSat Probe System	**Ground Control System**
• EPS	• Descent Testing
• MS	• Communications
• Sensors	• Mechanisms
• FSW	• Deployment
• CDH	
• Descent Control	

CanSat Integration and Test Overview

Integrated Level Test

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

: Subsystem Level Test

: Integrated Level Test

CanSat Probe System

SENSOR		FSW
• Sensor Calibrations	Subsystems	• Algorithm Test
• Operatable Sensors Test		
CDH		**MS**
• Accurate Data Transfer Test		• Aerodynamic Test
• XBee Data Transfer Range and Configuration		• Weight Control Test
		• Servo Motor Adjustment
EPS	**RC**	**DCS**
• Voltage and Current MeasurmentTest	• Communication Test	• Velocity Test
		• Seperation of Probe Test

CanSat Integration and Test Overview

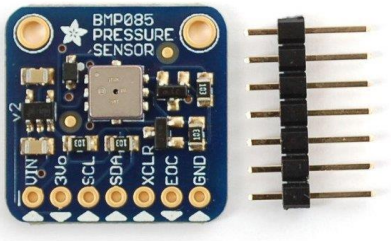
Environmental Level Test

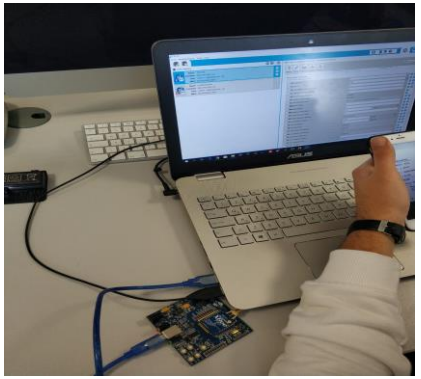
- Finally, environmental test plan is carried out as vibration test, drop test and thermal test according to their requirements.

CanSat Probe System	
Drop Test	Test must verify the container parachute and payload resistance against the deployment from rocket.
Vibration Test	This test must verify the accurate mounting and connections of all components.
Thermal Test	Test must verify the payload can operate accurately up to specified temperatures.

Subsystem Level Testing Plan

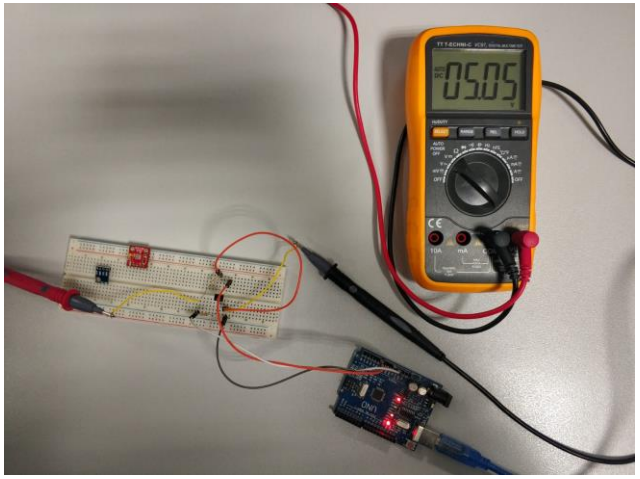
Sensor	
Test	**Description**
Sensor Calibraiton	All sensors are calibrated relatively a verified source.
Operatable Sensors	All sensors are checked to see if they works or not.
Test	**Description**
Communication Data Handling	
Accurate Data Transfer Test	Data transfer speed is checked besides accuracy between Xbee reciever and transmitter is tested.
XBee Data Transfer Range and Configuration	Xbee transfer module is tested to accurate data transfer with a certain distance. Also outdoor and indoor tests are done directly.

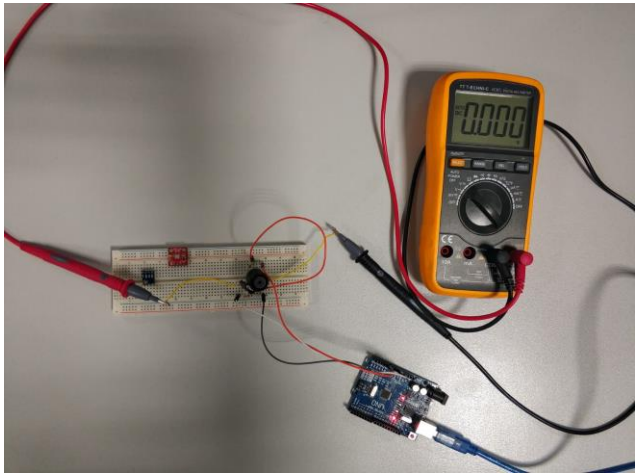




Subsystem Level Testing Plan

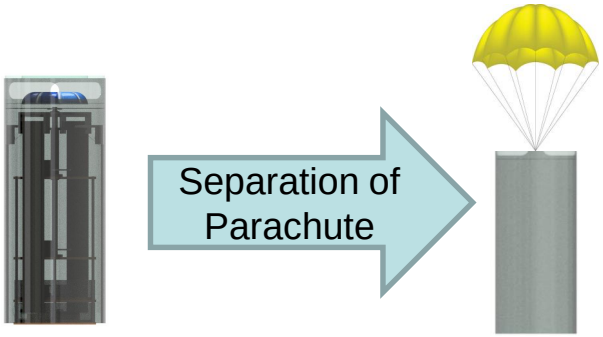
Electrical Power	
Test	**Description**
Voltage Measurment	Chosen power source battery is connected to components and voltage values are measured with multimeter.
Current Measurment	Operation currents are checked with referance to EPS calculations.
Radio Communication	
Test	**Description**
Communication	Noises are filtered by a filter.
Flight Software	
Test	**Description**
Algorithm Test	Code is checked with considering of time phases.

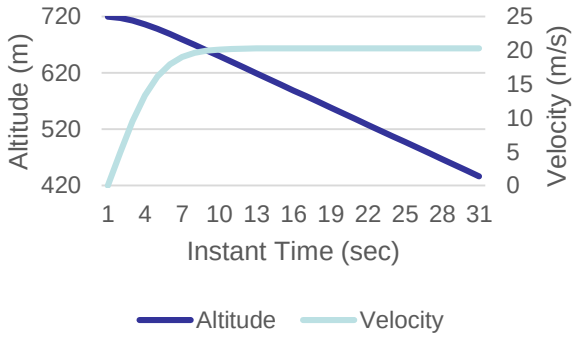




Subsystem Level Testing Plan

Mechanical	
Test	**Description**
Aerodynamic Test	Container and parachute design is inspected for aerodynamic flow.
Weight Control Test	Total mass is checked according to the requirements.
Servo Motor Adjustment	Servo voltage and current values are measured by multimeter
Descent Control	
Test	**Description**
Separation of Parachute Test	Parachute separation mechanism is tested during descent process.
Velocity Test	Parachute and autogyro speeds are tested duruing descent process at different altitudes.



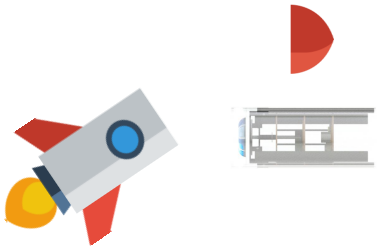


Integrated Level Functional Test Plan

- Integrated test level is interested with consistence of all components in common. Each subsystem may operate accurately. Integrated level test is related with problems may occur between subsystems due to interaction.
- CanSat probe is released with a drone at 720m height and free fall test is operated. Other tests will be realized in the future.

FSW

Deployment Test



Parachute Release Mechanism

- MS

Mechanical&Descent Control Test

CanSat & Autogyro Release

- EPS
- MS
- CDH
- Sensors

Communication&Descent Control Test

Descent of CanSat with drone & Data Communication & Free Fall Test

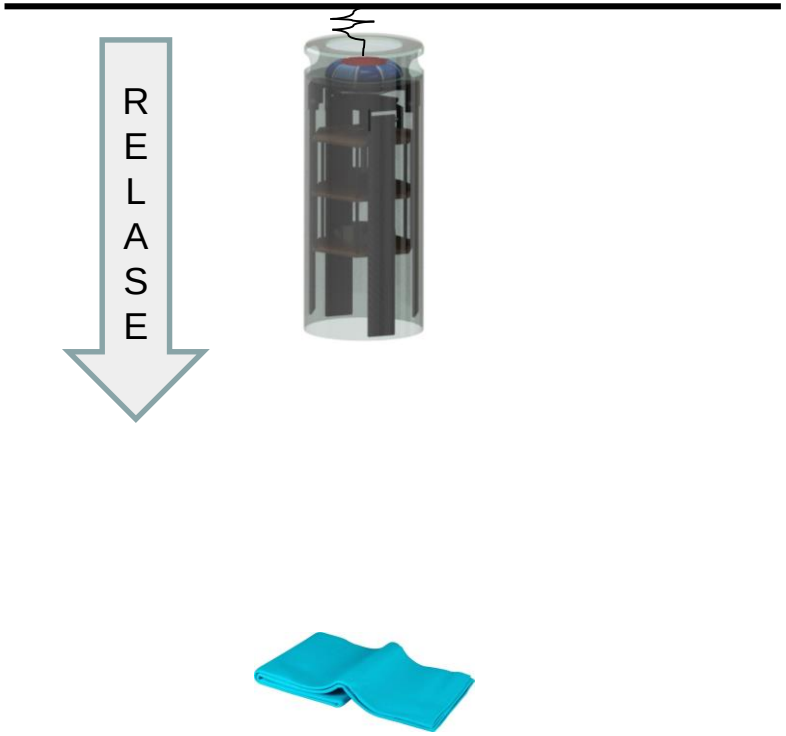
- EPS
- MS
- CDH
- Sensors

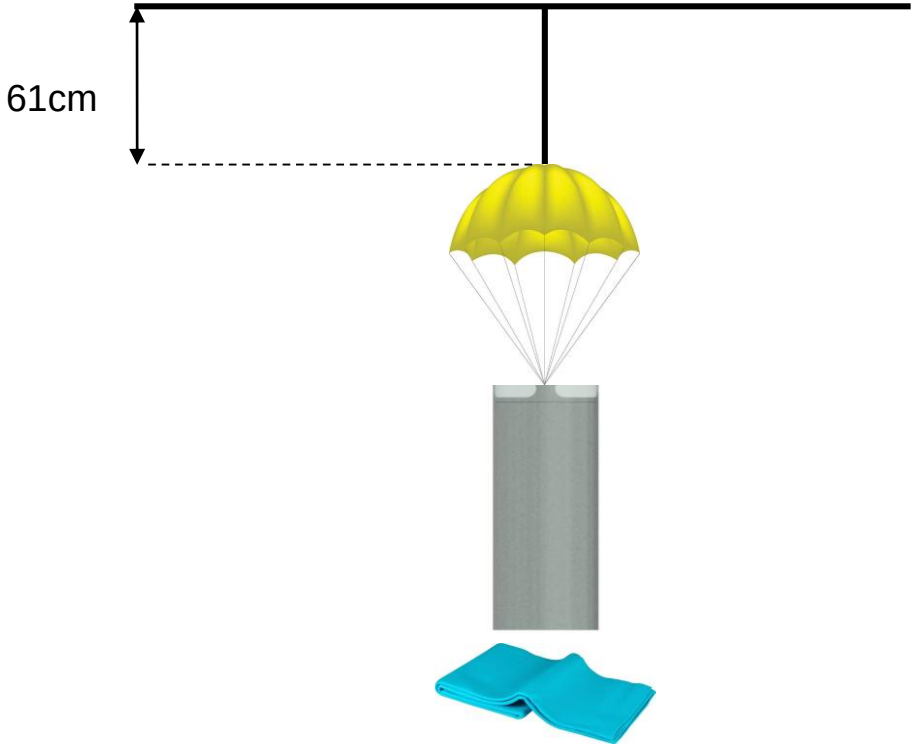
Integrated Level Functional Test Plan

SYSTEM	SUBSYTEM	TEST	TEST DESCRIPTION
CanSat Probe	Descent Control	Descent Testing	Integration of descent mechanisms will be tested at different altitudes like parachute and auto gyro will be examined to observe harmonizing problems.
	Mechanical	Mechanisms	Performance of servo will be observed and opening times of container and parachute will be observed.
Ground Control System	Communication	Communication	Noises occur during data transfer are realized and filtered as a result. Signal quality and loss observed during test.
	Descent Control	Deployment	Servo and parachute separations checked.

Environmental Test Plan

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





Environmental Test Plan

Thermal Test:

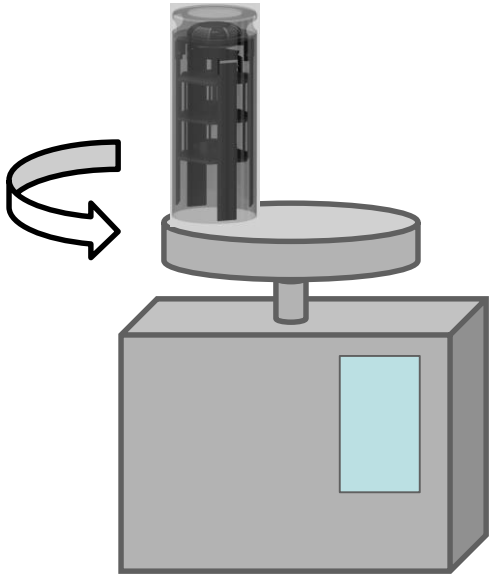
- CanSat probe will be heated up to 60˚C in a thermal chamber. Components are going to examined to verify that they continue to function under the thermal exposure for two hours. Condenser is used to decrease temperature value of electrical components inside of the science probe.

Environmental Test Plan

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

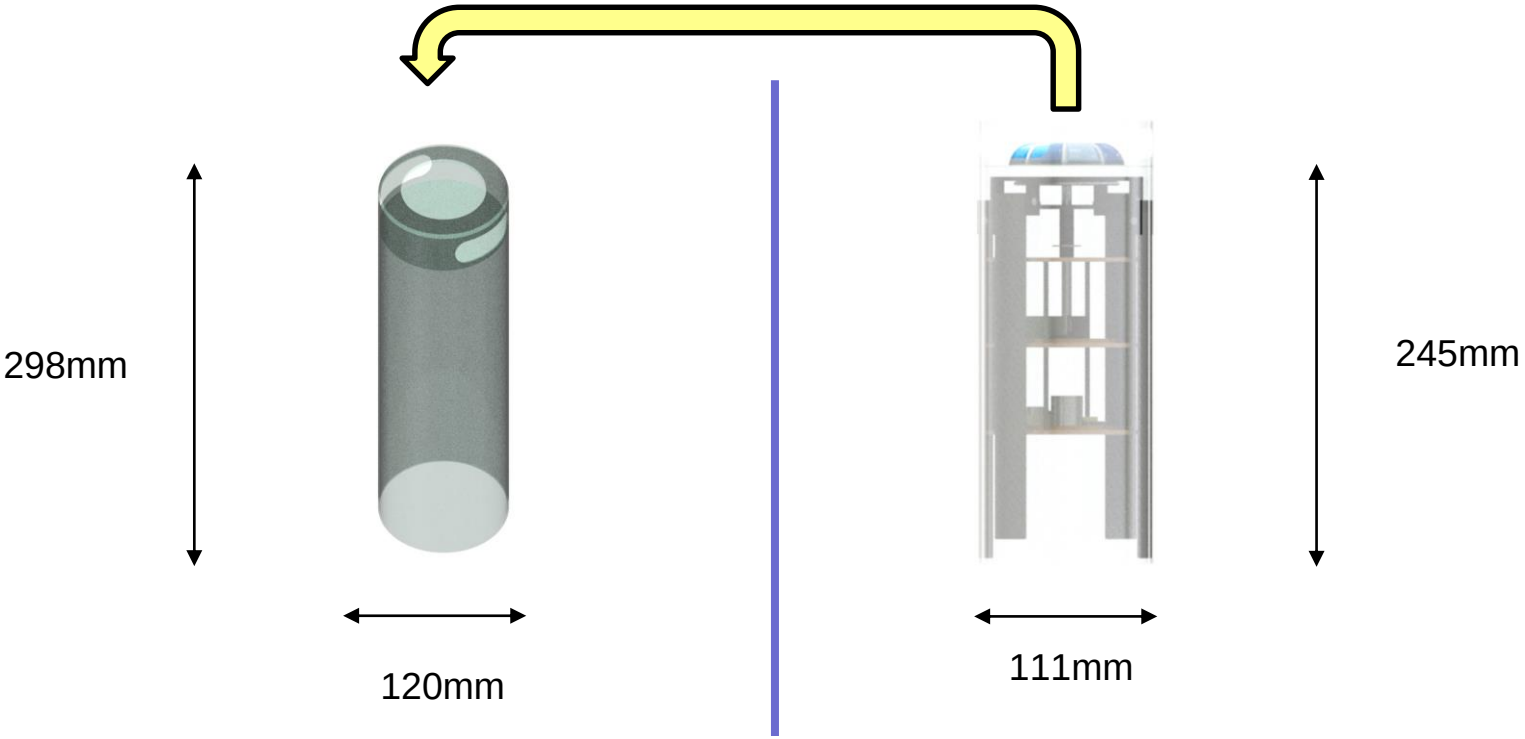
Sand Orbit

CanSat



Environmental Test Plan

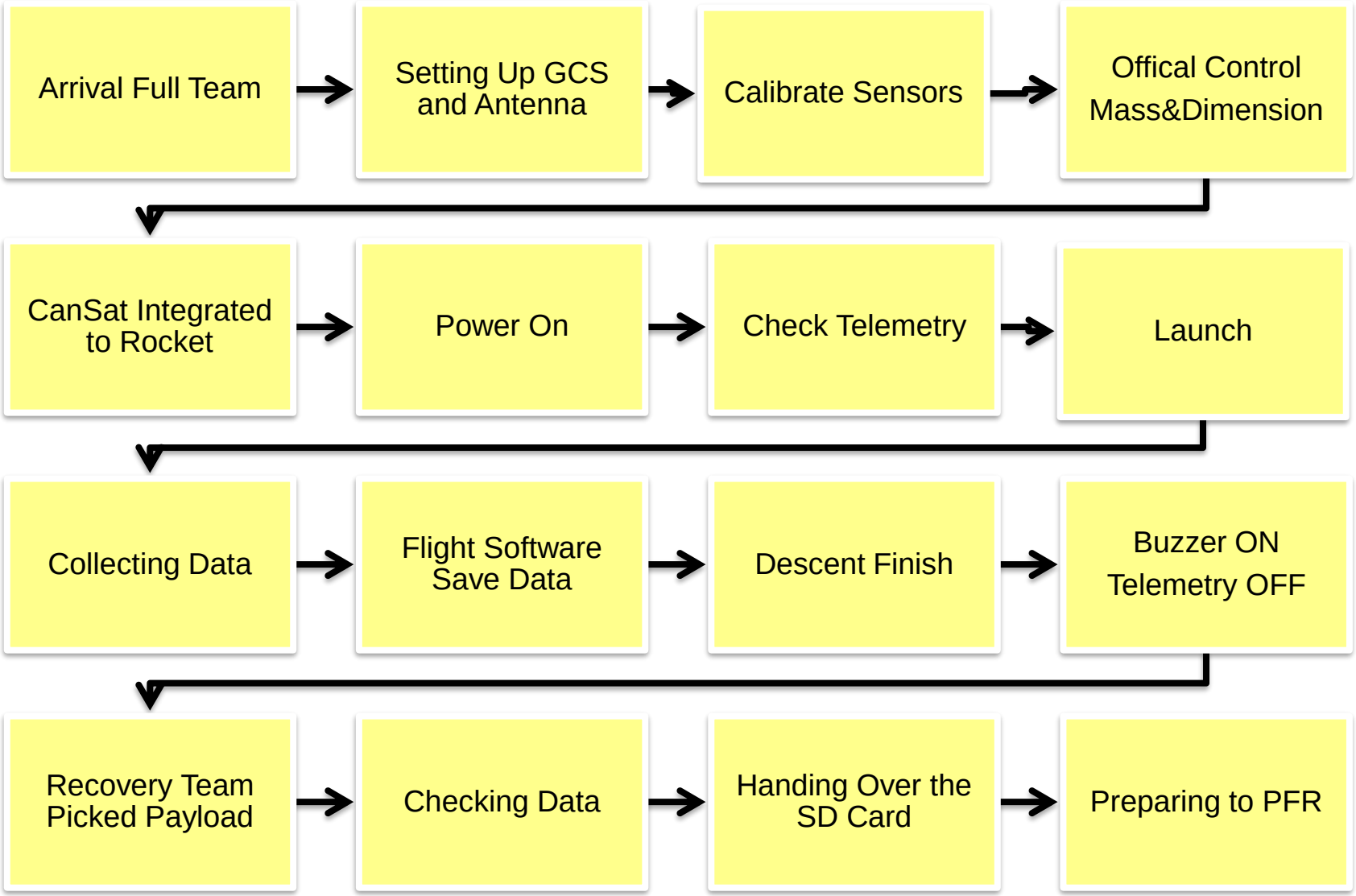
Fit Check: CanSat container sizes will be manufactured with respect to probe size in university laboratory. CanSat probe will be placed into the container and will be inspected as if system decline along descent process.



Mission Operations & Analysis

Suhan Mergen

Overview of Mission Sequence of Events



Overview of Mission Sequence of Events

Team member roles and responsibilities

- **Misson Control Officer:**

  Eyup Kocak(EK)

- **Ground Station Crew:**

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

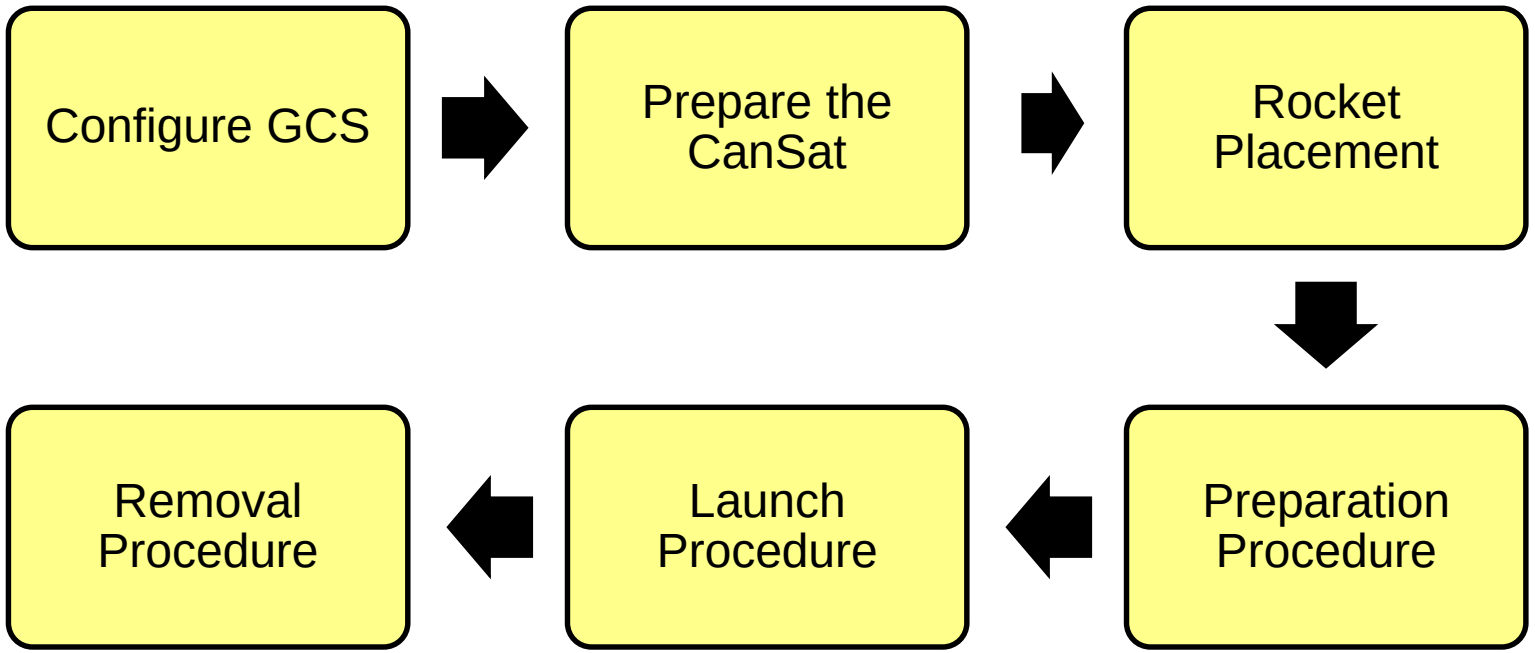
- **Recovery Crew:**

  Aydin Sisman(AS), Baran Karadag(BK)

- **CanSat Crew:**

  Bedirhan Ceylan(BC), Alpcan Altuntas(AA), Dogukan Kuyumcu(DK), Suhan Mergen(SM), Ulas Gulec(UG)

Mission Operations Manual Development Plan

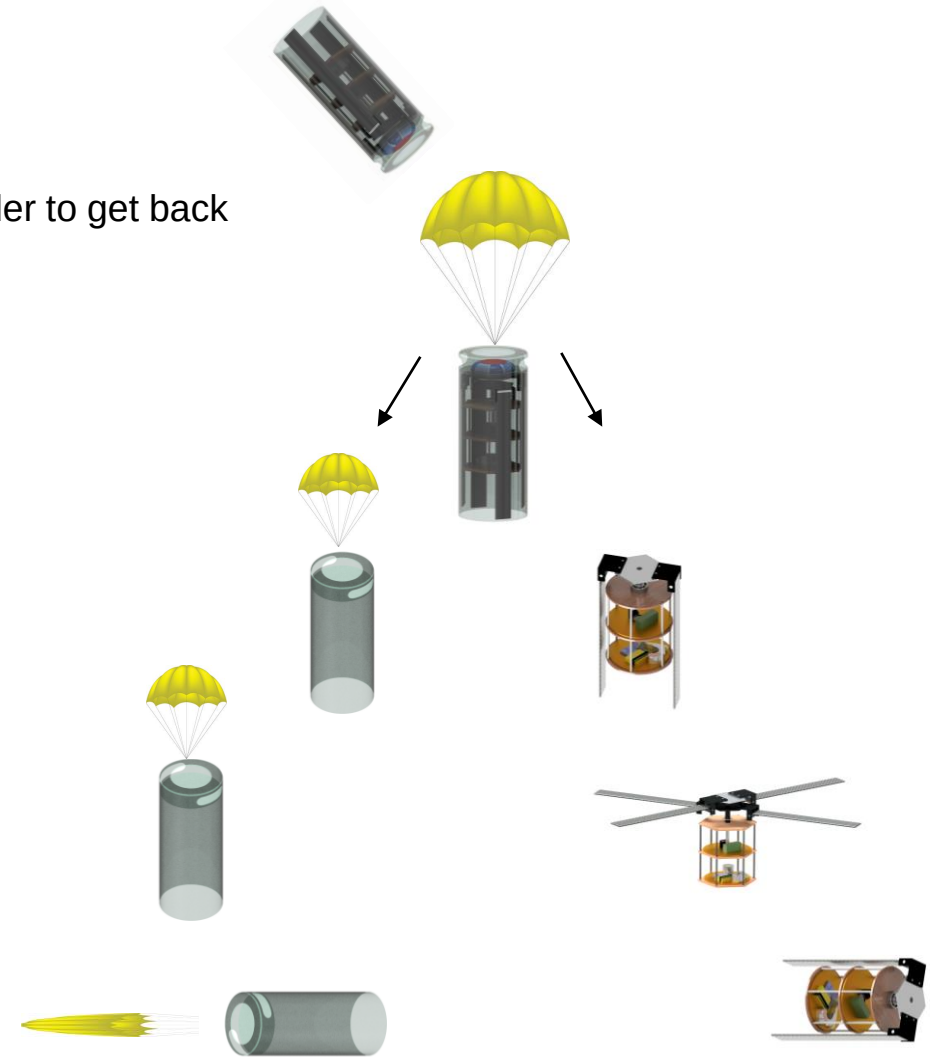


CanSat Location and Recovery

- **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 on the probe and the container.

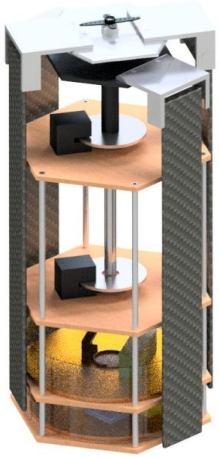


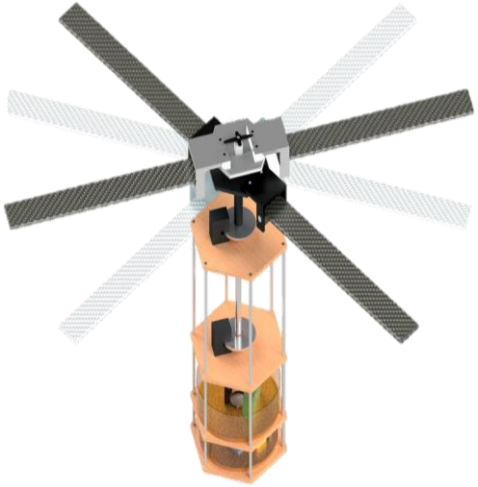
Requirements Compliance

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 (multiple slides, as needed)

# of CR	Requirement	Compliance	Reference Slide #	Comments
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Partial	75	Tests needed will be done.
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	20	
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	55,66	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	138	
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	-	
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply	-	
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Partial	39,71	Tests needed will be done

Requirements Compliance (multiple slides, as needed)

# 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	50	Tests needed will be done
9	The container shall release the payload at 450 meters +/- 10 meters.	Partial	51	Tests needed will be done
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Comply	52,59	
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Partial	52	Tests needed will be done
12	All descent control device attachment components shall survive 30 Gs of shock.	Partial	-	Tests needed will be done
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	72	
14	All structures shall be built to survive 15 Gs of launch acceleration.	Partial	-	Tests needed will be done

Requirements Compliance (multiple slides, as needed)

# of CR	Requirement	Compliance	Reference Slide #	Comments
15	All structures shall be built to survive 30 Gs of shock.	Partial	-	Tests needed will be done
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply		
17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial		Test needed will be done.
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	-	
20	The science payload shall measure altitude using an air pressure sensor.	Comply	27	
21	The science payload shall provide position using GPS.	Comply	27	

Requirements Compliance (multiple slides, as needed)

# of CR	Requirement	Compliance	Reference Slide #	Comments
22	The science payload shall measure its battery voltage.	Comply	33	
23	The science payload shall measure outside temperature.	Comply	31	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	35	
25	The science payload shall measure pitch and roll.	Comply	34	
26	The probe shall transmit all sensor data in the telemetry	Comply	77	
27	The Parachute shall be fluorescent Pink or Orange	Comply	138	
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	107	Tests needed will be performed.

Requirements Compliance (multiple slides, as needed)

# 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	107	Test will be performed.
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	107	
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	84	
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	84	
33	XBEE radios shall not use broadcast mode.	Comply	84	
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	153	
35	Each team shall develop their own ground station.	Partial	115	Test will be performed.

Requirements Compliance (multiple slides, as needed)

# of CR	Requirement	Compliance	Reference Slide #	Comments
36	All telemetry shall be displayed in real time during descent.	Comply	105,106	
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	85	
38	Teams shall plot each telemetry data field in real time during flight.	Partial	85	Tests will be performed
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	-	
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	-	
41	Both the container and probe shall be labeled with team contact information including email address.	Comply	138	

Requirements Compliance (multiple slides, as needed)

# 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	105	
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	99	
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	99	
47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Comply	93	
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Partial	-	Test will be performed.

Requirements Compliance (multiple slides, as needed)

# 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	95	
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	55	
51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Partial	130	Test will be done.
52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Comply	59	
53	The GPS receiver must use the NMEA 0183 GGA message format.	Comply	32	Datasheet information
54	The CANSAT must operate during the environmental tests laid out in Section 3.5.	Comply	120	

Requirements Compliance (multiple slides, as needed)

# of CR	Requirement	Compliance	Reference Slide #	Comments
55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	96	
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	36	Tests wil be performed
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.	Partial	36	Direction of camera will be assembled

Management

Suhan Mergen

CanSat Budget – Hardware

	No	Part	Model	Quantity	Cost($)	Procurement
ELECTRONICS	1	Microcontroller	Teensy 3.5	1	24,95	Actual
	2	Telemetry	Xbee Pro S1	1	24,50	Actual
	3	Microcontroller	Arduino Uno	1	23,38	Actual
	4	GPS	Adafruit Ultimate GPS Breakout	1	40,95	Actual
	5	Air presurre	Adafruit BMP180	1	9,95	Actual
	6	Air temperature	Adafruit BMP180	1	9,95	Actual
	7	Pitch and Roll	Adafruit MPU6050	1	8,31	Actual
	8	Camera	Adafruit Mini Spy Camera	1	12,50	Actual
	9	Memory	SunDisk Ultra	1	6,4	Budgeted
	10	Buzzer	YT12095	1	0,43	Budgeted
	11	Amplifier (Telemetry)	Own Design	2	15x2	Estimated
	12	Probe Antenna	Duck Antenna	2	7,88x2	Budgeted
	13	GCS Antenna	Duck Antenna	2	7,88x2	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 Power Source	USB Socket and Cable	1	2,5	Actual
	19	Real - Time Clock	Arduino DS1307	1	5,57	Budgeted

CanSat Budget – Hardware

	No	Part	Model	Quantity	Cost($)	Procurement
MECHANICS	1	Aluminum Chasis	3 meters	1.5 /meter	5,5	Actual
	2	Hardboard Body	0.35 meters square	4.2 / metersquare	1,5	Actual
	3	Push Pins	12	0.03 / each	0,36	Actual
	4	Propeller Parts	1 meters	1.5 / meter	1,83	Actual
	5	Parachute	1 meters square	2.7 / metersquare	2,7	Actual
	6	3 mm diameter steel rodhinges	50 cm	3 / meter	4,5	Actual
	7	Propeller	1 metersquare	245 / metersquare	40,00	Estimate

CanSat Budget – Hardware

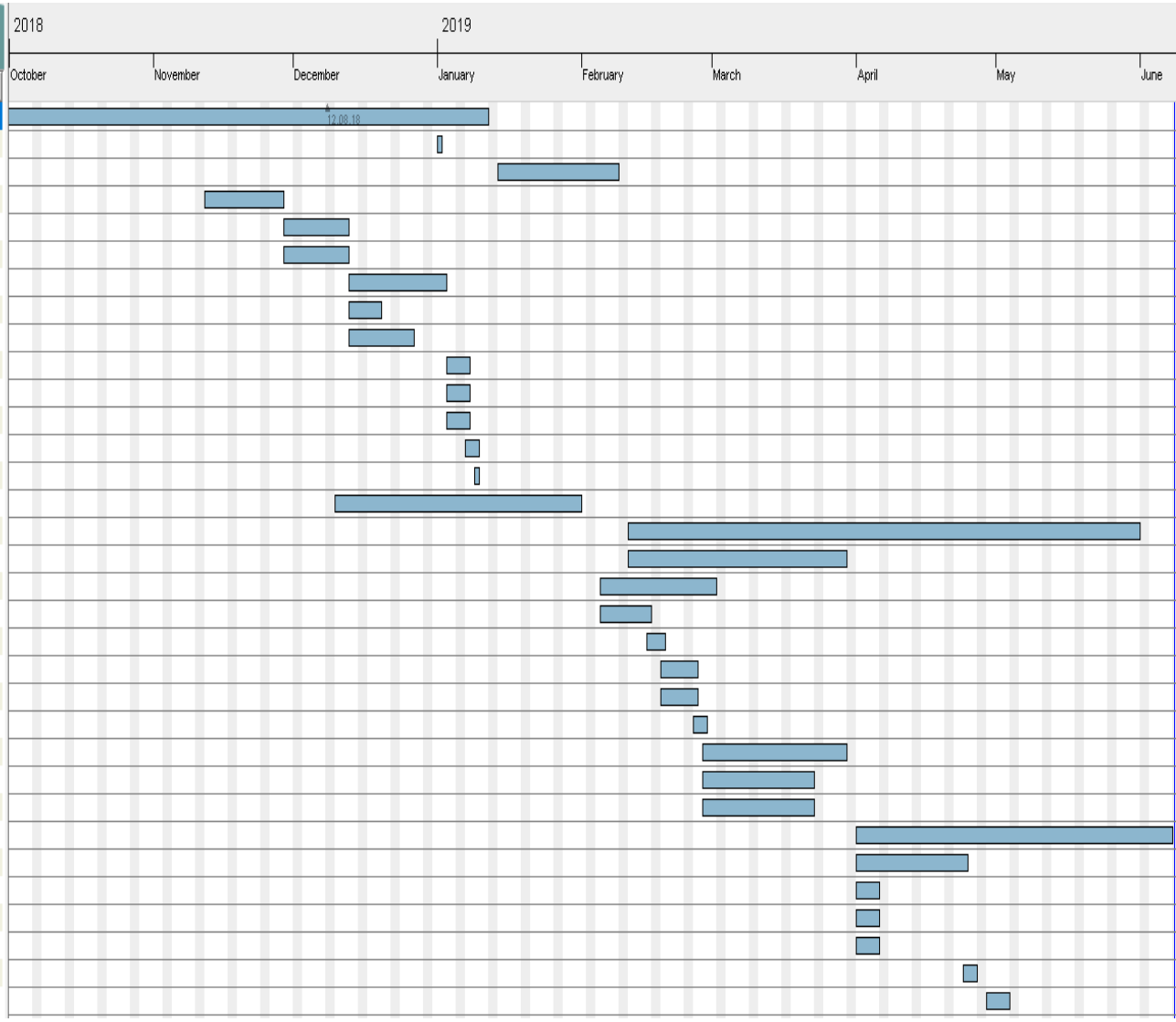
Total Electronics Cost	240,11$
Total Mechanics Cost	41,83$
Total Cost of All Components	281,94$

CanSat Budget – Other Costs

Other Costs	Quantity	Cost($)	Total Cost($)	Determination
Travel	11	704	7744	Estimated
Hotel	11(5 days)	250	2750	Estimated
Rental Cars	2(5 days)	208	416	Estimated
Computer	1	0	0	Owned
Umbrella and cooler for GCS	1	52	52	Estimated
Food	11(5 days)	140	1540	Estimated
Prototyping	2	281.94	563,88	Estimated
Grand Total			13065,88	

Program Schedule Overview

Name	Begin date	End date	Duration
First Semester	09.24.18	01.11.19	80
Christmas Holiday	01.01.19	01.01.19	1
Semester Holiday	01.14.19	02.08.19	20
Literature and Research for CanSat	11.12.18	11.28.18	13
Determining the System	11.29.18	12.12.18	10
Free-Fall Model	11.29.18	12.12.18	10
Order the Electronics Components	12.13.18	01.02.19	15
Development of FSW	12.13.18	12.19.18	5
Design of the Auto-Gyro/Container	12.13.18	12.26.18	10
Tests for Sensor Subsystem	01.03.19	01.07.19	3
Tests for Power Subsystem	01.03.19	01.07.19	3
Tests for Telemetry	01.03.19	01.07.19	3
Tested Electrical Components	01.07.19	01.09.19	3
Free Fall Test	01.09.19	01.09.19	1
Preparing to PDR	12.10.18	01.31.19	39
Second Semester	02.11.19	05.31.19	80
Critical Design Review (CDR)	02.11.19	03.29.19	35
Manufactoring of the Mechanical Components	02.05.19	03.01.19	19
Test All Subsystems Separately	02.05.19	02.15.19	9
Prototype Assembly Procces	02.15.19	02.18.19	2
Enviromental Tests	02.18.19	02.25.19	6
Telemetry and GCS Tests	02.18.19	02.25.19	6
Discussion of the Test Results	02.25.19	02.27.19	3
Preparing of the CDR	02.27.19	03.29.19	23
Performance Testing and Improving for Electronics	02.27.19	03.22.19	18
Improvement of the Auto-Gyro and Container Design	02.27.19	03.22.19	18
Preparing to Demo Flight	04.01.19	06.07.19	50
Manufactoring of the Auto-Gyro and Container	04.01.19	04.24.19	18
Combining Electronic Modules on a PCB	04.01.19	04.05.19	5
Prepare GCS Computer	04.01.19	04.05.19	5
Installation OS, Update, Setup	04.01.19	04.05.19	5
The CanSat Integrating	04.24.19	04.26.19	3
Last Check of the CanSat	04.29.19	05.03.19	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

Conclusions

Until now, we have explained our design with all mechanical, electrical and management system. The tasks which are accomplished and unfinished are listed below

Major Accomplishments	Major Unfinished Works
• Design criteria are achieved. • Modules and sensors are ordered, delivered and tested. • Algorithm for FSW is created. • GCS and GUI are created.	• Mechanical assembly isn't performed yet. • Mechanical system hasn't tested.

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

CanBee Team is ready for next missions.