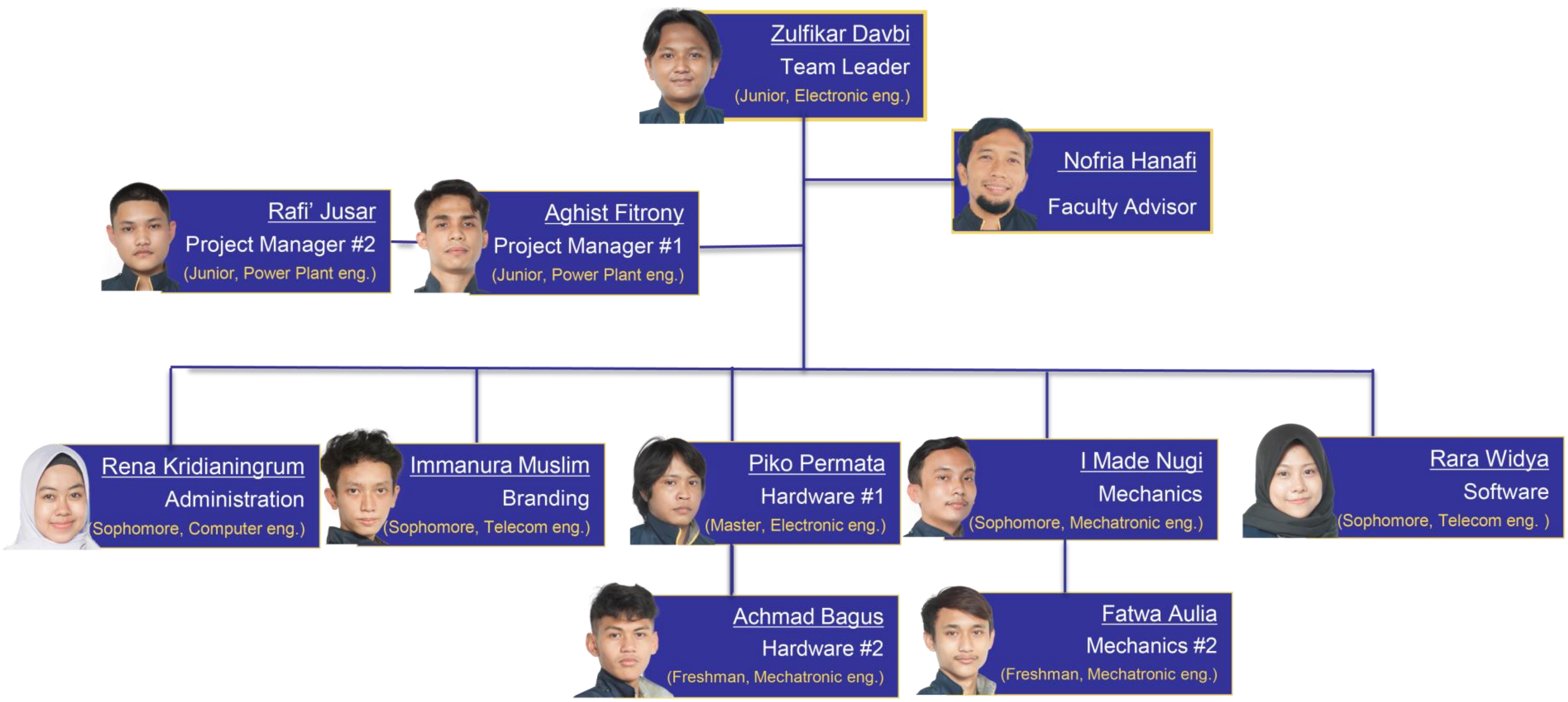
CanSat 2022
Critical Design Review (CDR)
Outline
Version 1.1

#1010

Bamantara EEPISAT

Presentation Outline

Team Organization



Acronyms

3D	Three Dimensional
A	Analysis
ABS	Acrylonitrile Butadiene Styrene
AC	Alternating Current
ADC	Analog to Digital Converter
BM	Bonus Mission
CAD	Computer Aided Design
CDH	Communication Data Handling
CONOPS	Concept of Operation
CDR	Critical Design Review
CSV	Comma Separated Value
D	Demonstration
dB	Decibel
dBi	Decibel Isotropic
DC	Direct Current
DCS	Descent Control System
EPS	Electrical Power System
FSW	Flight Software

G	Gravitational Force
GCS	Ground Control Station
GND	Ground
GPIO	General Peripheral Input Output
GPS	Global Positioning System
HDPE	High Density Polyethylene
I	Inspection
I/O	Input to Output
I2C	Inter-Integrated Circuit
I&T	Integration and Test
IDE	Integrated Development Environment
IMU	Inertial Measurement Unit
Li-Ion	Lithium-Ion
MCU	Microcontroller Unit
ME	Mechanical Subsystem
MQTT	Messaging Queuing Telemetry Transport
PCB	Printed Circuit Board

PFR	Post Flight Review
PLA	Polyactic Acid
PWM	Pulse Width Modulation
RAM	Random Access Memory
RN	Requirement Number
RPM	Revolutions per minute
RP-SMA	Reverse Polarity SMA
RTC	Real Time Clock
SD	Secure Digital
SPI	Serial Peripheral Interface
SS	Sensor Subsystem
UART	Universal Asynchronous Receiver / Transmitter (Serial)
UHMWPE	Ultra High Molecular Weight Polyethylene
VM	Verification Method
XCTU	Next Generation Configuration Platform for XBEE/RF Solutions

System Overview

Aghist Fitrony

Mission Summary

Main Objectives	

Design a CanSat that shall consist of a container and a payload. The payload shall be attached to the container by a 10 meter long tether.

1. The CanSat shall be launched to an altitude ranging from 670 meters to 725 meters above the launch site and deployed near apogee
2. After CanSat is deployed from the rocket, the CanSat shall descent using a parachute at a descent rate of 15 m/s
3. At 400 meters, the CanSat shall deploy a larger parachute to reduce the descent rate to 5 m/s.
4. At 300 meters, the CanSat shall release a tethered payload to a distance of 10 meters in 20 seconds.
5. During that time, the payload shall maintain the orientation of a video camera pointing in the south direction and the video camera shall be pointed 45 degrees downward to assure terrain is in the video.
6. The container shall transmit its telemetry once per second (1 Hz) and the container shall poll the payload for telemetry and relay that data four times per second (4 Hz).
7. All telemetry transmission shall stop and audio beacon shall active when the Container land.

Bonus Objectives	External Objectives
1. As the container is releasing the payload, the container shall contain a video camera and start recording to show the descent of the payload. 2. All videos are to be recorded and recovered when the CanSat is recovered from the field.	1. Our team goal for this year is to be first place in CanSat Competition 2022. 2. To gain experience in working on Engineering project, adapting to a teamwork environment, implementing project and time management.

System Requirement Summary (1/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#1	Total mass of the CanSat (science payloads and container) shall be 600 grams +/- 10 grams.	Competition Requirement	High	✓	✓	✓	
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement	High		✓	✓	
RN#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.	Competition Requirement	High		✓		
RN#4	The container shall be a fluorescent color; pink, red or orange.	Competition Requirement	Medium		✓		
RN#5	The container shall be solid and fully enclose the science payloads. Small holes to allow access to turn on the science payloads are allowed. The end of the container where the payload deploys may be open.	Competition Requirement	High		✓	✓	
RN#6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	High		✓		
RN#7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	High		✓		
RN#8	The container's first parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	High		✓	✓	✓
RN#9	The Parachutes shall be fluorescent Pink or Orange	Competition Requirement	Medium		✓		

System Requirement Summary (2/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#10	The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s after deployment while above 400 meters.	Competition Requirement	High	√		√	
RN#11	The descent rate of the CanSat shall be reduced to 5 meters/second +/-2 m/s when the CanSat descends below 400 meters.	Competition Requirement	High	√		√	
RN#12	0 altitude reference shall be at the launch pad.	Competition Requirement	High			√	
RN#13	All structures shall be built to survive 15 Gs of launch acceleration.	Competition Requirement	High		√	√	√
RN#14	All structures shall be built to survive 30 Gs of shock.	Competition Requirement	High		√	√	√
RN#15	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	High		√	√	
RN#16	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement	High			√	
RN#17	Mechanisms shall not use pyrotechnics or chemicals.	Competition Requirement	High		√		
RN#18	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.	Competition Requirement	High		√		

System Requirement Summary (3/8)

RN	Requirements	Reasons	Priority	Verification A	Verification I	Verification T	Verification D
RN#19	Both the container and payload shall be labeled with team contact information including email address.	Competition Requirement	High		√		
RN#20	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years should be included in this cost, based on current market value.	Competition Requirement	High	√	√		
RN#21	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Competition Requirement	High	√	√	√	
RN#22	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	High		√	√	
RN#23	XBEE radios shall not use broadcast mode.	Competition Requirement	High		√	√	
RN#24	The container shall include electronics to receive sensor payload telemetry.	Competition Requirement	High		√	√	
RN#25	The container shall include electronics and mechanisms to release the science payload on a tether.	Competition Requirement	High		√	√	
RN#26	The container shall include a GPS sensor to track its position.	Competition Requirement	High		√	√	
RN#27	The container shall include a pressure sensor to measure altitude.	Competition Requirement	High	√	√	√	
RN#28	The container shall measure its battery voltage.	Competition Requirement	High		√	√	

System Requirement Summary (4/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#29	The container shall transmit its telemetry once per second (1 Hz) in the formats described in the Telemetry Requirements section.	Competition Requirement	High			√	
RN#30	The container shall poll the payload for telemetry and relay that data four times per second (4 Hz) in the formats described in the Telemetry Requirements section.	Competition Requirement	High			√	
RN#31	The container shall stop polling and transmitting telemetry when it lands	Competition Requirement	High		√		√
RN#32	The container and science payload must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration.	Competition Requirement	High		√		√
RN#33	The container and payload must include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the cansat and in the stowed state.	Competition Requirement	High		√		√
RN#34	An audio beacon is required for the container. It shall be powered after landing.	Competition Requirement	High				√
RN#35	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	High		√	√	
RN#36	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Competition Requirement	High		√		

System Requirement Summary (5/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#37	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.	Competition Requirement	High		√	√	
RN#38	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	High		√	√	
RN#39	The Cansat must operate during the environmental tests laid out in Section 3.5.	Competition Requirement	High	√	√	√	√
RN#40	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Competition Requirement	High	√	√	√	√
RN#41	The science payload shall have their NETID/PANID set to their team number plus 5000. If the team number is 1000, sensor payload NETID is 6000.	Competition Requirement	High		√		
RN#42	The science payload shall transmit sensor telemetry to the container when polled.	Competition Requirement	High	√	√	√	
RN#44	The science payload shall include a pressure sensor, temperature sensor and rotation sensor.	Competition Requirement	High	√	√	√	
RN#45	The science payload shall include a video camera pointing 45 degrees up from the payload NADIR direction.	Competition Requirement	High	√	√	√	
RN#46	The science payload shall maintain orientation so the camera always faces south within +/- 20 degrees.	Competition Requirement	High	√	√	√	

System Requirement Summary (6/8)

RN	Requirements	Reasons	Priority	Verification A	Verification I	Verification T	Verification D
RN#47	The payload shall be connected to the container with a 10 meter tether.	Competition Requirement	High	√		√	
RN#48	At 300 meters, the payload shall be released from the container at a rate of .5 meters per second.	Competition Requirement	High	√		√	
RN#49	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.	Competition Requirement	High	√		√	√
RN#50	The container shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	Competition Requirement	High	√		√	√
RN#51	The container shall have its time set to UTC time to within one second before launch.	Competition Requirement	High		√	√	
RN#52	The container flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	Competition Requirement	High	√	√	√	√
RN#53	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude.	Competition Requirement	High			√	√
RN#54	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Competition Requirement	High		√	√	√

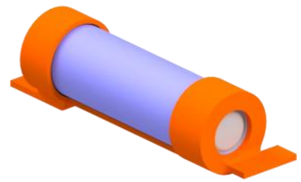
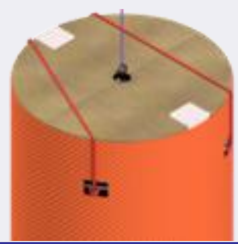
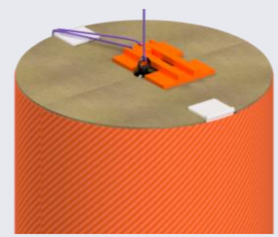
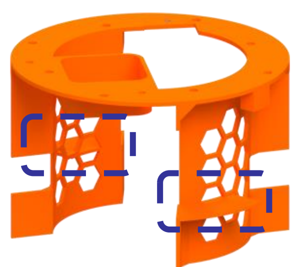
System Requirement Summary (7/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#55	The ground station shall command the CanSat to start transmitting telemetry prior to launch.	Competition Requirement	High		√	√	
RN#56	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Competition Requirement	High		√	√	√
RN#57	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.	Competition Requirement	High	√	√	√	√
RN#58	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	High		√	√	
RN#59	Each team shall develop their own ground station.	Competition Requirement	High	√	√	√	
RN#60	All telemetry shall be displayed in real time during descent on the ground station.	Competition Requirement	High	√	√	√	√
RN#61	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	High	√	√	√	
RN#62	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	High		√	√	
RN#63	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	High		√	√	

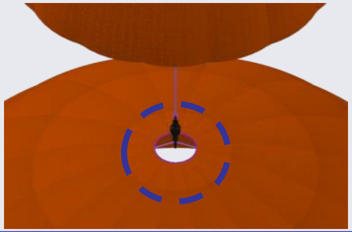
System Requirement Summary (8/8)

RN	Requirements	Reasons	Priority	Verification			
				A	I	T	D
RN#64	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.	Competition Requirement	High		✓		
RN#65	The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Competition Requirement	High		✓	✓	
RN#66	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the container.	Competition Requirement	High	✓	✓	✓	✓
RN#67	The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container.	Competition Requirement	High	✓	✓	✓	✓
RN#68	All video cameras shall be in color, have a resolution of at least 640x480 and record at a minimum of 30 frames a second.	Competition Requirement	Medium	✓			✓
BM	As the container is releasing the payload, the container shall contain a video camera and start recording to show the descent of the payload. All videos are to be recorded and recovered when the Cansat is recovered from the field.	Mission Guide	Medium	✓	✓	✓	✓

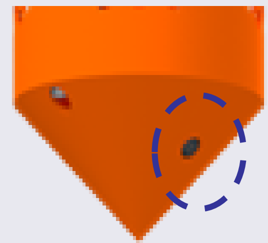
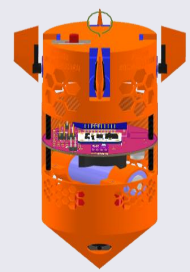
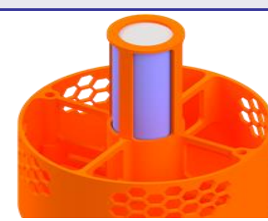
Summary of Changes Since PDR (1/6)

	Part	PDR	CDR	Rationale
Container Mechanical	Servo holder in locking system			Decrease unnecessary dimension.
	Battery Holder			Increase Durability of Battery Holder.
	Top lid locking mechanism.			To prevent first parachute to tangle with the rubber that hampers second parachute release.
	Payload Holder			Ease Manufacturing Process.

Summary of Changes Since PDR (2/6)

Part		PDR	CDR	Rationale
Container Mechanical & Descent Control	Additional Ring Feature	It doesn't exist		To prevent second parachute from slipping through top lid's hole.
	Container Body Cover	One layer of crepe paper composite.	Two layer of crepe paper composite.	Increase Durability of Body Cover.
	Container and Payload Height	Container: **397.4mm** Payload: **163.14 mm**	Container: **393.5 mm** Payload: **181.14 mm**	To assure the CanSat move freely in rocket payload section.
	Spill Hole and Side Holes Diameter	First parachute **8 mm** Second parachute **24.8 mm**	First parachute **16.8 mm** Second parachute **49.6 mm**	To increase stability of container.
	Descent Rate Estimates	First Parachute: **15 m/s** Second Parachute:**4.98 m/s**	First Parachute: **15.12 m/s** Second Parachute: **5.02 m/s**	Due to changes in mass of CanSat, it is necessary to recalculate it.

Summary of Changes Since PDR (3/6)

	Part	PDR	CDR	Rationale
Payload	Payload Camera Case			Decrease mass and save space.
	Payload Body Cover	One layer crepe paper composite.	Two layer crepe paper composite.	Increase durability of body cover.
	Payload's PCB	Two layer's of PCB 	One Layer of PCB 	Payload microcontroller unit is changed to Teensy 4.0.
	Payload Battery Holder			Olight 18650 dimension were not compatible to our design.

Summary of Changes Since PDR (4/6)

	Part	PDR	CDR	Rationale
Sensor Subsystem Design	Camera & Bonus Camera	The camera to record mission (located in payload) and bonus mission (located in container) is SQ23.	The camera to record mission (located in payload) and bonus mission (located in container) is SQ11.	SQ23 cameras are not available in Indonesia.
	Payload Battery Voltage Sensor	The ADC to acquire payload battery is STM32F407 ADC.	The ADC to acquire payload battery is teensy 4.0 ADC.	There is a change of microcontroller unit in payload.
	Part	**PDR**	**CDR**	**Reason**
Communication Data Handling	Payload Microcontroller Unit	STM32F407 Minimum System	Teensy 4.0	There's a trouble on manufacturing the microcontroller. Teensy 4.0 chosen as secondary option.
	Payload	SD Card Module	SD Card Module Removed	There is a peripheral on Teensy 4.0 to access SD Card directly.
	Driver Motor	L298N Driver Motor	MX1508 Driver Motor	To minimize weight.

Summary of Changes Since PDR (5/6)

	Part	PDR	CDR	Reason
Electrical Power Subsystem	Container Actuator	Servo in the container is supplied by a 5V bus from the boost converter.	Servo in the container is supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply servo.
	Container Actuator	Driver motor in the container is supplied by a 5V bus from the boost converter.	Driver motor in the container is supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply driver motor.
	Container Actuator	Camera in the container is supplied by a 5V bus from the boost converter.	Camera in the container is supplied by a 3.6V directly from battery	The boost converter output current is not sufficient to camera.
	Payload Actuator	4 servos in the payload are supplied by a 5V bus from the boost converter.	4 servos in the payload are supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply 4 servos.
	Container Power Budget	Container power consumption is 6.82 Wh.	Container power consumption is 6.00 Wh.	Recalculation of container power budget.
	Payload Power Budget	Payload power consumption is 4.61 Wh.	Payload power consumption is 5.59 Wh.	Recalculation of payload power budget due to MCU changed to Teensy 4.0.

Summary of Changes Since PDR (6/6)

	Part	PDR	CDR	Rationale
Flight Software	IDE	Using STM32Cube IDE	Using ArduinoIDE	Development STM32F4 Minimum System does not complete.
	Part	**PDR**	**CDR**	**Rationale**
GCS	GCS GUI	Graph is using Zedgraph Library	Graph is using Syncfusion Library	To avoid errors on the graph in the form of broken lines after running for approximately 30 minutes.

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

Pre-Launch

- Arrive at launch site.
- Pre-launch brief.
- Set up GCS and Antenna.
- System calibration and configuration based on GCS command.
- CanSat Final Check.
- Turn on CanSat and place it inside rocket.

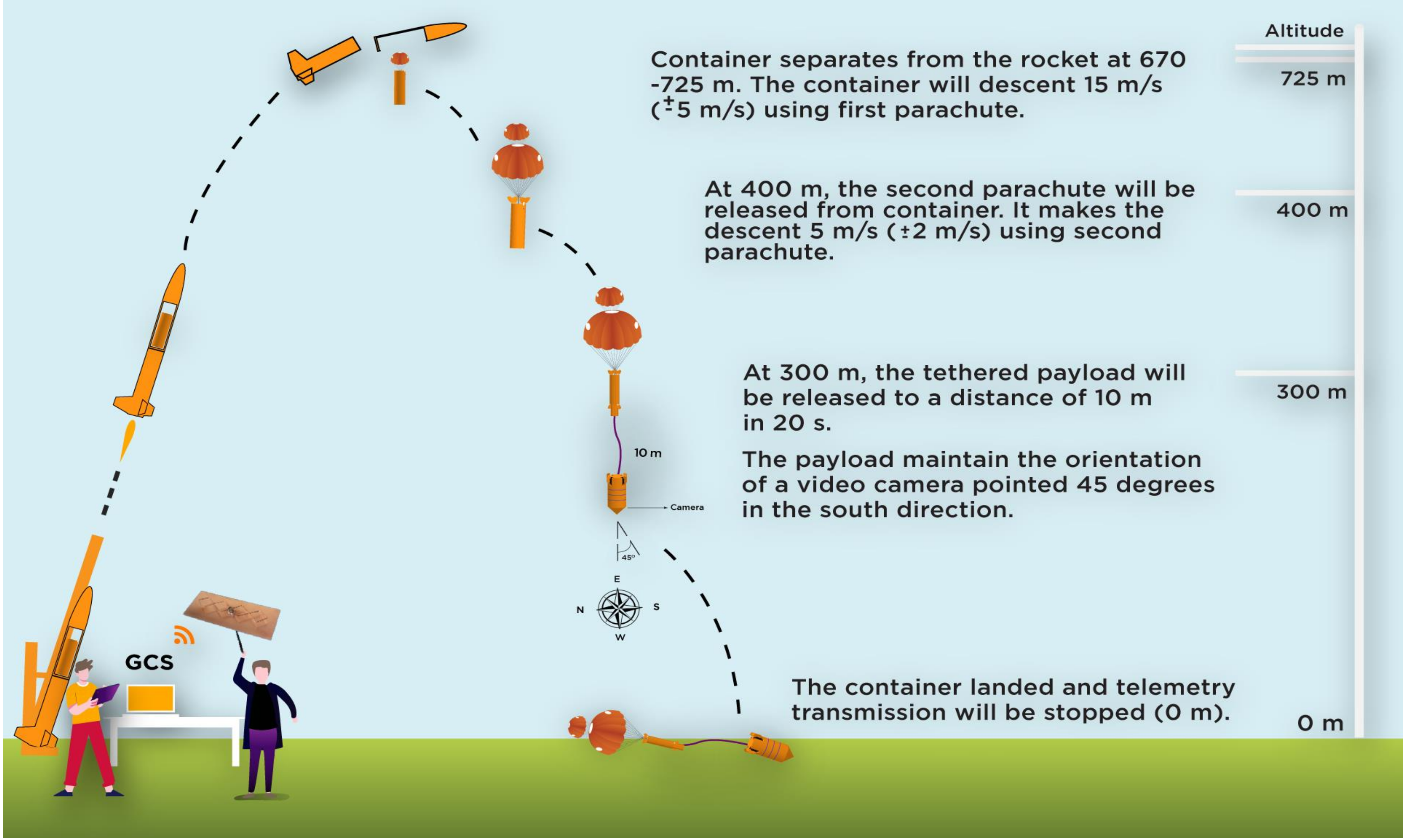
Launch

- Rocket launch with CanSat inside it.
- Rocket and CanSat separation (670–725m).
- First parachute deploy (Descent rate at 15m/s).
- Second parachute deploy at 400m (Descent rate at 5m/s).
- Container released tethered payload at 300m to a distance 10 meters in 20 seconds.
- Video started to record terrain pointed 45 degrees downward and maintain orientation pointing in south direction.
- Payload shall start transmitting data to container when it released from container.
- Container shall stop transmitting data to GCS when it landed.

Post-Launch

- Recover both Payload and Container.
- Inspect Payload and container for damage if any.
- Take the SD card from both container and payload.
- Analyze data received.
- PFR preparation.

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



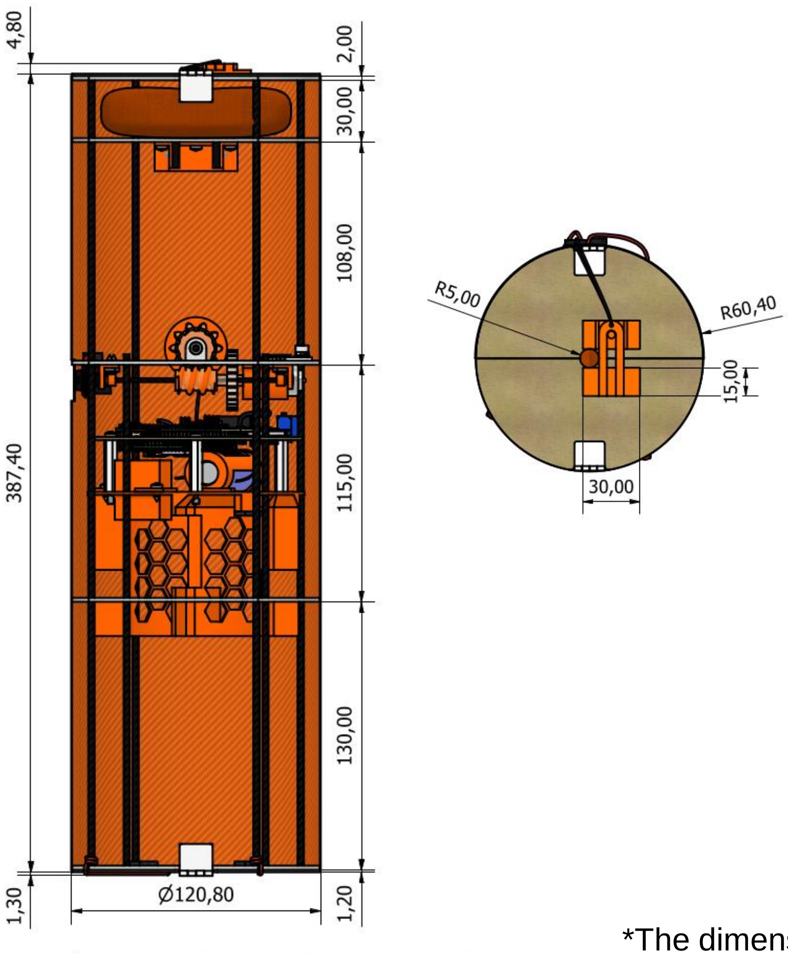
System Concept of Operations (CONOPS) (3/3)

Team Member Roles and Responsibilities

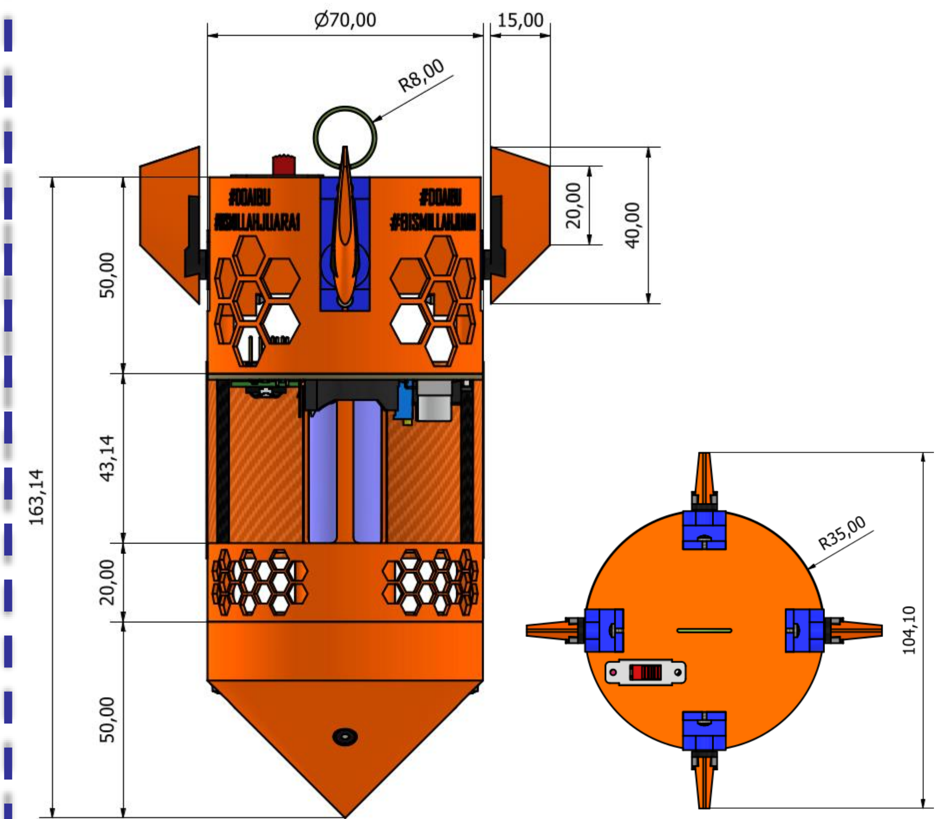
Roles	Member Name
Mission Control Officer - *Responsible for informing the Flight Coordinator when the team and their CanSat is ready to be launched.*	1. Zulfikar Davbi
Ground Station Crew - *Responsible for monitoring the ground station for telemetry reception and issuing commands to the CanSat.*	1. Rara Widya 2. Piko Permata
Recovery Crew - *Responsible for tracking the CanSat and going out into the field for recovery and interacting with the field judges.*	1. Aghist Fitrony 2. Rafi' Jusar W
CanSat Crew - *Responsible for preparing the CanSat ,integrating it into the rocket, and verifying its status.*	1. I Made Nugi 2. Achmad Bagus 3. Fatwa Aulia

Payload Physical Layout (1/4)

Container Dimension



Payload Dimension

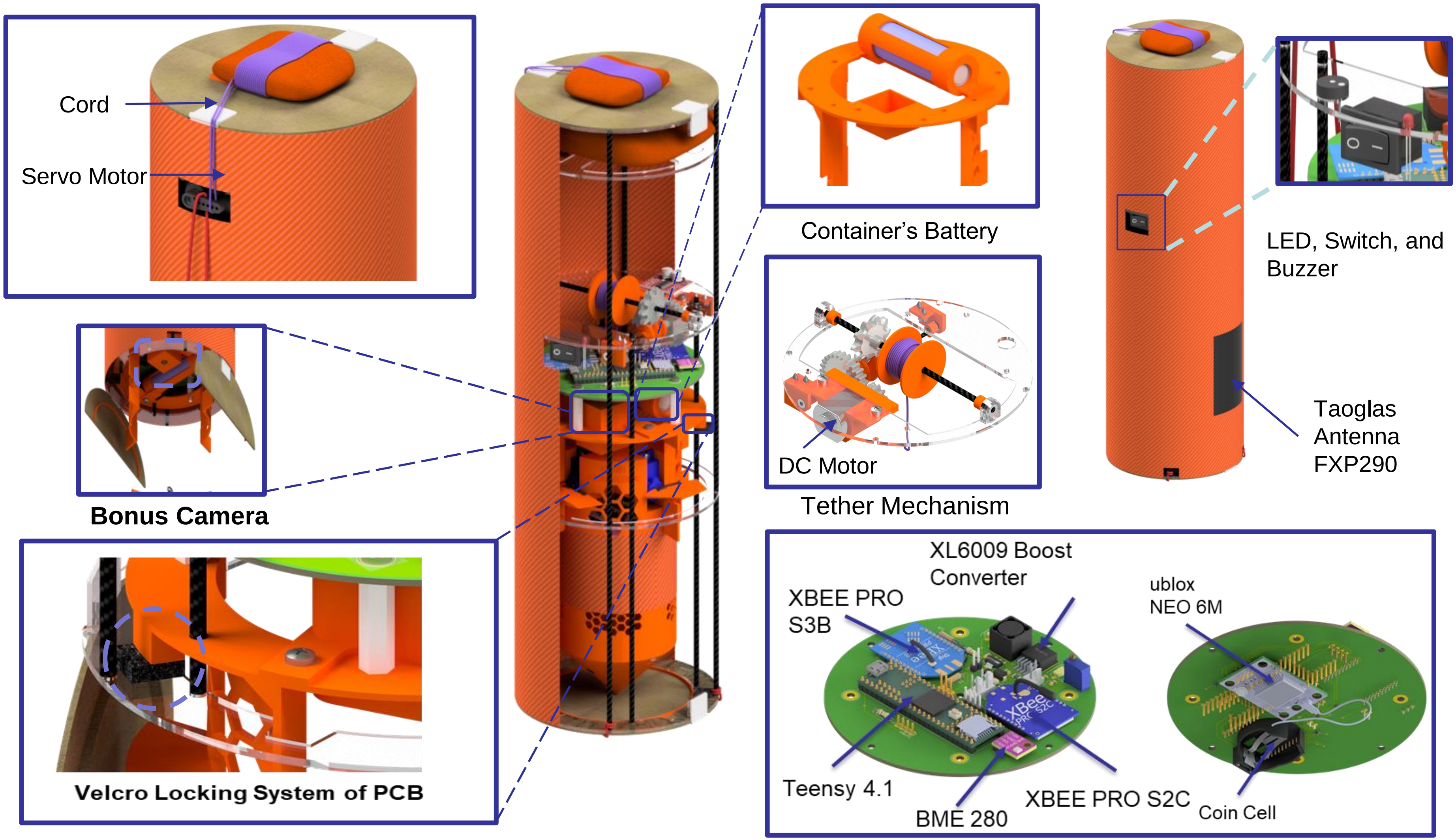


*The dimension of container and payload using technical drawing in CAD software

*All measurement units are in mm

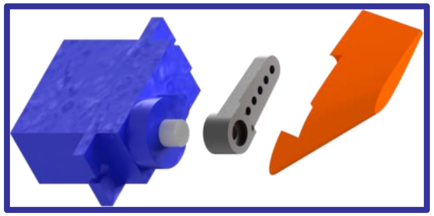
Payload Physical Layout (2/4)

Container Placement of Major Components



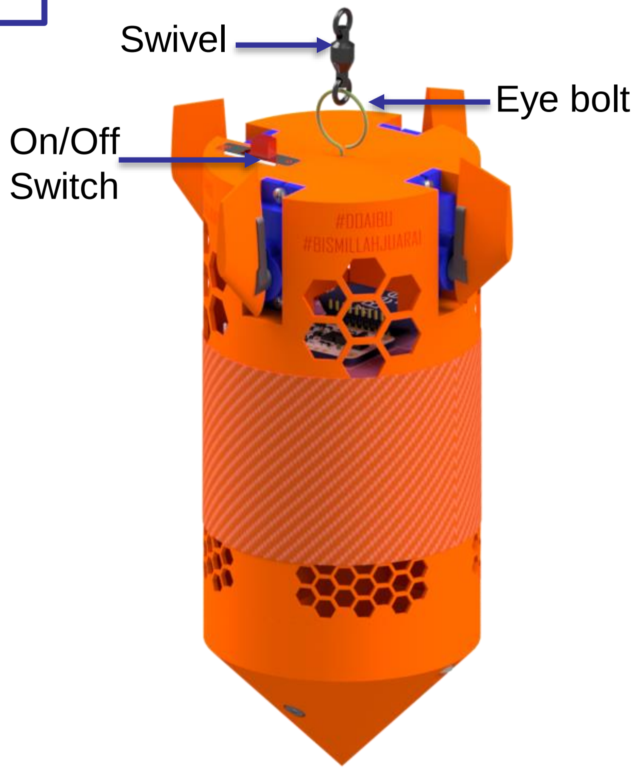
Payload Physical Layout (3/4)

Payload Placement of Major Components

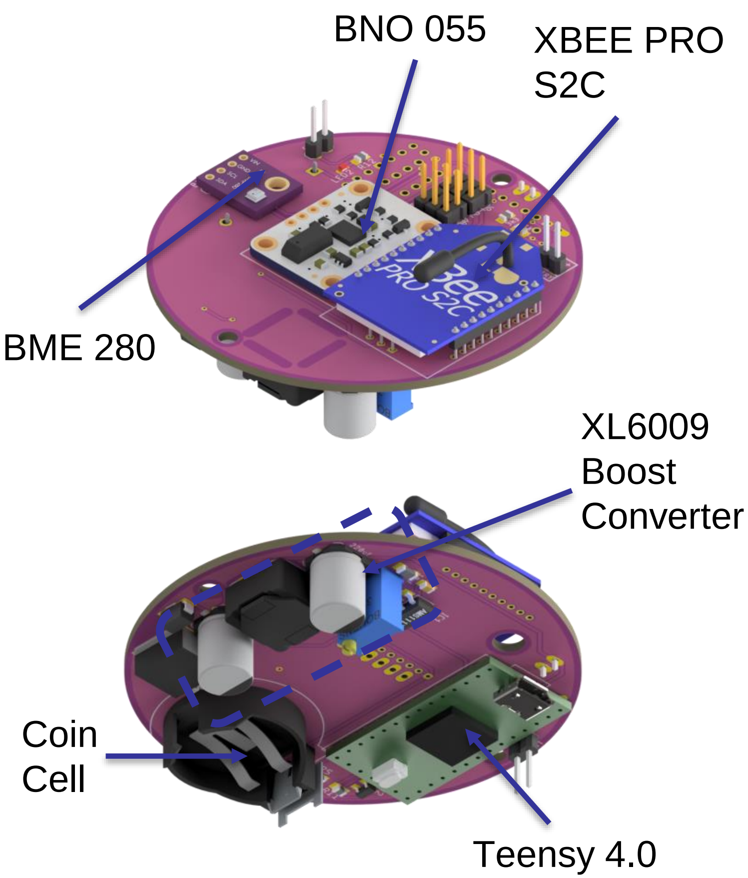


Fins Mechanism

Payload's Battery Holder

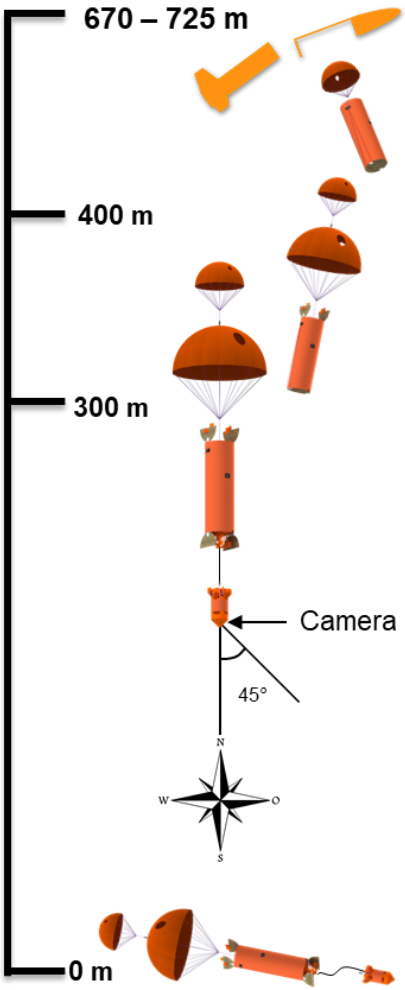


Electrical Component



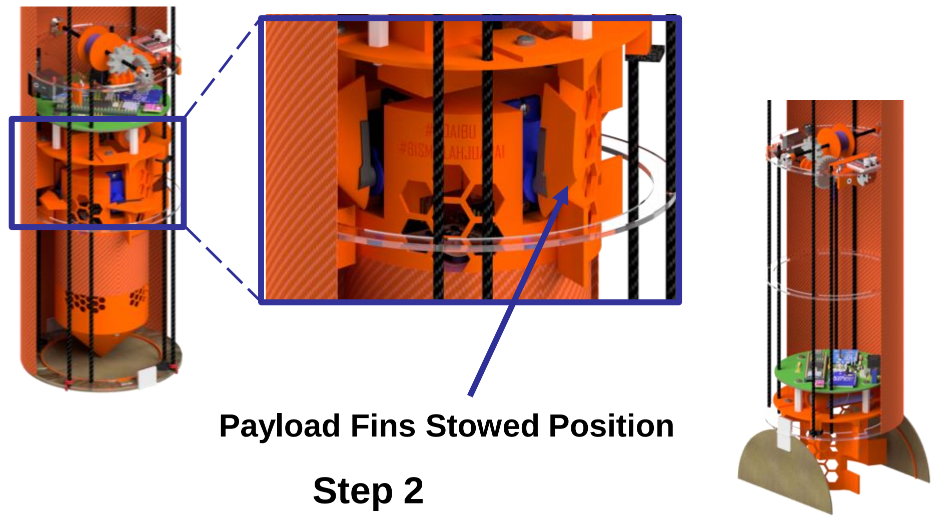
Payload Physical Layout (4/4)

Payload, Lunch, and Deploy Configuration Configuration



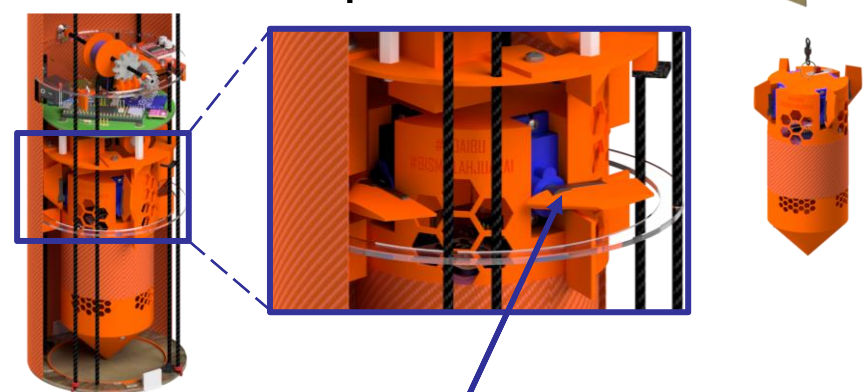
Container separates from the rocket at 670-725 m. The container will descent 15 m/s (±5 m/s) using first parachute.
At 400 m, the second parachute will be released from container. It makes the descent 5 m/s (±2 m/s) using second parachute.
At 300 m, the tethered payload will be released to a distance of 10 m in 20 seconds.
The payload maintain the orientation of a video camera pointed 45 degrees in the south direction.
The container landed and telemetry transmission will be stopped.

Step 1



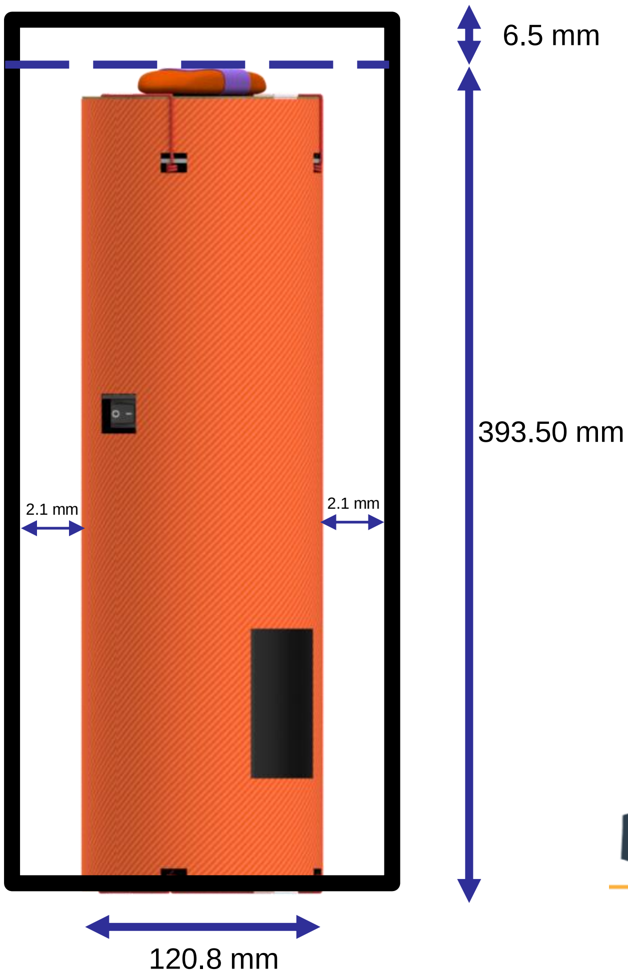
Payload Fins Stowed Position

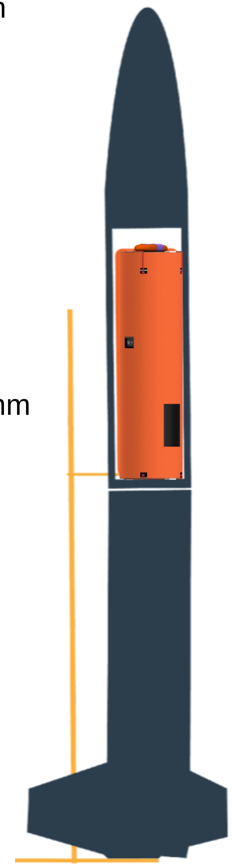
Step 2



Payload Fins Transition From Stowed Position

Launch Vehicle Compatibility





Dimensions (Section)	Height (mm)	Diameter (mm)
Container	393.5	120.8
Payload	181.14	70

Information:

1. CanSat consists of two parts: container and payload.
2. The dimensions of CanSat designed to prevent shaking in the rocket and provide gap to release.
3. No sharp protrusions
4. Rocket won't be used as part of CanSat operations

Sensor Subsystem Design

Piko Permata

Sensor Subsystem Overview

Sensor Type	Selected Model	Function	Located In
Air Pressure	BME280	To measure air pressure, the collected data will be converted to altitude	Container & Payload
Air Temperature	BME280	To measure temperature inside of container and payload	Container & Payload
GPS	Ublox Neo 6M	To acquire position or location	Container
Three-axis Sensors	BNO055	To measure gyro, accelerometer & magnetometer	Payload
Power Voltage	ADC Voltage Divider	To measure battery voltage	Container & Payload
Camera	Quelima SQ11	To record video	Container & Payload

Sensor Changes Since PDR

Part	PDR	CDR	Reason
Camera & Bonus Camera	The camera to record mission (located in payload) and bonus mission (located in container) is SQ23.	The camera to record mission (located in payload) and bonus mission (located in container) is SQ11.	SQ23 cameras are not available in Indonesia.
Payload Battery Voltage Sensor	The ADC to acquire payload battery is stm32F407 ADC.	The ADC to acquire payload battery is teensy 4.0 ADC.	There is a change of microcontroller unit in payload.

Container Air Pressure Sensor Summary (1/2)

Model	Range (hPa)	Sensitivity (hPa)	Voltage (V)	Current (µA)	Interface	Mass (g)	Accuracy (hPa)	Size (mm)	Cost ($)
BME 280✓	300 - 1100	0.0018	1.71 - 3.6	2.8	I2C	1.0	± 1.0	13.5 x 10.5 x 2	9.05

Data Format	(Altitude, m)
Equations	$$Altitude = 44330 \times \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right)$$ P : *Atmospheric pressure at current altitude (in hPa)* P_0 : *Atmospheric pressure at sea level (in hPa)*
Sample Output	Altitude = 121.9m Altitude = 122.2m Altitude = 122.0m

BME280 will collect pressure data according to the settings that have been set. After that the pressure data will be converted into altitude data.

Sample output in packet data:
1010,00:09:02.22,12,C,F,N,$\boxed{100.1}$,28.9,3.01,00:09:02,17.0199,189.0077,100.2,5,ASCENT,CXON

Container Air Pressure Sensor Summary (2/2)

Sensor Settings

We are using a standard initiation of adafruit library BME280. The sensor settings is:

- Sensor Mode : Normal Mode
- Temperature Sampling : Oversampling 16x
- Pressure Sampling : Oversampling 16x
- IIR Filter : Off
- Stand by time : 0.5 ms

Pressure Sensor Acquisition Process

Kalman Filter

1. Obtain input (U), after that calculate $\widehat{U}_{k+1}$ using this equations:

$$\kappa = \frac{P \cdot H}{H^2 \cdot P + \mathcal{R}}$$

$$\widehat{U}_{k+1} = \kappa \cdot (U - H \cdot \widehat{U})$$

$$P = (1 - \kappa \cdot H) \cdot P + Q$$

2. The $\widehat{U}_{k+1}$ is the output of Kalman Filter.

Container GPS Sensor Summary (1/2)

Model	Range (m)	Sensitivity (dBm)	Voltage (V)	Current (mA)	Interface	Mass (g)	Accuracy (m)	Size (mm)	Cost ($)
UBLOX NEO-6M✓	As long can connect to satellites	-162	2.7 – 3.6	67	UART	16.8	± 2.5	16 x 12.2 x 2.4	3.5

Data Format	(Time, hh:mm:ss) (Latitude, °) (Longitude, °) (Altitude, m) (Satellites, integer value showing number of satellites that was connected)
Equations	It will automatically calculate the distance of this sensor with reference to satellite (at least 3)
Sample Output	GPS TIME:19:50:17 GPS LATITUDE :-7.2936 GPS LONGITUDE :112.8079 GPS ALTITUDE :19.9 GPS SATELITES :6

UBLOX NEO-6M will connect to at least 3 satellites in the orbit and calculate the distance between them so it can make an output of GPS data.

Sample output in packet data:
1010,00:09:02.22,12,C,F,N,100.1,28.9,3.01,00:09:02,17.0199,189.0077,100.2,5,ASCENT,CXON

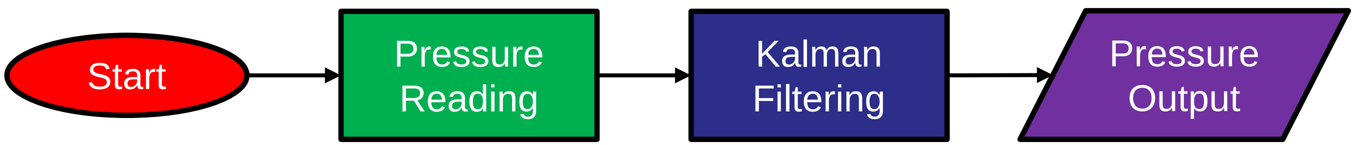
Container GPS Sensor Summary (2/2)

Sensor Settings

We are using a standard initiation of TinyGPS++ library. The sensor settings is already defined by manufacturer, the default mode are:

- Baud rate : 9600 baud
- Data : 8 bits
- Stop : 1 stop bit
- Parity : None
- Output Protocol : NMEA

Pressure Sensor Acquisition Process



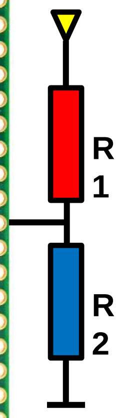
GPS Test

Longitude reading	: -7.2936
Latitude reading	: 112.8079
Longitude original	: -7.2936
Latitude original	: 112.8079

Container Voltage Sensor Summary (1/2)

Model	Range (V)	Sensitivity (V)	Voltage (V)	Current (μA)	Interface	Mass (g)	Accuracy (%)	Size (mm)	Cost ($)
ADC Teensy 4.1✓	0 – 3.3	0.000805	Embedded	Embedded	Analog	Embedded	± 2	Embedded	9.05

Data Format	(Battery Voltage, V)
Equations	$\textit{Battery Voltage} = \frac{3.3}{1024} \times \frac{R_1 + R_2}{R_2} \times \textit{ADC Read}$ R_1 : *First Resistor* R_2 : *Second Resistor*
Sample Output	Battery Voltage = 3.29V Battery Voltage = 3.29V Battery Voltage = 3.28V



Analog to Digital Converter will convert analog signal that represent battery voltage into binary numbers. After that our program will convert this reading into battery voltage nominal and process it through Moving Average

Sample output in packet data:
1010,00:09:02.22,12,C,F,N,100.1,28.9,$\boxed{3.01}$,00:09:02,17.0199,189.0077,100.2,5,ASCENT,CXON

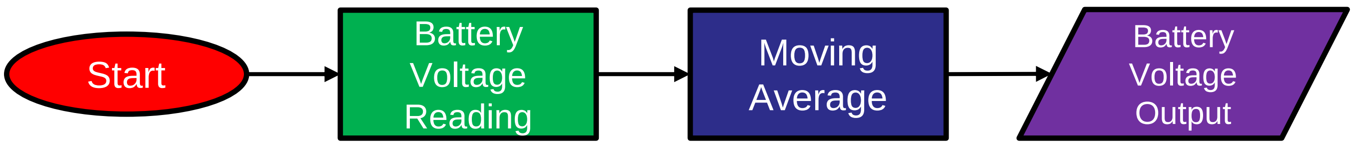
Container Voltage Sensor Summary (2/2)

Sensor Settings

From our calculation, we choose 1000 Ohm as our $\boldsymbol{R_1}$ and 3300 Ohm as our $\boldsymbol{R_2}$. the following is the detail of our calculation:

$$Vmax\ batt: V\ adc$$
$$4.2\ \mathrm{V}: 3.3\ \mathrm{V}$$
$$R_1 = 4.2\ \mathrm{V} - 3.3\ \mathrm{V} = 0.8 \times 1000 = 800\Omega \approx 1000\Omega$$
$$R_2 = 3.3\ \mathrm{V} \times 1000 = 3300\Omega$$

Pressure Sensor Acquisition Process



Moving Average

1. Obtain first 3 data of input (k = 3), after that calculate the output using this equation:

$$MA = \frac{1}{k} \sum_{i=n+k-1}^{k} P_i$$

2. After that we must throw the most old data and replace it with newer data and perform next calculations.
3. Do it continuously.

Payload Air Pressure Sensor Summary (1/2)

Model	Range (hPa)	Sensitivity (hPa)	Voltage (V)	Current (µA)	Interface	Mass (g)	Accuracy (hPa)	Size (mm)	Cost ($)
BME 280✓	300 - 1100	0.0018	1.71 - 3.6	2.8	I2C	1.0	± 1.0	13.5 x 10.5 x 2	9.05

Data Format	(Altitude, m)
Equations	$$Altitude = 44330 \times \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right)$$ *P : Atmospheric pressure at current altitude (in hPa)* P_0 *: Atmospheric pressure at sea level (in hPa)*

Sample Output	`Altitude = 121.9m`
	 `Altitude = 122.2m`
	 `Altitude = 122.0m`

BME280 will collect pressure data according to the settings that have been set. After that the pressure data will be converted into altitude data.

Sample output in packet data:
1010,00:09:02.22,12,C,F,N,100.1,28.9,3.01,00:09:02,17.0199,189.0077,100.2,5,ASCENT,CXON

Payload Air Pressure Sensor Summary (2/2)

Sensor Settings

We are using a standard initiation of adafruit library BME280. The sensor settings is:

- Sensor Mode : Normal Mode
- Temperature Sampling : Oversampling 16x
- Pressure Sampling : Oversampling 16x
- IIR Filter : Off
- Stand by time : 0.5 ms

Pressure Sensor Acquisition Process

Kalman Filter

1. Obtain input (U), after that calculate $\hat{U}_{k+1}$ using this equations:

$$\kappa = \frac{P \cdot H}{H^2 \cdot P + \mathcal{R}}$$

$$\hat{U}_{k+1} = \kappa \cdot (U - H \cdot \hat{U})$$

$$P = (1 - \kappa \cdot H) \cdot P + Q$$

2. The $\hat{U}_{k+1}$ is the output of Kalman Filter.

Payload Air Temperature Sensor Summary (1/2)

Model	Range (°C)	Sensitivity (°C)	Voltage (V)	Current (μA)	Interface	Mass (g)	Accuracy (°C)	Size (mm)	Cost ($)
BME 280✓	-40 - 85	0.01	1.71 - 3.6	2.8	I2C	1.0	± 1.0	13.5 x 10.5 x 2	9.05

Data Format	(Temperature, °C)
Equations	**There is no equation for this measurement.**
Sample Output	Temperature = 28.5*C Temperature = 28.5*C Temperature = 28.5*C

BME280 will collect temperature data according to the settings that have been set. After that the pressure data will be processed using moving average.

Sample output in packet data:
6010,15:00:10.01,433,T,100.1,28.2,3.12,1.120,2.120,3.120,1.120,2.120,3.120,1.120,2.120,3.120,0.0,STAND_BY

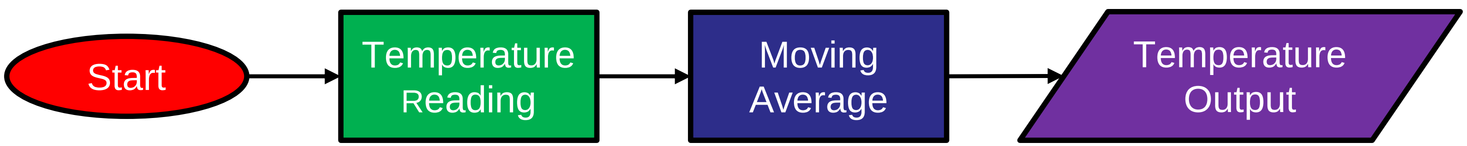
Payload Air Temperature Sensor Summary (2/2)

Sensor Settings

We are using a standard initiation of adafruit library BME280. The sensor settings is:

- Sensor Mode : Normal Mode
- Temperature Sampling : Oversampling 16x
- Pressure Sampling : Oversampling 16x
- IIR Filter : Off
- Stand by time : 0.5 ms

Temperature Sensor Acquisition Process



Moving Average

1. Obtain first 3 data of input (k = 3), after that calculate the output using this equation:

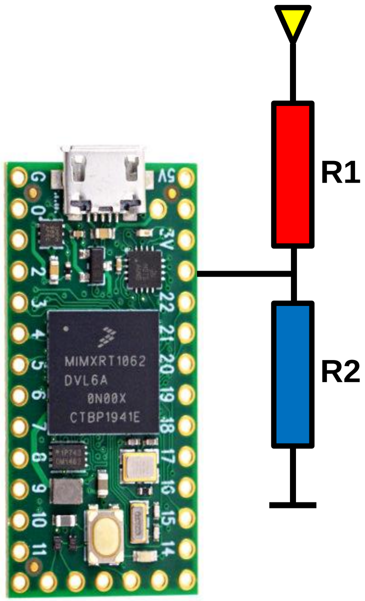
$$MA = \frac{1}{k}\sum_{i=n+k-1}^{k} P_i$$

2. After that we must throw the most old data and replace it with newer data and perform next calculations.
3. Do it continuously.

Payload Voltage Sensor Summary (1/2)

Model	Range (V)	Sensitivity (V)	Voltage (V)	Current (μA)	Interface	Mass (g)	Accuracy (%)	Size (mm)	Cost ($)
ADC Teensy 4.0✓	0 – 3.3	0.000805	Embedded	Embedded	Analog	Embedded	± 2	Embedded	9.05

Data Format	(Battery Voltage, V)
Equations	$\boldsymbol{Battery\ Voltage = \frac{3.3}{1024} \times \frac{R_1 + R_2}{R_2} \times ADC\ Read}$ $R_1: First\ Resistor$ $R_2: Second\ Resistor$
Sample Output	Battery Voltage = 3.29V Battery Voltage = 3.29V Battery Voltage = 3.28V



Analog to Digital Converter will convert analog signal that represent battery voltage into binary numbers. After that our program will convert this reading into battery voltage nominal.

Sample output in packet data:
6010,15:00:10.01,433,T,100.1,28.2, 3.12,1.120,2.120,3.120,1.120,2.120,3.120,1.120,2.120,3.120,0.0,STAND_BY

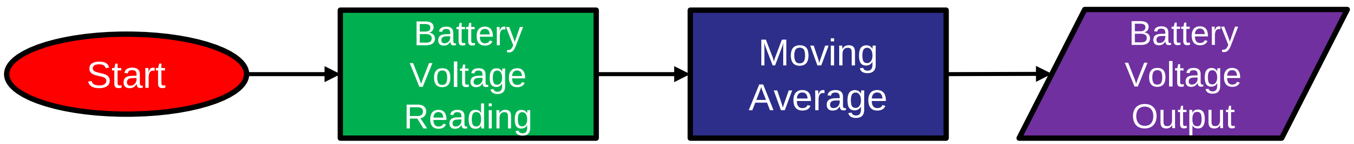
Payload Voltage Sensor Summary (2/2)

Sensor Settings

From our calculation, we choose … as our $\boldsymbol{R_1}$ and … as our $\boldsymbol{R_2}$. the following is the detail of our calculation:

$$Vmax\ batt: V\ adc$$
$$4.2\ \mathrm{V}: 3.3\ \mathrm{V}$$
$$R_1 = 4.2\ \mathrm{V} - 3.3\ \mathrm{V} = 0.8 \times 1000 = 800\Omega \approx 1000\Omega$$
$$R_2 = 3.3\ \mathrm{V} \times 1000 = 3300\Omega$$

Temperature Sensor Acquisition Process



Moving Average

1. Obtain first 3 data of input (k = 3), after that calculate the output using this equation:

$$MA = \frac{1}{k} \sum_{i=n+k-1}^{k} P_i$$

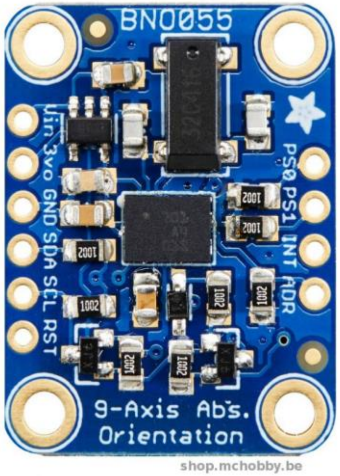
2. After that we must throw the most old data and replace it with newer data and perform next calculations.
3. Do it continuously.

Payload Rotation Control Sensor Summary

Model	Sensitivity	Voltage	Current	Interface	Mass	IMU	Size (mm)	Cost ($)
BNO055✓	**12.3**	**3.3 - 5**	**12.3**	**3.3 - 5**	**2**	**3 axis**	**5.2 x 3.8 x 1.1**	**45.95**

Range	Sensitivity
Gyro (2000 dps) Accelerometer (16 G) Magnetometer (1 uT)	**Gyro (16 bits) Accelerometer (14 bits) Magnetometer (13/13/15 bits)**

Data Format	(Gyrometer Roll, °), (Gyrometer Pitch, °), (Gyrometer Yaw, °) (Accelerometer Roll, °), (Accelerometer Pitch, °), (Accelerometer Yaw, °) (Magnetometer Roll, °), (Magnetometer Pitch, °), (Magnetometer Yaw, °) (Pointing Error, %)
Equations	Pointing Errors = Absolute Orientation – South Orientation
Sample Output	Gyro: x= 0.002 | y= 0.008 | z= -0.038 Mag: x= 41.188 | y= -22.375 | z= 16.062 Accl: x= 9.320 | y= -1.700 | z= -2.470



Sample output in packet data:

6010,15:00:10.01,433,T,100.1,28.2, 3.12,1.120,2.120,3.120,1.120,2.120,3.120,1.120,2.120,3.120,0.0,STAND_BY

Camera Summary

Model	Size (mm)	Weight (g)	Video Resolution (pixels)	Operating Voltage (V)	View Angle (°)	Video Frame Rate (FPS)	Interface	Cost ($)
Quelima SQ11✓	23 x 23 x 23	5.2	720/1080	5	180	30	Digital	4,53

Output Camera

Video

Length	00:00:25
Frame width	1280
Frame height	720
Data rate	9966kbps
Total bitrate	10222kbps
Frame rate	30.00 frames/second

Reasons

1. Small size camera with highest resolution.
2. SD card slot available.
3. Wide angle lens.

Note: We removed the camera from the case, because we designed our own camera case to minimize its size.

Bonus Camera Summary

Model	Size (mm)	Weight (g)	Video Resolution (pixels)	Operating Voltage (V)	View Angle (°)	Video Frame Rate (FPS)	Interface	Cost ($)
Quelima SQ11✓	23 x 23 x 23	5.2	720/1080	5	180	30	Digital	4,53

Output Camera

Video	
Length	00:00:25
Frame width	1280
Frame height	720
Data rate	9966kbps
Total bitrate	10222kbps
Frame rate	30.00 frames/second

Reasons

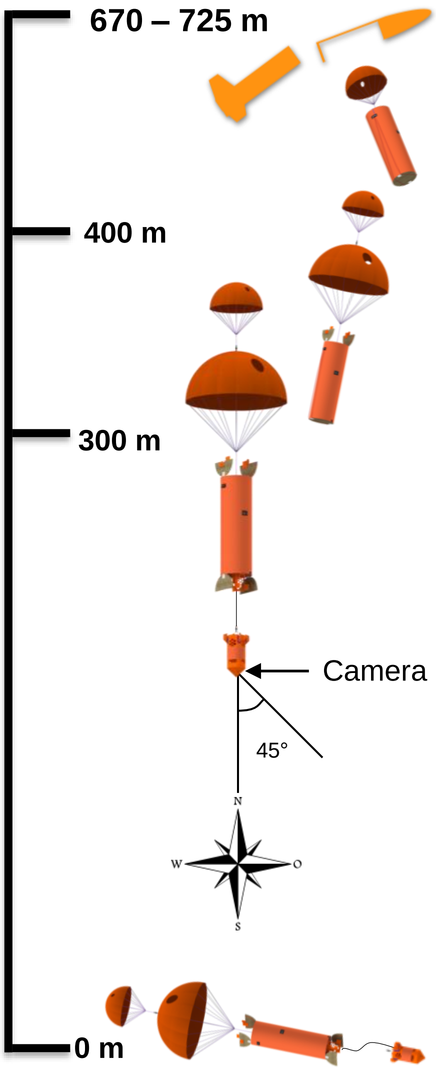
1. Small size camera with highest resolution.
2. SD card slot available.
3. Wide angle lens.

Note: We removed the camera from the case, because we designed our own camera case to minimize its size.

Descent Control Design

I Made Nugi

Descent Control Overview



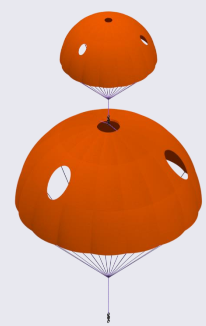
Container separates from the rocket at 670-725 m. The container will descent 15 m/s (±5 m/s) using first parachute.

At 400 m, the second parachute will be released from container. It makes the descent 5 m/s (±2 m/s) using second parachute.

At 300 m, the tethered payload will be released to a distance of 10 m in 20 seconds.

The payload maintain the orientation of a video camera pointed 45 degrees in the south direction.

The container landed and telemetry transmission will be stopped.

 **Container**	**Material:** Acrylic, Crepe Paper Composite, PLA+, and Paperboard Composite. **Dimension:** 393.5mm in height and 120.8 mm in diameter. **Feature:** Parachute attachment using Eye bolt, The 3D printed holder and PCB can slid to the bottom.
 **Parachute**	**First Parachute** **Material:** Orange ripstop nylon. **Dimension:** 206 mm in diameter. **Feature:** Spill hole and side hole as stabilizer with 16.8 mm in diameter. **Second Parachute** **Material:** Orange ripstop nylon. **Dimension:** 620 mm in diameter. **Feature:** Spill hole and side hole as stabilizer with 49.6 mm in diameter.
 **Payload**	**Material:** PLA+ and Crepe Paper Composite **Dimension:** 181.14 mm in height and 70 mm in diameter. **Feature:** Four Fins Mechanism

Descent Control Changes Since PDR (1/5)

Part	PDR	CDR	Rationale
Spill Hole and Side Holes Diameter	First parachute **8 mm** Second parachute **24.8 mm**	First parachute **16.8 mm** Second parachute **49.6 mm**	To increase stability of container.
Descent Rate Estimates	First Parachute: **15 m/s** Second Parachute:**4.98 m/s**	First Parachute: **15.12 m/s** Second Parachute: **5.02 m/s**	Due to changes in mass of CanSat, it is necessary to recalculate it.

Descent Control Changes Since PDR (2/5)

Descent Rate of Parachute Prototype Testing

CanSat First Parachute Descent	
Goal	The CanSat shall descend using two parachutes. First parachute at a rate of 15 m/s. At 400 meters, the CanSat shall deploy a second parachute to reduce the descent rate to 5 m/s
Procedure	1. The parachute was tied to the dummy CanSat with a weight of 600 g. 2. The object was dropped 12,76 m from the building. 3. Observe and measure time elapsed for the object land.
Result	It takes time to be fully stable descend with a descent rate of ± 15 m/s using the first parachute and ± 5 m/s using second parachute.

Documentations

Second Parachute Release Prototype Testing

CanSat Second Parachute Descent	
Goal	The second parachute is able to release from container after top lid opened.
Procedure	1. The second parachute is stowed under the top lid in folded position. 2. Top lid is unlocked using rubber locking system and first parachute pulls the second parachute. 3. Observe the second parachute is able to release from the container.
Result	The second parachute can release from the container with the help of pulling force by the first parachute. The second parachute is able deploy immediately after release.

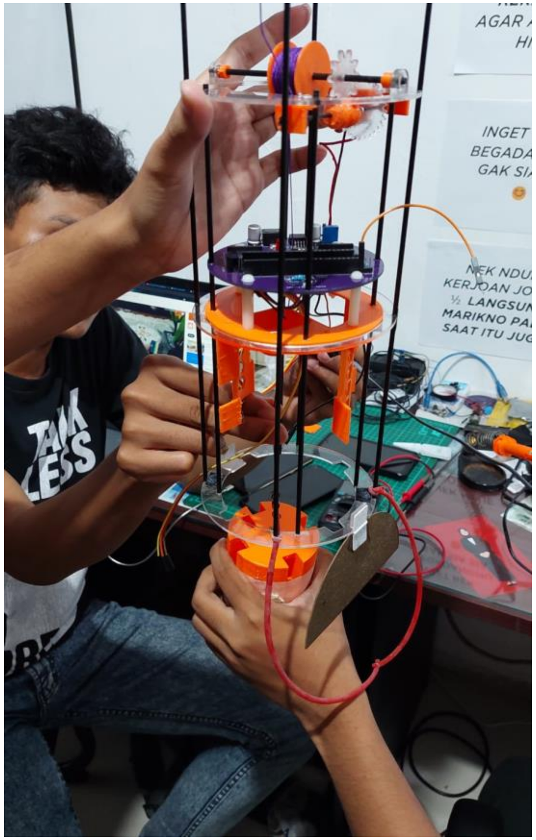
Documentations

Descent Control Changes Since PDR (4/5)

Tethered Payload Prototype Testing

Tether Payload Descent	
Goal	The CanSat shall release a tethered payload to a distance of 10 meters in 20 seconds
Procedure	1. Tether prototype was tied to Payload with a weight of ± 200 grams. 2. The object was unspooled from building. 3. Observe and measure the time it takes the object to reach a distance of 10 m using 1 m as assumption.
Result	The prototype is able to fully descend with a descent rate of ± 0.5 m/s.

Documentations



Payload Prototype Testing

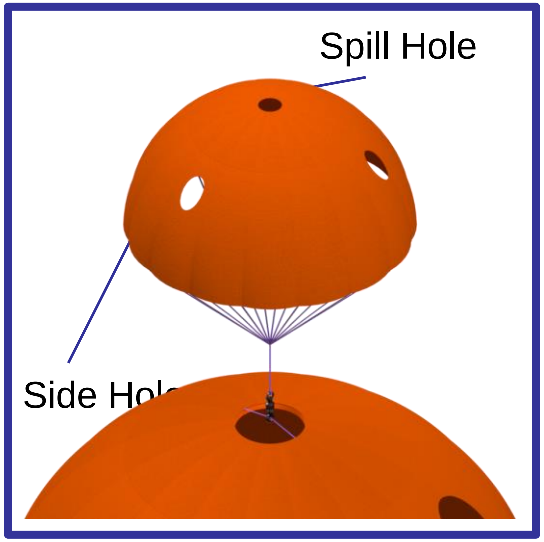
Payload Orientation	
Goal	The payload shall maintain the orientation of a video camera pointed 45 degrees downward in the south direction.
Procedure	1. Payload Prototype is tied to the container. 2. Twist tether cord to test if the fins mechanism is works properly 3. Observe if the payload is able to maintain orientation pointing in south direction.
Result	Servo can move the fins so the payload can rotate. But further improvement is required and still being developed.

Documentations

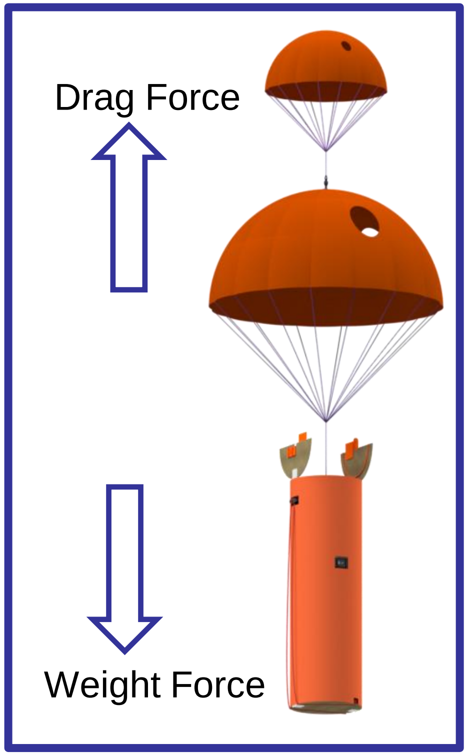
Container Descent Control Hardware Summary (1/5)

Container Descent Control Hardware

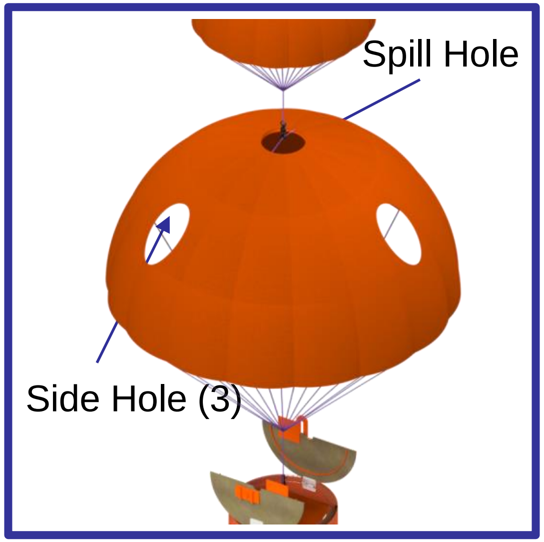
First Parachute



Size: 206 mm
Key Design: Round Parachute
Color Selection: Orange
Spill Hole: 16.8 mm in diameter
Side Hole: 16.8 mm in diameter



Second Parachute



Size: 620 mm
Key Design: Round Parachute
Color Selection: Orange
Spill Hole: 49.6 mm in diameter
Side Hole: 49.6mm in diameter

How Container Descent Control Hardware Works

We use parachutes to maintain the descent control of the container. Drag force will lift the parachute to achieve desired descent rate.

Container Descent Control Hardware Summary (2/5)

Passive Component of Container Descent Control Hardware

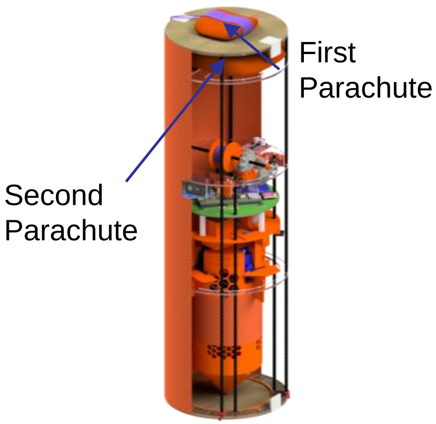
Key Design Considerations:
- The type of parachutes are round parachute with a spill hole and three side holes.
- The container focuses mass at the bottom.
- After the payload released, payload holder and PCB will slide to the bottom.

Color Selection:
- Parachutes are using orange ripstop nylon.
- The cover of container is orange crepe paper composite.
- Lids are using natural color of paper board.

Passive Component:
- The first parachute is connected to second parachute by a swivel.
- The second parachute is attached to container by a swivel and an eyebolt.

Container Descent Control Hardware Summary (3/5)

How Container Descent Control Hardware Stowed and Works

<table>
<tr><th>Pre-Deployment Configuration</th><th>First Parachute Descent Control</th><th>Second Parachute Descent Control</th><th>Full Deployed Configuration</th></tr>
<tr>
<td>
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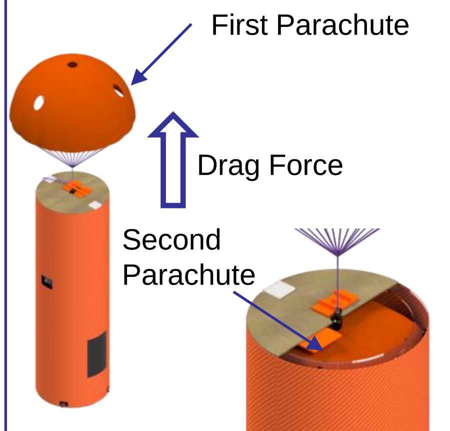
<td>
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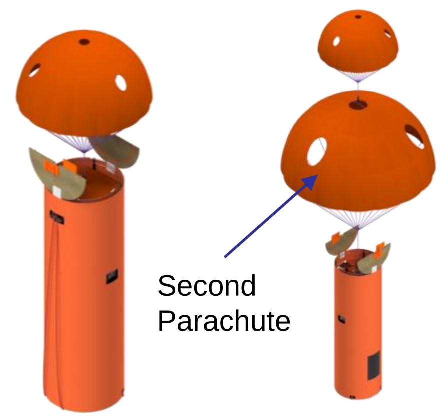
<td>
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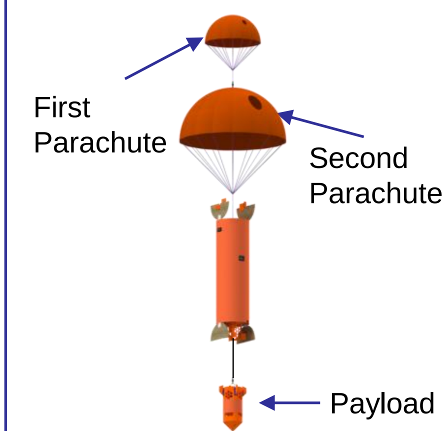
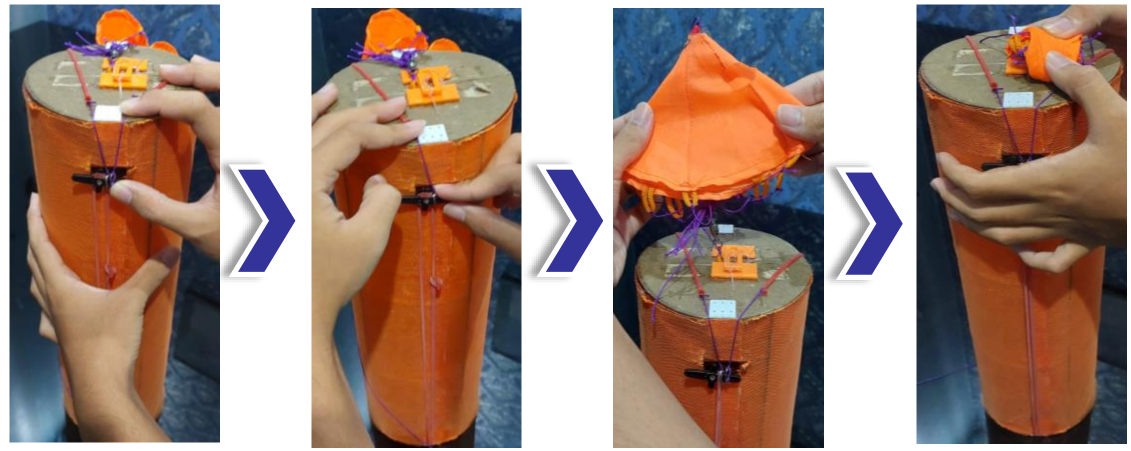
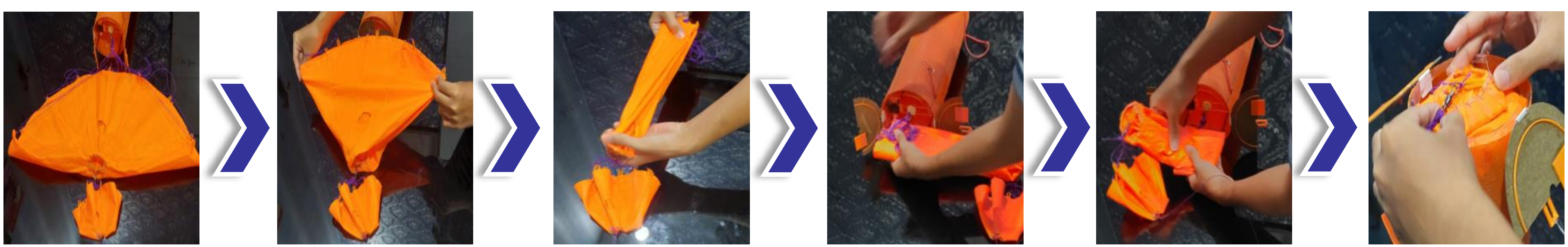
<td>
</td>
</tr>
<tr>
<td>The first parachute is placed on the top of container at folded position. The cord of parachute keeps the parachute to maintain its folded position before release. The first parachute will be attached by a Swivel as a connector with the second parachute through the top lid's hole</td>
<td>The parachute will be opened by the air-resistance assist. The second parachute is placed between top lid and parachute frame of the container in folded position and attached by an eye bolt to container</td>
<td>The second parachute deploys after the top lid opened, so the first parachute will pull the second parachute.
The second parachute can maintain stability of container because of spill hole and side hole. Swivel also can prevent the parachute from twisted that affect to stability.</td>
<td>The full deployed configuration has a descent rate of +- 5 m/s due to second parachute.</td>
</tr>
</table>

Container Descent Control Hardware Summary (4/5)

First Parachute Stowed Representation:
The first parachute will be outside container and attached to the second parachute. It will open as soon as deployed from the rocket. In order to open easily and quickly when the parachute exposed to air, it will be fold as shown in picture.



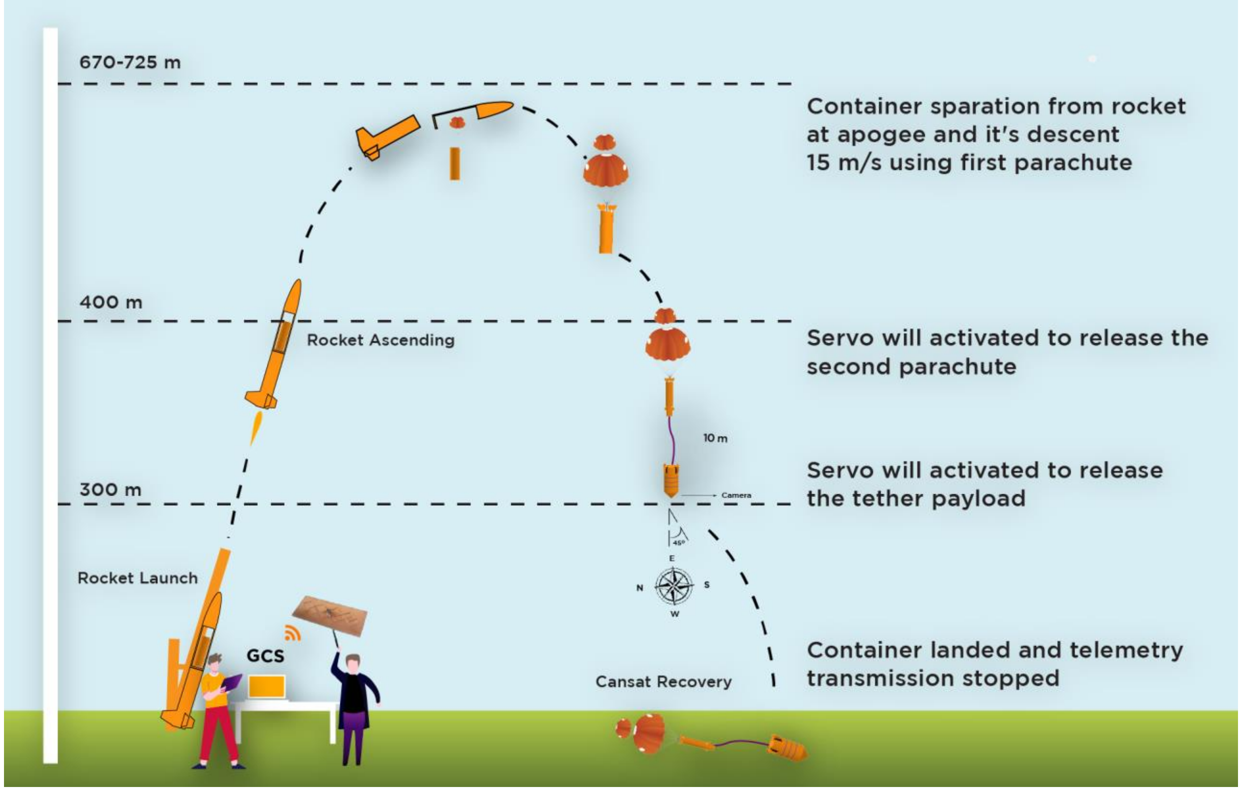
Second Parachute Stowed Representation:
The second parachute will be inside container and attached through an eye bolt. It will open as soon as top lid opens and first parachute pull upwards. In order to open easily and quickly when the parachute exposed to air, it will be fold as shown in picture.



Container Descent Control Hardware Summary (5/5)

Container Sensors Operation Sequence

Container altitude sensor will be measured to aid the descent control process. Altitude data is obtained from BME 280 that aims to open top lid and bottom lid. If the altitude data reaches at 400m it will command to activate the servo to open the top lid and bottom lid that release second parachute. When altitude data reaches at 300m it will command to activate the servo open the bottom lid that release tethered payload.



Sample Altitude

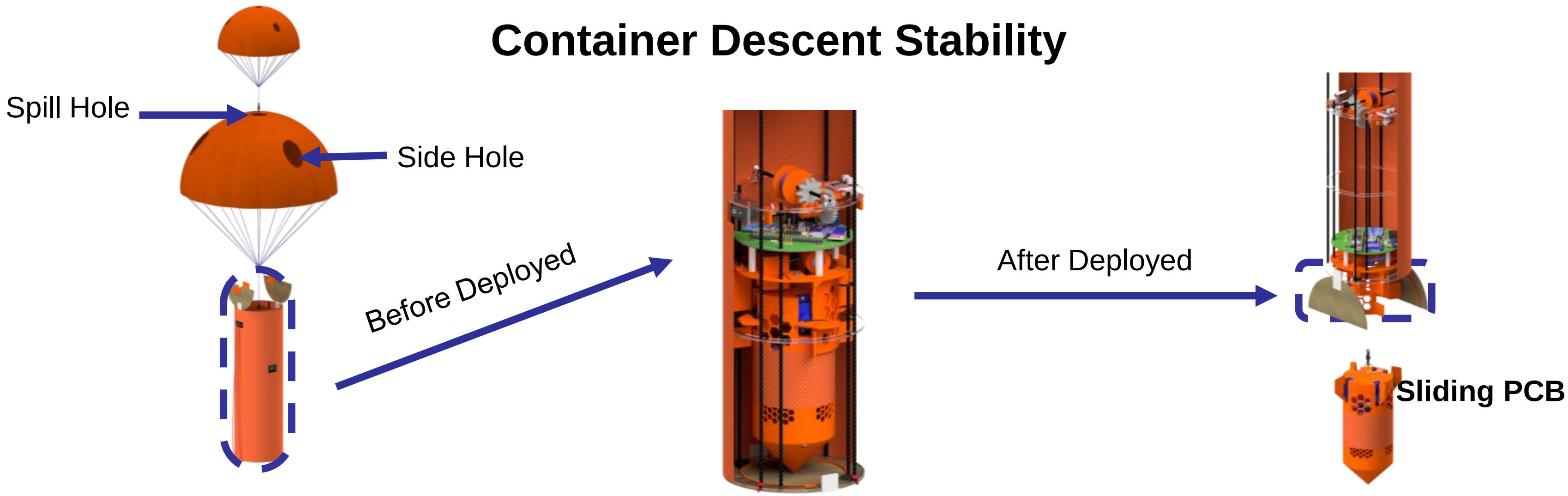
Altitude = 121.9m

Altitude = 122.2m

Altitude = 122.0m

Container and Payload Descent Stability Control Design (1/2)

Container Descent Stability

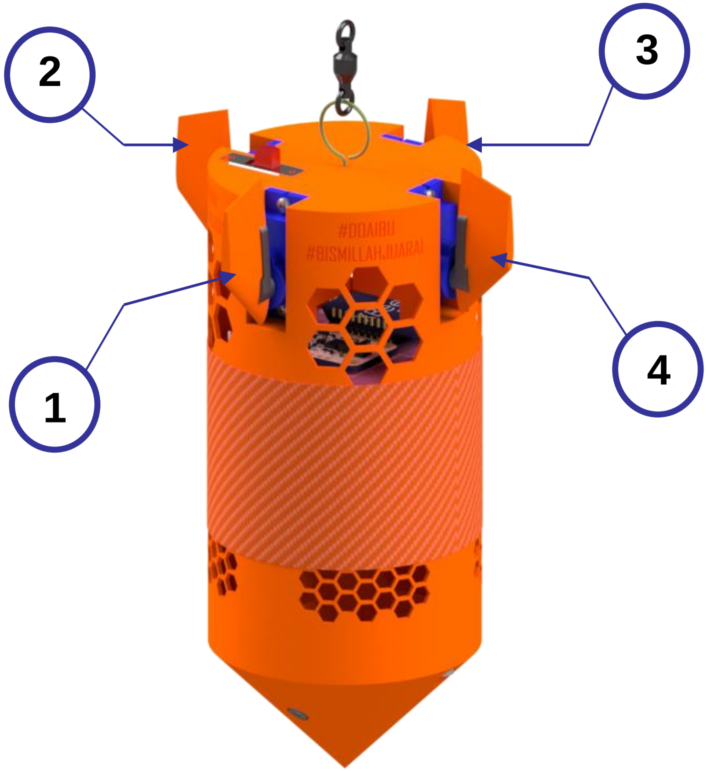


Information

Stability Type: Passive Control
Description:
Stability is maintained by placing major components at the bottom of the container so the mass is focused at the bottom. This strategy keeps the container from swaying.
After the payload has been unspooled, PCB and payload's holder will be sliding to the bottom of the container and locked by velcro to keep the container from swaying. The container's shape is a cylinder to maintain nadir direction.
Spill hole and side hole will also increase the stability of container. Adding a swivel on parachute cord will also reduce shock to container.

Container and Payload Descent Stability Control Design (2/2)

Payload Descent Stability



Information

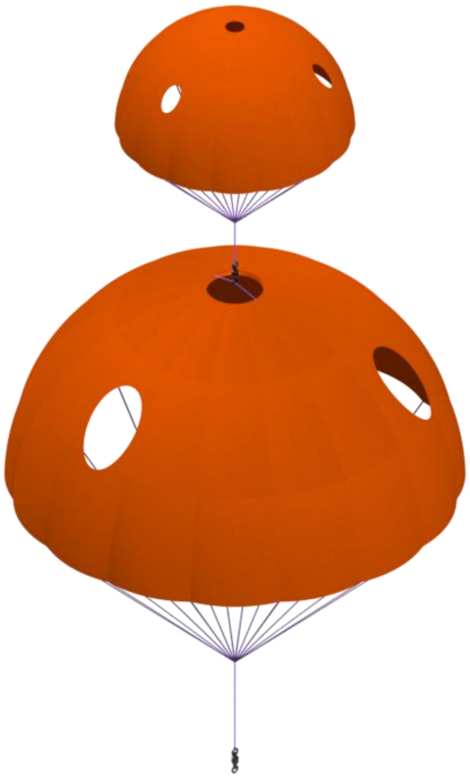
Type Stability: Active Control
Description:
The payload is using four fins mechanisms to maintain its stability. Each fin is moved by a servo. PID control is used to control fins mechanism. The payload will maintain the orientation of a video camera pointing in the south direction and pointed 45 degrees downward. This strategy also keeps the payload from swaying and maintain nadir direction.
Cone shape at the tip of payload also maintain stability of payload due to turbulent air below payload

Payload's Fins Movement

Axis \ Fin	1	2	3	4
Roll	✓	-	✓	-
Pitch	-	✓	-	✓
Yaw	✓	✓	✓	✓

Note: ✓ means fins that will be moved to maintain orientation of payload.

Descent Rate Estimates (1/6)



The descent rate of each descent phase will be estimated using different parameters
First Parachute Parameters: - Diameter of Parachute (*Dp*) - Diameter of Spill Hole and Side Hole (*Dsh*) Requirement: -Descent rate of 15 m/s $(\pm\ 5m/s)$
Second Parachute Parameters: - Diameter of Parachute (*Dp*) - Diameter of Spill Hole and Side Hole (*Dsh*) Requirement: -Descent rate of 5 m/s $(\pm 2m/s)$

First Parachute

We use the range of descent velocity between minimum [V min = 10 m/s] and maximum [Vmax = 20 m/s] to determine diameter of parachute.

$$\sqrt{\frac{8 \times m \times g}{\rho \times (v_{max})^2 \times \pi \times Cd}} \leq Dp \leq \sqrt{\frac{8 \times m \times g}{\rho \times (v_{min})^2 \times \pi \times Cd}}$$

$$\sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (20)^2 \times (3.14) \times (1.28)}} \leq \mathrm{Dp} \leq \sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (10)^2 \times (3.14) \times (1.28)}}$$

$$\mathbf{0.155\ m \leq\ Dp \leq 0.309\ m}$$

Information:

$Dp =\ The\ diameter\ of\ the\ parachute\ (m)$

$v\ =\ Descent\ speed\ (m/s)$

$\pi = 3.14$

$g = 9.8\ \ m/s^2$

$Dsh =\ Spill\ hole\ and\ side\ hole\ diameter\ (m)$

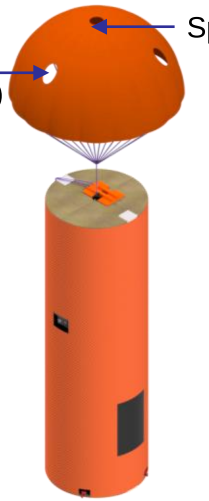
***Assumption**

$*\ Cd\ =\ 1.28\ (Coefficient\ drag\ of\ parachute)$

$*m =\ 0.6\ kg\ (container + payload)$

$*\ \rho = 1.225\ kg/m^3$

Chosen Diameter	Chosen Radius
0.206 m	**0.103 m**



Diameter of the spill hole and side hole is 8%-10% of parachute's diameter because we set tolerance of $\pm 2\%$.

Spill hole and side hole diameter = $Dsh\ =\ Dp\ x\ 8\%\ = \mathbf{0.0168\ m}$.

Spill hole and side hole radius = $\frac{Dsh}{2} = \mathbf{0.00824\ m}$.

Descent Rate Estimates (3/6)

Second Parachute

We use the range of descent velocity between minimum [V min = 3 m/s] and maximum [Vmax = 7 m/s] to determine diameter of parachute.

$$\sqrt{\frac{8 \times m \times g}{\rho \times (v_{max})^2 \times \pi \times Cd}} \leq Dp \leq \sqrt{\frac{8 \times m \times g}{\rho \times (v_{min})^2 \times \pi \times Cd}}$$

$$\sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (7)^2 \times (3.14) \times (1.28)}} \leq \mathrm{Dp} \leq \sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (3)^2 \times (3.14) \times (1.28)}}$$

$$\mathbf{0.442\ m \leq\ Dp \leq 1.03\ m}$$

Information:

$Dp =$ *The diameter of the parachute (m)*

$v =$ *Descent speed (m/s)*

$\pi = 3.14$

$g = 9.8\ m/s^2$

$Dsh =$ *Spill hole and side hole diameter (m)*

***Assumption**

$* Cd = 1.28$ (*Coefficient drag of parachute*)

*$m = 0.6\ kg$ (*container + payload*)

$* \rho = 1.225\ kg/m^3$

Chosen Diameter	Chosen Radius
0.62 m	**0.31 m**

Diameter of the spill hole and side hole is 8%-10% of parachute's diameter because we set tolerance of $\pm 2\%$.

Spill hole and side hole diameter = $Dsh = Dp\ x\ 8\% = \mathbf{0.0496\ m}$.

Spill hole and side hole radius = $\frac{Dsh}{2} = \mathbf{0.00248\ m}$.

CanSat (Container + Payload) Descent Rate

Information:

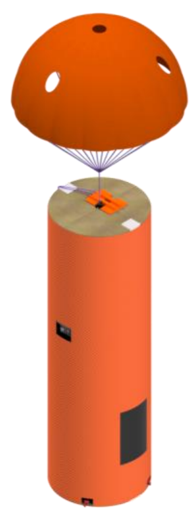
Container mass: 418.75 g
Payload mass: 190.77 g
Total mass: 609.52 g

First Parachute Descent Rate Estimate

$$v = \sqrt{\frac{8 \times m \times g}{\rho \times Dp^2 \times \pi \times Cd}}$$

$$v = \sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (0.206)^2 \times (3.14) \times (1.28)}}$$

$$\boldsymbol{v = 15.12\ m/s}$$



Second Parachute Descent Rate Estimate

$$v = \sqrt{\frac{8 \times m \times g}{\rho \times Dp^2 \times \pi \times Cd}}$$

$$v = \sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (0.62)^2 \times (3.14) \times (1.28)}}$$

$$\boldsymbol{v = 5,02\ m/s}$$

Container Descent Rate After Payload Release

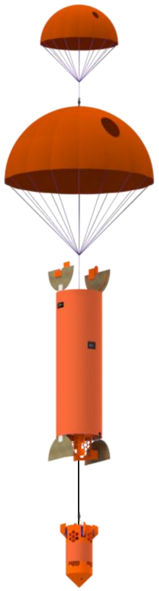
Information:
Container mass: 418.75 g Payload mass: 190.77 g Total mass: 609.52 g

Container Descent Rate After Payload Release

$$v = \sqrt{\frac{8 \times m \times g}{\rho \times Dp^2 \times \pi \times Cd}}$$

$$v = \sqrt{\frac{8 \times (0.6) \times (9.8)}{1.225 \times (0.62)^2 \times (3.14) \times (1.28)}}$$

$$\boldsymbol{v = 5,02\ m/s}$$



Note: Descent rate of the container after payload release does not affect the total mass because the payload is tethered to the container.

Descent Rate Estimates (6/6)

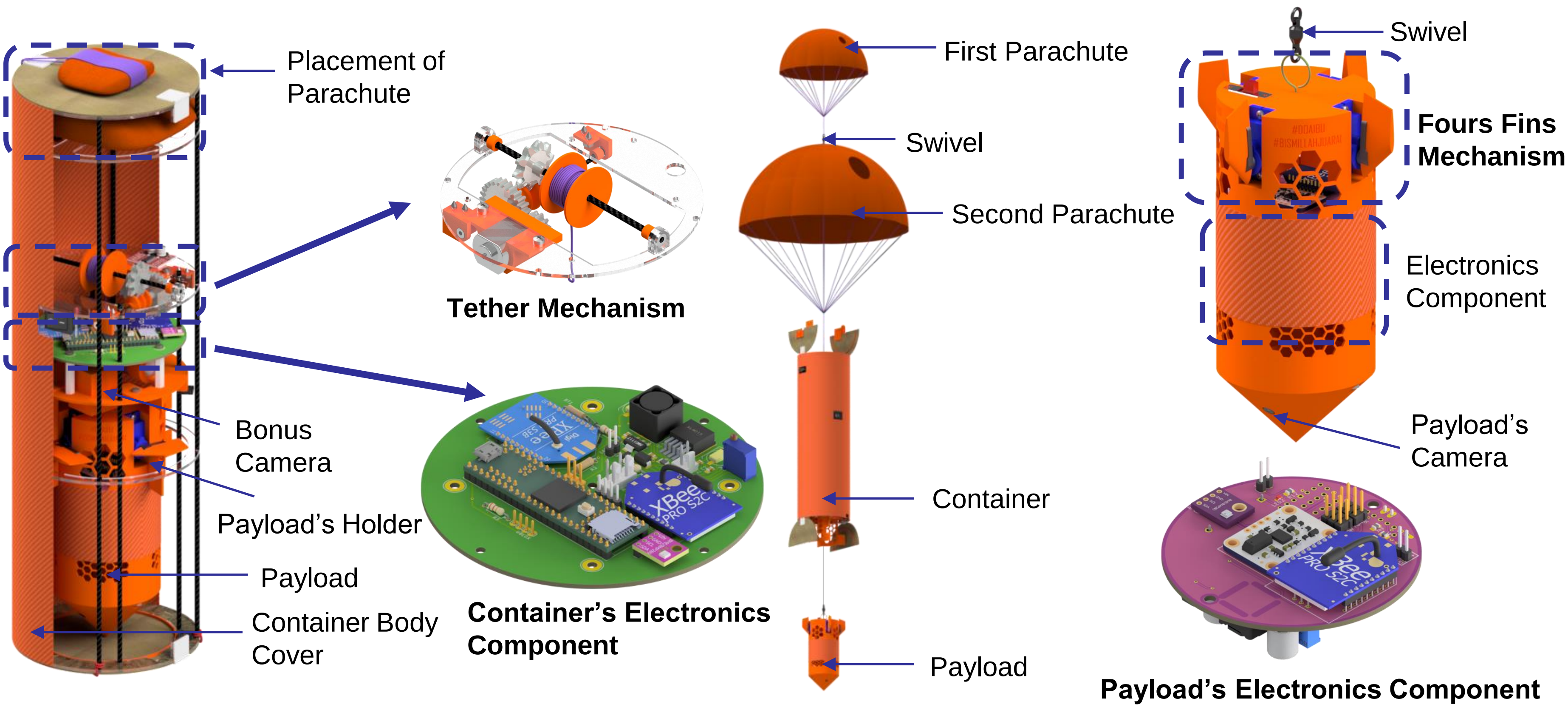
Final Result

Parachute Summary:	
Altitude	The descent rate of each descent phase will be estimated using parameters
725-400 m	Type parachute: Round parachute The diameter of first parachute: **206 mm** Spill hole diameter: **16.8 mm** The descent speed: **15,12 m/s** $\approx \mathbf{15\ m/s}$
400-0m	Type parachute: Round parachute The diameter of second parachute: **620 mm** Spill hole diameter: **49.6 mm** The descent speed: $\mathbf{5,02\ m/s} \approx \mathbf{5\ m/s}$
Container Summary:	
Using passive control for container stability. Focus of mass in the bottom of the container to keep the stability and decrease swing. It also help maintain nadir direction.	
Payload Summary:	
The Payload is using active control. Active control used is four fins mechanism to maintain orientation and nadir direction accurately.	

Mechanical Subsystem Design

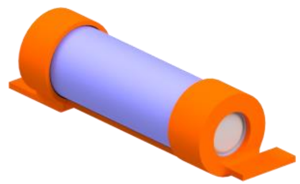
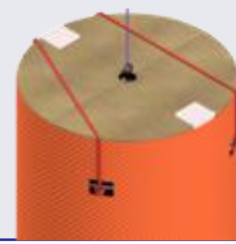
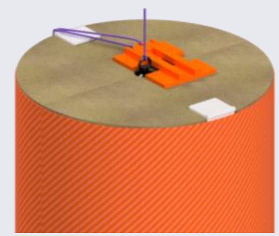
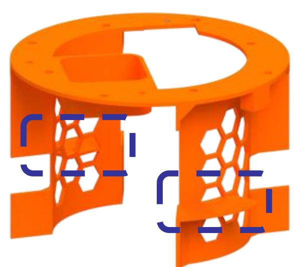
I Made Nugi

Mechanical Subsystem Overview

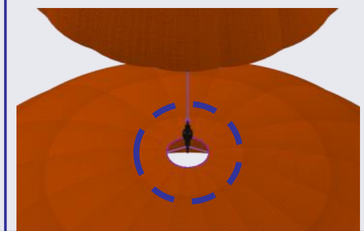
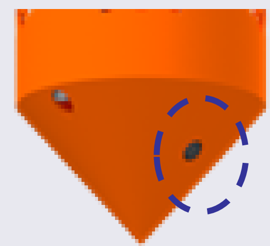


Container	Payload
Material: Acrylic, Crepe Paper Composite, PLA+, and Paperboard Composite. **Parachute**: Ripstop Nylon **Note:** The container has two parachutes, the first parachute is smaller than the second parachute.	**Material**: PLA+ and Crepe Paper Composite **Note:** The payload will be actively controlled by four fins mechanism.

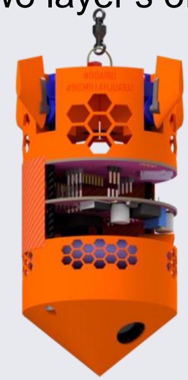
Mechanical Subsystem Changes Since PDR (1/3)

	Part	PDR	CDR	Rationale
Container	Servo holder in locking system			Decrease unnecessary dimension.
	Battery Holder.			Increase Durability of Battery Holder.
	Top lid locking mechanism.			To prevent first parachute to tangle with the rubber that hampers second parachute release.
	Payload Holder			Ease Manufacturing Process.

Mechanical Subsystem Changes Since PDR (2/3)

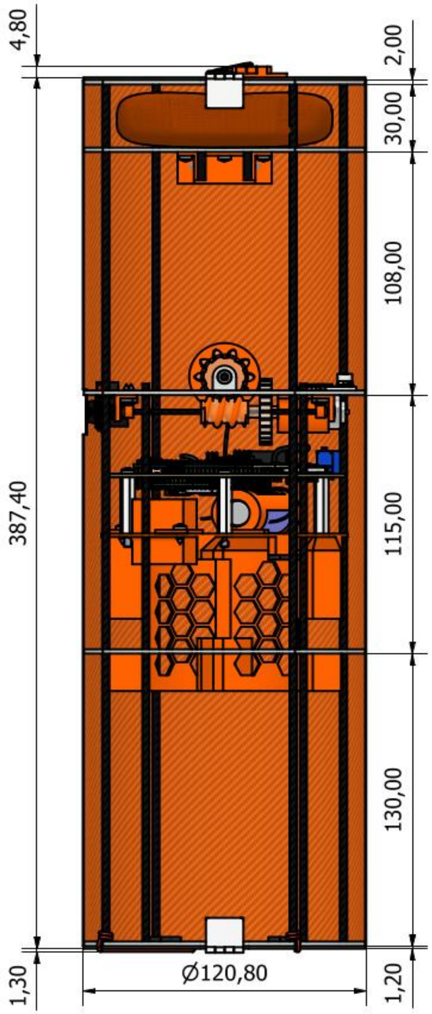
	Part	PDR	CDR	Rationale
Container	Additional Ring Feature.	It doesn't exist		To prevent second parachute from slipping through top lid's hole.
	Container Body Cover.	One layer of crepe paper composite.	Two layer of crepe paper composite.	Increase Durability of Body Cover.
Payload	Payload Camera Case.			Decrease mass and save space.
	Payload Body Cover.	One layer crepe paper composite.	Two layer crepe paper composite.	Increase durability of body cover.

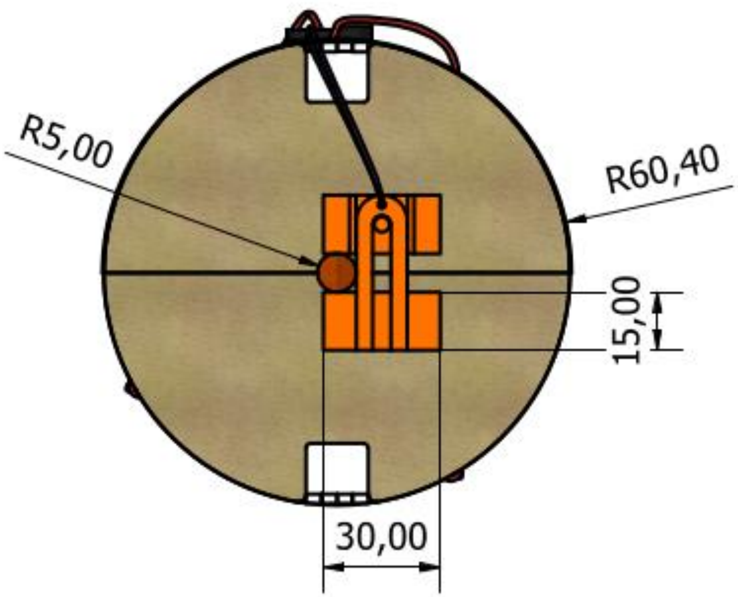
Mechanical Subsystem Changes Since PDR (3/3)

	Part	PDR	CDR	Rationale
Payload	Payload's PCB	Two layer's of PCB 	One Layer of PCB 	Payload microcontroller unit is changed to Teensy 4.0.
	Payload Battery Holder			Olight 18650 dimension were not compatible to our design.

Container Mechanical Layout of Components (1/6)

CAD Model of Container Structure

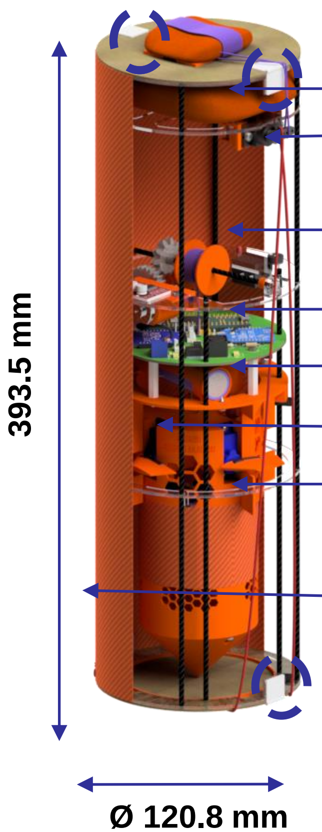


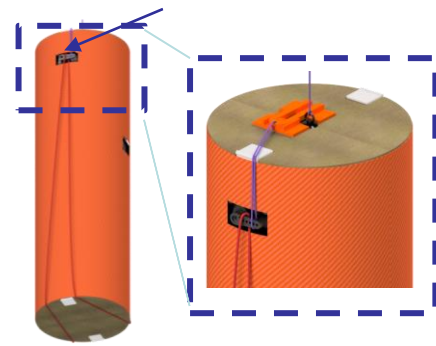


*The dimension of container and payload using technical drawing in CAD software

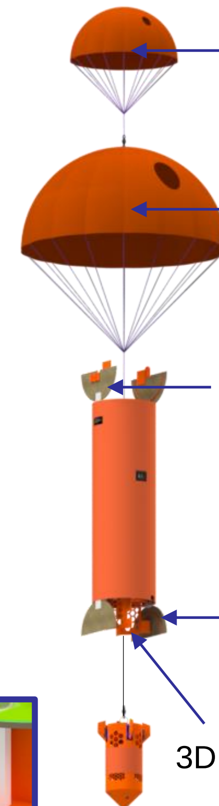
*All measurement units are in mm

Container Major Parts and Components (Mechanical)

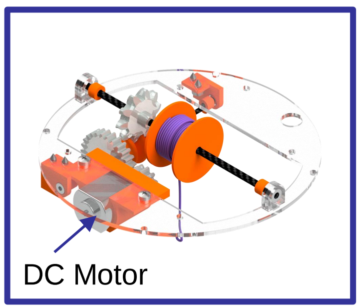




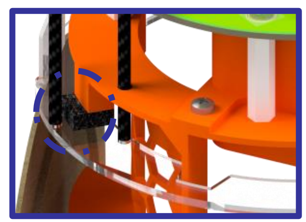
Locking System of Lids



3D Printed Holder



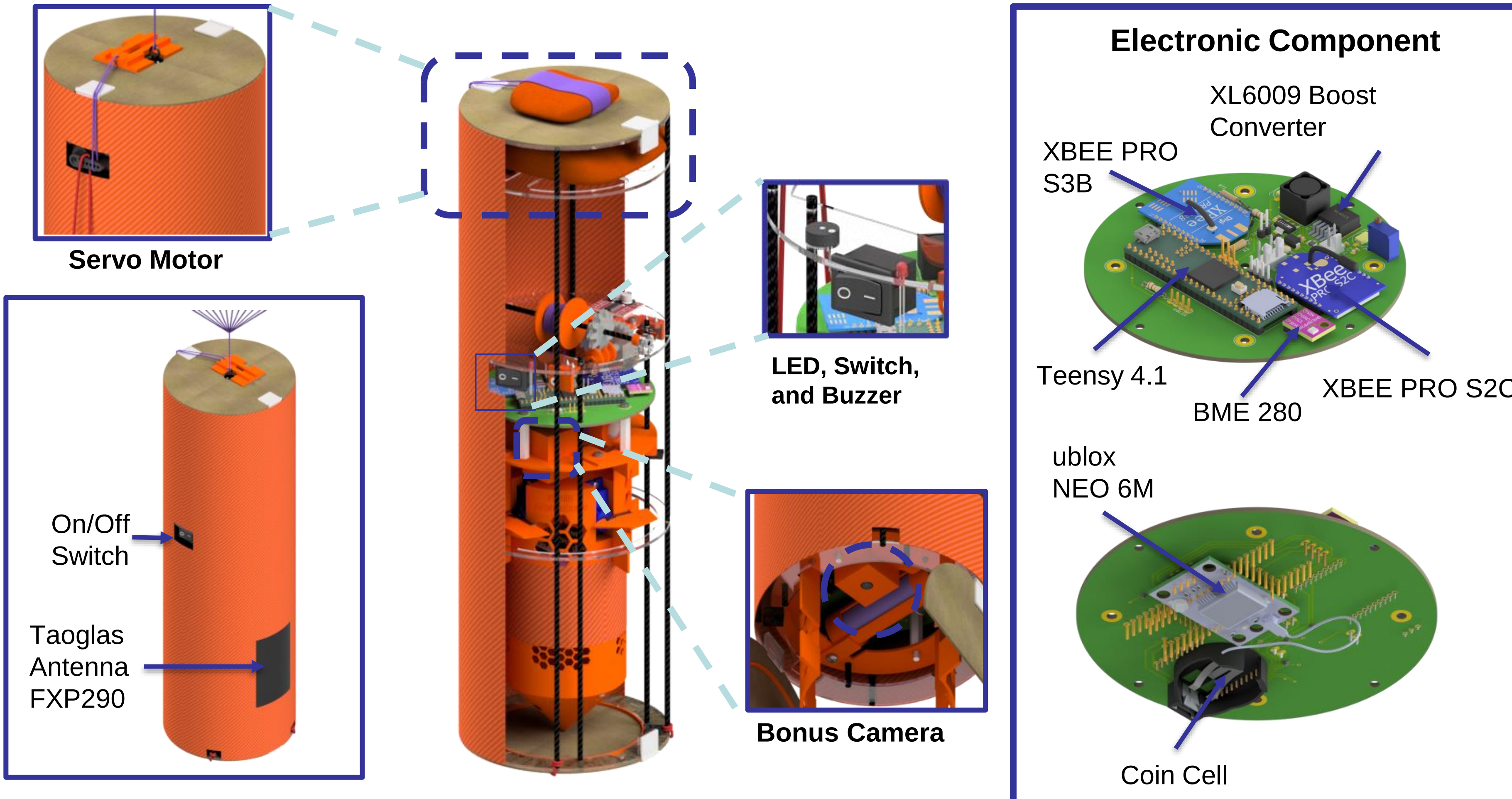
Tether Mechanism



Velcro Locking System of PCB

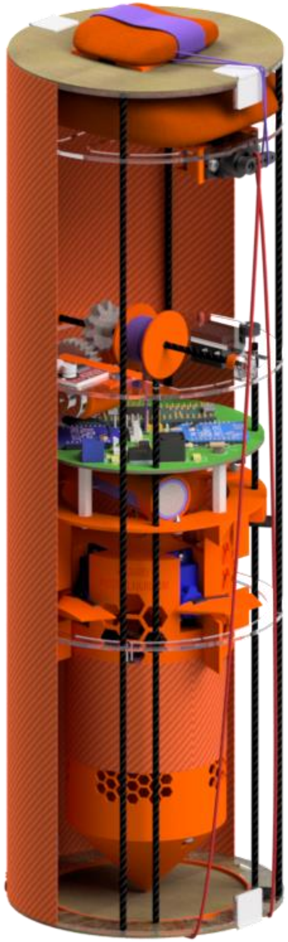
Container Mechanical Layout of Components (3/6)

Container Major Parts and Components (Electrical)



Container Mechanical Layout of Components (4/6)

Container Design Key Features



Structure and material

- Most of container material using crepe paper composite, acrylic, PLA+, carbon rod (3 mm in diameter), and paper board composite.
- The body cover of container was assembled from the crepe paper composite, carbon rod (3 mm in diameter), Acrylic, and Paper board composite.
- Same as the acrylic for the body cover frame. The carbon rod in the body cover acts as support and provides the rigidness of body cover, so that it is strong enough.
- Inside container the payload secured by 3d printed holder made of PLA+.
- Rounded edges (No sharp edges)
- Container fully encloses the science payload

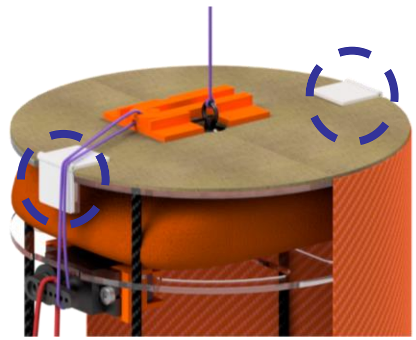
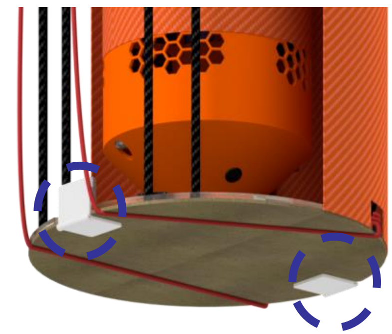
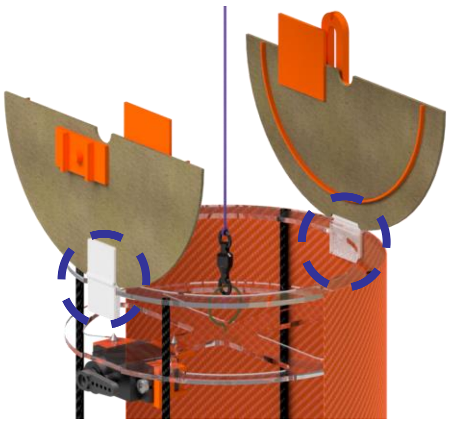
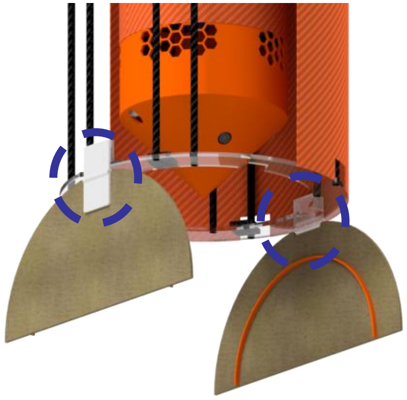
Functional part

- Servo is used to unlock both top lid and bottom lid.
- The hinges serve as joint to connect between part of container.

Container Mechanical Layout of Components (5/6)

Component attachment:
Hinges

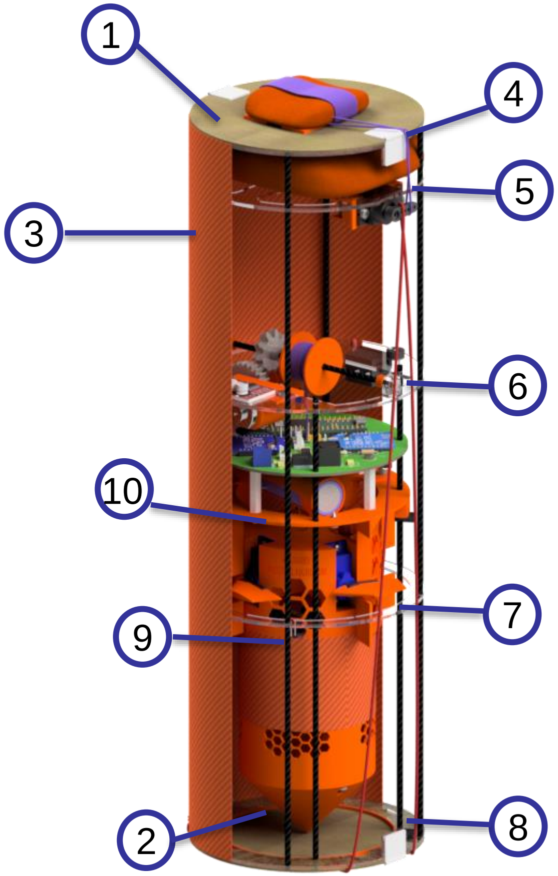
Container Attachment Points

	Top Lid	Bottom Lid
Pre-Deployment		
After-Deployment		

Container Mechanical Layout of Components (6/6)

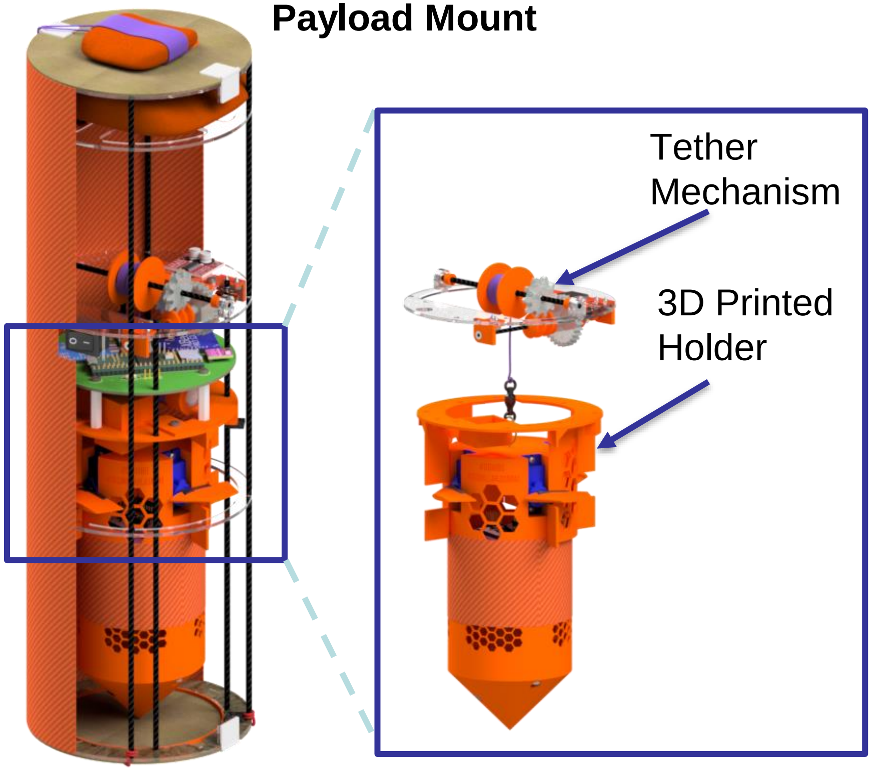
Structural Material

Part	Material
(1) Top Lid, (2) Bottom Lid	Paper Board Composite
(3) Container Body Cover	Crepe Paper With Tile Composite
(4) Top Lid Frame, (5) Parachute Frame, (6) Tether Frame, (7) Middle Frame, (8) Bottom Lid Frame	Acrylic
(9) Structure	Carbon Rod
(10) Payload Holder	PLA+ 3D Printing



Container Payload Mount

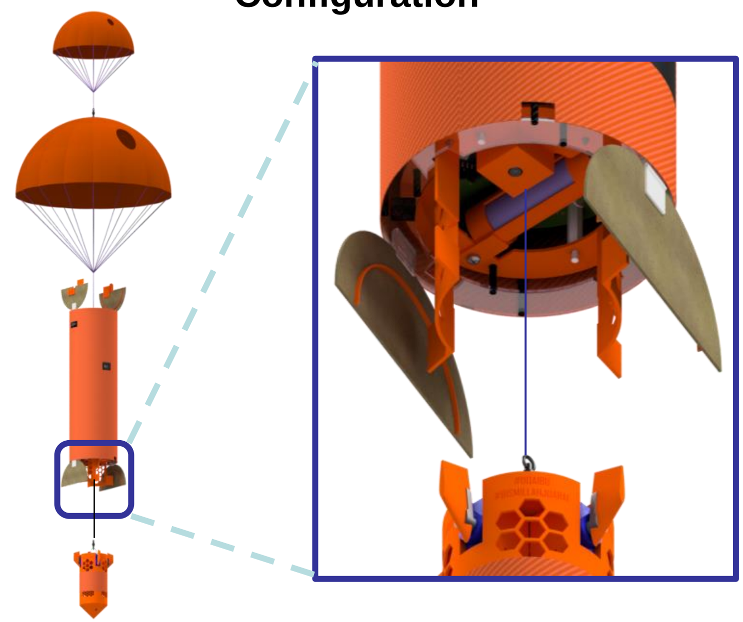
Payload Mount



Information:

Payload is secured inside container using 3D printed holder. The holder is used to reduce the shock and prevent shifting while the payload is stowed. The holder has a shape that matches with the payload shape.

Payload Mechanical Deployed Configuration

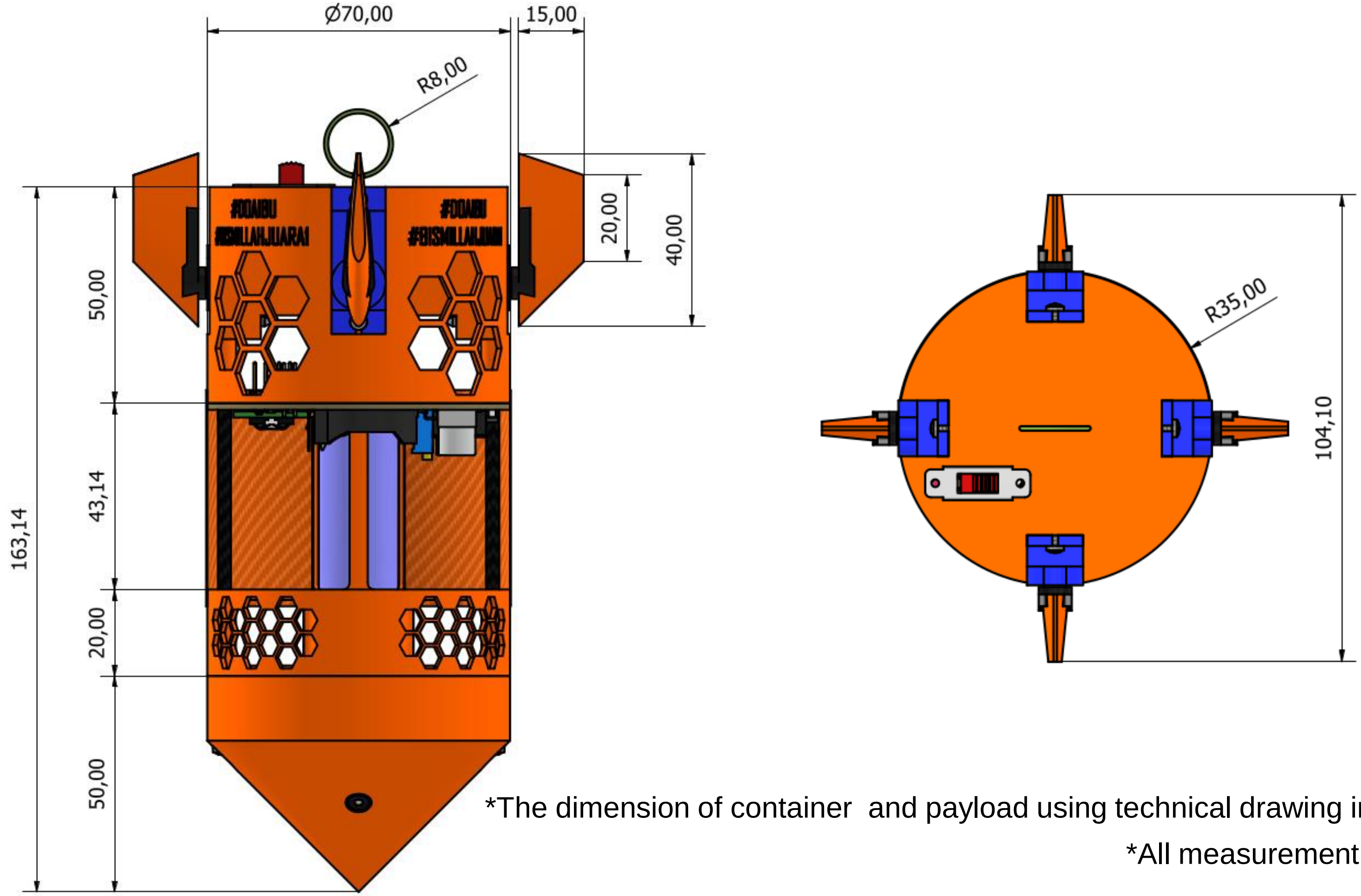


Information:

Payload can be deployed after bottom lid opened and tether mechanism activated. Bottom lid can be open if servo unlocks rubber locking system. Descent rate of payload will be controlled by tether mechanism.

Payload Mechanical Layout of Components (1/4)

Payload CAD Model Structure

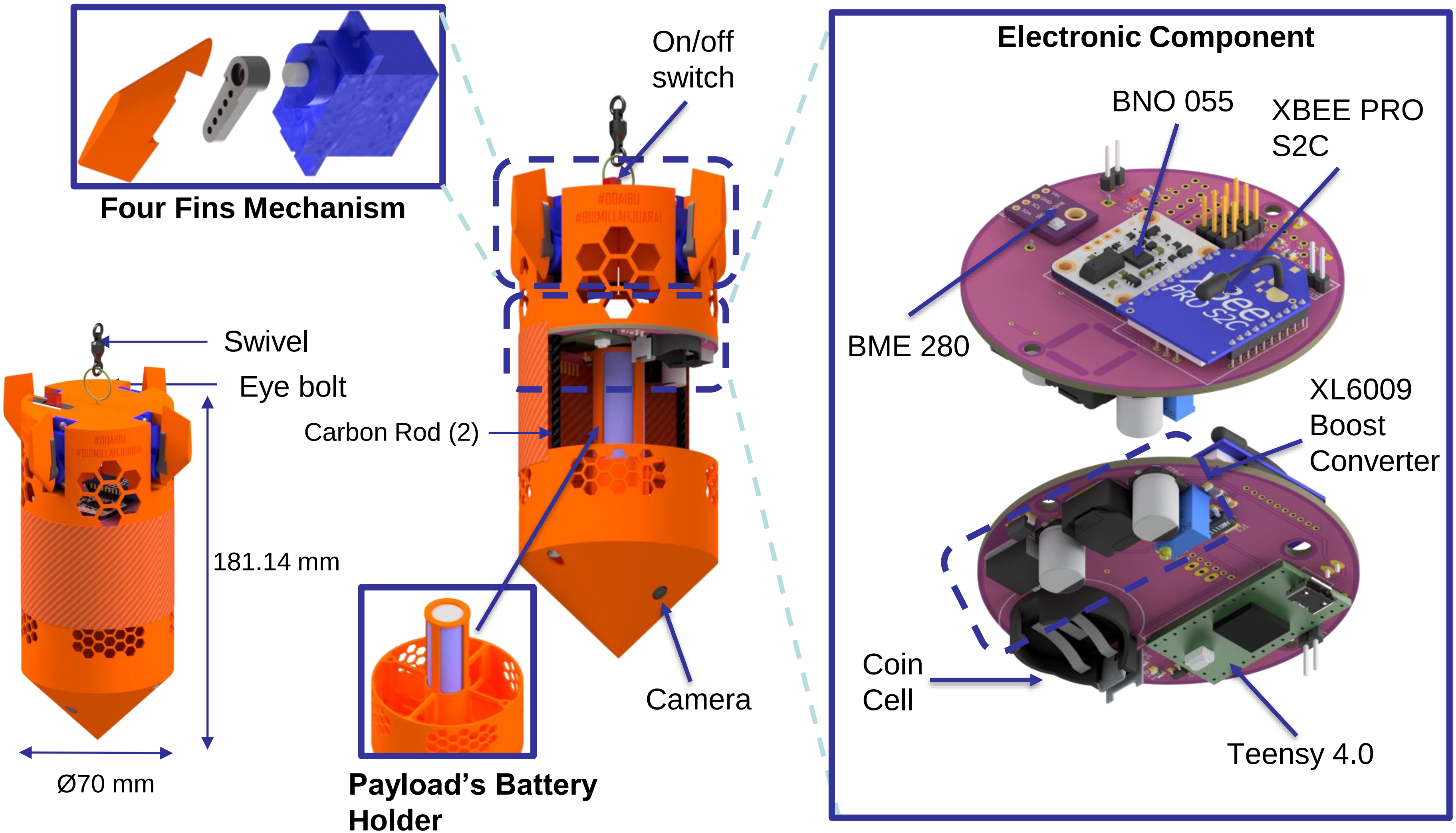


*The dimension of container and payload using technical drawing in CAD software

*All measurement units are in mm

Payload Mechanical Layout of Components (2/4)

Payload Major Parts and Component



Payload Mechanical Layout of Components (3/4)

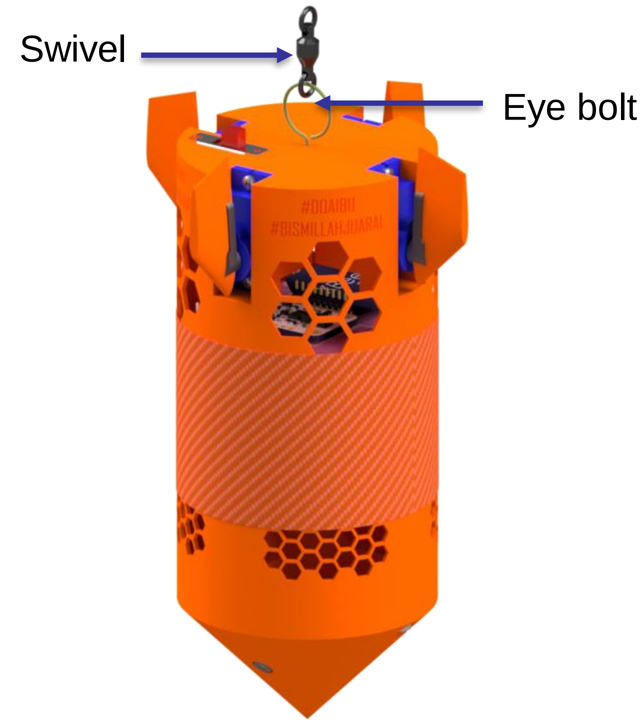
Payload Design Key Features

- Most of payload material will be made of crepe paper composite, PLA+, and carbon rod (3 mm in diameter).
- The body cover of payload was assembled from the crepe paper composite, carbon rod (3 mm in diameter), and PLA+.
- The carbon rod in the body cover acts as support and provides the rigidness of body cover, so that it is strong enough.
- The payload shape is cylinder and conical at the bottom.
- Payload fins are made of PLA+

Functional part

- Electronic component such as servo are using to move the fins.
- Swivel upper the payload are using to prevent the tether payload swinging.

Attachment Point of Payload

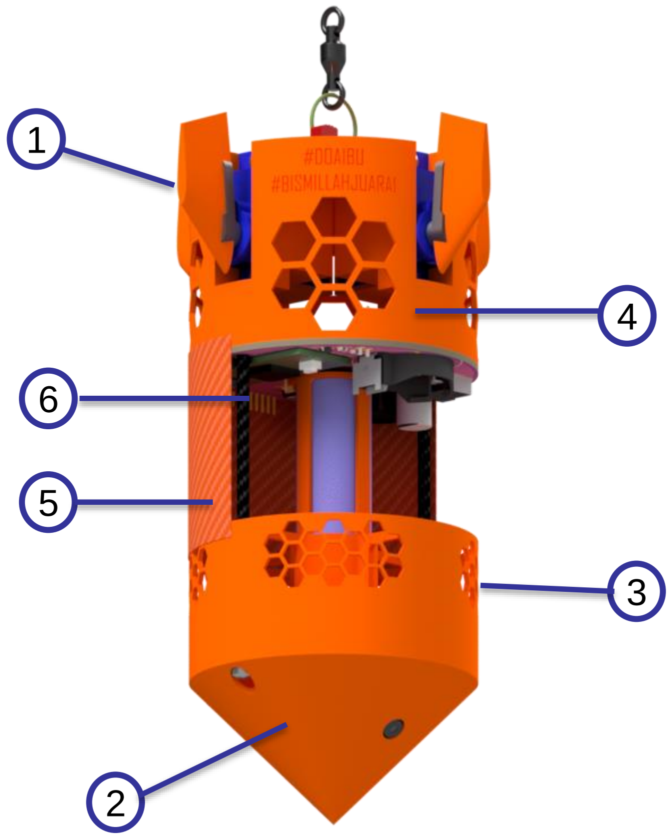


We are using swivel and Eye bolt as attachment point of payload which will be connected to the tether cord.

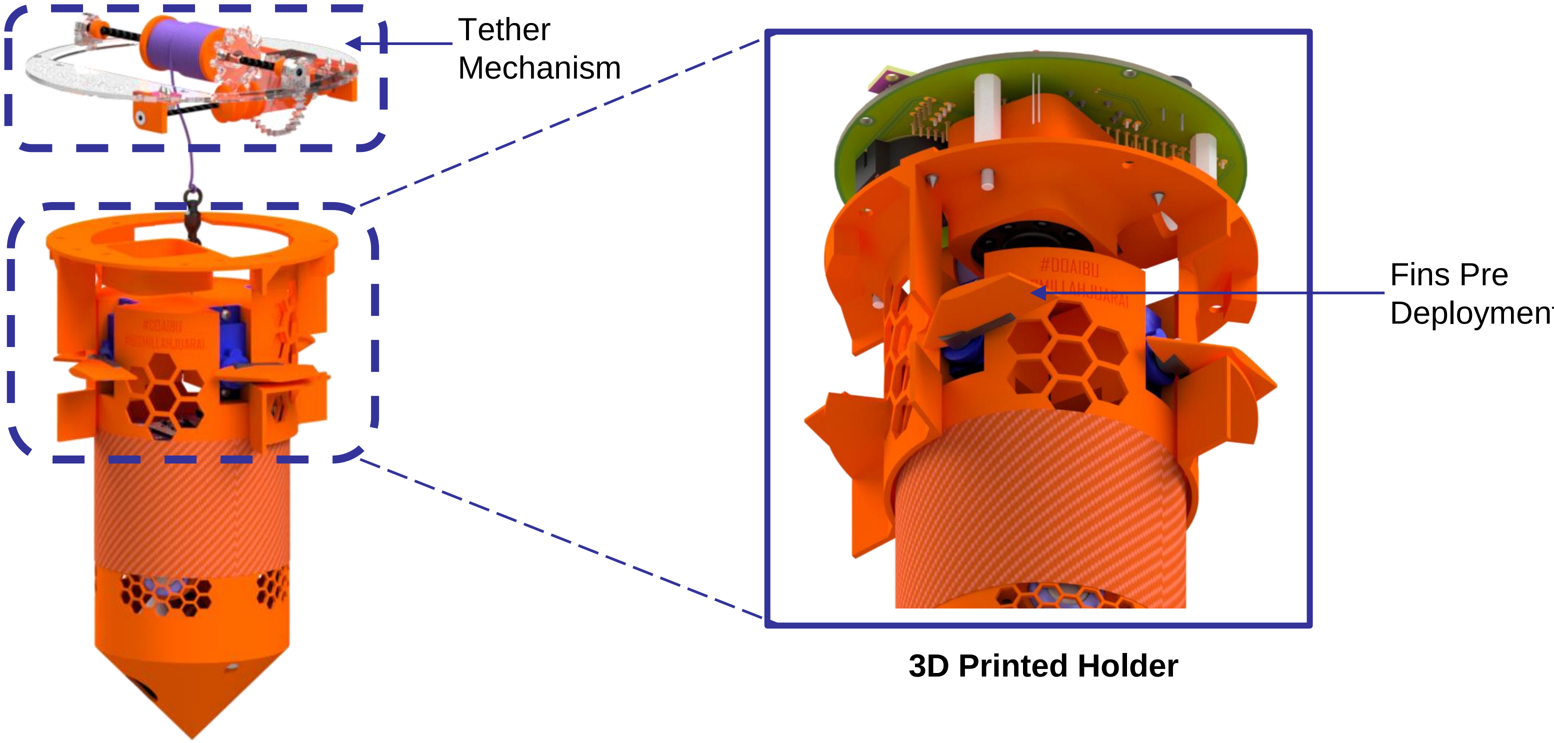
Payload Mechanical Layout of Components (4/4)

Payload Material

Part	Material
(1) Fins	PLA+ 3D Printing
(2) Payload Cone	
(3) Payload Shell	
(4) Payload Shell Fin Section	
(5) Payload's Body Cover	Crepe Paper and Tile Composite
(6) Structure	Carbon Rod



Payload Pre Deployment Configuration



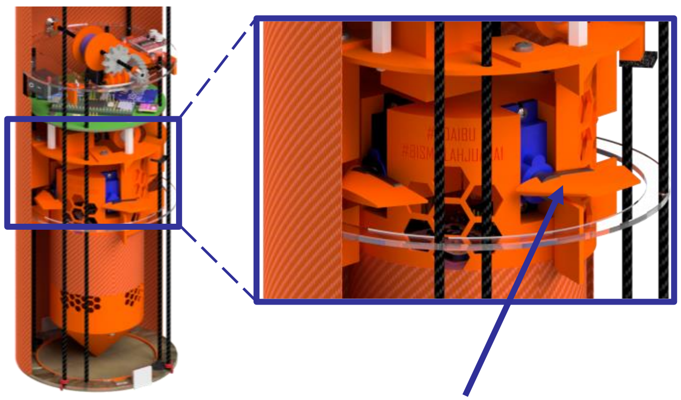
3D Printed Holder

Information

1. The 3D printed holder will be made of PLA+.
2. Holder is used to reduce the shock and prevent shifting while the payload is stowed.
3. The holder has a shape that matches with the payload shape.
4. Fins position in pre payload deployment condition will be 90 degrees to lock the payload position.

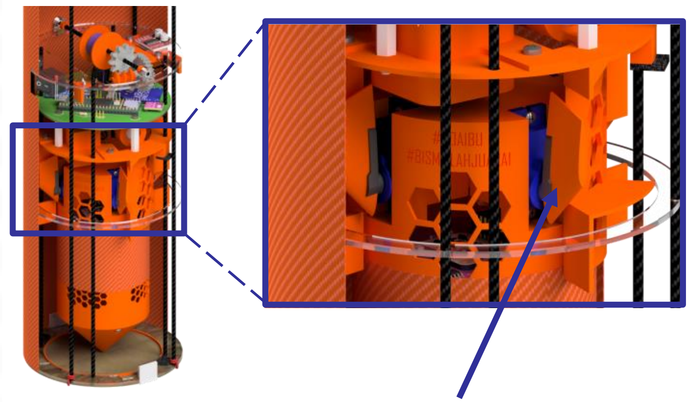
Payload Deployment Configuration

Step 1



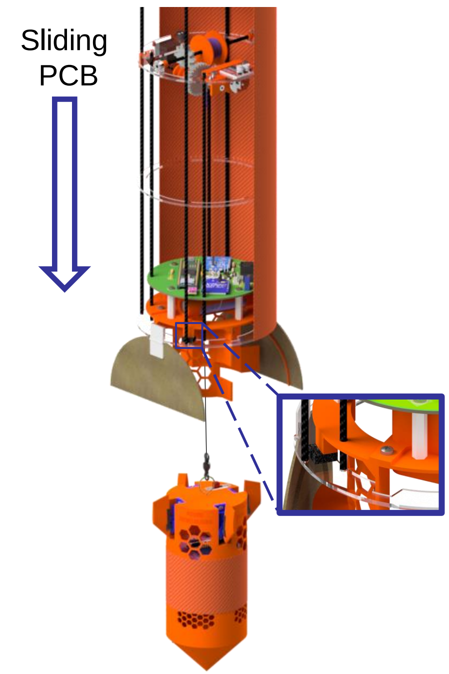
Payload Fins Stowed Position

Step 2



Payload Fins Transition From Stowed Position

Step 3



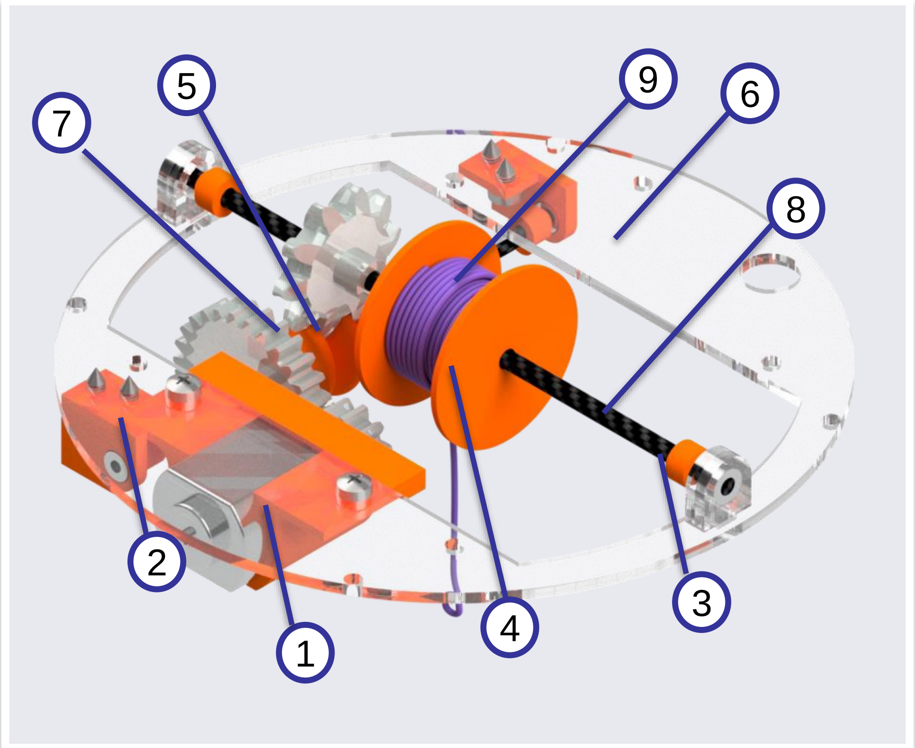
Information:

The payload will be released if the bottom lid opens, tether mechanism activates, and fins in deployed position. The payload will deploy by rotating the fins at 90 degrees. When the payload deployed, the PCB and payload's holder will be sliding to the bottom of the container and locked by Velcro .

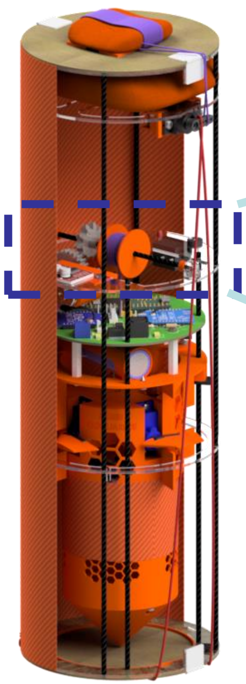
Tether Design Description (1/4)

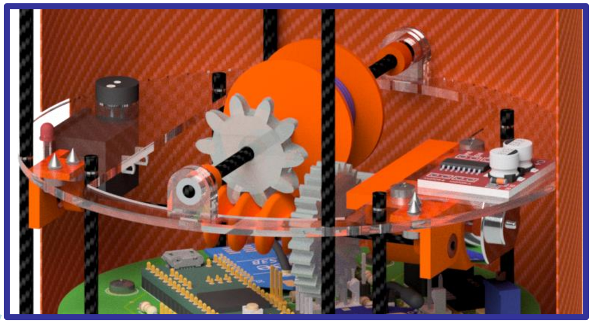
Tether Design and Material

Part	Material
(1) Motor Holder	PLA+ 3D Printing
(2) Gear Holder	
(3) Collar	
(4) Tether Spool	
(5) Worm Gear	
(6) Tether Frame	Acrylic
(7) Reduction Gear	
(8) Tether shaft	Carbon
(9) Tether Cord	Chinese Knotting Cord



How Tether Is Secured For Flight





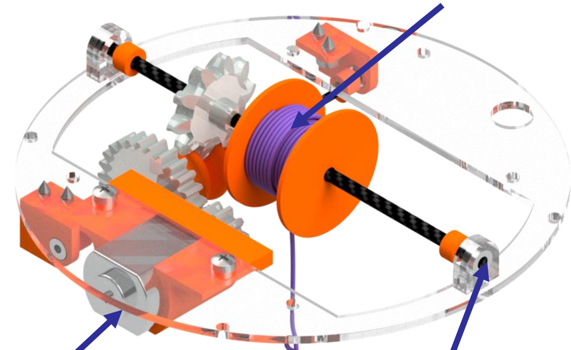
Tethered Mechanism Secured with Carbon Rod

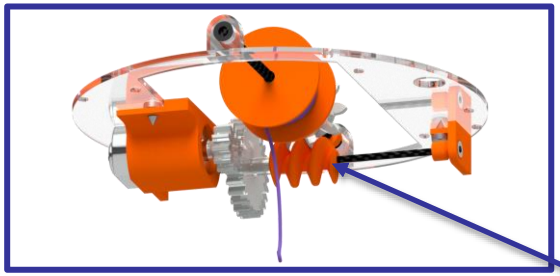
Information:

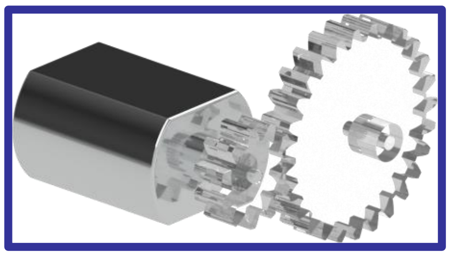
Tether will be hard glued to the carbon rod as standoff. We also bolt the tether firmly. All tether parts are also hard glued to assure the mechanism still rigid.. Tether will stay unspooled during flight due to gear torque and worm gear until the altitude reaches 300m.

Tether Design Description (3/4)

How Tether Is Unspooled And Releases 10 Meters In 20 Seconds







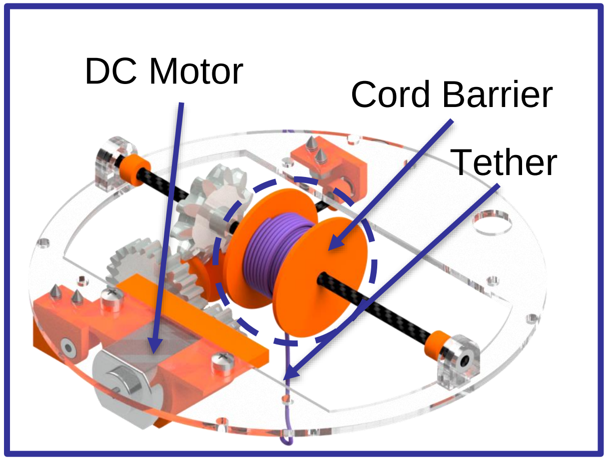
Reduction Gear Ratio 1:2.5

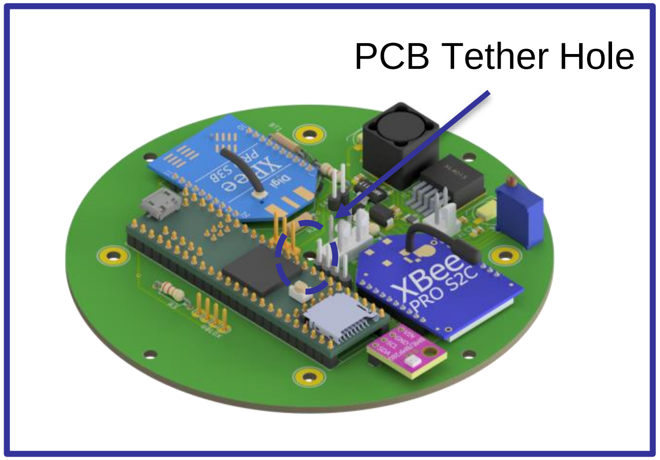
Information:

Tether will descent the payload accurately using DC motor and reduction gear. By using the ratio of (1 : 2.5) for reduction gear and (1 : 10) for worm gear. Therefore the unspooling rate of payload is controlled accurately to a distance of 10 meters in 20 seconds.

Tether Design Description (4/4)

How Tangling of The Tether Is Avoided



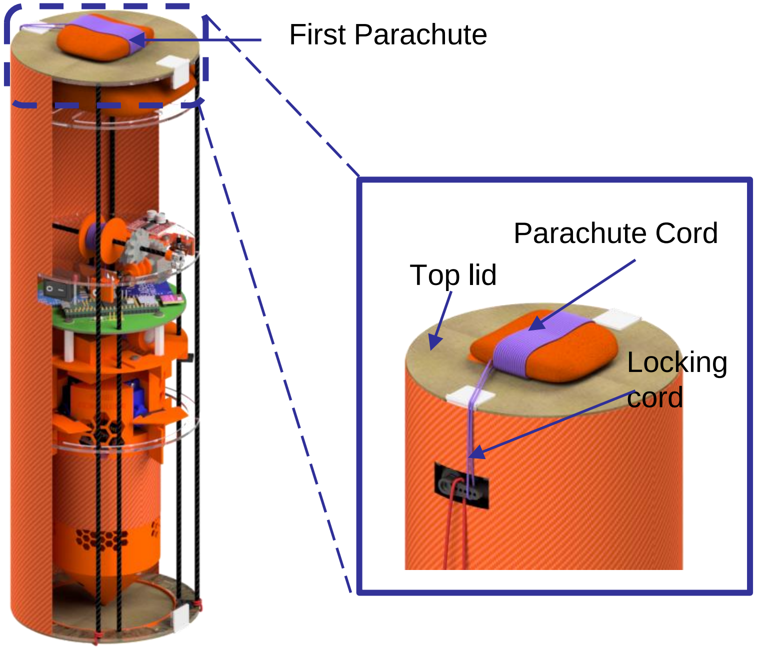


Information:

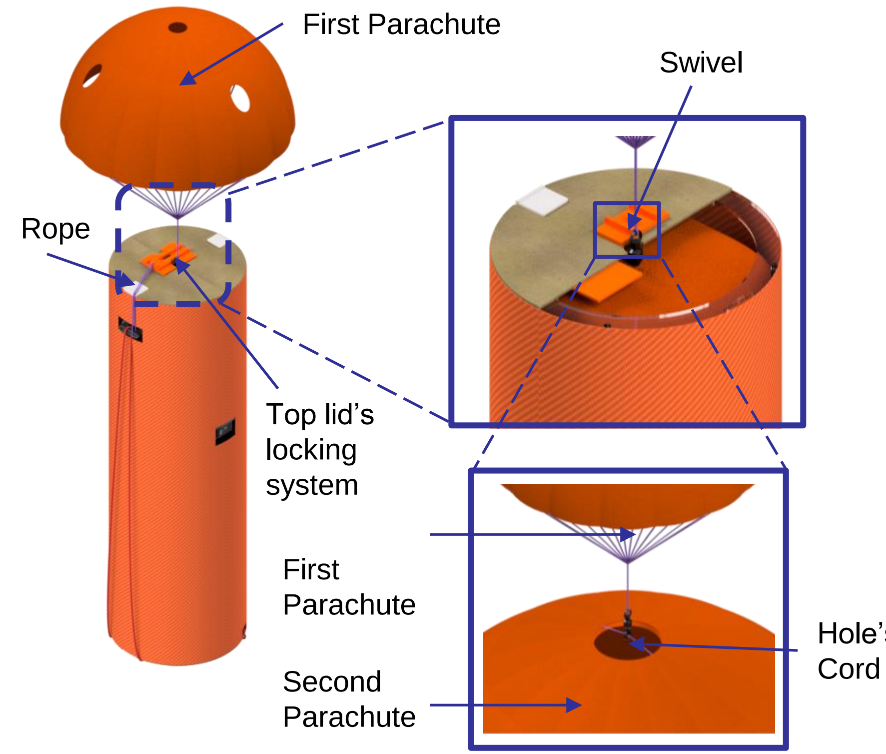
- Added tether cord barrier.
- Give a hole in the center of Container’s PCB for tether cord.
- Control the spinning rate of DC motor.
- Set the unspooling to the opposite direction from gear to prevent tether cord tangling to reduction gear.

Container Parachute Attachment Mechanism (1/2)

Before Deployment First Parachute



After Deployment First Parachute

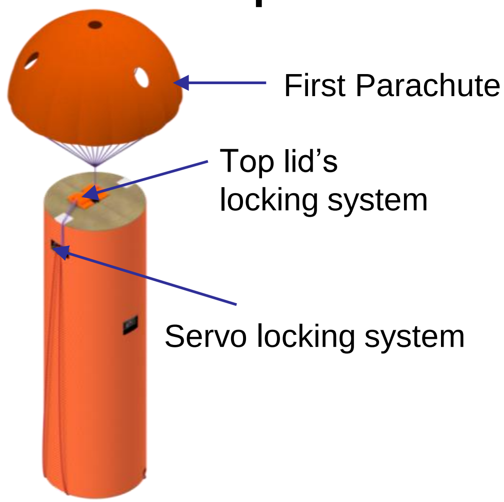


Information:

1. The first parachute is placed on the top of container at folded position.
2. The cord of parachute keeps the parachute to maintain its folded position before release.
3. The parachute will be opened by the air-resistance assist.
4. The first parachute will be attached by a Swivel as a connector with the second parachute through the top lid's hole
5. The second parachute will still be stowed under the top lid because the top lid is still closed by the rubber locking system.

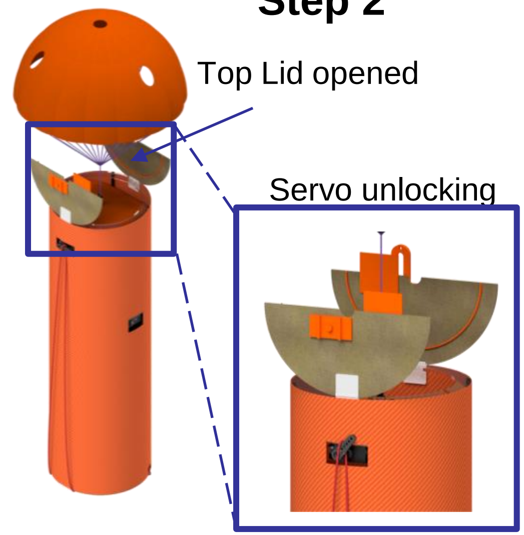
Container Parachute Attachment Mechanism (2/2)

Step 1



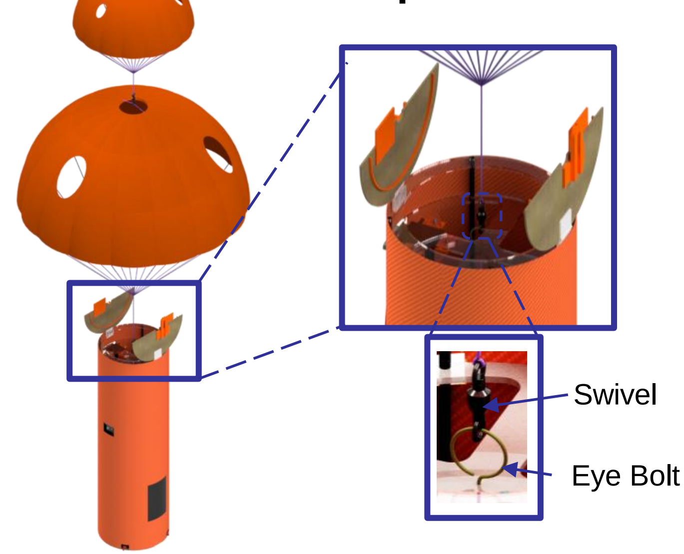
Second Parachute Stowed

Step 2



Second Parachute Transition Deployment

Step 3



Second Parachute Deployment

Information:

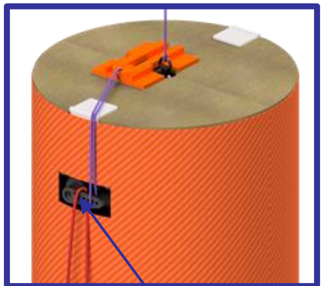
Step 1
The second parachute is placed between top lid and parachute frame of the container in folded position and attached by an eye bolt to container. The eye bolt is attached to parachute frame and hard glued. The top lid kept the second parachute inside container before release because it is held by the rubber locking system. The second parachute is connected to the first parachute through the top lid's hole with Swivel as a connector.

Step 2
At 400 m, servo activates to move the rubber that opens the top lid.

Step 3
After the top lid is opened, the first parachute will pull the second parachute by a Swivel to release from the container.

Structure Survivability (1/3)

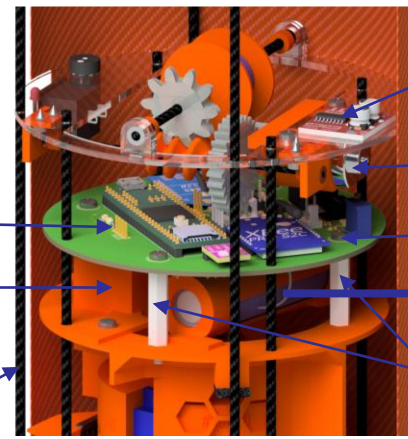
LED, Switch, and Buzzer



Servo Motor

Taoglas Antenna FXP290

Container



Steper Motor

DC Motor

PCB

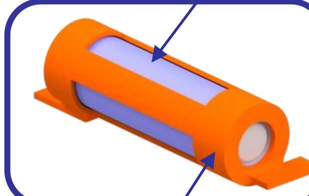
Bolt

Bonus Camera

Carbon Rod

Spacer

Electronics Component

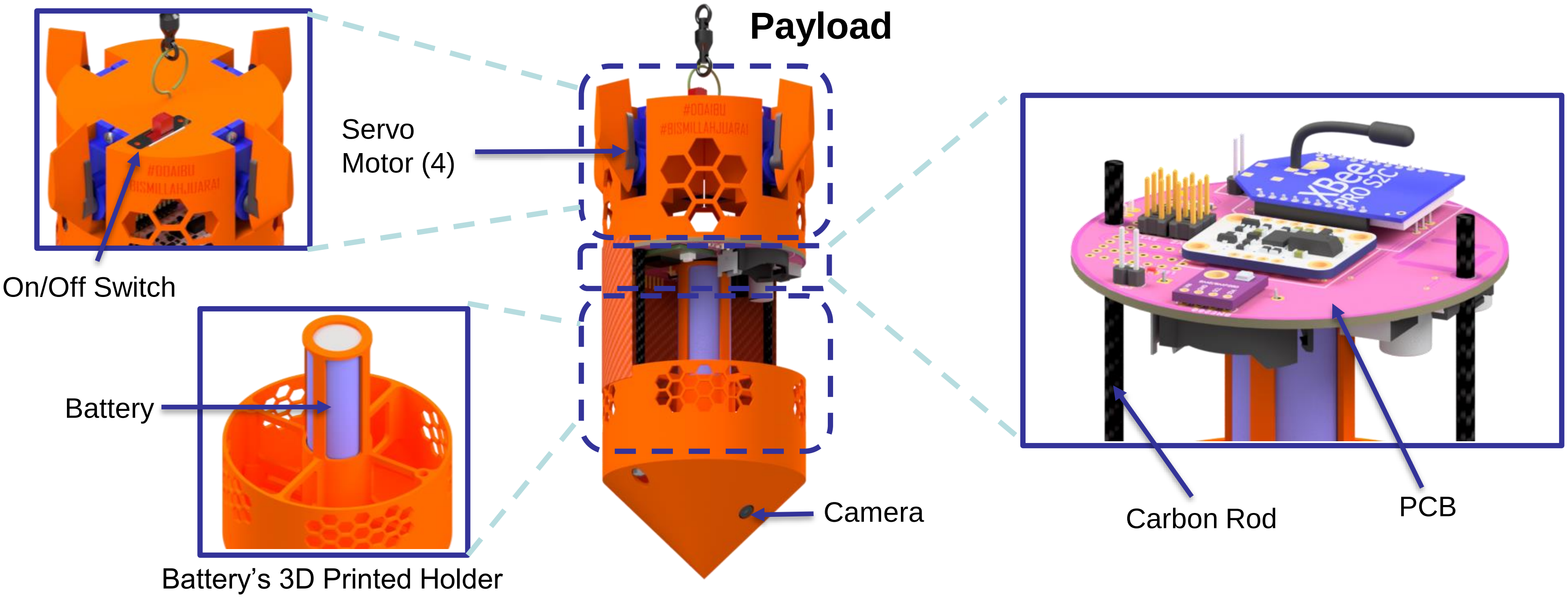


Payload's Battery

Battery's Holder

Mounting Method	Enclosures	Connection	Descent Control Attachment
1. Container's PCB is mounted using spacer. 2. Container's PCB is secured between carbon rod as standoffs.	1. Container's PCB will be fully enclosed inside its structural body. 2. The battery of the container will be kept by 3D printed holder to ease battery access. 3. Electronic components are secured with bolt.	1. Connectors of electronic components will be soldered and hot glued to the PCB. 2. Container batteries, camera, Taoglas Antenna FXP290, On/Off Switch, DC Motor and Servo Motor will be jumpered and secured to the electronic component.	1. The container's descent rate will be provided due to first and second parachute connected with Swivel. 2. To open both top and bottom lid, a servo will be used.

Structure Survivability (2/3)



Mounting Method	Enclosures	Connection	Descent Control Attachment
1. Payload's PCB is secured between carbon rod as standoffs.	1. Payload's PCB will be fully enclosed inside its structural body. 2. The battery of the payload will be kept by 3D printed holder to ease battery access.	1. Connectors of electronic components will be soldered and hot glued to the PCB. 2. Payload batteries, camera, and servo will be jumpered and secured to the electronic component.	1. The payload's descent will be provided due to the tether mechanism using DC motor and gears. 2. The payload is using four servos to maintain its orientation.

Structure Survivability (3/3)

Acceleration and Shock Force Requirements Testing

Requirement
CanSat survived given acceleration and shock force from 61cm feet attached to Cord . No electrical mounts disconnected, no parts falling off and no separation.
Testing
1. Attach 61cm cord to first parachute. 2. Add a floor mat or pillow below the test fixture. 3. Drop the CanSat. 4. Observe if any parts of the CanSat fall apart.
Result
The CanSat did not lose power. Inspect for any damage, or detached parts and verify telemetry is still being received.

Documentation

Note: Based on our testing in CDR Phase, we added a locking system on top lid to withstand given shock force and acceleration.

Mass Budget (1/4)

Container-Electrical Component					
Component	**Quantity**	**Mass Unit (g)**	**Mass (g)**	**Margins (g)**	**Determination**
Olight 18650 Battery	1	49.97	49.97		Measured
On/Off Switch	1	1.6	1.6		Measured
CR2032 Coin Cell	1	4.0	4.0		Measured
XL6009 Step-up	1	10.0	10.0		Measured
BME280	1	1.0	1.0		Measured
XBEE Pro S2C	1	4.0	4.0		Measured
XBEE Pro S3B	1	6.4	6.4		Datasheet
MG90 Servo Motor	1	14.6	14.6		Measured
DC Motor	1	24.0	24.0		Measured
Quelima SQ 11	1	3.3	3.3	0.66	Estimated
UBLOX NEO 6M	1	16.8	16.8		Measured
Buzzer	1	5 .0	5.0		Datasheet
3 mm LED	1	0.4	0.4		Measured
Teensy 4.1	1	8.8	8.8		Measured
MX1508 Driver Motor	1	2.2	2.2		Measured
Taoglas Antenna FXP290	1	1.5	1.5		Measured
PCB	1	24.65	24.65	4.93	Estimated
Spacer	4	0.75	3.0		Measured
Total Mass Electrical Component of Container			**181.22**	**5.59**	

Note: Due to the complexity of overall system, Mass estimation is derived from the 20% of its estimated value.

Mass Budget (2/4)

Container Structural Component					
Component	Quantity	Mass Unit (g)	Mass (g)	Margins (g)	Determination
Top Lid Frame	1	13.2	13.2		Measured
Parachute Frame	1	15.5	15.5		Measured
Tether Frame	1	31.3	31.3		Measured
Middle Frame	1	5.2	5.2		Measured
Bottom Lid Frame	1	9.9	9.9		Measured
Top Lid	1	9.7	9.7		Measured
Bottom Lid	1	10.0	10.0		Measured
Rubber	1	5.2	5.2		Measured
Battery Holder	1	4.4	4.4		Measured
3D Printed Holder	1	25.7	25.7		Measured
Battery Holder	1	4.53	4.53		Measured
Crepe Paper Composite	1	28.8	28.8	5.76	Estimated
Carbon Rod (395 mm)	4	4.1	16.4		Measured
Carbon Rod (250 mm)	4	2.65	10.5		Measured
Hinges	4	0.45	1.8		Measured
Parachutes	1	45.4	45.4	9.08	Estimated
Total Mass Structural Component of Container			**237.53**	**14.84**	

Note: Due to the complexity of overall system, Mass estimation is derived from the 20% of its estimated value.

Mass Budget (3/4)

Payload-Electrical Component					
Component	**Quantity**	**Mass Unit (g)**	**Mass (g)**	**Margins (g)**	**Determination**
Olight 18650 Battery	1	49.97	49.97		Measured
CR2032 Coin Cell	1	4.0	4.0		Measured
PCB	1	11.3	11.3	2.26	Estimated
On/Off Switch	1	0.1	0.1		Measured
XL6009 Step-up	1	10.0	10.0		Measured
BNO055	1	3.0	3.0		Measured
BME280	1	1.0	1.0		Measured
XBEE Pro S2C	1	4.0	4.0		Measured
Teensy 4.0	1	4.7	4.7		Measured
Quelima SQ 11	1	3.3	3.3	0.66	Estimated
SG90 Motor Servo	4	10.5	42.0		Measured
Total Mass Electrical Component of Payload			**133.37**	**2.92**	
Payload- Structural Component					
Fins	4	1.0	4.0		Measured
Payload Cone	1	12.2	12.2		Measured
Payload’s Body Cover	2	1.3	2.6	0.52	Estimated
Payload Shell	1	10.7	10.7	2.14	Estimated
Payload Shell Fin Section	1	26.5	26.5		Measured
Carbon Rod (63 mm)	2	0.7	1.4		Measured
Total Mass Payload – Structural Component			**57.4**	**2.66**	

Due to the complexity of overall system, Mass estimation is derived from the 20% of its estimated value.

Mass Budget (4/4)

RN#1 Total mass of the CanSat (science payload and container) shall be 600 grams ±10 grams

Total Mass	
Container	418.75 ± 20.43 g
Payload	190.77 ± 5.58 g
Total Mass of All System	**609.52 ± 26.01 g**

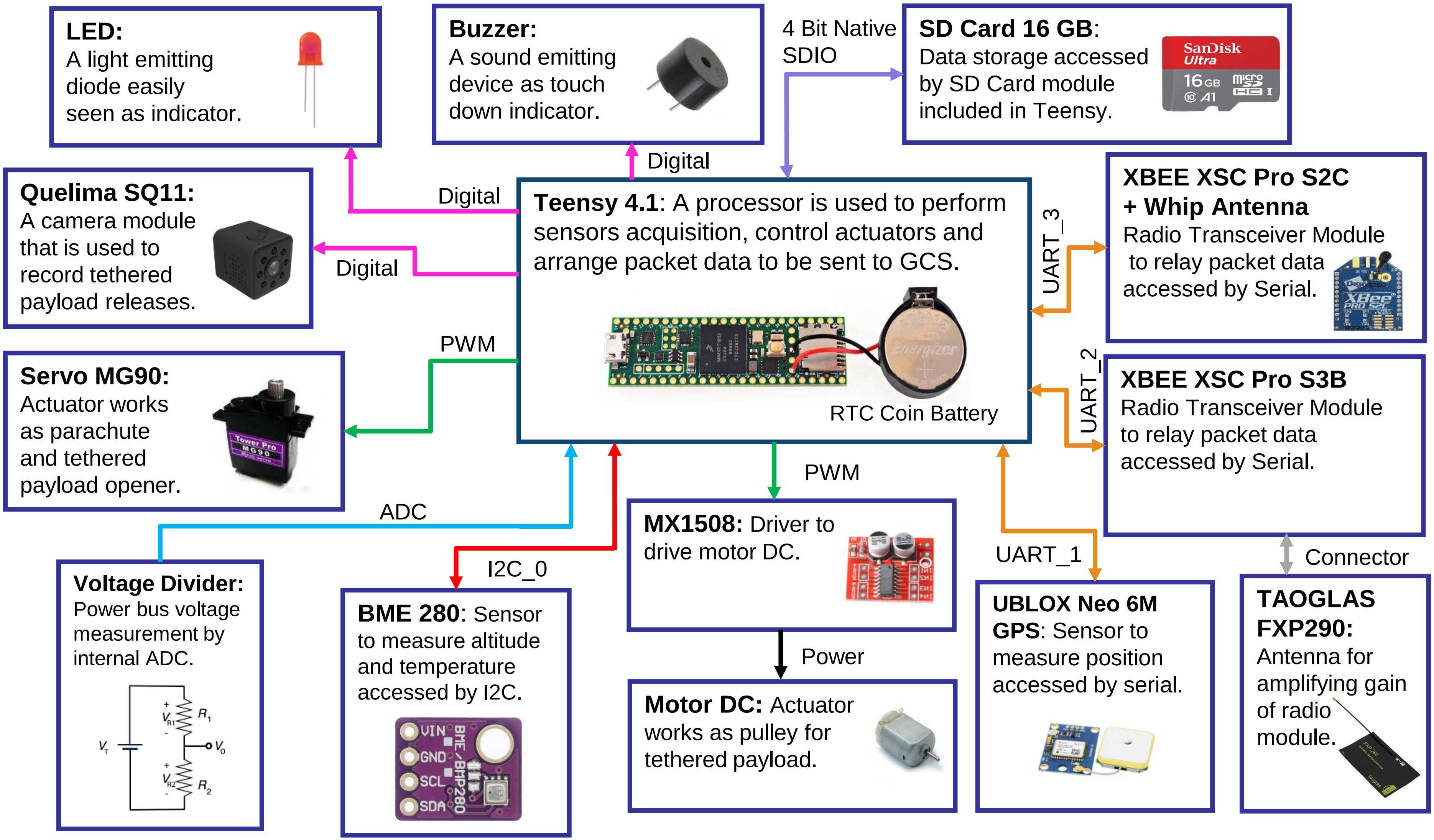
Margin
Mass Competition Requirement – Total Mass of All System = Margin **600 - 609.52 = - 9.52 g (Fulfill Mass Tolerance)** Uncertainties = **± 26.01 g**

Correction Method (Margin Competition ± 10g)	
If Total Mass system < 590 gram	We will increase the mass of materials with higher infill density with 3D printed material for container or payload.
If Total Mass system > 610 gram	We will change the material with more lighter material such as composite that has lower density for container and payload.

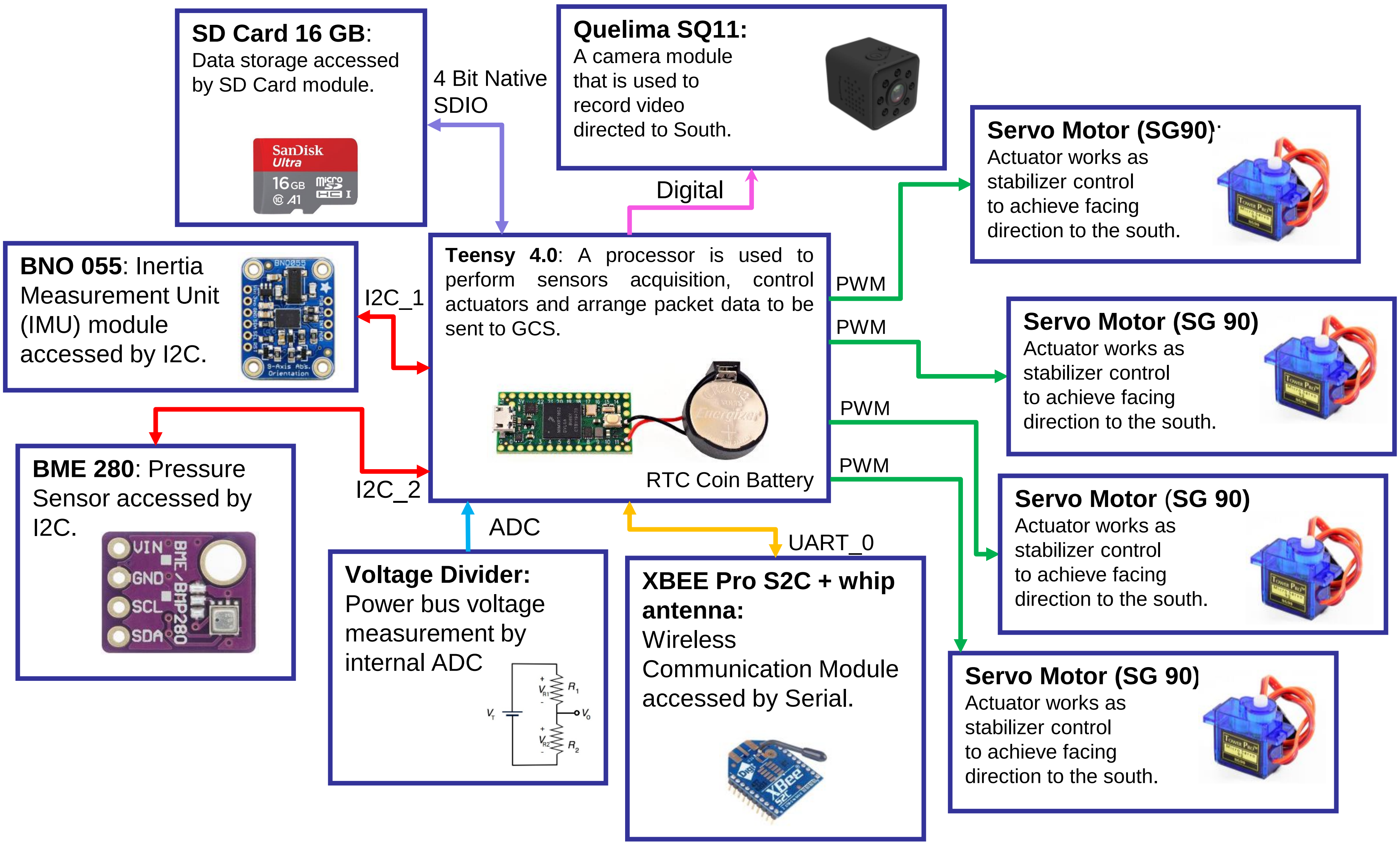
Communication and Data Handling (CDH) Subsystem Design

Piko Permata

CDH Overview (1/2)



CDH Overview (2/2)

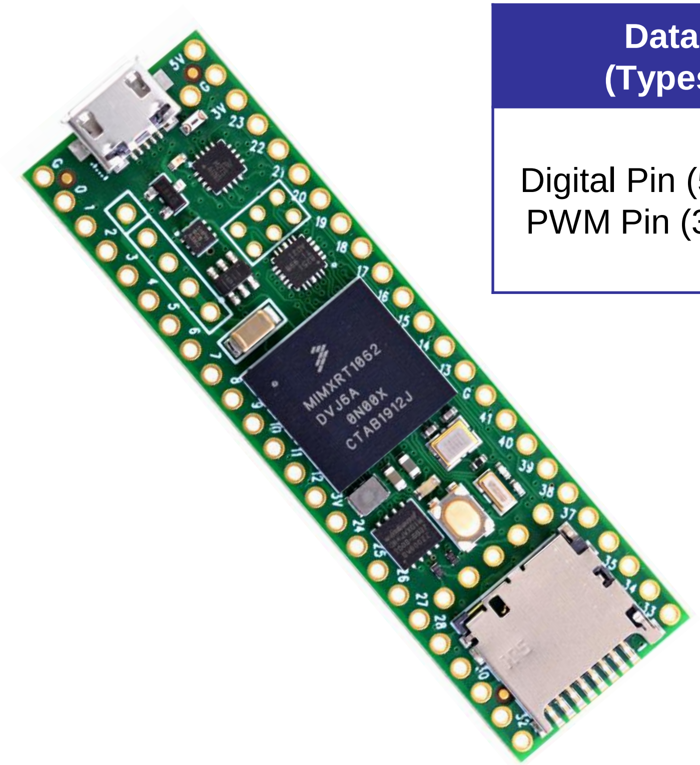


CDH Changes Since PDR

Part	PDR	CDR	Reason
Payload Microcontroller Unit	STM32F407 Minimum System	Teensy 4.0	There’s a trouble on manufacturing the microcontroller. Teensy 4.0 chosen as secondary option.
Payload	SD Card Module	SD Card Module Removed	There is a peripheral on Teensy 4.0 to access SD Card directly.
Driver Motor	L298N Driver Motor	MX1508 Driver Motor	To minimize weight.

Container Processor & Memory Selection (1/2)

Model	Data bus width (Bits)	Processor Speed (Mhz)	Power Consumption (mW)	Operating Voltage (V)	Size (mm)	Mass (g)
Teensy 4.1✓	32	600	500	3.6-5	60.96 x 17.78	16.95



Data Interfaces (Types & Number)		Memory Storage	Boot Time (s)	Cost ($)
Digital Pin (55) PWM Pin (35)	UART Pin (8) SPI Pin (3) I2C Pin (4)	EEPROM 4KB Flash 8MB RAM 1024KB	0.005	27.24

Reasons

1. It can be programmed by Arduino IDE, this will make the software development process faster.
2. It has suitable size of Flash Memory to store longer programming code.
3. It has an SD card slot and RTC embed to minimize board dimension.
4. It has a processor with a high speed without sacrificing aspects such as temperature and power requirements.

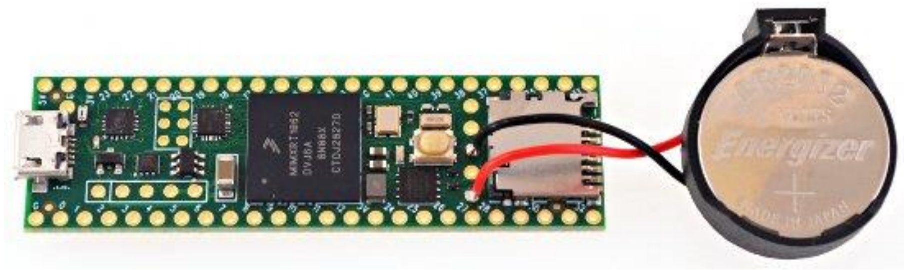
Container Processor & Memory Selection (2/2)

Model	Memory (GB)	Interface	Data Transfer Rate		Cost ($)
			Write (MB/s)	Read (MB/s)	
SanDisk Ultra✓	**16**	**SD Card Interface**	**98**	**98**	**6.00**

Reasons
1. More stable data transfer rate 2. It is more reliable and easy to use than using EEPROM. 3. Teensy 4.1 already has a peripheral to access it.

Container Real-Time Clock

Model	Operating Voltage (V)	Operating Current	Reset Tolerance	Accuracy (ppm)	Cost ($)
Built in Teensy RTC✓	3.3	Built-in	In reset conditions, software reads the last data from the SD card.	± 5 – 20	0



Reasons

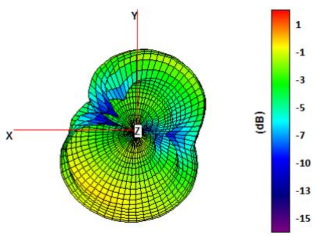
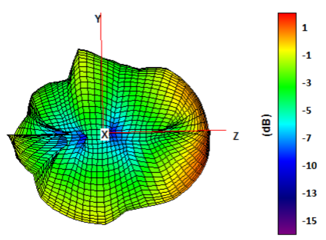
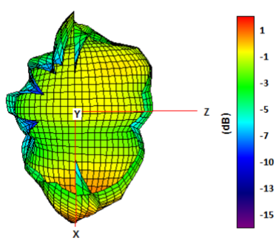
1. Minimize board size because it is included in Teensy 4.1.
2. Easy to use.
3. Free (included in Teensy 4.1)

Container Antenna Selection (1/2)

Container-to-Ground link

Model	Range (km)	Size (mm)	Frequency (Mhz)	Gain (dBi)	Mass (g)	Connector	Cost ($)
Taoglas FXP290✓	11.67	75.4 x 45.4	915	1.5	1.8	Micro FL	17.05

Radiation Patterns of Taoglas FXP290

XY	YZ	XZ
		

We have already test this antenna using several methods such as range test using vehicle. As the results are above 700m on average.

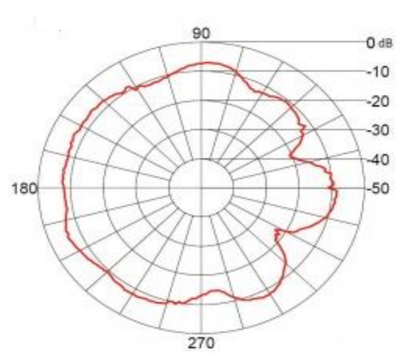
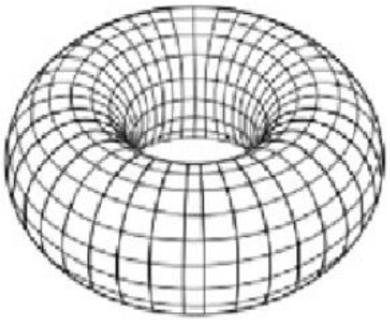
Reasons

1. It has a smaller size compared to the other antenna.
2. It can be mounted on XBEE using small micro fl.
3. It can be placed outside of the container.

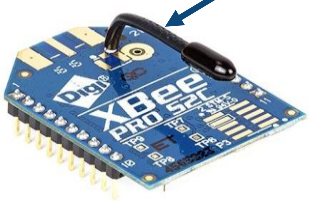
Container Antenna Selection (2/2)

Container-to-Payload link

Model	Range (km)	Size (mm)	Frequency (Ghz)	Gain (dBi)	Mass (g)	Connector	Cost ($)
Onboard Whip Antenna ✓	3.2	Include in board	2.4	2.1	Include in board	Onboard	0

Radiation Patterns of Whip Antenna	
Horizontal	Toroidal
	

We have already test this in the field free of obstacle and it can sends data telemetry until 350 meters. We only test it until 350 meters because its already sufficient for Container to Payload link.



Reasons
1. It doesn't need any extra space. 2. Free (included in XBEE Pro 2SC)

Container Radio Configuration (1/2)

Container-to-ground XBEE Radio Selection

Model	Sensitivity (dBm)	Range (km)	Receive Current (mA)	Transmit Current (mA)	Supply Voltage (V)	Frequency (Hz)	Transmit Power (dBm)	Mass (g)	Cost ($)
XBEE Pro S3B✓	-107	14	26	215	3.0 - 3.6	915 M	24 (250 mW)	5.2	57.52

XBEE Pro S3B

Reasons

1. It has wider range compared to the other XBEE.
2. It is more sensitivity compared to the other XBEE.

Container-to-payload XBEE Radio Selection

Model	Sensitivity (dBm)	Range (km)	Receive Current (mA)	Transmit Current (mA)	Supply Voltage (V)	Frequency (Hz)	Transmit Power (dBm)	Mass (g)	Cost ($)
XBEE Pro S2C✓	-101	3.2	31	120	2.1 - 3.6	2.4 G	18 (63 mW)	4.3	50.02

Using whip antenna

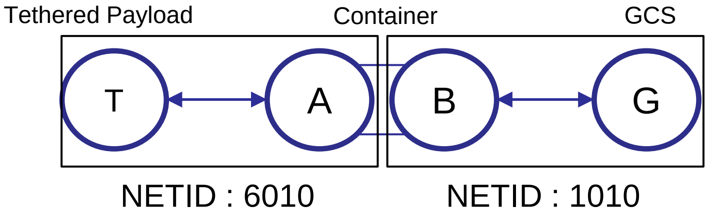
Reasons

1. It is suitable for communication between container and payload.
2. It has a lower transmit current for sending long packet data.
3. Cheapest XBEE Radio.

Container Radio Configuration (2/2)

Discussion of Transmission Control

XBEE Radio Model selection: There will be 2 pair types of XBEE, as radio modules. The first one is “XBEE Pro S3B” to relay data from the container into the ground control station and the second is “XBEE Pro S2C” to relay data from the container into the tethered payload. As seen below the “XBEE Pro S3B” is B and G and “XBEE Pro S2C” is A and T



Container net’s configuration

Transmission Control

1. The container telemetry data will be transmitted @1 Hz and relay payload telemetry data @4Hz to GCS.
2. The container will start sending data when commanded by GCS using command “CMD,1010,CX,ON”. If somehow the Teensy 4.1 runs into reset, it will recover the last packet count from SD Card, so the packet counting doesn’t reset.
3. All communication will be using unicast mode. For each state, the container will transmit data to GCS and relay telemetry data from the tethered payload after TP_RELEASE state.
4. After the CanSat lands, the container will stop transmitting data to GCS and stop polling payload telemetry data automatically.

Note : The container will have a timeout waiting for payload telemetry data to avoid collision between container and payload telemetry data

Container Telemetry Format (1/2)

Container Telemetry Data		
Data Format	**Sample Data**	**Description**
<TEAM_ID>	1010	the assigned team identification.
<MISSION_TIME>	00:09:02.22	UTC time in format hh:mm:ss.ss, where hh is hours, mm is minutes, and ss.ss is seconds (including hundredth of second).
<PACKET_COUNT>	12	the count of transmitted packets, which is to be maintained through processor reset. One cumulative count is used for transmission of both ‘C’ and ‘T’ packets.
<PACKET_TYPE>	C	the ASCII character ‘C’ for Container telemetry, character ‘T’ for Tethered Payload relay telemetry.
<MODE>	F	the ASCII character ‘F’ for flight (the default mode upon system start) and ‘S’ for simulation
<TP_RELEASED>	N	the ASCII character ‘N’ for not released and ‘R’ for released
<ALTITUDE>	100.1	the altitude in units of meters and must be relative to ground level. The solution must be 0.1 meters.
<TEMP>	28.9	the temperature in degrees Celsius with a resolution of 0.1 degrees C.
<VOLTAGE>	3.01	the voltage of the CanSat power bus. The resolution must be 0.01 volts.

Container Telemetry Format (2/2)

<GPS_TIME>	00:09:02	the time generated by the GPS receiver. The time must be reported in UTC and have a resolution of a second
<GPS_LATITUDE>	17.0199	the latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees North.
<GPS_LONGITUDE>	189.0077	the longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees West.
<GPS_ALTITUDE>	100.2	the altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters.
<GPS_SATS>	5	the number of GPS satellites being tracked by the GPS receiver. This must be an integer number.
<SOFTWARE_STATE>	ASCENT	the operating state of the container.
<CMD_ECHO>	CXON	the fixed text command id and argument of the last received command with no commas

Container Data Format will be transmitted with 1 Hz to the ground station as follows:
(**1010,00:09:02.22,12,C,F,N,100.1,28.9,3.01,00:09:02,17.0199,189.0077,100.2,5,ASCENT,CXON**)

Container Command Formats (1/2)

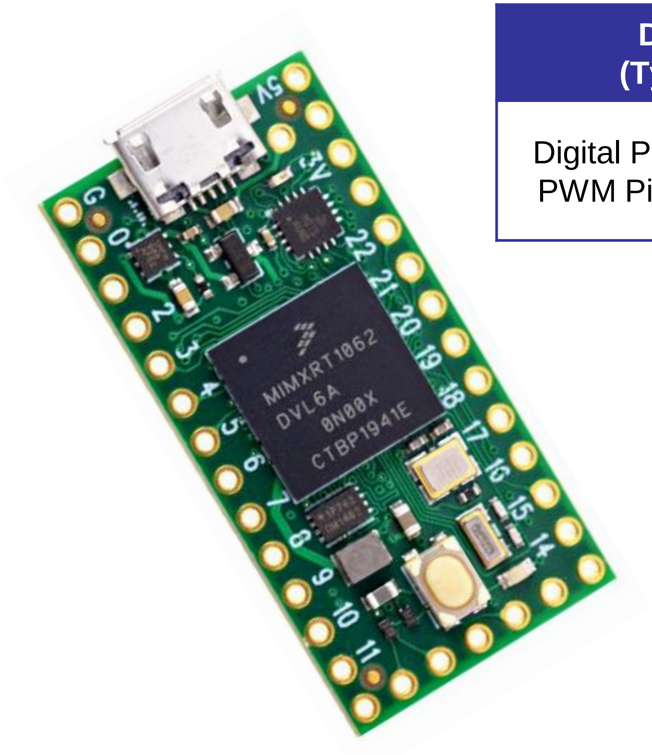
Type of Command	Command Format	Description	Example Data
CX: Container Telemetry On/Off Command	CMD, <TEAM_ID>, CX, <ON_OFF>	1. CMD and CX are static text. 2. <TEAM ID> is the assigned team ID 3. <ON_OFF> is the string 'ON' to activate the Container telemetry transmissions and 'OFF' to turn off the transmissions.	The command CMD,1010,CX,ON activates Container telemetry transmission, assuming the team id is 1010.
ST: Set Time	CMD, <TEAM_ID>, ST, <UTC_TIME>	1. CMD and ST are static text. 2. <TEAM ID> is the assigned team identification. 3. <UTC_TIME> is UTC time in the format hh:mm:ss	The command CMD,1010,ST,13:35:59 sets the mission time to the value given.
SIM: Simulation Mode Control Command	CMD, <TEAM_ID>, SIM,<MODE>	1. CMD and SIM are static text. 2. <TEAM_ID> is the assigned team identification. 3. <MODE> is the string 'ENABLE' to enable the simulation mode, 'ACTIVATE' to activate the simulation mode, or 'DISABLE' which both disables and deactivates the simulation mode.	Both the CMD,1010,SIM,ENABLE and CMD,1010,SIM,ACTIVATE commands are required to begin simulation mode

Container Command Formats (2/2)

Type of Command	Command Format	Description	Example Data
PX: Tethered Payload Transmission On/Off	CMD, <TEAM_ID>, PX, <ON_OFF>	1. For testing purpose only 2. CMD is static text. 3. PX are static text indicating to control telemetry for Tethered Payload. 4. <TEAM ID> is the assigned team identification. 5. <ON_OFF> is the string 'ON' to activate the Science Payload transmissions and 'OFF' to turn off the transmissions	CMD,6010,PX,ON will trigger the Container to relay a command to the Tethered Payload to begin telemetry transmissions.
SIMP: Simulated Pressure Data (to be used in Simulation Mode only)	CMD, <TEAM_ID>, SIMP, <PRESSURE>	1. CMD and SIMP are static text. 2. <TEAM ID> is the assigned team identification. 3. <PRESSURE> is the simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.	CMD,1010,SIMP,101325 provides a simulated pressure reading to the Container (101325 Pascals = approximately sea level). **Note:** only in simulation mode.
CAL: Container and payload reset and calibration	CMD, <TEAM_ID>, CAL	1. CMD and CAL are static text. 2. <TEAM ID> is the assigned team identification.	CMD,1010,CAL will reset the microcontroller on container and payload to set new mission reference.

Payload Processor & Memory Selection (1/2)

Model	Data bus width (Bits)	Processor Speed (Mhz)	Power Consumption (mW)	Operating Voltage (V)	Size (mm)	Mass (g)
Teensy 4.0 ✓	32	600	500	3.6-5V	35.56 x 17.78	6.9



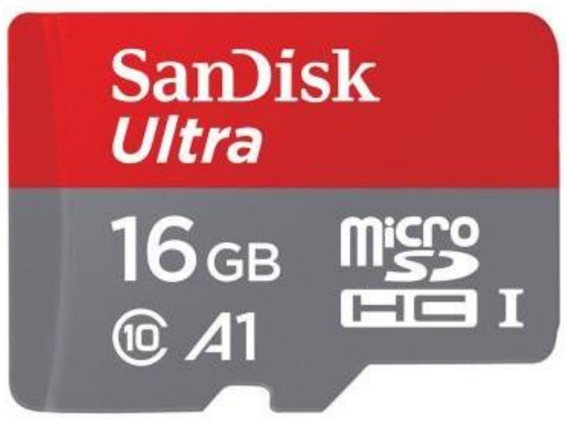
Data Interfaces (Types & Number)		Memory Storage	Boot Time (s)	Cost ($)
Digital Pin (40) PWM Pin (31)	UART Pin (7) SPI Pin (3) I2C Pin (3)	EEPROM 1KB Flash 1984MB RAM 1024KB	0.005	31.02

Reasons

1. It can be programmed by Arduino IDE, this will make the software development process faster.
2. It was the second choice if the minimum system failed to be manufactured.
3. It has an SD card slot and RTC embed to minimize board dimension.
4. It has a processor with a high speed without sacrificing aspects such as temperature and power requirements.

Payload Processor & Memory Selection (2/2)

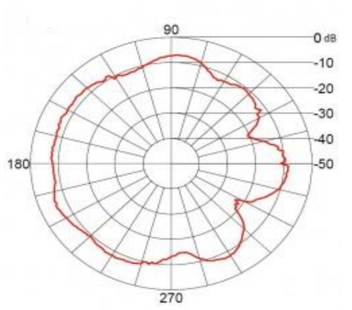
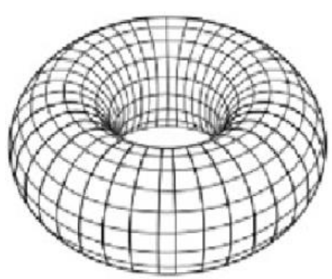
Model	Memory (GB)	Interface	Data Transfer Rate		Cost ($)
			Write (MB/s)	Read (MB/s)	
SanDisk Ultra✓	**16**	**SD Card Interface**	**98**	**98**	**6.00**



Reasons
1. More stable data transfer rate 2. It is more reliable and easy to use than using EEPROM. 3. Teensy 4.0 already has a peripheral to access it.

Payload Antenna Selection

Model	Range (km)	Size (mm)	Frequency (Ghz)	Gain (dBi)	Mass (g)	Connector	Cost ($)
Onboard Whip Antenna ✓	**3.2**	**Include in board**	**2.4**	**2.1**	**Include in board**	**Onboard**	**0**

<table>
<tr><th colspan="2">Radiation Patterns of Whip Antenna</th></tr>
<tr><td>Horizontal</td><td>Toroidal</td></tr>
<tr><td>
</td><td></td></tr>
</table>

Using whip antenna

Reasons
1. It doesn't need any extra space. 2. Free (included in XBEE Pro S2C).

We have already test this in the field free of obstacle and it can sends data telemetry until 350 meters. We only test it until 350 meters because its already sufficient for Container to Payload link.

Payload Radio Configuration (1/2)

Model	Sensitivity (dBm)	Range (km)	Receive Current (mA)	Transmit Current (mA)	Supply Voltage (V)	Frequency (Hz)	Transmit Power (dBm)	Mass (g)	Cost ($)
XBEE Pro S2C✓	**-101**	**3.2**	**31**	**120**	**2.1 - 3.6**	**2.4 G**	**18 (63 mW)**	**4.3**	**50.02**

Using whip antenna

Reasons

1. It is suitable for communication between container and payload.
2. It has a lower transmit current for sending long packet data.
3. Cheapest than others.

Payload Radio Configuration (2/2)

Overview of Radio Configuration

- As presented in the slide above we are using 2 “XBEE Pro S2C” for radio communication device between Container and Tethered Payload.
- We are using NETID 6010 because our team ID is 1010, as CanSat mission guide rules the NETID of telemetry between Container and Tethered Payload is team ID + 5000.

Transmission Control

1. The payload telemetry data will be transmitted to the container @4Hz
2. The transmission of payload packet data will commence at the container’s **TP_RELEASE** state. Before **TP_RELEASE** state, the payload remains idle.
3. When the CanSat landed, the tethered payload will stop sending data to the container.
4. If the tethered payload experience sudden reset, the container will send “0” data for all type data until tethered payload online.
5. For example frame in reset is:

6010,15:00:10.01,43,T,0.0,0.0,0.00,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.0,STAND_BY

Payload Telemetry Format (1/2)

Container Telemetry Data		
Data Format	**Sample Data**	**Description**
<TEAM_ID>	6010	the assigned team identification with added 5000.
<MISSION_TIME>	00:09:02.22	UTC time in format hh:mm:ss.ss, where hh is hours, mm is minutes, and ss.ss is seconds (including hundredth of second).
<PACKET_COUNT>	12	the count of transmitted packets, which is to be maintained through processor reset. One cumulative count is used for transmission of both ‘C’ and ‘T’ packets.
<PACKET_TYPE>	T	the ASCII character ‘C’ for Container telemetry, character ‘T’ for Tethered Payload relay telemetry.
<TP_ALTITUDE>	100.1	the tethered payload altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters
<TP_TEMP>	28.9	the tethered payload temperature in units degrees Celsius. The resolution must be 0.1 degrees C.
<TP_VOLTAGE>	3.01	the tethered payload power bus voltage in units volts. The resolution must be 0.01 V.
<GYRO_R, GYRO_P, GYRO_Y>	1.120,2.120,3.120,	the tethered payload gyro readings in degrees per second for the roll, pitch, and yaw axes.
<ACCEL_R, ACCEL_P, ACCEL_Y>	1.120,2.120,3.120,	the tethered payload accelerometer readings for the roll, pitch, and yaw axes.

Payload Telemetry Format (2/2)

<MAG_R, MAG_P, MAG_Y>	1.120,2.120,3.120,	the tethered payload magnetometer readings in gauss for the roll, pitch, and yaw axes.
<POINTING_ERROR>	0.0	the yaw pointing error in degrees. Zero degree of pointing error is due South.
<TP_SOFTWARE_STATE>	STAND_BY	the operating state of the payload.

Payload Data Format will be transmitted @4 Hz to the container, and container will relay it to GCS @4 Hz:
(6010,15:00:10.01,433,T,100.1,35.2,3.12,1.120,2.120,3.120,1.120,2.120,3.120,1.120,2.120,3.120,0.0,STAND_BY)

Electrical Power Subsystem Design

Piko Permata

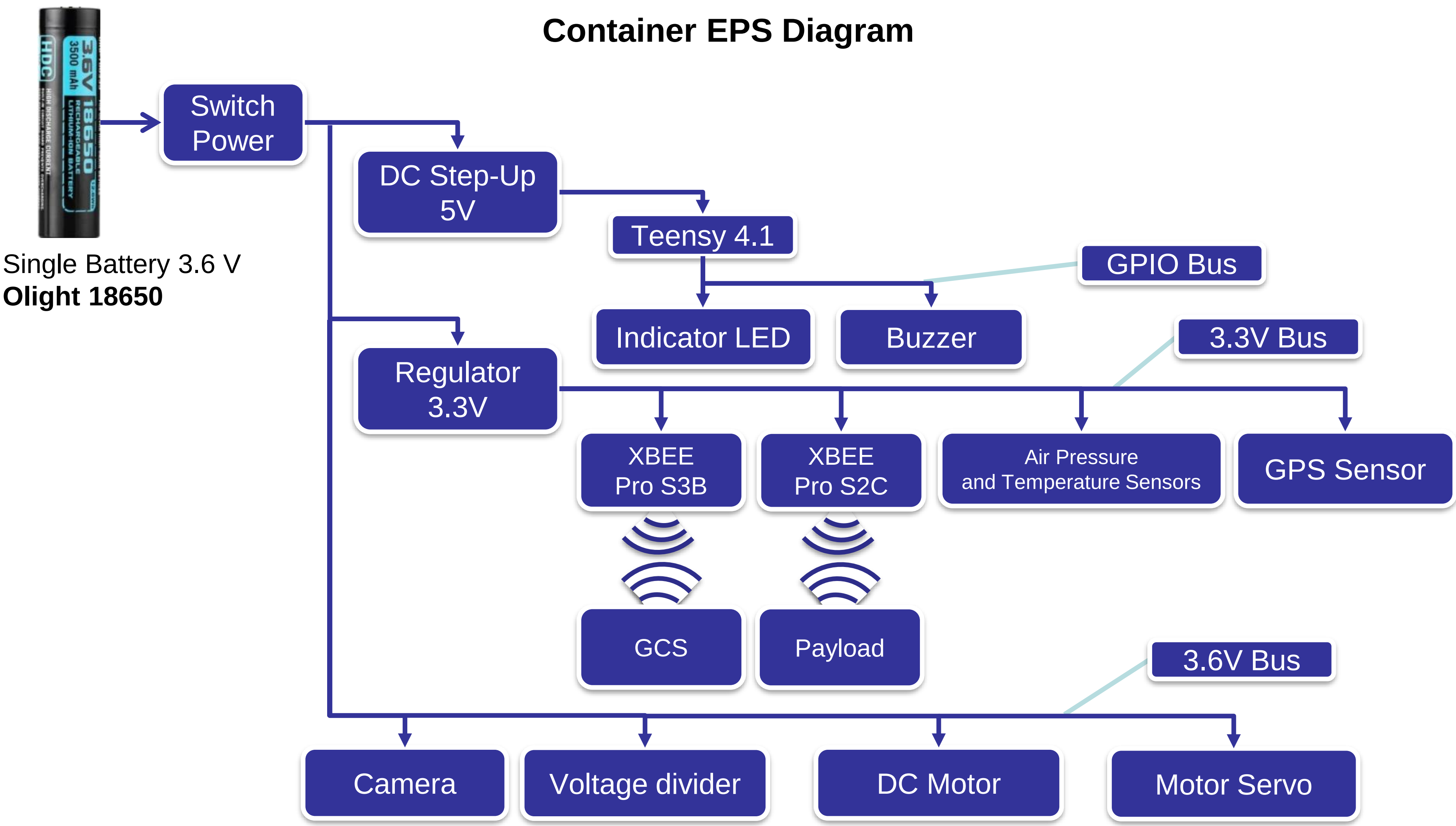
EPS Overview (1/4)

Container EPS Component

Component	Purpose
Power	1. An Olight 18650 3.6V battery is used to supply all components in the container. 2. A 3V coin battery is also used for Real-Time Clock (RTC) supply. 3. A power switch (external on/off switch) will be used to connect or disconnect the power and also used to reset the container. 4. Boost Converter is used to step up the voltage from battery level 3.6V to 5V for supply needed. 5. The 3.3V regulator is used to supply all sensors and XBEE in the container.
MCU	1. Teensy 4.1 will collect all data sensors and drive all actuators. It will be supplied by 5V output from the boost converter. 2. SD Card will save all sensors data. RTC will keep mission time in case of a sudden reset.
Sensors	1. BME280 will collect temperature and pressure data. It will be supplied by 3.3V from the voltage regulator. 2. Ublox NEO-6M will acquire position data. It will be supplied by 3.3V from the voltage regulator. 3. The Voltage divider will collect voltage data. It will be connected to 3.6V from the battery.
Actuators	1. DC motor will perform unspooling of tethered payload. It will be supplied by 3.6V straight from the Battery. 2. The servo motor will do the lid opening. It will be supplied by 3.6V straight from the Battery. 3. The camera will record release of the tethered payload. It will be supplied by 3.6V directly from battery. 4. LED Indicator will be on as an indicator of the system is running. It will be supplied by 3.3V from GPIO pin. 5. The buzzer will be on as a beacon when CanSat lands. It will be supplied by 3.3V from GPIO pin.
Communications	1. XBEE Pro S2C will transmit and receive data from the tethered payload. It will be supplied by 3.3V from the voltage regulator. 2. XBEE Pro S3B will transmit and receive data from the GCS. It will be supplied by 3.3V from the voltage regulator.

EPS Overview (2/4)

Container EPS Diagram



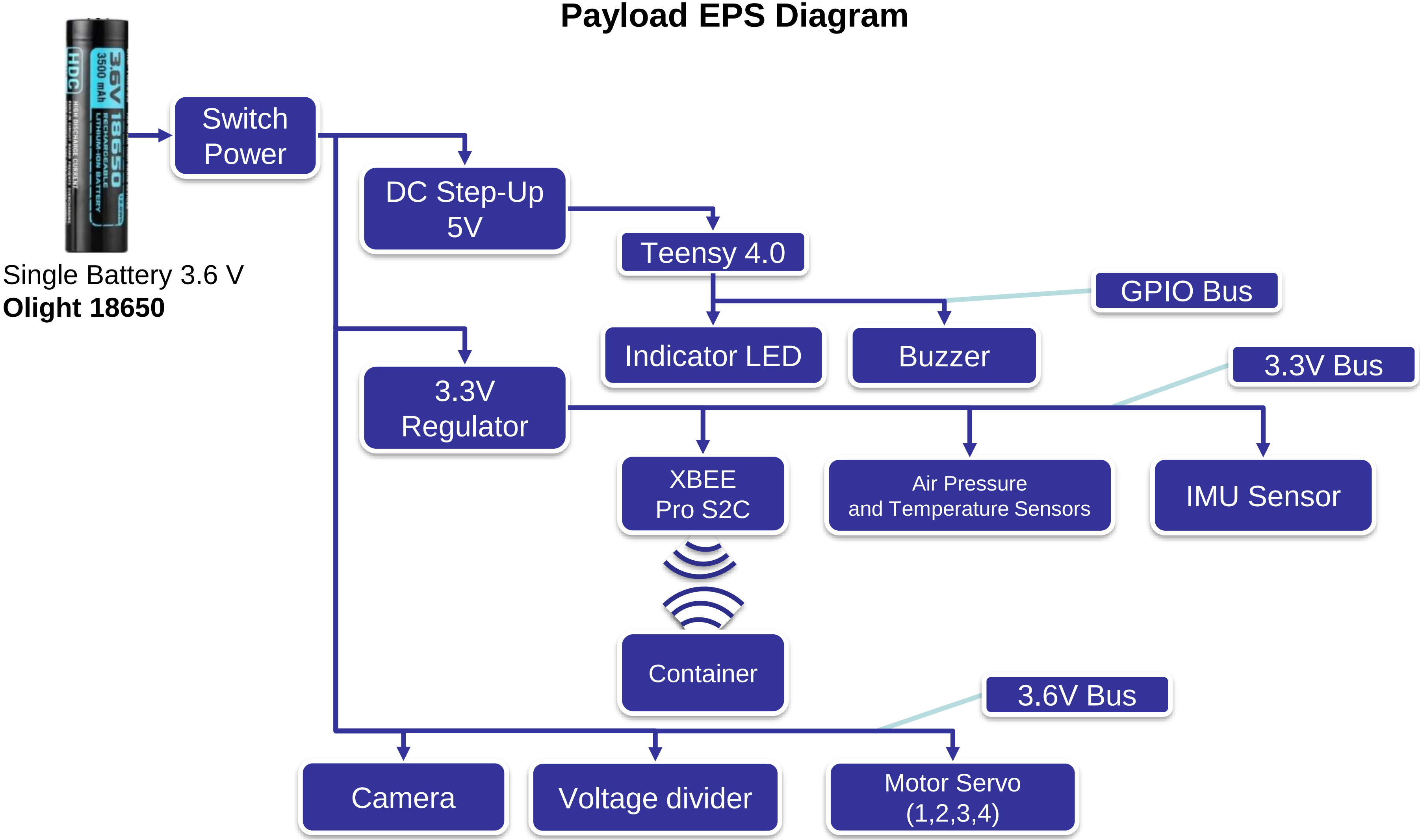
EPS Overview (3/4)

Payload EPS Component

Component	Purpose
Power	1. An Olight 18650 3.6V battery is used to supply all components in the payload. 2. A 3V coin battery is also used for Real-Time Clock (RTC) supply. 3. A power switch (external on/off switch) will be used to connect or disconnect the power and also used to reset the container. 4. Boost Converter is used to step up the voltage from battery level 3.6V to 5V for supply needed. 5. The 3.3V regulator is used to supply all sensors and XBEE in the container.
MCU	1. Teensy 4.0 will collect all data sensors and drive all actuators. It will be supplied by 5V output from the boost converter. 2. SD Card will save all sensors data. RTC will keep mission time in case of a sudden reset.
Sensors	1. BME280 will collect temperature and pressure data. It will be supplied by 3.3V from the voltage regulator. 2. BNO055 will collect orientation data. It will be supplied by 3.3V from the voltage regulator. 3. The Voltage divider will collect voltage data. It will be connected to 3.6V from the battery.
Actuators	1. 4 servo motors will work to maintain the camera pointed at south direction and 45 degrees downward .It will be supplied by 3.6V straight from the battery. 2. Camera will be used to record terrain. It will be supplied by 3.6V directly from battery. 3. LED Indicator will be on as an indicator of the system is running. It will be supplied by 3.3V from GPIO pin.
Communications	XBEE Pro S2C will transmit and receive data from the container. It will be supplied by 3.3V from the voltage regulator.

EPS Overview (4/4)

Payload EPS Diagram

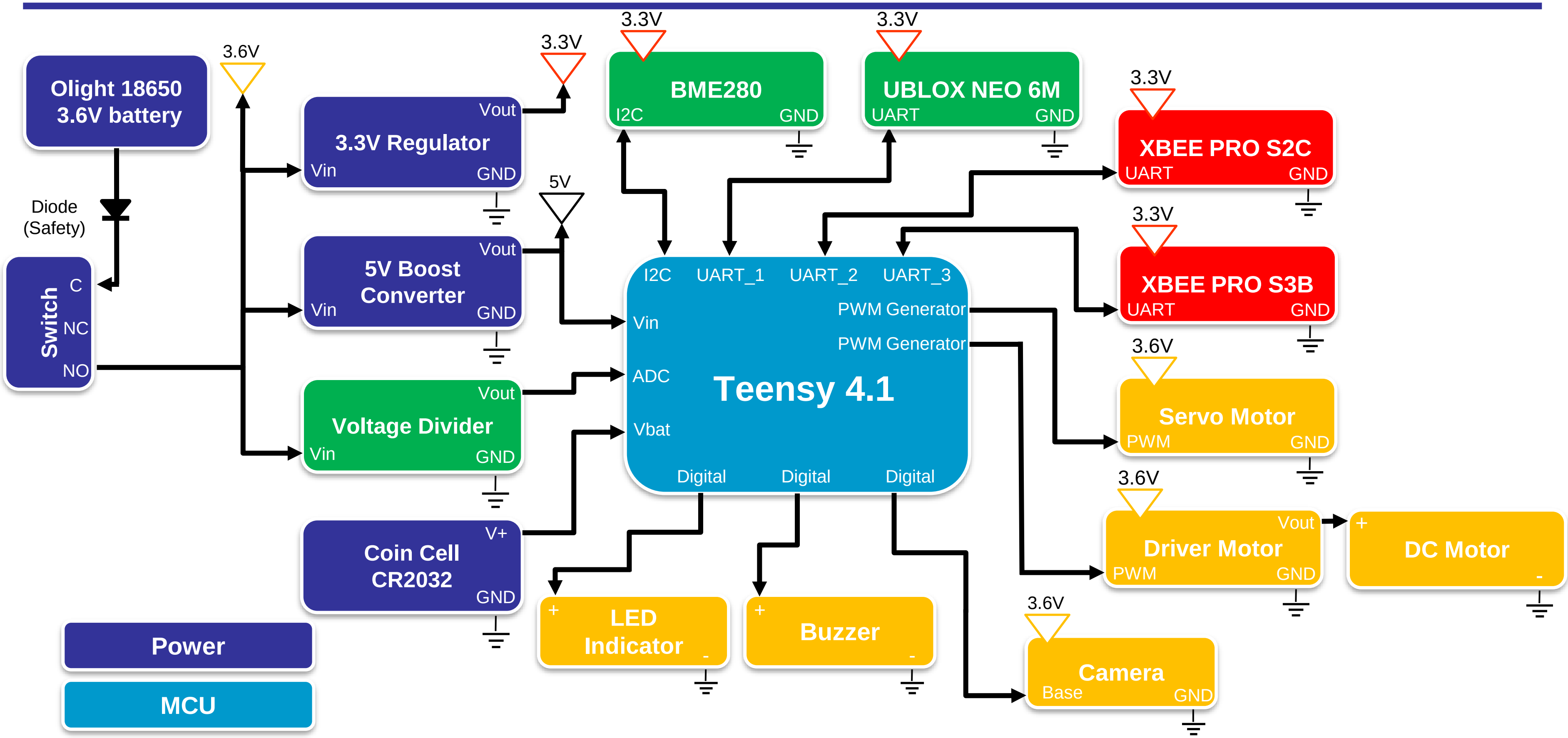


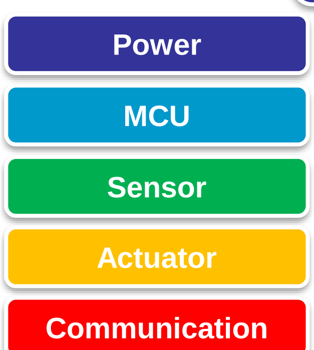
EPS Changes Since PDR

Electrical Power Subsystem Changes Since PDR

Part	PDR	CDR	Reason
Container Actuator	Servo in the container is supplied by a 5V bus from the boost converter.	Servo in the container is supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply servo.
Container Actuator	Driver motor in the container is supplied by a 5V bus from the boost converter.	Driver motor in the container is supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply driver motor.
Container Actuator	Camera in the container is supplied by a 5V bus from the boost converter.	Camera in the container is supplied by a 3.6V directly from battery	The boost converter output current is not sufficient to camera.
Payload Actuator	4 servos in the payload are supplied by a 5V bus from the boost converter.	4 servos in the payload are supplied by a 3.6V bus straight from the battery.	The boost converter output current is not sufficient to supply 4 servos.
Container Power Budget	Container power consumption is 6.82 Wh.	Container power consumption is 6.00 Wh.	Recalculation of container power budget.
Payload Power Budget	Payload power consumption is 4.61 Wh.	Payload power consumption is 5.59 Wh.	Recalculation of payload power budget due to mcu changed to Teensy 4.0.

Container Electrical Block Diagram



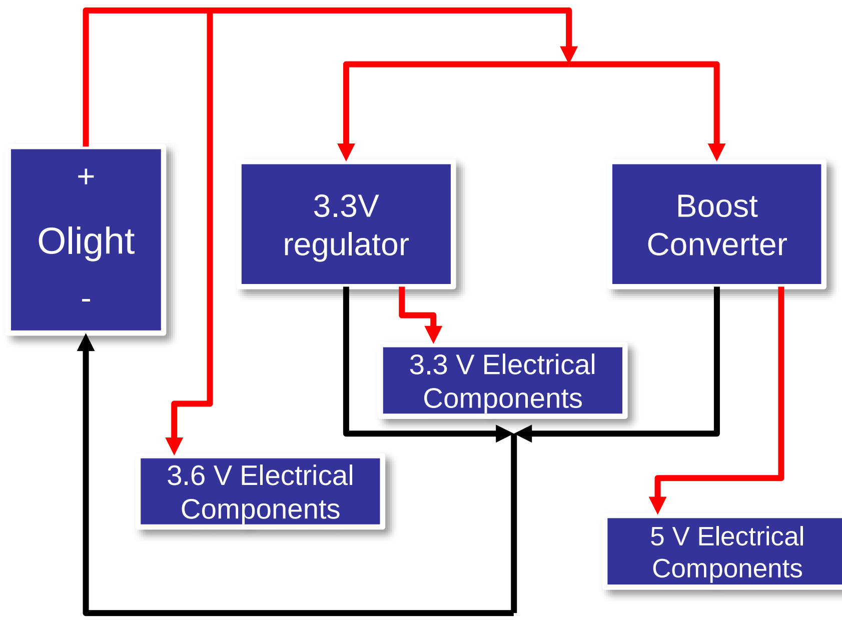


- Electronics system will be easily on/off by an external switch.
- Buzzer beeps and LED blinked when the system powered on.
- Cell coin battery used to supply internal RTC in MCU.

Container Power Source

Model	Battery Chemistry	Voltage (V)	Nominal Capacity (mAh)	Maximum Discharge Current	Weight (g)	Dimension (mm)		Cost ($)
						Height	Diameter	
OLIGHT 18650✓	Lithium Ion	3.6	3500	10 A	48.27	69.8	18.5	25.13

Only one battery cell to supply 3 rail voltage for electrical components.



Information

- The Olight 18650 battery supplies 3.6 volts. Single battery has an capacity of 3.6V and 3500mAh. The battery can generate until 10A continuously.
- The battery supplies the system until more than 2 hours.
- One battery can power all electronic components in the payload

Container Power Budget (1/2)

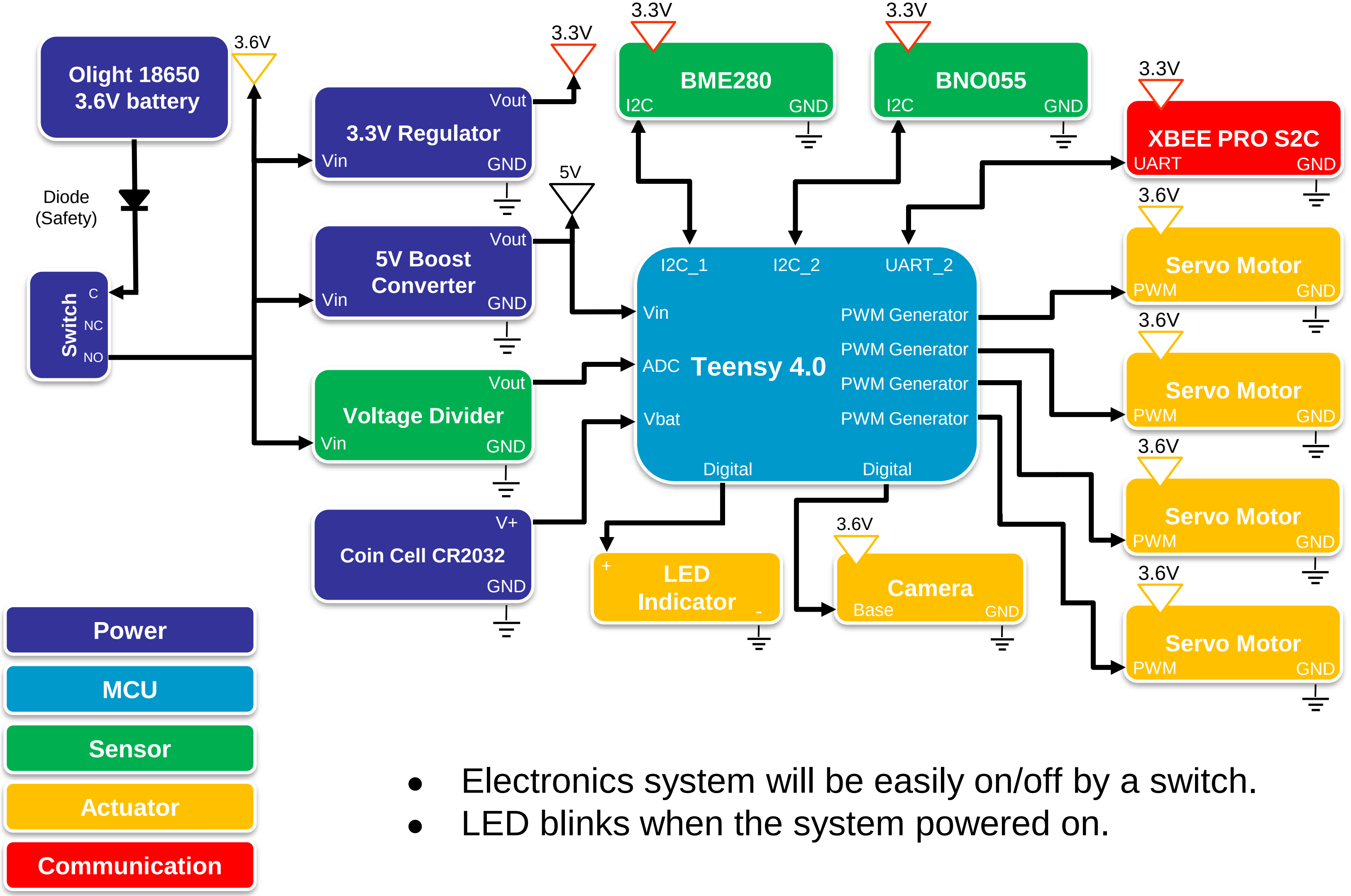
Component	Quantity	Source	Voltage (V)	Current (mA)	Duty Cycles in 1 Hour (%)	Power Consumption (Wh)
UBLOX - Neo 6m	1	Datasheet	3.3	67	100	0.2211
XBEE Pro S2C (Transmit)	1	Datasheet	3.3	120	50	0.198
XBEE Pro S2C (Receive)	1	Datasheet	3.3	31	50	0,05115
XBEE Pro S3B (Transmit)	1	Datasheet	3.3	215	100	0,7095
XBEE Pro S3B (Receive)	1	Datasheet	3.3	26	100	0.0858
BME280 (Pressure + Temp)	1	Datasheet	3.3	1.064	100	0.0035112
SQ11 - Camera	1	Datasheet	3.6	36	100	0.0648
Teensy 4.1	1	Datasheet	5	100	100	0.5
Buzzer 95 dB	1	Datasheet	3.3	80	100	0.264
Servo MG90	1	Datasheet	3.6	250	100	0.9
LED	1	Estimated	3.3	0.3	100	0.00099
Voltage Divider	1	Measured	3.6	0.878	100	0.0031608
Total						3.002012
Consumption for 2 Hours						**6.004024**

Container Power Budget (2/2)

Selected Container Power: Olight 18650 ✓

Available power	= Voltage x Capacity
	= 3.6 V x 3.5 Ah
	= **12.6 Wh**
Power consumption (Wh)	= 6.004024 Wh
Margins	= Available power – Power consumption
	= 12.6 Wh – 6.004024 Wh
	= **6.595976 Wh**

Payload Electrical Block Diagram

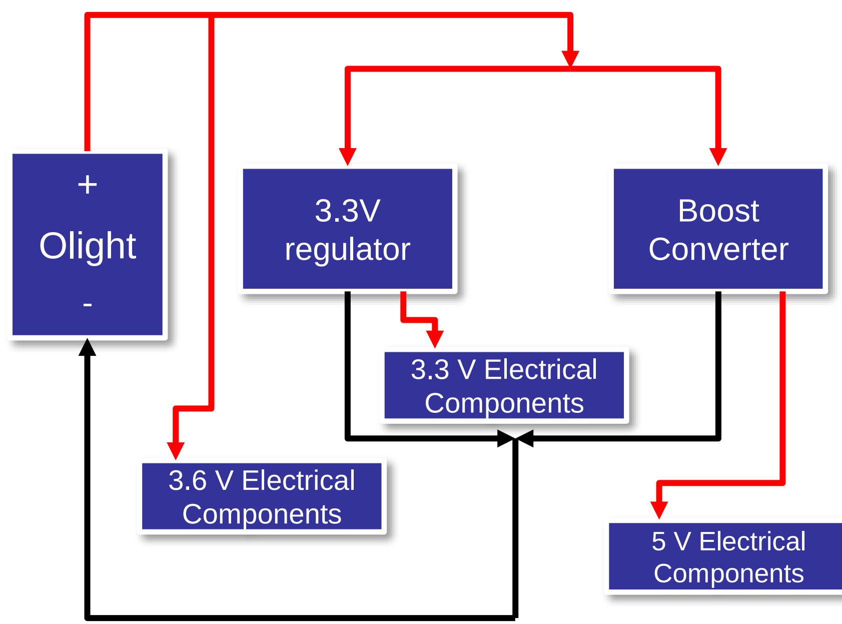


- Electronics system will be easily on/off by a switch.
- LED blinks when the system powered on.

Payload Power Source

Model	Battery Chemistry	Voltage (V)	Nominal Capacity (mAh)	Maximum Discharge Current	Weight (g)	Dimension (mm)		Cost ($)
						Height	Diameter	
OLIGHT 18650✓	Lithium Ion	3.6	3500	10 A	48.27	69.8	18.5	25.13

Only one battery cell to supply 3 rail voltage for electrical components.



Information

- The Olight 18650 battery supplies 3.6 volts. Single battery has an capacity of 3.6V and 3500mAh. The battery can generate until 10A continuously.
- The battery supplies the system until more than 2 hours.
- One battery can power all electronic components in the payload

Payload Power Budget (1/2)

Component	Quantity	Source	Voltage (V)	Current (mA)	Duty Cycles in 1 Hour (%)	Power Consumption (Wh)
Teensy 4.0 (include RTC)	1	Datasheet	5	100	100	0.5
XBEE Pro S2C (Transmit)	1	Datasheet	3.3	120	100	0.396
XBEE Pro S2C (Receive)	1	Datasheet	3.3	31	100	0.123
BME 280 (Pressure + Temp)	1	Datasheet	3.3	1.064	50	0.0017556
BNO055	1	Estimated	3.3	12.3	50	0.020295
Servo SG90	4	Datasheet	3.6	250	50	1.8
SD Card Module	1	Datasheet	3.3	20	50	0.0033
SQ11 - Camera	1	Datasheet	3.6	36	50	0.1296
LED	1	Estimated	3.3	0.3	50	0.00099
Voltage Divider	1	Measured	3.6	0.878	50	0.0015804
Total						2.976521
Consumption for 2 Hours						**5.953042**

Selected Payload Power: Olight 18650 ✓

Available power	=	Voltage x Capacity = 3.6 V x 3.5 Ah
	=	**12.6 Wh**
Power consumption (Wh)	=	5.953042 Wh
Margins	=	Available power – Power consumption
	=	12.6 – 5.953042 Wh
	=	**6.646976 Wh**

Flight Software (FSW) Design

Rara Widya

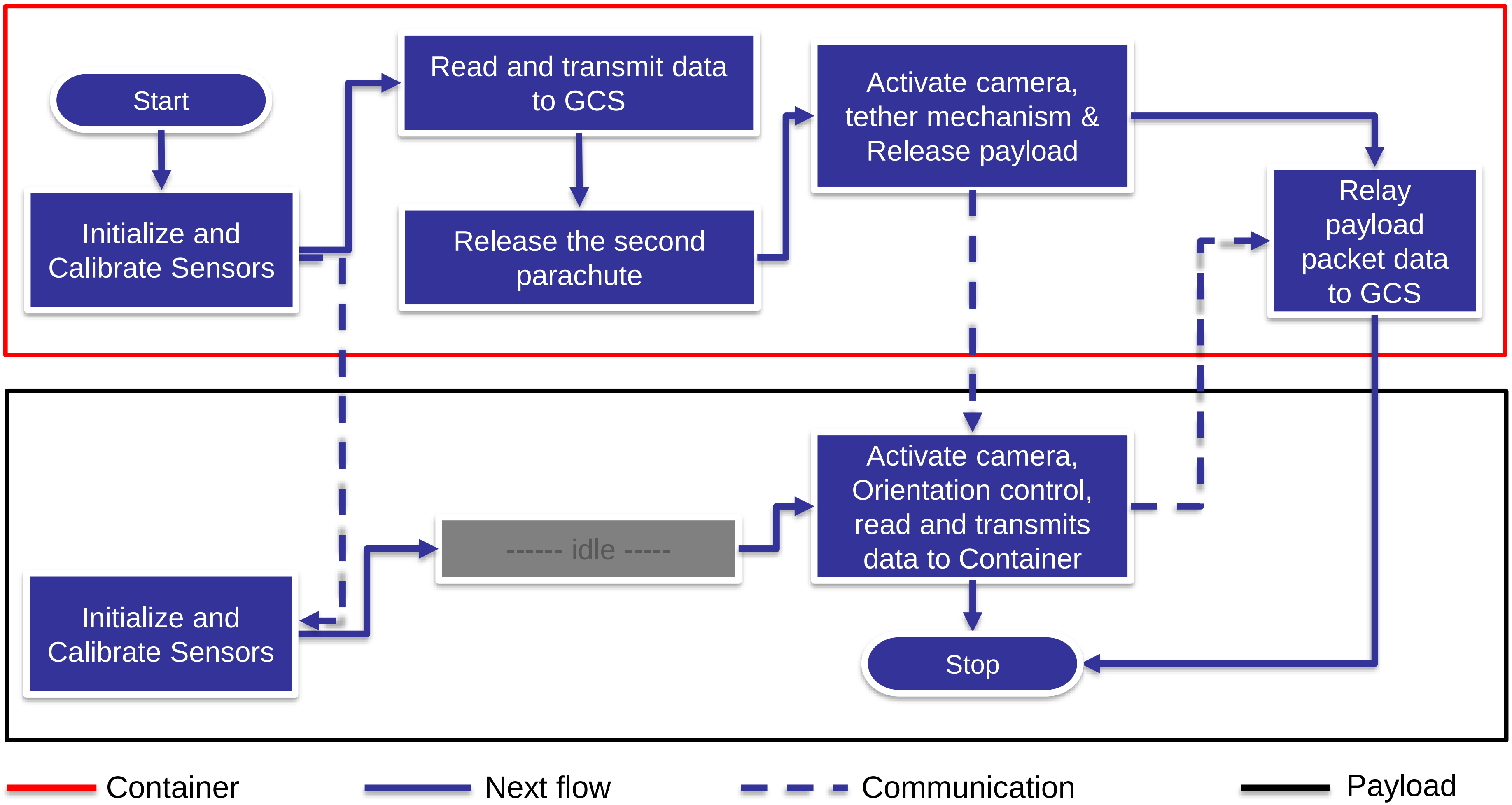
FSW Overview (1/4)

CanSat FSW Tasks
CanSat will collect data from sensors during ascent until it lands and transmits the data to GCS. At 300m, the container will release the payload using tether mechanism. The EEPROM and SD Card are used to back up the data and store the video on the container. A video camera will be added to the payload pointed 45 degrees downward in the south direction to assure the terrain is in the video. The bonus video camera will be added to the container record and show the descent of the payload.

Programming languages	Development Environment
C/C++	Arduino IDE XCTU RealTerm

FSW Overview (2/4)

CanSat FSW Architecture



FSW Overview (3/4)

Container FSW Task
1. The container will set the new mission reference when receiving **SIM CAL** from the GCS and save calibration data to the EEPROM. 2. The container FSW mode will read from EEPROM on the Teensy 4.1, the default mode is Flight mode, and when the container receives command **SIM ENABLE** and **SIM ACTIVATE** from the GCS, the container will enter the simulation mode. 3. The container will be collecting data from the sensors and tethered payload then save it to the SD CARD, the container data will be transmitted @1Hz rate followed by @4Hz payload telemetry data to GCS via XBEE Pro S3B. 4. When the state is **SECOND_PARACHUTE**, the container will control the servo to open the top lid to release the second parachute. 5. When the state is **TP_RELEASE**, the container will open the bottom lid by the servo and start unspooling the tethered payload controlled by the DC motor. At the same time, the container will trigger a bonus video camera to start recording. 6. After the tethered payload is released, the container will automatically command tethered payload to initiate telemetry. 7. The buzzer will be activated when the state is **TOUCH_DOWN**, and all telemetry transmission will be stopped. The buzzer will beep continuously until the switch is off. 8. The mission will be completed.

FSW Overview (4/4)

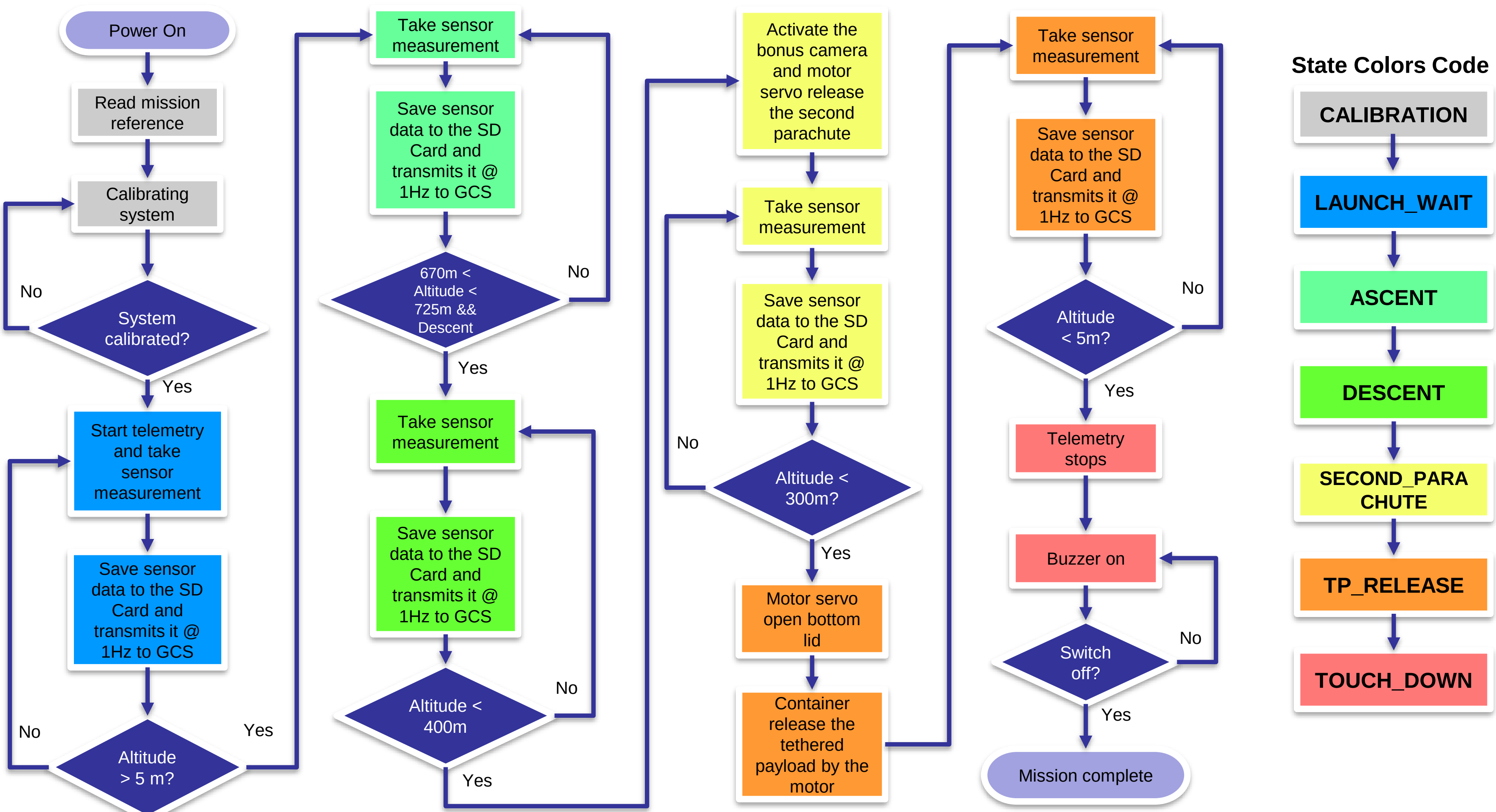
Payload FSW Task
1. The payload will set the new mission reference when receiving **SIM CAL** from the GCS and save calibration data to the EEPROM. 2. When the payload enters the **RELEASE** state, the payload will collect the packet data then save it to the SD CARD, the payload packet data will be transmitted @4Hz to the container via XBEE Pro S2C. At the same time, the payload will trigger the camera to record terrain. 3. The orientation of the payload will be controlled by four fins attached to the payload to maintain the video camera pointed 45 degrees downward in the south direction to assure the terrain in the video. 4. When the state is **TOUCH_DOWN**, all telemetry data transmission will be stopped. 5. The mission will be completed.

FSW Changes Since PDR

Part	PDR	CDR	Rationale
IDE	Using STM32Cube IDE	Using ArduinoIDE	Development STM32F4 Minimum System does not complete.

Container CanSat FSW State Diagram (1/3)

Container Software State Diagram



Container CanSat FSW State Diagram (2/3)

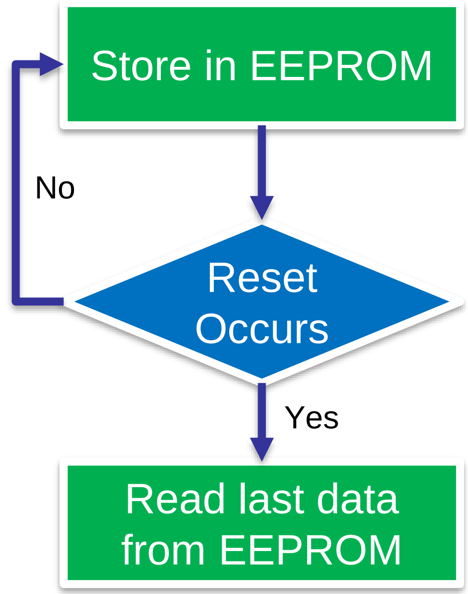
Mechanism Activations
1. At 400m descent position, Teensy 4.1 will activate the servo to open the top lid, to deploy second parachute. 2. At 300m descent position, Teensy 4.1 will activate : ▪ Bonus camera to record the payload release mechanism. ▪ Servo to open the bottom lid, so the tethered payload can be released. ▪ DC motor to control the tether mechanism.

Major Decision Points In The Logic
Altitude will be the major decision parameter among other parameter used as consideration

Data Storage	Sampling Of Sensor	Communications
1. Video and backup telemetry data will be stored on the SD Card. 2. EEPROM is used for recovery after reset.	The data sensor will be sampled at 1 Hz (1000ms).	Payload communicates using XBEE Pro S3B and transmits to GCS. All commands will be included in CDH.

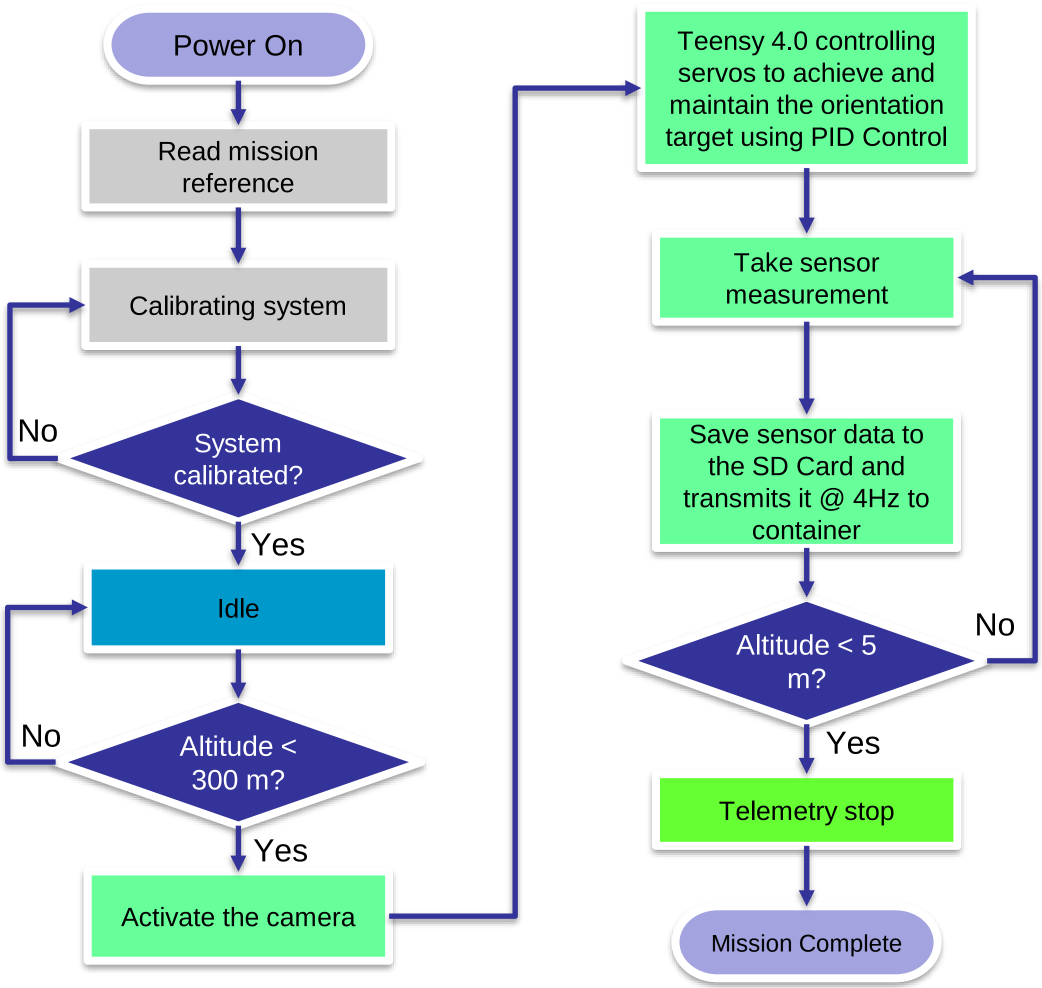
Container CanSat FSW State Diagram (3/3)

Container Data Recovery
Teensy 4.1 will recover (stored in EEPROM): • Packet count • Last State • Command Echo • Reference altitude **Reason for Reset:** Temporary power loss occurs

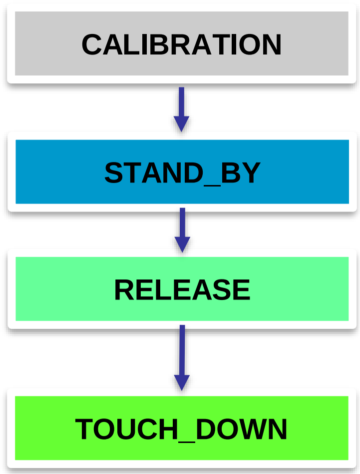


Payload CanSat FSW State Diagram (1/3)

Payload Software State Diagram



State Colors Code



Payload CanSat FSW State Diagram (2/3)

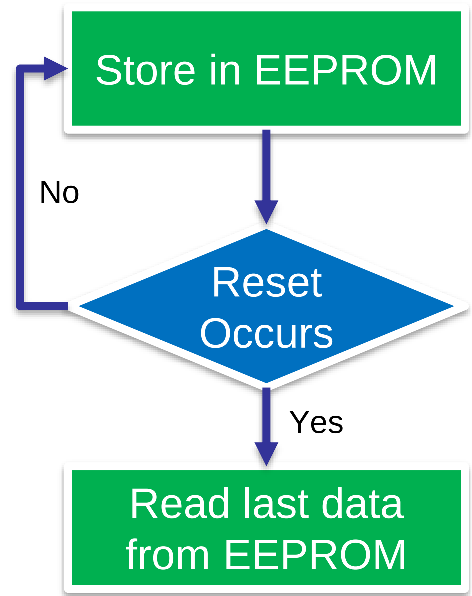
Mechanism Activations
At 300m, Teensy 4.0 will activate : • The camera to record terrain • The four servos will control the fin to point 45 degrees downward in the south direction to assure the terrain is in the video.

Major Decision Points In The Logic
The altitude will be the major decision parameter among other parameters used as consideration.

Data Storage	Sampling Of Sensor	Communications
1. Video and backup telemetry data will be stored on the SD Card. 2. EEPROM is used for recovery after reset.	The data sensor will be sampled at 4 Hz (250 ms).	Payload communicates using XBEE Pro S2C and transmits to the container. All commands will be included in CDH.

Payload CanSat FSW State Diagram (3/3)

Payload Data Recovery
Teensy 4.0 will recover (stored in EEPROM): • Packet count • Last State • Command Echo • Reference altitude **Reason for Reset:** Temporary power loss occurs **Power Management** For two hours flight is enough with 3.6V OLIGHT 18650 3500 mAh battery.



Simulation Mode Software (1/2)

Simulation Mode

1. Simulation mode is for testing, pre-flight demonstration, and contingency, where launch operations are not possible. The telemetered pressure sensor data should reflect the commanded simulation values, not the actual sensor readings.
2. To activate the simulation mode, GCS must send **SIM ENABLE** followed by **SIM ACTIVATE** to the container.
3. The values other than the pressure and altitude (calculated from the pressure values) will be actual sensor readings. The relayed tethered payload telemetry will contain actual sensor values.
4. The barometric pressure data will be read by a .csv file in the GCS and transmit value by the command to the container at a rate of one data per second.
5. After the simulation mode is active, flight software will receive barometric pressure sensor command (SIMP) from GCS and use the received values as if they were actual barometric pressure readings in the calculation of altitude, determination software state, and when to release the tethered payload.
6. After GCS sends the **SIM DISABLE**, the flight software will switch to flight mode.

Simulation Mode Software (2/2)

Simulation Mode Commands

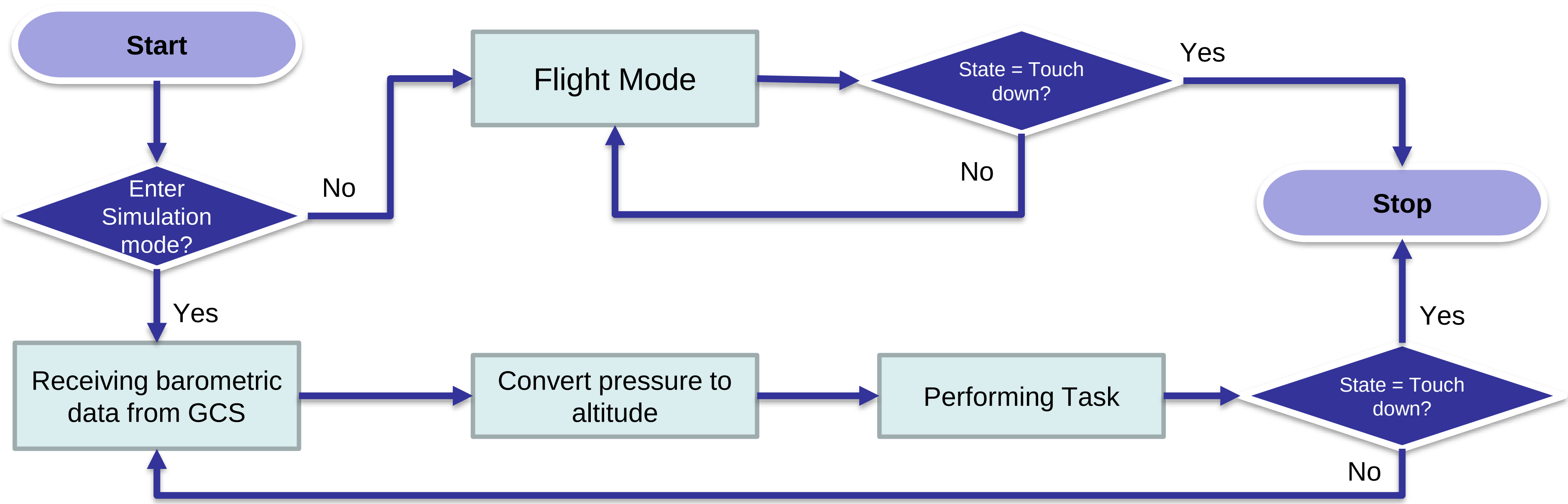
CMD,<TEAM_ID>,SIM,<MODE>

<MODE> consists of :
- **‘ENABLE’** to enable simulation mode;
- **‘ACTIVATE’** to activate simulation mode; or
- **‘DISABLE’** to disable and deactivate simulation mode

CMD,<TEAM_ID>,SIMP,<PRESSURE>

This command provides a simulated pressure reading to the Container

Simulation Mode Flowchart



Software Development Plan (1/4)

Prototyping and Prototyping Environments		
Subject	**Prototyping Environment**	**Prototyping Procedure**
Teensy 4.1 and Teensy 4.0	Arduino IDE	Programming and debugging are done in Arduino IDE and the data will be monitored in the serial monitor.
Sensors	Breadboard and PCB	Each sensor is tested on the breadboard separately.

Software Development Plan (2/4)

Software Subsystem Development Sequence	
Subsystem	**Development Sequence**
Sensors	• **Sensor trade and selection** - select the best sensors for our application • **Individual sensor programming** - program container sensor and program payload sensor with ArduinoIDE.
State Mechanism	Integrate all sensors and test it in state mechanism.
XBEE Telemetry	• **Testing GCS and container communication** – Configure and test all container sensors data that will be transmitted to GCS • **Testing payload and container communication** – Configure and test all payload sensors data that will be transmitted to container.
Orientation mechanism	Program payload orientation mechanism with four servos controlling the fins.
Tethered payload release mechanism	Program opening bottom lid with a servo and tether mechanism using DC motor.
Integrate all	Integrate all software subsystem to ensure all system works well.

Development Team

1. Rara Widya Paramartha Hapsari
2. Piko Permata Ilham Prasetyo

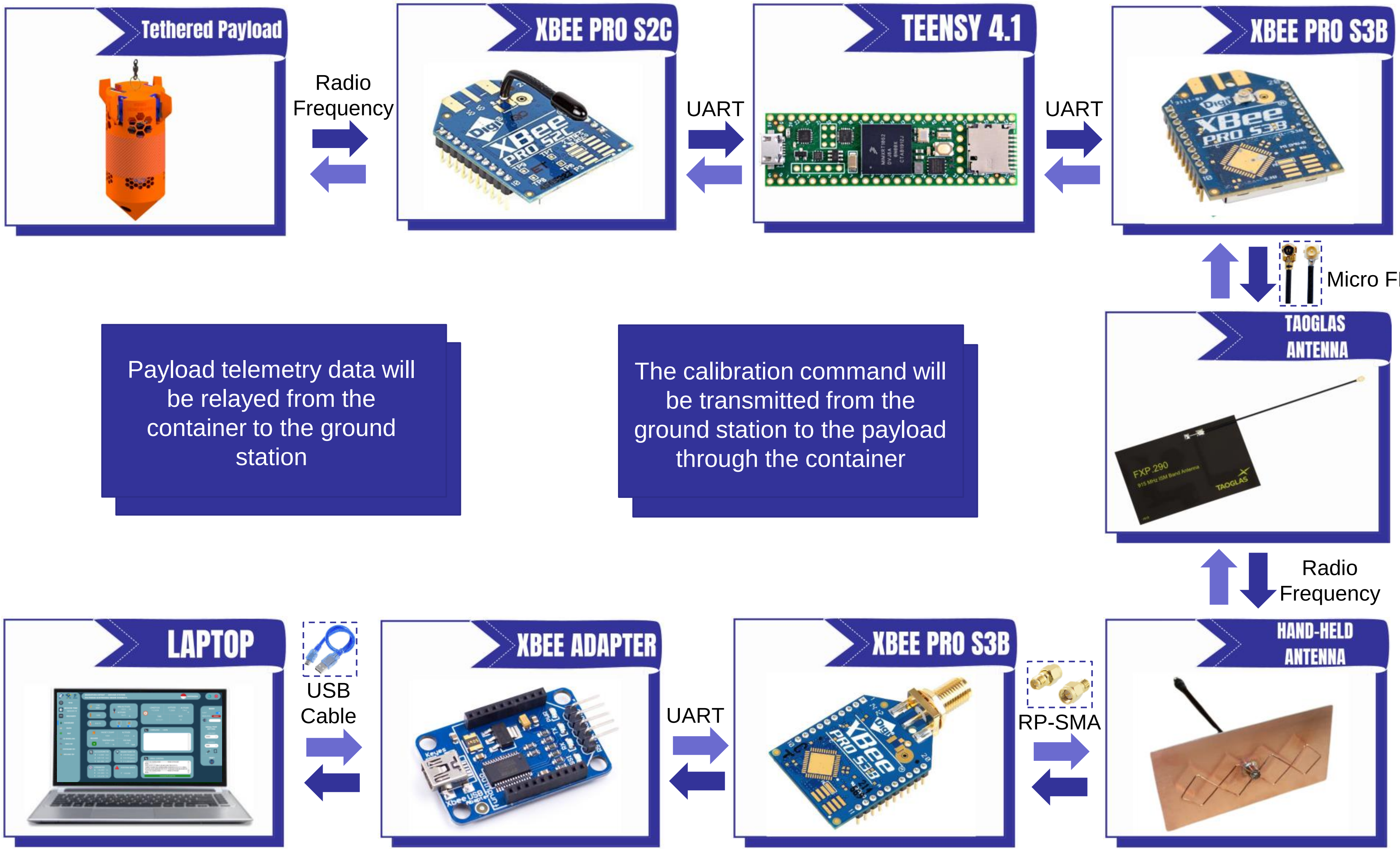
Software Development Plan (3/4)

Test Methodology	
1. Necessary software is installed to Arduino IDE and to help the software development. 2. Telemetry software tests are simulated using XCTU. 3. Sensors and hardware were tested separately. 4. Test the states mechanism for container and tethered payload. 5. Test the system recovery for container and tethered payload.	6. Test the telemetry data and communication commands using hardware. 7. Test the flight mode software using GCS. 8. Test the simulation mode software using GCS. 9. Check whether the FSW meets the competition requirements. 10. Test integrated sensors and hardware according to mission.
Progress Since PDR	
Container Development Update	**Payload Development Update**
1. Sensors were calibrated and tested. 2. Container flight software states has been tested. 3. Container is able to receive commands from GCS properly. 4. Container data recovery was tested? 5. Simulation mode has been tested with GCS. 6. Container software development has been made based on mission guide.	1. Sensors were calibrated and tested. 2. Payload flight software states has been tested. 3. Payload data recovery was tested? 4. Payload communication between container and GCS has been tested. 5. Payload software development has been made based on mission guide.

Ground Control System (GCS) Design

Rara Widya

GCS Overview



GCS Changes Since PDR

Part	PDR	CDR	Rationale
GCS GUI	Graph is using Zedgraph Library	Graph is using Syncfusion Library	To avoid errors on the graph in the form of broken lines after running for approximately 30 minutes.

GCS Design

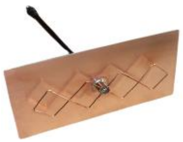
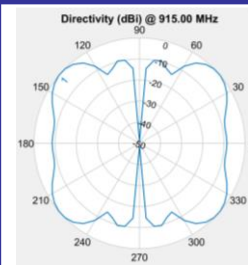
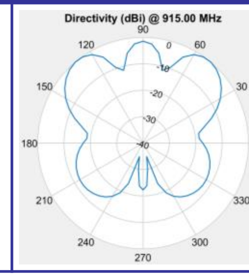
RP-SMA

UART

Specifications	
Battery	GCS Laptop can operate 2.5 hours on battery from fully charged
Overheating Mitigation	There will be an external laptop cooling fan with power source from power bank and also an umbrella
Auto Update Mitigation	Auto update and internet connection will be disabled before the launch

USB Cable

GCS Antenna (1/2)

Model	Frequency Range (MHz)	Gain (dBi)	Beamwidth (Horizontal / Vertical)	Direction	Range (km)	Cost ($)	Antenna Pattern: Horizontal	Antenna Pattern: Vertical
 **Double Biquad Antenna**	915	8.94	45°/30°	Directional	3.5	11.8		

Selected Mounting Antenna Design:	Hand-Held Antenna

The antenna will be hand-held for easy targeting and minimize data loss since the Container altitude will change over time.

Selected Antenna:	Double Biquad Antenna

Reasons:

1. Large horizontal and vertical beam width to compensate pointing error
2. Easy to hold and cheaper than Yagi Antenna
3. Saves space for packaging because it has shorter directors compared to Yagi Antennas
4. Better range.

GCS Antenna (2/2)

Link Budget Calculation

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

$$= 24 + 8.94 - 0 - 101.2 - 5 + 1.5 - 0$$

$$= -\mathbf{71.76\ dBm}$$

All of losses are ignored, except L_{FS} and L_M

$\boldsymbol{Misc\ Losses = 5\ dBi\ (estimated)}$

Free Space Path Loss Calculation

$$FSPL = 20\ log_{10}(d) + 20\ log_{10}(f) + 32.44$$

$$= 9.54 + 59.22 + 32.44$$

$$= \mathbf{101.2\ dB}$$

$\boldsymbol{Distance = 3\ km}\ (predicted)$

$$-71.76\ \mathrm{dBm} > -107\ \mathrm{dBm}$$

Information :

$P_{RX} = Received\ Power\ (dBm)$
$P_{TX} = Transmitted\ Power\ Output\ (dBm)$
$G_{TX} = Transmitter\ Antenna\ Gain\ (dBi)$
$L_{TX} = Losses\ from\ Transmitter\ (dB)$
$L_{FS} = Free - Space\ Path\ Loss\ (dB)$
$L_M = Misc\ Losses\ (dB)$
$G_{RX} = Receiver\ Antenna\ Gain\ (dBm)$
$L_{RX} = Losses\ from\ Receiver\ (dB)$

Information :

$FSPL = Free - Space\ Path\ Loss\ (dB)$
$d = Distance\ between\ the\ antennas\ (km)$
$f = Frequency\ (MHz)$

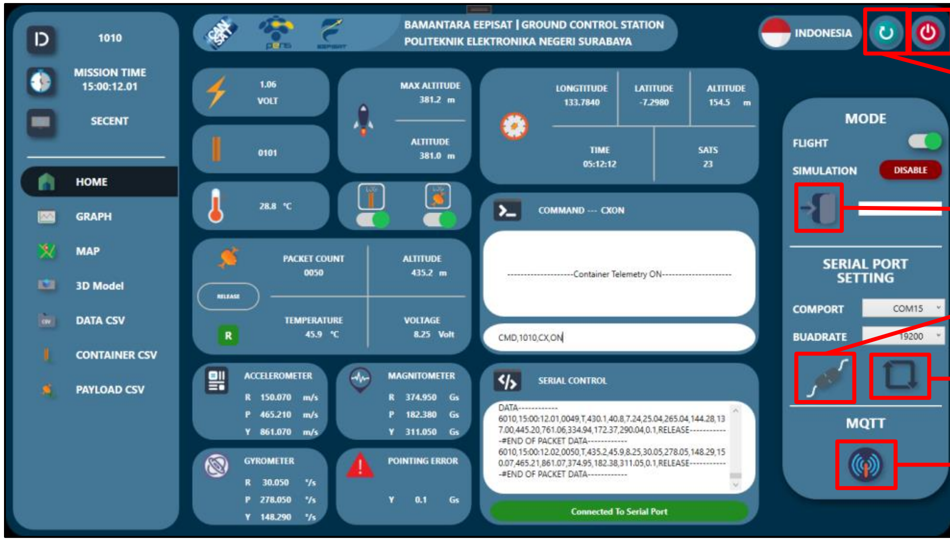
$XBee\ Receiver\ Sensitivity = -107\ dBm$

Our margin is **35.24 dBm** which can provides a reliable operation and it's sufficient for the requirement

GCS Software (1/5)

Commercial Off The Shelf (COTS) Software Packages Used	▪ Visual Studio 2019 Community Edition ▪ XCTU (XBee Program Software)
Real-time Plotting Software Design	The telemetry data that received from the serial port will be transferred to the PC by USB connector, and processed with C# using Syncfusion and C# Windows Presentation Foundation (WPF) library to display in real time the telemetry and finally data will be saved in a .csv file.
Command Software And Interface	There will be a command text box to calibrate all the telemetry data, and command the container also the tethered payload to start transmitting the telemetry data. To calibrate air pressure sensors and inertial measurement sensor, the calibration command will be sent to container and forwarded to payload. The air pressure sensor will acquire reference 0 meter pressure and save it. As for inertial measurement sensor will sent the stage of calibration to GCS until all component in the sensors are fully calibrated.
Telemetry Data Recording And Media Presentation To Judges For Inspection	Telemetry data in as a .csv file, the screenshot of the interface, and media data recorded from the container using the camera will presented to the judges via USB memory storage device.
Description of .csv Telemetry File Creation For Judges	▪ All received telemetry data will be saved as .csv (Comma Separated Value) file. In CSV format, data is separated by comma. ▪ CSV file name will be “Flight_1010_C.csv for the Container Telemetry. ▪ CSV file name will be “Flight_1010_T.csv for the Tethered Payload.
Simulation Mode Description	GCS will command SIMULATION ENABLE and SIMULATION ACTIVATE to the container. And then GCS will read the row of the .csv file that contains the barometric pressure data and it will be transmitted to flight software at a one second interval by Simulated Pressure Data Command for start to simulate the altitude.
Commanding	GCS crew will send the command to the container via a command text box. The command will be typed manually (described in Container Command Format subsection), when the enter key is pressed the command will transmit to the container.

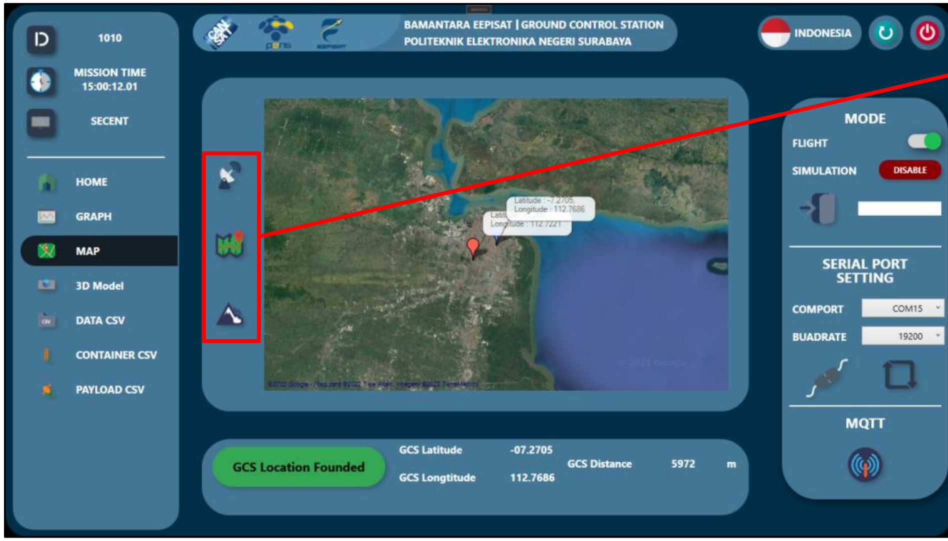
GCS Software (2/5)



Dashboard View

Graph View

GCS Software (3/5)

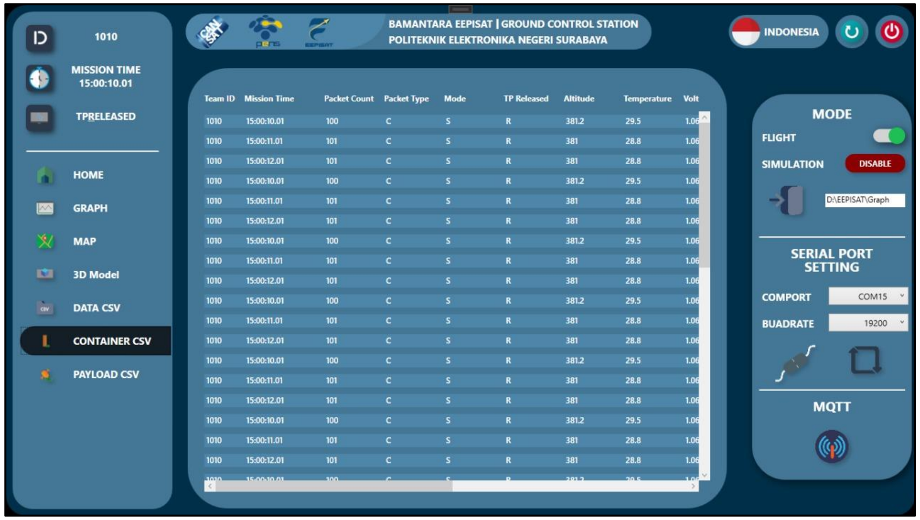


Map Type Button

Map View

Data CSV View

GCS Software (4/5)



Container CSV View

Payload CSV View

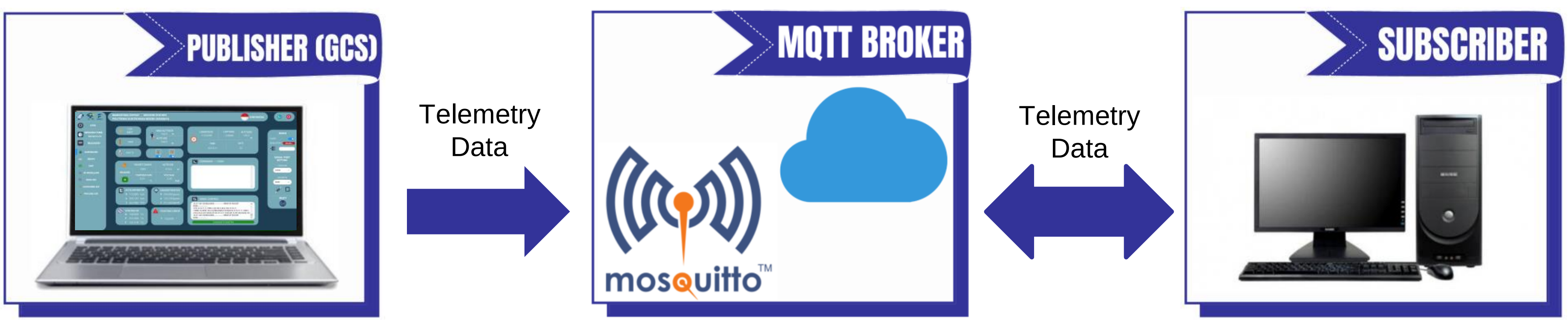
GCS Software (5/5)

Progress Since PDR

- ✓ GCS can transmit all the command to FSW.
- ✓ GCS can receive and visualize all the telemetry data in label, chart, and map in real-time.
- ✓ GCS can save the telemetry data files in .csv format for Container, Tethered Payload.
- ✓ GCS can read a .csv file that contains barometric pressure data and transmit it to container in one second interval (1Hz) in simulation mode.
- ✓ GCS can submit the telemetry data files in .csv format for Container and Tethered Payload to the MQTT Broker.
- ✓ The antenna has been made and tested, the results are appropriate.

MQTT Integration

MQTT Server Remote Connect and Telemetry Packets Submit	• Ground station software will connect to the MQTT broker that has been setup by the committee in cansat.info in port 1883. The team topic is teams/1010. • Ground station software will read a .csv file that contains Container and Tethered Payload telemetry data and split it into the lines and will locate element 2 that is Packet Type. If the Packet Type is ‘C’ and ‘T’ the ground station software will transmit data to the broker. • Ground station software use C# for develop the MQTT Client and use Paho-MQTT for the MQTT library.
MQTT Data Submission	There will be a toggle slide button that can publish telemetry data in .csv format to the MQTT Broker and save the telemetry data into .csv file.
MQTT Test Plans	To test if the ground station software can submit the telemetry data in .csv format by going to CanSat MQTT Broker that has been setup by the committee in CanSat.info.



CanSat Integration and Test

Aghist Fitrony

CanSat Integration and Test Overview (1/3)

Preparation for required test condition → Component testing of each subsystem → Subsystem level testing → Integrated level functional testing → Enviromental testing

Subsystem Level	Integrated Level	Enviromental
1. Sensors 2. CDH 3. EPS 4. Radio communications 5. FSW 6. Mechanical 7. Descent Control	1. Descent testing 2. Communications 3. Mechanisms 4. Deployment 5. Simulation	1. Drop test 2. Thermal test 3. Vibration test 4. Fit Check 5. VACUUM test

CanSat Integration and Test Overview (2/3)

Subsystem Level Testing Details
Sensors: All sensors will be installed to the PCB with microcontroller to start processing data (output will be displayed on serial monitor of Arduino IDE) .
CDH: XBEE configuration tested on PCB and using XCTU software to ensure if there’s no error occurred while data transmission.
EPS: Connect battery to all electronic components to ensure it will last for 2 hours.
Radio Communications: Communication range test using XBEE and antenna.
FSW: State test and recovery test to ensure the software worked properly.
Mechanical: Mechanisms such as auto-gyro, hinges, servos and release mechanisms will be tested to meet competition requirements.
Descent Control: Descent rate of container and payload will be tested at certain heights.
Integrated Level Testing Details
Descent Testing: CanSat’s descent rate will be tested to accomplish calculation we’ve made.
Communications: XBEE communication through GCS-Container-Payload will be tested using antenna and verify telemetry data meet competition requirements.
Mechanisms: Mechanical parts will be tested to survive required force limits by testing the all mechanisms repeatedly.
Deployment: Servo and rubber will be tested to ensure both top and bottom lid opens properly. Tether mechanism also will be tested to deploy the tethered payload.
Simulation: Testing Flight Software and GCS to perform simulation mode.

CanSat Integration and Test Overview (3/3)

Enviromental Testing Details
Drop Test: 61 cm cord will connect CanSat and 2m height fixed bar. Drop test will then be conducted and CanSat power, components, and mountings will be observed
Thermal Test: Placing CanSat inside DIY insulated thermal box. Heat will be generated from blower and maintain this condition between 55-60℃ for 2 hours.
Vibration Test: Vibration test will be performed by using random orbital sander to verify the mounting integrity of all components, mounting connections, structural integrity, and battery connections.
Fit Check: CanSat's dimensions will be measured using micrometer callipers, ruler, and tape.
Vacuum Test: CanSat will be placed on Vacuum Chamber to start collecting data using telemetry format when peak altitude has reached.
Simulation: Testing Flight Software and GCS to perform simulation mode.
Simulation Testing Details
GCS: Simulation command from GCS works properly and read .csv files from judges
Flight Software: Simulation command could trigger microprocessor to processing data from GCS

Subsystem Level Testing Plan (1/2)

Subsystem Level Testing Plan	
Sensors	• Sensors on the breadboard will be tested. • Calibrate sensors until the accuracy rate is high. • Repeat testing.
CDH	• Ensure accuracy and speed of the data sent to ground station is correct. • XBEE data transfer range and configuration. • Ensure data format is corresponding to mission guide.
EPS	• Ensure total power is enough to power all electric components. • Checking for damages such as short circuits. • Battery Watt hour capacity is measured to calculate margin.
Radio Communications	• Range test will be performed. • Beam and stability test will be performed. • Repeat testing.

Subsystem Level Testing Plan (2/2)

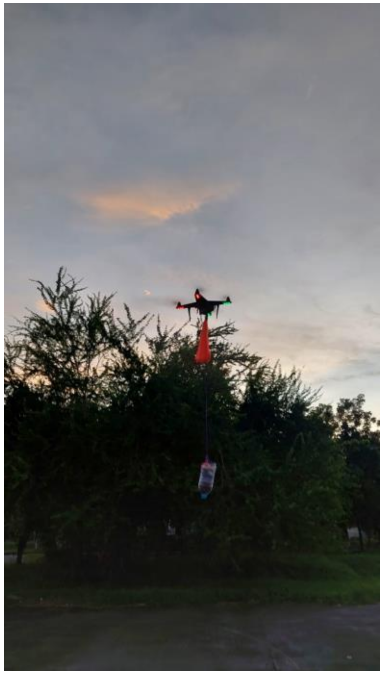
FSW	• Ensure recovery data in case of microcontroller resets • State testing • Flight Algorithm test
Mechanical	• Servos and hinges will be inspected carefully to ensure freedom of operation • DC Motor will be inspected carefully to ensure freedom of operation • Auto-Gyro of payload will be tested inside vertical wind tunnel. • Ensure both top and bottom lid opens without being jammed.
Descent Control	• Parachute drop will be tested to calculate drag force • Ensure the container descends aerodynamically stable

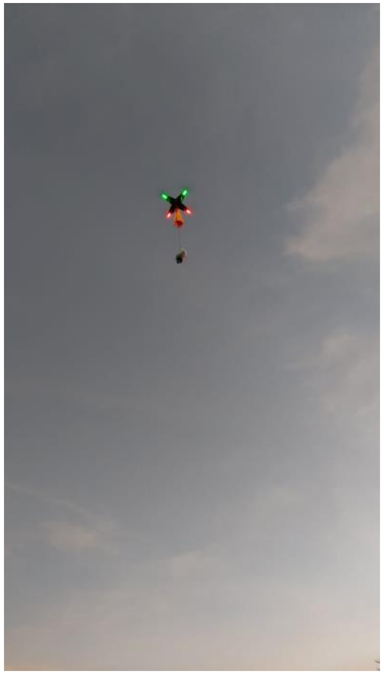
Integrated Level Functional Test Plan (1/3)

Descent Testing

1. This test is to verify that CanSat descends at a speed corresponding to mission guide.
2. We tied a dummy CanSat to a drone with mass of 600g to verify its descent rate.

Documentations



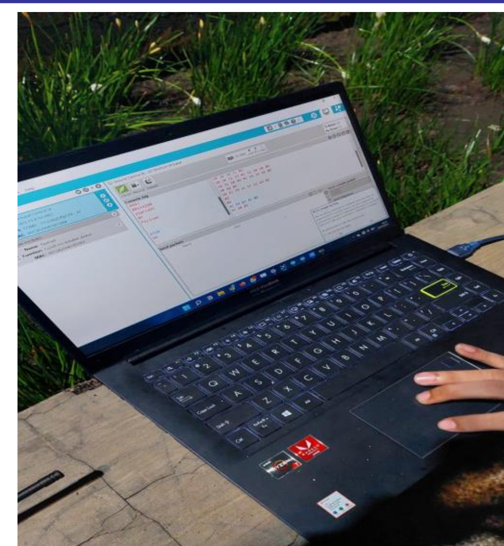


Integrated Level Functional Test Plan (2/3)

Communications

1. This test is to verify that the communication system worked properly.
2. We will run the flight software to run the XBEE communication at 1Hz for container and 4hz for payload with various range. The data shall appear in GCS monitor.
3. Ensure data received is in correct format to mission guide.

Documentations



Integrated Level Functional Test Plan (3/3)

Mechanisms

1. This test is to verify that payload is able to release from the container and parachute mechanisms worked properly.
2. Release triggering test using pressure sensor that converts into altitude to ensure payload releases at 450m.
3. Check main mechanisms components condition after several tests such as hinges and servos to ensure it survives given force limits.
4. Check attachment points such as swivel and eyebolt to ensure parachute stay attached due to forces.

Deployment

1. Deploying Container and payload in various altitude
2. Parachute deployment will be tested in various altitude
3. Ensure there is no sharp edges and obstacle that prevents CanSat from deploying.

Integrated Level Functional Test Plan (3/3)

Simulation

1. This test is designed to verify if Ground Station shall have the capability to read a .csv file of barometric pressure data that simulates the mission profile and transmit the values via commands to the Container at a rate of one per second (1Hz).
2. We will test it by preparing barometric data in .csv file to ensure GCS is able to read .csv file.
3. Test if GCS is able to transmit the pressure value at one second interval (1Hz) to flight software.

Environmental Test Plan (1/5)

Drop Test

This test is designed to verify that the container parachute and attachment point will survive the deployment from the rocket payload section which can be very violent.

1. Power on CanSat.
2. Verify telemetry is being received.
3. Raise CanSat by a 61 cm non-stretching cord
4. Release the CanSat.
5. Verify the CanSat did not lose power. Inspect for any damage, or detached parts and verify telemetry is still being received. (CanSat mission guide)

Thermal Test

This test is to verify the CanSat and container can operate in a hot environment. We will be using a thermal chamber and hot air gun as heat source.

1. Place CanSat into a thermal chamber and Hot Air Gun as heat source
2. Turn on the CanSat.
3. Close and seal the thermal chamber.
4. Turn on the heat source.
5. Turn off the heat source when the internal temperature reaches 60°C and turn on the heat source when the temperature drops to 55°C for two hours
6. Perform visual inspection and any functional tests to verify the CanSat survived the thermal exposure. (Cansat mission guide)

Picture of Test Fixture

Environmental Test Plan (3/5)

Vibration Test

This test is designed to verify the mounting integrity of all components, mounting connections, structural integrity, and battery connections. We will be using orbital sander for vibration test.

1. Power on the CanSat and verify accelerometer data is being collected.
2. Plaster CanSat above the sander and power up the orbital sander.
3. Once the sander is up to full speed, wait 5 seconds.
4. Power down the sander to a full stop.
5. Repeat it four more times.
6. Inspect the CanSat for damage and functionality. Verify accelerometer data is still being collected. (CanSat mission guide).

NRT PRO-925HD Random Orbital Sander

Vacuum Test

This test is designed to verify deployment operation of the payload.

1. Suspend the fully configured and powered CanSat in the vacuum chamber.
2. Turn on the vacuum to start pulling a vacuum.
3. Monitor the telemetry and stop the vacuum when the peak altitude has been reached.
4. Let the air enter the vacuum chamber slowly and monitor the operation of the CanSat.
5. Collect and save telemetry
6. Make the saved telemetry available for the judges to review. (CanSat mission guide)

Picture of Test Fixture

Fit Check

This test is designed to verify if the CanSat is able to fit in rocket. We use micrometer calipers to measure the dimensions of CanSat to ensure it is able to fit in rocket.

Test Procedures Descriptions (1/3)

Test Proc	Test Description	RN	Pass/Fail Criteria	Status
1	Air Pressure Sensor Test.	27,44	Altitude from data is similar with actual altitude.	**Pass**
2	Air Temperature Sensor Test.	42	Temperature data is similar with actual temperature.	**Pass**
3	GPS Sensor Test	26	Showing correct time and location.	**Pass**
4	Voltage Sensor Test	28	Voltage data is similar with calculation shown on Avometer.	**Pass**
5	Camera Test	45,46, 68	Result of video capturing minimum resolution of 640x480 and 30 fps.	**Pass**
6	Rotational Sensor Test	44	RPM data is similar with tachometer.	**Pass**
7	Power Consumption Test	40	Actual power consumption similar with calculation result measured using Avometer.	**Pass**
8	XBEE Communication Test and Antenna Range Test	21,63	Communication data sent and received by GCS from 750m distance.	**Pass**
9	Data Transmission at 1Hz Test	29	The data must be in correct order at 1 Hz rate.	**Pass**
10	FSW State Test	58	State changes along as altitude increases and descends that calculated from pressure.	**Pass**
11	Testing of Data Recovery Algorithm	49,50	The data (altitude reference, packet count, states, coordinate, etc) recovered to EEPROM and continuing process.	**Pass**

Test Procedures Descriptions (2/3)

Test Proc	Test Description	RN	Pass/Fail Criteria	Status
12	GCS Interface Test	59,60, 61,62	All telemetry data received are displayed in GCS interface (graph and csv)	Pass
13	GCS PC Battery Test	63	GCS PC is still working after 2 hours of usage.	Pass
14	GCS Data Inspection and Data Format Save Test	52,56, 66	The data displayed in engineering unit and plotted in .csv file automatically.	Pass
15	GCS Communication Test	55	GCS is able to send command to container to start send the telemetry data.	Pass
16	MQTT Test	53,56	Telemetry data can submitted telemetry data in .csv file and displayed on CanSat MQTT Broker	Pass
17	Container Descent Test	10,11	Container descents at descent rate of 15m/s (±5m/s) for first parachute and 5m/s (±2m/s) for second parachute.	Pass
18	Tethered Payload Test	48	Payload descends at descent rate of 0.5m/s that connected to a 10m tether.	Pass
19	CanSat Deployment Test	3	CanSat Doesn’t have any sharp edges.	Pass
20	Second Parachute Deployment Test	11	Second parachute able to deploy from container through top lid.	Pass
21	Payload Deployment Test	48	Payload able to deploy from container successfully.	Pass

Test Procedures Descriptions (3/3)

Test Proc	Test Description	RN	Pass/Fail Criteria	Status
22	Payload Maintain Orientation Test	45,46	Fins mechanism able to maintain orientation of a video camera pointing in the south direction and video camera shall be pointed 45 degrees downward to assure terrain is in the video.	Upcoming
23	Drop Test	13,39	CanSat survived a drop from 2 feet attached to cord. No parts falling off, no separation.	Upcoming
24	Thermal Test	39	No CanSat materials warp, weaken, change characteristics, or fail to function.	Upcoming
25	Vibration Test	14,39	All mounting integrity of all components, mounting connections, structural integrity, and battery connections survived	Upcoming
26	Vacuum Test	39	FSW is able to detect the altitude from pressure changes inside the vacuum chamber	Upcoming
27	Fit Check	1,2,3 9	Total Mass of CanSat 600 gr +/- 10 grams and dimension of CanSat under 125 x 400 mm	Pass

Simulation Test Plan

GCS

This test is designed to verify if Ground Station shall have the capability to read a .csv file of barometric pressure data that simulates the mission profile and transmit the values via commands to the Container at a rate of one per second (1Hz).

We will test it by preparing barometric data in .csv file. Then, GCS will read data that contains barometric pressure value and transmit it to flight software at one second interval (1Hz) by **Simulated Pressure Data** command to start simulate altitude. The altitude value that has been converted by flight software will be received by GCS.

Flight Software

This test is designed to verify that the data barometric pressure from GCS generated it in altitude. We will enable simulation mode with **ENABLE** from GCS. After that we begin the simulation mode with **ACTIVATE** to stop reading pressure from container sensor. Substituted the data of sensor with .csv file from committee and make sure it transmitted to GCS in altitude data. At 101325 Pascals = approximately sea level barometric data will be saved to EEPROM as altitude ground level reference.

Mission Operations & Analysis

Aghist Fitrony

Overview of Mission Sequence of Events (1/4)

1. Arrival
- Team Arrival at launch site
- Set up GCS and antenna
- Score sheet review and checklist

2. Pre-Launch
- Communication inspection
- Mechanism inspection
- Container and Payload Assembly
- Ensure tethered payload stowed firmly
- CanSat dimension and weight check

3. Rocket Integration
- Final Inspection before launch
- Collect CanSat, turn it on, integrate into rocket and ensure communication with GCS.

Overview of Mission Sequence of Events (2/4)

4. Mission

- Rocket launch with CanSat inside it
- Flight monitoring
- Display GCS to the judges and collecting telemetry data during mission
- Recovery crew preparation

5. Recovery

- Search for container by fluorescent colour, audio beacon and GPS.
- Tracking payload by GPS and fluorescent colour
- Retrieve data from SD Card both container and payload

6. Data Analysis

- GCS data analysis and acquisition.
- Deliver SD card and telemetry data to judges for scoring.
- Launch day team evaluation.
- PFR preparation.

Overview of Mission Sequence of Events (3/4)

Roles	Member Name
Mission Control Officer *- Responsible for informing the Flight Coordinator when the team and their CanSat is ready to be launched.*	1. Zulfikar Davbi
Ground Station Crew *- Responsible for monitoring the ground station for telemetry reception and issuing commands to the CanSat.*	1. Rara Widya 2. Piko Permata
Recovery Crew *- Responsible for tracking the CanSat and going out into the field for recovery and interacting with the field judges.*	1. Aghist Fitrony 2. Rafi' Jusar W
CanSat Crew *- Responsible for preparing the CanSat ,integrating it into the rocket, and verifying its status.*	1. I Made Nugi 2. Achmad Bagus 3. Fatwa Aulia

Overview of Mission Sequence of Events (4/4)

Antenna construction and ground system setup	CanSat Assembly
1. Prepare GCS equipment . 2. Connect XBEE to laptop by XBEE adapter and connect Antenna to XBEE by RP-SMA Male. 3. Turn on PC and disable windows auto update. 4. Perform communication test to ensure all data retrieved. 5. Antenna held by team member.	1. Assemble electrical component. 2. Mount each component and Stow payload inside container. 3. Fold Parachute. 4. Turn on CanSat
CanSat Test	**Delivery of Telemetry Data File**
1. CanSat fit and mass check. 2. Drop test 3. Separation mechanism test. 4. Antenna and communication test. 5. Sensor calibration and electronics component check. 6. CanSat final check.	1. GCS receive telemetry data from XBEE 2. GCS save received telemetry data in .csv file format. 3. Retrieve .csv from file manager into PC and move it into USB flash drive. 4. GCS Operator delivers .csv file using USB Drive.

Field Safety Rules Compliance

Mission Operations Manual	Description
Ground Station Configuration	1. Laptop and antenna preparation. 2. Communication check and testing.
CanSat Preparation	1. CanSat assembly. 2. Sensor calibration. 3. Mass and size checking. 4. Calibration system by command from GCS.
CanSat Integration	1. Fit check. 2. Drop test 3. Battery verification.
Launch Preparation	1. Final communication check. 2. Check CanSat stowed state inside rocket.
Launch Procedure	1. Pre-launch checks. 2. Verify with the ground station that the ground station is ready for launch.

Development Status

1. There will be two (2) Mission Operations Manual will be assembled to a three ring binder. It consists of five section and each section will start on its own page according on mission guide book of CanSat.
2. Each member will familiarize themselves with the manual before launch day. Safety of each person on launch day is crucial.
3. Mission Operations Manual has been downloaded from CanSat competition website. It will be updated as we encounter changes before launch day.

CanSat Location and Recovery

CanSat Recovery
1. Recovery crew will maintain visual contact with container and payload to aid recovery. 2. Container and payload will be orange colored to ease recovery process. 3. We will be providing team information on the outer structure of container. 4. Container has a buzzer that will continuously buzzing when it landed. 5. We also track both container and payload through GPS.

CANSAT COMPETITION 2022
Team #1010 BAMANTARA EEPISAT
eepisatindonesia@gmail.com
+62 821-3919-5755
PENS Campus, Surabaya,
Jawa Timur, Indonesia

We will place this sticker to our container and payload’s body

Mission Rehearsal Activities

Ground System Radio Link Check *Rehearsed on March 24th 2022*	1. Ensure if GCS receive data properly from XBEE. 2. Command testing and calibration from GCS.
Powering On/ Off CanSat *Rehearsed on April 15th 2022*	1. Turn on CanSat by external switch 2. Visual verification of loose electronic components before turning on 3. Ensure serial sent to ground station is correct
Launch Configuration Preparations *Rehearsed on April 20th 2022*	1. Assembly CanSat into operating configuration. 2. Fit Check 3. Main mechanisms check.
Loading CanSat in the launch vehicle *Rehearsed on April 25th 2022*	1. CanSat is placed inside DIY rocket envelope with the dimensions as in competition requirements. 2. Visual verification for sharp edges before loading into rocket.
Telemetry processing, archiving and analysis *Rehearsed on April 27th 2022*	1. Realtime graph check. 2. Ensure the data processed saved into .csv file. 3. Analyse data that displays on GCS GUI. 4. Deliver telemetry data to judges via USB.
Recovery *Rehearsed on May 19th 2022*	1. Recovery will commence after telemetry is stoped. 2. Last GPS location and fluorescent colour will ease recovery.

Requirements Compliance

Aghist Fitrony

We have prepared and designed CanSat by analyzing and identifying the CanSat Mission Guide 2022 .The system will be tested according to CanSat Integration and Test section.

- We have complied 63 requirements based on CanSat Mission Guide 2022.
- There are 5 partially complied requirements that require further tests. Improvement will be needed to comply our system to get fully comply and it's discussed at CDR phase.
- There are not any requirements that doesn't comply to our design.

= Comply

= Partial

= No Comply

Requirements Compliance (1/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#1	Total mass of the CanSat (science payloads and container) shall be 600 grams +/- 10 grams.	**Comply**	94-97	
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	**Comply**	28	
RN#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**	28	
RN#4	The container shall be a fluorescent color; pink, red or orange.	**Comply**	68	
RN#5	The container shall be solid and fully enclose the science payloads. Small holes to allow access to turn on the science payloads are allowed. The end of the container where the payload deploys may be open.	**Comply**	28	
RN#6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	**Comply**	28	
RN#7	The rocket airframe shall not be used as part of the CanSat operations.	**Comply**	28	
RN#8	The container's first parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	**Comply**	89	
RN#9	The Parachutes shall be fluorescent Pink or Orange	**Comply**	54	
RN#10	The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s after deployment while above 400 meters.	**Comply**	61-66	

Requirements Compliance (2/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#11	The descent rate of the CanSat shall be reduced to 5 meters/second +/-2 m/s when the CanSat descends below 400 meters.	**Comply**	61-66	
RN#12	0 altitude reference shall be at the launch pad.	**Comply**	140-145	
RN#13	All structures shall be built to survive 15 Gs of launch acceleration.	**Partial**	173	Require improvements on drop test.
RN#14	All structures shall be built to survive 30 Gs of shock.	**Partial**	175	Not yet tested on vibration machine
RN#15	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	**Comply**	91-93	
RN#16	All mechanisms shall be capable of maintaining their configuration or states under all forces.	**Partial**	91-93	Require further improvements.
RN#17	Mechanisms shall not use pyrotechnics or chemicals.	**Comply**	68	
RN#18	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**	68	
RN#19	Both the container and payload shall be labeled with team contact information including email address.	**Comply**	188	
RN#20	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years should be included in this cost, based on current market value.	**Comply**	204-207	

Requirements Compliance (3/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#21	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	107-108	
RN#22	XBEE radios shall have their NETID/PANID set to their team number.	Comply	108	
RN#23	XBEE radios shall not use broadcast mode.	Comply	108	
RN#24	The container shall include electronics to receive sensor payload telemetry.	Comply	29-44	
RN#25	The container shall include electronics and mechanisms to release the science payload on a tether.	Comply	29-44	
RN#26	The container shall include a GPS sensor to track its position.	Comply	34-35	
RN#27	The container shall include a pressure sensor to measure altitude.	Comply	32-33	
RN#28	The container shall measure its battery voltage.	Comply	36-37	
RN#29	The container shall transmit its telemetry once per second (1 Hz) in the formats described in the Telemetry Requirements section.	Comply	108	
RN#30	The container shall poll the payload for telemetry and relay that data four times per second (4 Hz) in the formats described in the Telemetry Requirements section.	Comply	108	
RN#31	The container shall stop polling and transmitting telemetry when it lands	Comply	108	

Requirements Compliance (4/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#32	The container and science payload must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration.	**Comply**	68	
RN#33	The container and payload must include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the CanSat and in the stowed state.	**Comply**	108	
RN#34	An audio beacon is required for the container. It shall be powered after landing.	**Comply**	126	
RN#35	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	**Comply**	126	
RN#36	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	**Comply**	127, 131	
RN#37	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**	73-75	
RN#38	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	**Comply**	68	
RN#39	The Cansat must operate during the environmental tests laid out in Section 3.5.	**Partial**	173-177	Not yet tested on several tests

Requirements Compliance (5/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#40	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	128-129, 132-133	
RN#41	The science payload shall have their NETID/PANID set to their team number plus 5000. If the team number is 1000, sensor payload NETID is 6000.	Comply	117	
RN#42	The science payload shall transmit sensor telemetry to the container when polled.	Comply	117	
RN#44	The science payload shall include a pressure sensor, temperature sensor and rotation sensor.	Comply	38-44	
RN#45	The science payload shall include a video camera pointing 45 degrees up from the payload NADIR direction.	Comply	45	
RN#46	The science payload shall maintain orientation so the camera always faces south within +/- 20 degrees.	Partial	53	The Payload is still being developed.
RN#47	The payload shall be connected to the container with a 10 meter tether.	Comply	85-88	
RN#48	At 300 meters, the payload shall be released from the container at a rate of .5 meters per second.	Comply	87	
RN#49	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	142, 145	

Requirements Compliance (6/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#50	The container shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	**Comply**	109	
RN#51	The container shall have its time set to UTC time to within one second before launch.	**Comply**	109-110	
RN#52	The container flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	**Comply**	146-147	
RN#53	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude.	**Comply**	146-147	
RN#54	The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	**Comply**	146-147	
RN#55	The ground station shall command the CanSat to start transmitting telemetry prior to launch.	**Comply**	157	
RN#56	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	**Comply**	157	
RN#57	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**	157	
RN#58	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	**Comply**	142, 145	

Requirements Compliance (7/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#59	Each team shall develop their own ground station.	**Comply**	152	
RN#60	All telemetry shall be displayed in real time during descent on the ground station.	**Comply**	157	
RN#61	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	**Comply**	157-161	
RN#62	Teams shall plot each telemetry data field in real time during flight.	**Comply**	157-161	
RN#63	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**	152	
RN#64	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**	155	
RN#65	The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	**Comply**	157	
RN#66	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the container.	**Comply**	146-147	
RN#67	The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container.	**Comply**	117	

Requirements Compliance (8/8)

RN	Requirement	Compliance	Ref Slides	Notes
RN#68	All video cameras shall be in color, have a resolution of at least 640x480 and record at a minimum of 30 frames a second.	**Comply**	45	
BM	As the container is releasing the payload, the container shall contain a video camera and start recording to show the descent of the payload. All videos are to be recorded and recovered when the Cansat is recovered from the field.	**Comply**	46	

Management

Rena Kridianingrum

Status of Procurements (1/3)

Mechanical Procurement

Components	Quantity	Order	Receive	Status
Resin Epoxy	2	10/19/21	10/19/21	Received
Chinese Knotting Cord	1	10/22/21	10/22/21	Received
Akrilik A3 2mm	1	12/29/21	12/31/21	Received
Carbon fiber rod solid 3mm	6	12/11/21	12/11/21	Received
Crepe Paper	2	01/21/22	01/21/22	Received
Ribstop Nylon / m^2	1	02/04/22	02/04/22	Received
PLA +	1	02/04/22	02/04/22	Received
Paperboard	1	02/24/22	02/24/22	Received
Rubber	1	02/18/22	02/20/22	Received
Hinges	4	02/24/22	02/24/22	Received

Status of Procurements (2/3)

Electronics Procurement

Components	Quantity	Order	Receive	Status
u-blox NEO-6M	1	10/19/21	10/19/21	Received
DC Motor	1	10/22/21	10/22/21	Received
SG90 Servo Motor	4	10/22/21	10/22/21	Received
BNO055	1	11/18/21	11/18/21	Received
Battery Charger 18650 (2 Slot)	1	11/21/21	11/21/21	Received
Olight 18650 Battery	2	12/07/21	03/11/22	Received
CR2032 Coin Cell	2	12/25/21	12/25/21	Received
Taoglas Antenna FXP290	1	12/29/21	01/04/22	Received
MX1508 Driver Motor	1	01/12/22	01/12/22	Received
MG90 Servo Motor	1	01/12/22	01/12/22	Received
Teensy 4.1	1	01/26/22	01/26/22	Received
Buzzer	1	02/05/22	02/05/22	Received
XL6009 Step-up	2	02/25/22	02/25/22	Received
PCB	3	03/01/22	03/01/22	Received
Orbital Sander NRT Pro	1	03/03/22	03/03/22	Received
XBEE Pro S3B	2	03/08/22	03/10/22	Received
Mini Camera SQ11	2	03/24/22	03/26/22	Received
Teensy 4.0	1	03/26/22	03/28/22	Received
3 mm LED	2	n/a	n/a	In Stock
Micro USB	2	n/a	n/a	In Stock
BME280	2	n/a	n/a	In Stock
XBEE Pro S2C	1	n/a	n/a	In Stock
XBEE Adaptor	3	n/a	n/a	In Stock
SanDisk Ultra 16 GB SD Card	4	-	-	Not Yet Ordered
Slide Switch	2	-	-	Not Yet Ordered
Spacer	4	-	-	Not Yet Ordered
On/Off Switch	2	-	-	Not Yet Ordered

Status of Procurements (3/3)

Ground Station Procurement

Components	Quantity	Order	Receive	Status
Double Biquad Antenna	1	01/28/22	01/28/22	Received
RP SMA	1	01/28/22	01/28/22	Received
XBEE S3B	1	03/08/22	03/08/22	Received
USB Cable	1	n/a	n/a	In Stock
XBEE Adaptor	1	n/a	n/a	In Stock

CanSat Budget – Hardware (1/4)

Mechanics Components

Components	Quantity	Unit Cost ($)	Total Cost ($)	Considerations
PLA +	1	18.05	18.05	Actual
Acrylic A3 2mm	1	1.39	1.39	Actual
Resin Epoxy	1	16.03	16.03	Actual
Ripstop Nylon / m^2	1	1.39	1.39	Actual
Carbon fiber rod solid 3mm	6	1.05	6.3	Actual
Crepe Paper	2	0.28	0.56	Actual
Chinese Knotting Cord	1	1.39	1.39	Actual
Paperboard	1	0.49	0.49	Actual
Tile / m^2	1	0.87	0.87	Actual
Rubber	1	0.35	0.35	Actual
Hinges	4	4.26	17.04	Actual
Total Cost Mechanics Component ($)			**63.86**	

CanSat Budget – Hardware (2/4)

Electrical and Electronics Components

Components	Quantity	Unit Cost ($)	Total Cost ($)	Considerations
BME280	2	9.05	18.10	Actual
u-blox NEO-6M	1	3.50	3.50	Actual
Teensy 4.1	1	27.24	27.24	Actual
BNO055	1	45.95	45.95	Actual
Quelima SQ 11	2	4.53	9.06	Actual
MG90 Servo Motor	1	2.07	2.07	Actual
MX1508 Driver Motor	1	1.75	1.75	Actual
SanDisk Ultra 16 GB SD Card	4	6.00	24.00	Actual
Buzzer	1	0.56	0.56	Actual
Slide Switch	2	0.35	0.70	Actual
3 mm LED	2	0.14	0.28	Actual
Micro USB	2	2.81	5.62	Actual
Battery Charger 18650 (2 Slot)	1	2.81	2.81	Actual
XBEE Pro S3B	1	57.52	57.52	Actual
XBEE Pro S2C	2	50.02	100.04	Actual
XBEE Adaptor	3	5.27	15.81	Actual
Taoglas Antenna FXP290	1	17.05	17.05	Actual
XL6009 Step-up	2	2.00	4.00	Actual
Spacer	4	0.14	0.56	Actual
PCB	3	1.05	3.15	Actual
SG90 Servo Motor	4	1.45	5.80	Actual
CR2032 Coin Cell	2	0.17	0.34	Actual
On/Off Switch	2	0.14	0.28	Actual
Orbital Sander NRT Pro	1	31.35	31.35	Actual
Teensy 4.0	1	31.02	31.02	Actual
DC Motor	1	4.54	4.54	Actual
Olight 18650 Battery	2	25.13	50.26	Actual
Total Cost Electrical and Electronics Components ($)			**463.36**	

CanSat Budget – Hardware (3/4)

Ground Station Components

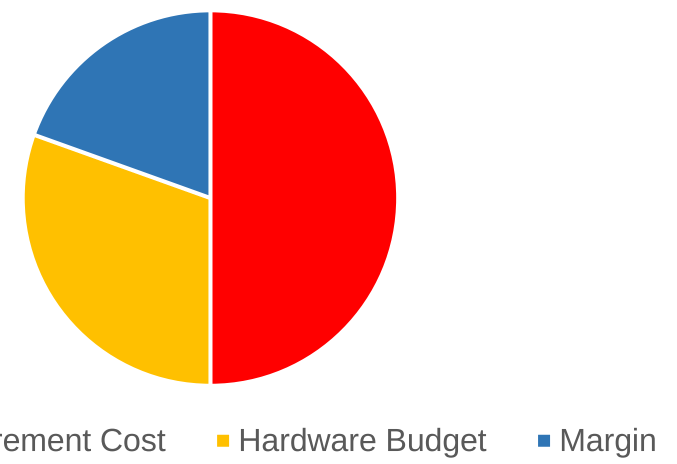
Components	Quantity	Unit Cost ($)	Total Cost ($)	Considerations
Double Biquad Antenna	1	11.8	11.8	Actual
XBEE S3B	1	57.52	57.52	Actual
XBEE Adaptor	1	5.27	5.27	Actual
USB Cable	1	2.5	2.5	Actual
RP SMA	1	5.32	5.32	Actual
Total Cost Ground Station Component ($)			**82.41**	

CanSat Budget – Hardware (4/4)

Hardware Parts	Total ($)
Total Cost Mechanics Component	63.86
Total Cost Electronics Component	463.36
Total Cost Ground Station Components	82.41
Total Hardware Budget ($)	**609.63**

CanSat Requirement Cost – Hardware Budget = Margin

$ 1000 - $ 609.63 = $ 390.37



CanSat Budget – Other Costs (1/2)

Others Cost

Components	Quantity	Unit Cost ($)	Total Cost ($)	Considerations
Registration	1	200	200	Actual
Prototyping	1	100	100	Estimated
RT Flight (CGK-NRT-CHR)	10 person	2,020.90	20,209	Estimated
RT Train Ticket	10 person	39.90	399	Estimated
Visa	10 person	203.00	2,210	Estimated
Uniform	10 person	14.00	140,00	Actual
Sim Card	1 unit	70.00	70.00	Actual
Hotel	Two rooms for five nights	2,638.29	2,638.29	Estimated
Car Rental	One cars for six days	1,472.65	1,472.65	Estimated
Total Other Costs ($)			**27,438.94**	

Income

Sources of Income	Total ($)
PENS College	2,000
Sponsors	26,500
Total Income ($)	**28,500**

CanSat Budget – Other Costs (2/2)

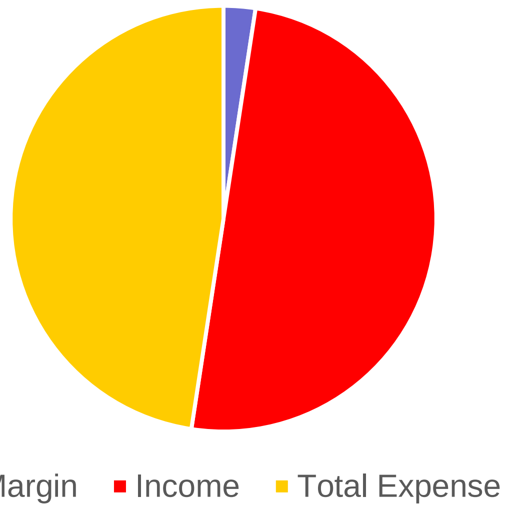
- **Overall Cost**

PDR Phase	
Categories	Cost ($)
Total Hardware	633.03
Total Other Cost	15,401.01
Total Expense	**16,034.04**

CDR Phase	
Categories	Cost ($)
Total Hardware	609.63
Total Other Cost	**27,438.94**
Total Expense	**28,048.57**

Overall Margin

Income – Total Expense = Margin
$ 28,500 - $ 28,048.57 = **$ 61.06**



Program Schedule Overview

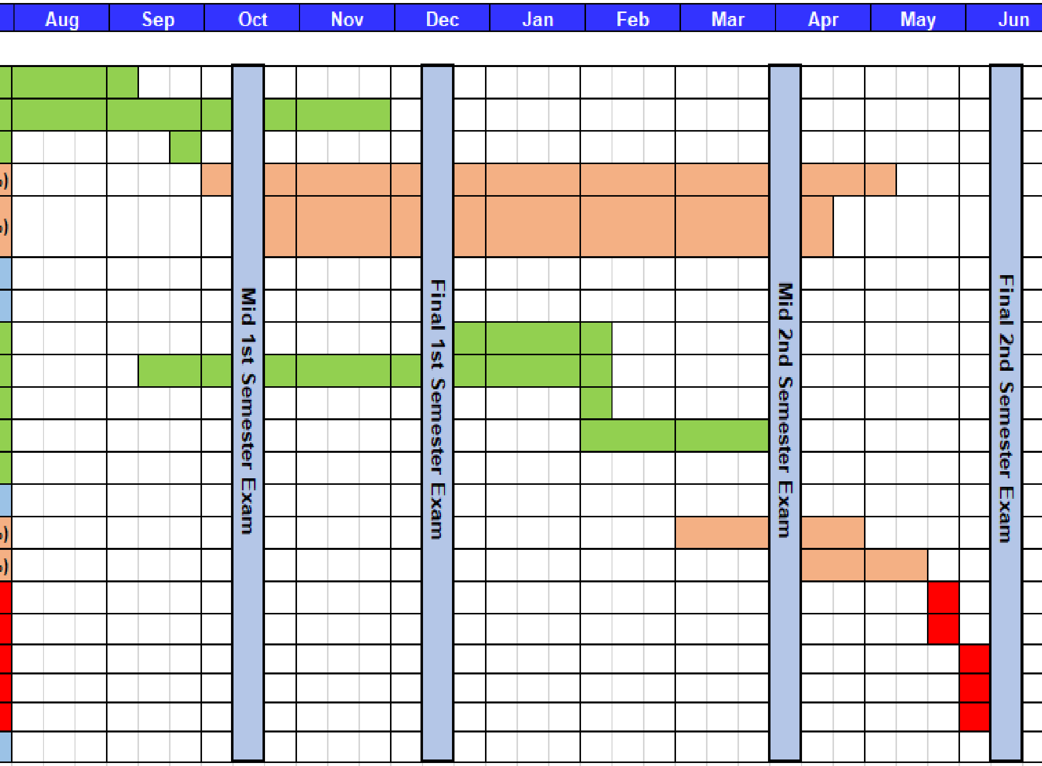
CANSAT PROJECT SCHEDULE

Cansat2022 :
Team #1010 Bamantara EEPISat

Project Start Date : 30-Aug-21
Project Leader : Zulfikar Davbi

PM=Project Manager **MC** = Mechanics **HW** = Hardware
SW = Software **AD** = Administration **BT** = Brand

Task	Assign	Start	End	Days	Status
Summary					
Team Member Recruitment	ALL	30-Aug-21	15-Sep-21	16	100%
Registration	PM	30-Aug-21	28-Nov-21	90	100%
Internal Funding	AD	23-Sep-21	28-Sep-21	5	100%
Sponsorship	AD,BT	09-Oct-21	13-May-22	216	Ongoing (85%)
Procurement of Components & Materials	HW, MC,SW	20-Oct-21	30-Mar-22	161	Ongoing (80%)
Mid 1st Semester Exam	ALL	11-Oct-21	15-Oct-21	4	Exam
Final 1st Semester Exam	ALL	13-Dec-21	17-Dec-21	4	Exam
Team Member Vacation	ALL	24-Dec-21	13-Feb-22	51	100%
PDR Preparation	ALL	19-Sep-21	01-Feb-22	135	100%
PDR Submission	PM	01-Feb-22	01-Feb-22	1	100%
CDR Preparation	ALL	01-Feb-22	01-Apr-22	59	100%
CDR Submission	PM	01-Apr-22	01-Apr-22	1	100%
Mid 2nd Semester Exam	ALL	04-Apr-22	08-Apr-22	4	Exam
System Integration	ALL	01-Mar-22	26-May-22	86	Ongoing (70%)
System Improvement	ALL	04-Apr-22	26-May-22	52	Ongoing (50%)
Enviromental Test Submission	ALL	27-May-22	27-May-22	1	Upcoming
CanSat Shipping	ALL	30-May-22	30-May-22	1	Upcoming
FRR	ALL	10-Jun-22	10-Jun-22	1	Upcoming
Competition	ALL	09-Jun-22	12-Jun-22	3	Upcoming
PFR	PM	12-Jun-22	12-Jun-22	1	Upcoming
Final 2nd Semester Exam	ALL	13-Jun-22	17-Jun-22	4	Exam



= Completed
= Ongoing
= Exam
= Upcoming

Detailed Program Schedule (1/3)

Task	Assign	Start	End	Days	Status	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Mechanical																
Mission Guide Study	MC	02-Sep-21	13-Sep-21	11	100%											
Cansat 1st Design	MC	14-Aug-21	28-Nov-21	106	100%											
Cansat 2nd Design	MC	26-Oct-21	03-Jan-22	69	100%											
Material Trade	MC	13-Sep-21	03-Oct-21	20	100%											
Procurement of Materials	MC	20-Oct-21	30-Mar-22	161	Ongoing (80%)											
Mass Budget Calculate	MC	01-Jan-22	04-Jan-22	3	100%											
Prototype Manufacturing	MC	03-Sep-21	30-Sep-21	27	100%											
Prototype Testing	MC	07-Oct-21	08-Nov-21	32	100%											
System Integrating	MC	01-Mar-22	26-May-22	86	Ongoing (70%)											
System Testing	MC	15-Apr-22	27-Apr-22	12	Ongoing (50%)											
System Improvement	MC	04-Apr-22	26-May-22	52	Ongoing (50%)											

Mid 1st Semester Exam

Final 1st Semester Exam

Mid 2nd Semester Exam

Final 2nd Semester Exam

= Completed
= Exam
= Mechanical
= Ongoing
= Upcoming

Detailed Program Schedule (2/3)

Task	Assign	Start	End	Days	Status	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Hardware																
Mission Guide Study	HW	02-Aug-21	13-Aug-21	11	100%											
Component Trade	HW	14-Aug-21	16-Sep-21	33	100%											
Component Testing	HW	16-Sep-21	08-Oct-21	22	100%											
Flight Algorithm	HW	08-Oct-21	17-Nov-21	40	100%											
Procurement of Components	MC	20-Oct-21	30-Mar-22	161	Ongoing (80%)											
Container PCB Design	HW	27-Oct-21	04-Dec-21	38	100%											
Payload PCB Design	HW	27-Oct-21	04-Dec-21	38	100%											
XBEE Communication Test	HW	11-Nov-21	03-Dec-21	22	100%											
Electrical Prototype Test	HW	22-Dec-21	27-Jan-22	36	100%											
System Integrating	HW	01-Mar-22	26-May-22	86	Ongoing (70%)											
System Testing	HW	15-Apr-22	27-Apr-22	12	Ongoing (50%)											
System Improvement	HW	04-Apr-22	26-May-22	52	Ongoing (50%)											
Camera Tracking Test	HW	01-Apr-22	30-Apr-22	29	Ongoing (80%)											

Mid 1st Semester Exam

Final 1st Semester Exam

Mid 2nd Semester Exam

Final 2nd Semester Exam

= Completed

= Exam

= Hardware

= Ongoing

= Upcoming

Detailed Program Schedule (3/3)

Task	Assign	Start	End	Days	Status	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Software																
Mission Guide Study	SW	02-Aug-21	13-Aug-21	11	100%			Mid 1st Semester Exam		Final 1st Semester Exam				Mid 2nd Semester Exam		Final 2nd Semester Exam
GCS Design	SW	14-Aug-21	16-Nov-21	94	100%											
Antenna Trade	SW	07-Sep-21	17-Sep-21	10	100%											
Improve Antenna Design	SW	12-Nov-21	03-Jan-22	52	100%											
MQTT Development	SW	12-Feb-21	20-Feb-21	13	100%											
Antenna Manufacturing	SW	10-Mar-22	20-Mar-22	10	100%											
Antenna Range Test	SW	01-Apr-22	30-Apr-22	29	Ongoing (70%)											
System Integrating	SW	30-Mar-22	10-Apr-22	11	Ongoing (90%)											
System Testing	SW	15-Apr-22	27-Apr-22	12	Ongoing (50%)											
System Improvement	SW	04-Apr-22	26-May-22	52	Ongoing (50%)											

= Completed
= Exam
= Software
= Ongoing
= Upcoming

Shipping and Transportation

Transportation	
Person	Surabaya – Jakarta: Indonesian Overnight Train Jakarta – Charlotte: **United Airlines** Charlotte – Blacksburgh: Rental Car
Shipping	
Cansat and Tools	Surabaya – Charlotte: **Cargo (FedEx)** Shipping Address 1: Committee Office Shipping Address 2: Indonesian Embassy in Washington, DC

Notes:

- Restricted items such as batteries will be shipped since the United Airlines prohibit those items.
- In order to minimize trouble for transporting the tools and CanSat, we will send one set of the CanSat and tools using cargo service and another set carried along with us aboard without batteries.

Conclusions (1/2)

Division	Major Accomplishments	Major Unfinished work	Testing To Complete
Hardware	1. All sensors has been tested. 2. XBEE Communication test completed. 3. Flight Software test completed and currently being tested into full system.	1. Integration with software.	1. Payload camera orientation test.
Mechanical	1. Container is finished and is being used to fit the actual payload. 2. Tether mechanism test completed. 3. Several environmental test has been completed.	1. Design improvement of CanSat based on testing results and evaluation. 2. Overall system integration.	1. Enviromental test.
Software	1. GUI Design completed. 2. MQTT Development test completed. 3. Antenna has been built and tested.	1. Integration with hardware	-
Administration	1. Sponsorship and partnership contracted. 2. Travel and shipment plans have been established.	1. Waiting for other sponsors.	-
Brand Team	1. Official social media still active. 2. Social media expansion to LinkedIn and Facebook.	1. Developing the social media and website promotion.	-

Conclusions (2/2)

Bamantara EEPISAT Are Ready to Proceed to The Next Stage of Development

1. Critical Design Phase is completed for mechanical, software, electronic systems.
2. Major mechanisms has been tested and there will be further improvements to assure it runs without a problem.
3. Travel and shipment plans have been established for competition day in Virginia Tech, Blacksburg, VA.