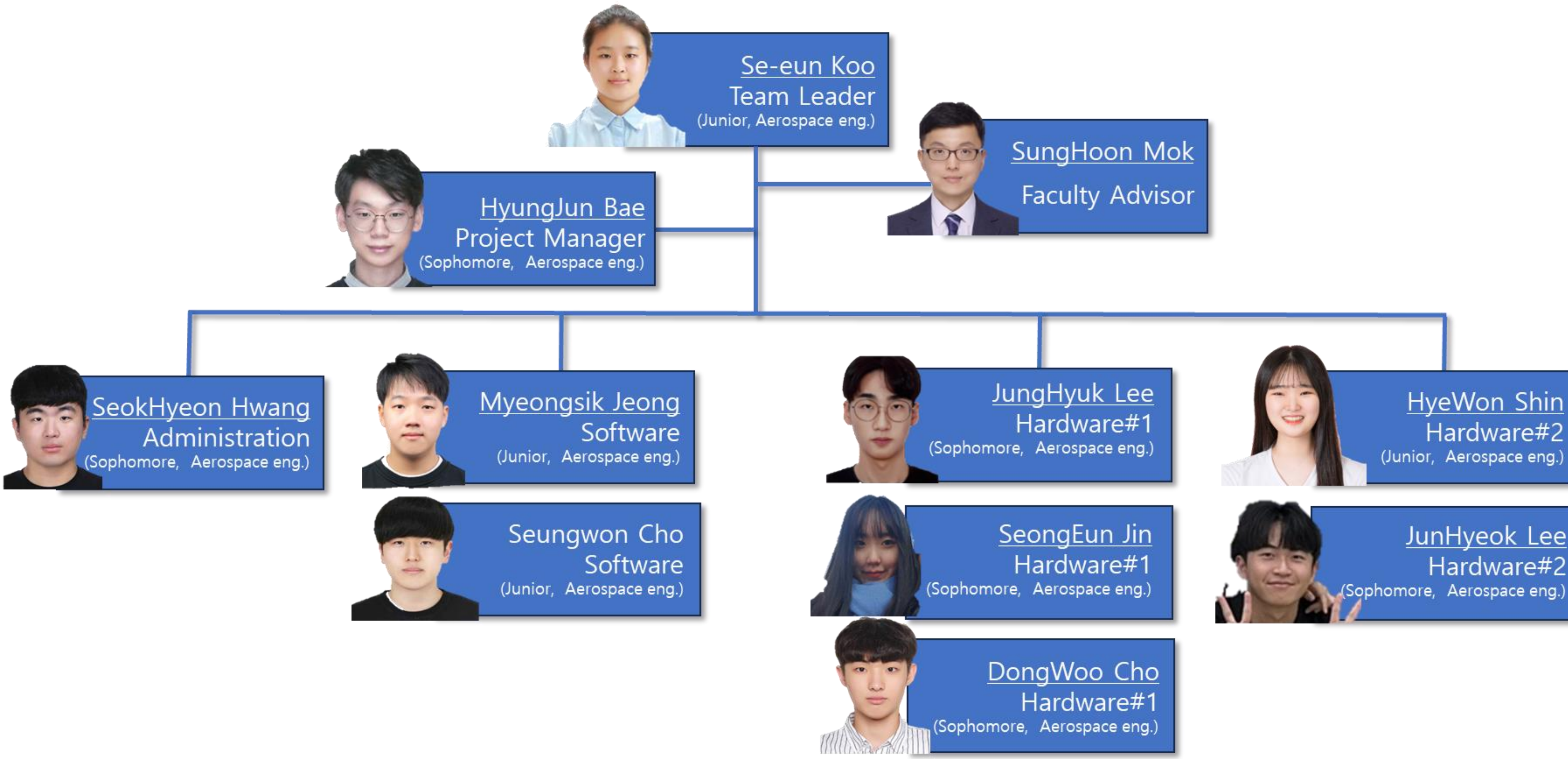
CanSat 2024
Critical Design Review (CDR)
Outline
Version 3.0

Team #2036

Inharo

Presentation Outline

Team Organization



Acronyms (1/2)

Acronyms	Definition
3D	Three Dimensional
AC	Alternating Current
ADC	Analog-to-Digital Converter
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
BCN	Beacon
BMS	Battery Management System
CAL	Calibration
CDH	Communication Data Handling
CDR	Critical Design Review
CMD	Command
CONOPS	Concept of Operations
COTS	Commercial off the shelf
CSV	Comma Separated Values
CX	Communication
dB	Decibel
dBi	Decibel Isotropic
dBm	Decibel Milliwatts

Acronyms	Definition
DC	Direct Current
DEP	Deployment
DOF	Degree of Freedom
EMI	Electromagnetic Interference
EMS	Electromagnetic Susceptibility
EOL	End of Line
EPS	Electrical Power Subsystem
ESTA	Electronic System for Travel Authorization
FSPL	Free Space Path Loss
FSW	Flight Software
GCS	Ground Control Station
GND	Ground
GPIO	General-Purpose Input/Output
GPS	Global Positioning System
HS	Heat shield
I/O	Input/Output
I2C	Inter-Integrated Circuit
ID	Identity

Acronyms (2/2)

Acronyms	Definition
IDE	Integrated Development Environment
IMU	Inertial Measurement Unit
MCU	Microcontroller Unit
MIL-STD	Military Standards
NETID	Network Identity
PANID	Personal Area Network Identifier
PC	Parachute
PCB	Printed Circuit Board
PCM	Protection Circuit Module
PDR	Preliminary Design Review
PFR	Post Flight Review
PLA	Polylactic Acid
PVC	Polyvinyl chloride
RAM	Random Access Memory
REL	Release
RP-SMA	Reverse Polarity SMA
RTC	Real Time Clock

Acronyms	Definition
SD	Secure Digital
SDIO	Secure Digital Input/Ouput Interface
SIM	Simulation
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver-Transmitter
USART	Universal Synchronous and Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
UTC	Coordinated Universal Time
ZB	ZigBee
Acronyms	**Verification Methods**
A	Analysis
I	Inspection
T	Test
D	Demonstration

System Overview

Presented by Se-eun Koo

Mission Summary

Main object	
Designing the CanSat with the heat shield and parachute to keep the egg safe.	
1	The CanSat reaches 725 m with rocket.
2	The CanSat decelerates to 10~30 m/s by deploying the aero-braking heat shield.
3	The CanSat releases aero-braking heat shield at 100 m.
4	The CanSat decelerates to less than 5 m/s with a parachute.
5	The released heat shield descends at a speed ranging from 10 to 30 m/s.
6	The CanSat will be safely recovered with the egg and recorded data.

Bonus object
A spy camera built into the CanSat collects the videos, capturing the moments when the CanSat is deployed from the rocket and the release of the parachute.

Summary of Changes Since PDR (1/2)

Section	Part	PDR	CDR	Rationale
Mechanical	Descent Control	Small Parachute of Nose cone	Deleted	• After calculating the descent speed, it is considered unnecessary.
	Descent Control	Rotation Control by shape of parachute unit	New Rotation Control System using rear stabilizers	• The new version is more effective at controlling rotation.
	Mechanical Subsystem	Parachute unit using lid & servo motor with torsion spring	Parachute unit using rubber band & servo motor & eye bolt	• The new version is easier to deploy
	Mechanical Subsystem	Capsule Egg Container	New Cylindrical Egg Container	• The new version is easier to put the egg in and out. • Much buffer is available.
	Mechanical Subsystem	Heat shield deployment by unlocking rachet gear	Passive deployment when releasing from rocket frame	• A simpler deployment method. • No risk of malfunction.

Summary of Changes Since PDR (2/2)

Section	Part	PDR	CDR	Rational
Electrical	Sensor subsystem	SDP31	MPXV7200DP	• The speed sensor purchased does not fit the size of the pitotube
	Sensor subsystem	Adafruit's mini spy camera	Quelima SQ11	• Mini spy camera was not available for purchase
Software	Flight software	GPS is read in the sensor reading cycle	GPS communication cycle	• For the purpose of implementing NMEA message reception

System Requirement Summary (1/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
1	The CanSat shall function as a nose cone during the rocket ascent portion of the flight.	Mechanical		√		√
2	After deployment from the rocket, the CanSat shall deploy its heat shield/aerobraking mechanism.	Mechanical			√	√
3	At 100 meters, the CanSat shall deploy a parachute and release the heat shield.	Mechanical			√	√
4	Upon landing, the CanSat shall stop transmitting data.	Software		√		√
5	Upon landing, the CanSat shall activate an audio beacon.	Software		√		√
6	The CanSat shall carry a provided large hens egg with a mass range of 51 to 65 grams	Mechanical		√		
7	0 altitude reference shall be at the launch pad.	Mechanical			√	
8	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	Mechanical	√		√	√
9	At 100 meters, the CanSat shall have a descent rate of less than 5 m/s.	Mechanical	√		√	√

System Requirement Summary (2/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
10	The CanSat mass shall be 900 grams +/- 10 grams without the egg being installed.	Mechanical			√	
11	Nose cone radius shall be exactly 71 mm	Mechanical	√	√		
12	Nose cone shoulder radius shall be exactly 68 mm	Mechanical	√	√		
13	Nose cone shoulder length shall be a minimum of 50 mm	Mechanical	√	√		
14	CanSat structure must survive 15 Gs vibration	Mechanical			√	√
15	CanSat shall survive 30 Gs shock.	Mechanical			√	√
16	The CanSat shall perform the function of the nose cone during rocket ascent.	Mechanical		√		
17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Mechanical Electronics		√		
18	The CanSat shall deploy a heat shield after deploying from the rocket	Mechanical		√		

System Requirement Summary (3/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
19	The CanSat shall protect a hens egg from damage during all portions of the flight.	Mechanical			√	√
20	If the nose cone is to be considered as part of the heat shield, the documentation shall identify the configuration.	Mechanical		√		
21	After the CanSat has separated from the rocket and if the nose cone portion of the CanSat is to be separated from the rest of the CanSat, the nose cone portion shall descend at less than 10 meters/second using any type of descent control device.	Mechanical			√	√
22	Easily accessible power switch is required	Electronics		√		√
23	Power indicator is required	Electronics		√	√	
24	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Electronics	√		√	√

System Requirement Summary (4/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
25	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Software	√	√		√
26	XBEE radios shall have their NETID/PANID set to their team number.	Software	√			√
27	XBEE radios shall not use broadcast mode.	Software	√			√
28	The probe shall transmit telemetry once per second.	Software	√			√
29	The probe telemetry shall include altitude, air pressure, temperature, battery voltage, CanSat tilt angles, air speed, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Software	√			√
30	CanSat shall measure its speed with a pitot tube during ascent and descent.	Software	√			√
31	The probe shall include a video camera pointing horizontally.	Software	√	√		
32	The video camera shall record the flight of the CanSat from launch to landing.	Software	√			√

System Requirement Summary (5/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
33	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	GCS		√		
34	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	GCS	√		√	
35	Telemetry shall include mission time with 1 second or better resolution.	GCS	√		√	√
36	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	GCS	√		√	√
37	Each team shall develop their own ground station.	GCS	√			√
38	All telemetry shall be displayed in real time during descent on the ground station.	GCS	√		√	
39	Teams shall plot each telemetry data field in real time during flight.	GCS	√		√	

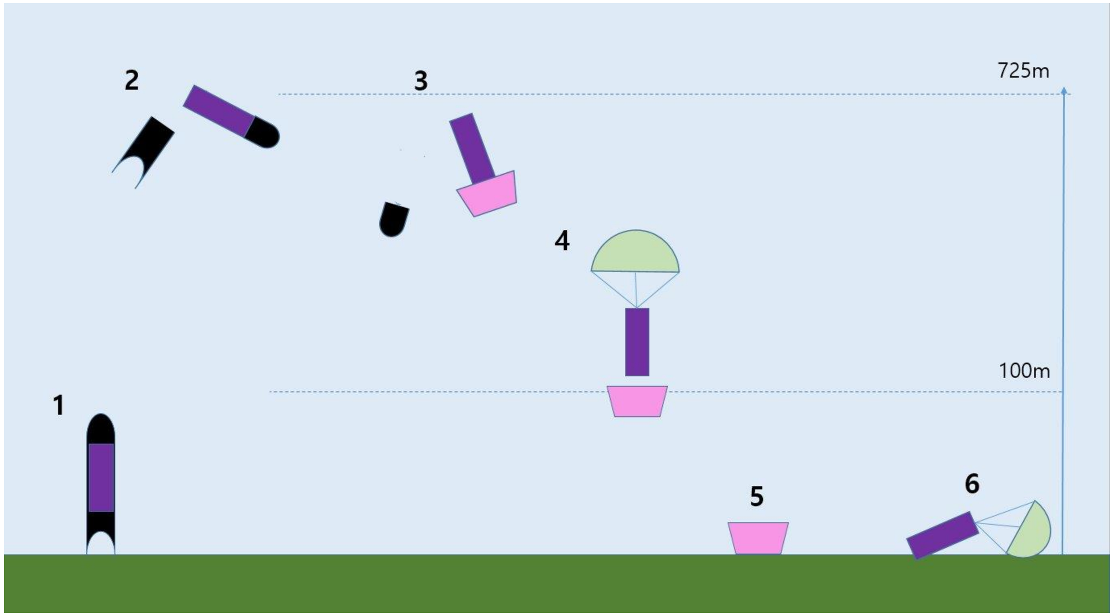
System Requirement Summary (6/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
40	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Software GCS	√	√	√	
41	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.	GCS	√	√		
42	The ground station shall use a table top or handheld antenna.	GCS		√		
43	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	GCS	√	√	√	
44	The CanSat shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	Software		√	√	√

System Requirement Summary (7/7)

Req	Description	Subsystem	Verification			
			A	I	T	D
45	The CanSat shall have its time set to within one second UTC time prior to launch.	Software	✓	✓	✓	
46	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	Software		✓		
47	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Software	✓	✓		
48	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Software	✓	✓	✓	

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



Step	Description
1	The CanSat is stowed inside the rocket.
2	At 725m, the CanSat is deployed from the rocket.
3	Aero-braking heat shield decelerates the CanSat to a speed of 10m/s ~ 30m/s. The nosecone is separated, descending with a speed of under 10m/s.
4	At 100m, the heat shield is released, and the parachute decelerates the CanSat to under 5m/s.
5	The released heat shield will descend with a speed of under 10m/s.
6	The CanSat lands safely.

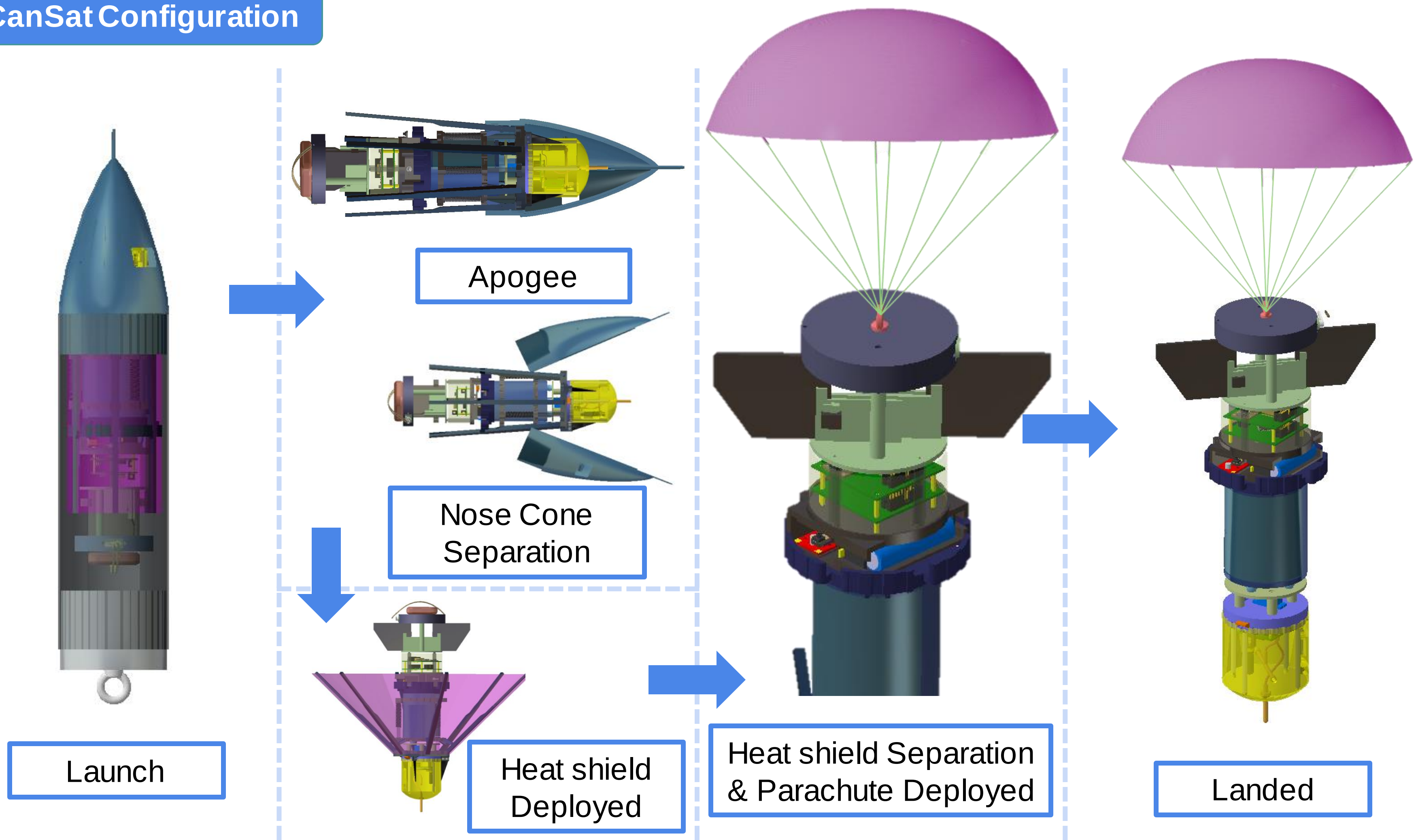
System Concept of Operations (CONOPS)(2/3)

Role	Member	Description
Mission Control Officer	• Se-eun Koo	• Mission Control Officer manage the team and do countdown for launch.
CanSat Team	• SeungWon Cho • JungHyuk Lee • DongWoo Cho • JunHyeok Lee	• Cansat Team prepare to check the Cansat operate well and assemble the CanSat. • CanSat Team intergrate the CanSat into the rocket.
Recovery Team	• HyeWon Shin • SeongEun Jin	• Recovery Team recover the CanSat.
Ground Station Team	• HyungJun Bae • SeokHyeon Hwang • Myeongsik Jeong	• Ground Station Team set up the ground station and construct the antenna. • Groun Station team monitor the CanSat.

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

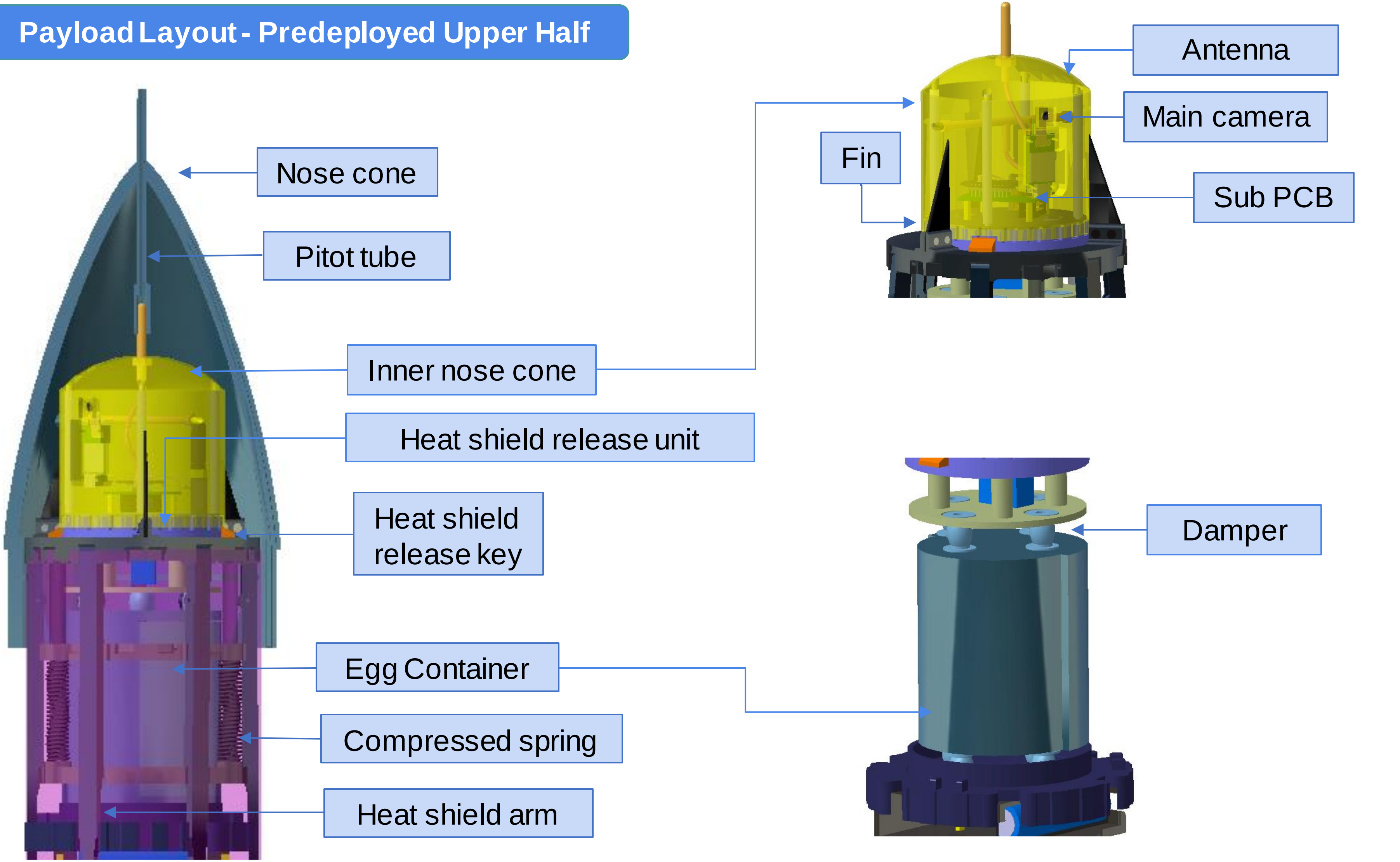
Step	phase	Description	team
1.	Pre - launch	• The CanSat team intergrates the Cansat inside the rocket. • Ground Station team sets up ground station.	Ground Station team CanSat team
2.	Launch	• Mission Control Officer do launch countdown. • The rocket is launched.	Mission Control Officer
3.	Deployment	• At 725m, the CanSat is deployed from the rocket.	Ground Station team
4.	Nosecone separation	• Aero-braking heat shield decelerates the CanSat to a speed of 10m/s ~ 30m/s. • The nosecone is separated, descending with a speed of under 10m/s.	Ground Station team
5.	Heat shield separation	• At 100m, the heat shield is released, and the parachute decelerates the CanSat to under 5m/s.	Ground Station team
6.	Heat shield descent	• The released heat shield will descend with a speed of under 10m/s.	Ground Station team
7.	Post – launch recovery	• The CanSat lands safely. • The CanSat recovered by recovery team.	Recovery team
8.	Data reduction	• The Ground station team receive and verify telemetry data and analysis it. • The Ground station team deliver the ground station data to the ground station judge by thumb drive.	Ground Station team

CanSat Configuration

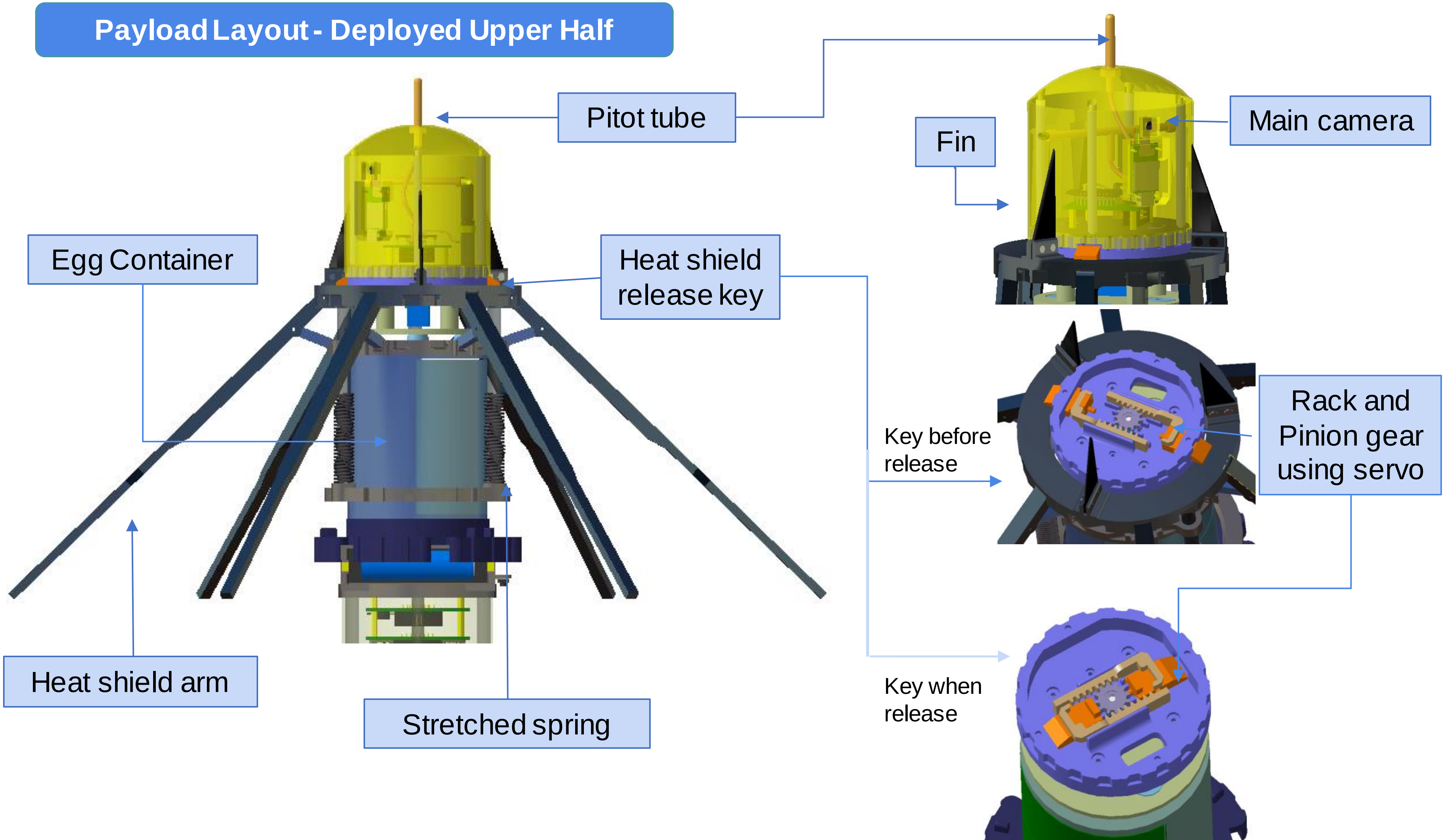


CanSat Physical Layout (2/6)

Payload Layout - Predeployed Upper Half

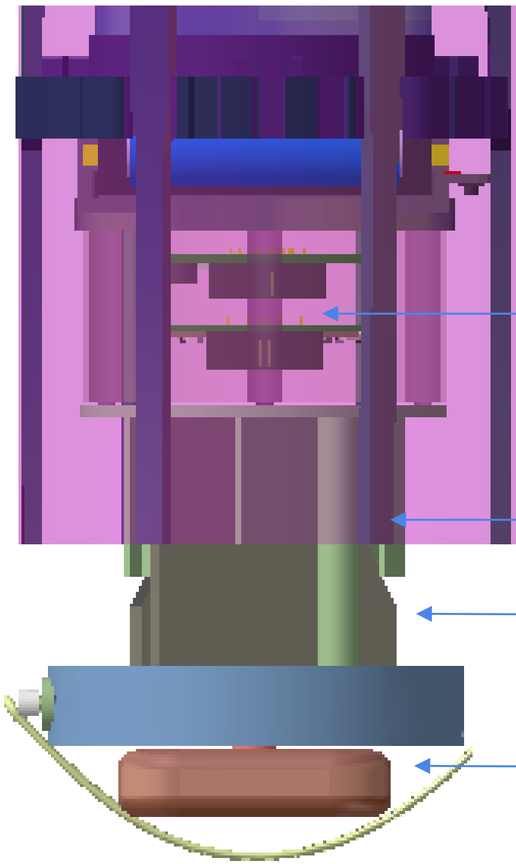


Payload Layout - Deployed Upper Half



CanSat Physical Layout (4/6)

Payload Layout - Lower Half



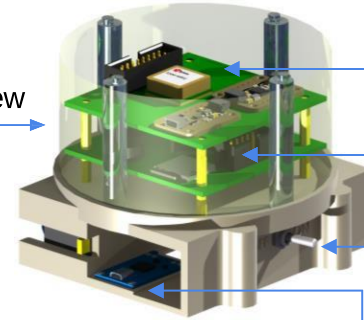
Main PCB

Heat shield arm

Rotation Control Unit

Parachute unit

Front View



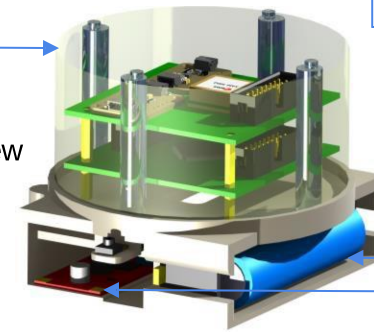
Sensors

Microprocessor

Power switch

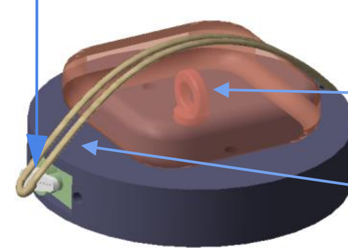
Umbilical Cable Port

Rear View



3.7V Battery

Regulator



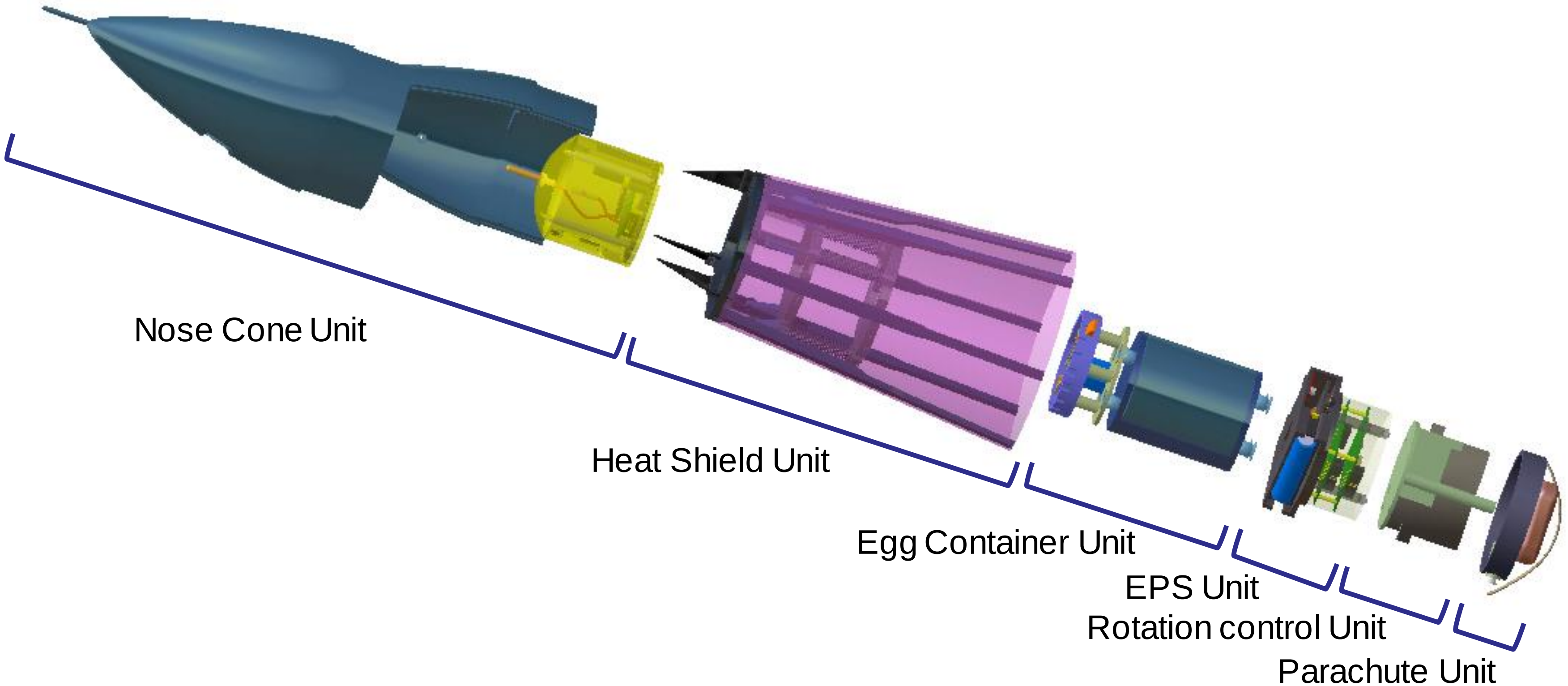
Servo

Eye bolt

Elastic band

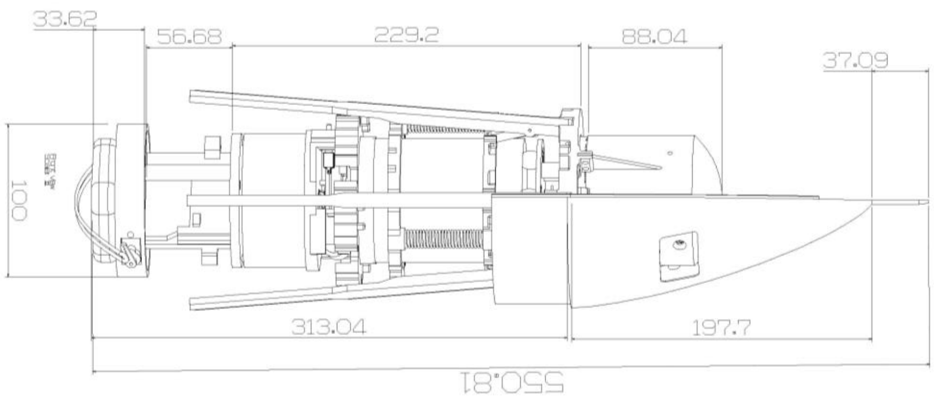
CanSat Physical Layout (5/6)

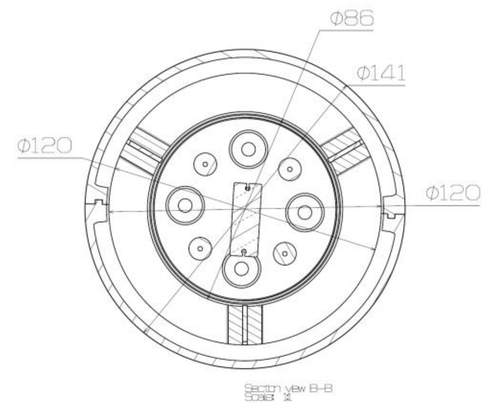
Exploded View

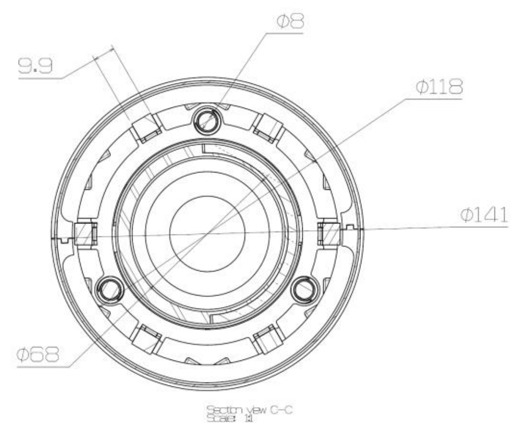


CanSat Physical Layout (6/6)

CAD Model and Dimension Drawings





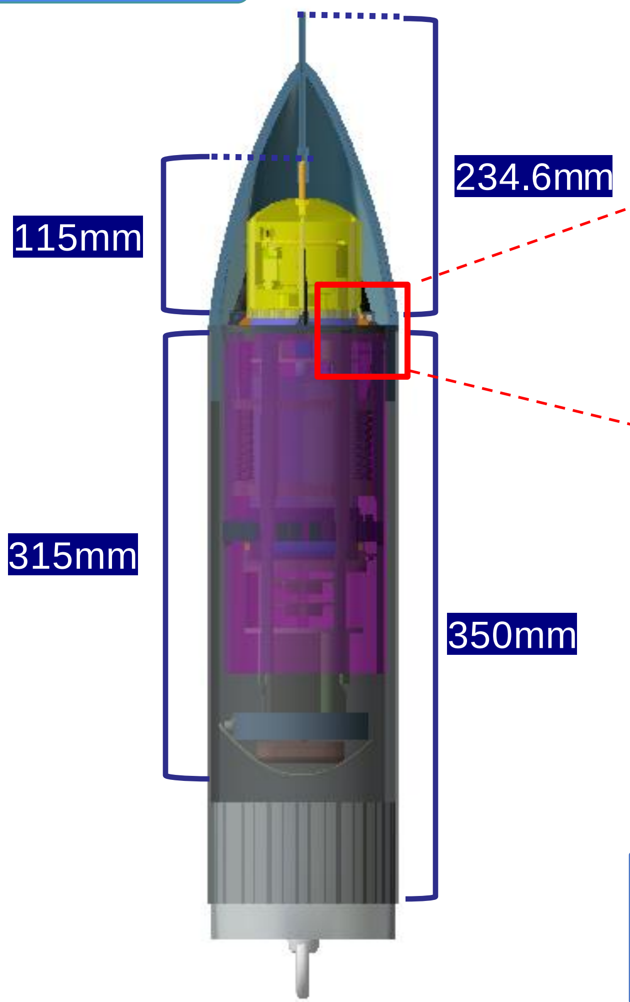


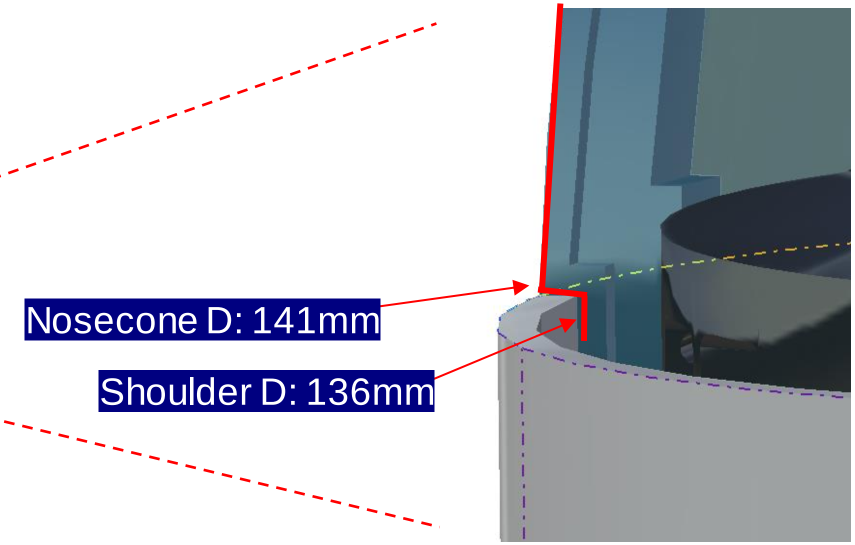
Information

- Top left : Dimensions for the overall payload
- Top right : Radial Dimensions for the Heat Shield
- Bottom right : Radial Dimensions for the Egg Container
- All dimensions in the drawing meet mission specifications.
- All measurement units are in mm

Launch Vehicle Compatibility

Dimensions





	Vehicle	CanSat	Nosecone	Shoulder	Payload Margin
Height	350 mm	315 mm	234.6mm	50mm	**43 mm**
Diameter	136 mm	120 mm	141mm	136mm	**16 mm**

The CanSat has no sharp edges or protrusions and is symmetrical in shape.

Sensor Subsystem Design

Presented by Seungwon Cho

Sensor Subsystem Overview

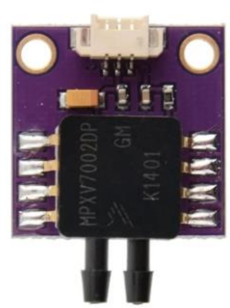
Required	Sensor	Purpose
Air Pressure	BMP390	• Measure pressure data to determine altitude during flight
Air Temperature	BMP390	• Measure temperature data
Battery Voltage	On-board ~~sensor~~ ADC	• Measure the battery voltage
Speed	MPXV7200DP	• Measure differential pressure data to determine the payload speed during flight
Orientation	BNO055	• Measure the absolute orientation, payload acceleration and angular velocity to determine the attitude of the payload
GPS	SAM-M8Q	• Get the location of CanSat
Camera	Quelima SQ11	• Record the video during missions

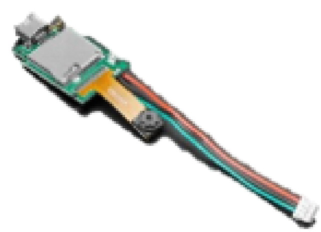
Sensor Changes Since PDR

Required	PDR Sensor	CDR Sensor	Rationale
Speed	SDP 31	MPXV7002DP	Since the SDP31 speed sensor we purchased does not fit the size of the pitotube, we bought a sensor that fits exactly the pitotube.
Camera	Adafruit's Mini spy camera	Quelima SQ11	We could not purchase Adafruit's Mini spy camera because it was out of stock

Speed sensor change

Camera change





Payload Air Pressure Sensor Summary

Model	Interface	Accuracy (Pa)/(m)	Range (hPa)	Voltage (V)	Current (μA)	Size (mm)	Weight (g)	Cost ($)
BMP390	I2C/SPI	± 3 / ± 0.25	300 - 1250	3.3	3.2	30 x 20 x 5	3	14.2

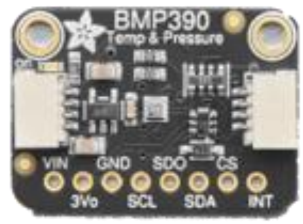
Equation	$altitude = 44330 \times \left(1 - \left(\frac{p}{p_0}\right)^{\frac{1}{5.255}}\right)$ p = *Current measured barometric pressure* p_0 = *Barometric pressure measured at sea level* Altitude will be calculated using the above equation
Sample output	10149960 10149631 10149412 10149638 10149631 The sample output is pressure (Pa) * 100
Data format	**(Altitude, m)**

Rationale
• ± 0.25 meters accuracy • Built in temperature sensor • Small mass

Payload Air Temperature Sensor Summary

Model	Interface	Accuracy (°C)	Range (°C)	Voltage (V)	Current (µA)	Size (mm)	Weight (g)	Cost ($)
BMP390	I2C/SPI	± 1.5	-40 - +85	3.3	3.2	30 x 20 x 5	3	14.2

Equation	$Temperature = RAW\ data\ read\ from\ register \times 0.01$ $(\ There\ is\ np\ exact\ detailed\ formula)$
Sample output	2391 2434 2618 2664 The sample output is temperature(°C)*100
Data format	**(Temperature, °C)**



Rationale
• ± 0.5 accuracy • Integrated with pressure sensor • Easy to coding

Payload GPS Sensor Summary

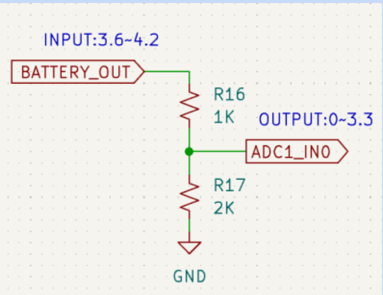
Model	Interface	Accuracy (m)	Range	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
SAM-M8Q	UART DDC	2.5 (Horizontal)	-	3.3	67 (max)	42x 42 x 9	40	52.8

Equation	The sensor automatically calculates it
Sample output	\$GPGSV,4,3,15,19,11,162,,20,68,330,29,25,04,272,37,29,20,318,31* \$GPGSV,4,4,15,30,14,119,,40,06,259,45,41,27,238,* \$GPGSV,4,3,15,19,11,162,,20,68,332,30,25,04,272,,29,20,318,27* \$GPGSV,4,2,15,11,73,056,20,12,06,244,48,13,29,189,10,15,05,214,31* The sample output is NMEA message.
Data format	**(Latitude , °) , (Longitude , °) , (Altitude , m)**

Rationale
• Internal antenna • Libraries readily available • High accuracy

Payload Voltage Sensor Summary

Model	Interface	Accuracy (LSB)	Range (V)	Voltage	Current	Size	Weight	Cost
Internal ADC	Analog	± 2	0 – 3.3	Embedded				

Equation	$$\{\mathrm{ADC_{IN}}\} = \frac{\mathrm{R}_{17}}{R_{16} + \mathrm{R}_{17}} \times \{BATTERY_{OUT}\}$$
Sample output	3055 3117 3113 3124 3123 The sample output is ADC value
Data format / Diagram	**(Raw data)** 

Rationale

- No additional cost
- Already in the system
- Only two register required

Speed Sensor Summary

Model	Interface	Accuracy (%)	Range (kPa)	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
MPXV 7002DP	Analog	± 2.5	± 2	5.0	10 (max)	28 x 22 x 12	2.8	54.2

Equation

$$V_{out} = V_s(P \times 0.009 \times 0.04)$$
$$\pm\left(PressureError \times Temp.Mult. \times 0.009 \times V_s\right)$$
$$V_s = 5.0V \pm 0.25V$$
$$Speed\ Value = Internal\ calculation\ process\left(using\ V_{out}\right)$$

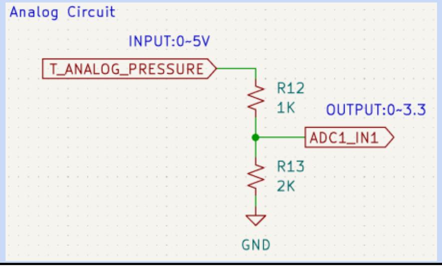
Sample output

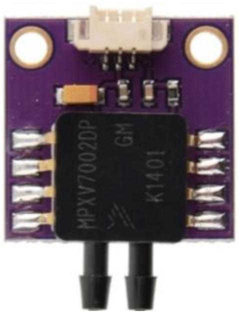
2069
2069
2067
2069

The sample output is ADC value

Data format / Diagram

(Velocity , m/s)





Rationale

- ± 2.5 accuracy
- Wide measurement range
- Easy to coding

Payload Tilt Sensor Summary

Model	Interface	Sensitivity (LSB/mg)	Range (g)	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
BNO055	I2C UART	1	±2 - ±16	3.3	12.3 (max)	20 x 27 x 4	3	46

Equation	$(\text{tilt angle x}) = \dfrac{a_x}{\sqrt{(a_x^2 + a_y^2 + a_z^2)}}$ $(\text{tilt angle y}) = \dfrac{a_y}{\sqrt{(a_x^2 + a_y^2 + a_z^2)}}$
Sample output	see table below
Data format	**(x , m/s^2) , (y , m/s^2) , (z , m/s^2)**

0.08	1	9.77
0.08	0.99	9.72
0.08	1	9.72
0.07	0.99	9.72
0.08	1.01	9.72

Rationale

- Light weight
- High accuracy
- Include gyroscope and magnetometer

Payload Rotation Sensor Summary

Model	Interface	Sensitivity (LSB/°/s)	Range (°/s)	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
BNO055	I2C UART	16	±125 - ±2000	3.3	12.3 (max)	20 x 27 x 4	3	46

Equation	$DPS = \frac{Raw\ value}{sensitivity}$ (sensor automatically calculates it)
Sample output	0.0625 0.125 0 0 -0.125 0.0625 -0.0625 -0.0625 0 0 0.25 0.0625 0.125 -0.0625 0.0625
Data format	**(x , °/s) , (y , °/s) , (z , °/s)** **(Gyroscope , dps)**

Rationale
• Light weight • High accuracy • Include accelerometer and magnetometer

Camera Summary

Model	Interface	Frame rate (fps)	Resolution	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
Quelima SQ11	GPIO SD card	30	1280 x 720	5.0	80	23 x 23 x 23	5.2	4.3

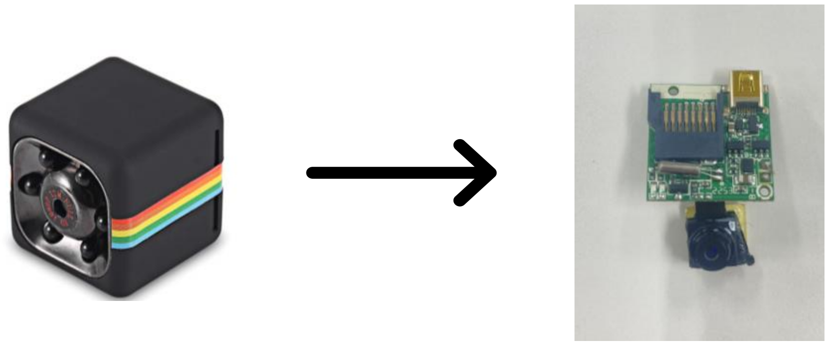
※ The camera will be disassembled for customization before use

Rationale
• Cost efficient • Embedded SD card reader (32GB) • Video resolution and fps fulfills requirements

Bonus Camera Summary

Model	Interface	Frame rate (fps)	Resolution	Voltage (V)	Current (mA)	Size (mm)	Weight (g)	Cost ($)
Quelima SQ11	GPIO SD card	30	1280 x 720	5.0	80	23 x 23 x 23	5.2	4.3

※ The camera will be disassembled for customization before use



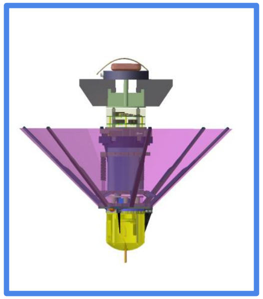
Rationale
• Cost efficient • Embedded SD card reader (32GB) • Video resolution and fps fulfills requirements

Descent Control Design

Presenter JunHyeok Lee

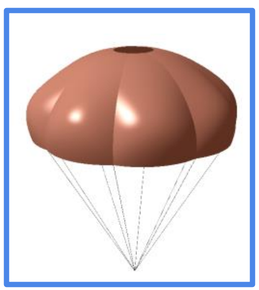
Descent Control Overview

725~100m

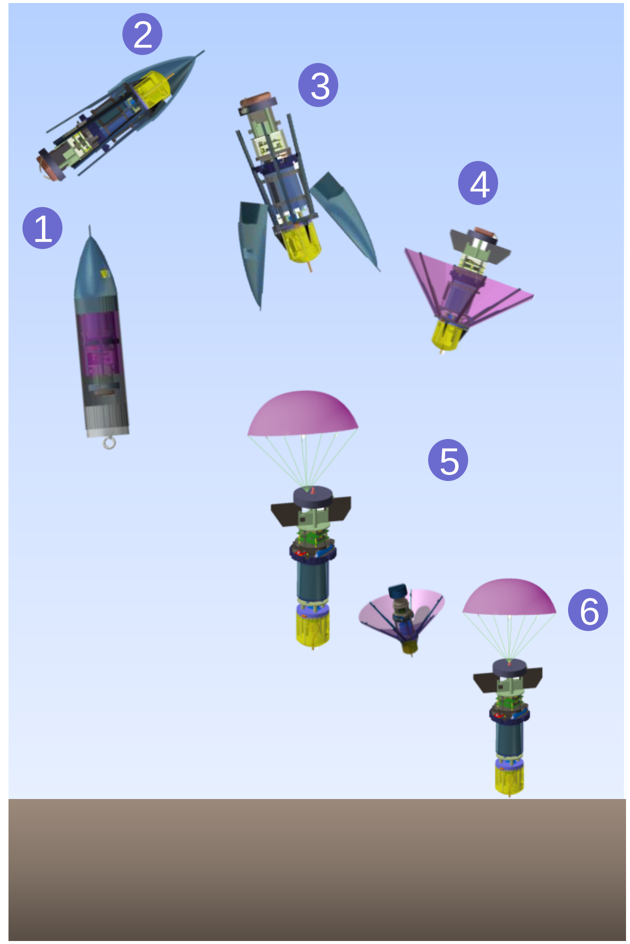


- Heat shield diameter: 43cm
- Using Ripstop Nylon Material
- 3D printed arms using PLA+
- Control the descent rate by increasing air resistance area

100~0m



- Parachute diameter: 85cm
- Using Ripstop Nylon Material
- 8 lines
- One spiral hole (diameter 8.5 cm)

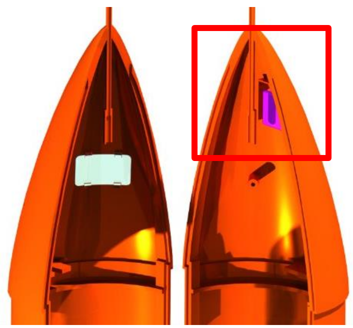
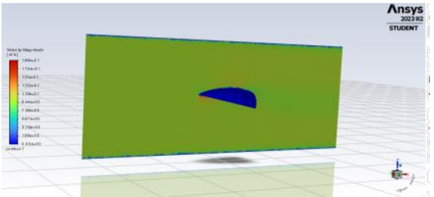
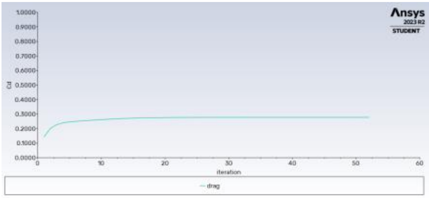


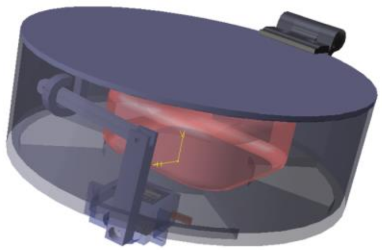
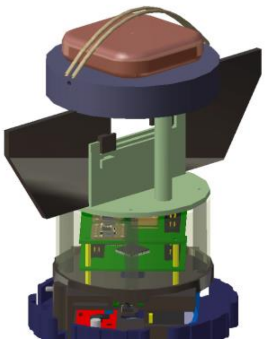
The CanSat is separated from the rocket at an altitude of up to 725 m.

After deployment, unfold the heat shield to adjust the descent speed to between 10 and 30 m/s. (Target speed is 15 m/s $\pm$5 m/s)

At 100m, release the heat shield and deploy the parachute to adjust the speed to less than 5 m/s.

Descent Control Changes Since PDR(1/2)

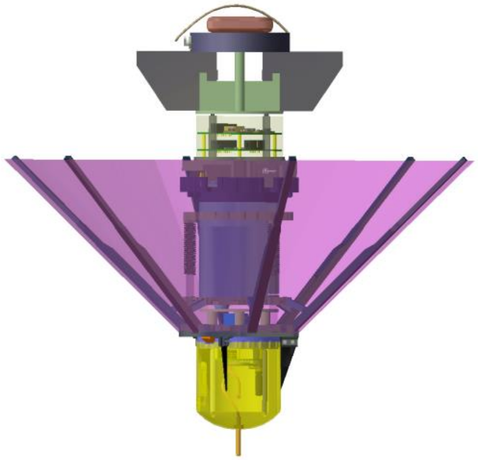
Part	PDR	CDR	Rationale
Small Parachute	 Attaching a small parachute to the outer nose cone.	Deleted	  The PDR said that a small parachute could be attached on the separated outer nose cone if necessary to satisfy the descent speed, but the calculation determined that additional parachutes were not needed because the expected descent speed of the outer nose cone was approximately 7.68m/s.

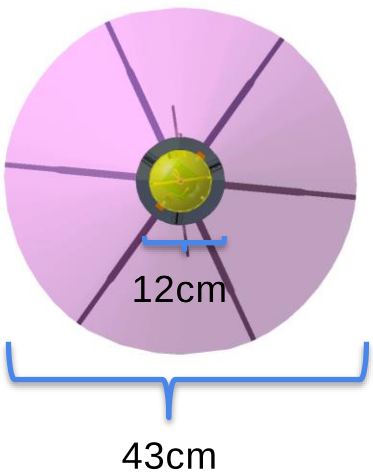
Part	PDR	CDR	Rationale
Payload Rotation Control Strategy After Releasing the heat shield	 4 holes (After heat shield is separated)	 2 rear stabilizers (After heat shield is separated)	The new version is more effective at controlling rotation.

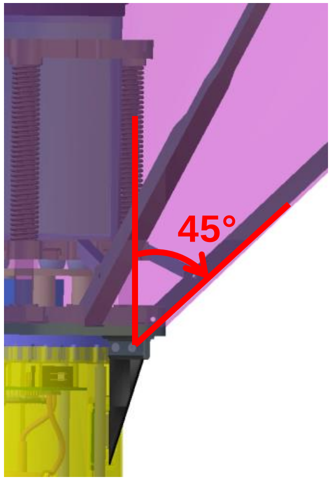
Prototype Testing

- Because we couldn't build all the systems, we couldn't proceed with all the tests of the descent control system. Therefore, we conducted the function test of the parachute with the same weight as the planned CanSat. For this, it was dropped from approximately 20m high from the top of the building, and as a result, we confirmed that the descent rate was successfully decelerated to approximately 3m/s.

Payload Aerobraking Descent Control Hardware Summary(1/2)







Angle of 45 degree

Aerobraking Descent Control Hardware

- **Key design considerations**

→ The overall structure is symmetrical.

→ Heavy parts of the payload were placed underneath to lower the center of mass below the neutral point, ensuring angular stability.

→ Three fins were mounted in front of the heat shield, along with two rear stabilizers positioned in front of the parachute module, to control rotation throughout the flight.

→ Utilize the spring's elasticity to quickly enable the heat shield to perform aerobraking functions.

- **Color selection(s)**

→ Using pink ripstop nylon.

- **Active component**

→ The spring is kept compressed in the rocket fuselage and when the payload is separated, the spring is tensioned and the lower holder is pushed out to open the six heat shield arms.

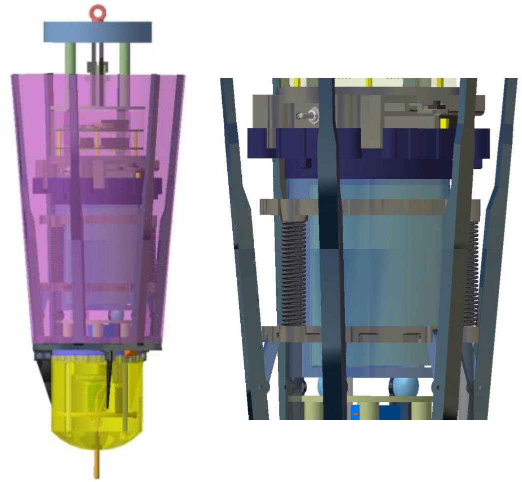
- **Size (diameter)**

→ Wide diameter = 43cm, Narrow diameter = 12cm

→ Angle with probe = 45°

Payload Aerobraking Descent Control Hardware Summary(2/2)

Pre-Deployment

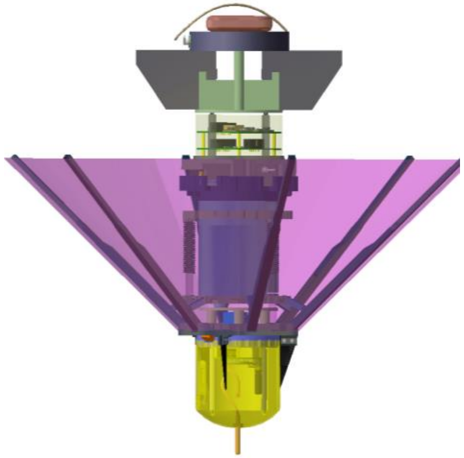


- The heat shield is stowed with the spring compressed and fixed with airframe.

Aerobraking Descent Control

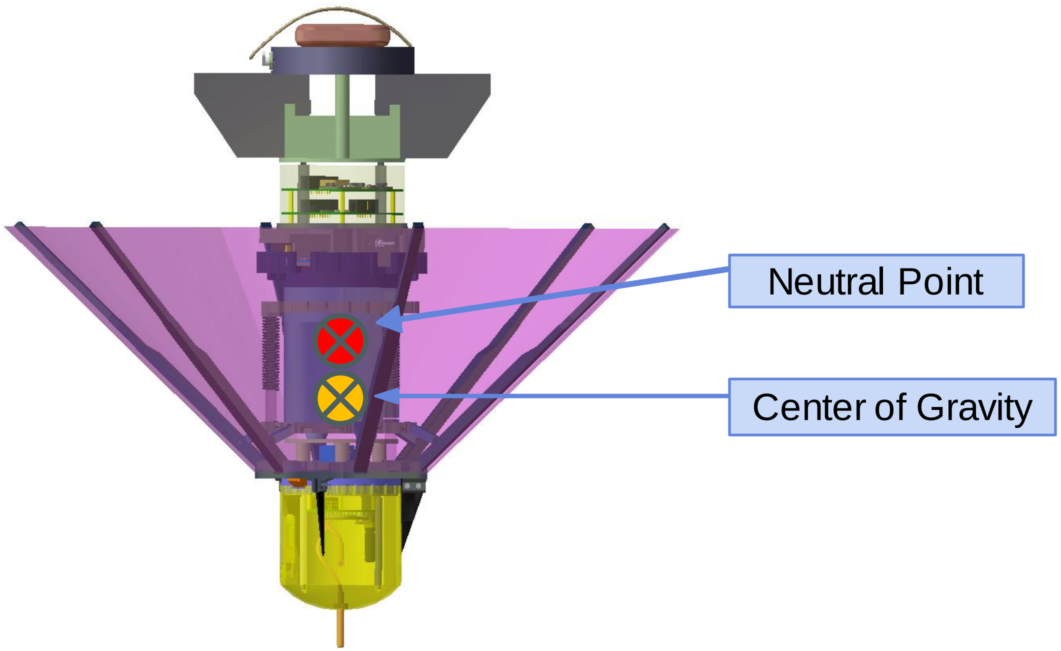
- As soon as the CanSat is separated from the rocket, the compressed spring is tensioned, and six heat shield arms are deployed to open the heat shield.

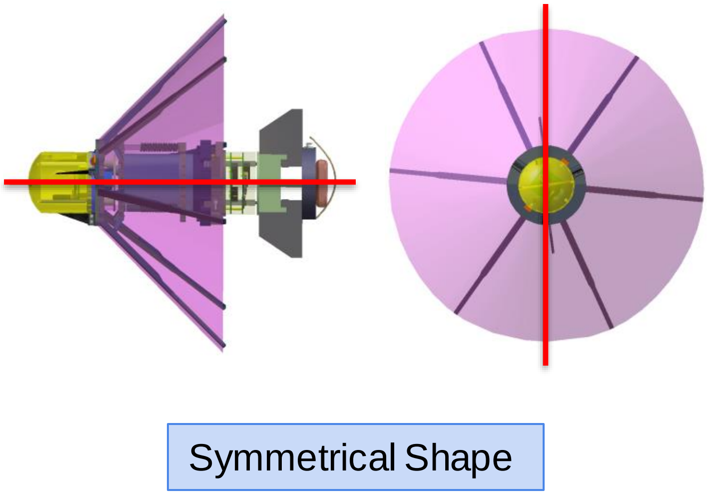
Full Deployment



- The heat shield is deployed at an angle of 45 degrees to decelerate CanSat to about 15 m/s.
- The stability is passively controlled by positioning the center of mass as low as possible.
- The rotation is passively controlled using three fins located in front of the heat shield.

Payload Descent Stability Control Design

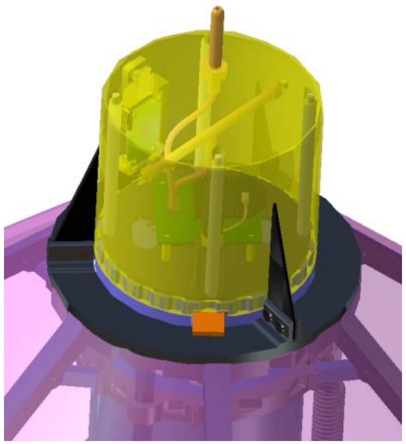




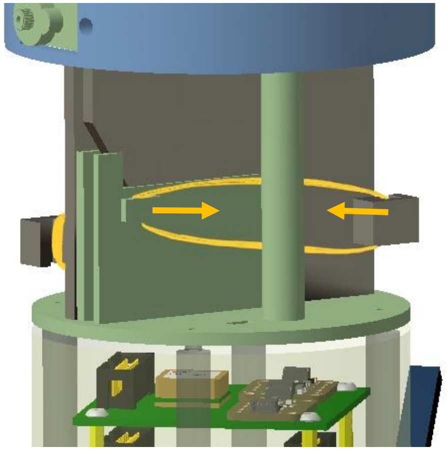
Information

- The overall structure is symmetrical.
- The inner space of the heat shield can be utilized, so heavy parts were placed underneath to position the center of mass as low as possible.
- As a result, the center of gravity was positioned below the neutral point to have angle stability.
- Using **Passive Stability Control** strategy through design

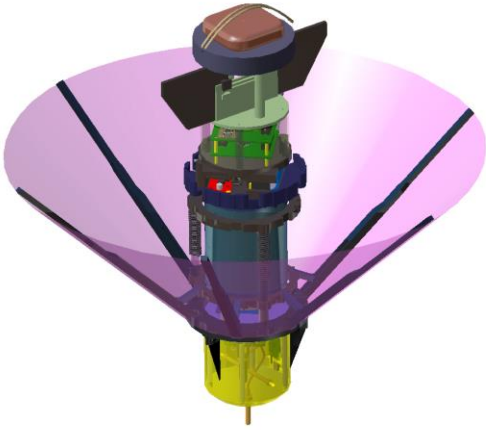
Payload Rotation Control Strategy



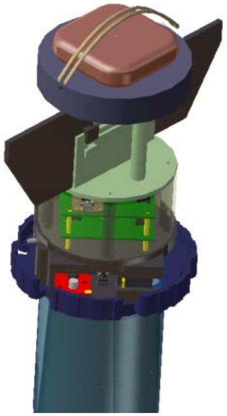
Three fins



Before the rear stabilizers are deployed by the rubber band



Rear stabilizers deploy with deployment of the heat shield

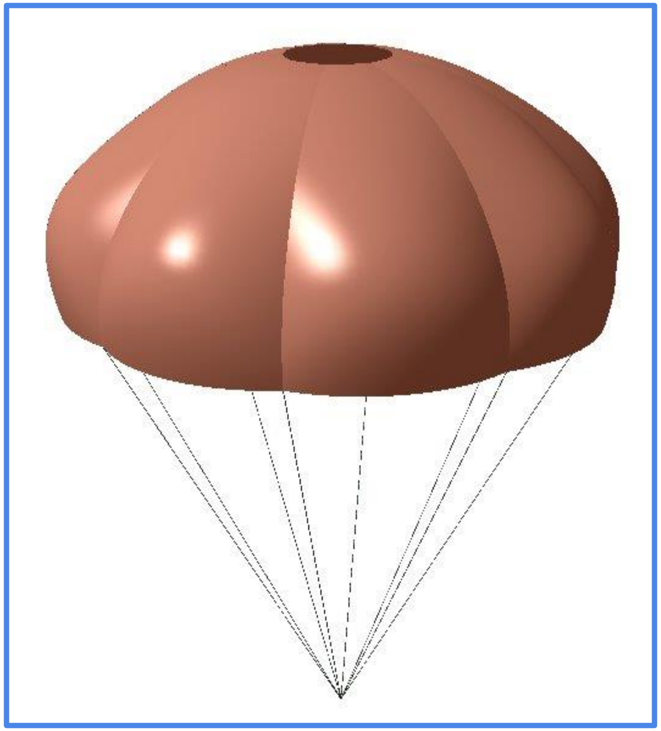


Rear stabilizers after release of the heat shield

Information

- While the heat shield is deployed and descending, three **fins** are attached in front of the heat shield to control rotation.
- As the heat shield is separated and the parachute is deployed, the two **rear stabilizers** in front of the parachute unit control the rotation.
- The rear stabilizers are fixed by the rocket airframe with rubber bands tensioned, and when the CanSat is separated, the rubber bands are restored to their original state, causing the stabilizers to protrude out.
- Using **Passive Rotation Control** strategy through design.
- The CanSat's **Passive Rotation Control** maintains **a consistent direction for the camera.**

Payload Parachute Descent Control Hardware Summary(1/3)



Descent Control Hardware

- **Key design considerations**
  → The type of parachute are round parachute with a spill hole

- **Color selection(s)**
  → Using pink ripstop nylon

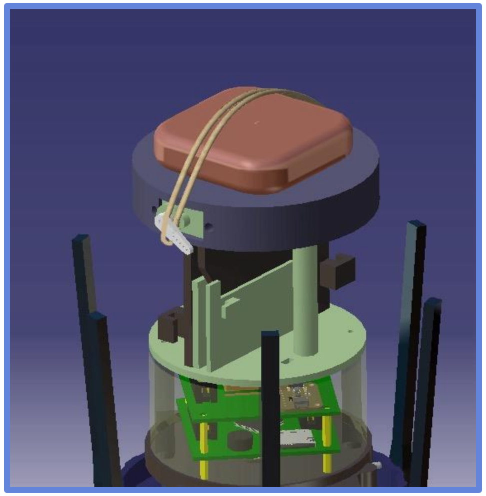
- **Passive component**
  → The parachute is attached to the payload through the eye bolt.

- **Active component**
  → The servo fixes the rubber band, and when the rubber band is released through the rotation of the servo, the parachute opens.

- **Size (diameter)**
  → Parachute = 85cm, Spill hole = 8.5cm
  → String length = 98cm

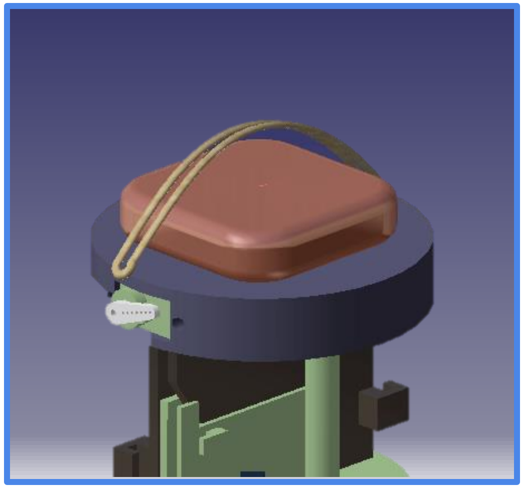
Payload Parachute Descent Control Hardware Summary(2/3)

Pre-Deployment



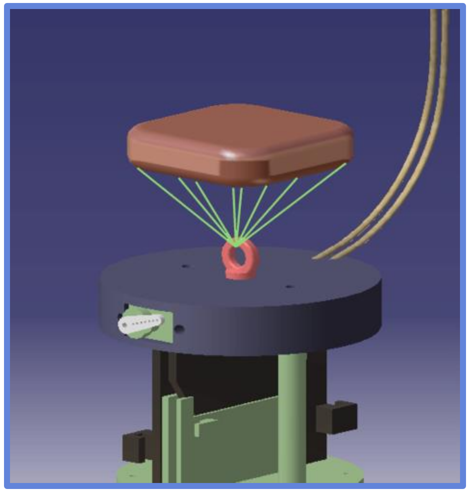
- The parachute is at the top of the payload and the folded parachute is connected to the eyebolt through a strong knot.
- The 3d-printed eyebolt was attached to the payload with epoxy.
- The parachute is fixed by a rubber band and a servo motor.

Deployment



- At 100m, the heat shield is separated and the servo motor rotates.
- At this time, the rubber band fixed by the servo motor is released and the parachute is deployed.

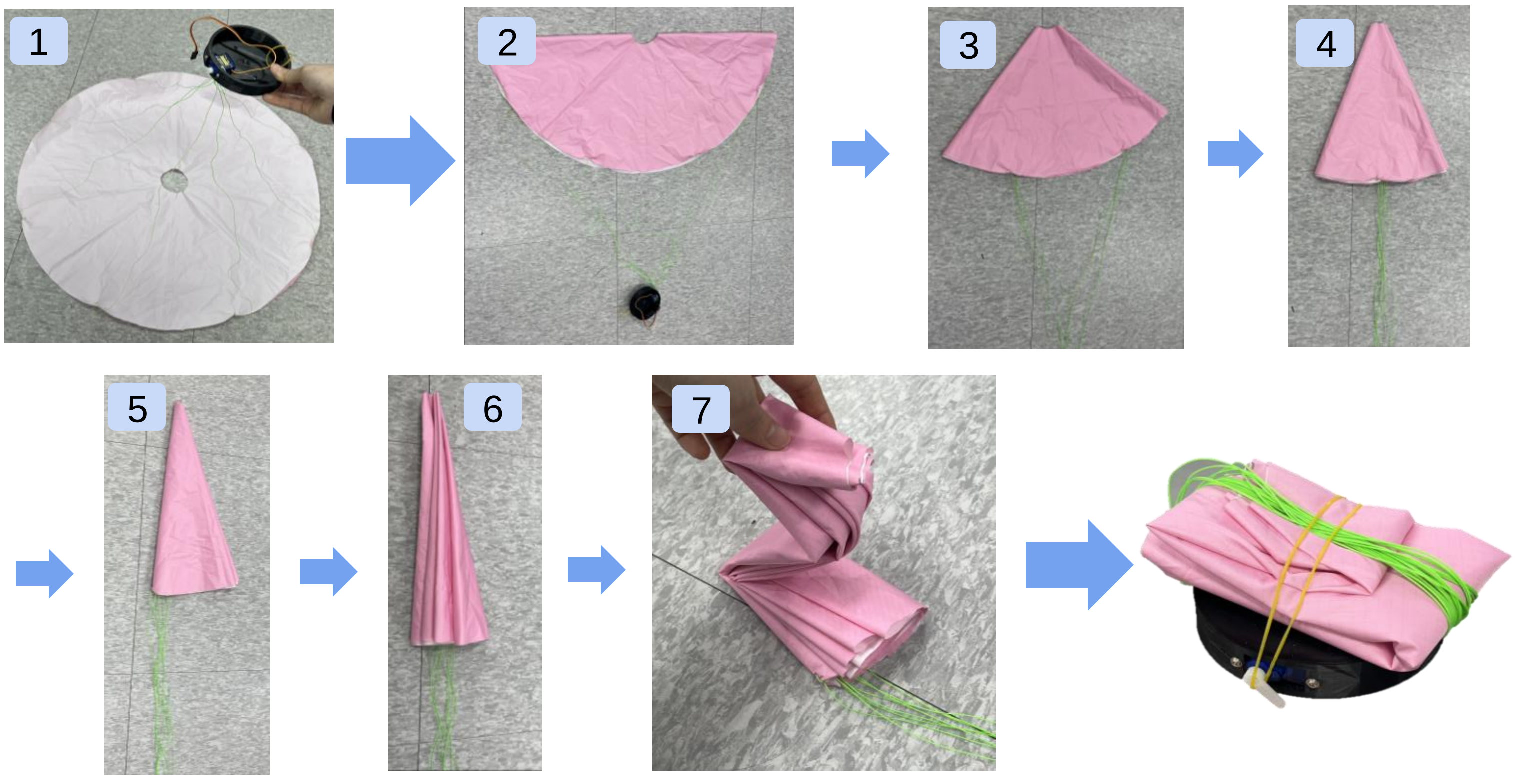
Full Deployment



- The parachute is deployed and the payload decelerates to reach the target speed of under 5m/s, and the payload lands safely on the ground.

Payload Parachute Descent Control Hardware Summary(3/3)

How parachute is stowed



Information

- The parachute is secured to eye bolts. Also, the parachute folds eight times in total.
- The folded parachute is secured by a rubber band and a servo motor to prevent it from loosening.

Descent Rate Estimates(1/6)

Magnitudes & Symbols

Magnitude	Symbol
Force Drag	F_d
Gravitational Force	F_g
Drag Coefficient of Parachute	C_{dp}
Drag Coefficient of heat shield	C_{dh}
Gravitational Acceleration	g
Air Density	ρ
Velocity	v
Mass	m
Area of Parachute	A_p
Area of heat shield	A_h
Diameter of Parachute	D_p
Diameter of heat shield	D_h

Formulas

Parachute	Heat shield
$F_d = \frac{1}{2}\rho v^2 A_p C_{dp}$	$F_d = \frac{1}{2}\rho v^2 A_h C_{dh}$
$F_g = mg = F_d$	$F_g = mg = F_d$
$mg = \frac{1}{2}\rho v^2 A_p C_{dp}$	$mg = \frac{1}{2}\rho v^2 A_h C_{dh}$
$v^2 = \frac{2mg}{\rho A_p C_{dp}}$	$v^2 = \frac{2mg}{\rho A_h C_{dh}}$
$A_p = \frac{2mg}{\rho v^2 C_{dp}}$	$A_h = \frac{2mg}{\rho v^2 C_{dh}}$
$A_p = \pi r^2 = \frac{\pi D_p^2}{4}$	$A_h = \pi r^2 = \frac{\pi D_h^2}{4}$
$D_p = \sqrt{\frac{8mg}{\pi \rho v^2 C_{dp}}}$	$D_h = \sqrt{\frac{8mg}{\pi \rho v^2 C_{dh}}}$

Assumptions and Values

Symbol	Value
m	0.65 kg
C_{dp}	1.3
g	9.81 m/s²
ρ	1.225 kg/m³
v_{max}	5 m/s
v_{min}	3 m/s

* When calculating the parachute deceleration speed, weight (m) is used by subtracting the heat shield and nose cone weight from the total maximum weight of the parachute.

* The approximate drag coefficient value(C_{dp}) of a hemispherical parachute is typically set to about 1.3

Parachute Calculations

Parachute
$F_d = \frac{1}{2}\rho v^2 A_p C_{dp} = F_g = mg = \mathbf{6.3765N}$
$\frac{2mg}{\rho v^2 C_{dp}}, \quad \frac{2*0.65*9.81}{1.225*5^2*1.3} \leq A_p \leq \frac{2*0.65*9.81}{1.225*3^2*1.3}$
$\mathbf{0.32 \leq A_p \leq 0.89}$
$\sqrt{\frac{4*0.32}{\pi}} \leq D_p = \sqrt{\frac{4A_p}{\pi}} \leq \sqrt{\frac{4*0.89}{\pi}}$
$\mathbf{0.64 \leq D_p \leq 1.06}$
Spill hole diameter(m) = 10% of parachute diameter Parachute string length (m) = 115% of parachute diameter

Descent Rate Estimates(3/6)

Determination of Diameter of Parachute

- According to the previous calculation results, a parachute diameter within the range of **64 cm to 106cm** shall be used to satisfy the given velocity conditions (5 m/s or less).
- Therefore, **85 cm**, which is the average value of the two values, is used as the diameter of the parachute.
  ➔ Spill hole diameter(D_{sh}) = 8.5cm
  ➔ Parachute string length = 98cm

Symbol	Value
m	0.65 kg
C_{dp}	1.3
g	9.81 m/s^2
ρ	1.225 kg/m^3
F_d	6.3765 N
A_p	0.6221 m^2
D_p	0.89 m
D_{sh}	0.15 m

Parachute (v_{des})
$A_p = \frac{\pi D_p^2}{4} = \frac{\pi * 0.85^2}{4} = 0.567$
$v_{des} = \sqrt{\frac{2mg}{\rho A_p C_{dp}}} = \sqrt{\frac{2 * 0.65 * 9.81}{1.225 * 0.567 * 1.3}} = 3.76\, m/s$

When the diameter is 85cm, the estimated descent rate = 3.76 m/s

Descent Rate Estimates(4/6)

Assumptions and Values

Symbol	Value
$\boldsymbol{m}$	0.9 kg
$\boldsymbol{C_{dh}}$	0.47
$\boldsymbol{g}$	9.81 m/s²
$\boldsymbol{\rho}$	1.142 kg/m³
$\boldsymbol{v_{max}}$	30 m/s
$\boldsymbol{v_{min}}$	10 m/s

Heat shield Calculations

Heat shield
$F_h = \frac{1}{2}\rho v^2 A_h C_{dh} = F_g = mg = \mathbf{8.829\ N}$
$A_h = \frac{2mg}{\rho v^2 C_{dh}}, \frac{2 * 0.9 * 9.81}{1.142 * 30^2 * 0.47} \leq A_h \leq \frac{2 * 0.9 * 9.81}{1.142 * 10^2 * 0.47}$
$\mathbf{0.0366 \leq A_p \leq 0.329}$
$\sqrt{\frac{4 * 0.0366}{\pi}} \leq D_h = \sqrt{\frac{4A_h}{\pi}} \leq \sqrt{\frac{4 * 0.329}{\pi}}$
$\mathbf{0.216 \leq D_p \leq 0.647}$

Descent Rate Estimates(5/6)

Determination of Diameter of heat shield

- From the precious results, we should use the diameter of the heat shield within the range of 21.6cm to 64.7cm to satisfy the given velocity conditions.
- Therefore, we use a diameter of **43cm** that satisfies the range.

Heat shield Calculations

Symbol	Value
C_{dh}	0.47
g	9.81 m/s^2
ρ	1.142 kg/m^3
m	0.9 kg
A_h	0.145 m^2
D_h	0.43 m

Heat shield (v_{des})
$A_h = \frac{\pi D_h^2}{4} = \frac{\pi * 0.43^2}{4} = 0.145$
$v_{des} = \sqrt{\frac{2mg}{\rho A_h C_{dh}}} = \sqrt{\frac{2 * 0.9 * 9.81}{1.142 * 0.145 * 0.47}} = 15.06$

When the diameter is 43cm, the estimated descent rate = 15.06 m/s

Descent Rate Estimates(6/6)

Summary

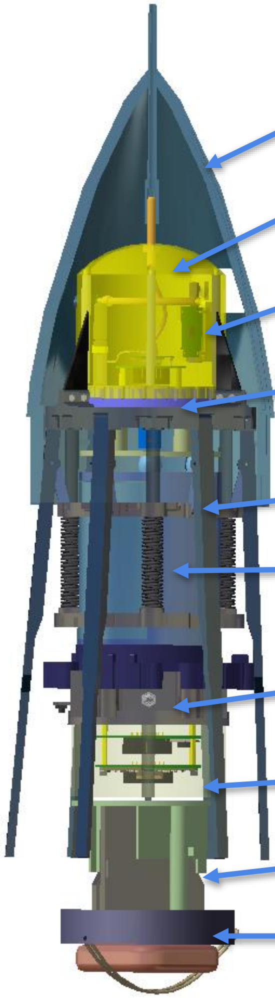
	Parachute		Heat shield
Target Velocity (m/s)	3.76		15.06
Area (m^2)	**Parachute**	0.567	0.145
Diameter (cm)	**Parachute**	85	43
	Spill hole	8.5	
String length (cm)	98		

Mechanical Subsystem Design

Presenter JungHyuk Lee

Mechanical Subsystem Overview

Major Structural Elements

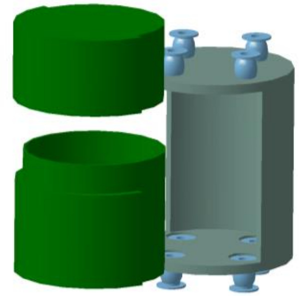
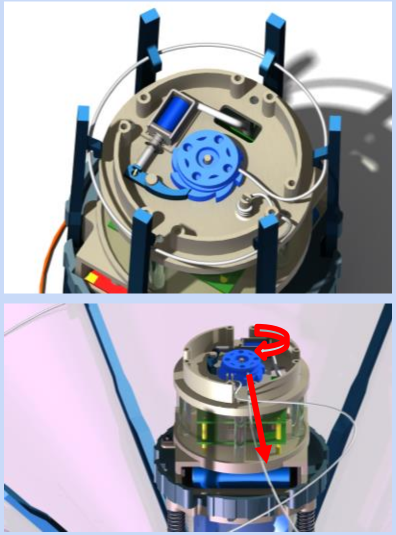


Interface Definitions

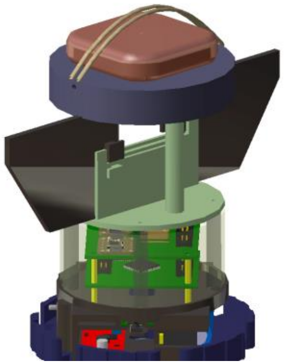
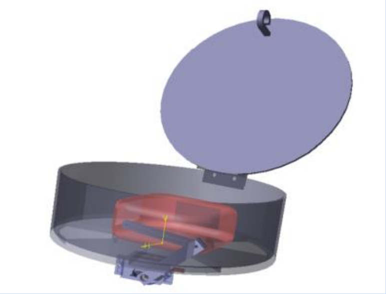
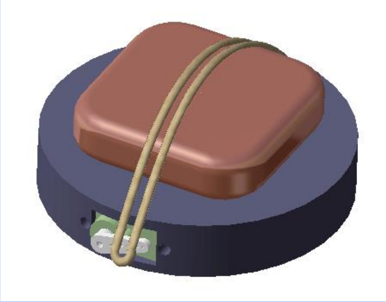
*Note: All connections marked with red lines are secured using M2 Bolts and Loctite

Material	Structural Element
PLA+	Heat shield Assembly, Egg Container, Nose Cone, Inner Nose Cone, Heat shield Releaser Assembly, Parachute Container, Electronic Assembly, Rotation Control Unit Assembly
Ripstop Nylon Fabric	Parachute, Heat shield
Steel	Heat shield Spring
Carbon Fiber	Heat shield Rod
Rubber	Egg Container Damper. Rubber Band

Mechanical Subsystem Changes Since PDR(1/2)

Part	PDR	CDR	Rationale
Egg container	 Capsule	 New Cylindrical	The new version is easier to put the egg in and out. Much buffer is available.
Heat shield Deployer	 Heat shield Deployer	Deleted	The mechanism was simplified. It can prevent situations where the heat shield fails to deploy due to either a power outage or malfunction of the servo motor

Mechanical Subsystem Changes Since PDR(2/2)

Part	PDR	CDR	Rationale
Rotation Control Unit	Absence	 Added	The new method enables more effective rotation control than the existing method.
Parachute Unit	 A lid with a torsion spring & servo motor	 A rubber band & servo Add eye bolt	The new version of the mechanism is simpler and lighter in weight.

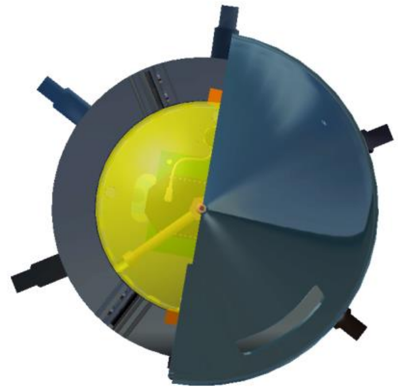
Payload Mechanical Layout of Components(1/4)

CAD Model and Dimension Drawings

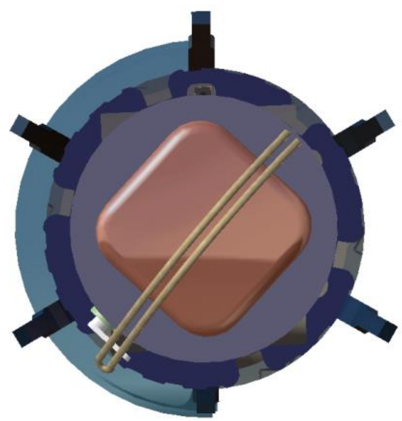
A front view	Top view	Dimension

A front view

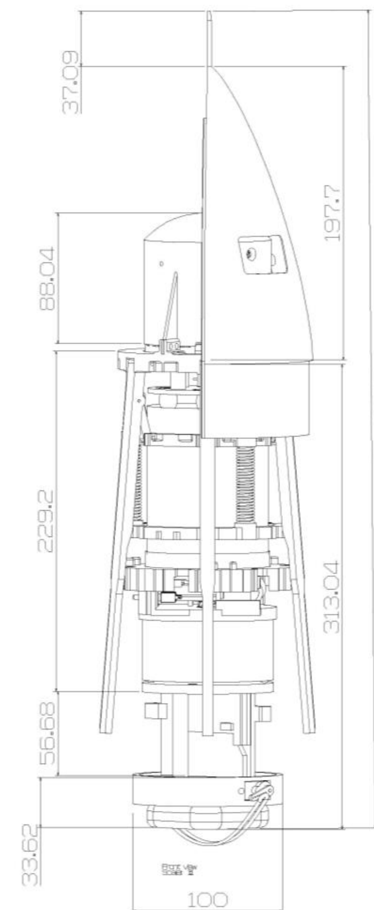
Top view



Bottom view

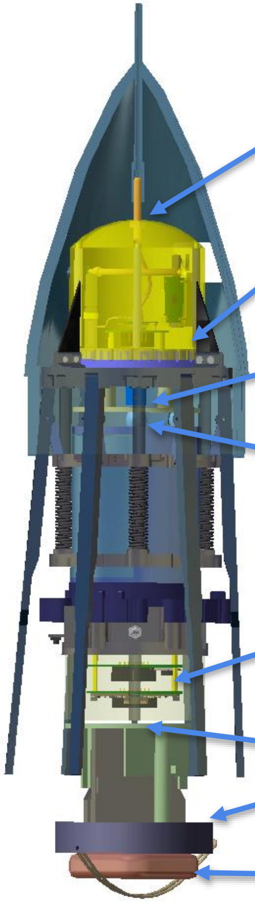


Dimension



Payload Mechanical Layout of Components(2/4)

Payload Attachment Points



Pitot tube are attached by M2 bolts

Heat shield module is locked by deployment mechanism

Damper plate for damper space is attached by M2 bolts

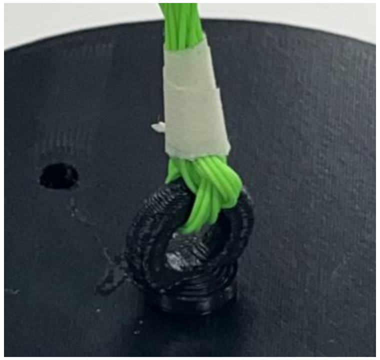
Egg Container is attached to the payload by rubber damper & anti-drop pin

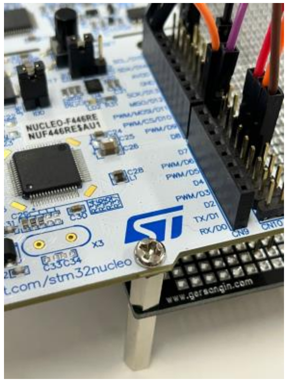
EPS and PCB are attached by M3 bolts

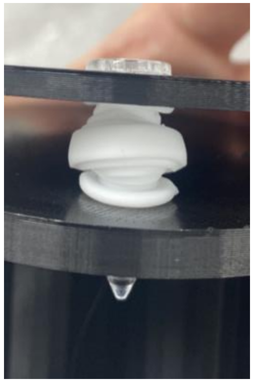
Rotation control unit and parachute unit are attached by M2 bolts

Parachute is attached by rubber band

Confirmation of fastening

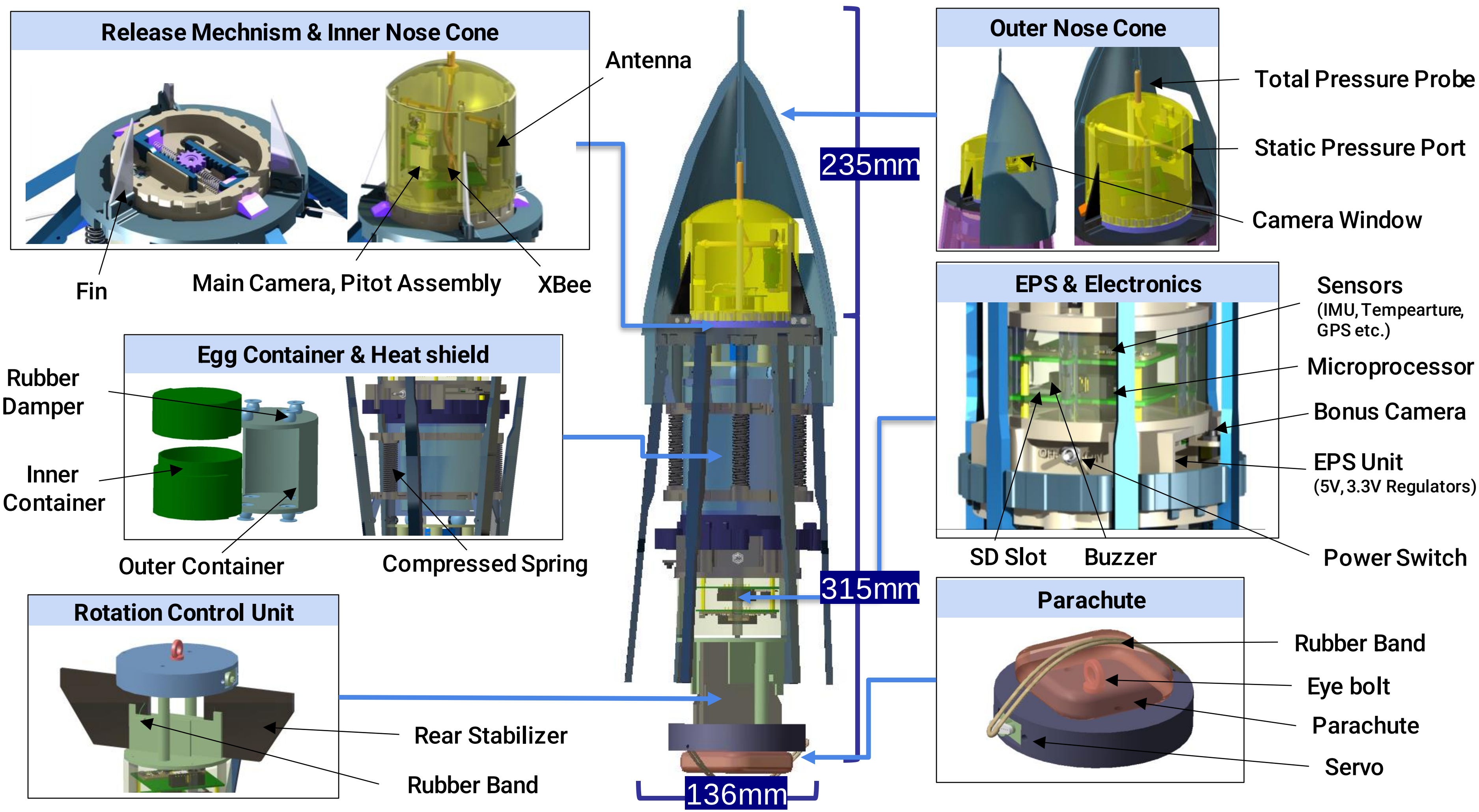






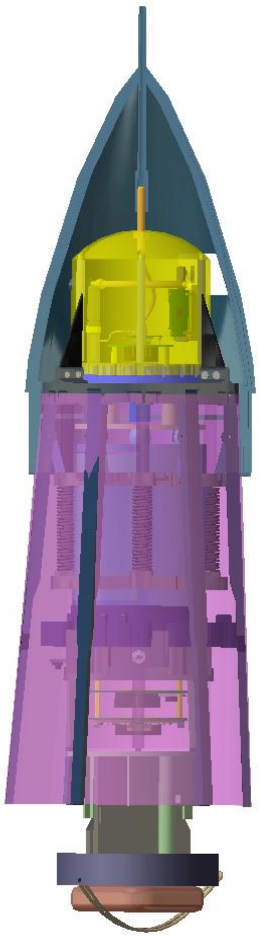
Payload Mechanical Layout of Components(3/4)

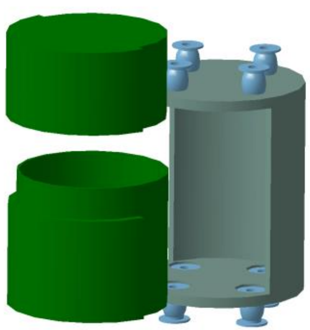
Major Mechanical Parts and Mechanisms



Payload Mechanical Layout of Components(4/4)

Structure Materials

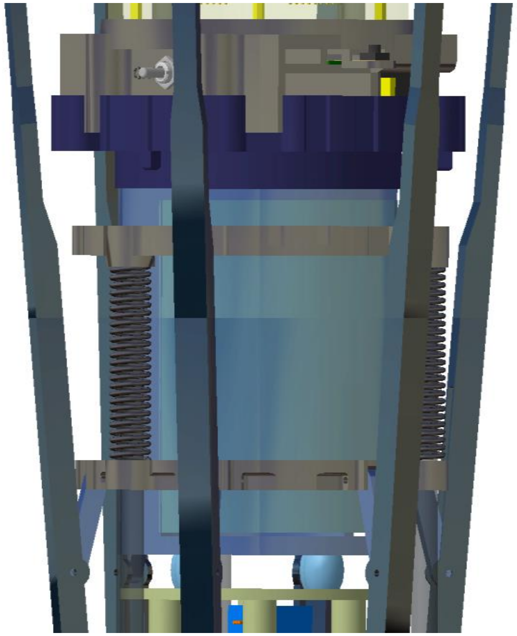




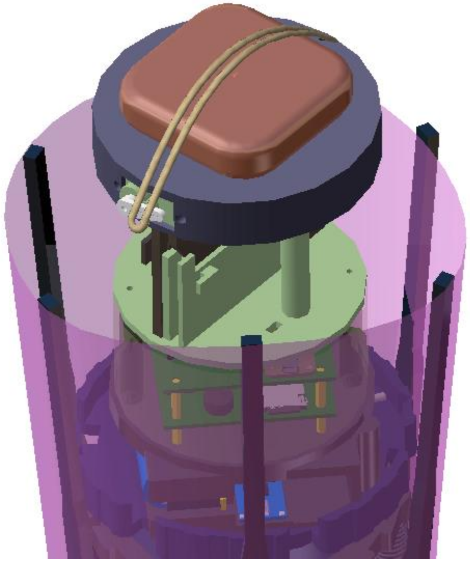
Material	Structural Element
 **PLA+**	Heat shield Assembly, Egg Container, Nose Cone, Inner Nose Cone, Heat shield Releaser Assembly, Parachute Container, Electronic Assembly, Rotation Control Unit Assembly
 **Ripstop Nylon Fabric**	Parachute, Heat shield
 **Steel**	Heat shield Spring
 **Carbon Fiber**	Heat shield Rod
 **Rubber**	Egg Container Damper, Rubber Band

Payload Aerobraking Pre Deployment Configuration

Pre-deployment Configuration secured into the rocket airframe



Compressed Spring

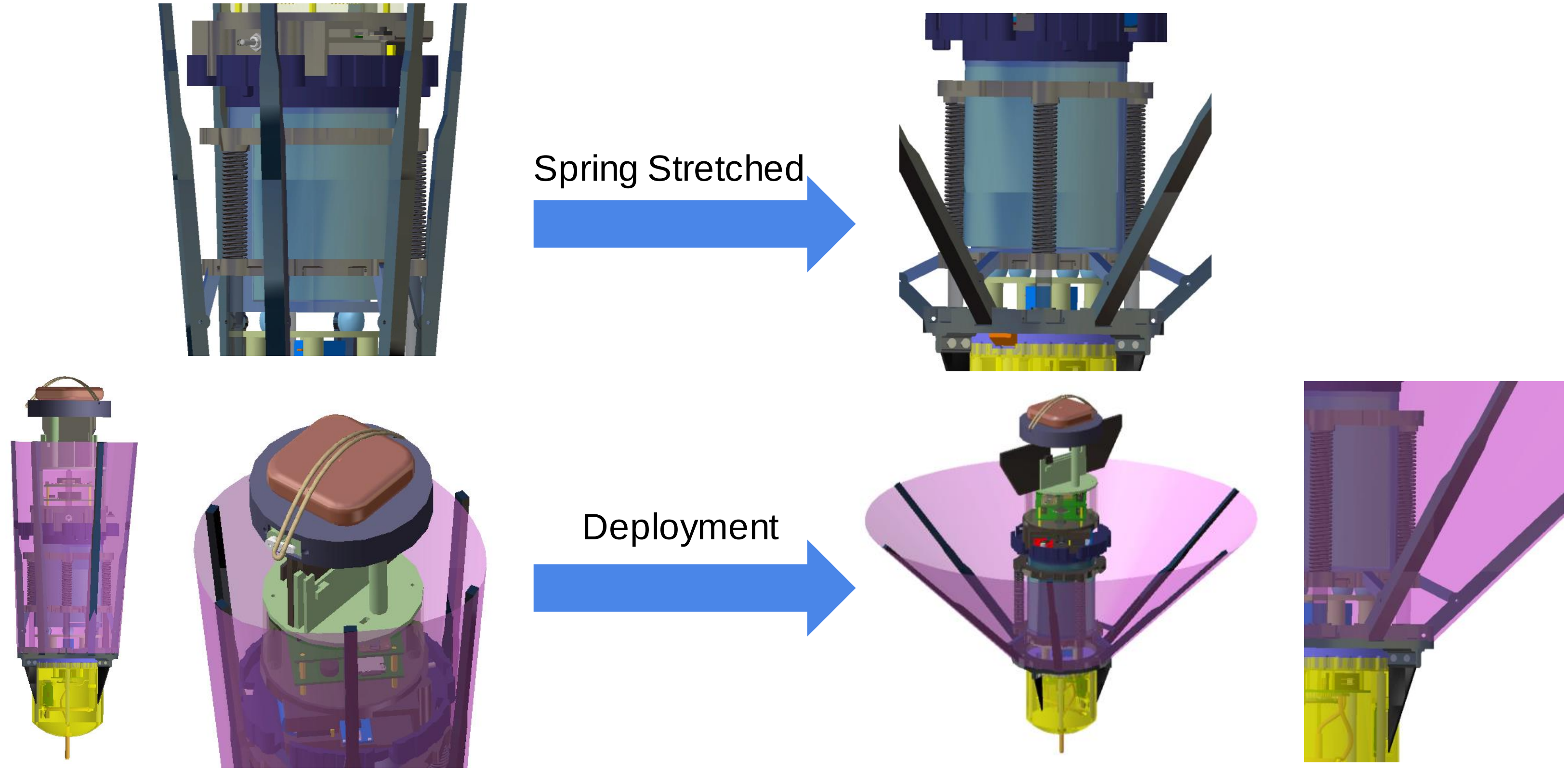


6 arms are stowed by wall of the rocket

Information

- The heat shield is folded and the CanSat will be placed in the rocket.
- Six arms of the heat shield are secured using the rocket airframe.
- The three springs that are used for deploying the heat shield is remained compressed.
- It can be deployed immediately after separation without any unexpected situation such as malfunction of the servo motor.

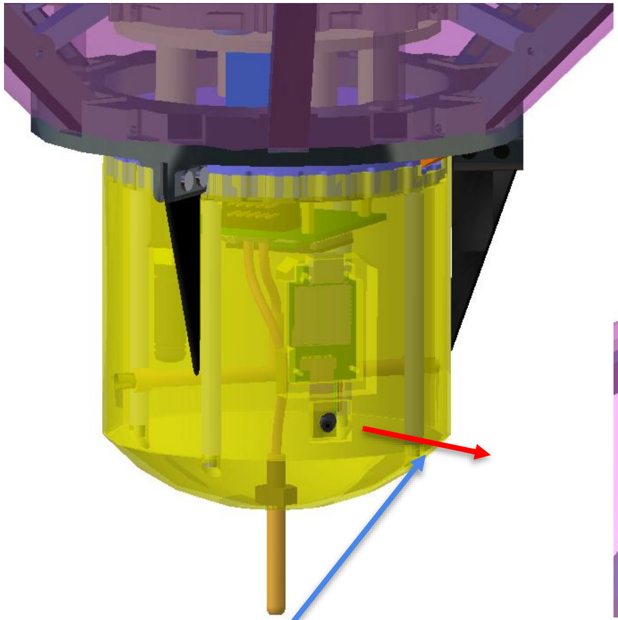
Payload Aerobraking Deployment Configuration

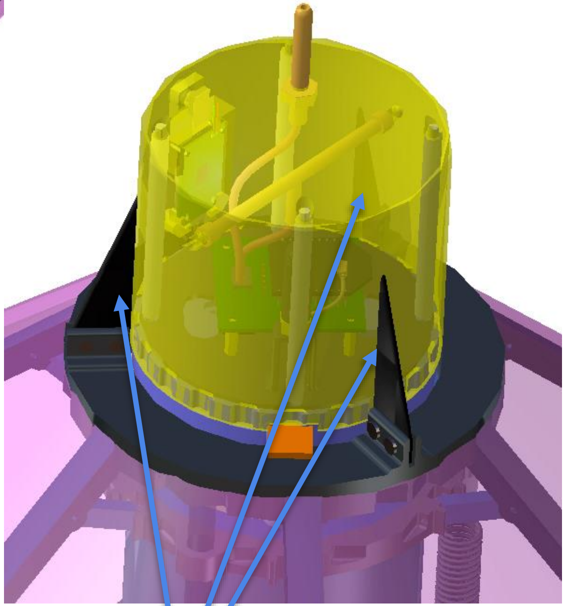


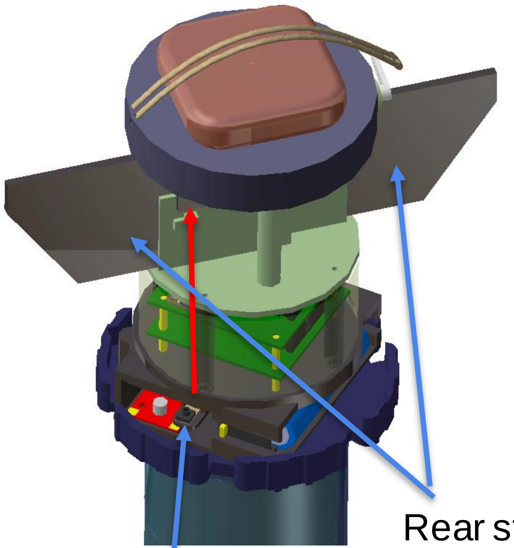
Information

- The heat shield module consists of 3D printed arms, holders, and three springs.
- When the spring is compressed, the six arms of the heat shield are held in place by the rocket airframe.
- The six heat shield arms are deployed as the CanSat is separated from the rocket.

Camera Pointing Control







Main Camera Pointing

Three Fins for Rotation Control

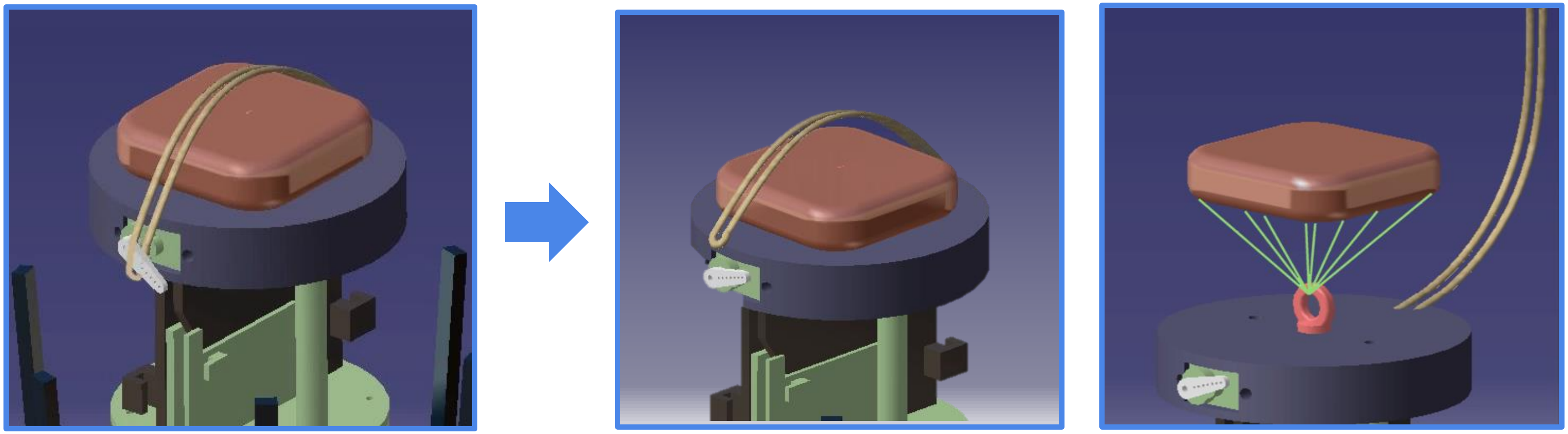
Bonus Camera Pointing

Rear stabilizers for Rotation control after release

Information

- The main camera is mounted on the inner nosecone to capture every moment from launch to descent.
- The main camera points horizontally. The bonus camera is mounted on the heat shield bottom plate.
- The bonus camera points vertically to check whether the parachute is deployed properly.
- When the heat shield is deployed, three fins located in front of the heat shield control rotation, and after the heat shield is separated, two rear stabilizers located in front of the parachute module control rotation.
- The CanSat's Passive Rotation Control maintains a consistent direction for the cameras.

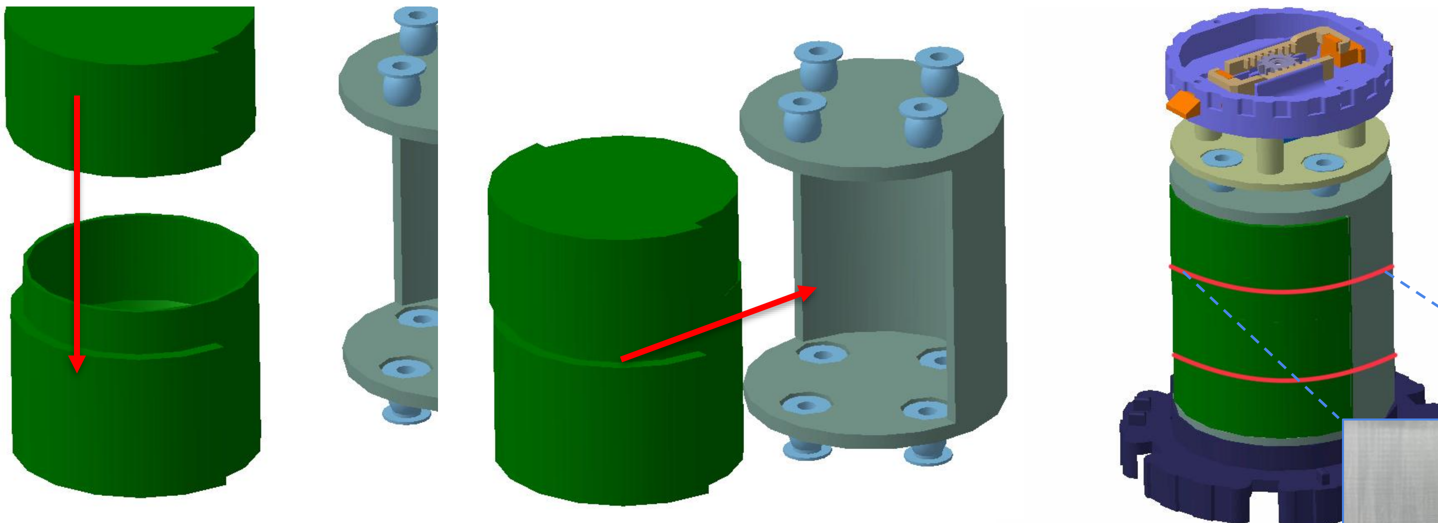
Payload Parachute Deployment Configuration



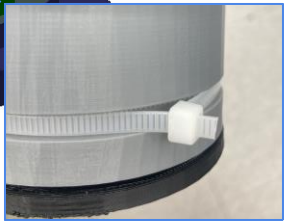
Information

- The parachute is deployed as a servo motor rotates and releases the rubber that have secured the parachute. (See PPT.49 for how parachute is stowed in payload.)
- The parachute is fixed with a strong knot on the eyebolt, which is firmly fixed to the payload before and after deployment.
- In the initial state, the rubber is connected to one hole drilled in the payload, and the other end is tightly hung by the servo motor. At this time, the folded parachute is located under the rubber and is restrained.
- When it rotates with the servo motor, the rubber is released and the parachute is deployed, gradually decelerating to 5m/s.

Payload Egg Containment Configuration



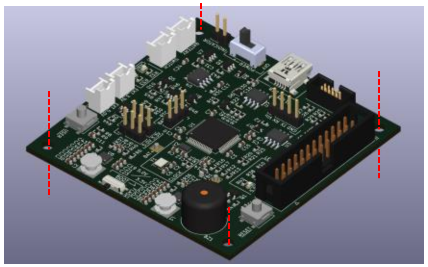
*Example used in prototype



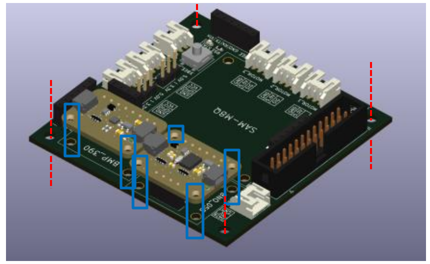
Information

- The egg container consist of inner cylinder and outer cylinder, which are made of PLA+.
- Wrap the egg with a cushioning material such as bubble wrap and store it within the two inner cylinders.
- The inner cylinder is coupled to the outer cylinder and then secured using a zip-tie.
- The outer cylinder is connected to the body using eight rubber dampers.
- The rubber dampers reduce the impact on the egg.

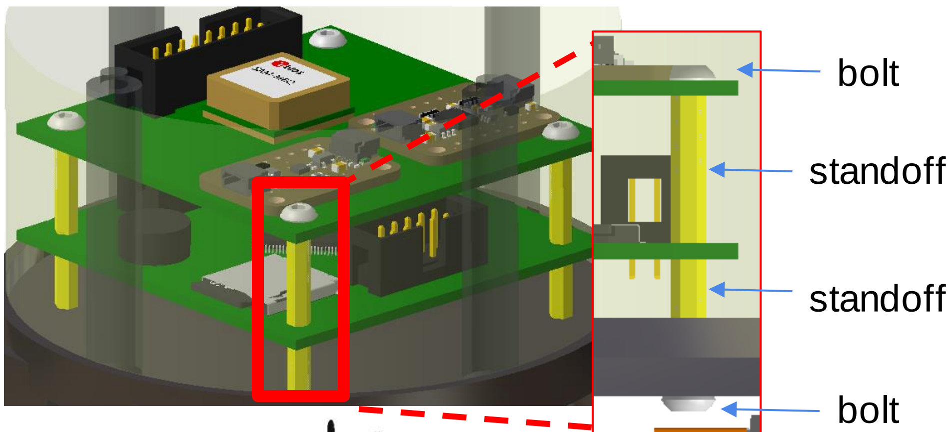
Structure Survivability(1/3)

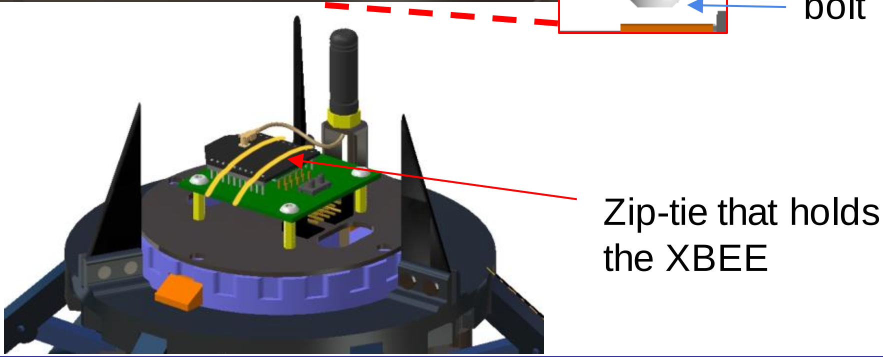


Attached with metal standoffs



Secured using M3 bolts





Electronic Component

- **Electronic component mounting methods**

→ PCB and breakout boards attached with metal standoffs.

→ Each electronic component is secured using M3 bolts.

→ The cables were made to be robust against vibration using a latching mechanism.

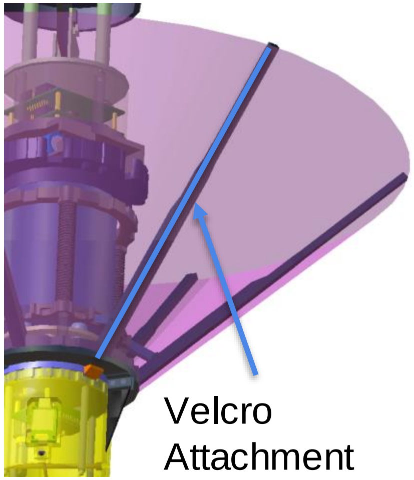
- **Electronic component enclosures**

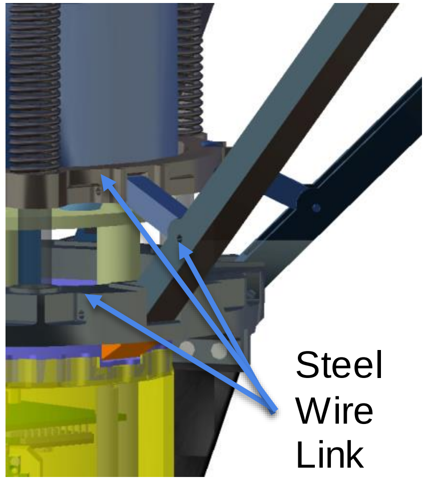
→ PCB will be fully enclosed inside its structural body.

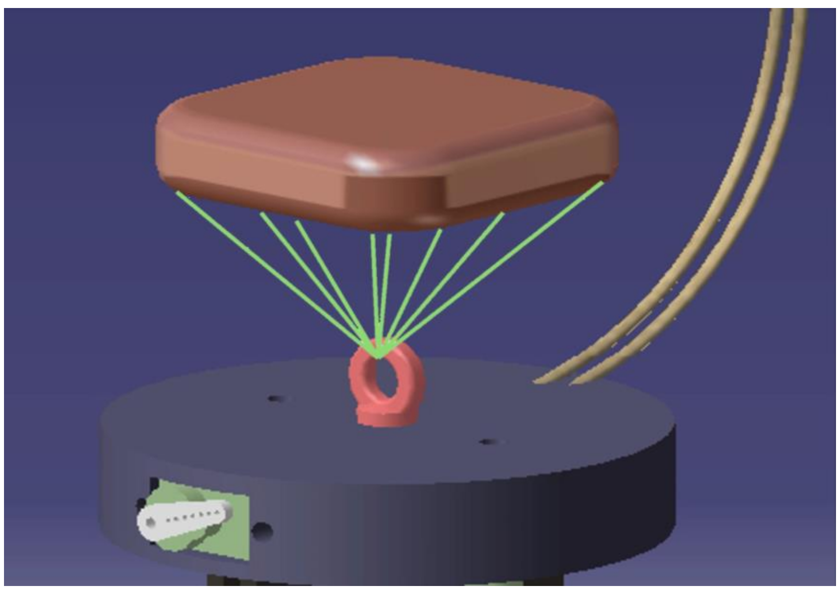
- **Securing electrical connections (glue, tape, etc.)**

→ The XBEE module and battery are securely attached using a zip-tie.

Structure Survivability(2/3)







Descent Control Attachments

- **Heat shield Attachments**

→ Attach Velcro between the ripstop nylon and the heat shield arm to fasten the nylon to the arm.

→ The heat shield arms, stretcher, and holder were connected using steel wire. Therefore, it is simple, but sturdy and easy to deploy.

- **Parachute Attachment**

→ The nylon parachute strings are connected to the eye bolt.

→ Use a rubber band and a servo motor to fasten the folded parachute.

Structure Survivability(3/3)

Requirements & Testing

- **Requirements**

→ CanSat structure must survive 15 Gs vibration.
→ CanSat shall survive 30 G shock.

- **Testing**

→ We didn't make all the components, so we conducted a simple test with the prepared parts.
→ The test confirmed that the durability was sufficient.
→ After all parts are built, we will test the payload to experience acceleration and impact.

- **Future Plan**

→ We will complete the fabrication of the entire prototype and conduct the test to make sure there's no problem with the descent.

Mass Budget(1/5)

Heat Shield

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Upper Holder	1	47.45	47.45	Estimated	4.75
Lower Holder	1	13	13	Estimated	1.3
Base Plate	1	20.15	20.15	Estimated	2.02
Arm	6	9.8	58.8	Estimated	5.88
Stretcher	6	1.4	8.4	Estimated	0.84
Rod	3	7	21	Estimated	2.1
Spring	3	2	6	Estimated	0.6
Heat Shield Total	-	-	**174.8**	-	**± 17.49**

Rotation Control Unit

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty
Rear stabilizer	2	8.9	17.8	Estimated	1.78
RCU Plate	1	31.3	31.3	Estimated	3.13
Rubber Band	2	0.3	0.6	Estimated	0.06
Rotation Control Unit Total	-	-	**49.7**	-	**± 4.97**

* We set estimated value from data of CATIA program and assumed the uncertainty of each estimated data as 10% of each value.

Mass Budget(2/5)

Egg Container

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Inner Container	1	92.8	92.8	Estimated	9.28
Outer Container	1	59.4	59.4	Estimated	5.94
Damping Rubber	8	2	16	Datasheet	
Egg Container Total	**-**	**-**	**168.2**	**-**	**± 15.22**

Nose Cone

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Left Nose Cone	1	48.5	48.5	Estimated	4.85
Right Nose Cone	1	46.55	46.55	Estimated	4.66
Inner Nose Cone	1	23.6	23.6	Estimated	2.36
Nose Cone Total	**-**	**-**	**118.65**	**-**	**± 11.87**

* We set estimated value from data of CATIA program and assumed the uncertainty of each estimated data as 10% of each value.

Mass Budget(3/5)

Heat Shield Releaser

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Releaser Assembly	1	33.6	33.6	Estimated	3.36
Gear	1	0.42	0.42	Estimated	0.04
Rack	2	1.4	2.8	Estimated	0.28
Holder	2	1.4	2.8	Datasheet	
Spring	2	0.05	0.1	Datasheet	
SG90 Servo	1	9	9	Datasheet	
Heat Shield Releaser Total	-	-	**48.72**	-	**± 3.68**

Parachute

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Parachute	1	10	10	Estimated	0.1
Parachute Container	1	65	65	Estimated	6.5
SG90 Servo	1	9	9	Datasheet	
Parachute Total	-	-	**84**	-	**± 6.6**

* We set estimated value from data of CATIA program and assumed the uncertainty of each estimated data as 10% of each value.

Electronics

Component	Quantity	Mass(g)	Mass sum(g)	Source	Uncertainty(g)
Electronic Assembly	1	53.9	53.9	Estimated	5.39
PCB Rod	8	2	16	Datasheet	
PCB Board	3	1	3	Estimated	0.3
BMP390	1	3	3	Datasheet	
BNO055	1	3	3	Datasheet	
MPXV7002DP	1	2.8	2.8	Datasheet	
SAM-M8Q	1	40	40	Datasheet	
Quelima SQ11	2	5.2	10.4	Datasheet	
Lithium-Ion Battery	1	47	47	Datasheet	
Battery Holder	1	14	14	Datasheet	
Buzzer	1	2	2	Datasheet	
5V Regulator	1	2	2	Datasheet	
3.3V Regulator	1	0.6	0.6	Datasheet	
Switch	1	8	8	Datasheet	
XBee3 Pro	1	3	3	Datasheet	
Antenna	1	42	42	Datasheet	
Electronics Total	**-**	**-**	**250.7**	**-**	**± 5.69**

* We set estimated value from data of CATIA program and assumed the uncertainty of each estimated data as 10% of each value.

Mass Budget(5/5)

Summary

Subsystem	Mass(g)	Uncertainty(g)
Heat shield	174.8	± 17.49
Rotation Control Unit	49.7	± 4.97
Egg Container	168.2	± 15.22
Nose Cone	118.65	± 11.87
Heat shield Releaser	48.72	± 3.68
Parachute	84	± 6.6
Electronics	250.7	± 5.69
Total	**894.77**	± 65.52
Margin	**+5.23 g**	

Method of correction to meet mass requirement

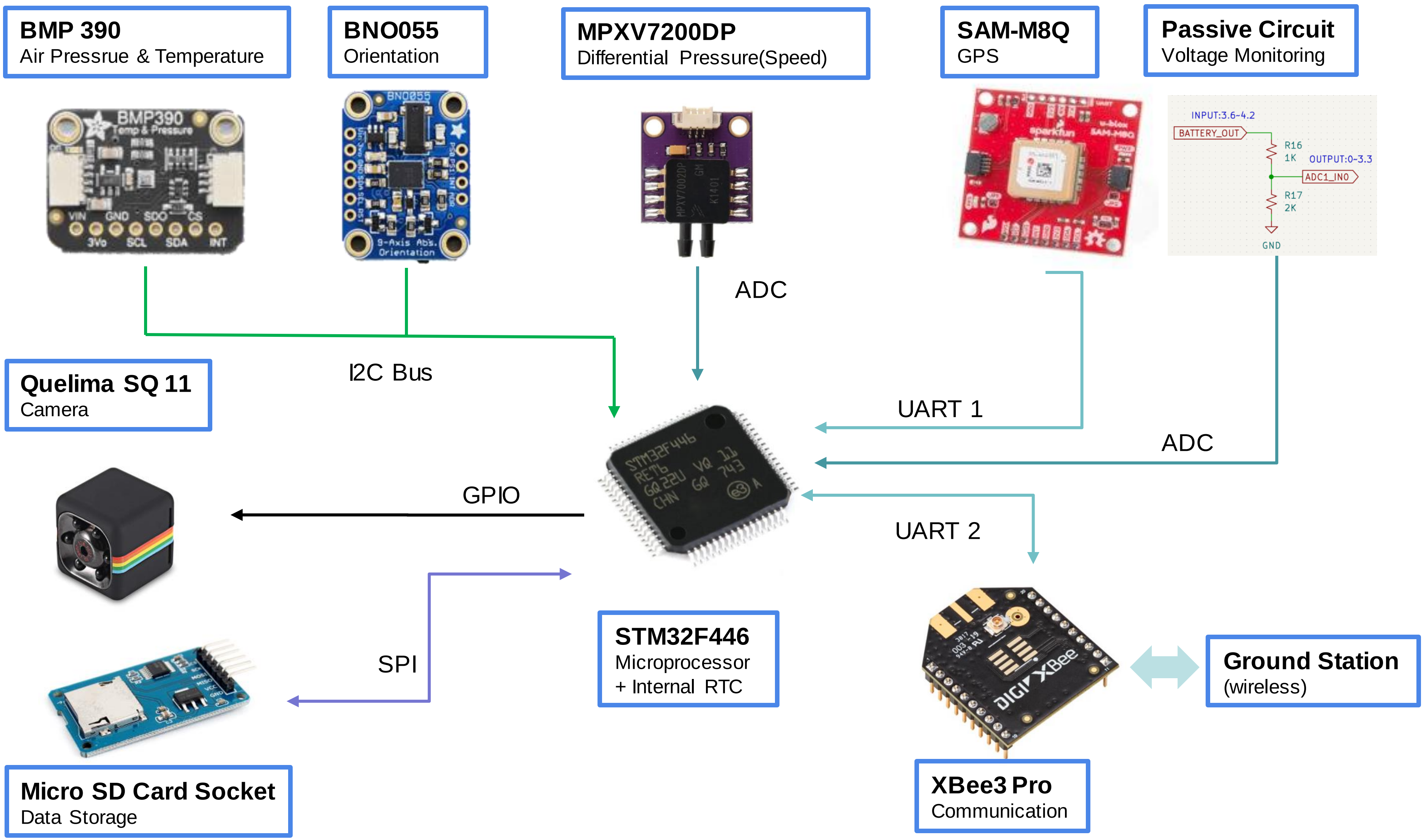
- Most of structural parts are 3D printed using PLA+ material, and the mass requirement can be met by adjusting the infill density.
- If the mass is below the requirement, additional mass can be added to the inner nose cone. This helps lower the mass center.
- If the mass exceeds the requirement, utilize a perforated pattern to minimize it.

* We set estimated value from data of CATIA program and assumed the uncertainty of each estimated data as 10% of each value.

Communication and Data Handling (CDH) Subsystem Design

Presented by HyungJun Bae

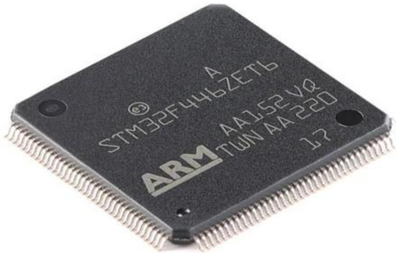
CDH Overview



CDH Changes Since PDR

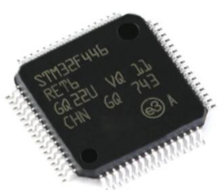
Part	PDR	CDR	Rationale
Processor	**STM32 F446ZE (LQFP-144)**	**STM32 F446RE (LQFP-64)**	• Much easier to layout the PCB • Much cheaper than F446ZE

Processor change



Payload Processor & Memory Selection (1/2)

Processor

Model	Boot Time	Processor Speed	Memories	Interface	Ports	Cost ($)
STM32 F446RE	< 3 ms	Up to 180 MHz	512 KB [Flash] 128 KB [SRAM]	4 x I2C 4 x USART 4 x SPI	50x I/O 3 x ADC	3.288
	**Power Consumption**		**Package**	**Data Bus Width(bit)**	**Mass(g)**	**Size**
	0.33 Wh @ 3.3 V		LQFP 64	32	0.36	10mm x10mm

Selected Processor	Reasons
STM32 F446RE	• High performance • Enough data interfaces & memories • Experience with the microcontroller • Customized design is possible. • **Small package size**

Payload Processor & Memory Selection (2/2)

Memory

Model	Interface	Compatible	Capacity	Voltage	Size(mm)	Cost ($)
SZH-EKBZ-005	SPI	MicroSD	Up to 32 GB	3.3 or 5 V	42x24	5.38 (SD Card Included)

Selected Memory		Reasons
	**SZH-EKBZ-005**	• Debugging of the memory is much easier • Enough storage capacity • Voltage regulator included • Cost efficient

Payload Real-Time Clock

Payload real-time clock

Model	Clock	Accuracy	Reset Tolerance	Interface	Input Voltage	Cost ($)
STM32 F446RE (Internal RTC)	32 kHz	±500ppm	Using a coin battery to supply power for the RTC.	Internal Bus	Integrated in STM32	0

Note : When Vdd is not present, the STM32 automatically switches the power source to Vbat , which is connected to the coin battery, and supplies power for the RTC, clock oscillator and backup registor.

Selected RTC		Reasons
	**STM32 F446RE (Internal RTC)**	• No additional devices. • Internal calibration is possible. • During a 1-hour operation, 500 ppm accuracy results in only a 1.8-seconds error which within the acceptable range.

Payload Antenna Selection

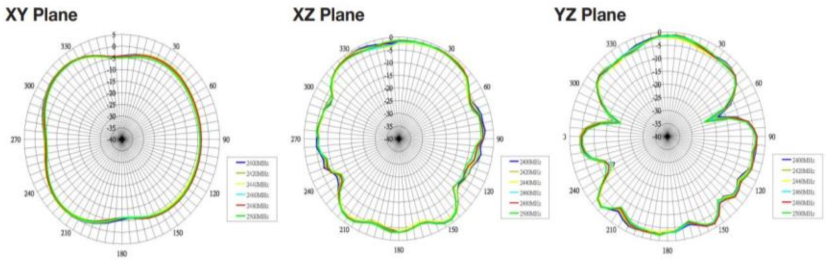
Payload antenna

Model	Type	Frequency Range(GHz)	Gain (dBi)	Pattern	Connector	Dimensions (mm)	Maximum Range*	Cost ($)
Delta 20	stubby	2.4 – 2.5	0	Omni-Directional	RP-SMA	L28.5 x W7.9 Ø	~5.5 km	11.16

* Refer to the 'GCS Antenna' section for maximum range.

Mass	Performance
3g (measured)	When tested with a prototype model, there was no interrupt.

Radiation Patterns



Reasons

- Light weight and small size
- Omni directional pattern

Payload Radio Configuration

Model Selection

Module	Frequency	Type	Power	Sensitive	Range
Digi Xbee3® PRO Zigbee 3.0 TH	2.4GHz	U.FL	+19 dBm	-103 dBm	~ 3200 m

* According to the Korean Radio Waves Act, the utilization of the 900 MHz band is prohibited without obtaining prior authorization.

Radio Configuration

Usage	Identifier	Protocol	NETID	Address(16bit)	Baud Rate	Node Type
Payload	Device	802.15.4	0x2036	0x1111	115200	End Device
GCS	Coordinator			0xCCCC		Coordinator

Transmission Control

- After the CanSat is turned on, it maintains a connection with the GCS until successfully landed.
- The Payload's XBee will be set to 'No Sleep' mode which prevents unexpected connection lost.
- The telemetry data will be transferred periodically(1Hz) when It receives the 'CX_ON' Command.
- Two XBee modules are using 'API Mode', which utilizes frame structure to enhance stability and enable remote configuration.
- Unicast transmission will be used.

Payload Telemetry Format (1/3)

Field	Format / Unit	Description
<TEAM_ID>	2036	The assigned four digit team number(2036).
<MISSION_TIME>	'HH:mm:ss'	UTC time format based on a 24-hour system, where 'HH' is hours, 'mm' is minutes, and 'ss' is seconds.
<PACKET_COUNT>	-	The total count of transmitted packets. This value can be reset to zero by command and increment automatically when a packet is sent.
<MODE>	'F' | 'S'	The character 'F' denotes the flight mode, while 'S' denotes the simulation mode.
<STATE>	-	The operating state of the software.
<ALTITUDE>	0.1 [m]	The altitude relative to the ground level at the launch site.
<AIR_SPEED>	1 [m/sec]	The air speed measured with the pitot tube during both ascent and descent.
<HS_DEPLOYED>	'P' | 'N'	When the heat shield is deployed, it indicates 'P'; otherwise, it shows 'N'.
<PC_DEPLOYED>	'C' | 'N'	When the parachute is deployed, it indicates 'C'; otherwise, it shows 'N'.
<TEMPERATURE>	0.1 [℃]	The temperature in degrees Celsius.
<VOLTAGE>	0.1 [V]	The voltage of the CanSat power bus.
<PRESSURE>	0.1 [kPa]	The air pressure of the sensor.

Payload Telemetry Format (2/3)

Field	Format / Unit	Description
<GPS_TIME>	1 [sec]	The time from the GPS receiver.
<GPS_ALTITUDE>	0.1 [m]	The altitude from the GPS receiver in meters above mean sea level
<GPS_LATITUDE>	0.0001 [degrees]	The latitude from the GPS receiver in decimal degrees with a resolution of 0.0001 degrees North.
<GPS_LONGITUDE>	0.0001 [degrees]	The longitude from the GPS receiver in decimal degrees with a resolution of 0.0001 degrees West.
<GPS_SATS>	-	The number of GPS satellites being tracked
<TILT_X>	0.01 [degrees]	The angle of the CanSat X-axis, which perpendicular to the gravity vector(Z-axis).
<TILT_Y>	0.01 [degrees]	The angle of the CanSat Y-axis, which perpendicular to the gravity vector(Z-axis).
<ROT_Z>	0.1 [degrees/sec]	The rotation rate of the CanSat along the Z-axis.
<CMD_ECHO>	-	The text of the last command received and processed by the CanSat. More details are described in the 'Payload Command Formats' Section.
<OPTIONAL>	-	No additional information will be used.

*Each fields is separated by a comma and the telemetry data will be encoded using ASCII.

Payload Telemetry Format (3/3)

Telemetry Format

TEAM_ID,	MISSION_TIME,	PACKET_COUNT,	MODE,
STATE,	ALTITUDE,	AIR_SPEED,	HS_DEPLOYED,
PC_DEPLOYED,	TEMPEARTURE,	VOLTAGE,	PRESSURE,
GPS_TIME,	GPS_ALTITUDE,	GPS_LATITUDE,	GPS_LONGITUDE,
GPS_SATS,	TILT_X	TILT_Y,	ROT_Z,
CMD_ECHO			

Payload sends packets at a rate of 1 Hz

Example*

2036,	22:08:25,	159,	F,
DESCENT,	326.3,	15.9,	P,
N,	27.3,	3.5,	101.3,
22:08:25,	321.6,	37.5326,	127.0246,
10,	5.51	3.24,	1.2
CXON			

* For readability, seperated each field using a tab.
* In actual telemetry packet, there is **no space** between each field.

Payload Command Formats (1/2)

Command Data Format	CMD,<TEAM_ID>,<COMMAND>,<ARGUMENT>

Required Commands

Command	Argument	Example	Description
CX	**ON**	CMD,2036,CX,ON	Enable and activate telemetry
	OFF	CMD,2036,CX,OFF	Disable and deactivate telemetry
ST	**<HH:mm:ss>**	CMD,2036,ST,19:18:54	Set the time based on the UTC time format
	GPS	CMD,2036,ST,GPS	Set the time based on the GPS time
SIM	**ENABLE**	CMD,2036,SIM,ENABLE	Enable the simulation mode
	ACTIVATE	CMD,2036,SIM,ACTIVATE	Activate the simulation mode
	DISABLE	CMD,2036,SIM,DISABLE	Disable and deactivate the simulation mode
SIMP	**<Pressure>**	CMD,2036,SIMP,101325	Send pseudo atmospheric pressure data with a resolution of one Pascal
CAL	**-**	CMD,2036,CAL	Perform altitude calibration, setting it to zero at the launch pad.
BCN	**ON**	CMD,2036,BCN,ON	Activate the audio beacon
	OFF	CMD,2036,BCN,OFF	Deactivate the audio beacon

* Command string is all capitalized without any spaces.

Payload Command Formats (2/2)

Command Data Format	CMD,<TEAM_ID>,<COMMAND>,<ARGUMENT>

Optional Commands

Command	Argument	Example	Description
DEP	**HS**	CMD,2036,DEP,HS	Deploy the heat shield manually
	PC	CMD,2036,DEP,PC	Deploy the parachute manually
REL	**HS**	CMD,2036,REL,HS	Release the heat shield manually
TEST	**[Element]**	CMD,2036,TEST,[Element]	Activate the test procedures
INIT	**-**	CMD,2036,INIT	Initialize all systems(actuators, sensors etc.)
RESET	**-**	CMD,2036,RESET	Reset the hardware

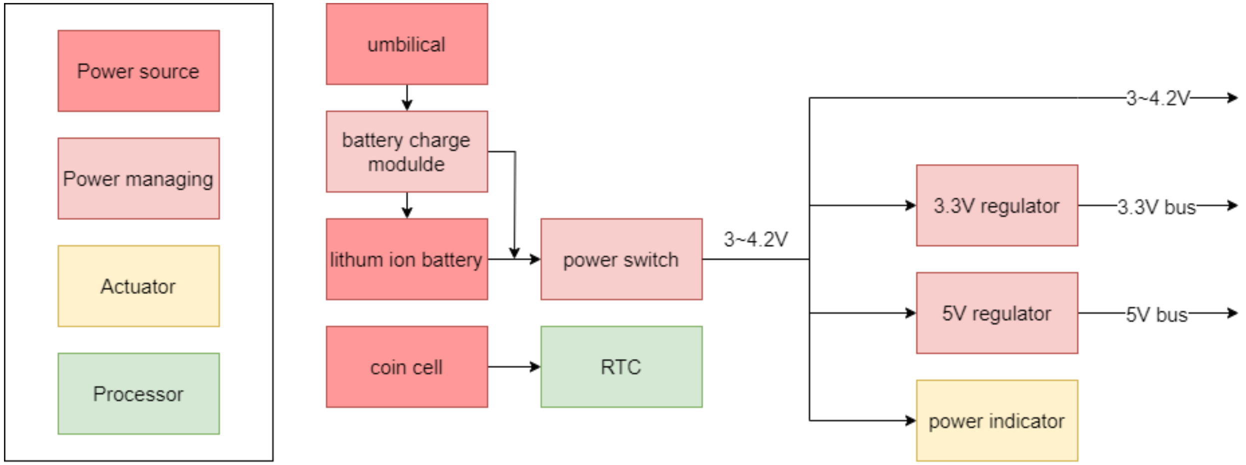
* Command string is all capitalized without any spaces.

Electrical Power Subsystem Design

Presented by Myeongsik Jeong

EPS Overview

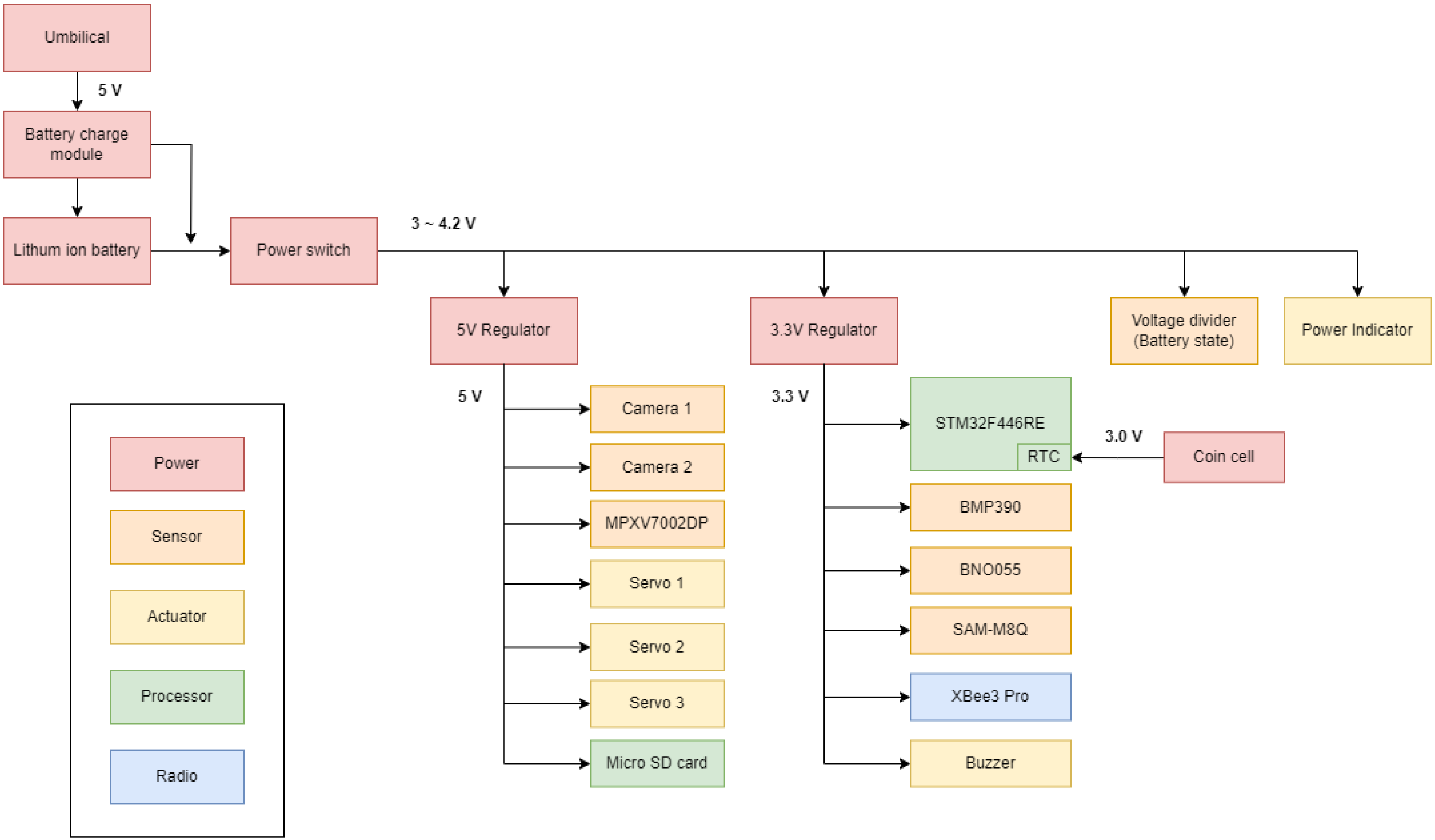
Category	component	Purpose
Power source	Umbilical	Power the board while testing and inspecting Recharge the lithium ion battery
Power source	Lithium-ion battery	Main power source of the CanSat
Power source	Coin cell	Keep RTC value when main power is gone
Power managing	Battery charging module	Charge battery / Deliver umbilical power to the CanSat
Power managing	Power switch	Easily accessible power switch
Power managing	5V regulator	Power the cameras and the servos
Power managing	3.3V regulator	Power the MCU, sensors and XBEE radio
Actuator	Power indicator	Indicates the power state



EPS Changes Since PDR

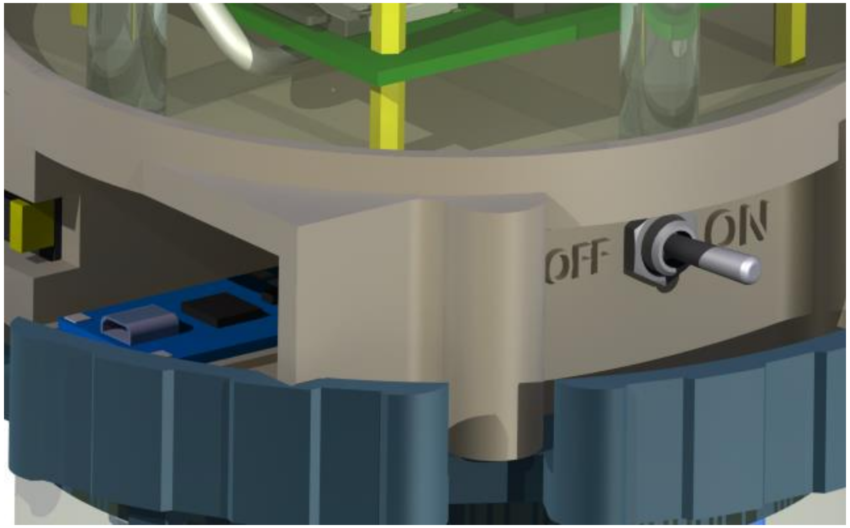
Required	PDR Sensor	CDR Sensor	Rationale
Speed	SDP 31	MPXV7002DP	Recalculation of the power budget due to change of the sensor
Camera	Adafruit's Mini spy camera	Quelima SQ11	Recalculation of the power budget due to change of the sensor

Payload Electrical Block Diagram (1/2)



Electrical accessibility

- The easily accessible power switch and umbilical power source port are located in the middle of the CanSat.
- USB Type-C cable is used for the umbilical power source



Information

- Commonly used for various devices' charger.
- We can easily access reliable power source.

Payload Power Source (1/2)

Main Battery

Model	Size (mm)	Weight (g)	Type	Voltage (V)	Maximum current (mA)	Capacity (mWh)	Energy density (mWh/g)	Needed quantity	Cost ($)
ZM18650-2600-KC01	18φ x 69	47	Li-ion	3.7	2600	9435	200	1	3.72

Selected Battery		Reasons
	**ZM18650-2600-KC01**	▪ Sufficient maximum current ▪ Sufficient capacity ▪ Integrated fuse ▪ High energy density ▪ Single cell configuration available

Payload Power Source (2/2)

Backup Battery

Battery Holder

Selection

Model	Size (mm)	Type	Voltag e (V)	Capacity (mAh)	Cost ($)	Qty.
CR2032 Coin Cell	20	Lithium metal	3.0	250	2.10	1

Information

- Battery will be mounted in battery holder
- No BMS needed
  Using single cell configuration
  Battery has integrated PCM

Payload Power Budget (1/3)

3.3 V Bus

Category	Component	Operating current	Duty cycl e	Power consumption	Source
Processor	STM32F446RE	50 mA @ Run Mode	2 h	0.33 Wh	datasheet
Sensor	BMP390	195 uA @ 25Hz Std. Mode	2 h	0.0013 Wh	datasheet
Sensor	BNO055	12.3 mA @ Normal Mode	2 h	0.0812 Wh	datasheet
Sensor	SAM-M8Q	29 mA	2 h	0.19 Wh	datasheet
Sensor	XBee3 Pro	135 mA @ 19 dBm	2 h	0.891 Wh	datasheet
Actuator	Buzzer	30mA @ max	2 h	0.198 Wh	datasheet
			Total	1.6915 Wh	

2.2855 Wh / (80% Efficiency) = 2.114 Wh

Payload Power Budget (2/3)

5.0 V Bus

Category	Component	Operation current	Duty cycle	Power consumption	Source
Camera	Quelima SQ11 (2)	80 mA	2h	0.8 Wh	datasheet
Actuator	Sg90 servo (3)	10 mA @ idle	2h	0.1 Wh	datasheet
		250 mA @ operation	5s	0.0017 Wh	datasheet
Sensor	MPXV7002DP	10 mA	2 h	0.1 Wh	datasheet
Memory	Micro SD card	80 mA	2 h	0.8 Wh	datasheet
			Total	1.8017 Wh	

1.8017 Wh / (80% Efficiency) = 2.252 Wh

BAT Bus

Category	Component	Operation current	Duty cycle	Power consumption	Source
Power indicator	LED & Resistor	50mA	2h	0.42 Wh	Typical value
Voltage divider	3K Ohm Resistor	negligible	-	-	calculated
			Total	0.42 Wh	

Payload Power Budget (3/3)

Total energy consumption

Voltage	Electrical energy
3.3 V bus	2.114 Wh
5.0 V bus	2.252 Wh
Directly connected to battery	0.420 Wh
Total	4.786 Wh

Battery: 3.7V * 2550 mAh = 9435 mWh = 9.4 Wh

9.4 – 4.786 = 4.614 Wh margin

(4.614/9.4) * 100(%) = 49.1% margin

Flight Software (FSW) Design

Presented by Myeongsik Jeong

FSW Overview (1/3)

Overview of FSW
The task of FSW is to control the CanSat. CanSat reads the values of the sensors and transmits these values to the GCS. When the CanSat is deployed from the rocket, an aero-braking heat shield will be opened. At 100m, the heat shield is released and the parachute is deployed. Once the payload lands, it will sound a buzzer. A video is recorded during the entire mission, and the recorded video and measured data are stored in SD card and sent to GCS.

Programming languages	Developing Environments
• C/C++	• **STM32cubeIDE** • **XCTU**

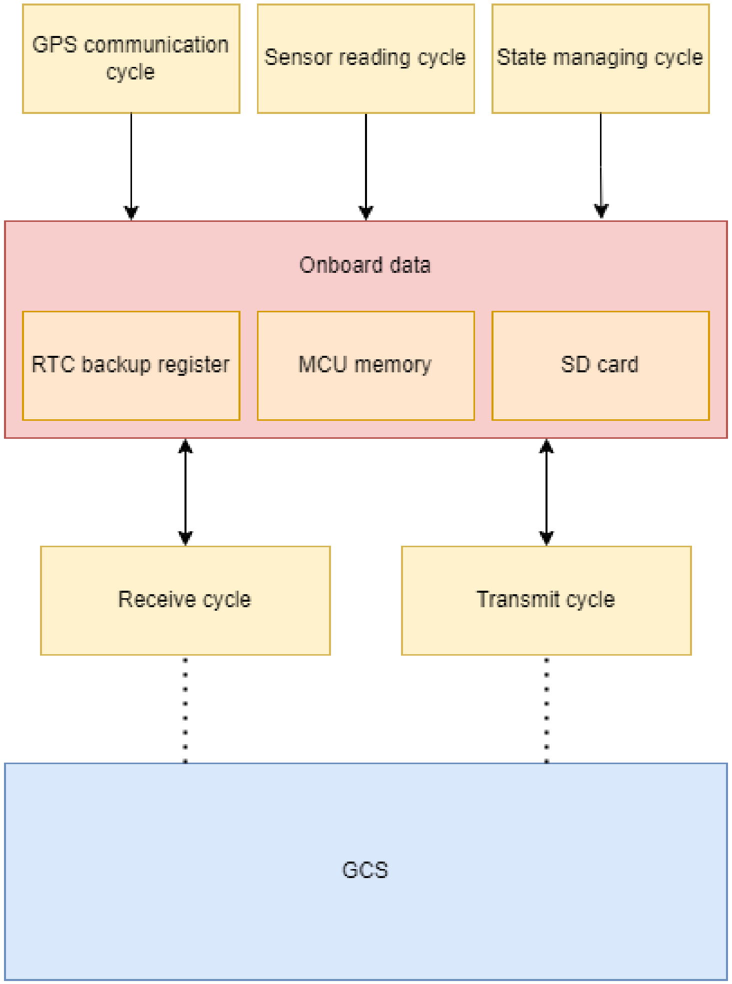
FSW Overview (2/3)

FSW tasks summary

- Sensor calibration
- Measuring the speed of rocket during ascent and of itself during descent using pitot tube
- Release the aero-braking heat shield and simultaneously deploy a parachute
- Capturing the horizontal view during ascent and descent during recording video
- Storing data and video on SD cards
- Communicates and transmits data effectively with GCS
- Stability verification during descent using tilt sensor
- Make data into packets

FSW Overview (3/3)

FSW Architecture



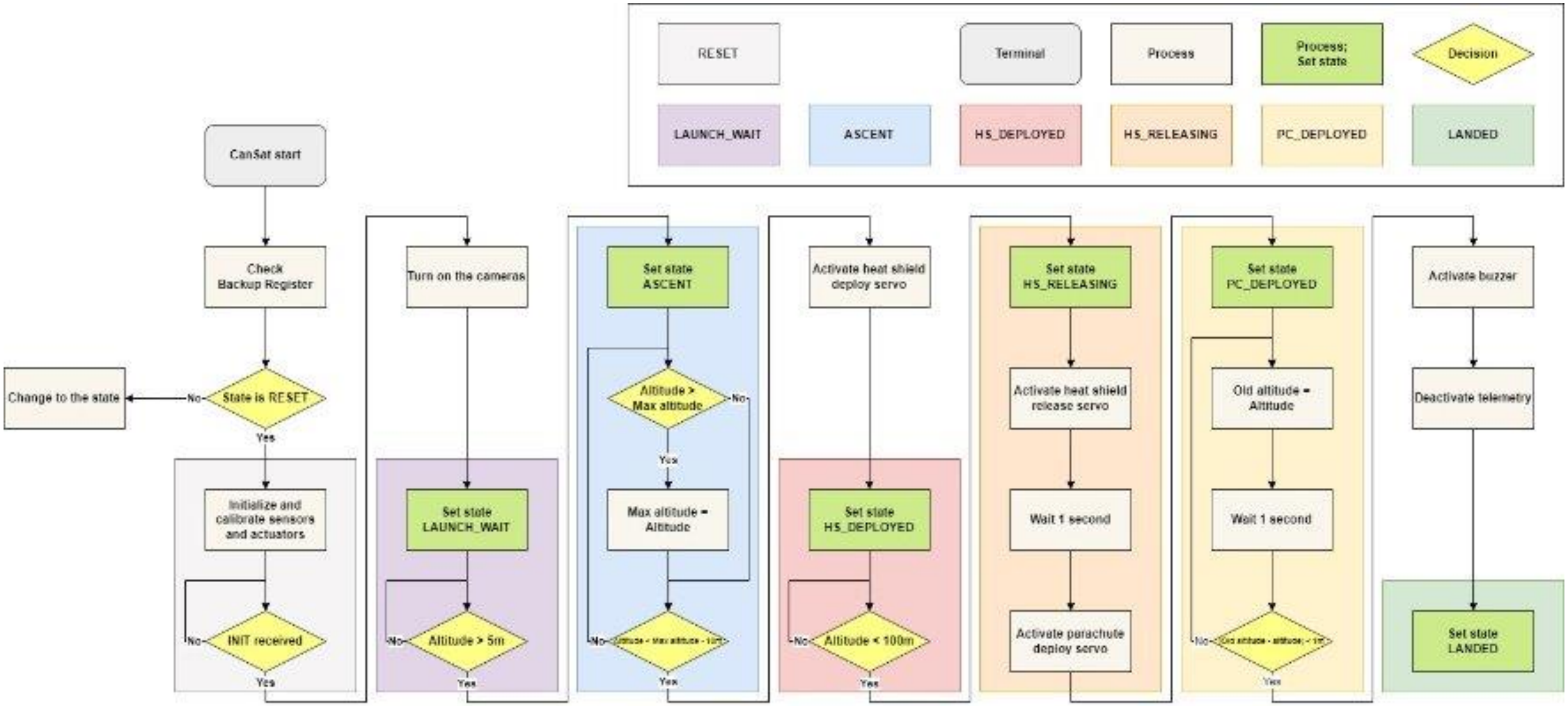
Information

- State managing cycle controls mission progress
- Receive cycle executes commands from GCS
- Transmit cycle activated if CX ON command received and transmits telemetry data 1 Hz
- All cycles operate simultaneously
- RTC backup register maintains data through reset
- Every telemetry data is saved in SD card for backup data
- Unlike in PDR, an additional cycle for communication with the GPS has been added.

FSW Changes Since PDR

Part	PDR FSW	CDR FSW	Rationale
FSW	-	Additional cycle for communication with the GPS	A minor change in the FSW architecture.

Payload CanSat FSW State Diagram (1/2)



Information

- State transitions are determined based on altitudes (calculated from barometeric pressure values) because only pressure data is provided in simulation mode.
- Mechanism, telemetry and camera activation / deactivation occurs through transition or HS_RELEASING state.

Payload CanSat FSW State Diagram(2/2)

Sampling rate	• Sensor data will be sampled as 1 Hz (1000ms)
Data storage	• MCU flash for general data • RTC backup register for mission time, launchpad altitude, packet count and state • SD card for backup telemetry data
Communication	• CanSat always receives commands, but execution depends on status - (e.g.) CanSat will not execute TEST command while flying • CanSat transmits telemetry 1 Hz if CX ON command received

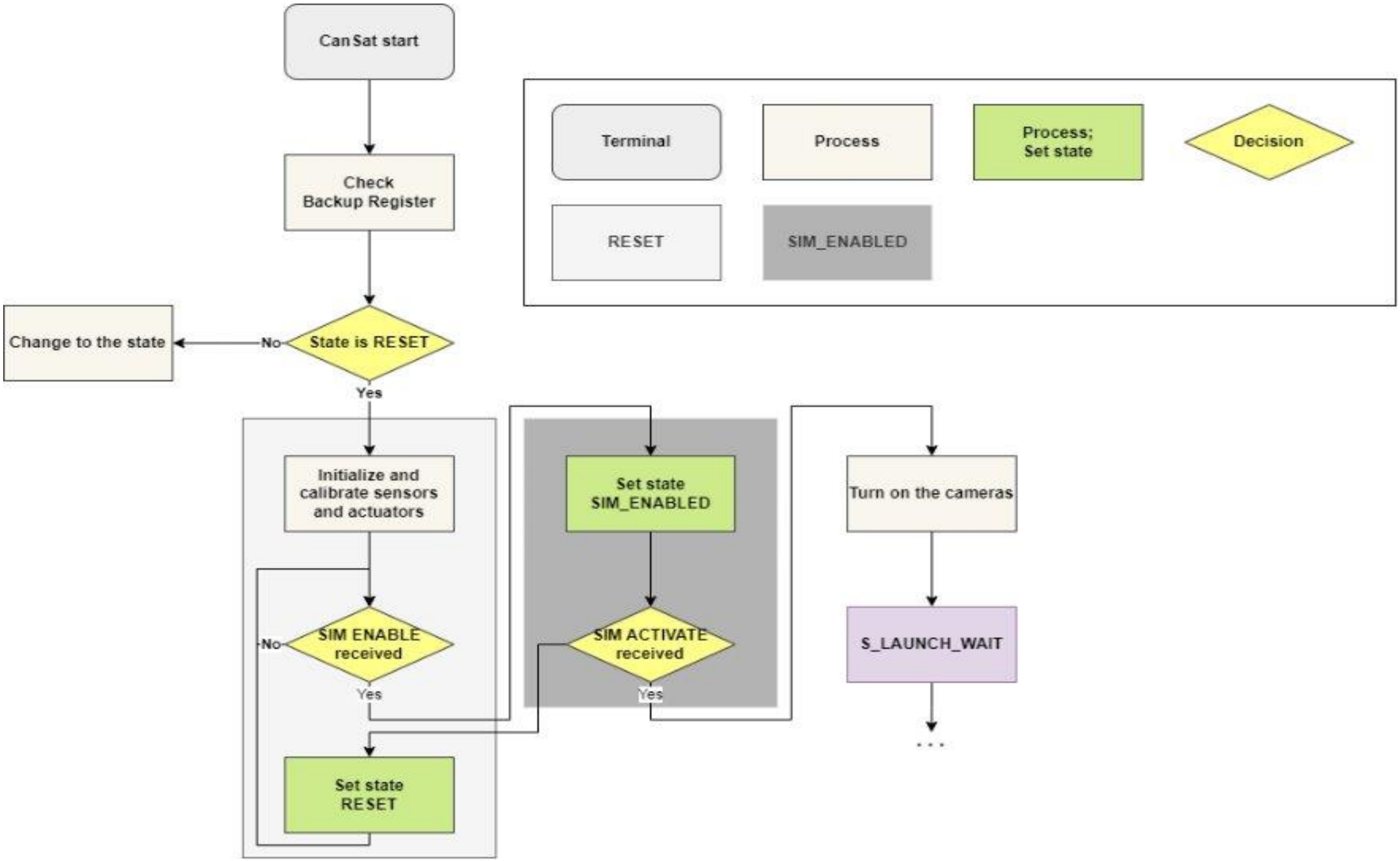
Reset reasons

- RESET command from GCS
- Temporary power loss due to vibration

Reset recovery

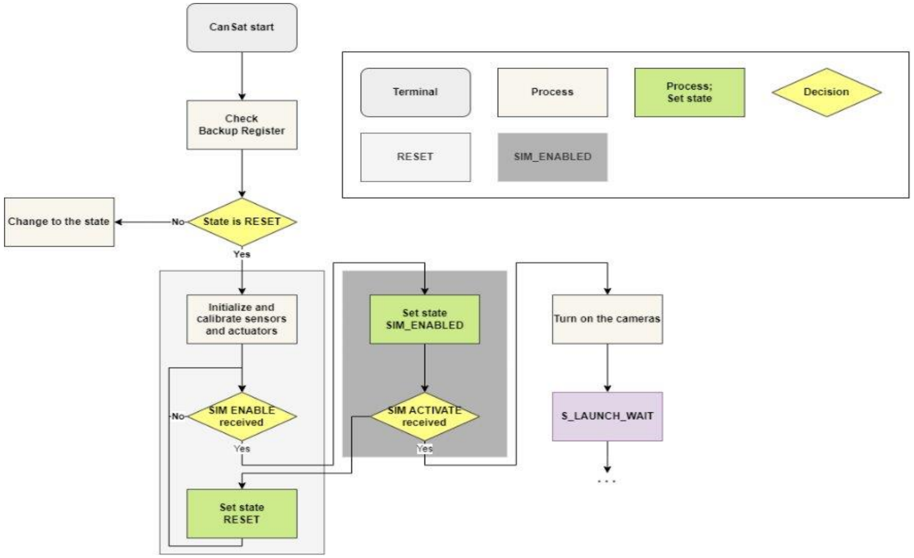
- RTC backup register is not affected by system reset and power loss
- When CanSat restarts, all needed data is read form RTC backup register

Simulation Mode Software (1/3)



Information

- State transitions are determined based on altitudes (calculated from barometric pressure values) because only pressure data is provided in simulation mode.
- Mechanism, telemetry and camera activation / deactivation occurs through transition or HS_RELEASING state
- In simulation mode, the CanSat is operated in the same manner as flight mode
- The CanSat always (even in flight mode) assigns the received SIMP pressure data to a variable that is distinct from the sensor pressure data
- FSW has additional states for simulation mode
- In simulation mode states, CanSat will use received pressure value for altitude calculation instead of sensor pressure data



Simulation Mode Software (3/3)

Simulation Mode Commands

SIM ENABLE	• Enable simulation mode • Available in RESET state only • Change state to SIM_ENABLED
SIM ACTIVATE	• Start simulation mode • Change state to S_LAUNCH_WAIT • Available in SIM_ENABLED state only • Any other command will change state to RESET
SIM DISABLE	• Stop simulation mode • Change state to RESET • Available in any simulation states

Information

- RESET, REL and DEP commands are also available in simulation mode

Software Development Plan

Software development	Test methodology
To understand the entire process, we initially create a FSW state diagram before starting the development. We use Git and GitHub to establish an effective and efficient software development environment.	• Operation of each sensor, data calibration • Prototype free-fall test • Heat shield deployment test • Parachute deployment test • Data transmission and reception test • Flight mode and Simulation mode software test Tests are conducted at the aerospace campus.

Prototyping and prototyping environment	Late software development problem
To prepare for prototyping, we individually test each sensor on the breadboard. Once we confirm the normal operation of each sensor, we integrate them into a custom PCB.	The software team conducts meetings twice a week. If development progress is too slow, collaboration from members of other teams can be requested.

Progress since PDR

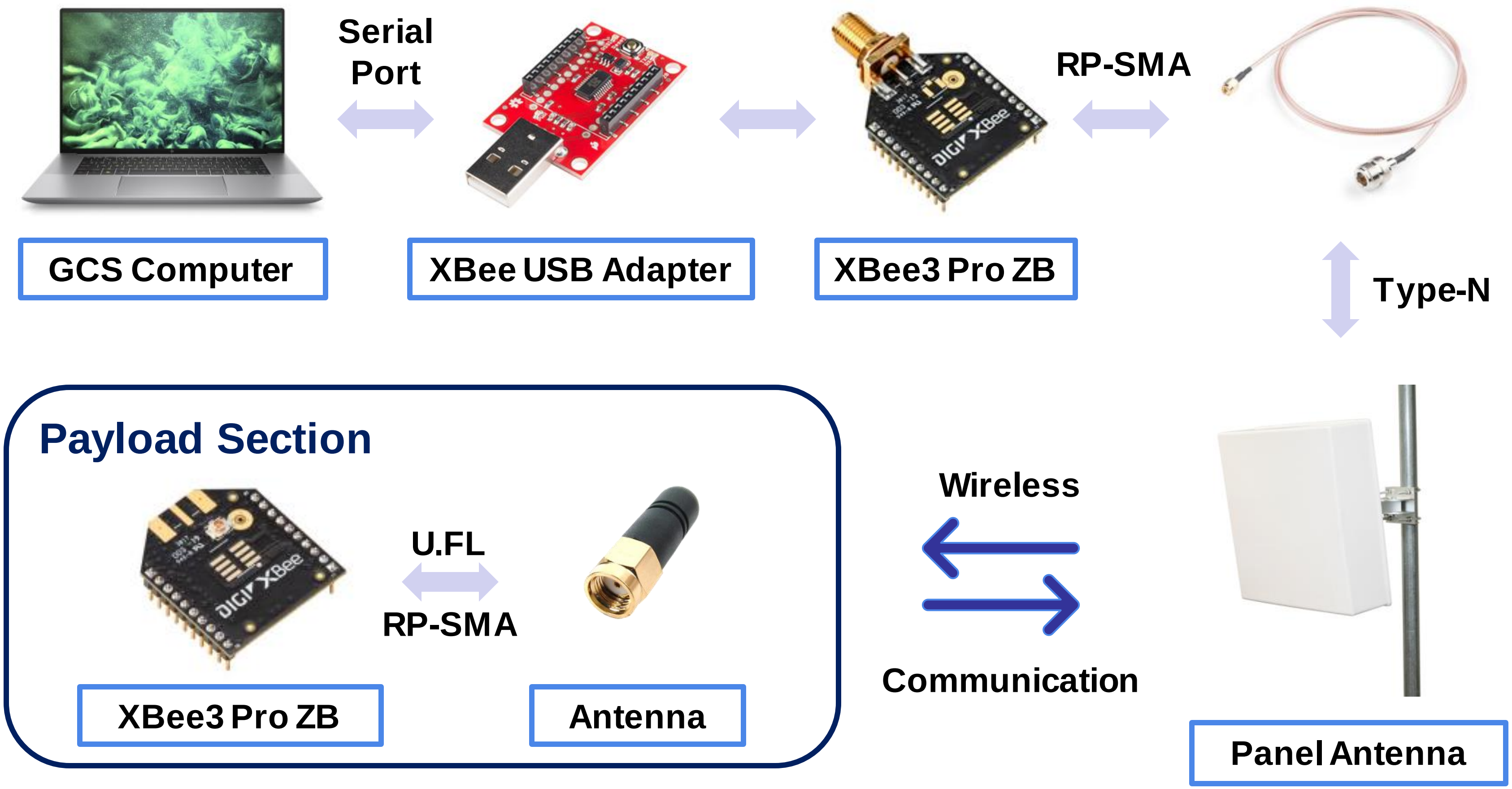
- We have written all the required functions of the sensors.
- All sensor operations were tested.

Development team : Hyungjun Bae, Myungsik Jung, Seungwon Cho

Ground Control System (GCS) Design

Presented by HyungJun Bae

GCS Overview

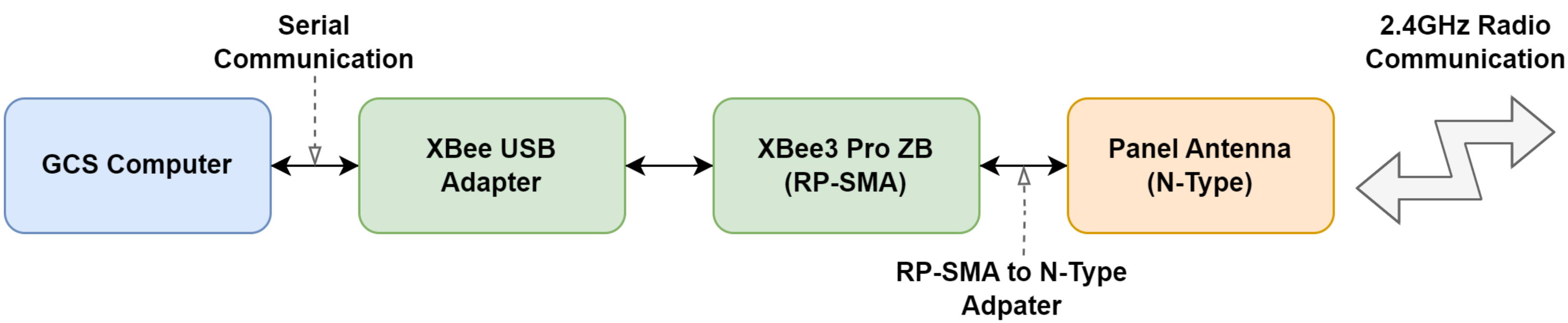


GCS Changes Since PDR

Required	PDR Sensor	CDR Sensor	Rationale
There were no changes to the Ground Control System			

GCS Design

GCS Diagram



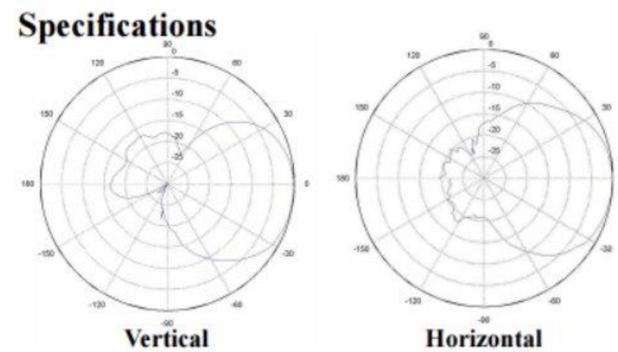
GCS Specifications	
Operation time	The GCS Laptop can operate for over 2 hours on a full charge. A backup portable power bank is available if necessary.
Overheating mitigation	We will use an umbrella to protect from the sun. We also use a laptop that complies with MIL-STD 810 regulations, ensuring its operation at high temperatures.
Auto update mitigation	Automatic updates for Windows will be temporarily paused for two weeks prior to the flight.

*A tripod will be used to track the CanSat.

GCS Antenna (1/2)

Model	Type	Frequency Range(MHz)	Gain (dBi)	Horizontal Width	Vertical Width	Dimension (mm)	Weight (g)	Cost ($)
PM-PP09	Panel	2400-2483	9	65°	64.9°	100x85x30	230	26.17

Selected GCS Antenna	Reasons
	• Cost efficient • Compact size compares to other antennas • Reasonable Gain • Acceptable band width



Antenna Mounting Design	Reasons
Tripod with Handle	• Portability • Requires less effort to control • Small size when folded • Stable control

GCS Antenna (2/2)

Link Budget Calculation

Symbol	Description
P_{TX}	Transmitter output power(dBm)
G_{TX}	Transmitter antenna gain(dBi)
L_{TX}	Transmitter losses(dB)
L_{FS}	Path loss(dB)
L_M	Miscellaneous losses(dB)
G_{RX}	Receiver antenna gain(dBi)
L_{RX}	Receiver losses(dB)
P_{RX}	Received power(dBm)

Symbol	Value
P_{TX}	$19\ dBm$
G_{TX}	$0\ dBi$
L_{TX}	$\approx 0\ dB$
L_{FS}	$106.1\ dB$
L_M	$15\ dB$ (Fade Margin)
G_{RX}	$9\ dB$
L_{RX}	$1dB$ (Approx.)

Free Space Path Loss(FSPL) Equation

$$L_{FS}(dB) = 20\log_{10}\left(4\pi \frac{distance}{wavelength}\right)$$

$$L_{FS} = 20\log_{10}\left(4\pi \frac{2000\ m}{0.125\ m}\right) = 106.1dB$$

※ Distance with margin

Radio Configuration

$$f = 2.4GHz$$

$$\lambda = \frac{c}{f} \approx \frac{3 \times 10^8\, m/s}{2.4 \times 10^9 s^{-1}} = 0.125\ m$$

Link Budget Equation

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

$$P_{RX} = 19 + 0 - 0 - 106.1 - 15 + 9 - 1 = -94.1\ dBm$$

Feature	Value
Received Power	$P_{RX} = -94.1\ dBm$
Xbee Receiving Sensitivity	$-103\ dBm$ (normal mode)
Link Budget Margin	$8.9\ dBm$

Maximum Distance Estimation

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

$$distance = 10^{\left(\frac{L_{FS}}{20}\right)} \times \frac{wavelength}{4\pi}$$

$$L_{FS} = 19 + 0 - 0 - 15 + 9 - 1 + 103 = 115\ dBm$$

$$distance = 10^{\frac{115}{20}} \times \frac{0.125}{4\pi} = 5593.7m$$

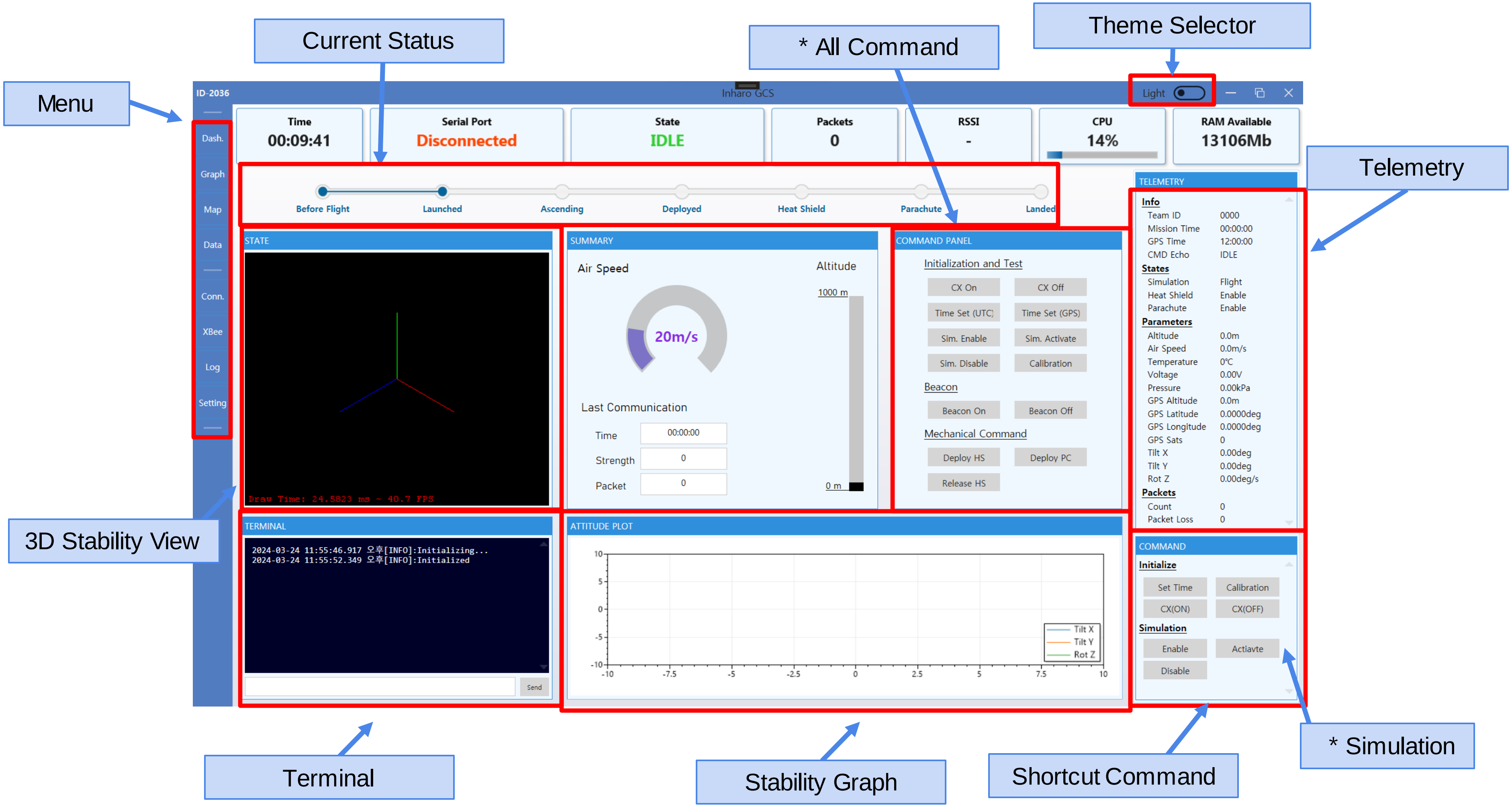
<u>Communication signals can be received.</u>

GCS Software (1/5)

Commercial off the shelf(COTS) software package used	•**IDE** : Visual Studio 2022 Community (C# .Net Core / WPF) •**XBee Configuration** : XCTU(provided by Digi) •**Other Libraries** : ScottPlot(plotting), GMap(map), MahApps(UI), XBee.Core
Real-time plotting software design	The GCS program will store telemetry data received from the serial port and visualize it in real-time using the ScottPlot library. All numerical telemetry data can be plotted.
Command software and interface	All commands are arranged into a single panel and can triggered by simply clicking the provided buttons, which sends command strings to the XBee module through the serial port. The program also supports manual commanding using the terminal.
Telemetry data recording and media presentation	When the program is started, all received telemetry data will be stored within the program. The GCS program also automatically saves the data to prevent unexpected termination, and the data from the CanSat can be presented through a plot, table or map.
Description of .csv telemetry file creation	Once the CanSat has landed, the telemetry data strings are saved as .csv file onto the provided USB memory stick, complying with the telemetry and csv file format. The file name will be 'Flight_2036.csv'.
Simulation mode	To activate simulation mode, send 'SIM_ENABLE' and 'SIM_ACTIVATE' commands sequentially located on the GCS command panel. Afterwards, the GCS will automatically read lines from the sam ple profile file using the 'StreamReader' class in C# and transmit simulated barometric pressure data to the CanSat at 1Hz, compliant with the command data format. (ex. "CMD,2036,SIMP,101325")
Progress since PDR	- A demonstration of receiving telemetry data from the XBee module was conducted. - Simulation mode was tested. - Minor changes to the UI have been made.

GCS Software (2/5)

※ When command buttons are pressed, the command will be sent to the XBee through the serial port.



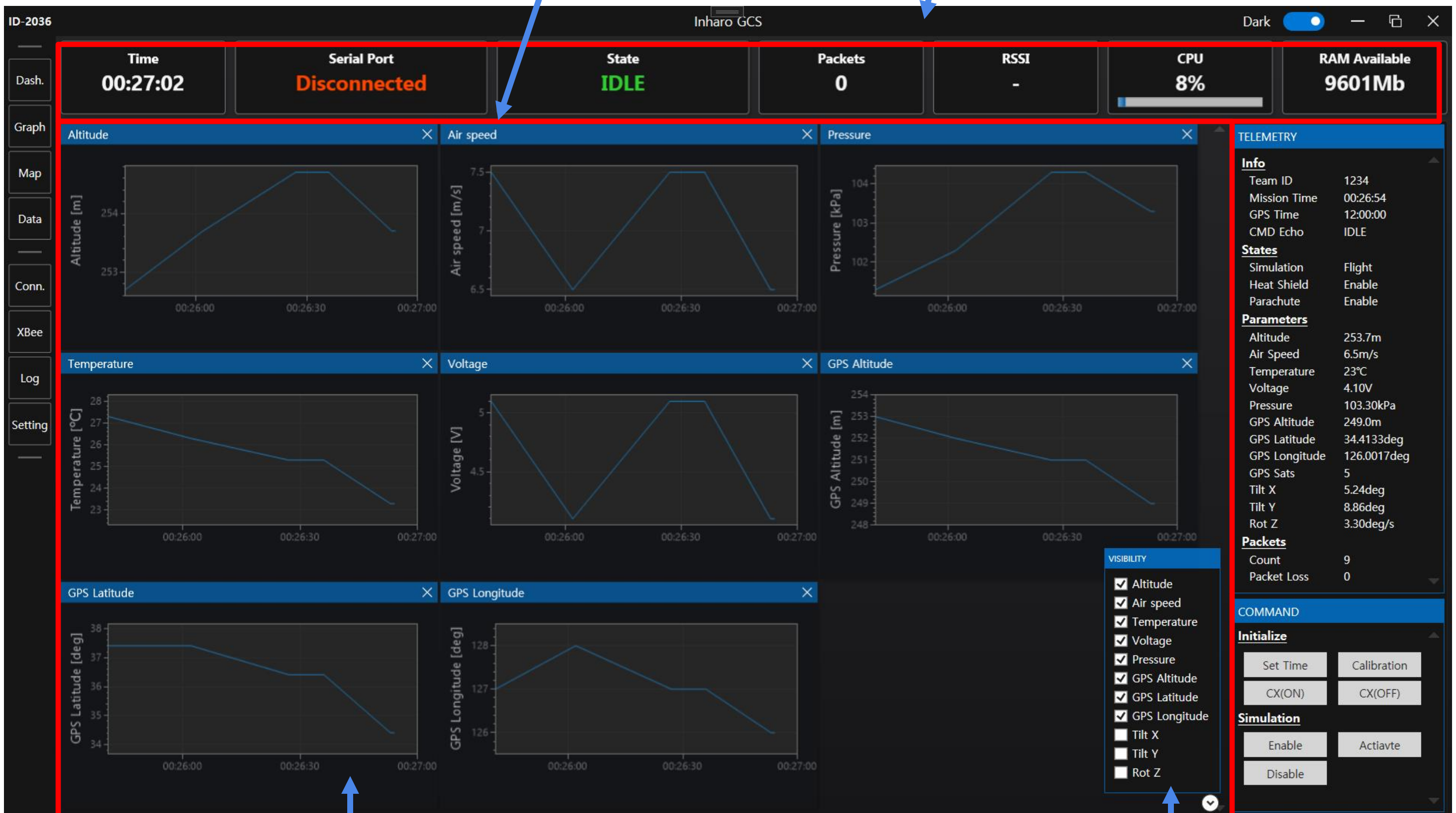
※ Simulation data file will be automatically loaded when the file is located in the same directory of the program.

GCS Software (3/5)

Real-Time Plot

Information Bar

※ Dark theme is also supported



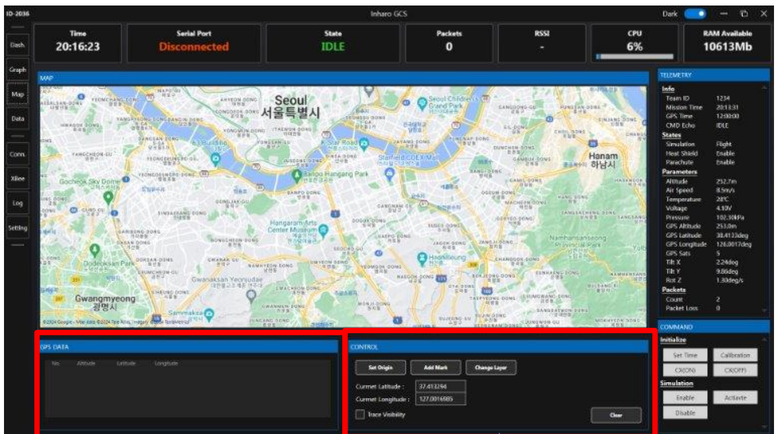
Display with engineering unit

Plot Selector

※ All numerical telemetry data can be plotted.

GCS Software (4/5)

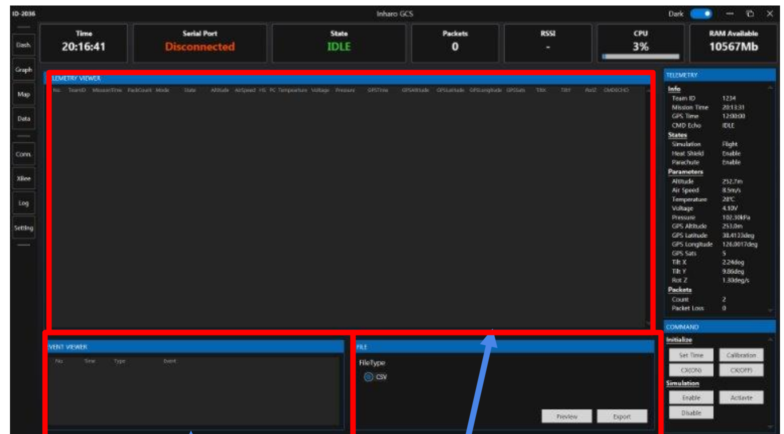
Map Viewer(GPS)



GPS Data Table

Map Control

Telemetry Viewer



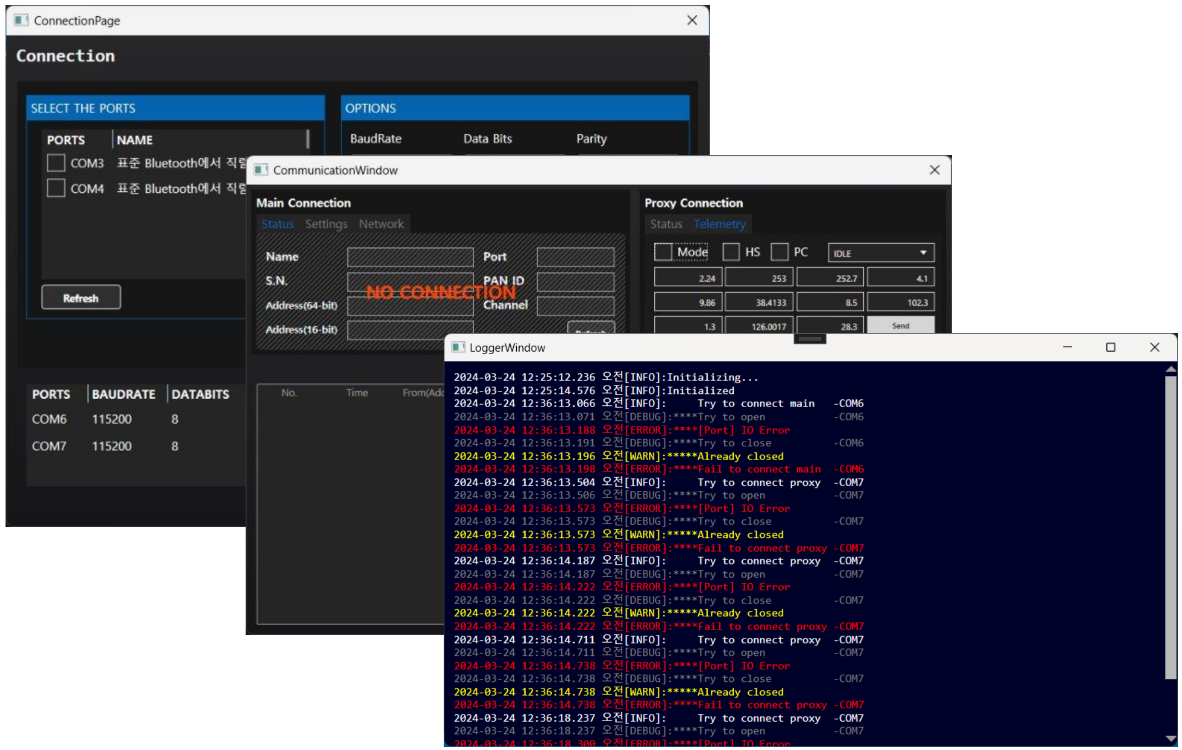
Command/Event Table

Telemetry Data Table

Export File(CSV)

GCS Software (5/5)

Connection, Communication and Logger Windows



CanSat Integration and Test

Presenter Se-eun Koo

CanSat Integration and Test Overview

Plan	description	test
Subsystem Level Testing Plan	• In this Subsystem Level Testing plan, we test the individual component of CanSat operate well.	• Sensors • CDH • EPS • Radio communications • FSW • Mechanical • Descent Control
Integrated Level Functional Test Plan	• In this Integrated Level Functional Test plan, we integrate the components, and test the mechanism of the CanSat operate well.	• Descend testing • Communications • Mechanisms • Deployment
Environmental Test Plan	• In this Environmental Test plan, we test the durability of CanSat by referring to the CanSat Mission Guide 2024 file.	• Drop test • Thermal test • Vibration test • Fit check • Vacuum test
Simulation Test Plan	• In this Simulation Test Plan, we test the simulation mode and verify the operation of the CanSat using the pseudo barometric data.	• Simulation Test

Subsystem Level Testing Plan(1/3)

#	Sub system	Component	Test Plans	Pass requirement
1	**Sensors**	BMP390 (Air Pressure)	• Compare measuring altitude location with known altitudes.	• Sensors compared by other measurement tools and check the sensors operate correctly.
		BMP390 (Air Temperature)	• Compare measured temperature with thermometer.	
		MPXV7200DP (Differential Pressure)	• Compare measured speed to speed obtained from GPS and IMU sensors.	
		BNO055 (IMU)	• Compare measured tilt angle to actual tilt angle. • Test error level of IMU drift.	
		SAM-M8Q (GPS)	• Compare measured location with known location.	
		Voltage ADC	• Compare measured voltage with voltmeter value.	

Subsystem Level Testing Plan(2/3)

#	Sub system	Test Plans	Pass requirement
2	CDH	• Test the operation of STM 32F446. • Test whether the SD card module data is stored or not. • Transmit telemetry data and command format to verify communication.	• Cansat should operate correctly while handling the data.
3	EPS	• Test lithium-ion battery charging and discharging. • Test regulator operation (3.3 V, 5.0 V). • Test auxiliary battery operation. • Measure current consumption and test battery operation time.	• System can operate over 2 hours.
4	Radio Communi cations	• XBee3 Pro set up and confirmation of transmission and reception. • Test antenna sensitivity. • Test communication at a distance of 700m or more.	• Cansat can communicate at a distance of 700m or more.

Subsystem Level Testing Plan(3/3)

#	Sub system	Test Plans	Pass requirement
5	**FSW**	• Verify the state change algorithm. • Receiving microprocessor commands and verifying command processing. • Test the reset tolerance.	• Cansat should handle the commands and data • Cansat must hold its state when reset occurs
6	**Mechanical**	• Test the operation of the servo motor and check the deployment. • Check the structural reliability by applying force to the hinges or critical parts. • Verify the electrical parts mounting, such as battery, auto-gyro and sensors.	• Each actuator operates correctly • No structural fails occur
7	**Descent Control**	• Test the operation of the servo motor and check the de ployment. • Verify the parachute and the heat shield mechanism.	• Successfully deploy and release the descent control system

Integrated Level Functional Test Plan

#	System	Test Plans	Pass requirement
1	**Descend testing**	• The CanSat is lifted to an altitude of 100m using a drone and then ejected.	• The heat shield and parachute deployment, and the heat shield separation happen at a predetermined altitude. • Ensure the egg container can safely protect the egg without any damage.
2	**Communications**	• Test communication at a distance over 1000m. • Test the Antenna position. • Measure the telemetry packet loss and received signal strength. • All command will be tested.	• The CanSat communicates well with the ground station at a distance over 1000m using antenna. • The Ground control software must accurately display received telemetry and successfully send all commands.
3	**Mechanisms**	• Test the servo motor operation. • Test the parachute deployment. • Test the heat shield deployment. • Test the mechanism for releasing triggers.	• The CanSat releases the heat shield and deploys the heat shield and the parachute at a predetermined altitude. • The servo motors operate well through entire flight. • No structural issues should occur at all. • There are no issues to release the triggers.
4	**Deployment**	• Test the parts that deploy parachute and heat shield.	• Ensure that the deployment of the heat shield and parachute is on time.
5	**Simulation**	• Test the simulation mode procedure after receiving two simulation commands. (SIM_ENABLE and SIM_ACTIVATE)	• Ensure the command is handled well. • Verify that simulation data can be received.

Environmental Test Plan

#	Test	Test Plans
1	**Drop test**	• The goal of drop test is to ensure that the CanSat endures about 30 Gs of shock. • Use a 61cm non-stretching cord and an eye bolt to test the CanSat. • Test the power supply and connection of the CanSat in this situation and ensure that there is no damage to the CanSat parts.
2	**Thermal test**	• The goal of thermal test is to ensure that the CanSat endures hot temperatures. • Keep the CanSat insulated and maintained 2 hours at 60 degrees Celsius using a hair dryer. In this process, check whether the parts of the CanSat are working well.
3	**Vibration test**	• The goal of vibration test is to ensure that the CanSat endures the vibrations of the rocket and by air resistance. • Put the CanSat into an orbital sander, and check that accelerometer data is being collected. After operating the sander, ensure that there is no damage to the CanSat parts.
4	**Fit Check (Dimension verification)**	• The goal of the fit check is to ensure that the CanSat fits into the rocket. • We will check the CanSat parts connected each other strongly.
5	**Vacuum test**	• The goal of vacuum test is to ensure that the CanSat endures the changing of air pressure. • We will make vacuum chamber and use it for testing the parts of the CanSat to see if they work well even under the changed air pressure.

Test Procedures Descriptions (1/4)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
1	Air Pressure Sensor Test	45	The CanSat shall measure its altitude using air pressu re with a resolution of 0.1m.
2	Air Temperature Sensor Test	46	The CanSat shall measure its internal temperature in degrees Celsius with a resolution of 0.1degrees.
3	Differential Pressure Sensor Test	44	The CanSat shall measure its speed with a pitot tube during ascent and descent in meters per second.
4	IMU Sensor Test	47,48	The CanSat shall measure its angle stability in degrees with a resolution of 0.01 degrees and rotation in degrees per second with a resolution of 0.1 degrees
5	GPS Sensor Test	43	The CanSat shall measure time[1s], altitude[0.1m], latitude[0.0001 degrees], longitude[0.0001 degrees] and number of satellites from the GPS receiver.
6	Battery Voltage Sensor Test	49	The CanSat shall measure the voltage of the Cansat power bus with a resolution of 0.1 volts.
7	Camera Operation Test	50,51,52	Video taken with the camera module shall be properly recorded with a minimum resolution of 640x480 pixels and a minimum of 30 frames per second during flight.

Test Procedures Descriptions (2/4)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
8	Microprocessor and Memory Test	-	Reset recovery algorithm must be performed when hardware reset occurred.
9	Telemetry and Command Test	43,55	Telemetry and command formats must be followed.
10	Power Supply and Consumption Test	36,37,38	The CanSat supplies stable 3.3V and 5.0V power and operates for more than 2 hours.
11	ESI/EMS Test	-	The CanSat shall operate under an overvoltage and reverse polarity condition.
12	Xbee communication Test	40,41,42	The CanSat and ground station can communicate without interference.
13	Antenna Range Test	-	The CanSat communicates well with ground station at a distance over 1000m.
14	FSW State Transition Test	6,7,53,56	The Nose cone, heat shield and parachute must deploy in a predetermined state. When a hardware reset occurred, it must recover the previous state.
15	GCS Operation Test	54,58,59, 60,61,63, 64,65,66, 67,68	The ground control software should be bug-free and capable of recording telemetry data for more than 2 hours.

Test Procedures Descriptions (3/4)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
16	Structural Strength Test	31	The CanSat shall withstand approximately 30 Gs of shock, operate without power loss and avoid structural damage.
17	Structural Stability Test	21,22,23, 26,27	After deployment of the heat shield and parachute,rotation and tumbling of the CanSat must be controlled.
18	Servo Operation Test	26	Servo motor operates correctly when control signal transmitted to the servo.
19	Heat Shield Deployment Test	3,28,29	The CanSat shall open an aero-braking heat shield and its descent rate shall be between 10 to 30 meters/sec.
20	Parachute Deployment Test	5	At an altitude of 100 meters, the probe shall release the aero-braking heat shield and simultaneously deploy a parachute to reduce the descent rate to less than 5 meters/sec.
21	Nose Cone Deployment Test	1,14,15, 16,17,20, 33	The nose cone portion shall descend at less than 10 meters/second when it deployed.

Test Procedures Descriptions (4/4)

Test Proc	Test Description	Rqmts	Pass Fail Criteria
22	Simulation Mode Test	63	Simulation mode shall be activated and disactivated by command.
23	Simulation Data Processing Test	64	Simulated pressure data must be processed.
24	Drop Test	19	The CanSat shall withstand approximately 30 Gs of shock, operate without power loss and avoid structural damage.
25	Thermal Test	-	Heat the Cansat to 60℃ for a period of 2 hours and verify that they continue to function.
26	Vibration Test	18	Put the CanSat into an orbital sander, and check that accelerometer data is being collected. After operating the sander, ensure that there is no damage to the CanSat parts.
27	Fit Check	21	Ensure that the CanSat fits into the rocket
28	Vacuum Test	-	Make vacuum chamber and use it for testing the parts of the CanSat to see if they work well even under the changed air pressure

Simulation Test Plan

Information

- CanSat enters simulation mode when it sequentially receives SIM_ENABLE and SIM_ACTIVATE commands from GCS.
- In simulation mode, the ground station reads the barometric pressure data file and sends it to the CanS at using SIMP command.
- In simulation mode, the CanSat performs its mission as if it were actually flying based on the correspon ding air pressure data. At this time, the pressure data received from the Ground station is used.
- State progression is based on altitude calculated from actual or simulated pressure data.

```
if (is_simulation(state)){
  altitude = calculate_altitude(simulated_pressure);
}

else {
  altitude = calculate_altitude(actual_pressure);
}
```

Mission Operations & Analysis

Presenter Se-eun Koo

Overview of Mission Sequence of Events(1/2)

During the launch process, we assign roles to team members. There is one mission control officer and three sub-teams: CanSat team, Recovery team, and Ground Station team.

Mission Control Officer	CanSat Team	Recovery Team	Ground Station Team
• Se-eun Koo	• SeungWon Cho • JungHyuk Lee • DongWoo Cho • JunHyeok Lee	• HyeWon Shin • SeongEun Jin	• HyungJun Bae • SeokHyeon Hwang • Myeongsik Jeong

Overview of Mission Sequence of Events(2/2)

Mission Sequence	description	Team
Arrival	• All teams arrive at the launch site.	All
Pre – Launch	• The CanSat team assemble the CanSat and prepare to launch the CanSat on the launch site. • The ground station team set up the ground station and construct Antenna. • The Cansat team assemble and test the CanSat.	CanSat Team Ground Station Team
Launch	• The CanSat team turn on the CanSat and take the CanSat on the launch pad. • The ground station team check the connection to the CanSat.	CanSat Team Ground Station Team
Flight	• The ground station team monitor the CanSat.	Ground Station Team
Recovery	• The recovery team recover the CanSat.	Recovery Team
Data Analysis	• The Ground station team receive and verify telemetry data file. • The Ground station team analysis data. • The Ground station team deliver the ground station data to the ground station judge by thumb drive.	Ground Station Team

Field Safety Rules Compliance

Section Name	Content
Ground Station Configuration	• Set up PC laptop and antenna. • Ensure the communication to the CanSat.
CanSat Preparation	• Check the battery charge. • Check if the sensor is operating. • Put an egg into the container of the CanSat.
CanSat Integration	• Integrate the CanSat into the rocket and verify functionality.
Launch Preparation	• Prepare for launch in accordance with the detailed description in the mission guide.
Launch Procedures	• Launch the CanSat in accordance with the detailed description in the mission guide.

Development Status

- MOM template has been downloaded from the CanSat website and development has begun.
- Will be filled in further as changes are encountered leading up to the Flight Readiness Review.
- MOM will include not only a step-by-step checklist, but also individual time-based tasks in the Appendix.
- Each member of the team will receive a copy of the MOM with the field safety rules on launch day for reference.

CanSat Location and Recovery

CanSat Recovery Plan

The Recovery Team will do the CanSat recovery project.

Using the CanSat's GPS, the location of the CanSat is determined.

And the CanSat's buzzer is used to help recovery by making a buzzing sound.

The recovery team finds the CanSat using this location and buzzer, and recovers the CanSat.

The color of the CanSat is White and the color of the parachute is Pink.
It helps when finding the CanSat.

The heat shield is recovered by the recovery team.
The color of the heat shield is Pink.
It is the important to find the heat shield.

The CanSat and the heat shield will be labeled about Team name, team contact number, team contact e-mail.

Team name : Inharo
Team contact number : +8210-8269-2288
Team contact e-mail : i12210436@inha.edu

Mission Rehearsal Activities

Procedures	description
Ground system radio link check procedures	• We construct the Antenna and set up the Ground station and check the communication.
Powering on/off the CanSat	• We check the battery of CanSat and turn on the power of the CanSat.
Launch configuration preparations	• We assemble the CanSat and test the mechanism operate well and sensors.
Loading the CanSat in the launch vehicle	• We check the communication with CanSat and stowed the CanSat into the rocket.
Telemetry processing, archiving, analysis	• We check the telemetry data from CanSat and analysis the data.
Recovery	• We determine the location of CanSat by it's buzzer, color and GPS.

Currently, no rehearsals except for partial testing have been conducted. Since there is no rocket available for rehearsal, rehearsal will be carried out simultaneously during the descending test.
This is scheduled for May 4th.

Requirements Compliance

Presenter Se-eun Koo

Requirements Compliance Overview

We comply with 70 requirements listed in CanSat mission guide 2024.

There are 3 requirements that partially complied.

Most of the requirements have been met, and environmental and descent tests will be performed later.

→ **comply**

→ **partial compliance**

→ **no comply**

Requirements Compliance(1/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	The CanSat shall function as a nose cone during the rocket ascent portion of the flight.	**Comply**	20	
2	The CanSat shall be deployed from the rocket when the rocket motor ejection charge fires.	**Comply**	20, 26	
3	After deployment from the rocket, the CanSat shall deploy its heat shield/aerobraking mechanism.	**Comply**	20, 40	
4	A silver or gold mylar streamer of 50 mm width and 1.5 m length shall be connected to the CanSat and released at deployment. This will be used to locate and identify the CanSat.	**Comply**	23	
5	At 100 m, the CanSat shall deploy a parachute and release the heat shield.	**Comply**	40	
6	Upon landing, the CanSat shall stop transmitting data.	**Comply**	102	
7	Upon landing, the CanSat shall activate an audio beacon.	**Comply**	102	
8	The CanSat shall carry a provided large hens egg with a mass range of 51 to 65 g	**Comply**	68	

Requirements Compliance(2/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
9	0 altitude reference shall be at the launch pad.	Comply	86	
10	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	Comply	53,54	
11	At 100 m, the CanSat shall have a descent rate of less than 5 m/s.	Comply	51,52	
12	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost of the CanSat. Equipment from previous years shall be included in this cost, based on current market value.	Comply	156 - 160	
13	The CanSat mass shall be 900 g +/- 10 g without the egg being installed.	Comply	72 - 76	
14	Nose cone shall be symmetrical along the thrust axis.	Comply	26, 44-46	
15	Nose cone radius shall be exactly 71 mm	Comply	25, 26	
16	Nose cone shoulder radius shall be exactly 68 mm	Comply	25, 26	

Requirements Compliance(3/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
17	Nose cone shoulder length shall be a minimum of 50 mm	**Comply**	25, 26	
18	CanSat structure must survive 15 Gs vibration	**Partial**	71	To be tested
19	CanSat shall survive 30 G shock.	**Partial**	71	To be tested
20	The CanSat shall perform the function of the nose cone during rocket ascent.	**Comply**	20, 21	
21	The rocket airframe can be used to restrain any deployable parts of the CanSat but shall allow the CanSat to slide out of the payload section freely.	**Comply**	20, 58	
22	The rocket airframe can be used as part of the CanSat operations.	**Comply**	20, 58	
23	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	**Comply**	69	
24	No pyrotechnical or chemical actuators are allowed.	**Comply**	22, 23	

Requirements Compliance(4/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
25	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	**Comply**	21-23	
26	All mechanisms shall be capable of maintaining their configuration or states under all forces.	**Partial**	71	To be tested
27	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	**Comply**	21-23, 55	
28	The CanSat shall deploy a heat shield after deploying from the rocket.	**Comply**	40,102	
29	The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.	**Comply**	40	
30	At 100 m, the CanSat shall release a parachute to reduce the descent rate to less than 5 m/s.	**Comply**	40	
31	The CanSat shall protect a hens egg from damage during all portions of the flight.	**Comply**	68	
32	If the nose cone is to be considered as part of the heat shield, the documentation shall identify the configuration.	**Comply**	20-22	

Requirements Compliance(5/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
33	After the CanSat has separated from the rocket and if the nose cone portion of the CanSat is to be separated from the rest of the CanSat, the nose cone portion shall descend at less than 10 m/s using any type of descent control device.	**Comply**	41	
34	Lithium polymer batteries are not allowed.	**Comply**	95	
35	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**	95-96	
36	Easily accessible power switch is required	**Comply**	101	
37	Power indicator is required	**Comply**	93	
38	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	**Comply**	104-106	
39	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	**Comply**	84	
40	XBEE radios shall have their NETID/PANID set to their team number.	**Comply**	84	

Requirements Compliance(6/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
41	XBEE radios shall not use broadcast mode.	**Comply**	84	
42	The CanSat shall transmit telemetry once per second.	**Comply**	106	
43	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, CanSat tilt angles, air speed, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	**Comply**	87	
44	CanSat shall measure its speed with a pitot tube during ascent and descent.	**Comply**	61	One pitot tube passes through both nose cones.
45	CanSat shall measure its altitude using air pressure.	**Comply**	28	
46	CanSat shall measure its internal temperature.	**Comply**	28	
47	CanSat shall measure its angle stability with the aerobraking mechanism deployed.	**Comply**	28	
48	CanSat shall measure its rotation rate during descent.	**Comply**	28	

Requirements Compliance(7/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
49	CanSat shall measure its battery voltage.	**Comply**	33	
50	The CanSat shall include a video camera pointing horizontally.	**Comply**	37-38	
51	The video camera shall record the flight of the CanSat from launch to landing.	**Comply**	66	Camera Window exists
52	The video camera shall record video in color and with a minimum resolution of 640x480.	**Comply**	37-38	
53	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	**Comply**	114-115	
54	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	**Comply**	117	
55	Telemetry shall include mission time with 1 second or better resolution.	**Comply**	85	
56	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	**Comply**	103	

Requirements Compliance(8/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
57	Each team shall develop their own ground station.	**Comply**	111-121	
58	All telemetry shall be displayed in real time during descent on the ground station.	**Comply**	115	
59	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) and the units shall be indicated on the displays.	**Comply**	117	
60	Teams shall plot each telemetry data field in real time during flight.	**Comply**	115	
61	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	**Comply**	111	
62	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**	114	
63	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	**Comply**	115	

Requirements Compliance(9/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
64	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.	**Comply**	115-116	
65	The ground station shall use a table top or handheld antenna.	**Comply**	114	
66	Because the ground station must be viewed in bright sunlight, the displays shall be designed with that in mind, including using larger fonts (14 point minimum), bold plot traces and axes, and a dark text on light background theme.	**Comply**	117	
67	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	**Comply**	115	
68	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**	83	

Requirements Compliance(10/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
69	The CanSat shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	**Comply**	89	
70	The CanSat shall have its time set to within one second UTC time prior to launch.	**Comply**	86	
71	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	**Comply**	115	
72	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	**Comply**	105-106	
73	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	**Comply**	107	

Management

Presenter Se-eun Koo

Status of Procurements(1/3)

Parts with a long delivery period due to overseas delivery were purchased **first (January 4, 2024)** before PDR, and parts needed for CDR and prototyping were purchased **secondarily (March 19, 2024)**. Additional expenditures planned are for **PCB production and environmental testing, which are planned for the second week of April.**

Component	Quantity	Status	Ordered date	Received date
Digi XBee3 PRO	1	received	24/01/04	24/01/11
Adafruit BMP390	1	received	24/01/04	24/01/10
Adafruit 9-DOF IMU BNO055	1	received	24/01/04	24/01/11
Sparkfun GPS SAM-M8Q	1	received	24/01/04	24/01/10
Sandisk Ultra microSD card 32GB	3	received	24/01/04	24/01/07
Pitot tube	1	received	24/01/04	24/01/07
PLA+ Filaments	2	received	24/01/04	24/01/07
Servo motor SG90	4	received	24/01/04	24/01/07
Spring set	1	received	24/01/04	24/01/07
parachute polyester fabric	2	received	24/01/04	24/01/07
MTS-102 toggle	1	received	24/01/04	24/01/07
1/4W 1% Resistance kit	1	received	24/01/04	24/01/07
BSS138	10	received	24/01/04	24/01/07

Status of Procurements(2/3)

Component	Quantity	Status	Ordered date	Received date
PCB Support Metal M-10 mm	10	received	24/01/04	24/01/07
General LED 6 types kit	1	received	24/01/04	24/01/07
Eyebolt M10	2	received	24/01/04	24/01/07
MicroSD Card Socket Module	1	received	24/01/04	24/01/07
Lithium Battery	1	received	24/01/04	24/01/08
Battery Holder	1	received	24/01/04	24/01/07
Battery charging module	1	received	24/01/04	24/01/07
SM-1205C Buzzer	1	received	24/01/04	24/01/06
DC/DC conversion module	1	received	24/01/04	24/01/07
Step-Up/Step-Down Voltage Regulator	1	received	24/01/04	24/01/07
100 x 160 Substrate	2	received	24/01/04	24/01/07
PCB Support Metal F-20 mm	10	received	24/01/04	24/01/07
Siretta delta 20	1	received	24/01/04	24/01/07

Status of Procurements(3/3)

Component	Quantity	Status	Ordered date	Received date
Instantaneous adhesive	2	received	24/01/04	24/01/07
Solder Week FR150-86	1	received	24/01/04	24/01/07
Refill type flux pen container	1	received	24/01/04	24/01/07
Refill brush	1	received	24/01/04	24/01/07
Open circuit for 3 color jumper	1	received	24/01/04	24/01/07
Stainless steel round head cross bolt M2x8	100	received	24/01/04	24/01/07
Nut_M2	100	received	24/01/04	24/01/07
Pinheader Single 1x40Pin Straight(2.54mm)	2	received	24/01/04	24/01/07
Double-sided silicone tape	1	received	24/01/04	24/01/07
Transparent PVC plate	1	received	24/01/04	24/01/07
Indicator module	1	received	24/03/19	24/03/22
sq11 mini camera	2	received	24/03/19	24/03/22
Differential pressure sensor MPXV7002DP	1	received	24/03/19	24/03/24
STM32 NUCLEO-F446RE	1	received	24/03/19	24/03/20

CanSat Budget – Hardware(1/4)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate	Reuse
Digi XBee3 PRO	1	48.5	48.5	Actual	x
Adafruit BMP390	1	14.2	14.2	Actual	x
Adafruit 9-DOF IMU BNO055	1	46	46	Actual	x
Sparkfun GPS SAM-M8Q	1	52.8	52.8	Actual	x
Sandisk Ultra microSD card 32GB	3	4.6	13.8	Actual	x
Pitot tube	1	9.9	9.9	Actual	x
PLA+ Filaments	2	15.1	30.2	Actual	x
Servo motor SG90	4	1.23	4.92	Actual	x
Spring set	1	3.8	3.8	Estimate	x
parachute polyester fabric	2	3.0	6.0	Actual	x
MTS-102 toggle	1	0.5	0.5	Actual	x
1/4W 1% Resistance kit	1	1.0	1.0	Estimate	x
BSS138	10	0.3	3	Actual	x

CanSat Budget – Hardware(2/4)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate	Reuse
PCB Support Metal M-10 mm	10	0.1	1	Estimate	x
General LED 6 types kit	1	1.8	1.8	Actual	x
Eyebolt M10	2	1.8	3.6	Actual	x
MicroSD Card Socket Module	1	0.8	0.8	Actual	x
Lithium Battery	1	3.7	3.7	Actual	x
Battery Holder	1	1.7	1.7	Actual	x
Battery charging module	1	0.8	0.8	Actual	x
SM-1205C Buzzer	1	0.4	0.4	Actual	x
DC/DC conversion module	1	6.7	6.7	Actual	x
Step-Up/Step-Down Voltage Regulator	1	8.4	8.4	Actual	x
100 x 160 Substrate	2	6.4	12.8	Actual	x
PCB Support Metal F-20 mm	10	0.1	1	Estimate	x
STM32 NUCLEO-F446RE	1	26.0	26.0	Actual	x
Siretta delta 20	1	11.2	11.2	Actual	x

CanSat Budget – Hardware(3/4)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate	Reuse
Instantaneous adhesive	2	2.0	4.0	Actual	x
Solder Week FR150-86	1	2.4	2.1	Actual	x
Refill type flux pen container	1	13.6	13.6	Actual	x
Refill brush	1	9.2	9.1	Actual	x
Open circuit for 3 color jumper	1	0.3	0.3	Actual	x
Stainless steel round head cross bolt M2x8	100	0.1	10	Actual	x
Nut_M2	100	0.1	10	Actual	x
Pinheader Single 1x40Pin Straight(2.54mm)	2	0.2	0.4	Actual	x
Double-sided silicone tape	1	2.9	2.9	Actual	x
Transparent PVC plate	1	10.2	10.2	Actual	x
Indicator module	1	1.6	1.6	Actual	x
sq11 mini camera	2	4.3	8.6	Actual	x
Differential pressure sensor MPXV7002DP	1	54.2	54.2	Actual	x

CanSat Budget – Hardware(4/4)

Hardware total price : 441.52 $

We comply the requirement that the cost of the CanSat shall be under 1000$

CanSat Budget – Other Costs(1/2)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate
Antenna	1	26.5	26.5	Actual
Register fee	1	200	200	Actual
plane ticket	10	1500	15000	Estimate
Accommodation	10	200	2000	Estimate
ESTA fee	10	21	210	Estimate
Car rental	2	1100	2200	Estimate
Food expenses	10	250	2500	Estimate

Other costs total price : 22136.5$

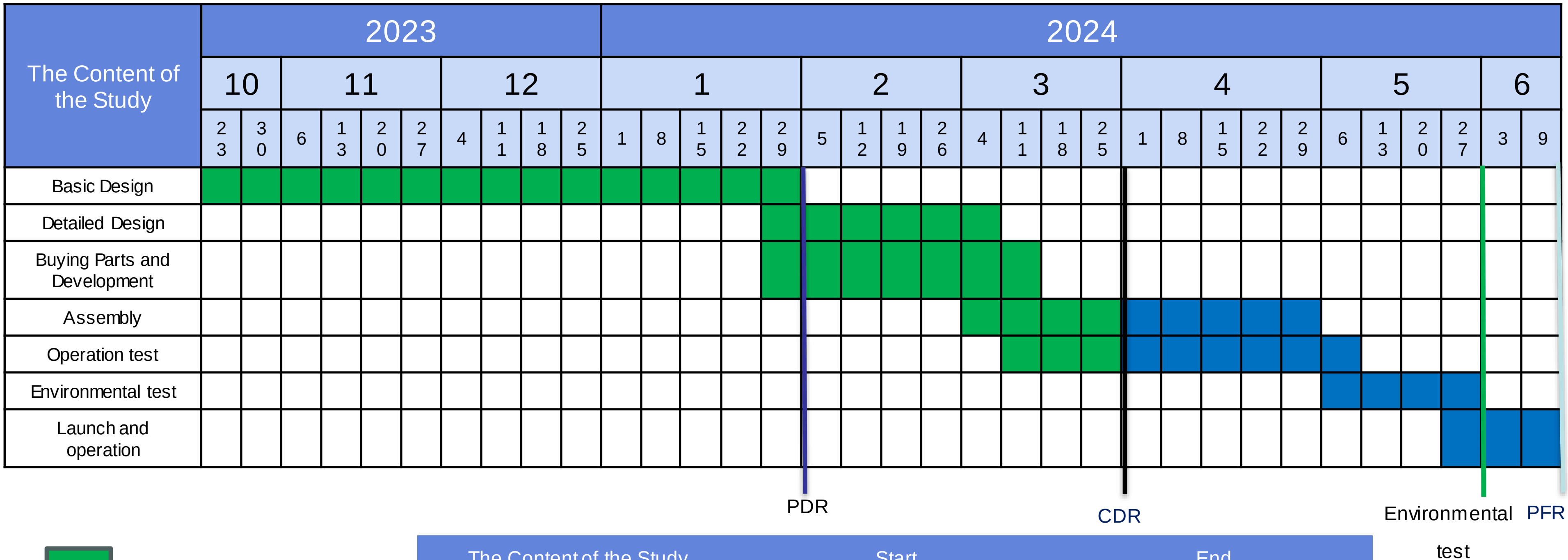
CanSat Budget – Other Costs(2/2)

Team income

Source	Total price($)	Actual/Estimate
Sponsorship	15000	Estimate
University	2500	Actual

Total income : 17500$(Estimate)

Program Schedule Overview



: Completed

: Upcoming

The Content of the Study	Start	End
Basic Design	23-Oct-23	29-Jan-24
Detailed Design	29-Jan-24	04-Mar-24
Buying Parts, Development and testing	29-Jan-24	11-Mar-24
Assembly	04-Mar-24	29-Apr-24
Operation test	11-Mar-24	6-May-24
Environmental test	06-May-24	27-May-24
Launch and operation	27-May-24	9-Jun-24

12/4 - 12/8	Final exam
12/18 - 3/4	Winter vacation
2/9 - 2/12	Korean New Year
4/22 - 4/26	Mid term exam

Detailed Program Schedule(1/4)

Mechanical

: Completed

: Upcoming

The content of the study	2023										2024																						
	10		11				12				1					2				3				4					5				Responsibility
	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	4	11	18	25	1	8	15	22	29	6	13	20	27	
System Requirement Review																																	All Team
Initial Brainstorming																																	All Team
Heat Shield Design																																	Mechnical Team
Parachute Design																																	Hyewon Shin
Assembly CAD Design																																	Junghyuk Lee & Dongwoo Cho
Component Deliveries																																	Se-eun Koo
CAD modification after PDR																																	Junghyuk Lee & Dongwoo Cho
Prototyping																																	Junghyuk Lee & Dongwoo Cho
Assembly																																	Mechanical Team
Environmental Test																																	All Team

PDR

CDR

Environmental Test

12/4 - 12/8 Final exam

12/18 - 3/4 Winter vacation

2/9 - 2/12 Korean New Year

4/22 - 4/26 Mid term exam

overall accomplishment : 82%

Detailed Program Schedule(2/4)

Electronics

: Completed

: Upcoming

The content of the study	2023										2024																							Responsibility
	10		11				12				1					2				3				4					5					
	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	4	11	18	25	1	8	15	22	29	6	13	20		27	
Mission guide study	Completed	Completed	Completed	Completed	Completed																													All Team
Trade study	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed																										All Team
Circuit Design using KiCad						Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed																			Electronic Team
Perfboard Testing													Completed	Completed	Completed	Completed	Completed	Completed																Electronic Team
Component Deliveries													Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed													Electronic Team
1st PCB prototyping																		Completed	Completed	Completed	Completed	Completed												Se-eun Koo
2nd PCB prototype development / testing																						Completed	Completed	Upcoming										Electronic Team
Final PCB order																								Upcoming	Upcoming	Upcoming								Se-eun Koo
Assembly																									Upcoming	Upcoming	Upcoming	Upcoming						Electronic Team
Environmental Test																													Upcoming	Upcoming	Upcoming	Upcoming	Upcoming	All Team

PDR

CDR

Environmental Test

12/4 - 12/8 Final exam

12/18 - 3/4 Winter vacation

2/9 - 2/12 Korean New Year

4/22 - 4/26 Mid term exam

overall accomplishment : 79%

Detailed Program Schedule(3/4)

Software

: Completed

: Upcoming

The content of the study	2023										2024																						Responsibility
	10		11				12				1					2				3				4					5				
	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	4	11	18	25	1	8	15	22	29	6	13	20	27	
GCS Design																																	HyungJun Bae
GCS Development																																	HyungJun Bae
GCS Integration																																	HyungJun Bae
Communication Test																																	Software Team
Sensor Test																																	Seungwon Cho
Actuator Test																																	Myeongsik Jeong
FSW Design																																	Myeongsik Jeong
FSW Development																																	Seungwon Cho
FSW Integration																																	Software Team
Assembly																																	Software Team
Environmental Test																																	All Team

PDR CDR Environmental Test

12/4 - 12/8 Final exam

12/18 - 3/4 Winter vacation

2/9 - 2/12 Korean New Year

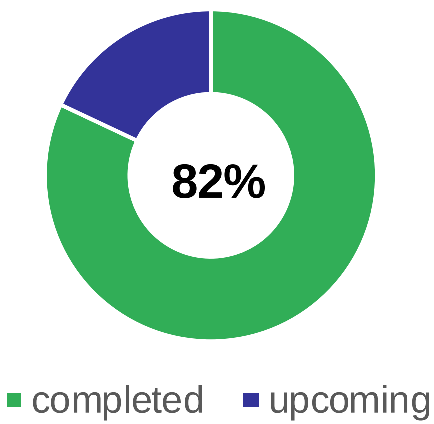
4/22 - 4/26 Mid term exam

overall accomplishment : 73%

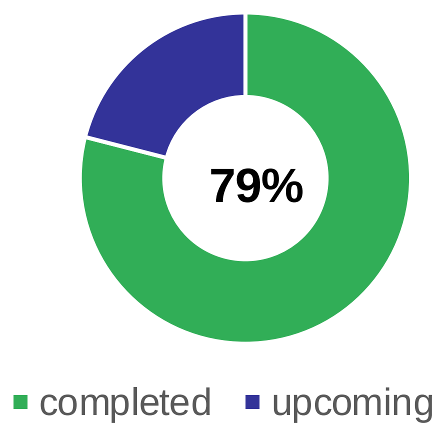
Detailed Program Schedule(4/4)

Overall accomplishment

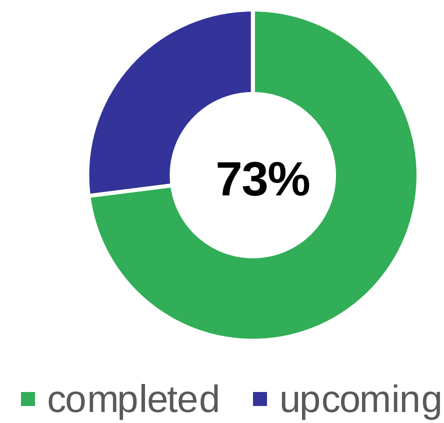
Mechanical



Electronics



Software

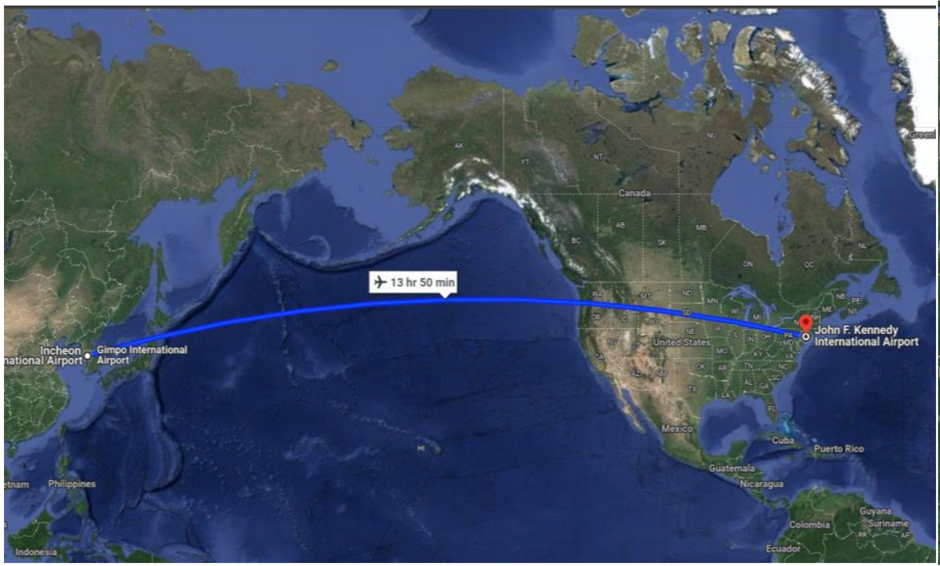


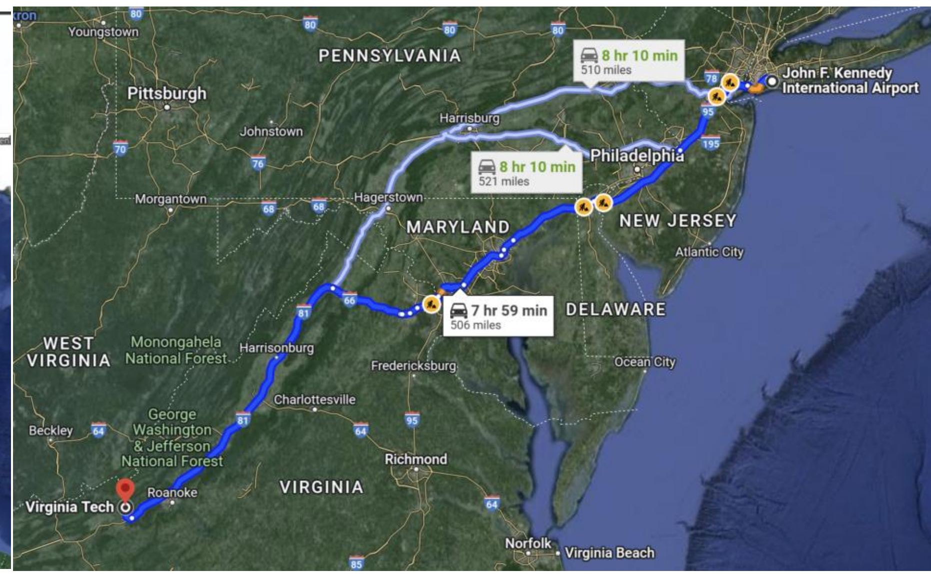
	assign	2024.04.10	2024.05.20	2024.06.01
Goal Accomplishment	**Mechanical**	88%	97%	100%
	Electronics	85%	95%	100%
	Software	85%	95%	100%

Shipping and Transportation

Shipping and Transportation plan

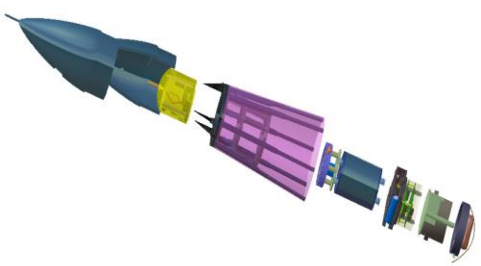
- We will be departing from Republic of Korea and all CanSat components will be transported in cabin baggage as they meet the cabin baggage allowance size regulations.
- Due to carry-on baggage regulations, the total battery capacity may be less than 100 Wh, so both the battery and the laptop will be transported as carry-on baggage.
- We get to Virginia Tech by plane and car rental.

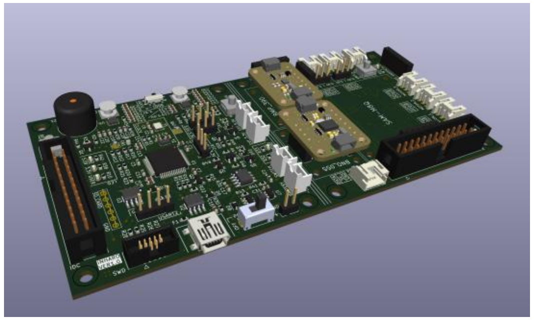


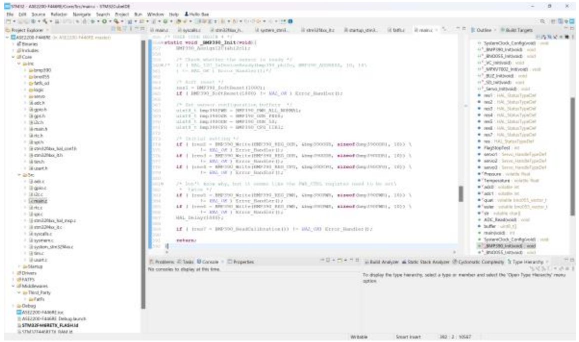


Conclusions (1/2)

Team	Mechanical	Electronics	Software
Accomplishments (Status)	• Made CAD prototype • Actual 3D printed each component • Several modification for more stable flight	• Verify the sensor's operation • The schematic design and PCB layout have been completed	• Individual sensor and actuator handling code for CanSat operation was written. • Ground control software UI & functions were implemented.







<Mechanical>

<Electronics>

<Software>

Conclusions (2/2)

Team	Mechanical	Electronics	Software
Unfinished Works	• Establishing the final version of the prototype • Having environmental test	• Scrutinize the PCB and order it • Test the operation of the CanSat	• Integrate the GCS and FSW • Debugging the software
Testing to complete	• Vibration test • Shock test • Drop test	• Integration test • PCB functionality test	• Algorithm test • Communication test • Reset tolerance test

Readiness for the Next Stage
We completed all necessary design steps and tested the mechanisms, schematics, and components used in the system. From now on, we will assemble hardware, software, and electronic subsystems to build a prototype close to the final product. The prototype will undergo environmental tests to strengthen the CanSat and we will build a final product that can perform all missions.