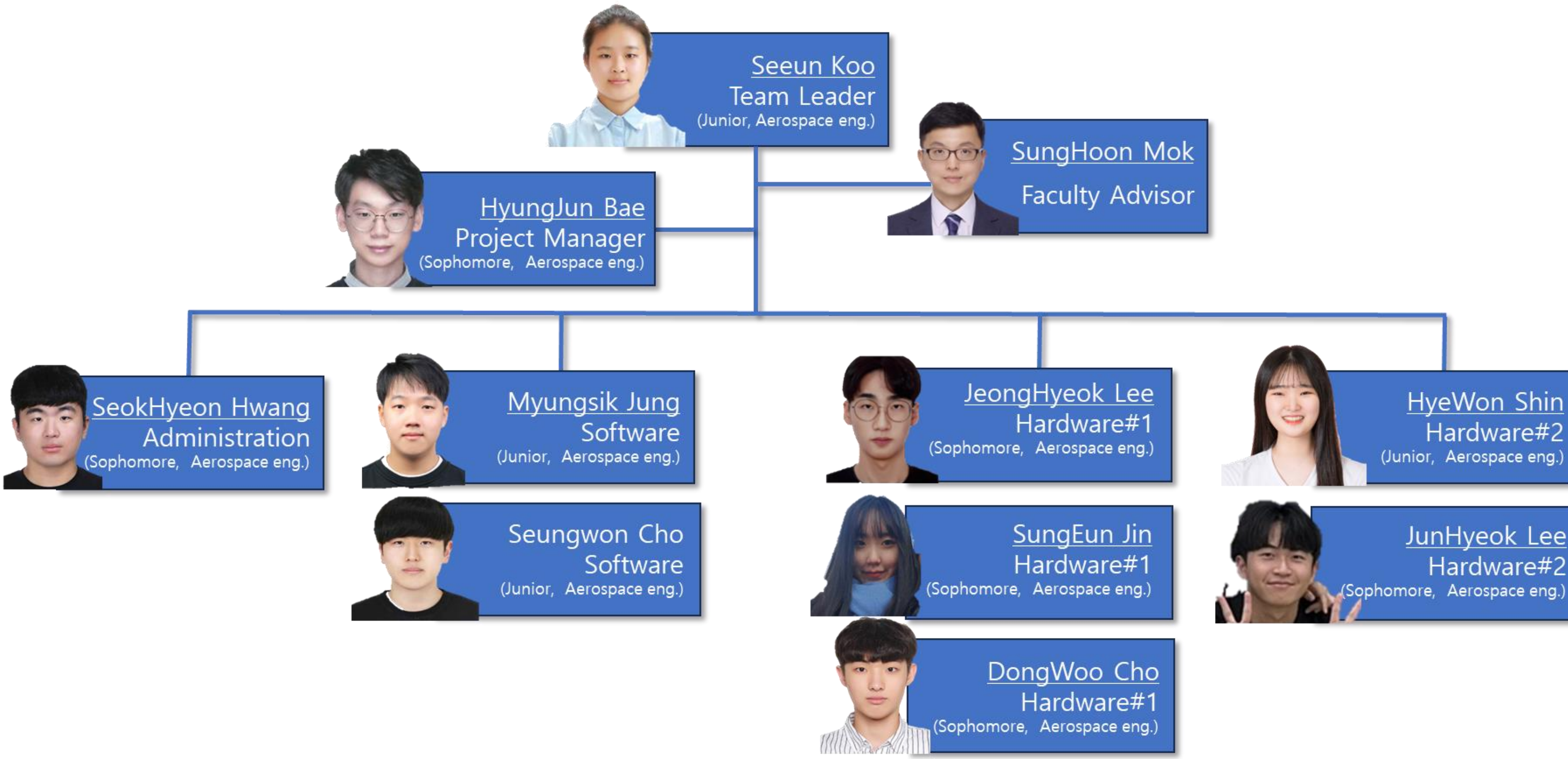
CanSat 2024
Preliminary Design Review (PDR)
Outline
Version 1.2

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
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
IDE	Integrated Development Environment
IMU	Inertial Measurement Unit

Acronyms (2/2)

Acronyms	Definition
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 Input/Ouput Interface
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

Systems Overview

Presented by Seeun 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.

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)

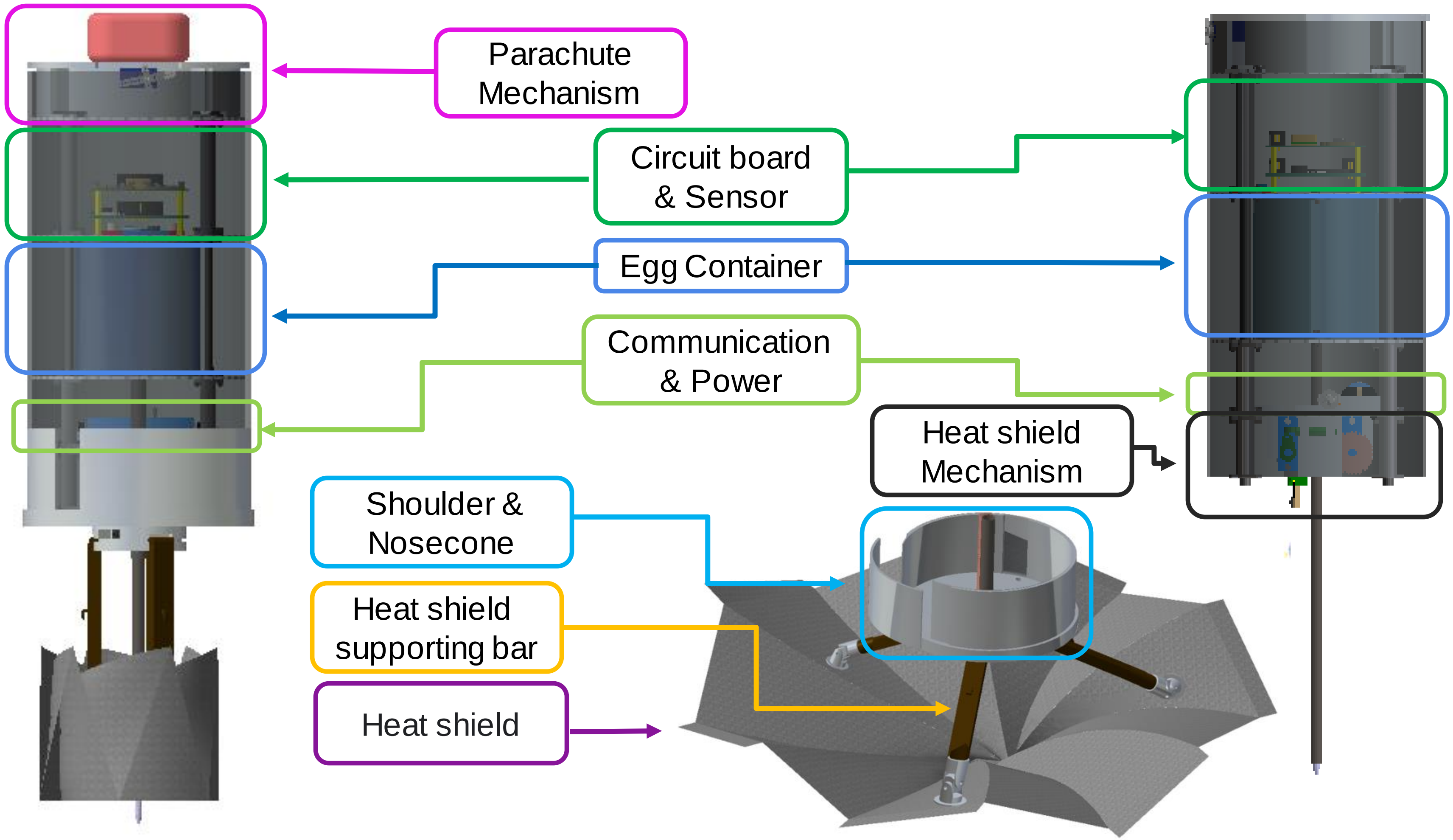
Req	Description	Subsystem	Verification			
			A	I	T	D
40	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Software GCS	√	√	√	
41	When in simulation mode, the ground station shall transmit 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	✓	✓	✓	

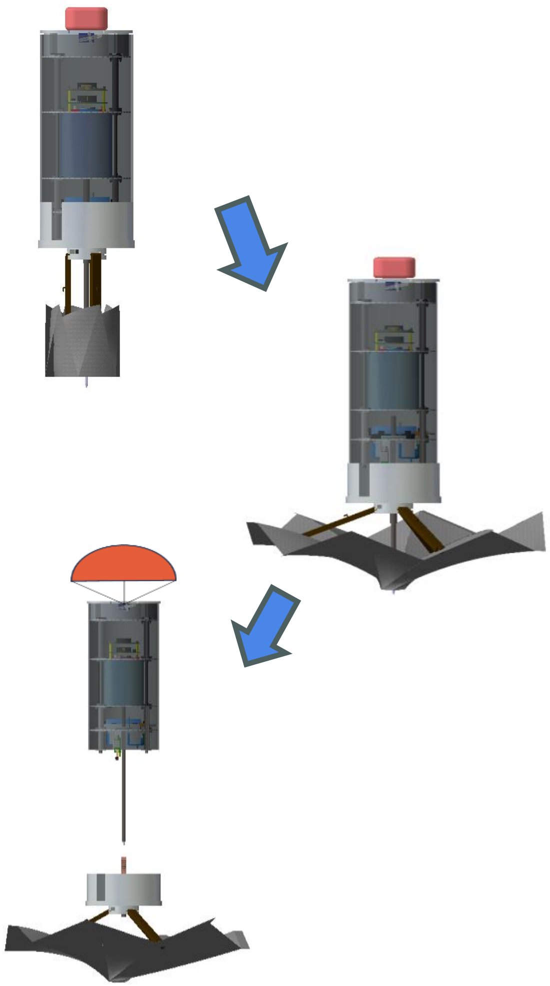
System Level CanSat Configuration Trade & Selection(1/4)

Strategy A : Origami Style



System Level CanSat Configuration Trade & Selection(2/4)

Strategy A : Origami Style



Information

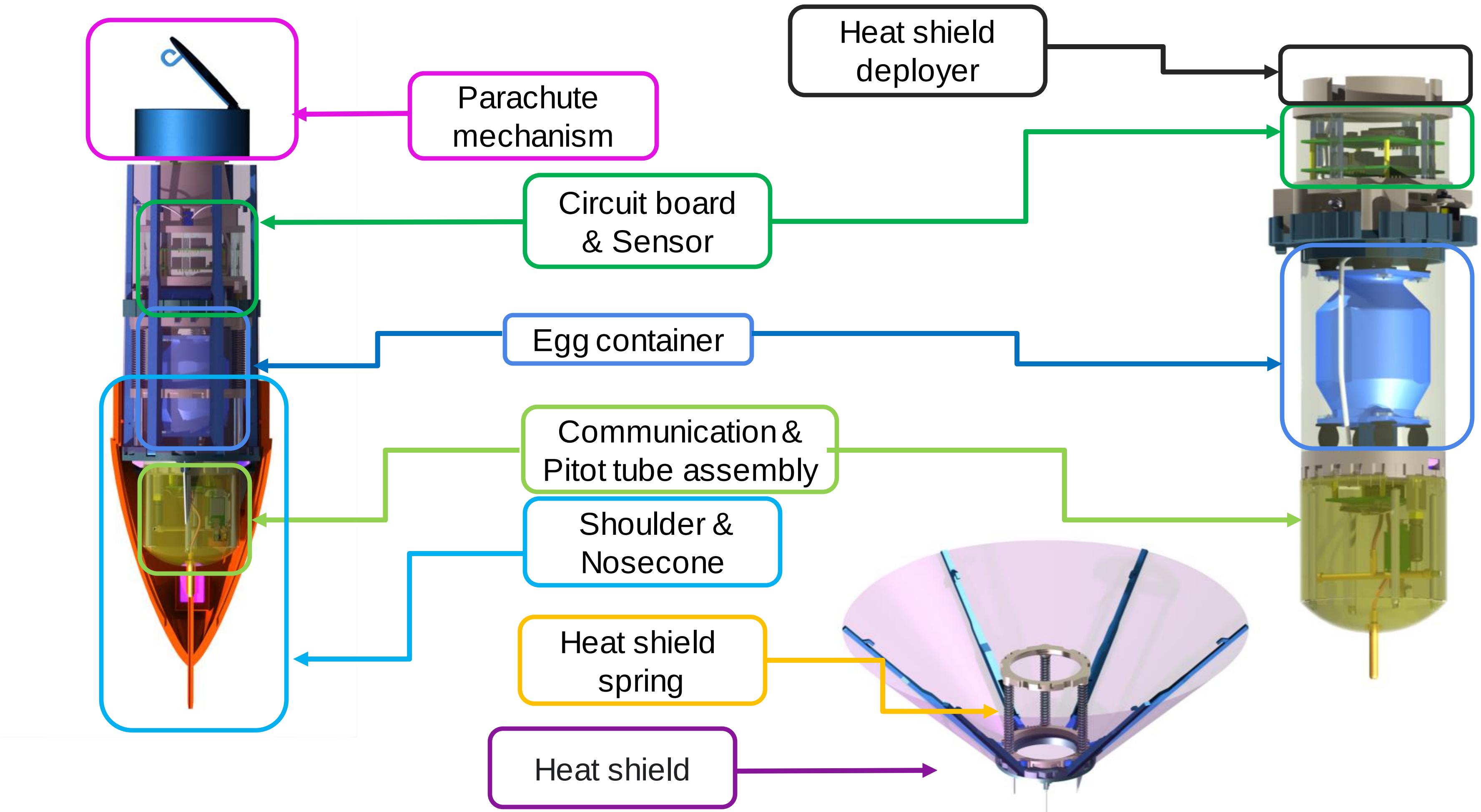
- We drew inspired from a star shade design presented by NASA's New World Mission.
- As the pinion rotates, the bar stretches and the folded heat shield unfolds.
- As it deploys, the floor bulkhead moves to make the CanSat more stable.
- Ensure stability by placing heavy components, such as battery and egg container, as low as possible.

Concept of Operation (CONOPS)

- The Floor bulkhead acts as a shoulder and nosecone.
- At around 700m, a servo motor with a pinion rotates, unfolding the heat shield.
- At 100m, the rope holding the heat shield is released and the pinion is rotated by the remaining length of the rack.
- As the parachute deploys, the CanSat body and the heat shield system smoothly separate due to the difference in relative speed.

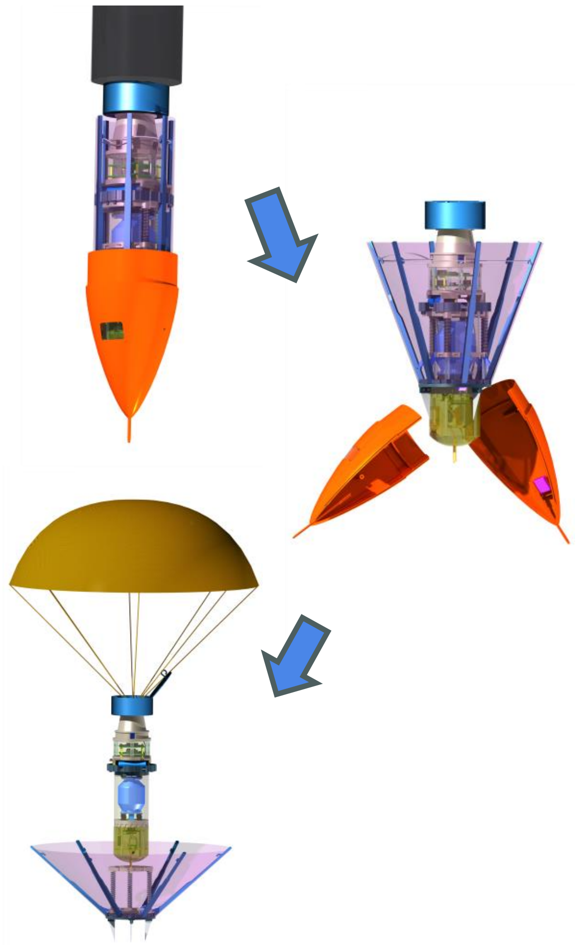
System Level CanSat Configuration Trade & Selection(3/4)

Strategy B : Classic Umbrella Style



System Level CanSat Configuration Trade & Selection(4/4)

Strategy B : Classic Umbrella Style



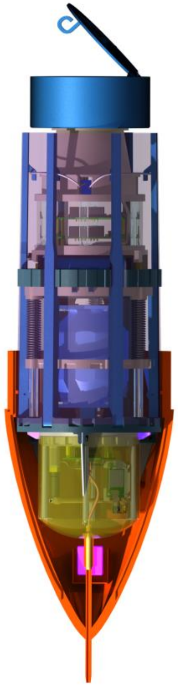
Information

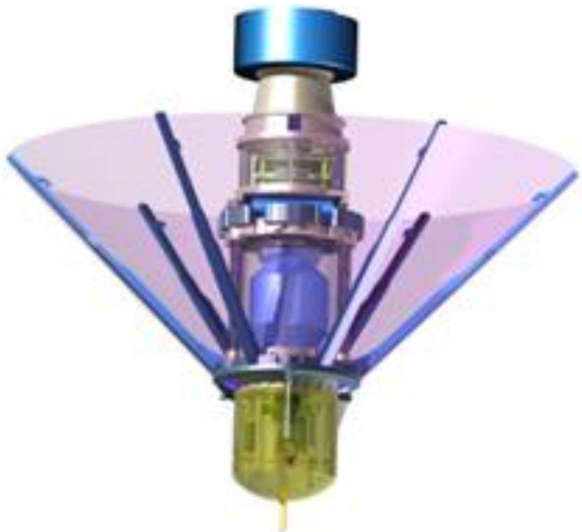
- The heat shield is depolyed like an umbrella.
- Inside the nose cone, the protective shell is situated. The shell protects the payload from heat and shock.
- The mass center is close to the neutral point, and it contributes to static stability.
- The mechanism is structurally simple.

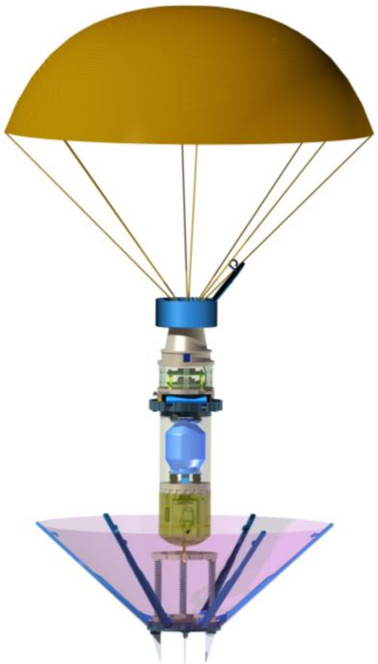
Concept of Operation (CONOPS)

- The heat shield is fastened by a string and folded into the container.
- When the payload is deployed from the rocket at 700m, the ratchet gear releases the string and the compressed spring spreads the heat shield. The nose cone is detached in this stage. (The nose cone has a small parachute for a safe descent.)
- At 100m, the rack and pinion assembly releases the heat shield and the main parachute will be deployed. The heat shield smoothly slides out the payload.

System Level Configuration Selection

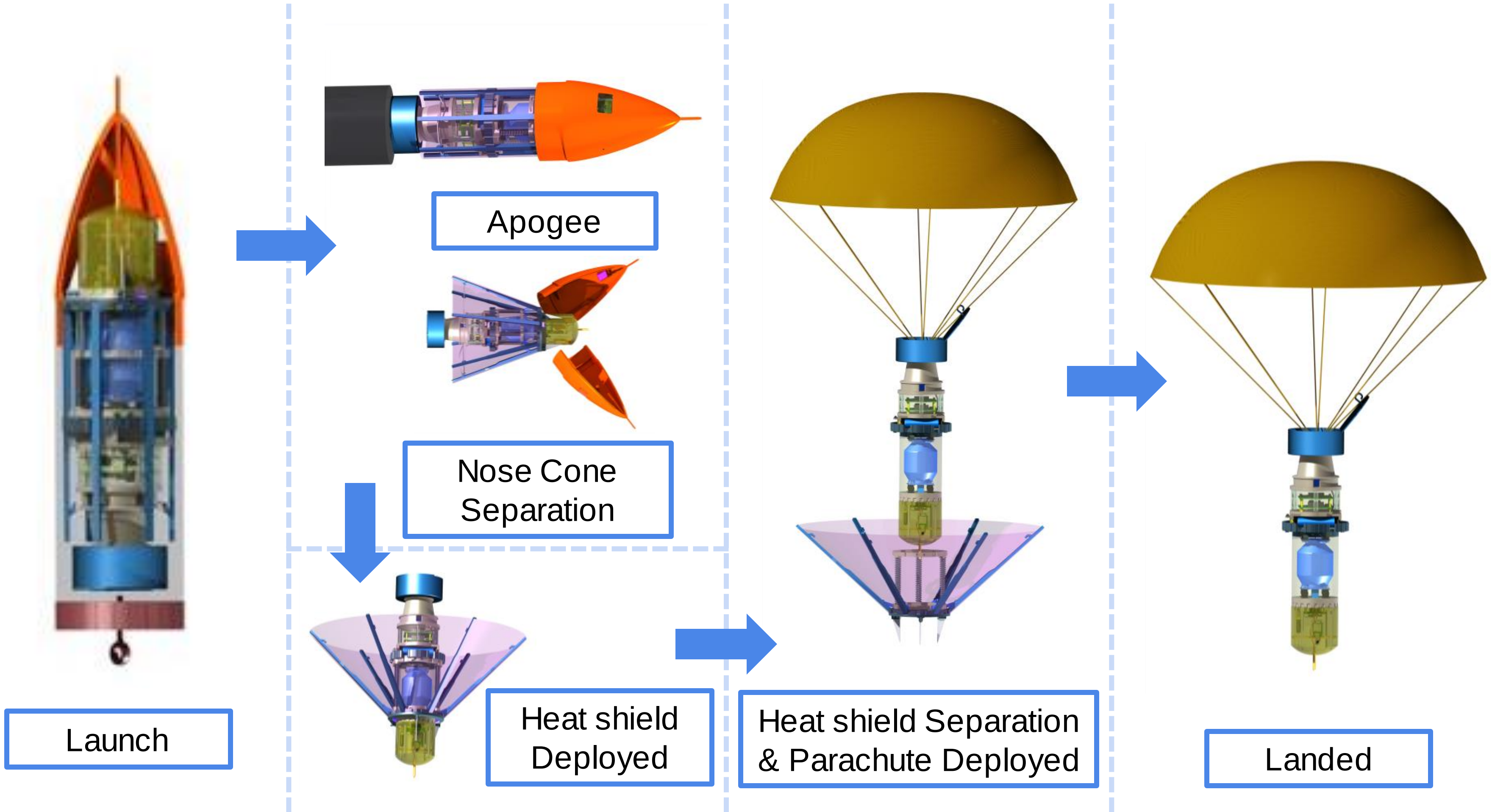






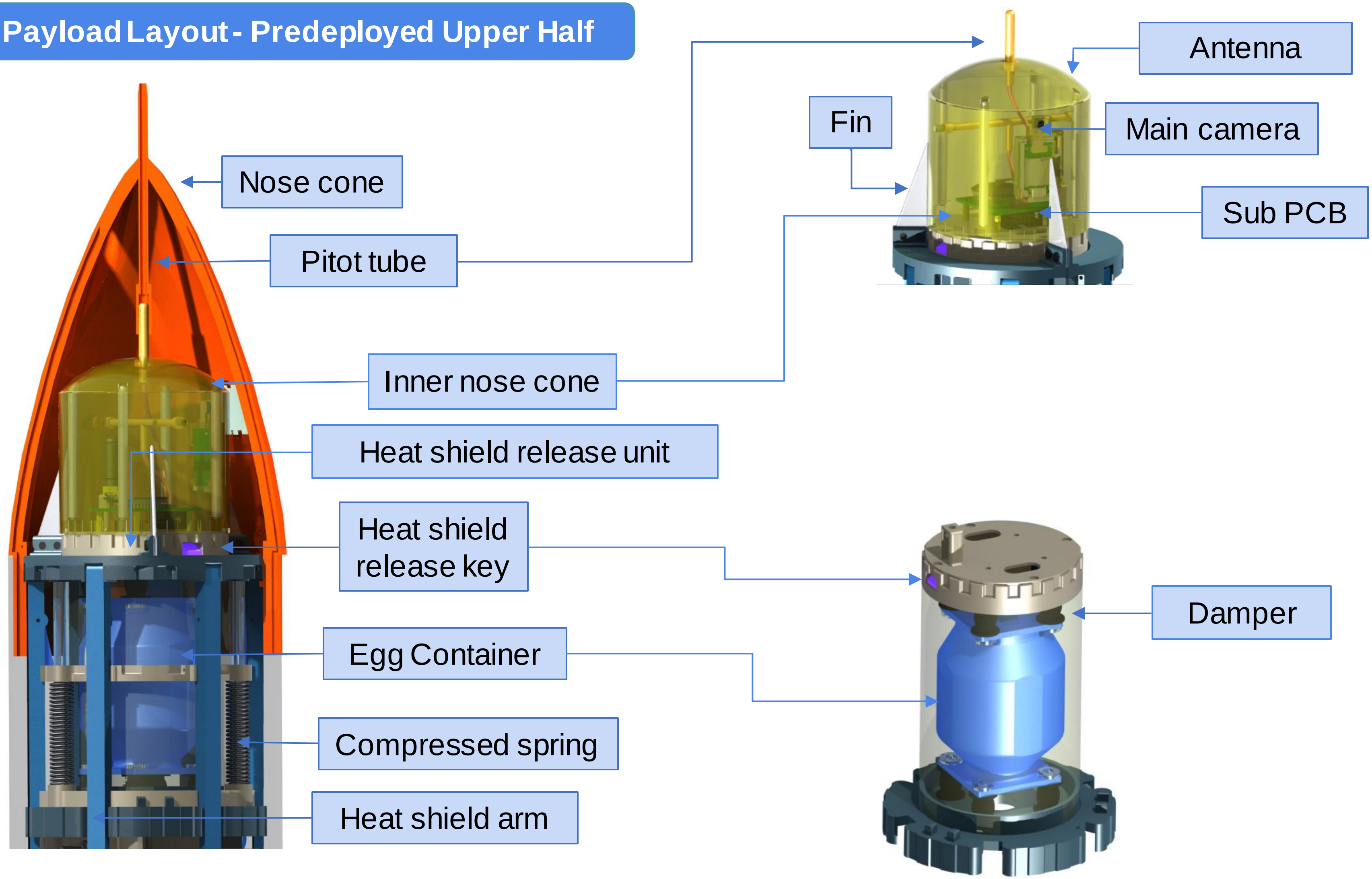
Selection	Reasons for selection
Strategy B	• The center of gravity is located below to ensure passive stability. • Nose cone shape with minimal air resistance makes it easy to reach high altitude. • It is easy to modify the prototype. • Higher space utilization and less power consumption make it easy for collaboration between Electronics, Software, and Mechanical teams.

CanSat Configuration



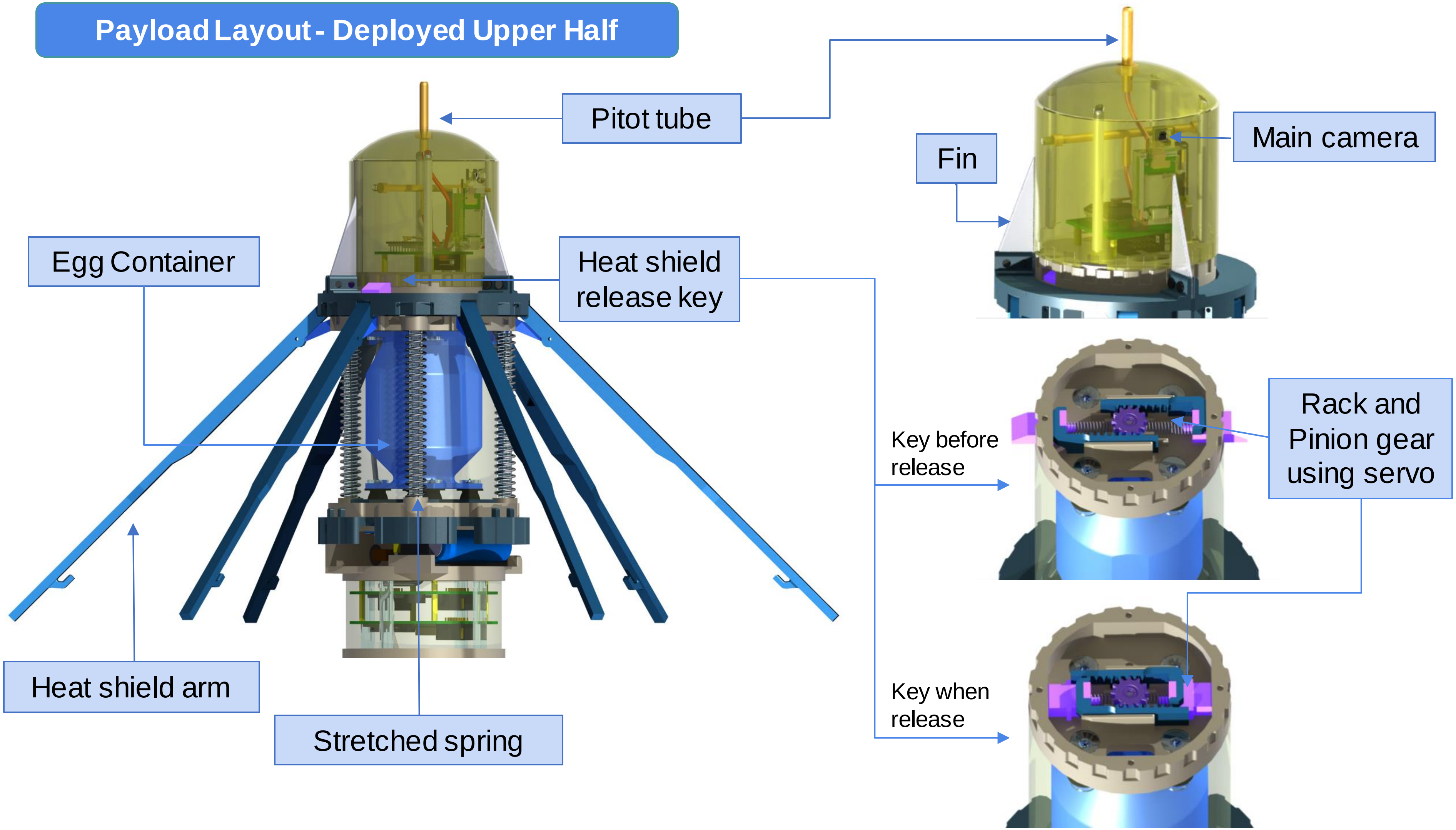
Physical Layout(2/6)

Payload Layout - Predeployed Upper Half



Physical Layout(3/6)

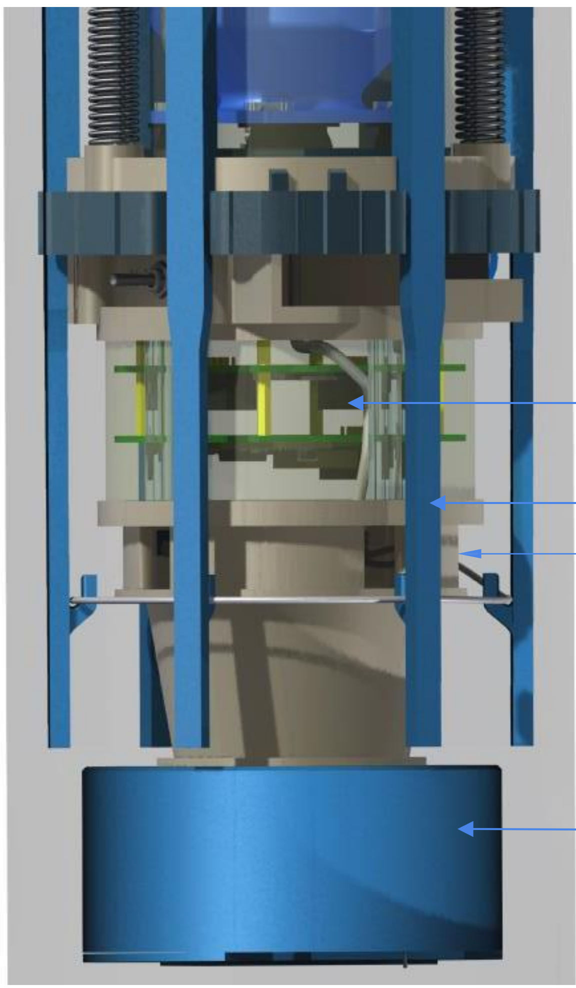
Payload Layout - Deployed Upper Half

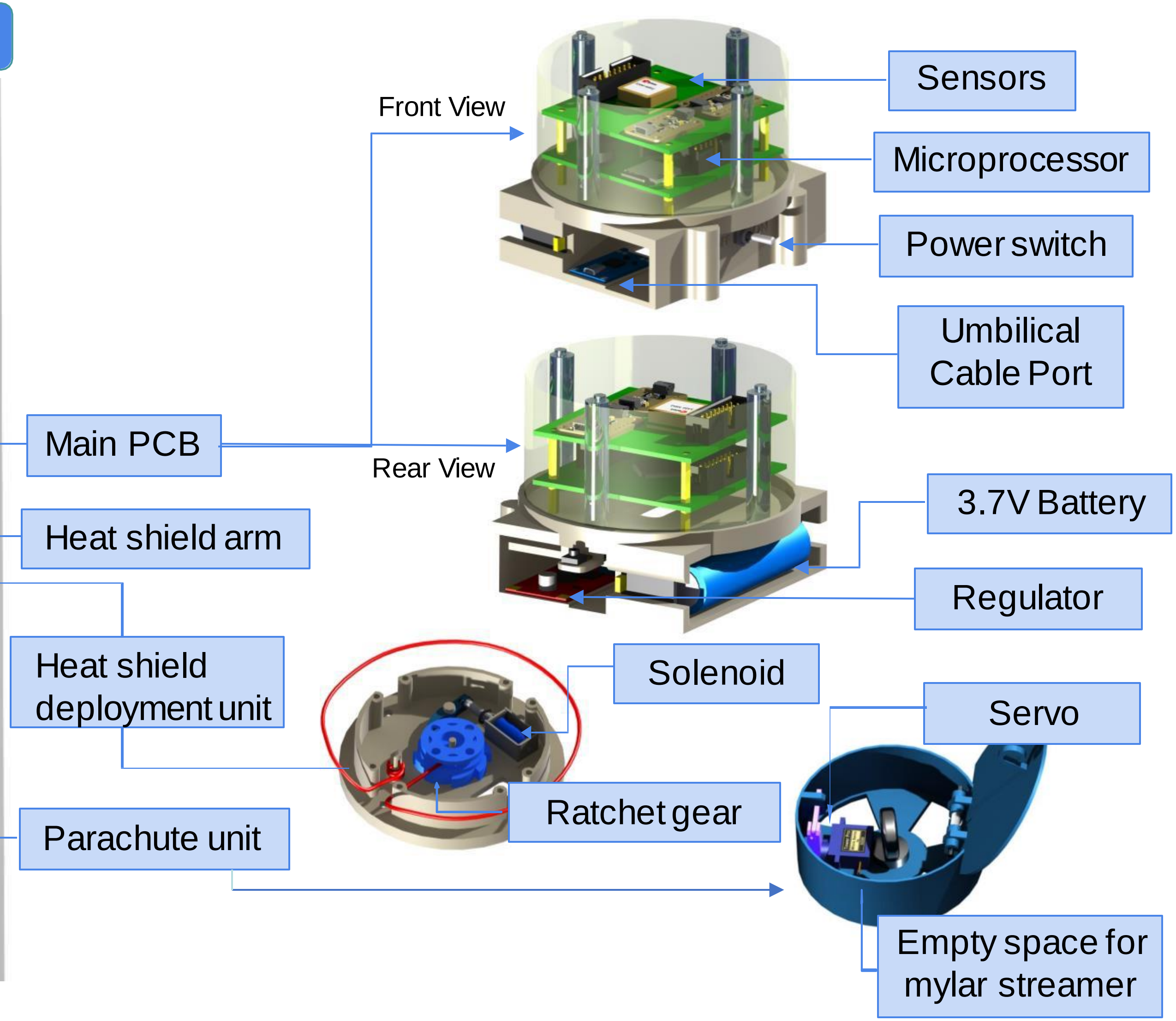


Physical Layout(4/6)

(If You Want)

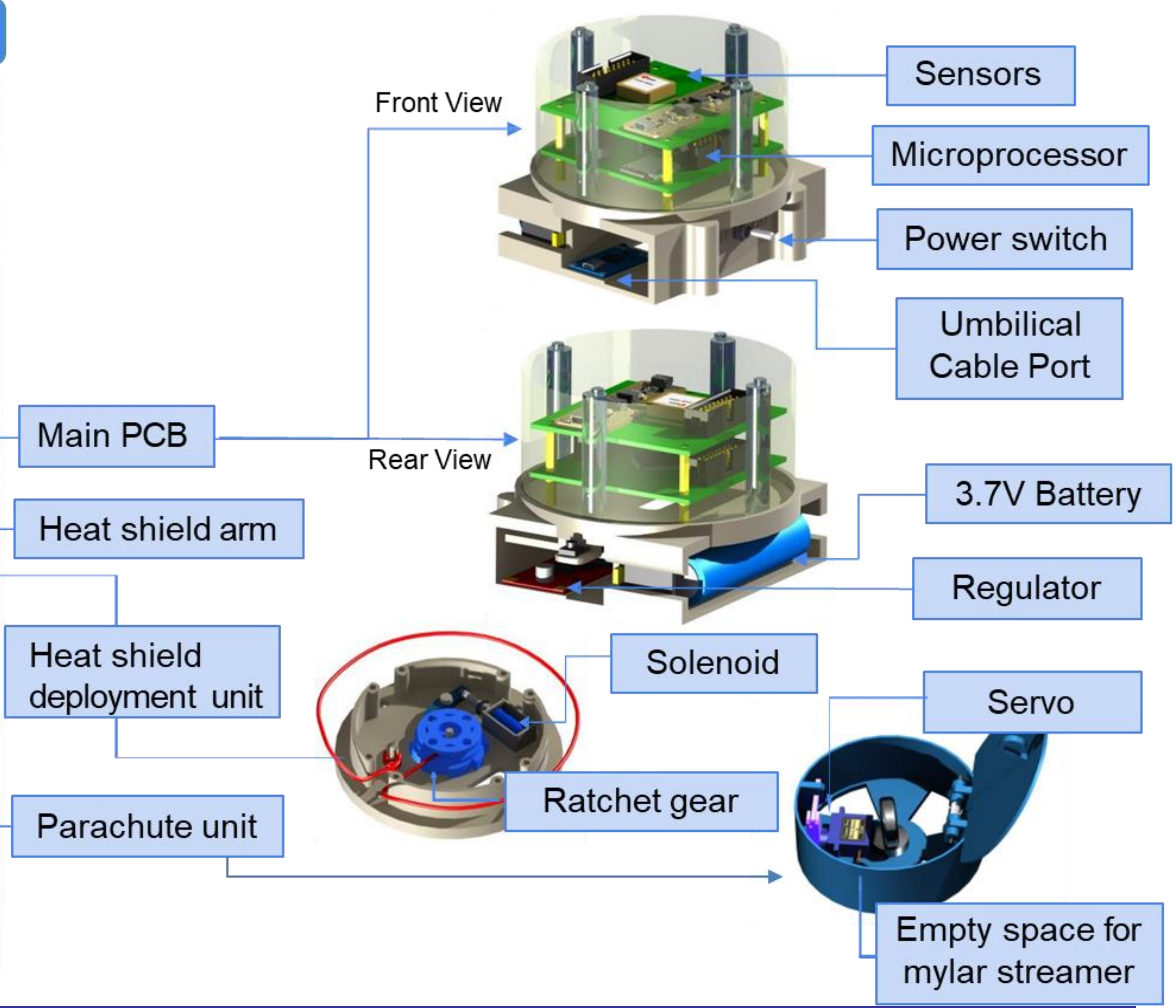
Payload Layout - Lower Half





Team Logo Here (If You Want)

Payload Layout - Lower Half



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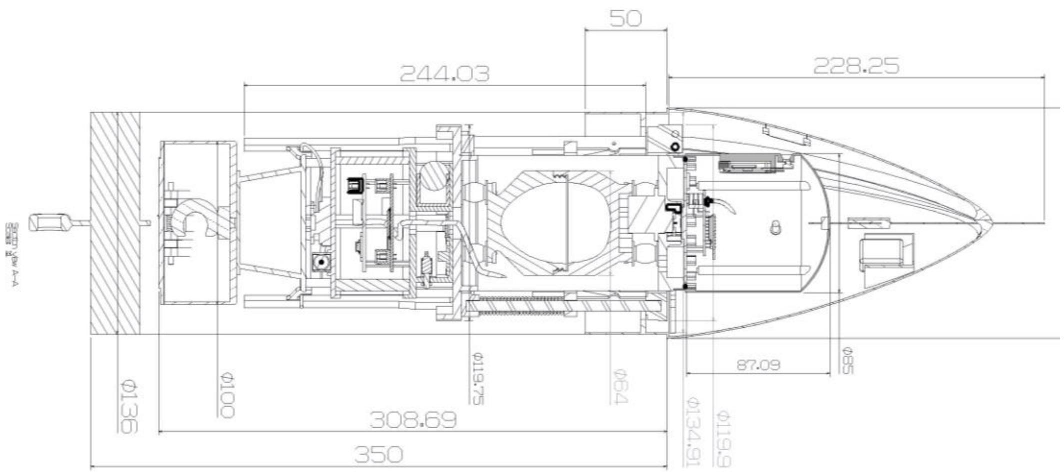
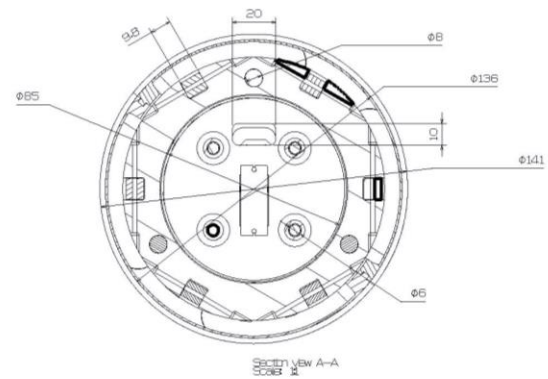
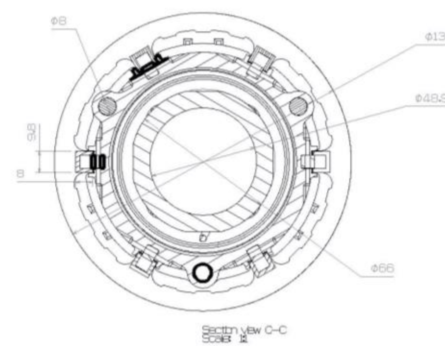
Physical Layout(5/6)

Dimensioned Drawing





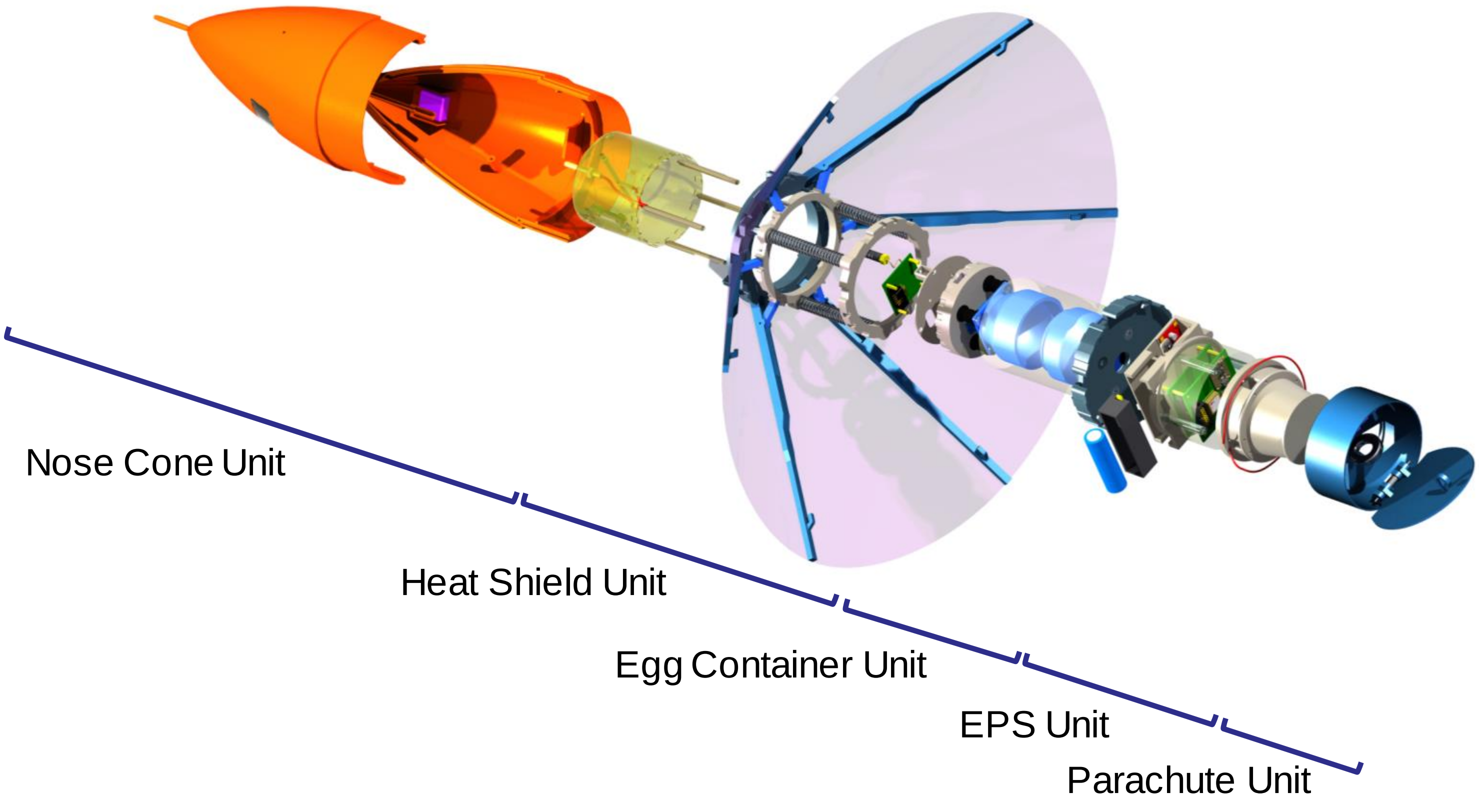


Information

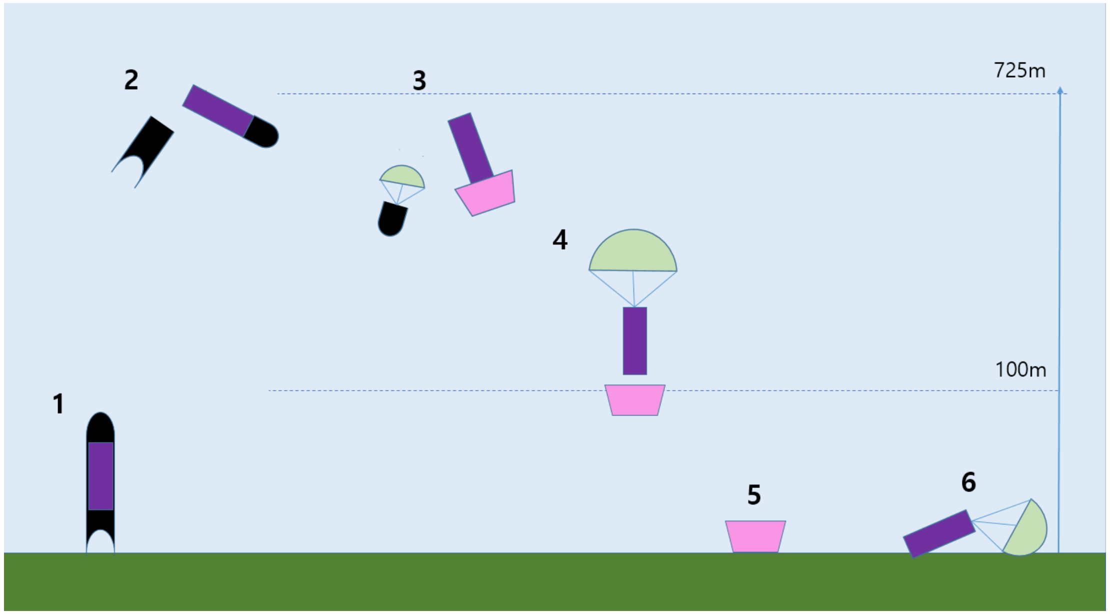
- Top left : Dimensions for the overall payload
- Top right : Radial Dimensions for the Heat Shield
- Bottom right : Radial Dimensions for the Egg Container

Physical Layout(6/6)

Exploded View



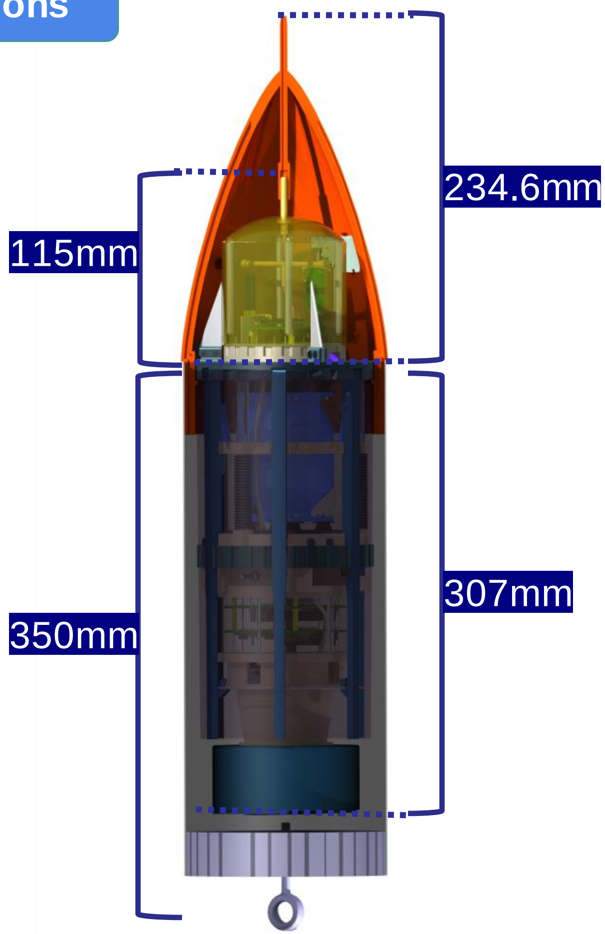
System Concept of Operations

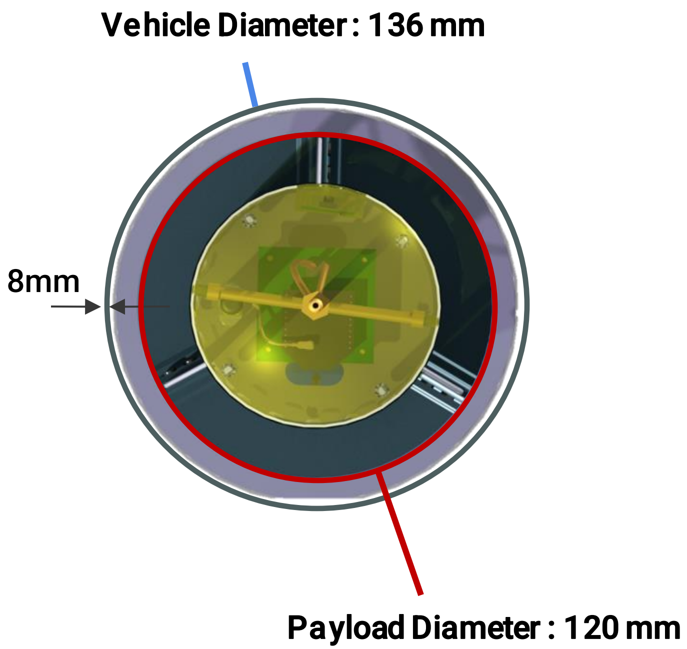


Step	Description
1	The CanSat is stowed inside the rocket.
2	At 725m, the CanSat is deployed from the rocket.
3	Aero-braking heat shield decelerates the CanSat to a speed of 10m/s ~ 30m/s. The nosecone is separated, descending with a speed of under 10m/s.
4	At 100m, the heat shield is released, and the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

Launch Vehicle Compatibility

Dimensions





	Vehicle	CanSat	Nosecone	Payload Margin
Height	350 mm	307 mm	234.6mm	43 mm
Diameter	136 mm	120 mm	141mm	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	Measure the battery voltage
Speed	SDP31	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	Mini Spy Camera	Record the video during missions

Payload Air Pressure Sensor Trade & Selection

Model	Interface	Accuracy	Current Consumption (µA)	Range (hpa)	Size (mm)	Cost ($)
BMP390	I2C/SPI	± 3 Pascals/ ± 0.25 meters	3.2	300 - 1250	2 x 2 x 0.75	10.95
BMP388	I2C/SPI	± 8 Pascals/ ± 0.5 meters	3.4	300 - 1250	2 x 2 x 0.75	9.95
BMP280	I2C/SPI	± 12 Pascals/ ± 1 meters	2.7	300 - 1100	2 x 2.5 x 0.95	9.95

Selected Sensor		Reasons
	**Adafruit BMP390**	• High pressure accuracy • Built in temperature sensor • small mass

Payload Air Temperature Sensor Trade & Selection

Model	Accuracy (℃)	Range (℃)	Size (mm)	Cost ($)
BMP390	± 0.5	-40 ~ 85	2 x 2 x 0.75	10.95
BMP388	± 0.5	-40 ~ 85	2 x 2 x 0.75	9.95
ds18b20	± 0.5	-55 ~ 125	10 x 15	1.3

Selected Sensor		Reasons
	**Adafruit BMP390**	• Integrated with pressure sensor • High accuracy • Easy to coding

Payload Battery Voltage Sensor Trade & Selection

Model	Interface	Voltage (V)	Resolution (bit)	Size (mm)	Cost ($)
STM32 ADC	Analog	0 ~ 3.3	12	Embedded	0
INA260	I2C	0 ~ 3.6	16	5 x 6.4	8

Selected Sensor		Reasons
	**STM32 ADC**	• No additional cost • Easy to use • Only two resistor required • Already in the system

Payload Speed Sensor Trade & Selection

Model	Interface	Accuracy (%)	Range (kPa)	Size (mm)	Cost ($)
SDP31	I2C	± 3	-0.5 ~ 0.5	5 x 8 x 5	33.7
MPXV5010DP	Analog	± 5	0 ~ 10	10.5 x 10.5 x 5.4	22.4

Selected Sensor		Reasons
	**SDP31**	• High accuracy • Small size • Perfect fit for pitot tube

Payload Tilt Sensor Trade & Selection

Model	Interface	Voltage (V)	Accelerometer Range (g)	DOF	Mass (g)	Cost ($)
BNO055	I2C/UART	3.3	± 2 / ± 4 ± 8 / ± 16	9 axis	2.0	29.95
MPU6050	I2C	3.3	± 2 / ± 4 ± 8 / ± 16	6 axis	2.5	2.5
MPU9250	I2C/SPI	3 - 5	± 2 / ± 4 ± 8 / ± 16	9 axis	3	15

Selected Sensor		Reasons
	**BNO055**	• High accuracy • Include gyroscope and magnetometer • Light weight

Rotation Sensor Trade & Selection

Model	Interface	Voltage (V)	Gyroscope Range (rad/s)	DOF	Mass (g)	Cost ($)
BNO055	I2C/UART	3.3	± 125 ~ ± 2000	9 axis	2.0	29.95
MPU6050	I2C	3.3	± 250 / ± 500 ± 1000 / ± 2000	6 axis	2.5	2.5
MPU9250	I2C/SPI	3 - 5	± 250 / ± 500 ± 1000 / ± 2000	9 axis	3	15

Selected Sensor		Reasons
	**BNO055**	• High accuracy • Include accelerometer and magnetometer • Light weight

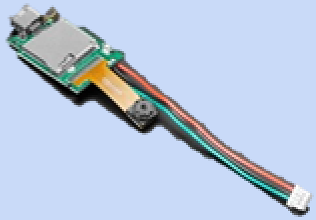
Payload GPS Sensor Trade & Selection

Model	Interface	Resolution (m)	Weight (g)	Operating Current (mA)	Rate (Hz)	Cost ($)
SAM-M8Q	UART	2.5	13	29	18	42.95
BN-220	UART	2.5	5.3	50	1	14
MTK3339	UART	3.0	4	20	16	42

Selected Sensor		Reasons
	**SAM-M8Q**	• High accuracy • Libraries readily available • Internal antenna

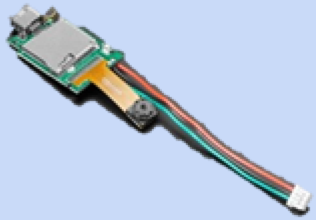
Payload Camera Trade & Selection

Model	Resolution / Frame Rate (fps)	Size (mm)	Weight (g)	Voltage (V)	Cost ($)
Adafruit Spycamera	640 x 480 / 30 fps	28.5 x 17 x 4.2	2.8	3.7 - 5.0	12.50
TTL Serial JPEG Camera	640 x 480 / 30 fps	32 x 32 x 32	3.0	5.0	39.95
Quelima SQ11	1280 x 720 / 30 fps	23 x 23 x 23	5.2	5.0	4.53

Selected Sensor		Reasons
	**Adafruit Spycamera**	• Cost efficient • Video resolution and fps fulfills requirements • Dimensions and Weight advantage • Embedded SD card reader

Bonus Camera Trade and Selection

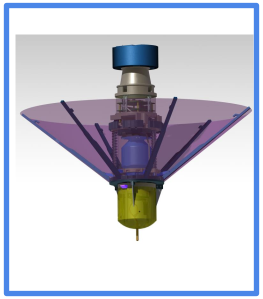
Model	Resolution / Frame Rate (fps)	Size (mm)	Weight (g)	Voltage (V)	Cost ($)
Adafruit Spycamera	640 x 480 / 30 fps	28.5 x 17 x 4.2	2.8	3.7 - 5.0	12.50
TTL Serial JPEG Camera	640 x 480 / 30 fps	32 x 32 x 32	3.0	5.0	39.95
Quelima SQ11	1280 x 720 / 30 fps	23 x 23 x 23	5.2	5.0	4.53

Selected Sensor		Reasons
	**Adafruit Spycamera**	• Cost efficient • Video resolution and fps fulfills requirements • Dimensions and Weight advantage • Embedded SD card reader

Descent Control Design

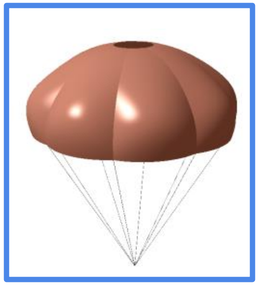
Presented by DongWoo Cho and JeongHyeok Lee

725~100m

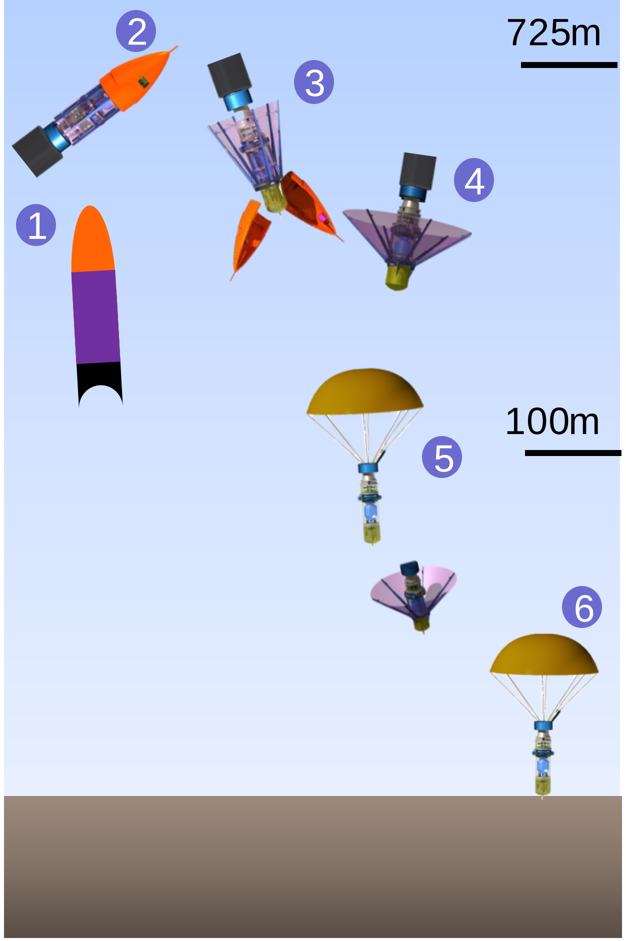


- Heat shield diameter: 43cm
- Using Ripstop Nylon Material
- 3D printed arms using PLA
- Control the descent rate by increasing air resistance area

100~0m



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



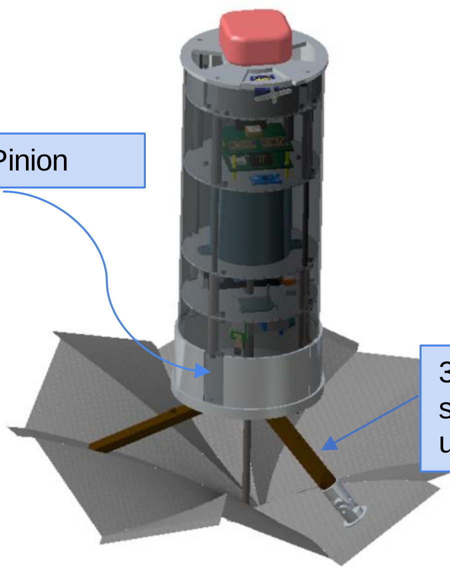
The CanSat is separated from the rocket at an altitude of up to 725 m.

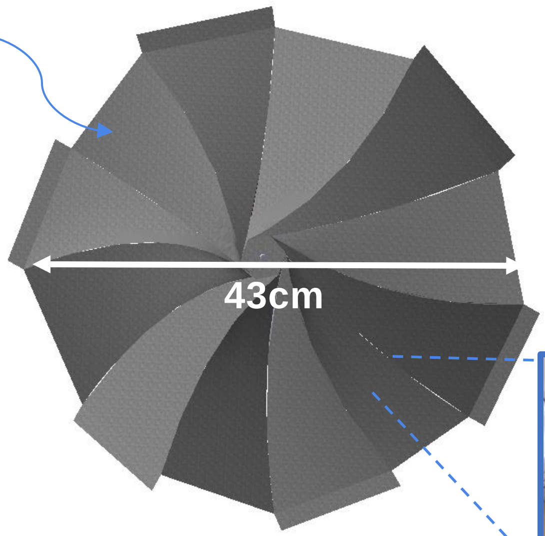
After deployment, unfold the heat shield to adjust the descent speed to between 10 and 30 m/s. (Target speed is 15 m/s ±5 m/s)

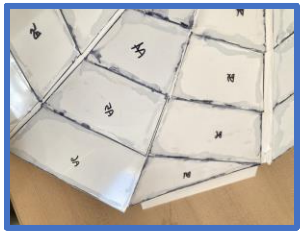
At 100m, release the heat shield and deploy the parachute to adjust the speed to less than 5 m/s.

Payload Aerobraking Descent Control Strategy Selection and Trade(1/3)

Strategy A : Origami Style





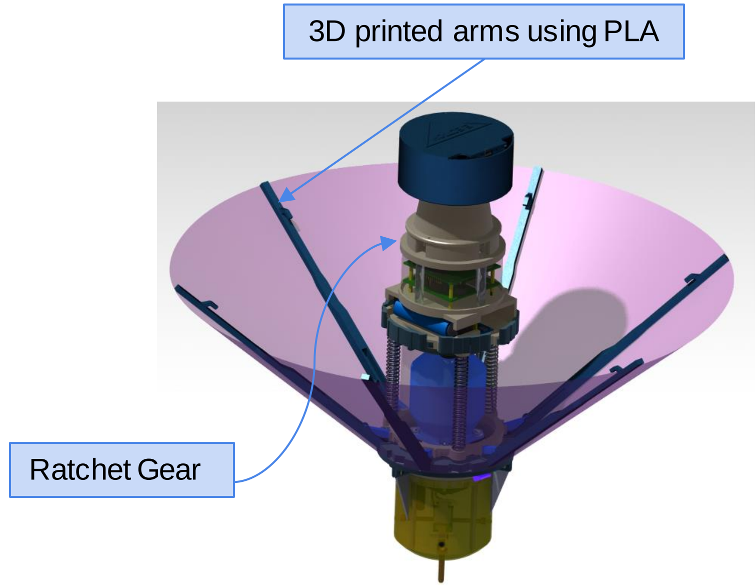


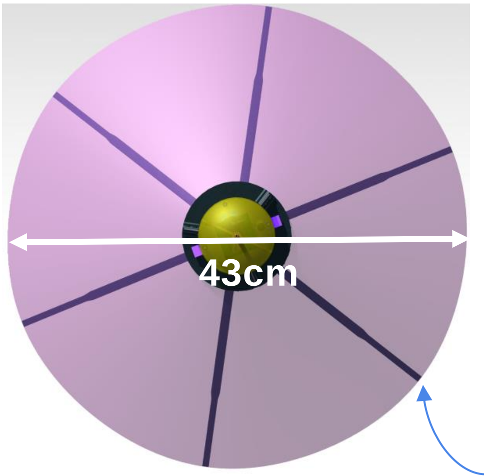
Information

- After launch, the heat shield is deployed at an angle of approximately 52° through the rack and pinion.
- Designed with a diameter of 43cm to decelerate at a speed of 15m/s
- The heat shield is paper based and attatched with an acrylic tiles that can provide strength and a heat shield effect.

Payload Aerobraking Descent Control Strategy Selection and Trade(2/3)

Strategy B : Classic Umbrella Style



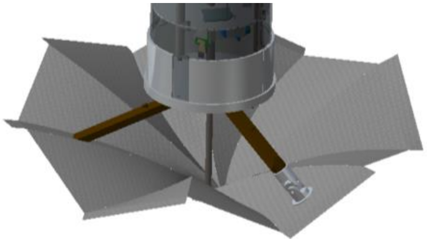
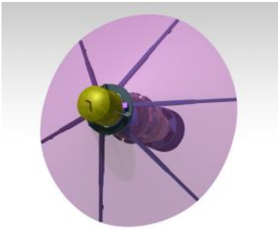


Information

- Immediately after separation of the CanSat, the heat shield is deployed at an angle of approximately 45° using the Ratchet Gear.
- Use nylon fabric with a diameter of 43 cm to decelerate at a speed of approximately 15 m/s.
- A circular heat shield to ensure that the pressure is uniformly dispersed.
- Simple circular fabric for ease of manufacture and maintenance.

Payload Aerobraking Descent Control Strategy Selection and Trade(3/3)

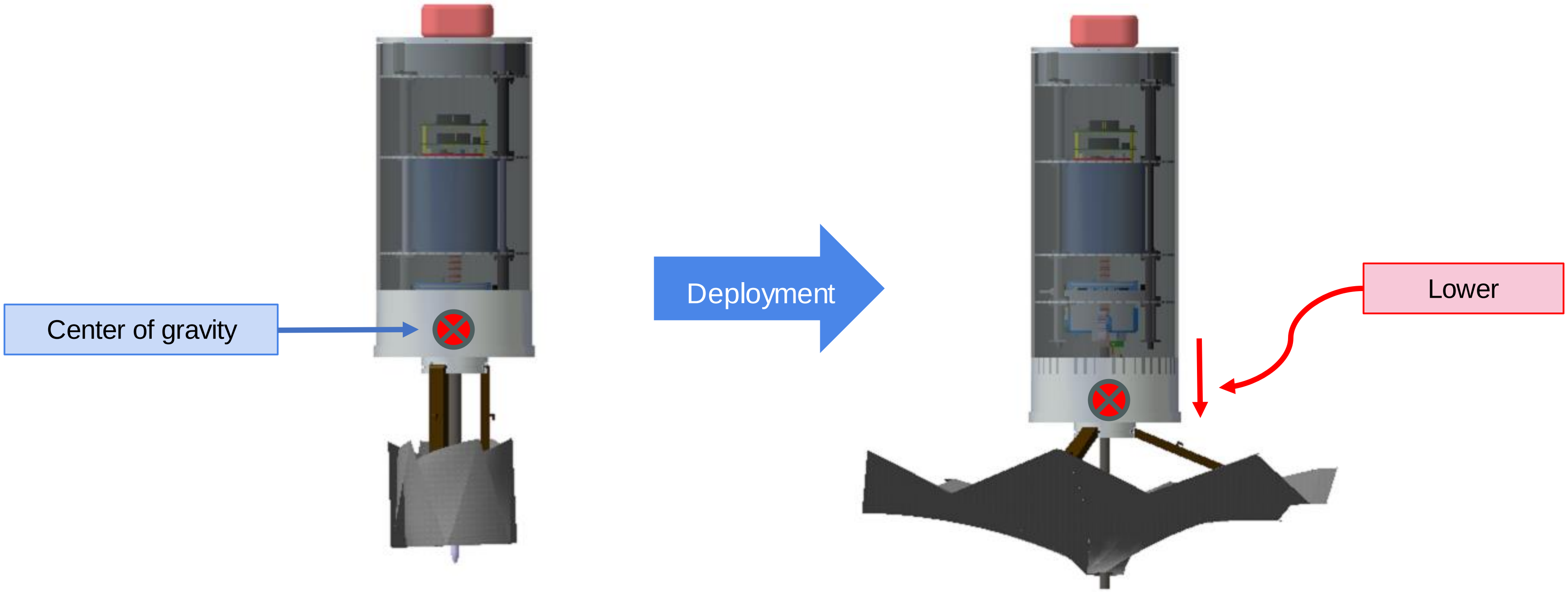
Trade and Selection

Strategy	A: Origami Style	B: Classic Umbrella Style
Shape		
Pros	• Since the material is acrylic, its heat i nsulation and rigidity are higher than f abric.	• High reliability of tumbling • Because the heat shield is circular, the exact area for descent control can be adjusted.
Cons	• Potential possibility of tumbling and rotation • Descent control can be challenging if the wind is very strong.	• Descent control can be challenging if the wind is very strong.

Selection	Reasons for selection
Strategy B	Strategy B is more reliable, more efficient, and easier to control descent than Strategy A

Payload Aerobraking Descent Stability Control Strategy Selection and Trade(1/3)

Strategy A : Origami Style

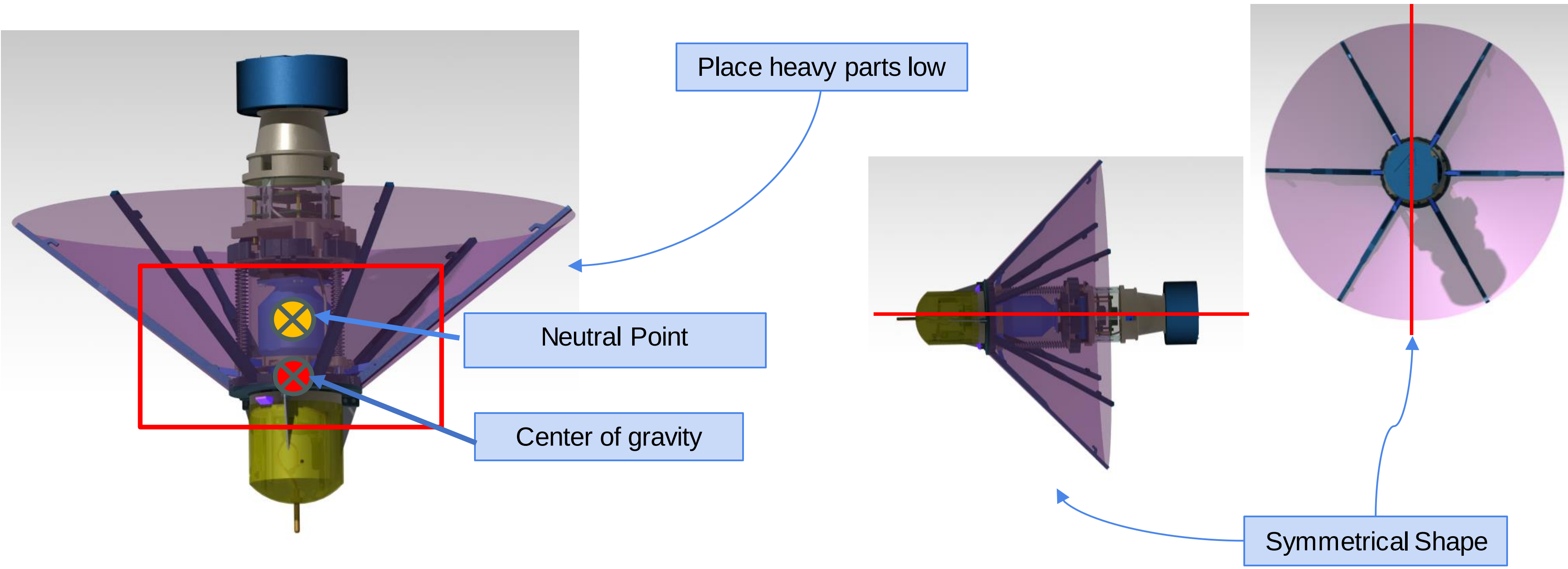


Information

- Place heavy components at the bottom.
- When deployed, the center of gravity lowers, improving stability.
- Using **Passive Stability Control** strategy through design.

Payload Aerobraking Descent Stability Control Strategy Selection and Trade(2/3)

Strategy B : Classic Umbrella Style



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 Aerobraking Descent Stability Control Strategy Selection and Trade(3/3)

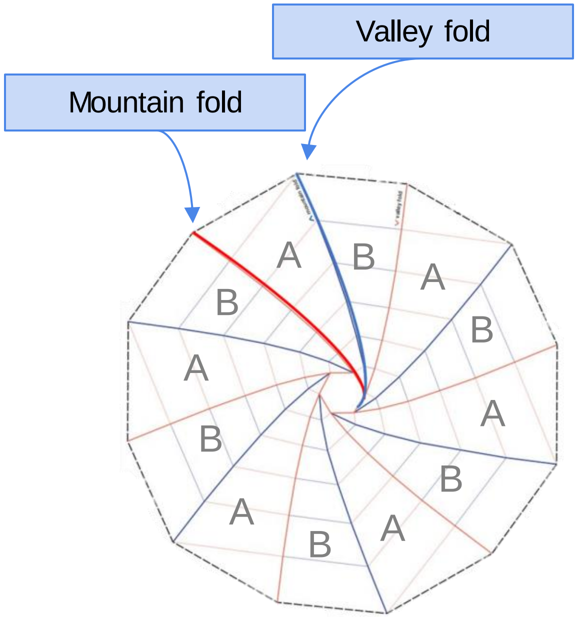
Trade and Selection

Strategy	A: Origami Style	B: Classic Umbrella Style
Pros	• Passive control using a symmetrical shape is easy. • Deploying the heat shield increases stability.	• The center of mass can be placed as low as possible. • Passive control using a symmetrical shape is easy. • The deployment of the heat shield is stable.
Cons	• There is limitation in activation of heat shield deployment.	• If there is a strong gust, it can be unstable.

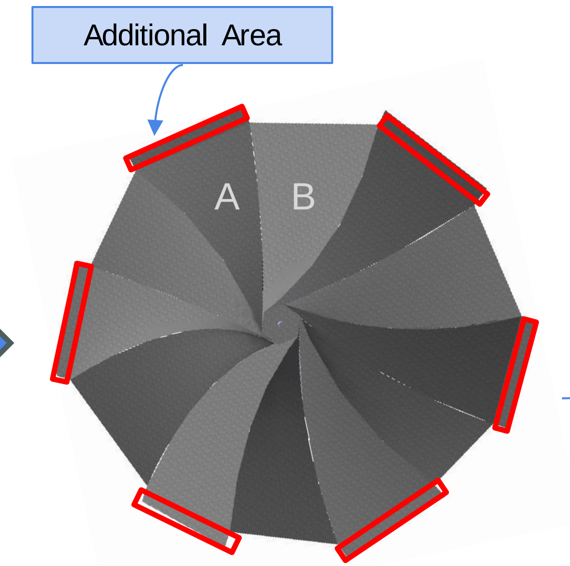
Selection	Reasons for selection
Strategy B	• Since Strategy B can deploy the heat shield faster than Strategy A, descent stability control is more reliable.

Payload Rotation Control Strategy Selection and Trade(1/3)

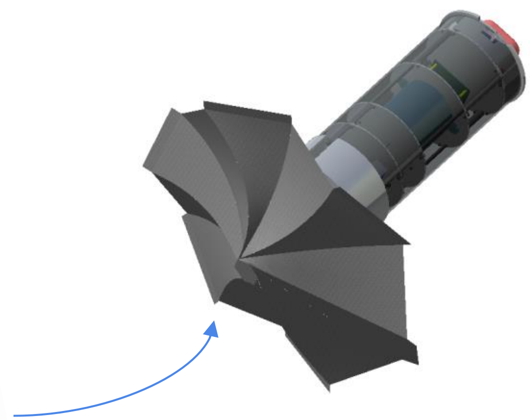
Strategy A : Origami Style



Origami Diagram(NASA)



Newly Designed Form(Inharo)



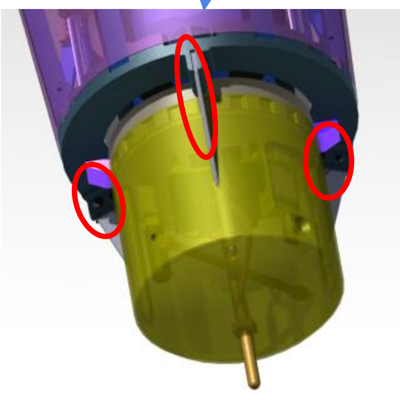
Information

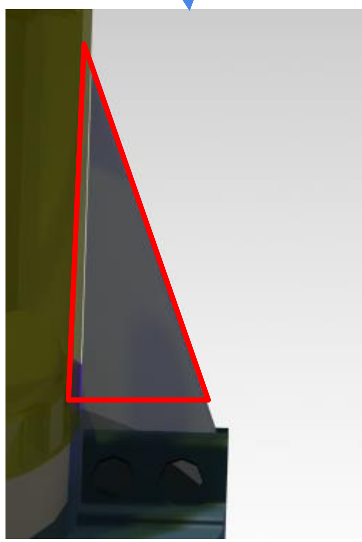
- When using the origami diagram provided by NASA as a heat shield, rotation occurs because of the different effective areas of sections A and B resulting from the folding shape.
- Additional areas are attached to make the effective areas of section A and section B the same.
- Using **Passive Rotation Control** strategy through design.

Payload Rotation Control Strategy Selection and Trade(2/3)

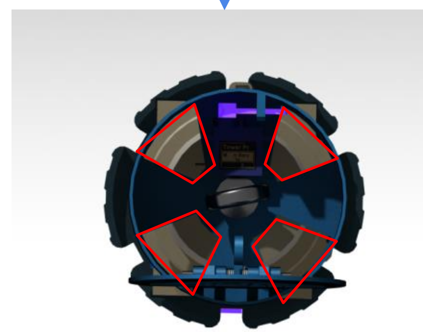
Strategy B : Classic Umbrella Style

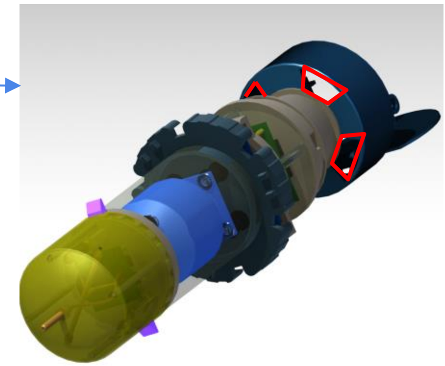
Three fins for rotation control





Four Holes for rotation control





Information

- While the heat shield is deployed and descending, three **fins** are attached in front of the heat shield to control rotation.
- When the heat shield is separated, the parachute lid opens, and the parachute is deployed, the rotation is controlled by **four holes** at the bottom of the parachute barrel.
- Using **Passive Rotation Control** strategy through design.

Payload Rotation Control Strategy Selection and Trade(3/3)

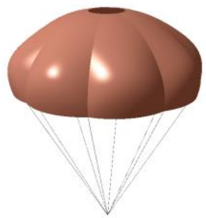
Trade and Selection

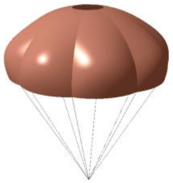
Strategy	A: Origami Style	B: Classic Umbrella Style
Pros	• Easily prevents rotation by increasing the area.	• Easily prevents rotation by using three Fins.
Cons	• Rotation cannot be prevented if the di mensions of the additional area chan ge due to disturbance.	• Difficulty coping with unexpected situ ations due to lack of active control sy stem.

Selection	Reasons for selection
Strategy B	• Strategy B can prevent rotation by external factors relatively better than strategy A and has a rotation strategy even after the heat shield is released.

Payload Parachute Descent Control Strategy Selection and Trade(1/2)

Trade and Selection

Shape	Shape 1	shape 2
Feature	 **Hemispherical parachute** with one spill hole	 **Cross parachute**
Pros	• Simple Design • High Drag Coefficient • High Aerodynamic Stability	• Easy to make • Easy to store • Reduced Pendulum Effect
Cons	• Long production time • Relatively difficult to store • Reduced Precision in Landing	• Low drag coefficient • Relative instability • Potential for Tangles

Selection	Reasons
	We chose hemispherical parachute because of its simplicity in design, which improves stability and ease of placement. We prioritized high stability and certainty of deployment, and judged that more stable flight would be possible through the spill hole of hemispherical parachutes.

Payload Parachute Descent Control Strategy Selection and Trade(2/2)

Trade and Selection

Material	Material 1		Material 2	
Feature		**Ripstop nylon**		**Polyester**
Pros	• Lightweight • High Durability • Cost-Effective		• High Durability • Low Sun Sensitivity (Minimal Color Changes)	
Cons	• High Sun Sensitivity • High Moisture Absorption		• Relative heavy • High Cost	

Selection	Reasons
	The reason we chose Ripstop nylon for the parachute material is its advantages in budget and weight considerations. Ripstop nylon offers excellent lightweight properties and is relatively affordable, providing sufficient durability within the budget constraints.

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

Parachute Calculations

Symbol	Value
$\boldsymbol{m}$	0.65 kg
$\boldsymbol{C_{dp}}$	1.3
$\boldsymbol{g}$	9.81 m/s²
$\boldsymbol{\rho}$	1.225 kg/m³
$\boldsymbol{v_{max}}$	5 m/s
$\boldsymbol{v_{min}}$	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($\boldsymbol{C_{dp}}$) of a hemispherical parachute is typically set to about 1.3

Parachute
$F_d = \frac{1}{2}\rho v^2 A_p C_{dp} = F_g = mg = \mathbf{6.3765N}$
$\frac{2mg}{\rho v^2 C_{dp}},\quad \frac{2*0.65*9.81}{1.225*5^2*1.3} \le A_p \le \frac{2*0.65*9.81}{1.225*3^2*1.3}$
$\mathbf{0.32 \le A_p \le 0.89}$
$\sqrt{\frac{4*0.32}{\pi}} \le D_p = \sqrt{\frac{4A_p}{\pi}} \le \sqrt{\frac{4*0.89}{\pi}}$
$\mathbf{0.64 \le D_p \le 1.06}$
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/s²
ρ	1.225 kg/m³
F_d	6.3765 N
A_p	0.567 m²
D_p	0.85 m
D_{sh}	0.085 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)

Heat shield Calculations

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

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

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/s²
ρ	1.142 kg/m³
m	0.9 kg
A_h	0.145 m²
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

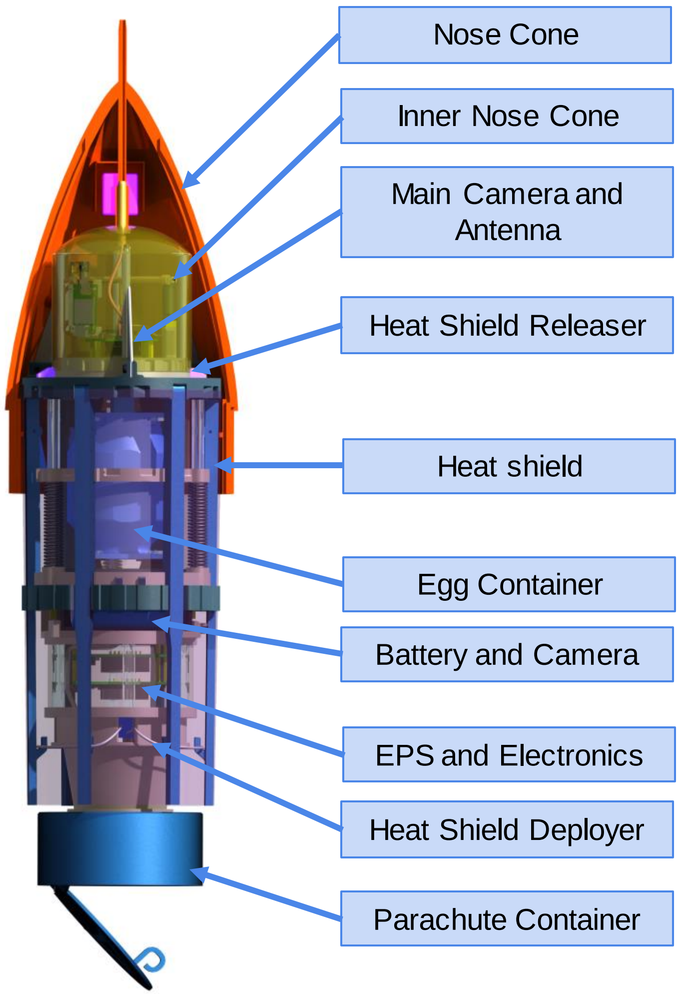
<table>
<tr><th></th><th colspan="2">Parachute</th><th>Heat shield</th></tr>
<tr><td>Target Velocity (m/s)</td><td colspan="2">3.76</td><td>15.06</td></tr>
<tr><td>Area (m²)</td><td>Parachute</td><td>0.567</td><td>0.145</td></tr>
<tr><td rowspan="2">Diameter (cm)</td><td>Parachute</td><td>85</td><td rowspan="2">43</td></tr>
<tr><td>Spill hole</td><td>8.5</td></tr>
<tr><td>String length (cm)</td><td colspan="2">98</td><td></td></tr>
</table>

Mechanical Subsystem Design

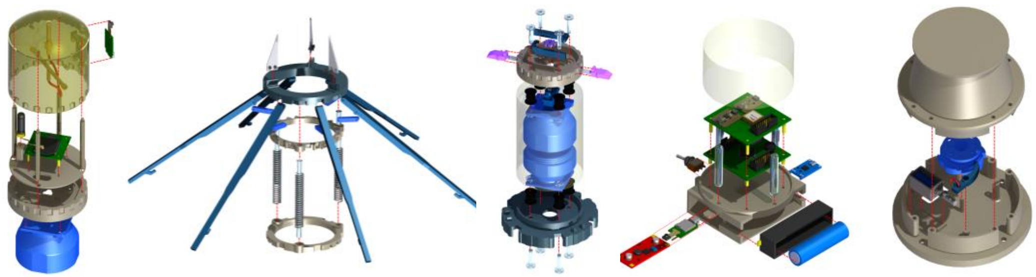
Presented by DongWoo Cho and JeongHyeok Lee

Mechanical Subsystem Overview

Major Structural Elements



Interface Definitions

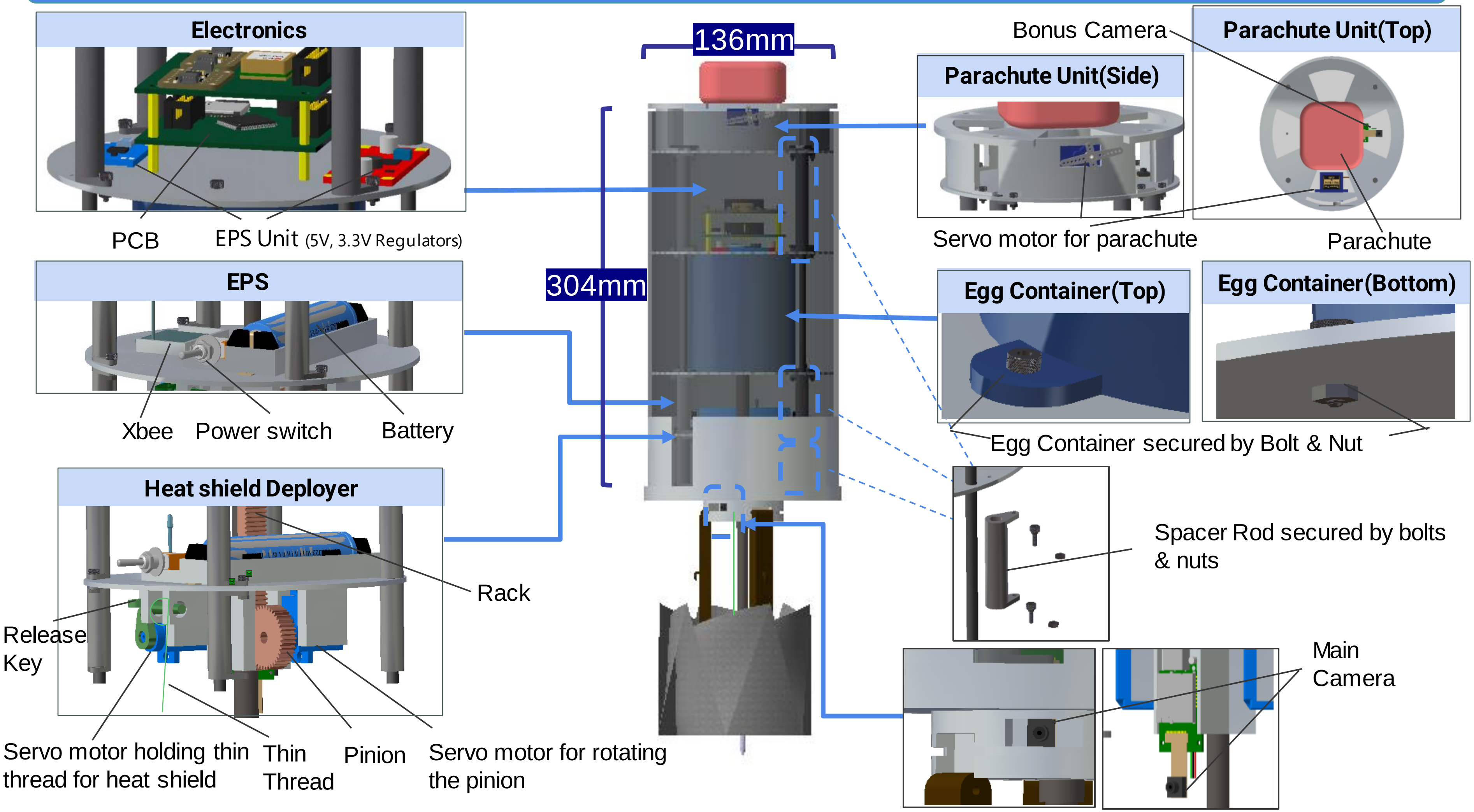


*Note: All connections marked with red lines are secured using M2 Bolts and Loctite

Material	Structural Element
PLA	Heat shield Assembly, Heat shield Deployer Assembly, Egg Container, Nose Cone, Inner Nose Cone, Heat shield Releaser Assembly, Parachute Container, Electronic Assembly
Ripstop Nylon Fabric	Parachute, Small Parachute, Heat shield
Steel	Heat shield Spring, Heat shield Releaser Spring
Carbon Fiber	Heat shield Rod
Rubber	Egg Container Damper

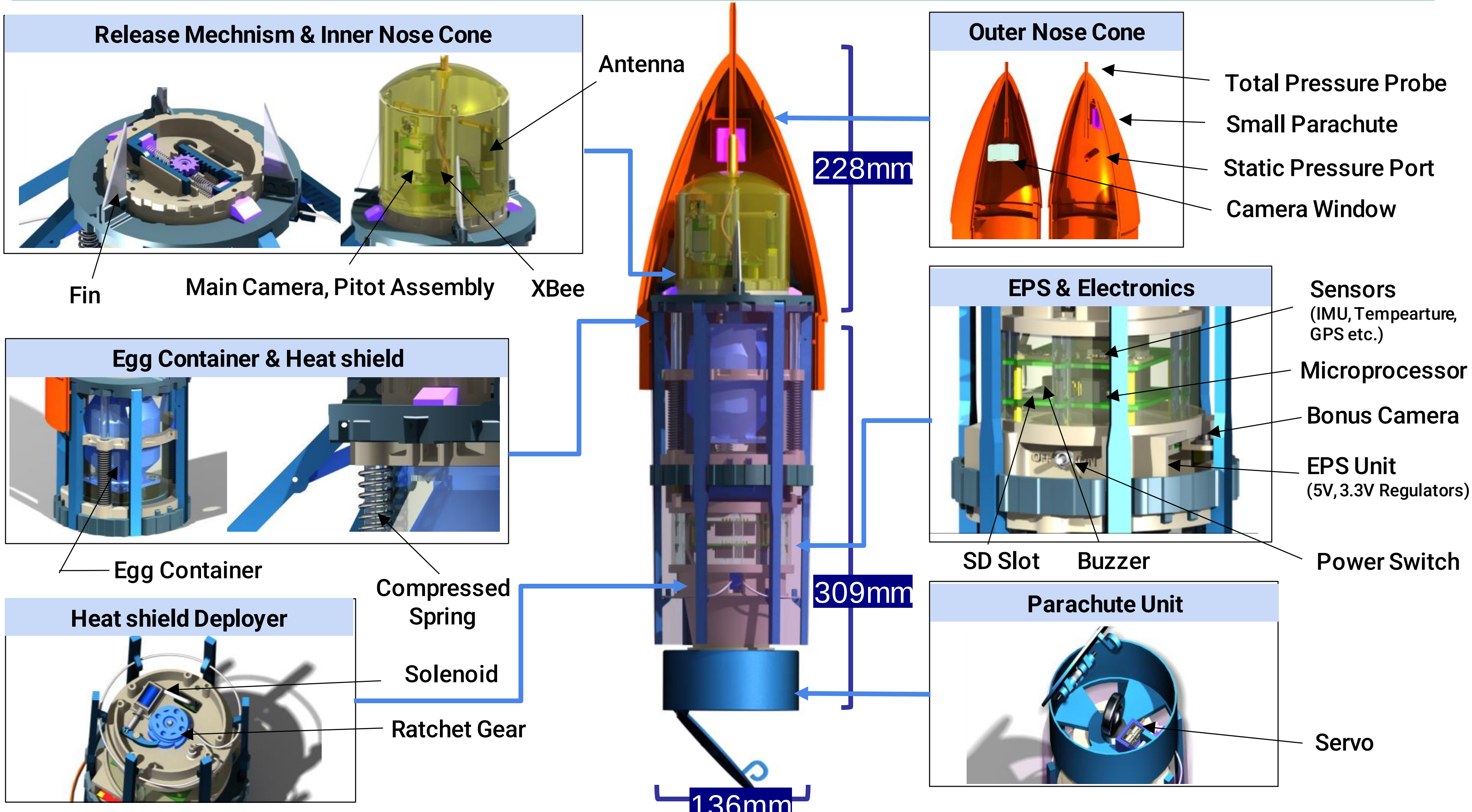
Payload Mechanical Layout of Components Trade & Selection(1/3)

Strategy A : Origami Style



Payload Mechanical Layout of Components Trade & Selection(2/3)

Strategy B : Classic Umbrella Style



Payload Mechanical Layout of Components Trade & Selection(3/3)

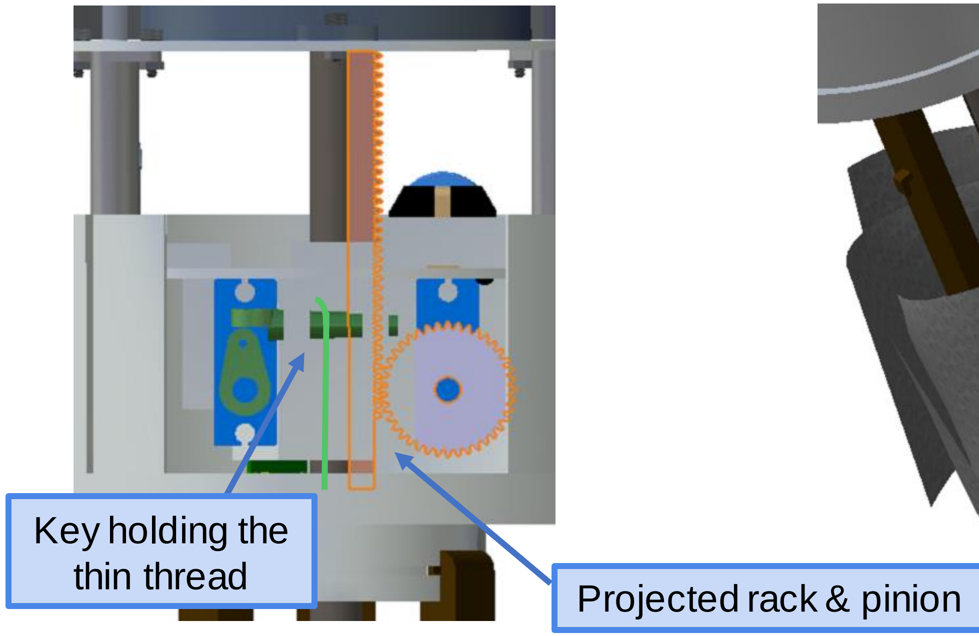
Strategy	A: Origami Style	B: Classic Umbrella Style
Pros	• Easily optimizable • Sufficient area for placing parts	• Simpler layout • The space inside the heat shield arms can be used for parts
Cons	• Center of gravity is relatively high due to deploying mechanism.	• Cross section of the payload decreases due to heat shield arms • Requiring sophisticated calculations due to the spring

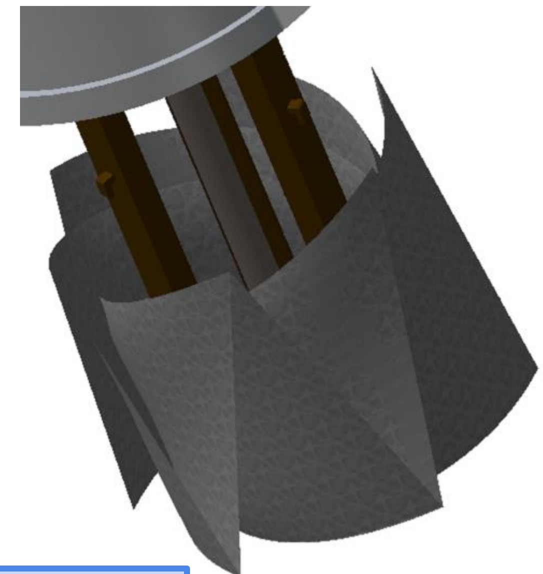
Selected	Reasons
B (Classic Umbrella style)	• Layout B is more suitable for placing parts that we need and space of layo ut B is enough to place our parts.

Material	Components
PLA	Nose cone, heat shield assembly, parachute container etc.
Nylon	Parachute and heat shield
Acrylic	Cover of PCB and payload

Payload Aerobraking Pre Deployment Configuration Trade & Selection(1/3)

Strategy A : Origami Style



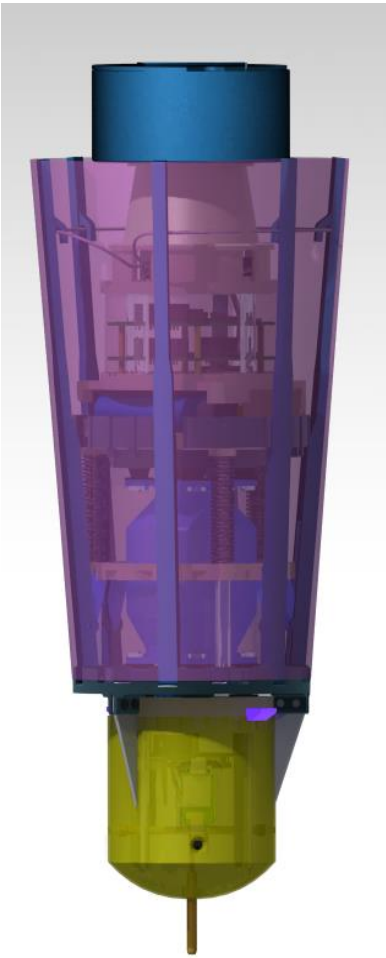


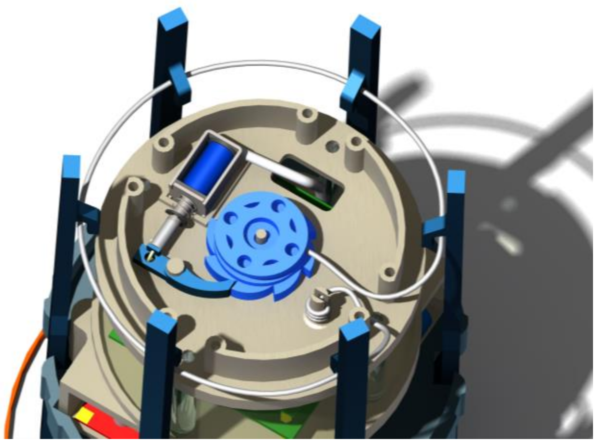
Information

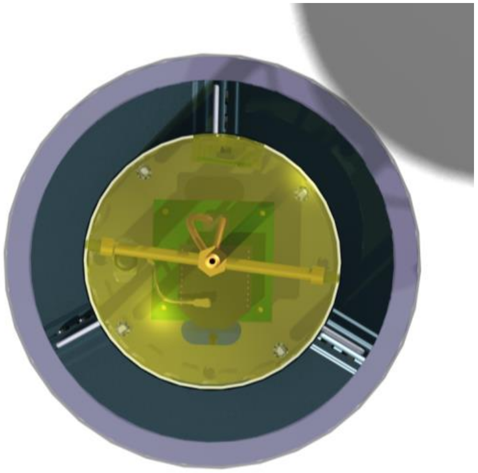
- The servo motor and pinion are fixed to the bulkhead.
- The rack is raised to a stationary position and the key holds the thin thread to maintain the distance between the bulkhead and the heat shield.
- The heat shield is folded in an origami-style and attached to three supporting bars and the tube penetrating the payload.

Payload Aerobraking Pre Deployment Configuration Trade & Selection(2/3)

Strategy B : Classic Umbrella Style



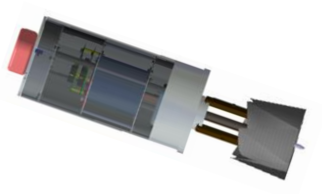




Information

- The heat shield is folded and the CanSat will be placed in the rocket.
- The heat shield arms are secured with a string and ratchet assembly.
- The CanSat has sufficient clearance with the container, allowing it to slide out easily.

Payload Aerobraking Pre Deployment Configuration Trade & Selection(3/3)

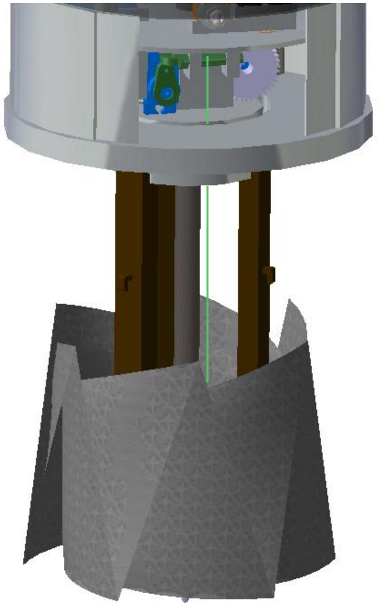
Strategy	A: Origami Style	B: Classic Umbrella Style
Shape		
Pros	• Easy to maintain pre-deployment configuration without any locking mechanism. • No protruding components on the surface.	• Easily slide out from the container. • Inner nose cone for stability before the heat shield is deployed
Cons	• Due to supporting bar, space utiliz ation is difficult.	• Risk of the ratchet gear unlocking.

Selected	Reasons for selection
B (Classic Umbrella style)	Maintaining a stable attitude before the heat shield is our first priority.

Payload Aerobraking Deployment Configuration Trade & Selection(1/3)

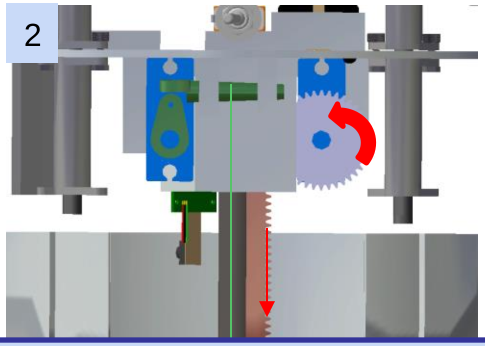
Strategy A : Origami Style

1

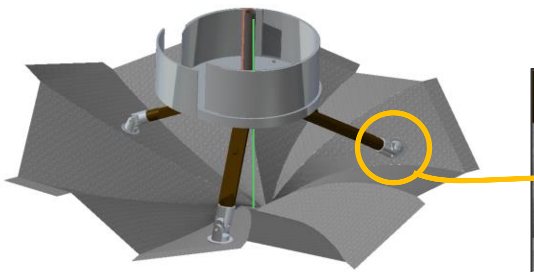


Pre-Deployment

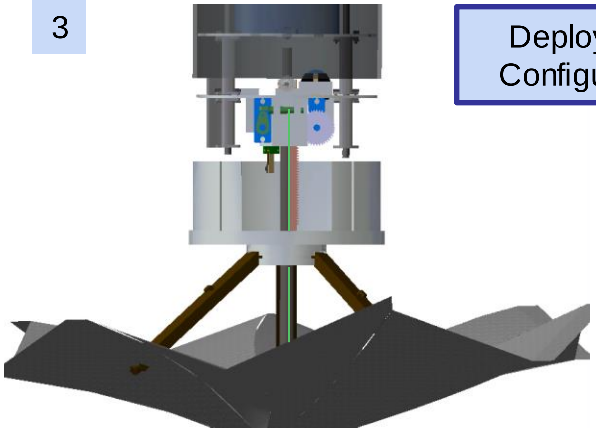
2



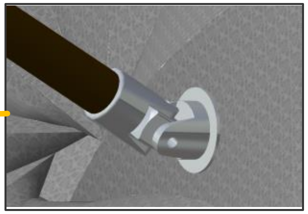
Rack and Pinion gear to stretch the bar



3



Deployment Configuration



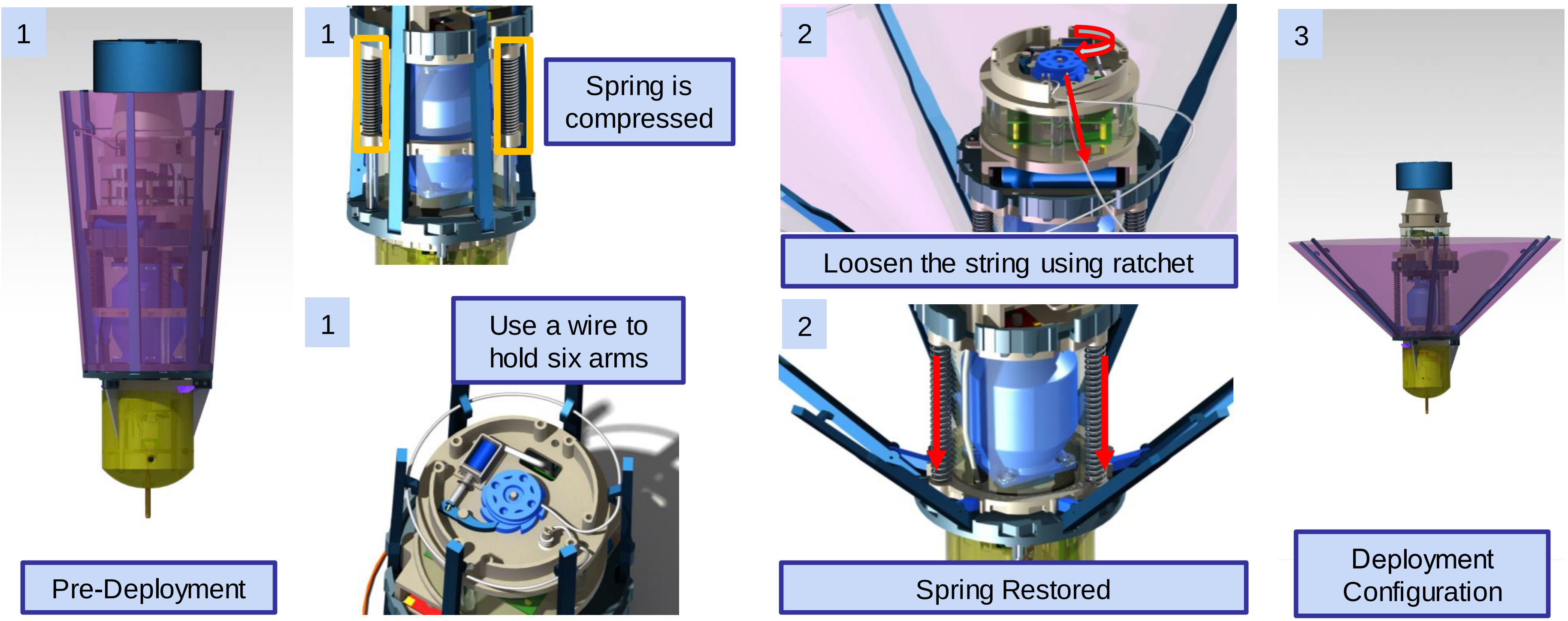
3D printed universal joint

Information

- There is a heat shield pipe covering the carbon pitot tube.
- Use rack and pinion gear mechanism to lower the heat shield pipe.
- Use a tension of thin thread connecting bottom of heat shield and bulkhead to prevent self-descent.
- To enhance flexibility of the heat shield, use 3D printed universal joint.

Payload Aerobraking Deployment Configuration Trade & Selection(2/3)

Strategy B : Classic Umbrella Style

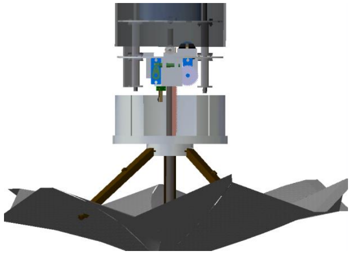


Information

- The heat shield module consists of 3D printed arms, holders, and three springs.
- When the spring is compressed, use a string to constrain the six arms.
- When the wire securing the arm is released using a ratchet, the spring returns to its original state and the heat shield is deployed.

Payload Aerobraking Deployment Configuration Trade & Selection(3/3)

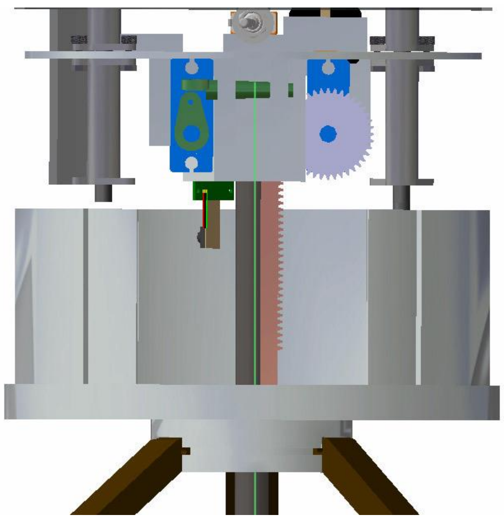
Trade and Selection

Strategy	A: Origami Style	B: Classic Umbrella Style
Shape		
Pros	• Lower mass center because of weight of heat shield.	• Simple and reliable deployment • Minimize motor use
Cons	• During the deployment process of the heat shield, rotation of the heat shield occurs. • Using moter for deployment results in slower deployment speed.	• Unexpected situations such as string twisting that restrains the heat shield may occur.

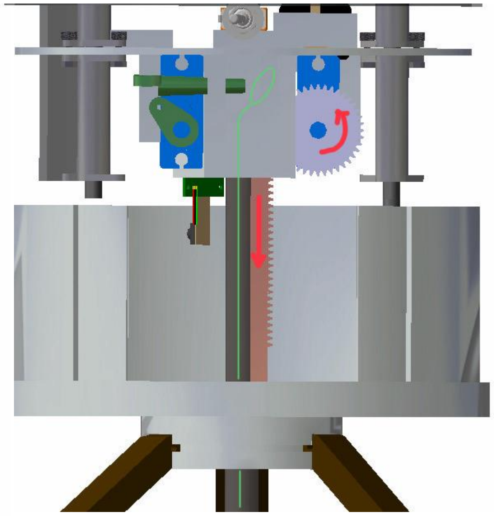
Selection	Reasons for selection
B (Classic Umbrella style)	Strategy B minimizes the use of the motor and is a simpler and more stable than strategy A

Payload Aerobraking Release Trade & Selection(1/3)

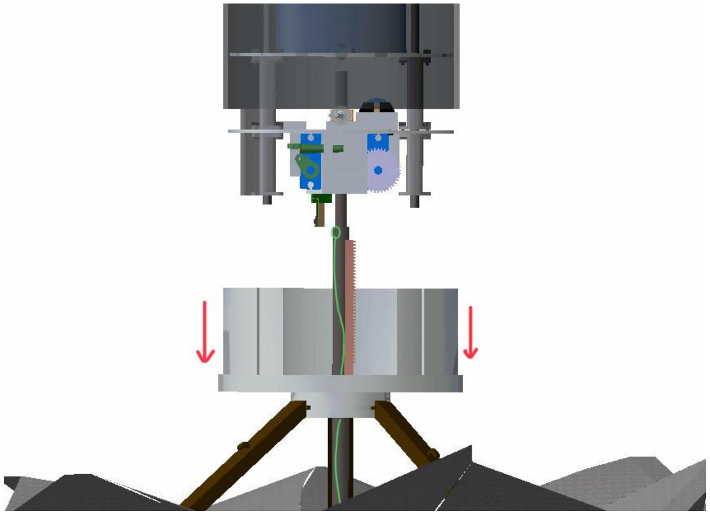
Strategy A : Origami Style



Before release



Release by servo rotation



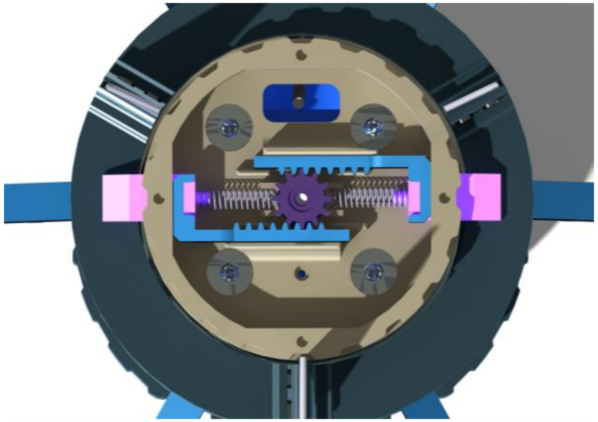
After release

Information

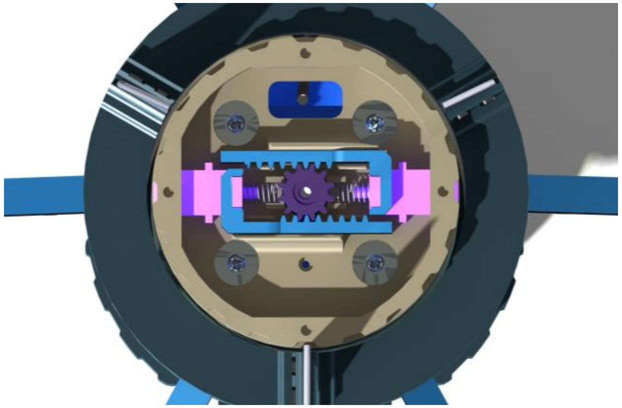
- Use a thin thread to apply tension to make deployment easier and to secure the heat shield to probe.
- The thread is connected to a key, which is attached to the bulkhead where the servos are mounted.
- At the release altitude, use the servo to unlock the key from the key holder to free the thread and rotate the pinion gear until it reaches the end of the rack gear.
- As there is nothing holding the heat shield to the probe, the heat shield will fall freely.

Payload Aerobraking Release Trade & Selection(2/3)

Strategy B : Classic Umbrella Style



Before release



Release by servo rotation

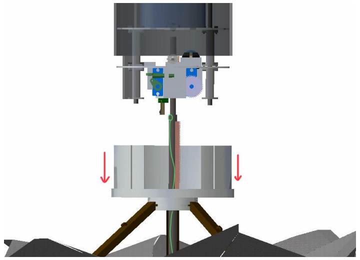
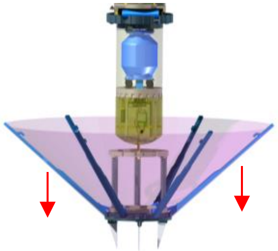
After release

Information

- When it reaches the release altitude, a servo motor is used to unlock the lock device connecting the p ayload and the heat shield.
- As the parachute is deployed and decelerates the payload, the heat shield separates and falls downward.

Payload Aerobraking Release Trade & Selection(3/3)

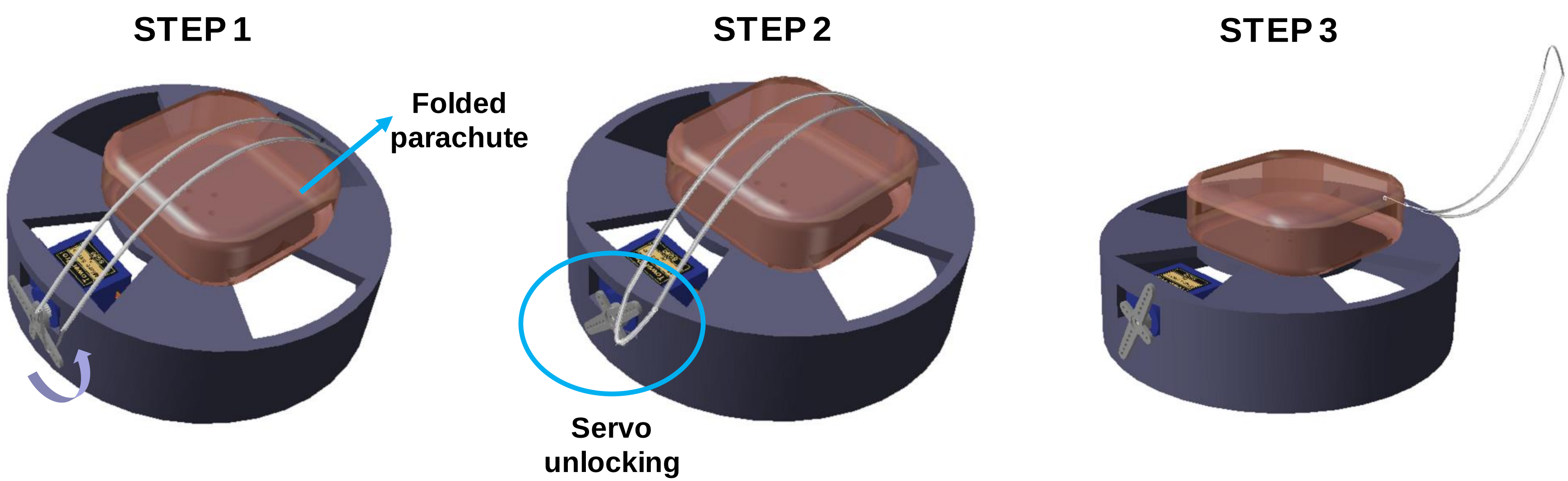
Trade and Selection

Strategy	A: Origami Style	B: Classic Umbrella Style
Shape		
Pros	• Due to the heavy weight of the heat s hield module, a stable release is poss ible.	• Simple and reliable mechanism • Fast release is possible
Cons	• Potential for the thread to get jammed on the key. • Two servos need to operate simultaneously.	• The heat shield may not be released if the lock is not inserted sufficiently.

Selection	Reasons for selection
B (Classic Umbrella style)	Strategy B has a simpler mechanism than strategy A and can release the heat shield more quickly.

Payload Parachute Deployment Configuration Trade & Selection(1/4)

Concept 1

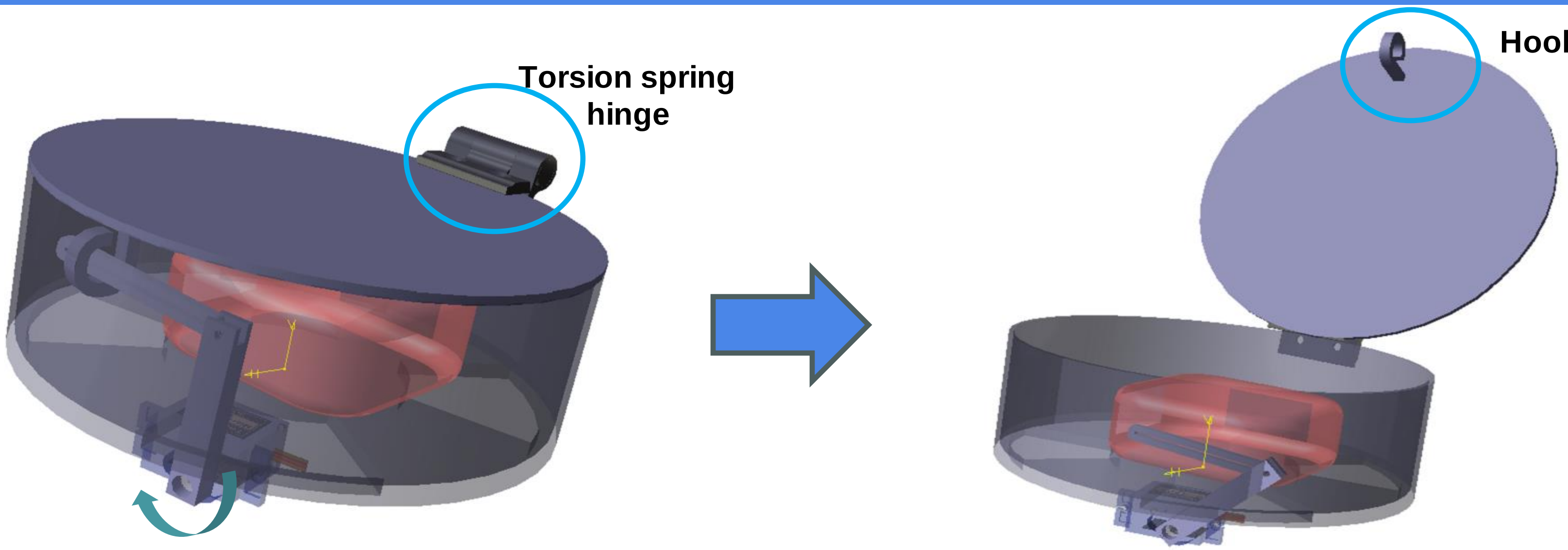


Information

- The parachute is deployed as a servo motor rotates and releases the thread that secures the parachute.
- The parachute connects to holes in the floor and remains in place before and after deployment.
- In the initial state, each end of the threads is connected to two holes in the support wall and the hron of the servo motor to secure the parachute.
- When deploying the parachute, the servo motor rotates and releases the thread.

Payload Parachute Deployment Configuration Trade & Selection(2/4)

Concept 2

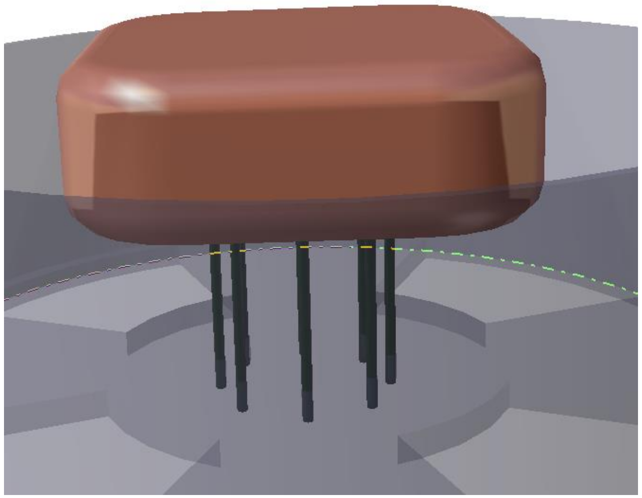


Information

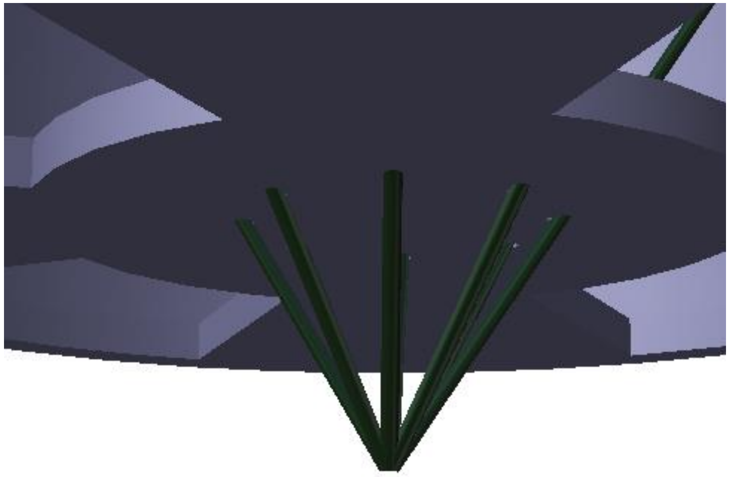
- Concept 2 deploys the parachute using a servo motor, a hook on a lid, and a torsion spring.
- The parachute connects to holes in the floor and never falls before and after deployment.
- In the initial state, two arms connected to the servo secure the lid by hooking it.
- When deploying the parachute, the servo motor rotates, pulling the hooked arm and opening the lid with the force of the torsion spring.
- A hole is created on the side of the body to allow wind to enter and unfold the parachute.

Payload Parachute Deployment Configuration Trade & Selection(3/4)

Parachute attachment to payload



Top view



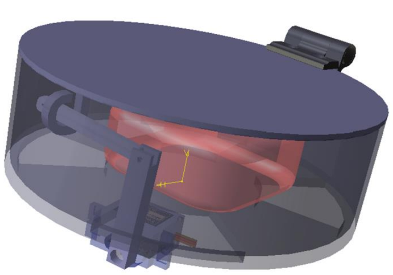
Bottom view

Information

- Eight strings, passing through holes drilled in the parachute storage, are knotted under the storage to attach the parachute to the payload.
- The attachment method is the same for both concept 1 and 2.
- We initially considered a small eye bolt for fixing, but adopted this method due to its weight and space-saving benefits.

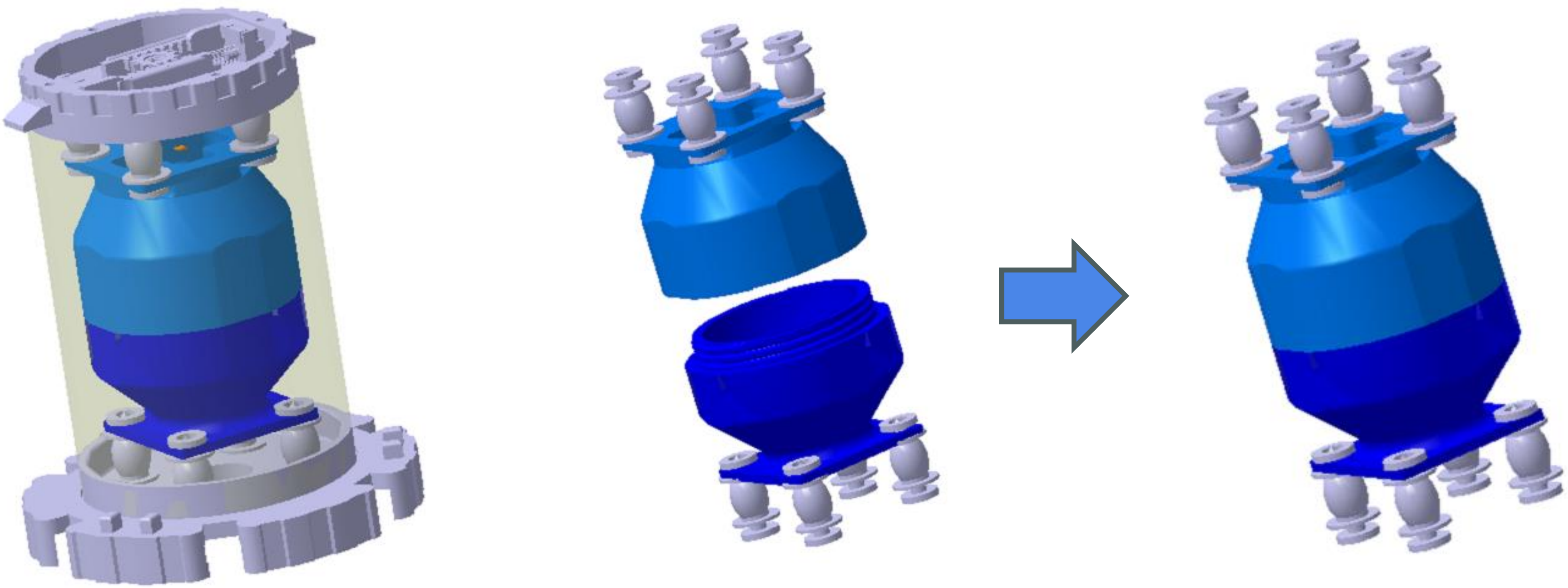
Payload Parachute Deployment Configuration Trade & Selection(4/4)

	Concept 1	Concept 2
Pros	• Light weight • Small volume • Easy to make	• The parachute is secured safely • Low risk of deployment failure • Convenience of storage and fixation
Cons	• Parachute may not be safe • Requires strong fixation • Deployment fails when the line breaks	• A heavy weight • A large volume

Selection	Reasons for selection
Concept 2 	Concept 2 has the advantage of having less risk of failure in deployment. The most important thing is not to fail in deploying the parachute at the exact time. The concept is chosen because ensuring deployment of the parachute at the exact time is most important. Additionally, it is resistant to external shock.

Payload Egg Containment Configuration Trade & Selection(1/3)

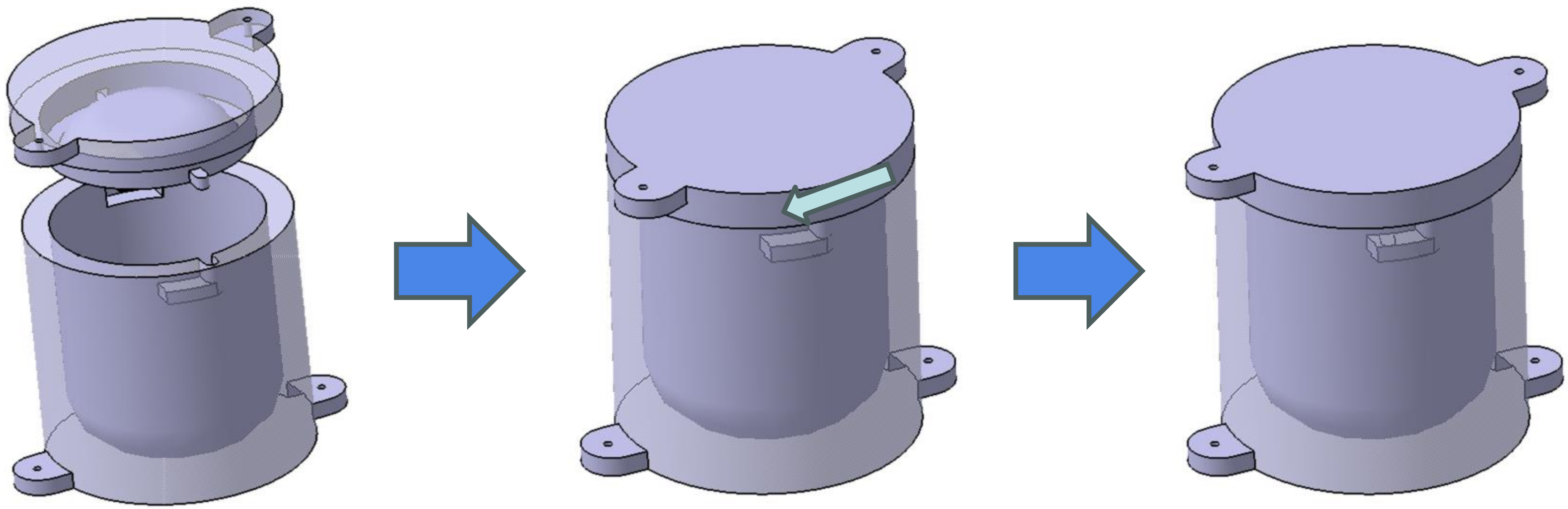
Concept 1



Structure	Mechanism	Pros	Cons
Capsule	• The egg is placed in a capsule with cushioning material. • The two capsule parts are held tightly together. • The rubber dampers reduce the impact on the egg.	• Small volume • Easy to load onto the payload. • Damper's shock relief	• Little space for cushioning

Payload Egg Containment Configuration Trade & Selection(2/3)

Concept 2



Structure	Mechanism	Pros	Cons
Cylindrical	• The egg is placed in a container with cushioning material. • The container has a screw-on lid. • Connected to the payload with bolts and nuts.	• Simple mechanism • Light weight	• Large volume

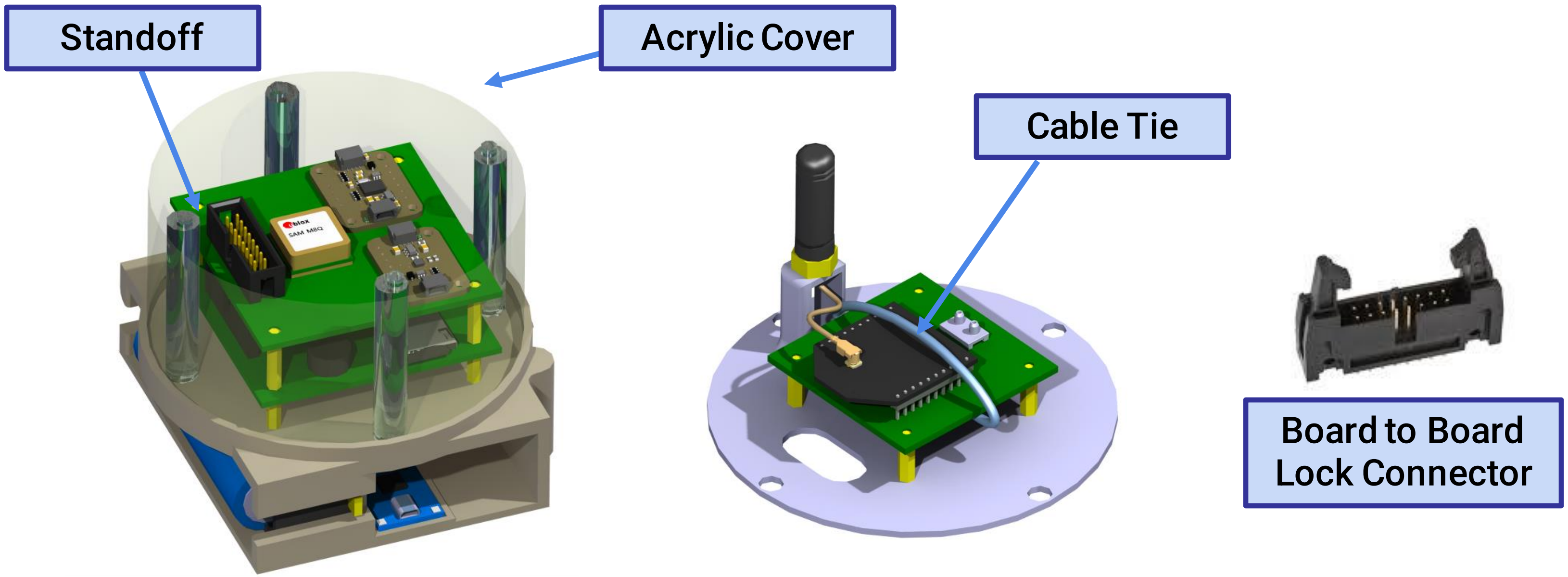
Payload Egg Containment Configuration Trade & Selection(3/3)

Selection	Reasons for selection
Concept 1 	• Most suitable for an umbrella style payload. • Small volume • Light weight • Dampers contribute to the safety of eggs.

PLA	• Easy to shape as desired and provides strong protection for the egg.

Protect Materials	Reasons for selection
Bubble wrap	• Easy to obtain • Inexpensive

Electronics Structural Integrity



Information

- All primary electronic components are soldered onto the PCB. If a functional module is available, it is directly soldered onto the PCB.
- The PCB boards are attached to the payload using screws and standoffs for secure fastening.
- A thin acrylic cylinder is used to protect the electronic components.
- If a pin header is used, fasten the electronic parts using cable ties.
- Each PCB is connected using a lock header.

Mass Budget(1/5)

Heat Shield

Component	Quantity	Mass(g)	Mass sum(g)	Source
Upper Holder	1	47.45	47.45	Estimated
Lower Holder	1	13	13	Estimated
Base Plate	1	20.15	20.15	Estimated
Arm	6	9.8	58.8	Estimated
Stretcher	6	1.4	8.4	Estimated
Rod	3	7	21	Estimated
Spring	3	2	6	Estimated
Heat Shield Total	-	-	**174.8**	-

Arm Holder

Component	Quantity	Mass(g)	Mass sum(g)	Source
Arm Holder Assembly	1	80.5	80.5	Estimated
Solenoid	1	12.6	12.6	Datasheet
Ratchet Assembly	1	5.6	5.6	Estimated
Arm Holder Total	-	-	**98.7**	-

Mass Budget(2/5)

Egg Container

Component	Quantity	Mass(g)	Mass sum(g)	Source
Container	1	102	102	Estimated
Damping Rubber	8	2	16	Datasheet
Egg Container Total	**-**	**-**	**118**	**-**

Nose Cone

Component	Quantity	Mass(g)	Mass sum(g)	Source
Left Nose Cone	1	58.5	58.5	Estimated
Right Nose Cone	1	56.55	56.55	Estimated
Inner Nose Cone	1	33.6	33.6	Estimated
Small Parachute	1	7	7	Estimated
Nose Cone Total	**-**	**-**	**155.65**	**-**

Mass Budget(3/5)

Heat Shield Releaser

Component	Quantity	Mass(g)	Mass sum(g)	Source
Releaser Assembly	1	33.6	33.6	Estimated
Gear	1	0.42	0.42	Estimated
Rack	2	1.4	2.8	Estimated
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**	-

Parachute

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

Mass Budget(4/5)

Electronics

Component	Quantity	Mass(g)	Mass sum(g)	Source
Electronic Assembly	1	53.9	53.9	Estimated
PCB Rod	8	2	16	Datasheet
PCB Board	3	1	3	Estimated
BMP390	1	7	7	Datasheet
BNO055	1	3	3	Datasheet
SDP31	1	0.2	0.2	Datasheet
SAM-M8Q	1	7	7	Datasheet
Mini Spy Camera	2	2.8	5.6	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	**-**	**-**	**214.3**	**-**

Mass Budget(5/5)

Summary

Subsystem	Mass(g)
Heat shield	174.8
Arm Holder	98.7
Egg Container	118
Nose Cone	155.65
heat shield Releaser	48.72
Parachute	84
Electronics	214.3
Total	**894.17**
Margin	**+5.83 g**

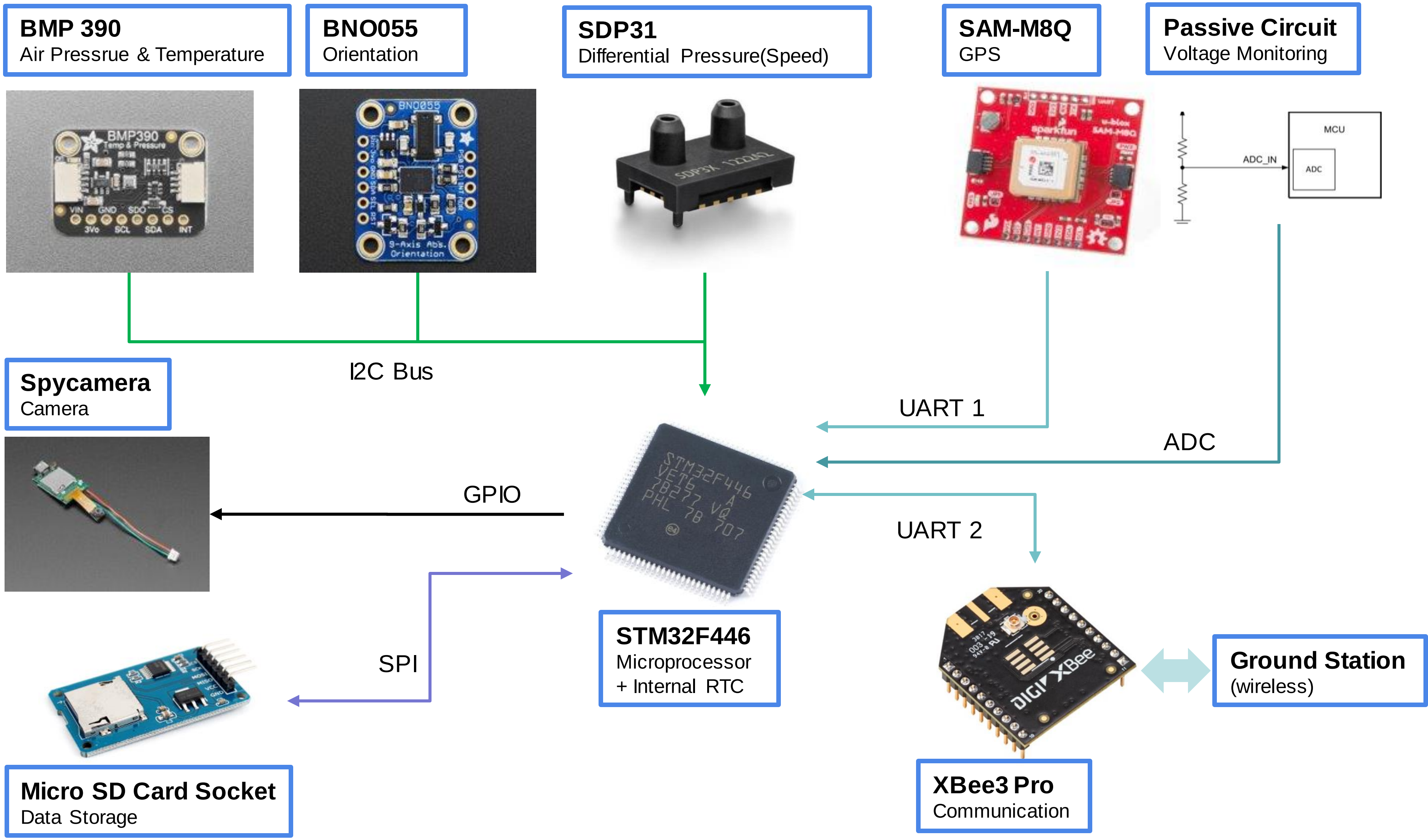
Method of correction to meet mass requirement

- 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.

Communication and Data Handling (CDH) Subsystem Design

Presented by HyungJun Bae

Payload Command Data Handler (CDH) Overview



Payload Processor & Memory Trade & Selection(1/2)

Processor

Model	Boot Time	Processor Speed	Memories	Interface	Ports	Cost ($)
STM32 F446ZE	< 3 ms	Up to 180 MHz	512 KB [Flash] 128 KB [SRAM]	4 x I2C 4 x USART 4 x SPI	114 x I/O 3 x ADC	11.64
ATmega2560	2.5 sec	16MHz	256 KB [Flash] 8KB [SRAM]	1 x I2C 5 x SPI 4 x USART	86 x I/O 16x ADC	14.82
Teensy 4.0 (ARM Cortex-M7)	5 ms	600 MHz	2048 KB [Flash] 1024 KB [RAM]	3 x I2C 3 x SPI	40 x I/O 2 x ADC	23.80

Selected Processor		Reasons
	**STM32 F446ZE**	• High performance • Enough data interfaces & memories • Experience with the microcontroller • Customized design is possible.

Payload Processor & Memory Trade & 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)
DFR0229	SPI	MicroSD	Up to 32 GB	5 V	20x28	10.76 (SD Card Included)

Selected Memory		Reasons
	**SZH-EKBZ-005**	• 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 F446ZE (Internal RTC)	32 kHz	±500ppm	Coin Battery	SPI	Integrated in STM32	0
SZH-EK047	32 kHz	±3.5ppm	Coin Battery	I2C	3.3 - 5.0 V	2.71

Selected RTC		Reasons
	STM32 F446ZE (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 Trade & Selection(1/2)

Payload antenna

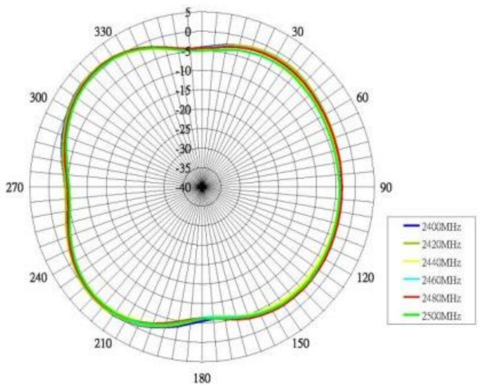
Model	Type	Frequency Range(GHz)	Gain (dBi)	Pattern	Connector	Dimensions (mm)	Maximum Range*	Cost ($)
Delta 20	stubby	2.4 – 2.5	0	Omni-Directional	RP-SMA	L28.5 x W7.9 Ø	~9.9 km	11.16
WRL-18086	PCB	2.4 - 2.5	3	Different by design	U.FL	50 x 10	~14.0 km	1.5
KPANR BD1045	monopole	2.4 - 2.5	2	Omni-Directional	SMA Male	48 x 17 x 8	~12.5 km	9.33

*Calculated using the Free Space Path Loss(FSPL) equation at 2.4GHz. Assuming that cable loss is negligeble.

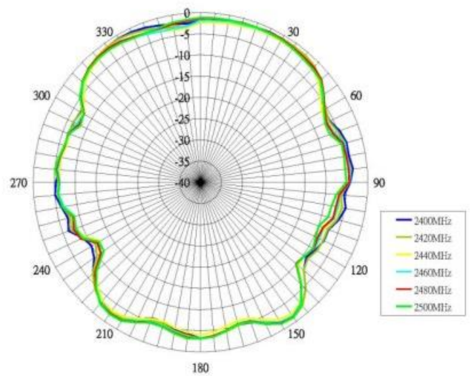
Selected Antenna		Reasons
	**Siretta Delta 20**	• Light weight • Small Size • Omni directional pattern (very close to isotropic compares to others) • Reliable datasheet

Radiation Patterns

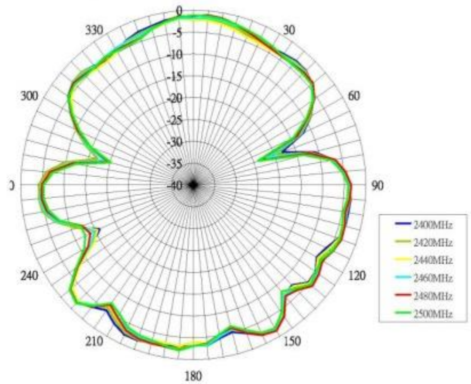
XY Plane



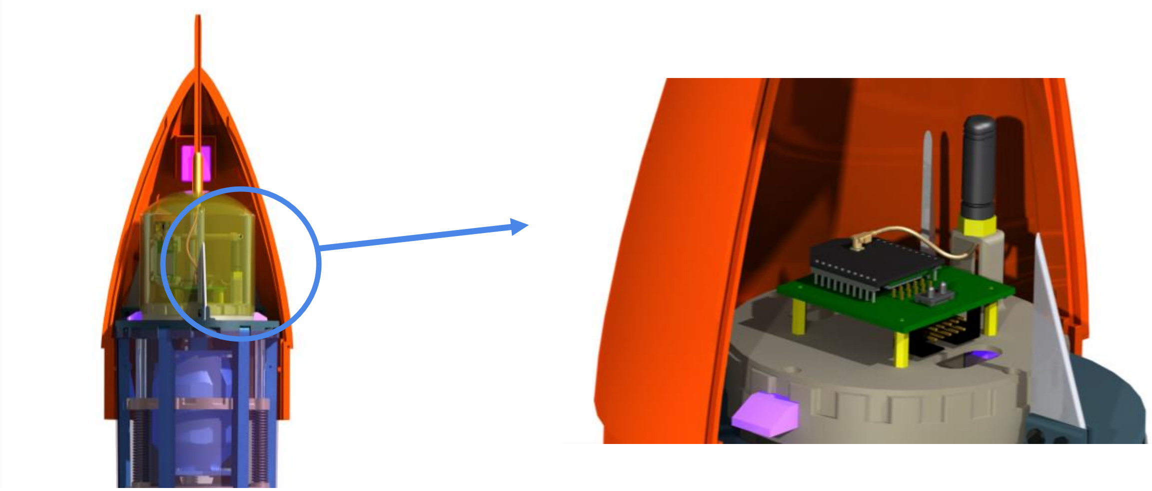
XZ Plane



YZ Plane



Location



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			

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

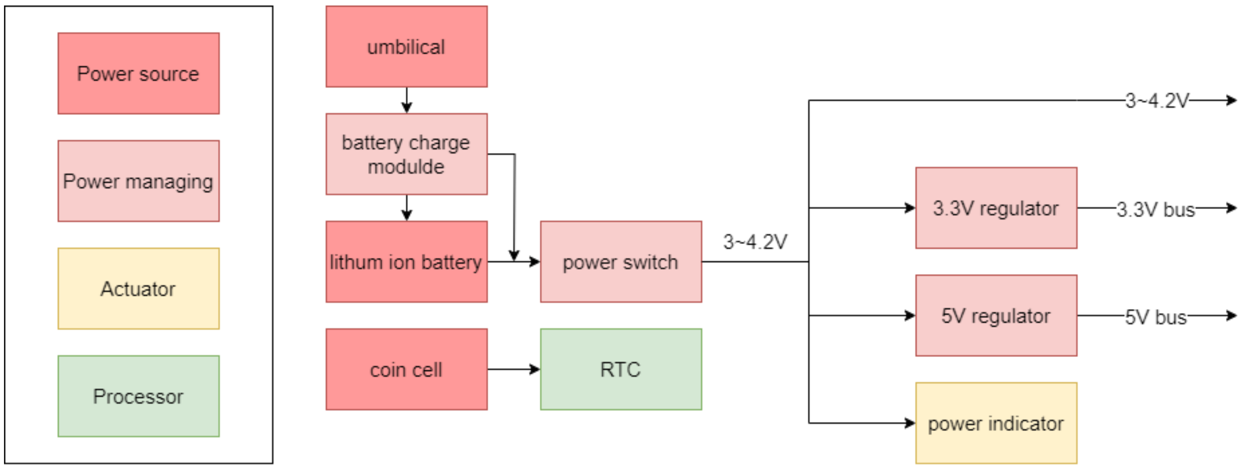
* Command string is all capitalized without any spaces.

Electrical Power Subsystem (EPS) Design

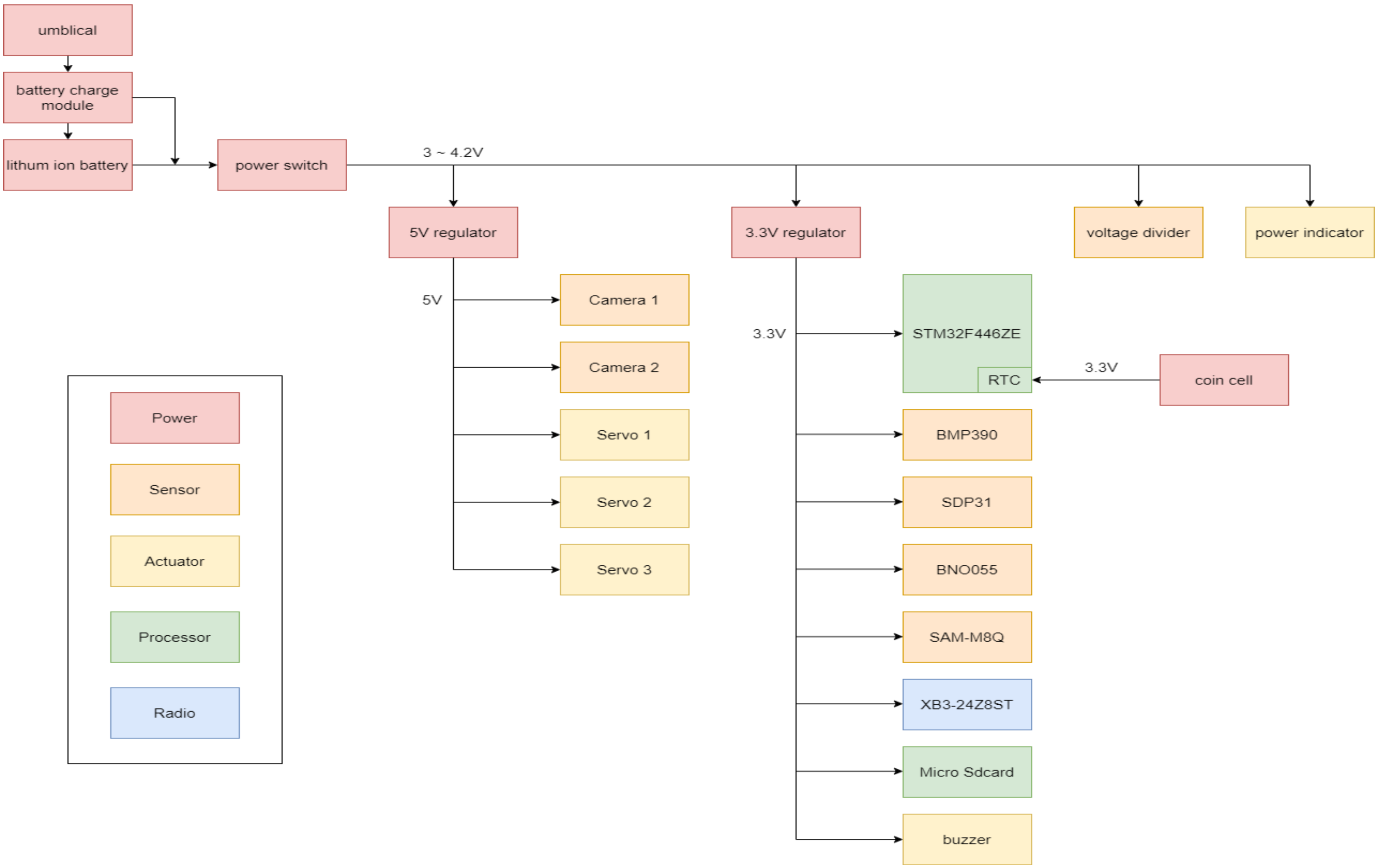
Presented by Myungsik Jung

EPS Overview

Category	component	Purpose
Power source	Umbilical	Power the board while testing and inspecting recharge lithium ion battery
Power source	Lithium ion battery	Main power source of CanSat
Power source	Coin cell	Keep RTC value after reset
Power managing	Battery charge module	Charge battery/deliver umbilical power to the CanSat
Power managing	Power switch	Easily accesible power switch
Power managing	5V regulator	Power cameras and servos
Power managing	3.3V regulator	Power MCU, sensors and XBEE radio
Actuator	Power indicator	Indicates power state



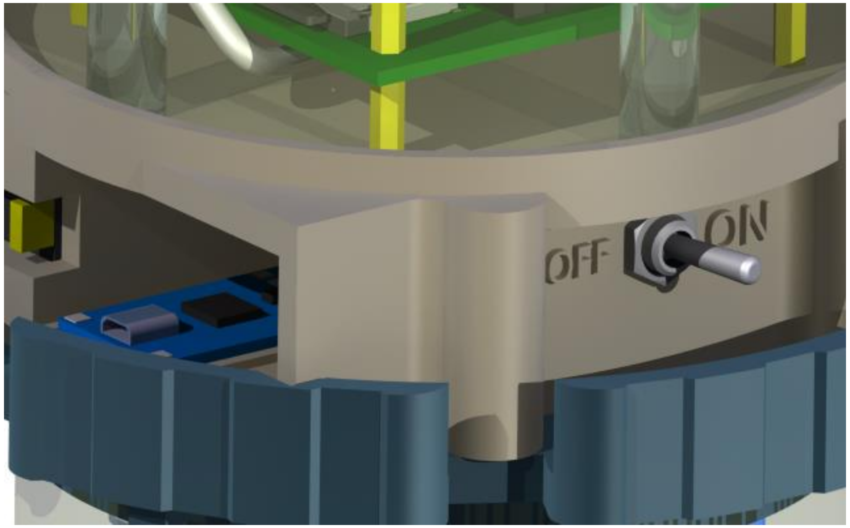
Payload Electrical Block Diagram(1/2)



Payload Electrical Block Diagram(2/2)

Electrical accessibility

- Easily accessible power switch and umbilical power source port
- USB type-C cable for umbilical



Information

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

Payload Power Trade & Selection(1/2)

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
ZM26650-5000-KC01	26φ x 69	95	Li-ion	3.7	6500	5000	195	1	5.77
Energizer LR6-4BP	14.5φ x50.5	23	Zn/MnO2	1.5	-	2850	173.5	3	2.08

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

Payload Power Trade & Selection(2/2)

Backup Battery

Battery Holder

Selection

Model	Size (mm)	Type	Voltage (V)	Capacity (mAh)	Cost ($)
CR2032 Coin Cell	20	Lithium metal	3.0	250	2.10
LR44 Coin Cell	11.6	Alkaline	1.5	120	0.40

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 cycle	Power consumption	Source
Processor	STM32F446ZE	50 mA @ Run Mode	2 h	0.33 Wh	datasheet
Sensor	BMP 390	195 uA @ 25Hz Std. Mode	2 h	0.0013 Wh	datasheet
Sensor	SDP 31	3.8 mA	2 h	0.0251 Wh	datasheet
Sensor	BNO 055	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
Memory	Micro sdcard	80 mA	2 h	0.528 Wh	datasheet
Actuator	Buzzer	30mA @ max	2 h	0.198 Wh	datasheet
			Total	2.245 Wh	

2.245 Wh / 90% regulator effiiency = 2.494 Wh

Payload Power Budget (2/3)

5.0 V Bus

Category	Component	Operation current	Duty cycle	Power consumption	Source
Camera	Spycamera (2)	110 mA	2h	1.1 Wh	datasheet
Actuator	Sg90 servo (3)	10 mA @ idle	2h	0.1 Wh	datasheet
		250 mA @ operation	5s	0.0017 Wh	datasheet
			Total	2.505 Wh	

2.505 Wh / 90% regulator efficiency = 2.783 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	1M Ohm Resistor	negligible	-	-	calculated
			Total	0.42 Wh	

Payload Power Budget (3/3)

Total energy consumption

Voltage	Electrical energy
3.3 V bus	2.494 Wh
5.0 V bus	2.783 Wh
Directly connected to battery	0.42 Wh
Total	5.697 Wh

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

9.4 – 5.697 = 3.703 Wh margin

(9.4/5.697 - 1) * 100(%) = 65% margin

Flight Software (FSW) Design

Presented by Myungsik Jung

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** • **Arduino IDE**

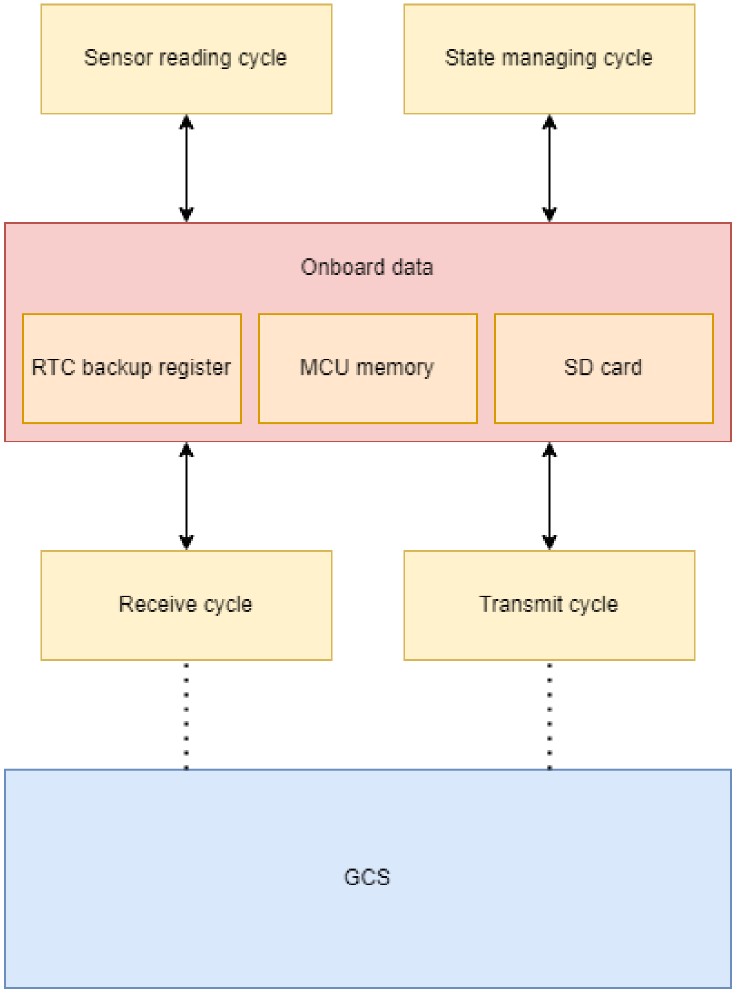
FSW Overview (2/3)

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)

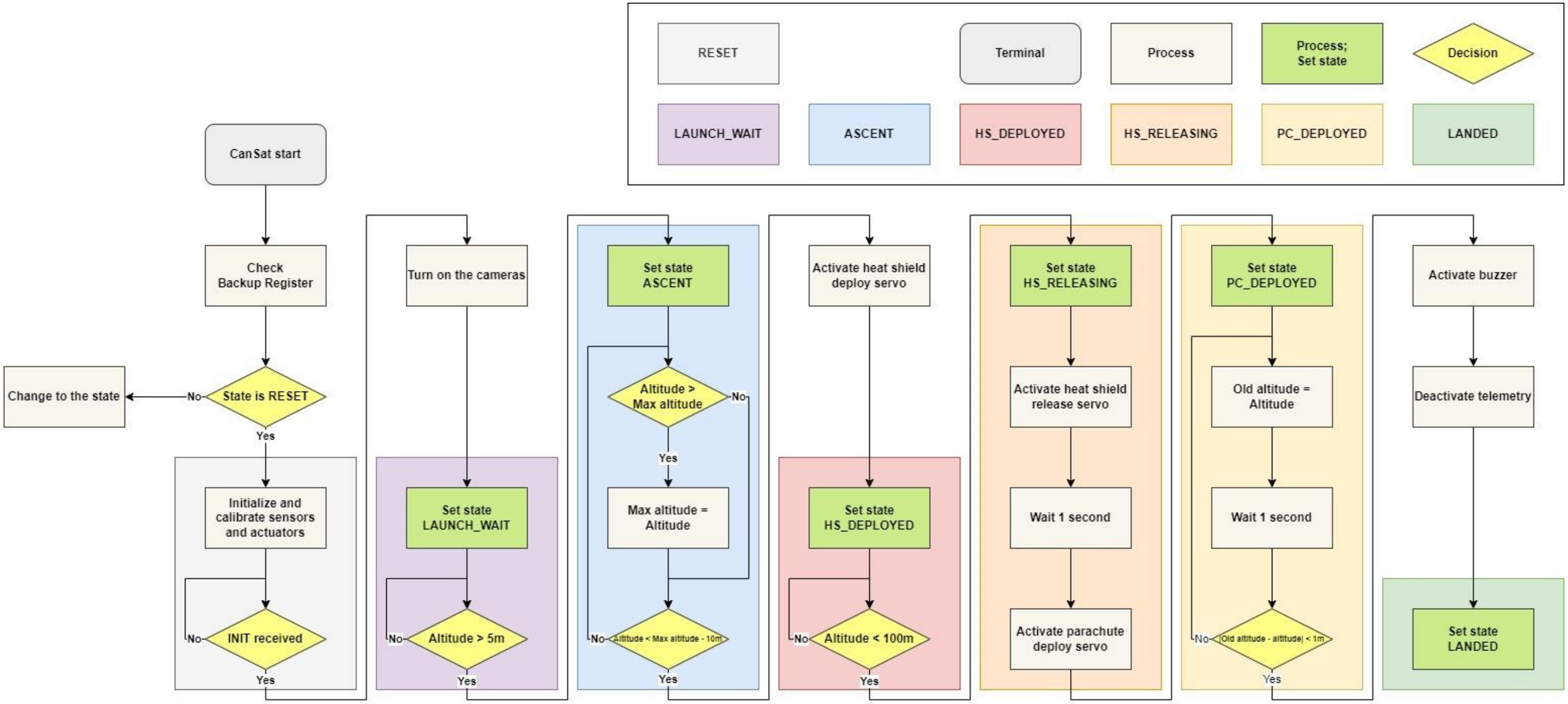
FSW Architecture



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

Payload 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 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

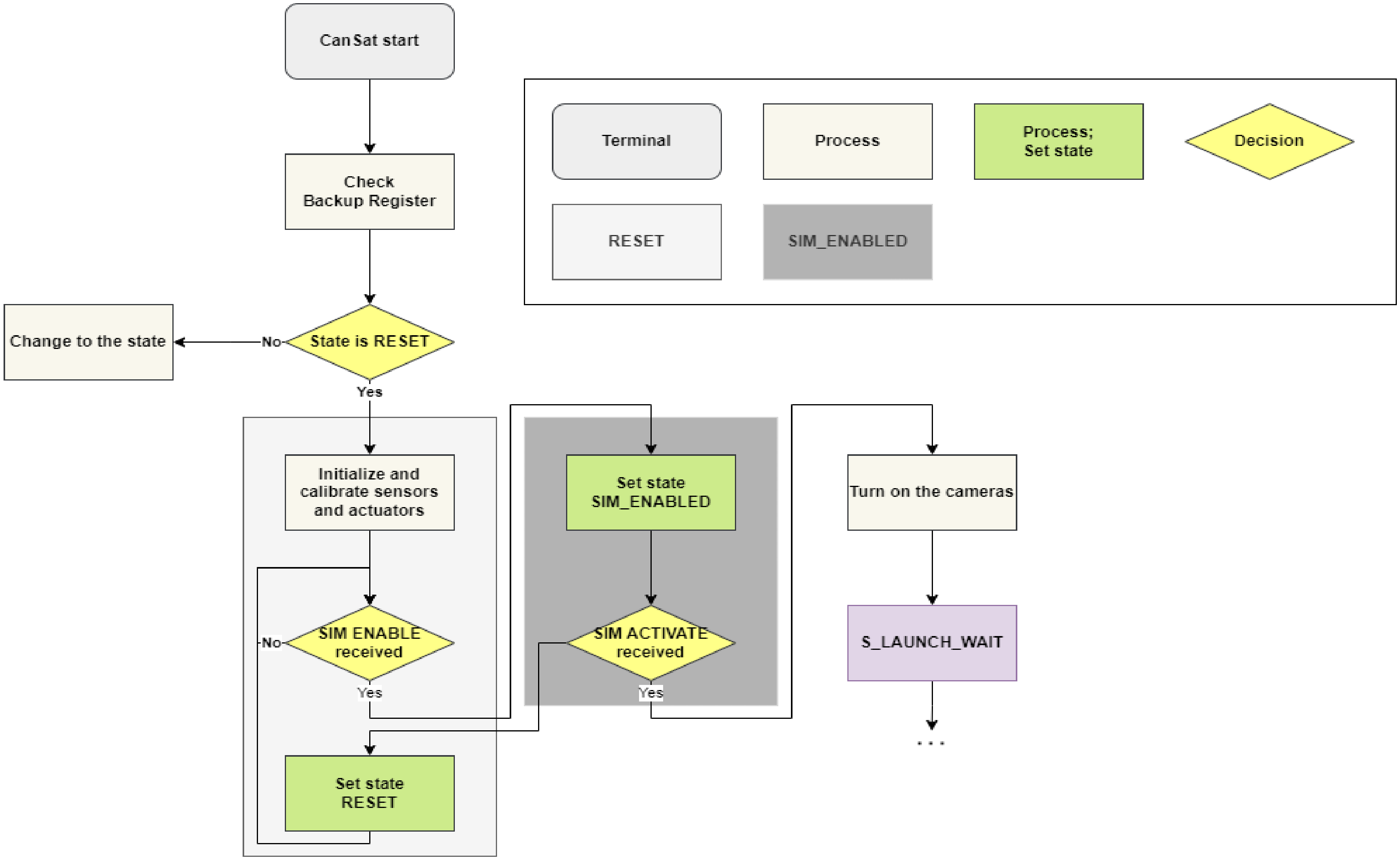
Reset reasons

- 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

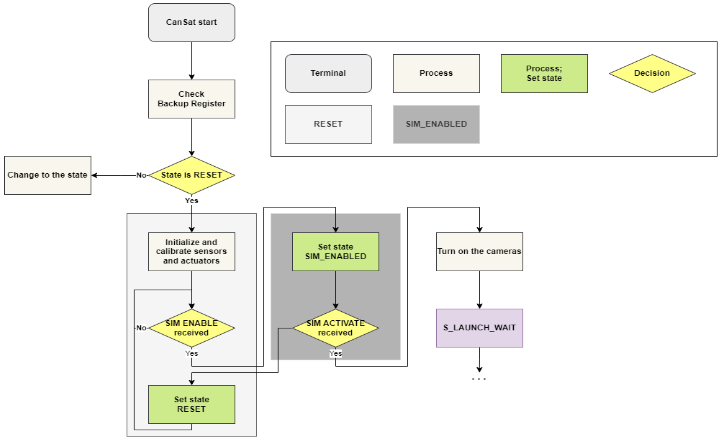
Simulation Mode Software (1/3)



Simulation Mode Software (2/3)

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 se nsor 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.

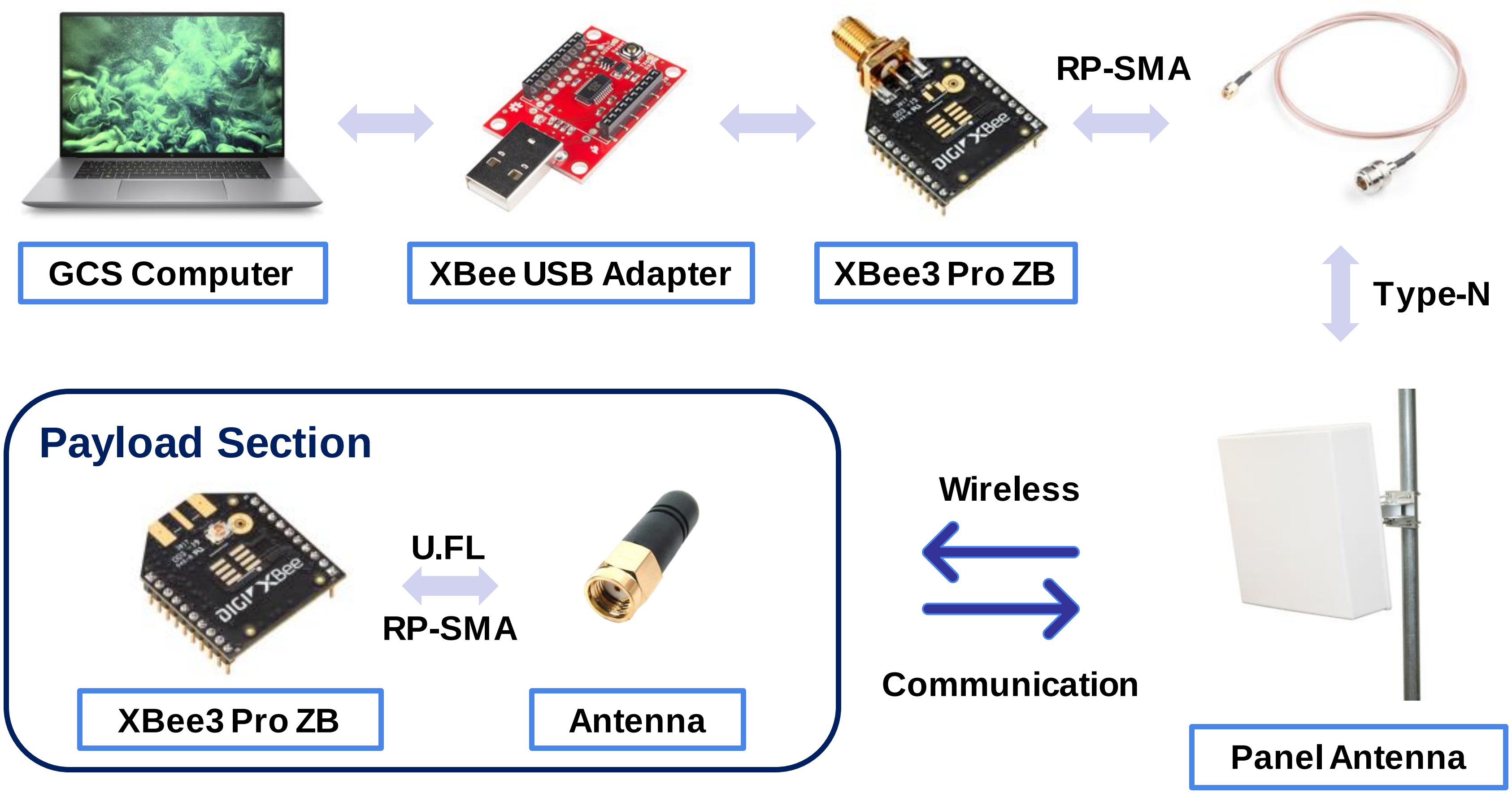
Prototyping and prototyping environment	Late software development problem
To prepare for prototyping, we individually test each sensor on the breadboard. Once we confirm the normal operation of each sensor, we integrate them into a custom PCB.	The software team conducts meetings twice a week. If development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

Development team : Hyungjun Bae, Myungsik Jung, Seungwon Cho

Ground Control System (GCS) Design

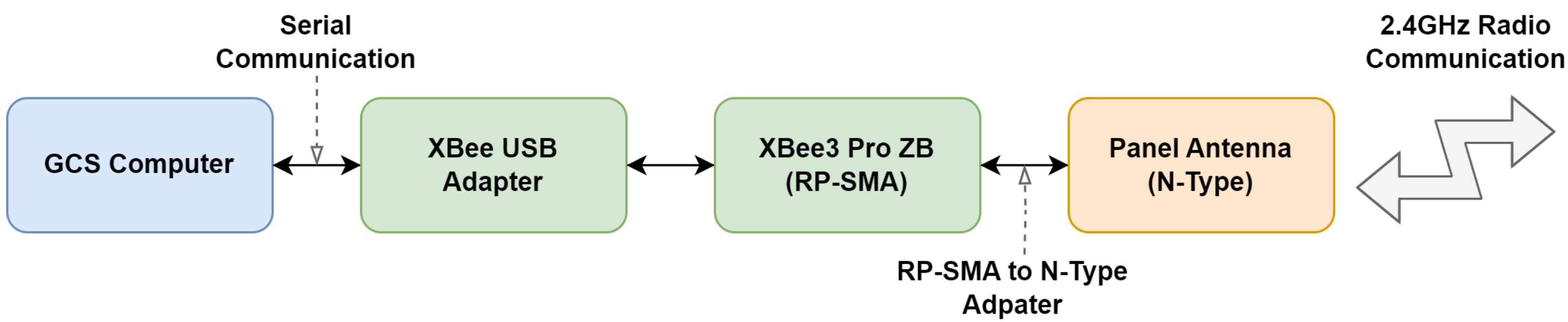
Presented by HyungJun Bae

GCS Overview



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 Trade & Selection (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
YAGI-14-2.4	Yagi	2400-2483	14	36°	35°	590x85x45	320	46.29
OM-08NFR-WP	Omni	2400-2483	8	360°	15°	390x15x15	300	49.35

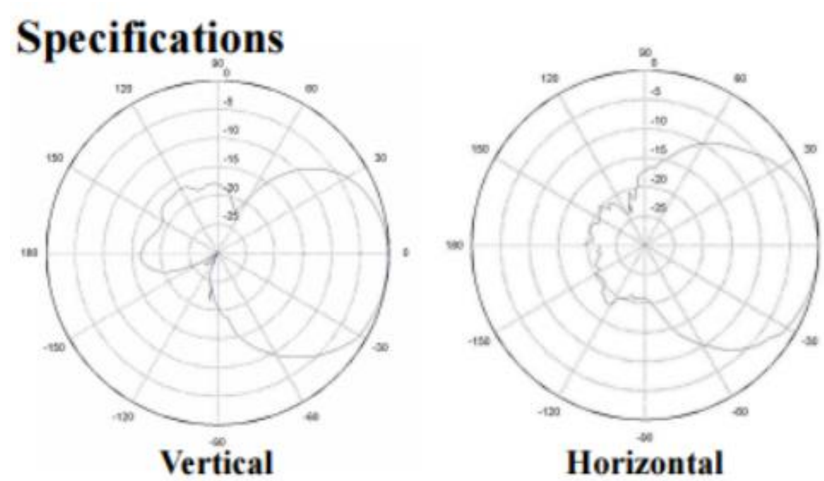
Selected GCS Antenna

PM-PP09
(Daeheung IT)

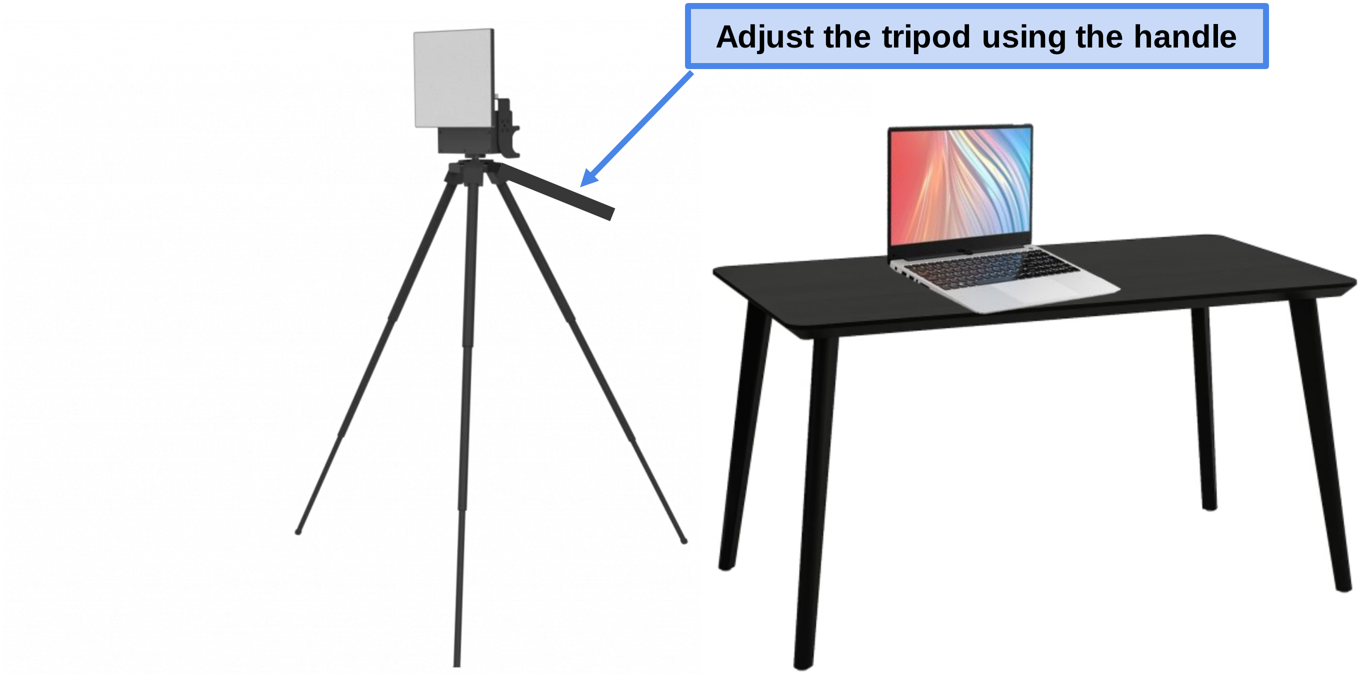
Reasons

- Cost efficient
- Compact size compares to other antennas
- Reasonable Gain
- Acceptable band width

Radiation Patterns



Antenna Mounting Design



Information

- For a stable connection, the panel antenna will be attached to the tripod. During the flight, the ground st ation crew manually adjusts it to track the CanSat.

GCS Software (1/5)

GCS Descriptions

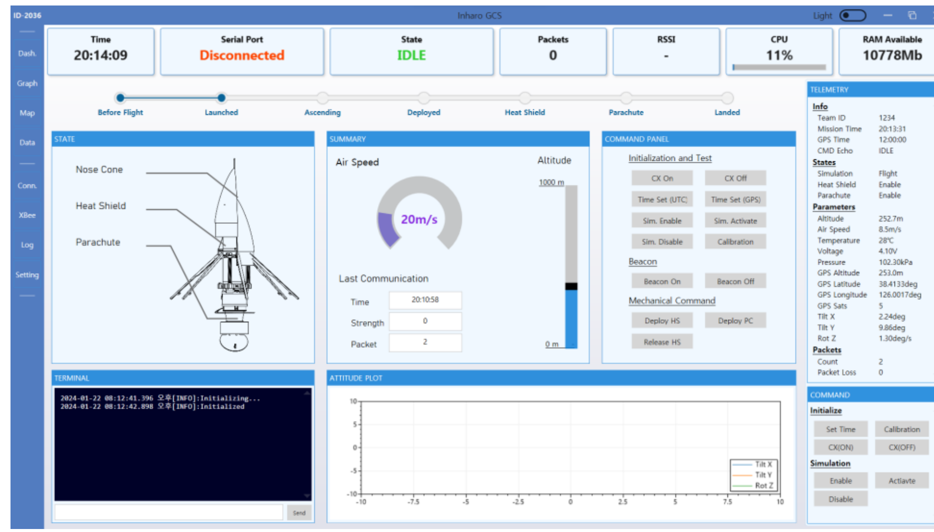
Telemetry display prototypes	The telemetry data can be visualized through labels, real-time plots and tables. For GPS data, the map view is utilized to display the position information.
Commercial off the shelf (COTS) software package used	• **IDE** : Visual Studio 2022 Community (C# .Net Core / WPF) • **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 we used are arranged into a single panel, and they are triggered by simply clicking the buttons provided. The program also supports manual commanding using the terminal.

GCS Software (2/5)

Telemetry data recording and media presentation	When the program is started, all received telemetry data will be stored within the program, counting the total number of received packets. 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.
Descripton of .csv telemetry file creation	Each telemetry field is seperated by comma(',') and individual telemetry data sets are distinguished by End of Line(EOL) characters('\r\n'), complying with the .csv file format. Once the CanSat has landed, the telemetry data strings are saved as .csv file onto the provided USB memory stick. The file name will be 'Flight_2036.csv'.
Simulation mode	To activate the simulation mode, send 'SIM_ENABLE' and 'SIM_ACTIVATE' comma nds sequentially which are located on the GCS command panel. Afterwards, the GCS will automatically read lines from the sample file and transmit simulated barometric pressure data to the CanSat at 1Hz. The Simulation mode can be deactivated using the 'SIM_DISABLE' command.

GCS Software (3/5)

Dashboard Design

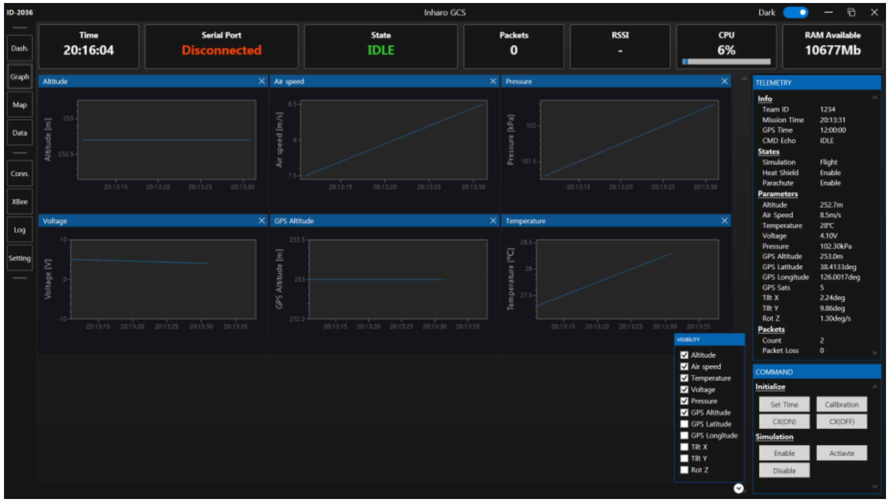


Information

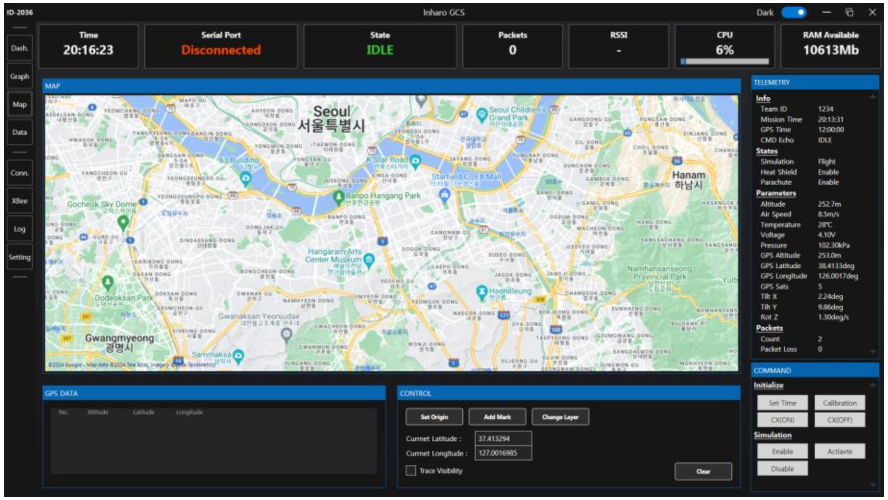
- There are two theme options: Bright and Dark.
- All measurements are displayed in engineering units.

GCS Software (4/5)

Graph View Design

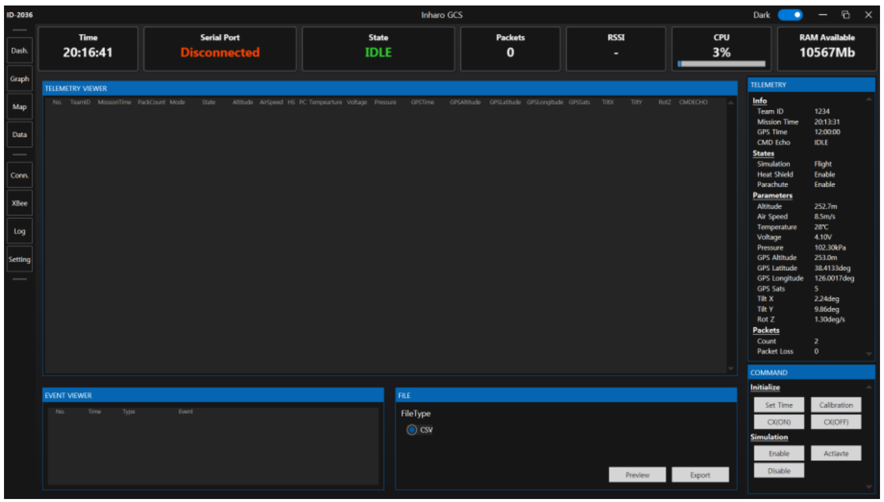


Map View Design

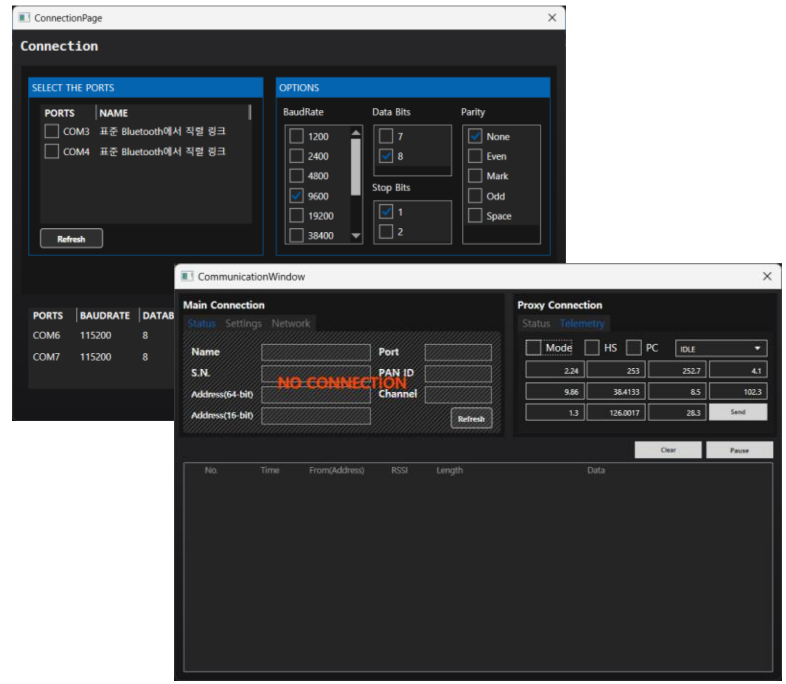


GCS Software (5/5)

Telemetry Viewer Design



Other Windows



CanSat Integration and Test

Presented by JeongHyeok Lee

CanSat Integration and Test Overview

Subsystem Level Testing Plan → **Integrated Level Functional Test Plan** → **Environmental Test Plan** → **Simulation Test Plan**

Subsystem Level Testing Plan	Integrated Level Functional Test Plan	Environmental Test Plan	Simulation Test Plan
Sensors	Descend testing	Drop test	Simulation Test
CDH	Communications	Thermal test	
EPS	Mechanisms	Vibration test	
Radio communications	Deployment	Fit Check	
FSW		Vacuum test	
Mechanical			
Descent Control			

Subsystem Level Testing Plan(1/2)

Sensors

component	Test Plans
Air Pressure sensor BMP390	• Compare measuring altitude location with known altitudes.
Air Temperature Sensor BMP390	• Compare measured temperature with thermometer.
Differential Pressure Sensor SDP31	• Compare measured speed to speed obtained from GPS sensor.
IMU Sensor BNO055	• Compare measured tilt angle to actual tilt angle. • Test error level of IMU drift.
GPS Sensor	• Compare measured location with known location.
Voltage Sensor	• Compare measured voltage with voltmeter value.

Subsystem Level Testing Plan(2/2)

Test	Test Plans
CDH	• Test the operation of STM 32F446. • Test whether the SD card module data is stored or not.
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.
Radio Communications	• XBee3 Pro set up and confirmation of transmission and reception. • Test antenna sensitivity. • Test communication at a distance of 700m or more.
FSW	• Receiving microprocessor commands and verifying command processing.
Mechanical	• Test the operation of the servo motor and check the deployment.
Descent Control	• Test the operation of the servo motor and check the deployment.

Integrated Level Functional Test Plan

Test	Test Plans	Pass requirement
Descend testing	• The CanSat is lifted to an altitude of 50m using a drone and then ejected.	• The heat shield and parachute deployment, and the heat shield separation happen at a predetermined altitude. • Ensure the cylinder can safely protect the egg without any damage.
Communications	• Test communication at a distance over 1000m.	• The CanSat communicates well with ground station at a distance over 1000m.
Mechanisms	• Test the servo motor operating mechanism. • Test the parachute deployment mechanism. • Test the heat shield deployment mechanism.	• The CanSat releases the heat shield and deploys the heat shield and the parachute at a predetermined altitud e. • The servo motors operate well through entire flight.
Deployment	• Test the parts that deploy parachute and heat shield.	• Ensure that the deployment of the heat shield and parachute is on time.

Environmental Test Plan

Test	Test Plans
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.
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.
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.
Fit Check	• 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.
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

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

Presented by JeongHyeok Lee

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
• Seeun Koo	• SeungWon Cho • JeongHyeok Lee • DongWoo Cho • JunHyeok Lee	• HyeWon Shin • SungEun Jin	• HyungJun Bae • SeokHyeon Hwang • Myungsik Jung

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 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 monitors the CanSat.	Ground Station Team
Recovery	• The recovery team recover the CanSat.	Recovery Team
Data Analysis	• The Ground station team verify data. • The Ground station team analysis data.	Ground Station Team

Mission Operations Manual Development Plan

Procedures	Development Plans
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 a egg into the cylinder of the CanSat.
CanSat Integration	• Integrate the CanSat into the rocket.
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.

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 emitting 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

Requirements Compliance

Presented by JeongHyeok Lee

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**

System Requirement Summary (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**	26	
3	After deployment from the rocket, the CanSat shall deploy its heat shield/aerobraking mechanism.	**Comply**	26,40	
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**	111	
7	Upon landing, the CanSat shall activate an audio beacon.	**Comply**	111	
8	The CanSat shall carry a provided large hens egg with a mass range of 51 to 65 g	**Comply**	76-78	

System Requirement Summary (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**	96	
10	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	**Comply**	55-57	
11	At 100 m, the CanSat shall have a descent rate of less than 5 m/s.	**Comply**	52-54	
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**	152-155	
13	The CanSat mass shall be 900 g +/- 10 g without the egg being installed.	**Comply**	80-84	
14	Nose cone shall be symmetrical along the thrust axis.	**Comply**	27,44-46	
15	Nose cone radius shall be exactly 71 mm	**Comply**	24,27	
16	Nose cone shoulder radius shall be exactly 68 mm	**Comply**	24,27	

System Requirement Summary (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**	24	
18	CanSat structure must survive 15 Gs vibration	**Partial**		To be tested
19	CanSat shall survive 30 G shock.	**Partial**		To be tested
20	The CanSat shall perform the function of the nose cone during rocket ascent.	**Comply**	15-20	
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**	27	
22	The rocket airframe can be used as part of the CanSat operations.	**Comply**	26-27	
23	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	**Comply**	59	
24	No pyrotechnical or chemical actuators are allowed.	**Comply**	21-23	

System Requirement Summary (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**		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, 59	
28	The CanSat shall deploy a heat shield after deploying from the rocket.	**Comply**	40,111	
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**	76-78	
32	If the nose cone is to be considered as part of the heat shield, the documentation shall identify the configuration.	**Comply**	15-21	

System Requirement Summary (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**	26	By small parachute
34	Lithium polymer batteries are not allowed.	**Comply**	102	
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**	102-103	
36	Easily accessible power switch is required	**Comply**	101	
37	Power indicator is required	**Comply**	99	
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**	92	
40	XBEE radios shall have their NETID/PANID set to their team number.	**Comply**	92	

System Requirement Summary (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**	92	
42	The CanSat shall transmit telemetry once per second.	**Comply**	112	
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**	95	
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**	29	
46	CanSat shall measure its internal temperature.	**Comply**	29	
47	CanSat shall measure its angle stability with the aerobraking mechanism deployed.	**Comply**	29	
48	CanSat shall measure its rotation rate during descent.	**Comply**	29	

System Requirement Summary (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**	29	
50	The CanSat shall include a video camera pointing horizontally.	**Comply**	29, 61	
51	The video camera shall record the flight of the CanSat from launch to landing.	**Comply**	61	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**	96	
54	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	**Comply**	123	
55	Telemetry shall include mission time with 1 second or better resolution.	**Comply**	94	
56	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	**Comply**	112	

System Requirement Summary (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**	117-126	
58	All telemetry shall be displayed in real time during descent on the ground station.	**Comply**	122	
59	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) and the units shall be indicated on the displays.	**Comply**	124	
60	Teams shall plot each telemetry data field in real time during flight.	**Comply**	122	
61	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	**Comply**	119	
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**	121	
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**	123	

System Requirement Summary (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**	123	
65	The ground station shall use a table top or handheld antenna.	**Comply**	121	
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**	124	
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**	123	
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**	93	

System Requirement Summary (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**	99	
70	The CanSat shall have its time set to within one second UTC time prior to launch.	**Comply**	96	
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**	123	
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**	113-114	
73	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	**Comply**	115	

Management

Presented by Seeun Koo

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
Sensirion SDP31	1	39.6	39.6	Actual	x
Adafruit 9-DOF IMU BNO055	1	46	46	Actual	x
GPS	1	52.8	52.8	Actual	x
Mini Spy Camera	2	15	30	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

CanSat Budget – Hardware(2/4)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate	Reuse
BSS138	10	0.3	3	Actual	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-F446ZE	1	26.0	26.0	Actual	x

CanSat Budget – Hardware(3/4)

Component	Quantity	Unit price($)	Total price($)	Actual/Estimate	Reuse
PCB Support Metal M-10 mm	10	0.1	1	Estimate	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
Instantaneous adhesive	2	2.0	4.0	Actual	x
Transparent PVC plate	1	10.2	10.2	Actual	x
Siretta delta 20	1	11.2	11.2	Actual	x

Hardware total price : 446.72 $

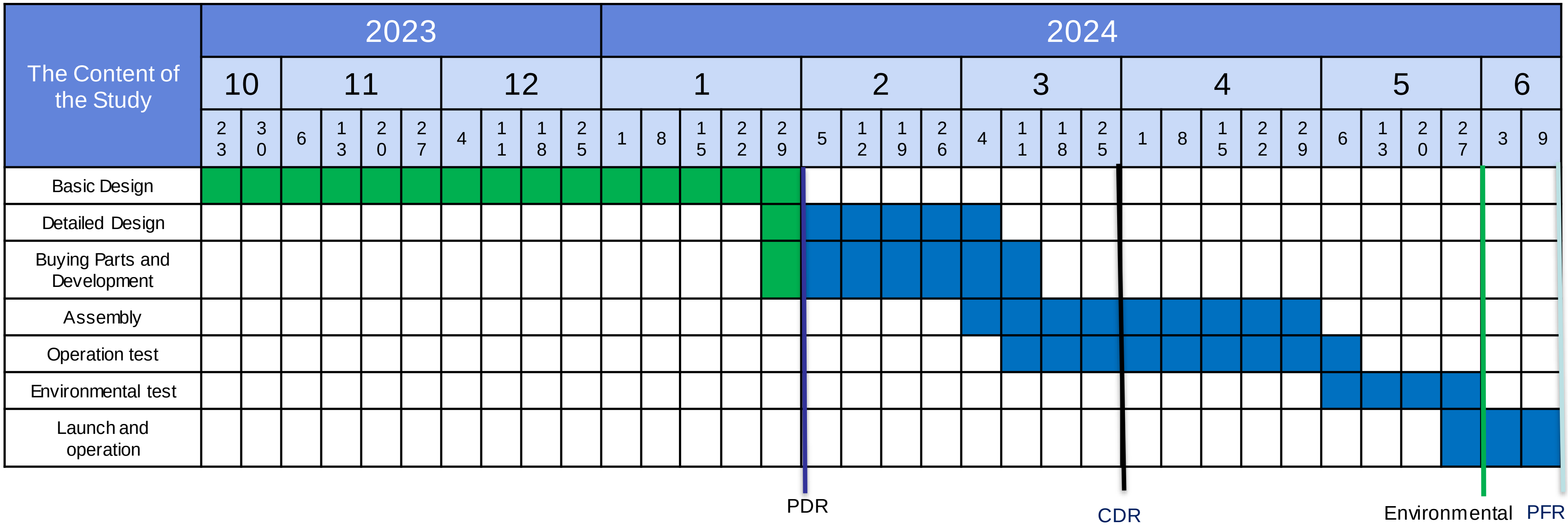
We comply the requirement that the cost of the CanSat shall be under 1000$

CanSat Budget – Other Costs

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

Other costs total price : 17,436.5$

Program Schedule Overview



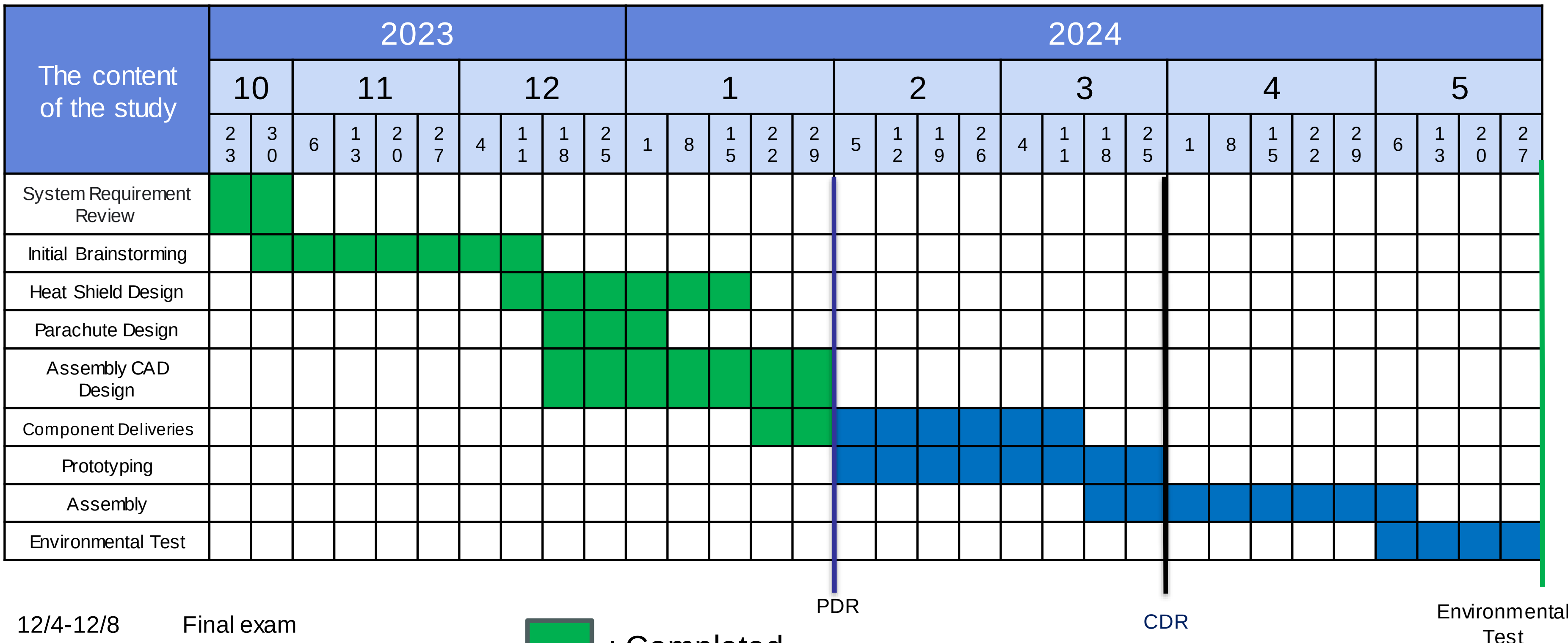
: Completed

: 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

Mechanical



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

: Completed

: Upcoming

Detailed Program Schedule(2/3)

Electronics

The content of the study	2023										2024																					
	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																														
Trade study	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed																								
1st PCB prototype development/testing						Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Upcoming	Upcoming															
Component Deliveries														Completed	Completed	Upcoming	Upcoming	Upcoming	Upcoming	Upcoming	Upcoming											
2nd PCB prototype development / testing																Upcoming	Upcoming	Upcoming	Upcoming	Upcoming												
Final PCB order																					Upcoming	Upcoming	Upcoming	Upcoming								
Assembly																						Upcoming	Upcoming	Upcoming	Upcoming	Upcoming	Upcoming	Upcoming				
Environmental Test																													Upcoming	Upcoming	Upcoming	Upcoming

PDR

CDR

Environmental Test

12/4-12/8 Final exam

12/18 - 3/4 Winter vacation

2/9-2/12 Korean New Year

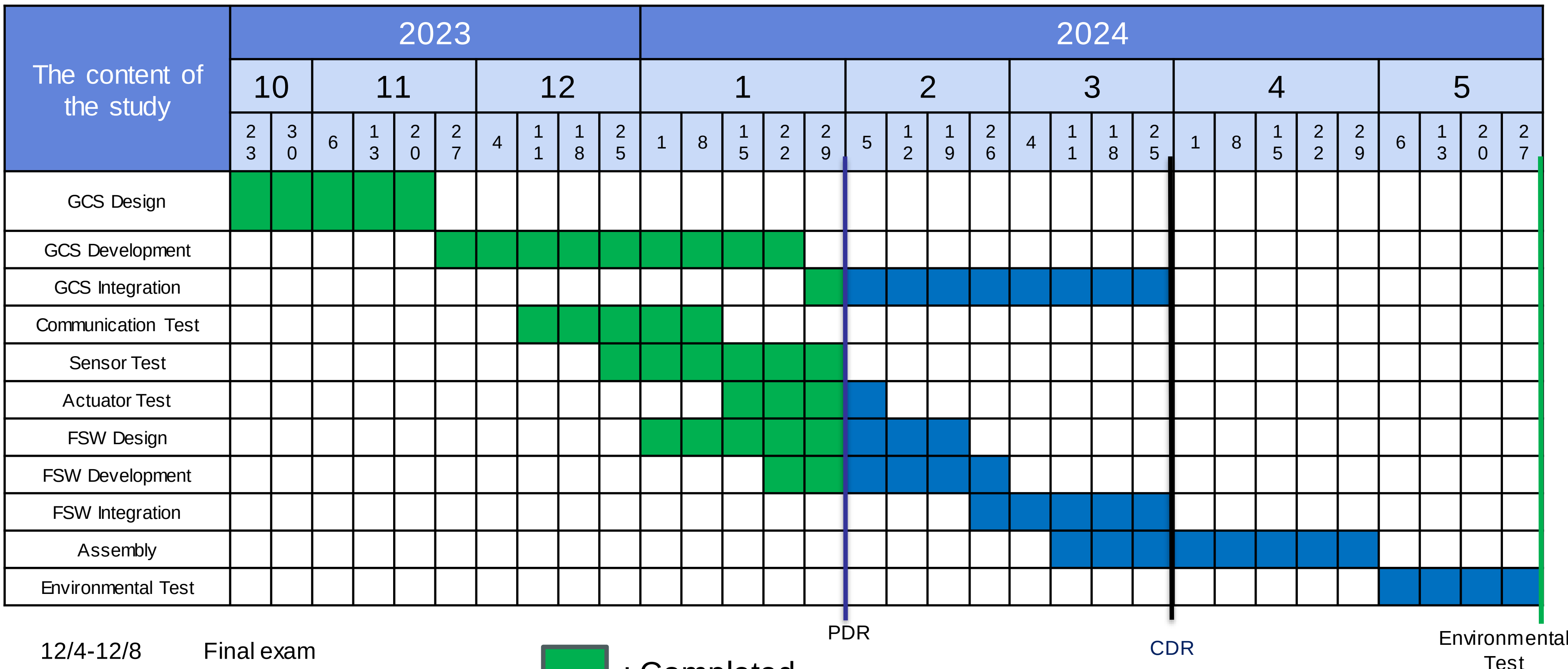
4/22 - 4/26 Mid term exam

: Completed

: Upcoming

Detailed Program Schedule(3/3)

Software



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

: Completed

: Upcoming

Conclusions

Team	Accomplishments	Unfinished Works
Mechanical	• All trade and selection have been completed for mechanism. • All critical parts have been tested using 3D printing. • The Digital Mock-Up is done.	• Manufacturing and prototyping • Test and check mechanism operation.
Electronics	• All electronic components are inspected.	• Test 1st PCB prototype • Develop 2nd PCB prototype • Software integration and testing
Software	• The development of GCS software is almost finished. • Alpha version of FSW was developed.	• Test for telemetry transfer • Software and hardware integration • Debugging the software

Readiness for the Critical Design Stage
We completed all necessary steps for the preliminary design stage, establishing the foundation for the system. From now on, we will use purchased parts to gain confidence in operation and integrate hardware, software, and electronics. In addition, we will manufacture prototypes that will undergo the environmental test and perform the mission.