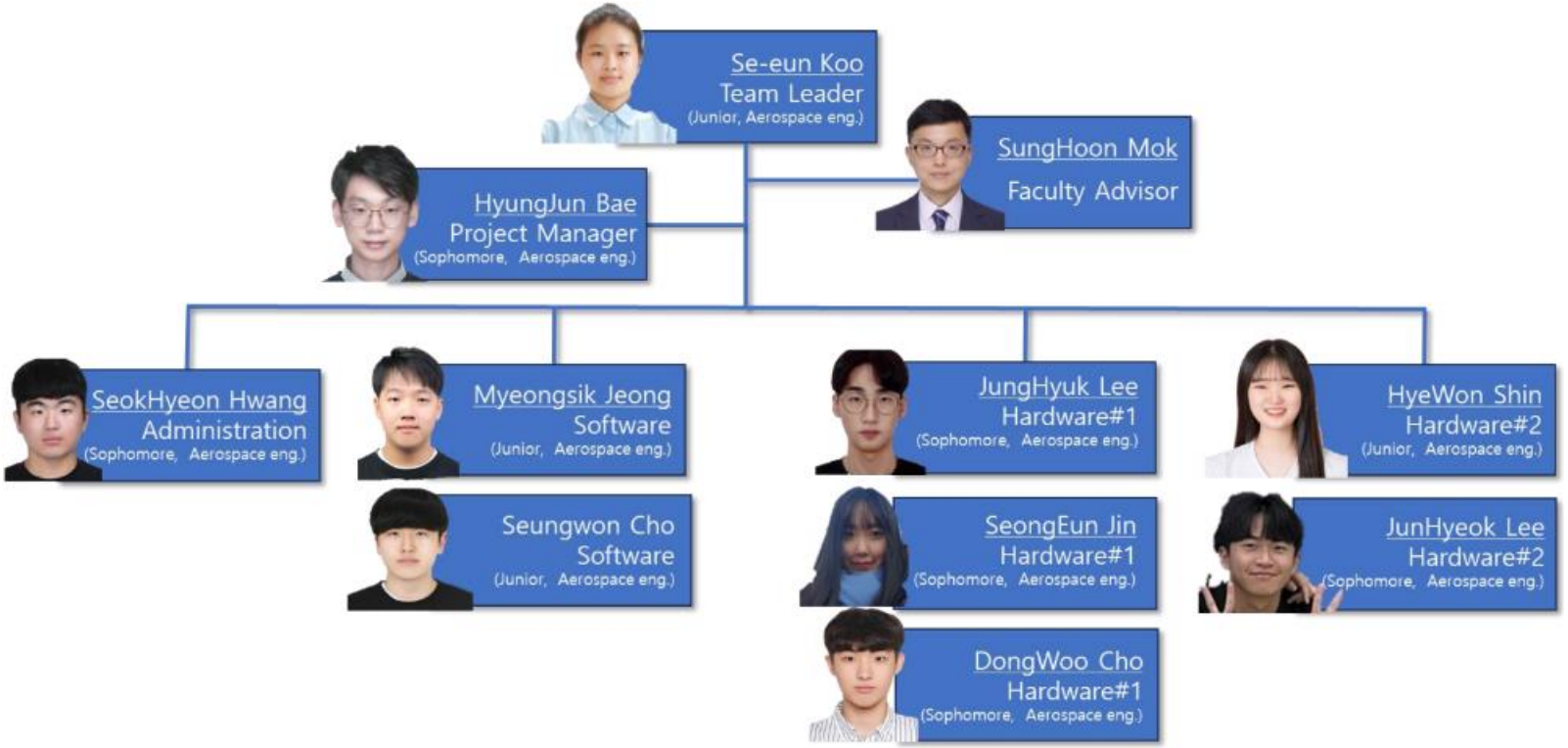
Post Flight Review

#2036

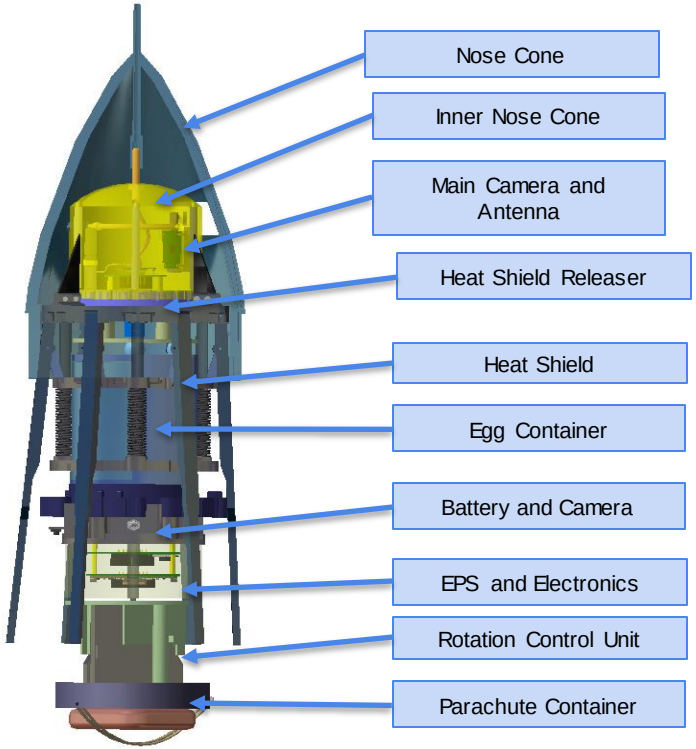
INHARO

Team organization

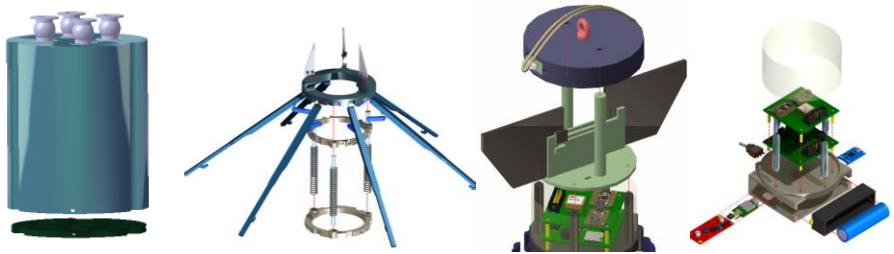


Systems Overview

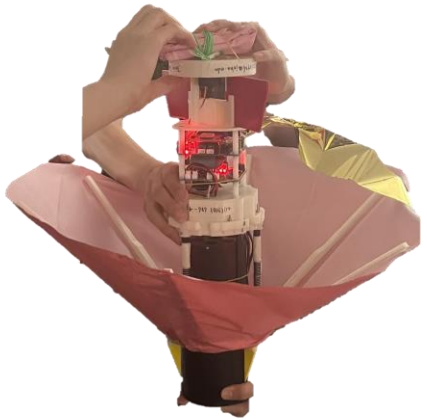
Major Structural Elements



Interface Definitions



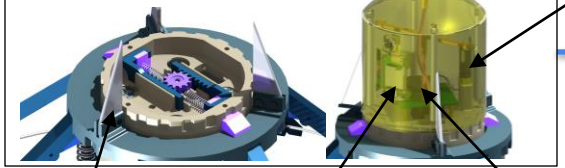
*Note: All connections marked with red lines are secured using M2 Bolts and Loctite



Systems Overview

Major Mechanical Parts and Mechanisms

Release Mechnism & Inner Nose Cone



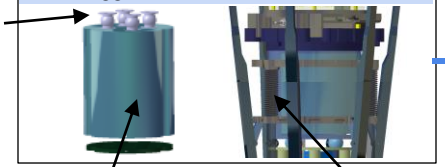
Antenna

Fin

Main Camera, Pitot Assembly

XBee

Egg Container & Heat shield

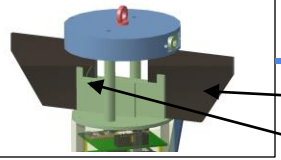


Rubber Damper

Egg Container

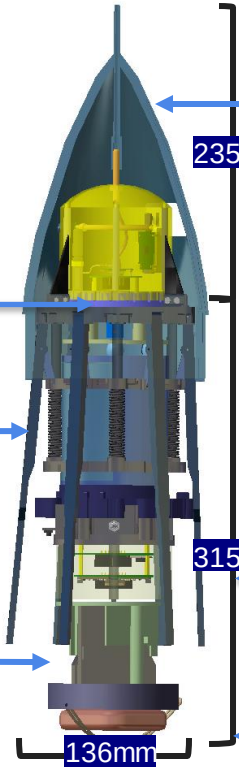
Compressed Spring

Rotation Control Unit

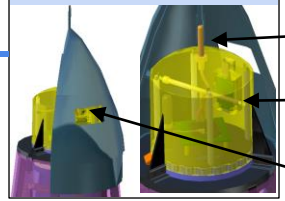


Rear Stabilizer

Rubber Band



Outer Nose Cone

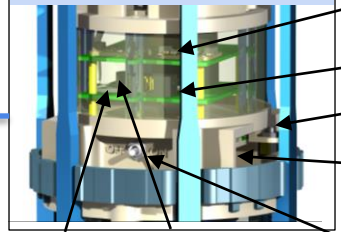


Total Pressure Probe

Static Pressure Port

Camera Window

EPS & Electronics



Sensors (IMU, Tempearture, GPS etc.)

Microprocessor

Bonus Camera

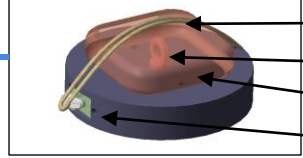
EPS Unit (5V, 3.3V Regulators)

SD Slot

Buzzer

Power Switch

Parachute



Rubber Band

Eye bolt

Parachute

Servo

Systems Overview

Major Electronic Mechanisms

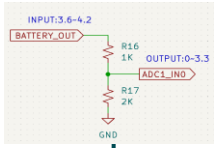
BMP 390
Air Pressrue & Temperature

BNO055
Orientation

MPXV7200DP
Differential Pressure(Speed)

SAM-M8Q
GPS

Passive Circuit
Voltage Monitoring



ADC

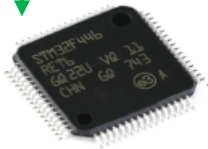
I2C Bus

Quelima SQ 11
Camera

UART 1

ADC

GPIO



UART 2

SPI

STM32F446
Microprocessor
+ Internal RTC

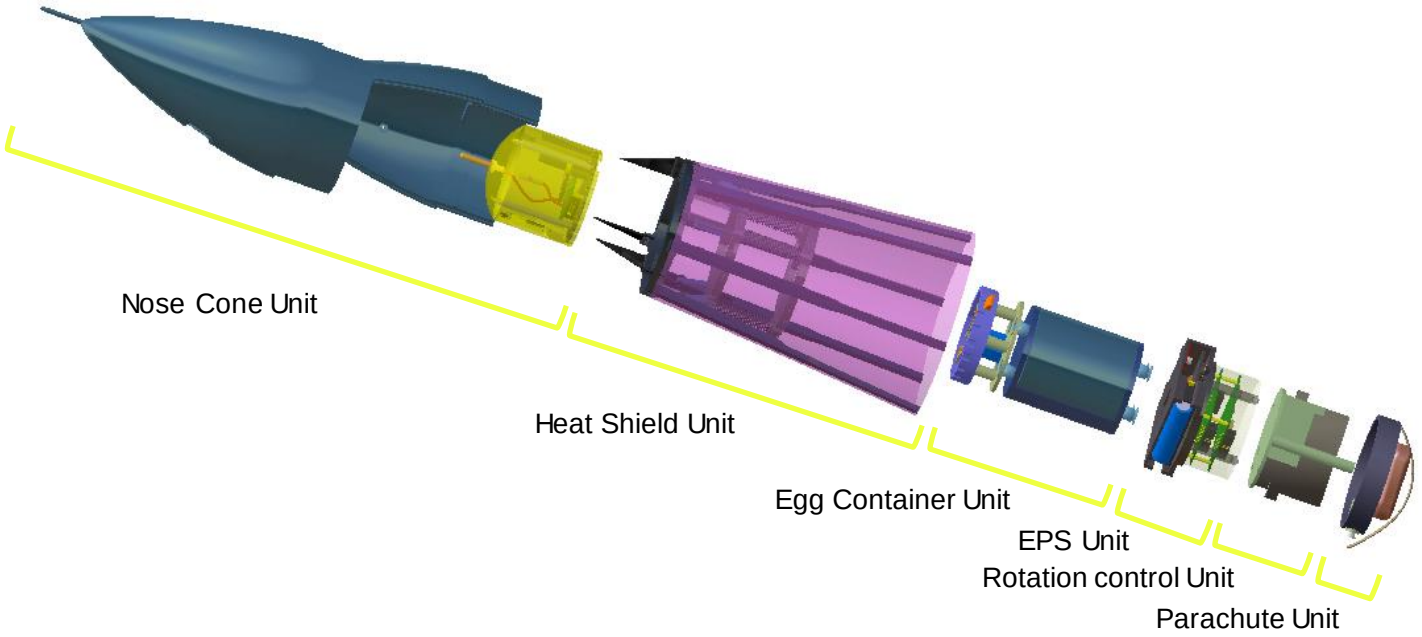
Ground Station
(wireless)

Micro SD Card Socket
Data Storage

XBee3 Pro
Communication

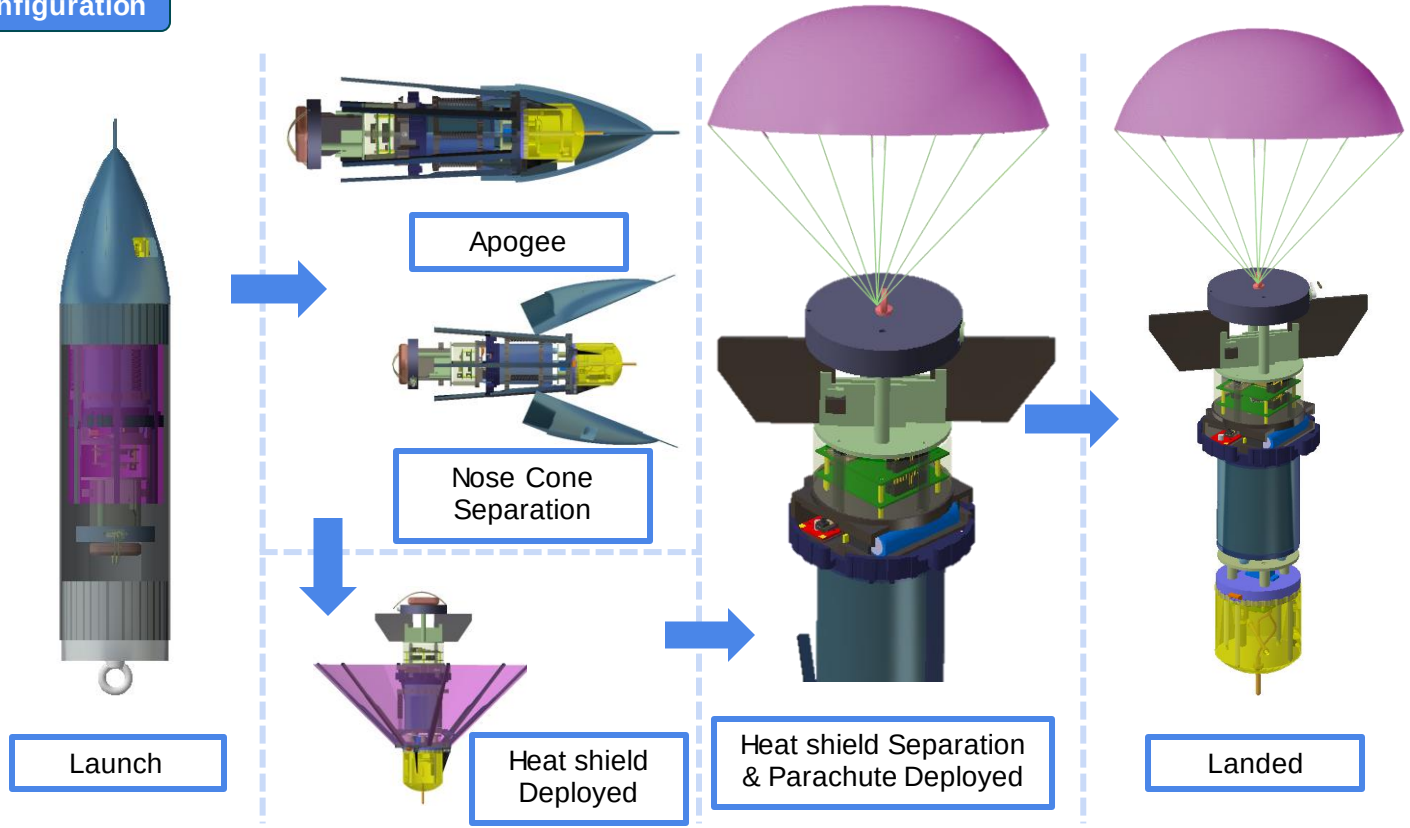
Systems Overview

Exploded View



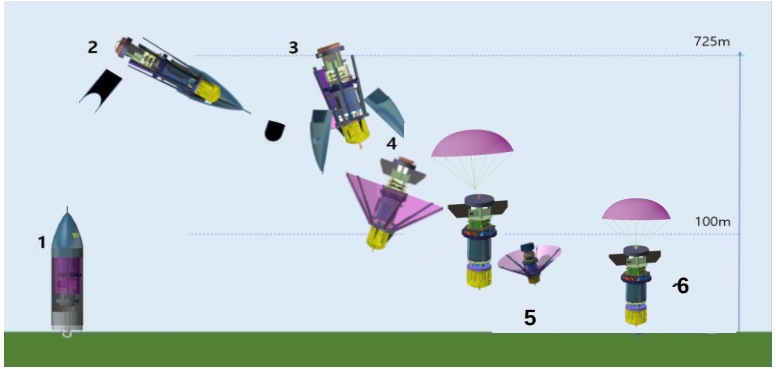
Systems Overview

CanSat Configuration



Comparison of planned and actual Conops

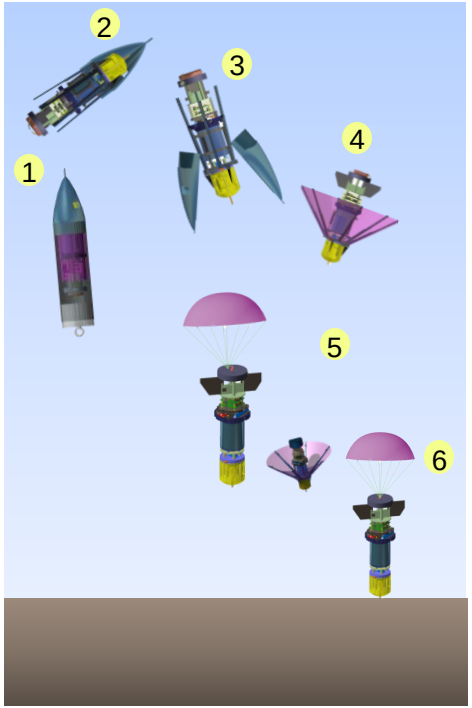
Planned Conops



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.

Comparison of planned and actual Conops

Planned Conops



Actual Conops & Comparison

Step	Description	Comparison
1	The CanSat is stowed inside the rocket.	Same as planned.
3 ~ 5	At 725m, the CanSat is deployed from the rocket. At the same time, the heat shield is deployed and decelerated to about 30 m/s.	We planned to deploy the heatshield simultaneously with the deployment from the rocket by the passive deployment mechanism, it was failed. So, we failed to decelerate the speed of the Cansat to our target descent speed.
	The half of nosecone is separated, and the parachute is deployed.	as the parachute string was already deployed before the parachute deployment altitude, we also failed to deploy the parachute normally and decelerate the descent speed as we planned.
6	The CanSat lands relatively safely.	our Cansat landed to the ground with the impact and it leads to the damage of some parts. (However, the eggs are alive!)

Comparison of planned and actual SOE

Mission Sequence	Planned	In The Field
Arrival	• All teams arrive at the launch site.	• Same as planned
Pre – Launch	• The CanSat team assemble the CanSat and prepare to launch the CanSat on the launch site. • The ground station team set up the ground station and construct Antenna. • The Cansat team assemble and test the CanSat.	
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.	
Flight	• The ground station team monitor the CanSat.	
Recovery	• The recovery team recover the CanSat.	
Data Analysis	• The Ground station team receive and verify telemetry data file. • The Ground station team analysis data. • The Ground station team deliver the ground stati on data to the ground station judge by thumb dri ve.	• Communication between the ground station and CanSat was not desired because the sensor was reset by the impact received during the rocket launch process. • It was impossible to analyze the data due to the lack of communication with CanSat

Flight Data Analysis – Partial Success

Data collected

State	Data(.xlsx)

Launch wait & Ascent (Launch)

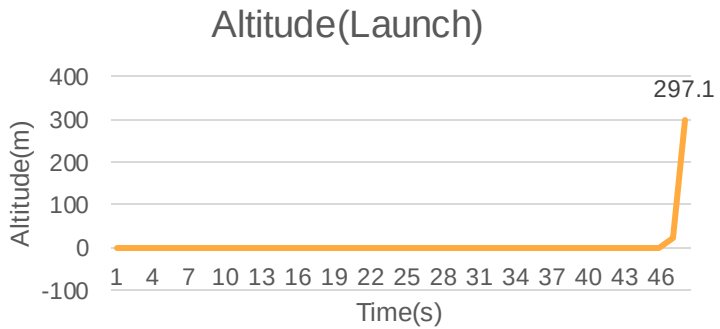
Team ID	Mission Ti	Packet Co	Mode	State	Altitude	Air Speed	HS Deploy	PC Deploy	Temperatu	Voltage	Pressure	GPS Time	GPS Altitu	GPS Latitu	GPS Longi	GPS Sats	TiltX	TiltY	RotZ	CMD Echo
2036	18:36:57	1133	F	F LANDED	-6.6	-1.5	N	N	25	3.4	92.1	18:36:57	819.9	38.3769	79.6077	12	-2.15	11.19	-15.1	NONE
2036	18:36:58	1134	F	F LANDED	-6.6	-2.8	N	N	25	3.3	92.1	18:36:58	819.8	38.3769	79.6076	12	-10.1	9.95	-1.3	NONE
2036	18:36:59	1135	F	F LANDED	-6.4	-3.2	N	N	24.9	3.3	92.1	18:36:59	820.1	38.3769	79.6076	12	-6.75	20.73	-7.3	NONE
2036	18:37:00	1136	F	F LANDED	-6.2	-4.5	N	N	24.9	3.3	92.1	18:37:00	820.3	38.3769	79.6076	12	-7.31	13.41	4	NONE
2036	18:37:01	1137	F	F LANDED	-6.2	-2.9	N	N	24.9	3.4	92.1	18:37:01	820.5	38.3769	79.6076	12	-16.26	10.55	-13.9	NONE
2036	18:37:02	1138	F	F LANDED	-6.4	-11.2	N	N	24.9	3.4	92.1	18:37:02	820.7	38.3769	79.6076	12	-10	15.18	1.8	NONE
2036	18:37:03	1139	F	F LANDED	-6.4	-5.5	N	N	24.9	3.3	92.1	18:37:03	820.7	38.3769	79.6076	12	-10.91	13.25	-41.7	NONE
2036	18:37:04	1140	F	F LANDED	-6.5	-5	N	N	24.9	3.3	92.1	18:37:04	820.7	38.3769	79.6076	12	-17.52	2.77	-26.7	NONE
2036	18:37:05	1141	F	F LANDED	-6.7	-2.7	N	N	24.9	3.3	92.1	18:37:04	820.7	38.3769	79.6076	12	-26.97	-19.39	-1.7	NONE
2036	18:37:06	1142	F	F LANDED	-6.2	2.4	N	N	24.8	3.3	92.1	18:37:05	820.5	38.3769	79.6076	12	-16.03	-8.18	3.9	NONE
2036	18:37:06	1143	F	F LANDED	-6.7	-3.6	N	N	24.9	3.3	92.1	18:37:06	820.4	38.3769	79.6076	12	-8.92	-5.62	21.3	NONE
2036	18:37:07	1144	F	F LANDED	-6.5	2	N	N	24.9	3.3	92.1	18:37:07	820.4	38.3769	79.6076	12	-10.45	6.15	-4.7	NONE
2036	18:37:08	1145	F	F LANDED	-6.5	-2.4	N	N	24.9	3.3	92.1	18:37:08	820.5	38.377	79.6076	12	-15.07	1.86	3.2	NONE
2036	18:37:09	1146	F	F LANDED	-6.7	-5.4	N	N	24.8	3.3	92.1	18:37:09	820.6	38.377	79.6076	12	-4.81	-0.63	-13.3	NONE
2036	18:37:10	1147	F	F LANDED	-6.6	-5.3	N	N	24.8	3.4	92.1	18:37:10	820.7	38.377	79.6076	12	-7.54	8.32	-27.3	NONE

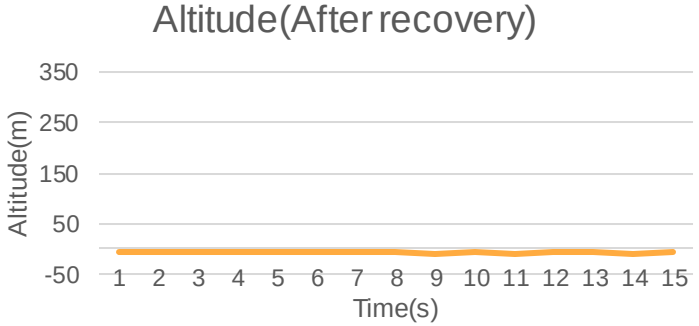
Landed (After recovery)

Team ID	Mission Ti	Packet Co	Mode	State	Altitude	Air Speed	HS Deploy	PC Deploy	Temperatu	Voltage	Pressure	GPS Time	GPS Altitu	GPS Latitu	GPS Longi	GPS Sats	TiltX	TiltY	RotZ	CMD Echo
2036	18:20:41	49	F	F LAUNCH	-0.4	-0.8	N	N	27.5	3.4	92.1	18:20:40	825	38.3756	79.6072	12	178.01	-179.52	0.4	ST UTC
2036	18:20:42	50	F	F LAUNCH	-0.3	-3.7	N	N	27.5	3.5	92.1	18:20:40	825	38.3756	79.6072	12	178.13	-179.94	-0.6	ST UTC
2036	18:20:43	51	F	F LAUNCH	-0.1	-1.9	N	N	27.5	3.3	92.1	18:20:42	825	38.3756	79.6072	12	177.89	-179.52	-0.1	ST UTC
2036	18:20:44	52	F	F LAUNCH	-0.2	-4.8	N	N	27.5	3.4	92.1	18:20:43	824.9	38.3756	79.6072	12	177.83	-179.34	0.1	ST UTC
2036	18:20:45	53	F	F LAUNCH	-0.4	1.7	N	N	27.5	3.4	92.1	18:20:44	825	38.3756	79.6072	12	178.07	-179.64	-0.4	ST UTC
2036	18:20:46	54	F	F LAUNCH	-0.2	-1.2	N	N	27.5	3.4	92.1	18:20:44	825	38.3756	79.6072	12	177.77	-179.4	-0.1	ST UTC
2036	18:20:46	55	F	F LAUNCH	-0.2	1.4	N	N	27.5	3.4	92.1	18:20:44	825	38.3756	79.6072	12	177.83	-179.4	0.2	ST UTC
2036	18:20:47	56	F	F LAUNCH	-0.3	-3.5	N	N	27.5	3.4	92.1	18:20:46	824.9	38.3756	79.6072	12	178.13	180	-2.6	ST UTC
2036	18:20:52	61	F	F ASCENT	22.7	57.6	N	N	27.5	3.4	91.8	18:20:50	825	38.3756	79.6072	12	-173.73	-176.24	-16.8	ST UTC
2036	18:20:55	64	F	F ASCENT	297.1	57.5	N	N	27.4	3.5	88.9	18:20:53	826.7	38.3755	79.6071	8	-11.11	-13.74	-102.6	ST UTC

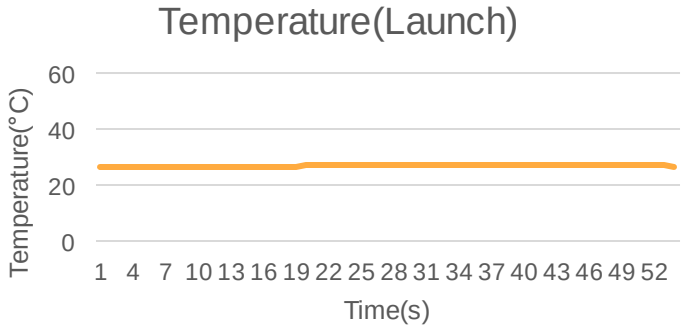
Flight Data Analysis - Partial Success

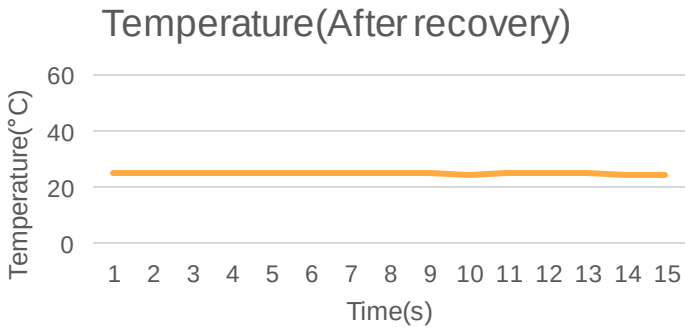
Payload altitude plot





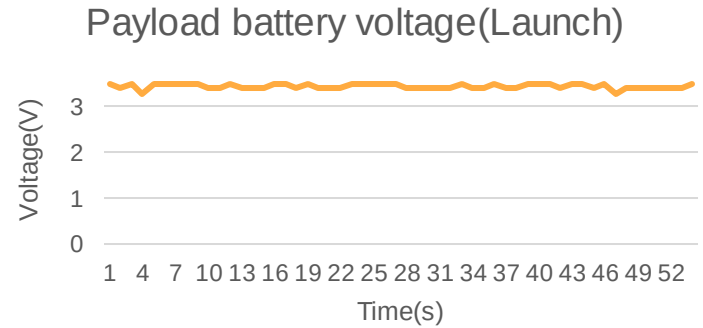
Payload temperature sensor plot

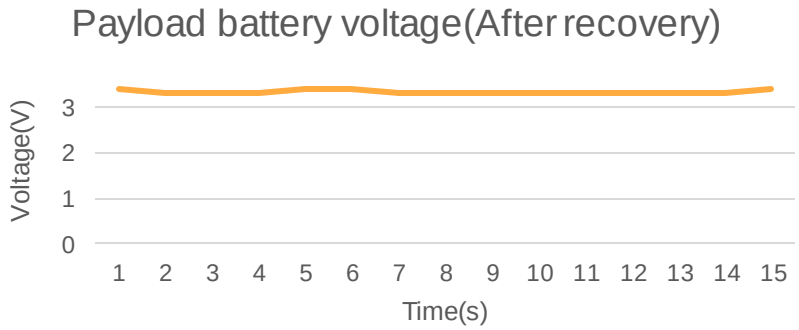




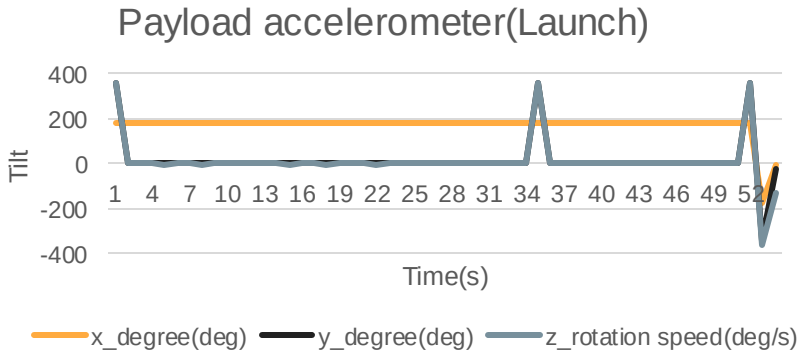
Flight Data Analysis - Partial Success

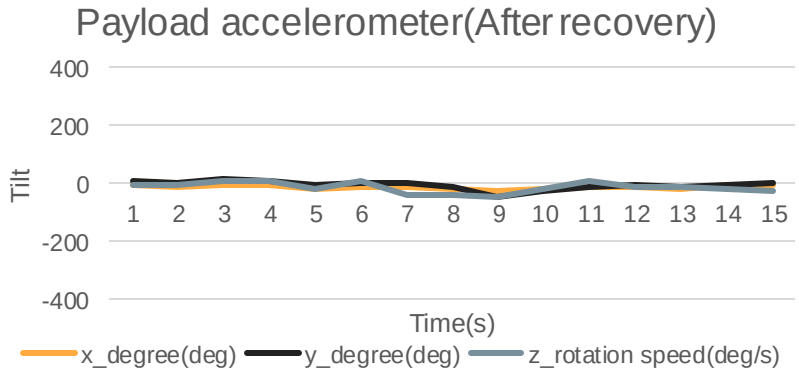
Payload battery voltage





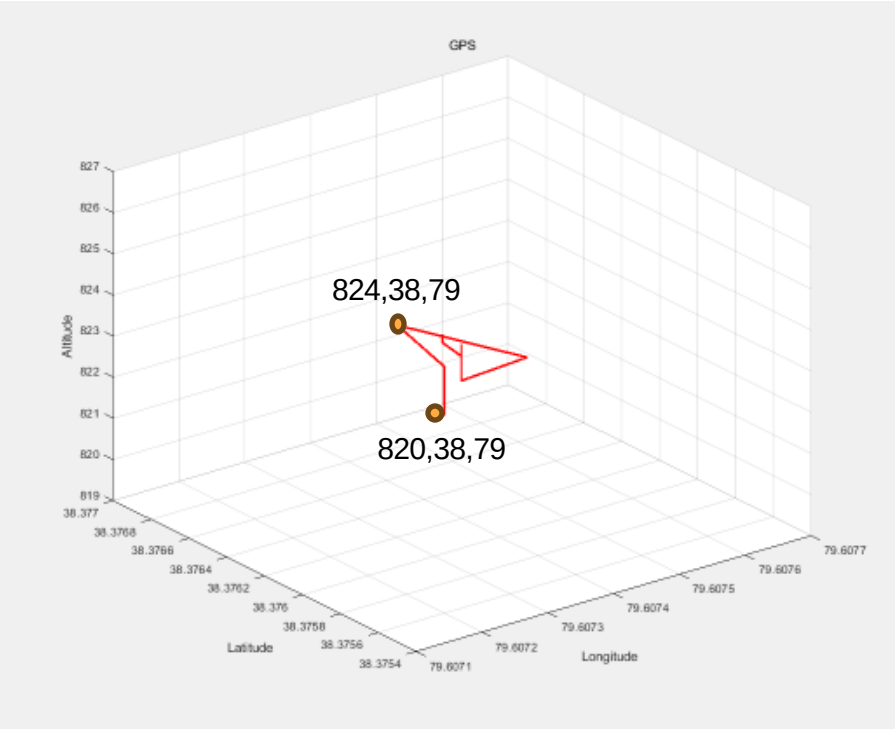
Payload accelerometer plot& Rotation plots





Flight Data Analysis - Partial Success

Payload GPS position plot



Launch

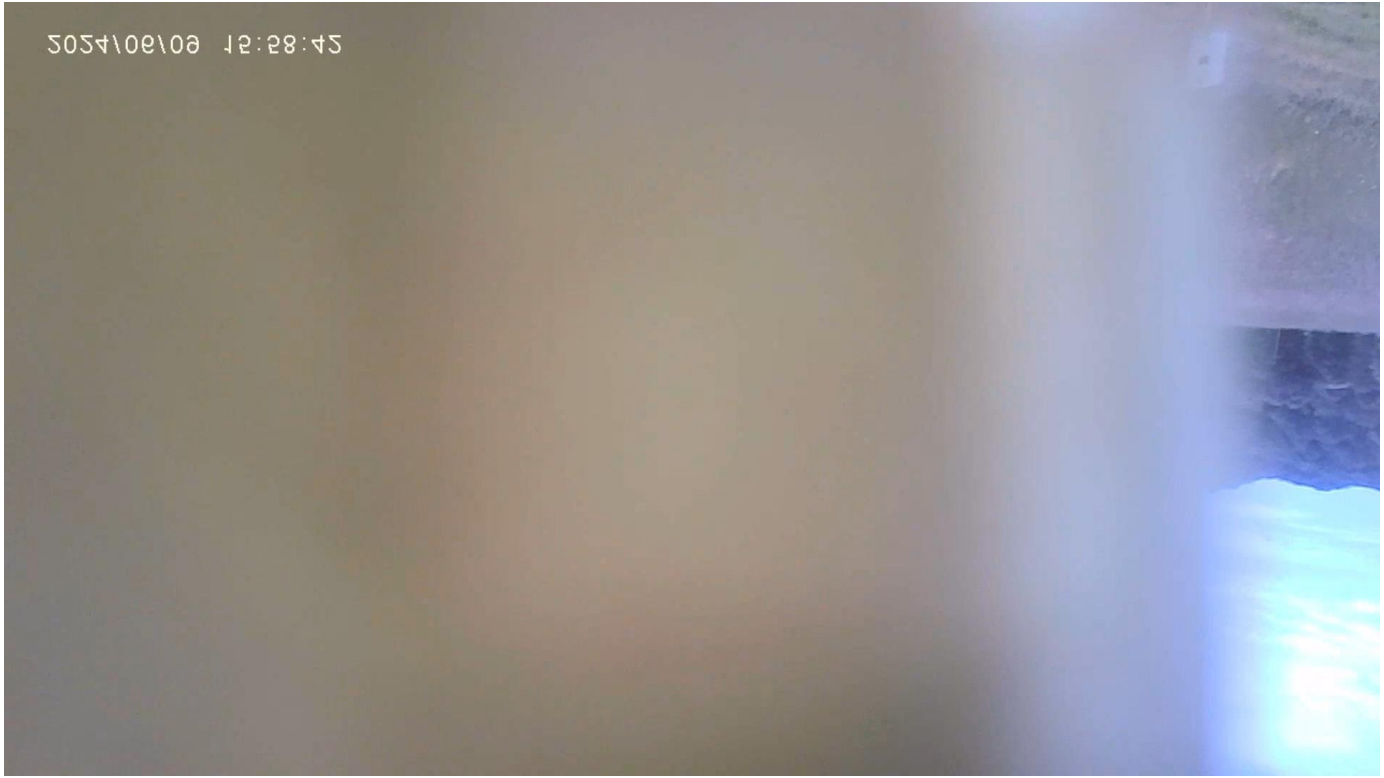
After recovery

Flight Data Analysis - Success

MAIN CAM

Payload Camera Video

https://m.site.naver.com/1oDPp



In the last part, we can hear the servo motor spinning twice.

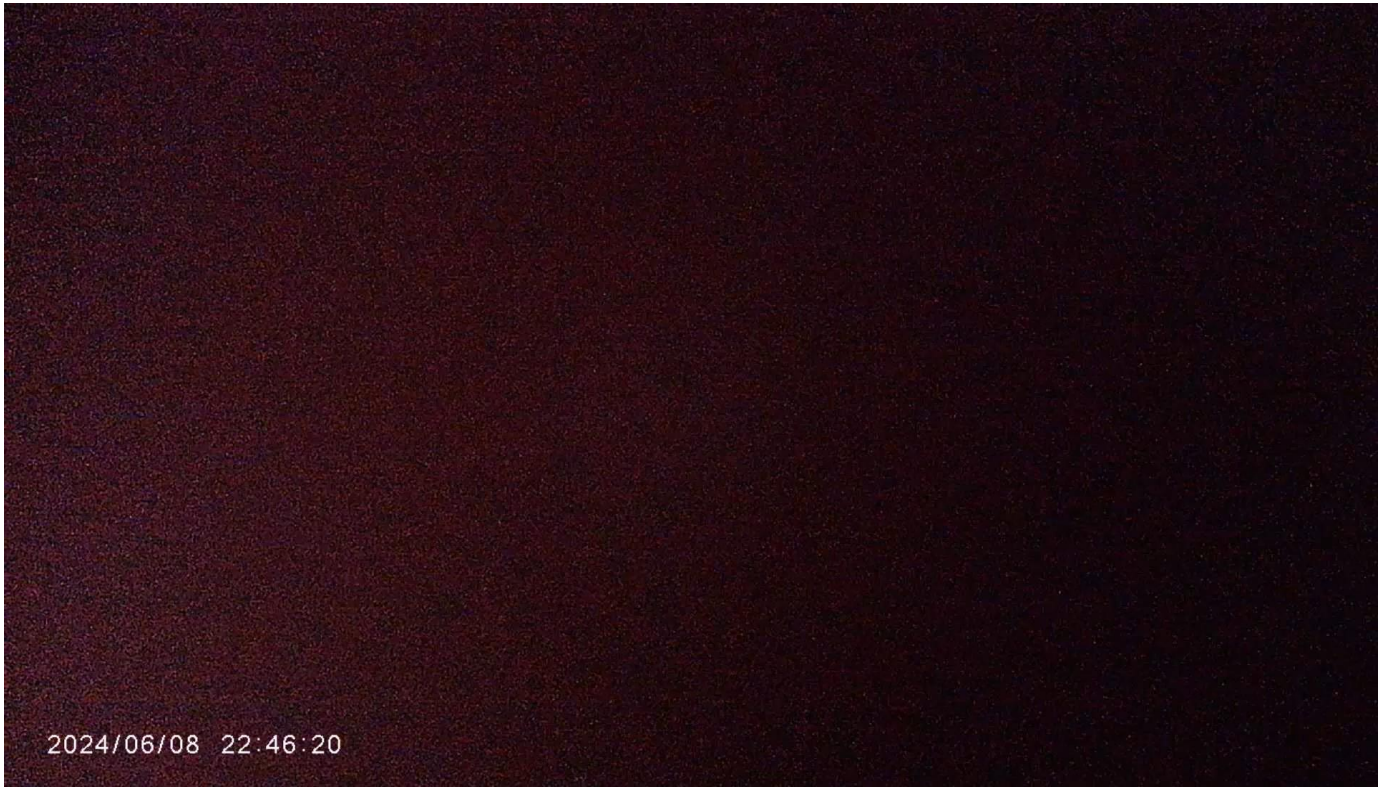
➔ Can check the normal operation of state change by elevation

➔ Relatively stable video, indicating that there was no rotation when falling

Flight Data Analysis - Success

Bonus Container Camera Video

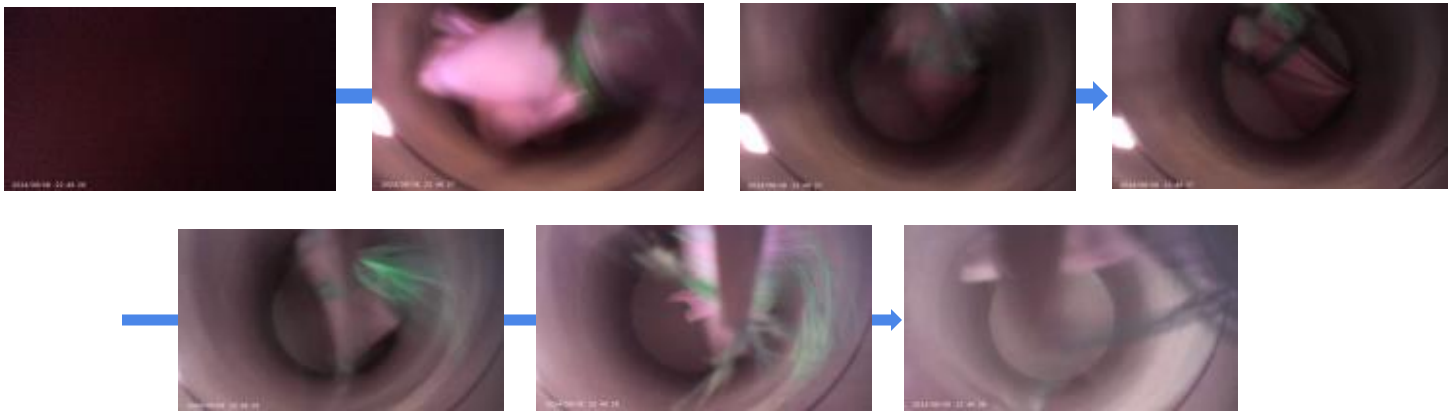
https://m.site.naver.com/1oDPW



BONUS CAM

Flight Data Analysis - Success

Bonus Container Camera Video

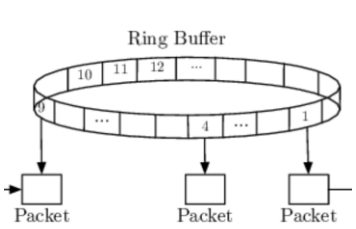


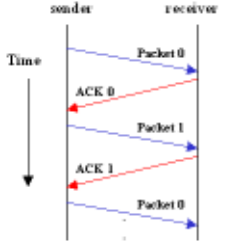
From the bonus camera video, we can see that the parachute plate was broken due to the impact at rocket launch.

➔ the servo motor wire connected to the parachute plate was released and caught in the heat shield arm, and the heat shield injection failed.

Ground Control Failure

Software reset occured





<The ring buffer & ACK transmission control are used>

2036	18:20:46	55	F	F LAUNCH
2036	18:20:47	56	F	F LAUNCH
2036	18:20:52	61	F	F ASCENT
2036	18:20:55	64	F	F ASCENT

But discrete packet is received

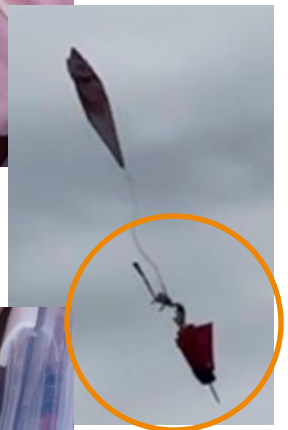
➔ Software reset might be occurred

Antenna directionality issue

We use the pannel antenna and It is difficult to know where the antenna is directing

Failure Analysis

Heat shield



Root Causes

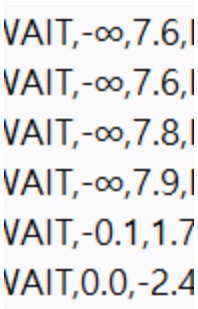
- The two columns of the RCU broke when launched. At this time, the servo line attached to the parachute plate twisted with the heat shield arm, and It unfolded only a little.
- However, the unfolding of the heat shield and some deceleration can be confirmed through the naked eye and the recorded video. The deceleration effect of the heat shield allowed the egg to be safely protected.

Corrective Actions

- Add or change springs to allow the heat shield to spread with greater elasticity.
- Added devices to secure the 'hit shield arm' to keep it unfolded in strong winds.

Failure Analysis

Sensor Subsystem



Identification

- Corrupted altitude data

Root Causes

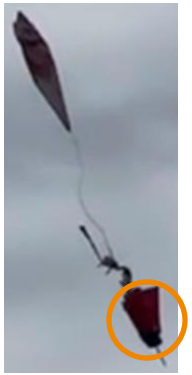
- BMP390 initialization failed

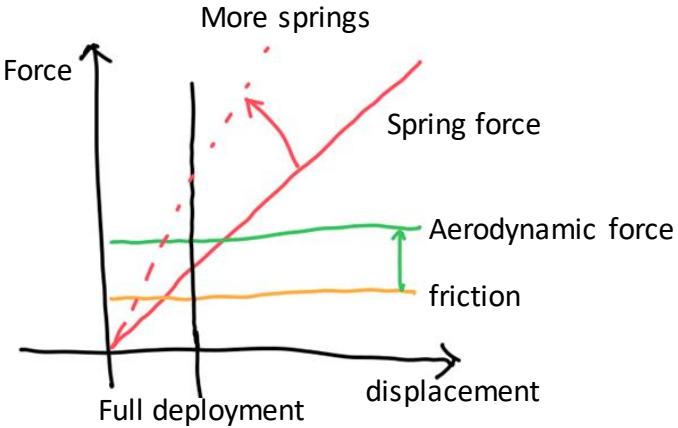
Corrective Actions

- after we conducted system reset, initialization, calibration using GCS command, the sensor worked properly

Failure Analysis

Mechanical Subsystem



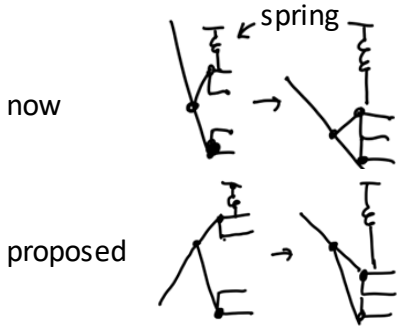


Identification

- failed to deploy heat shield
- Failed to release heat shield

Root Causes

- Under estimated the aerodynamic force
- Lack of release impulse due to parachute damage

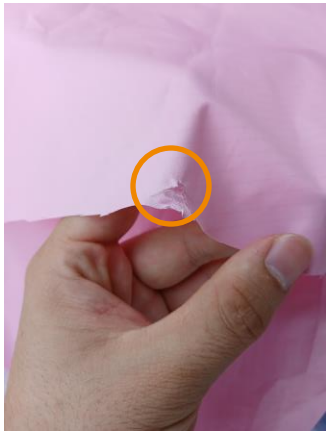


Corrective Actions

- Add more springs or change heatshield structure
- Heat shield can be a backup plan for a parachute failure
- We can add a function to detect parachute deployment in FSW so that the cansat release heat shield only when the parachute is properly deployed

Failure Analysis

Mechanical Subsystem



Identification

- Early deployment of parachute
- Parachute teared

Root Causes

- Parachute fastened with rubber band
- High-g during ascent caused parachute deployment

Corrective Actions

- Add a container to secure the parachute properly
- Reinforce the hole on parachute using some grommets

Failure Analysis

Mechanical Subsystem

Identification

- Nosecone interrupts camera view
- Nosecone stuck on the Cansat

Root Causes

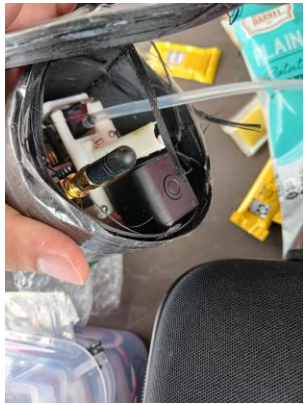
- Nosecone orientation is not constrained
- Part to constrain the nosecone's longitudinal position is not properly designed

Corrective Actions

- Modify nosecone design

Failure Analysis

Mechanical Subsystem



Material	Specific strength (kN m / kg)
ABS	39-43
PLA	43
PET	57-62
Balsa wood	521
Carbon-epoxy composite	785

Reference: wikipedia

Identification

- Structural failure of various parts

Root Causes

- Most of our elements are consist of PLA/ABS/lite weight PLA
- They have low specific strength

Corrective Actions

- Change materials to relatively high specific strength materials such as balsa wood, PET, composites

Failure Analysis

CDH Subsystem

6.5 Launch Schedule

All times are local time.

The launch will start at 1pm local time. All Cansats are to be submitted by noon. The time period is from 8am to 12pm local time and is available for launch preparations and check in. This is the time to prepare antennas, ground stations, and final Cansat tests and preparations.

Cansats must be submitted at the check-in by noon. Only one or two team members must be in line with the completed Cansat by noon. Teams who submit Cansats after the noon deadline will lose **100 points** from launch day points. Cansats must be in flight ready condition in order to be in line. Teams cannot be in line while working on the Cansat. The Cansat must be in the stowed configuration and off when submitted. Teams will be kicked out of the check-in line if they are seen working on their Cansat or their Cansat is not fully assembled in the stowed configuration.

The launch will start at 1pm and will be done in groups of five. Each team will be assigned a round which will be scheduled in one half hour increments. 15 minutes before the launch round, the teams assigned to the round shall retrieve their Cansat, turn it on and insert it into the rocket payload. Cansats shall not be disassembled at this stage. The Cansat must be flight ready and the only thing that can be done to the Cansat is to turn on the Cansat with the power switch. Any team that does not launch in their scheduled launch round will lose an additional 50 points. Any team that requires them to unload their Cansat from the rocket after the rocket is mounted on the launch pad will lose an additional **50 points**. Any team that requires disassembly of their Cansat will lose an additional **100 points**.

Cansat Turn-In	Score	Max Points	Notes
Cansat mass (g) 890 - 910		50	Performed at time of submission.
Cansat submitted on time at noon (Yes or No)		100	Time checked at time of submission.
Ground Station			
Telemetry displayed in real time during descent (Yes or No)		50	Ground Station Judge verifies
Data plotted in real time (20 pts per data field).		160	Ground Station Judge verifies. Verify how many of the 8 data elements are plotted.
Number of Payload Data Packets (2 Points per packet) start counting at start of launch. Data must show altitude change.		100	Ground station shows total packets received. The total over the flight will be recroded and scored.
Command to activate telemetry transmission is demonstrated.		100	Starting with telemetry off, CXON command is sent from the ground station to demonstrate command capability.
Flight Observations			
Payload Separated from Rocket		50	Streamer should be visible.
Return Check In			
Safe Landing		100	Cansat returned in one piece with no visible damage. It can fly again.
Egg intact		400	Team returns Cansat with egg in place to check-in to remove egg and show the judge.
Telemetry Analysis (evaluated from telemetry received on thumb drive)			
Number of Payload Data Packets (2 Points per packet) start counting at start of launch. Data must show altitude change.		200	Packets recoreded on CSV file are counted from launch to landing. Up to max 200 pts.
Total Points:	0	1310	

Identification

- SD card failure

Root Causes

- Unknown bug

Corrective Actions

- The telemetry data is assigned a maximum of 100 points, but if disassembly of the Cansat is required, there is a penalty of 150 points. So we decided to proceed with the failure

Failure Analysis

CDH Subsystem

```
    if (event_flag & E\
#ifdef DEBUG_MODE
        Buzzer_Once();
        memcpy(&cmd, usb_
        switch (cmd) {
```

Identification

- No telemetry off when landing

Root Causes

- Code for debugging was not deleted

Corrective Actions

- Use the '#ifdef' macro to differentiate between debug and release builds.

Failure Analysis

Electronic Power Subsystem

CMD Echo
NONE

Identification

- Reset occurred during the mission

Root Causes

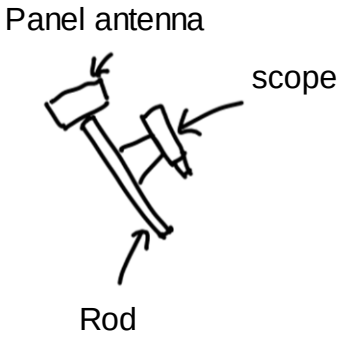
- Temporary power loss due to vibration and shock

Corrective Actions

- Solder battery connection / secure the connection with tape

Failure Analysis

Ground Control System



Identification

- Most of telemetry data lost

Root Causes

- Antenna direction error

Corrective Actions

- Add a scope to the antenna
- Mounted antenna to handheld antenna

Lessons Learned

What worked	What didn't
Ensuring the safety of Eggs during high-speed drops	Receiving telemetry packets
Attitude / rotation stability	structural weakness
Reset recovery	Failed to save data
Videos of two cameras are recorded and retrieved properly	Securing parachute before designated altitude
FSW executed all operation sequences correctly	Nosecone did not released as intended

Lessons Learned

Concusions

- Consider aerodynamic forces to ensure the mechanism functions properly in the design.
- Since communication interruptions are inevitable, the SD card must function reliably.
- Do not underestimate vibrations and shocks.
- Consider both strength and weight when selecting materials.