CanSat 2026
Critical Design Review (CDR)

Team # 1043

Daedalus

Presentation Outline

Team Organization

- **Trirayan Boontaganon** – Team Leader
  - **Asst. Prof. Jakrapop Wongwiwat, Ph.D.** – Advisor
  - **Rapassakorn Leelarujawanich** – Mechanical Lead
    - **Warithnun Kliesuwan** – Mechanical Team
      - **Pasin Thawornwiriyakul** – Mechanical Team
        - **Kris Raungrit** – Mechanical Team
    - **Bhornrawin Chinamornpong** – Mechanical Team
      - **Nopparuch Ungpipattanapong** – Mechanical Team
        - **Watcharaphong Geeratayaporn** – Mechanical Team
  - **Techit Monsakul** – Software and Ground Station Lead
  - **Watcharawit Leksuwankun** – Electronics and Firmware Lead
    - **Trirayan Boontaganon** – Electronics and Firmware Team

Acronyms (1/2)

Acronyms	Definition
ABS	Acrylonitrile Butadiene Styrene
ASA-LW	Lightweight Acrylonitrile Styrene Acrylate
CC	CanSat Crew
CF	Carbon-Fiber
CN	Command Name
CONOPS	Concept Of Operations
CSV	Comma Separated Value
DAQ	Data Acquisition
DC	Declaration
DCS	Descent Control System
FOV	Field Of View
FPS	Frames Per Second

Acronyms	Definition
FRR	Flight Readiness Review
FSW	Flight Software
GCS	Ground Control System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSC	Ground Station Crew
GUI	Graphic User Interface
HAB	High Altitude Balloon
I^2C	Inter-Integrated Circuit
LED	Light Emitting Diode
MCU	Microcontroller Unit
MCO	Mission Control Officer

Acronyms (2/2)

Acronyms	Definition
OCP	Over Current Protection
OVP	Over Voltage Protection
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PETG	Polyethylene Terephthalate Glycol
PFB	Pre Flight Briefing
PFR	Post Flight Review
PLA	Polylactic Acid
RAM	Random Access Memory
RC	Recovery Crew
RGB	Red Green Blue
RTC	Real Time Clock

Acronyms	Definition
UART	Universal Asynchronous Receiver/Transmitter
UAV	Unmanned Aerial Vehicle
VSWR	Voltage Standing Wave Ratio
m	Mass
g	Acceleration due to gravity
ρ	Density of air
v	Terminal velocity
Cd	Drag coefficient
A	Reference area
DR	Diameter of the external conical
Dr	Diameter of the internal conical

System Overview

Trirayan Boontaganon

Mission Objectives

- The CanSat consists of a payload and a container that mounts on the rocket, with the nosecone included in the payload.
- The container and payload are deployed from the rocket at the peak altitude due to motor ejection forces, with a maximum descent rate of 15 meters/second using an automatically deployed parachute.
- At 80% of peak altitude, the payload separates from the container and descends using a para-glider system at an average rate of 5 meters/second, steering toward a designated position to release an instrument (simulated by a hen’s egg) intact 2 meters above the ground.
- One camera captures the payload's separation and para-glider operation, while a second camera points downward to show the descent and the release of the instrument.
- The CanSat collects and transmits sensor data at a 1 Hz rate during ascent and descent, including temperature, battery status, altitude, tilt angle, rotation rate, and GPS position.

Bonus Mission

- We will participate in the Mark Walker Portable Ground Station Design Award.
- The payload container will be recovered after landing.

Summary of Changes Since PDR (1/2)

Subsystem	Changes	Rationales
Sensor	Magnetometer sensor is changed from LIS3MDL to BNO086.	More accurate data
	Payload release camera is changed from SQ11 to ESP-S3 cam.	Allows trigger record
Descent Control	No Changes	No Changes
Mechanical	Structure is changed from 3 partitions to 4 partitions.	Ease of assembly
	Changed electrical structures design.	Lower mass
	Container uses a simplified spring-mounted design.	More stable
	The payload release mechanism is redesigned.	Lower mass, ease of assembly
	Paraglider control uses a simplified side-mounted servo design .	Space efficient, ease of assembly, more stable
	Revised the egg container mounting method.	Manufacturability, tighter sealing

Summary of Changes Since PDR (2/2)

Subsystem	Changes	Rationales
CDH	No changes	No changes
EPS	Battery is changed from 3500 mAh to 3800 mAh.	More safety factor
FSW	GNSS sampling frequency is increased from 5 Hz to 18 Hz.	Improved descent control efficiency
	Magnetometer sampling frequency is increased from 10 Hz to 50 Hz	
	Calculation method is changed from PID to EMA.	Simplified processing
GCS	ngrok is included.	Provides remote monitoring
	Audio telemetry announcement is included.	Delivers real-time audio updates

System Requirement Summary (1/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
1	C1	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.	Operational		X		X
2	C2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Operational				X
3	C3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Operational				X
4	C4	After deployment, the CanSat payload and container shall descend at 15 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	Operational	X		X	
5	C5	At 80% flight peak altitude, the payload shall be released from the container.	Operational			X	X
6	C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Operational			X	X
7	C7	The payload shall descend at 5 meters/second averaged over the entire descent within +/- 3 meters/sec with the para-glider descent control system.	Operational	X		X	
8	C8	The payload shall steer toward a target location.	Operational			X	X
9	C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Operational			X	X
10	C10	The payload shall record video of the release of the payload from the container and the deployment of the para-glider descent control system.	Operational			X	X
11	C11	A second video camera shall point at the ground.	Operational			X	X
12	C12	The payload shall release a protected hen's egg when the payload is 2 meters +/- 0.5 m above the ground without breaking the egg.	Operational			X	X

System Requirement Summary (2/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
13	C13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat battery and electronics.	Operational		X	X	
14	C14	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.	Operational	X			
15	S1	The CanSat and container mass shall be 1000 grams +/- 10 grams.	Structural		X		
16	S2	The nose cone shall be symmetrical along the thrust axis.	Structural		X		
17	S3	Nose cone radius shall be exactly 70 mm.	Structural		X		
18	S4	Nose cone shoulder length shall be a minimum of 50 mm.	Structural		X		
19	S5	The nose cone shall be made as a single piece. Segments are not allowed.	Structural		X		
20	S6	The nose cone shall not have any openings allowing air flow to enter.	Structural		X		
21	S7	The nose cone height shall be a minimum of 76 mm.	Structural		X		
22	S8	CanSat structure must survive 15 Gs vibration.	Structural	X		X	
23	S9	CanSat shall survive 30 G shock.	Structural	X		X	
24	S10	The container shoulder length shall be 90 to 120 mm.	Structural		X		
25	S11	The container shoulder diameter shall be 136 mm.	Structural		X		
26	S12	Above the shoulder, the container diameter shall be 140 mm.	Structural		X		
27	S13	The container wall thickness shall be at least 2 mm when 3D printed and must not flex or be deformed when under stress.	Structural	X	X	X	
28	S14	The container length above the shoulder shall be 200 mm +/- 5%.	Structural		X		

System Requirement Summary (3/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
29	S15	The CanSat shall perform the function of the nose cone during rocket ascent.	Structural			**X**	**X**
30	S16	The CanSat container can be used to restrain any deployable parts of the CanSat payload but shall allow the CanSat to slide out of the payload section freely.	Structural			**X**	**X**
31	S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Structural		**X**		
32	S18	The CanSat container shall meet all dimensions in section F.	Structural		**X**		
33	S19	The CanSat container materials shall meet all requirements in section F.	Structural		**X**		
34	S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Structural	**X**		**X**	**X**
35	S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Structural	**X**		**X**	
36	M1	No pyrotechnical or chemical actuators is allowed.	Mechanism		**X**		
37	M2	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside nmentnnment to reduce potential risk of setting the vegetation on fire.	Mechanism		**X**		
38	M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Mechanism		**X**		
39	M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Mechanism		**X**		
40	E1	Lithium polymer batteries are not allowed.	Electrical		**X**		

System Requirement Summary (4/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
41	E2	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.	Electrical		X		
42	E3	An easily accessible power switch through the container is required.	Electrical		X		
43	E4	The container shall have small access holes for power switches of no more than 10 mm.	Electrical		X		
44	E5	Power indicator is required.	Electrical		X		
45	E6	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Electrical	X		X	
46	E7	The audio beacon shall operate on a separate battery.	Electrical		X		
47	E8	The audio beacon shall have an easily accessible power switch through the container.	Electrical		X		
48	X1	XBee radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBee radios are also allowed.	Communications		X		
49	X2	XBee radios shall have their NETID/PANID set to their team number.	Communications		X		
50	X3	XBee radios shall not use broadcast mode.	Communications		X		
51	X4	The CanSat shall transmit telemetry once per second.	Communications			X	X
52	X5	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Communications			X	X

System Requirement Summary (5/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
53	SN1	CanSat payload shall measure its altitude using air pressure.	Sensor			X	X
54	SN2	CanSat payload shall measure its internal temperature.	Sensor			X	X
55	SN3	CanSat payload shall measure its battery voltage.	Sensor			X	X
56	SN4	CanSat payload shall track its position using GPS.	Sensor			X	X
57	SN5	CanSat payload shall measure its acceleration and rotation rates.	Sensor			X	X
58	SN6	CanSat payload shall video record the deployment of the para-glider at 80% peak altitude.	Sensor			X	X
59	SN7	CanSat payload shall video record the ground during descent.	Sensor			X	X
60	SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Sensor			X	X
61	SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Sensor		X	X	X
62	SN10	CanSat payload shall measure its battery current.	Sensor			X	X
63	G1	The ground station shall command the CanSat to calibrate the altitude to zero when the CanSat is on the launch pad prior to launch.	Ground Station				X
64	G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Ground Station				X
65	G3	Telemetry shall include mission time with 1 second resolution.	Ground Station				X
66	G4	Each team shall develop their own ground station.	Ground Station				X
67	G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Ground Station				X

System Requirement Summary (6/7)

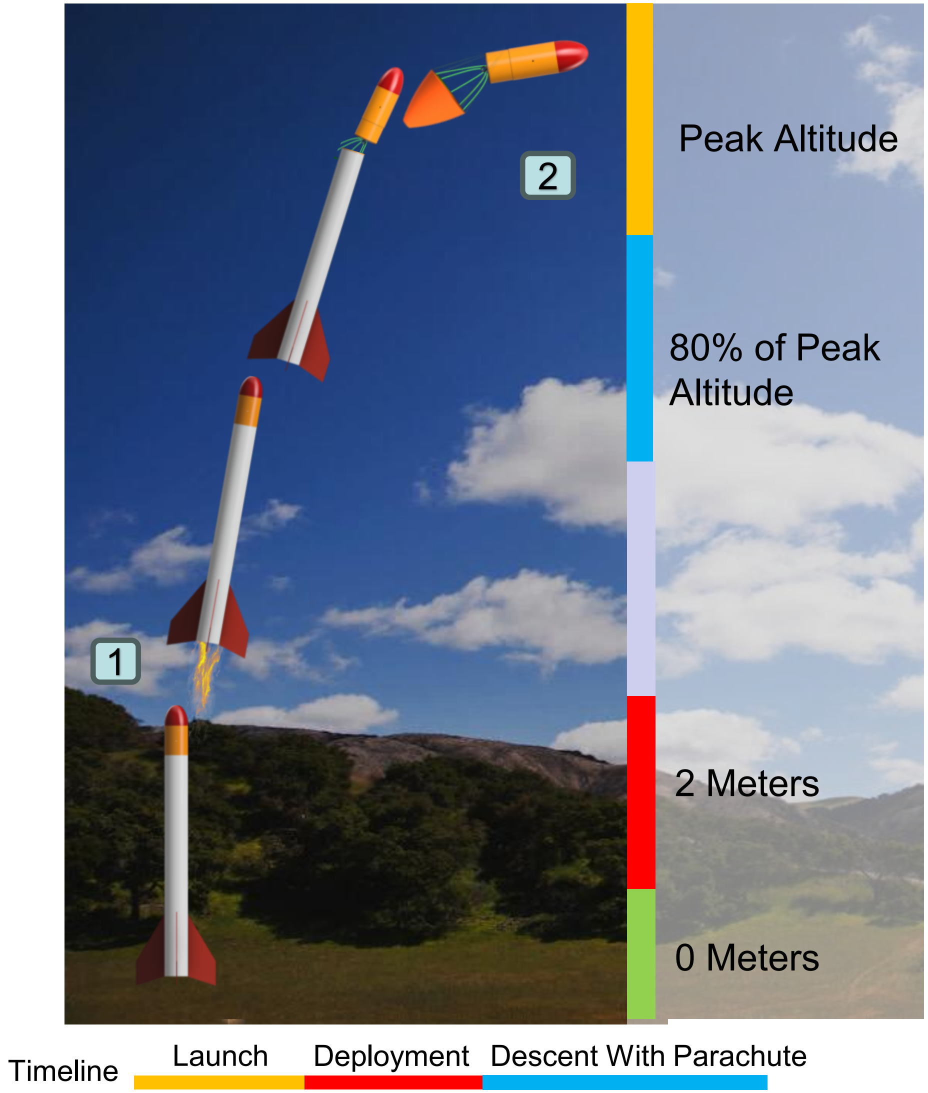
#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
68	G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Ground Station			X	X
69	G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Ground Station			X	X
70	G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Ground Station			X	X
71	G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and an antenna.	Ground Station			X	X
72	G10	The ground station must be portable so that 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.	Ground Station			X	X
73	G11	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.	Ground Station			X	
74	G12	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.	Ground Station			X	
75	G13	The ground station shall use a table top or handheld antenna.	Ground Station				X
76	G14	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.	Ground Station				X
77	G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Ground Station				X

System Requirement Summary (7/7)

#	Code	Requirement Descriptions	Subsystem	Verification			
				A	I	T	D
78	G16	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.	Ground Station			**X**	
79	G17	The ground station shall be able to activate all mechanisms on command.	Ground Station				**X**
80	F1	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.	Flight Software			**X**	
81	F2	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Flight Software				**X**
82	F3	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Flight Software				**X**
83	F4	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 file.	Flight Software			**X**	
84	F5	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Flight Software			**X**	
85	F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Flight Software			**X**	
86	F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Flight Software				**X**
87	F8	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Flight Software			**X**	

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

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



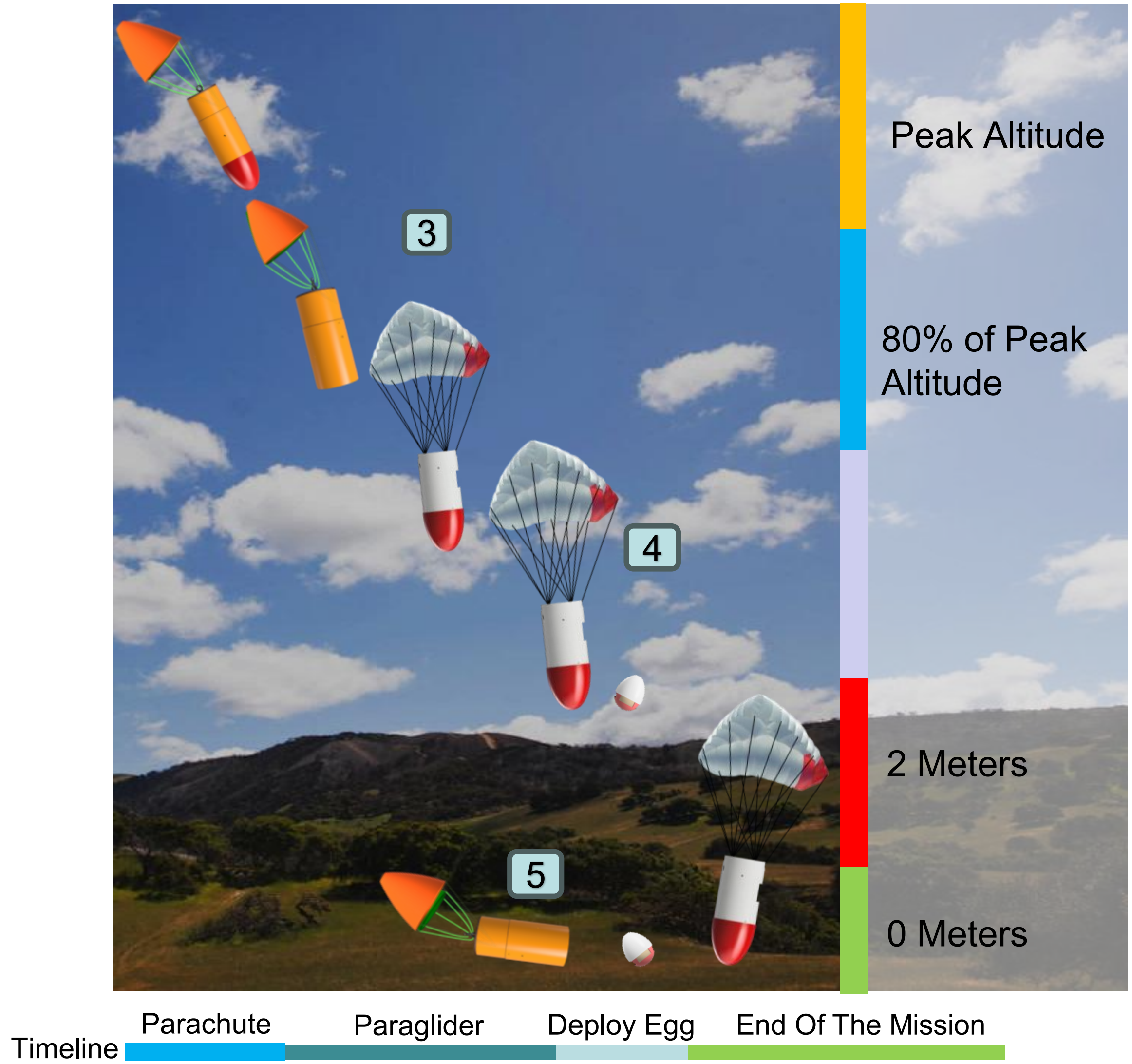
1 Launch

- The CanSat initiates video recording using two cameras.
- The CanSat begins sensor calibration and starts transmitting telemetry data.
- The CanSat is powered on and securely integrated into the launch vehicle.
- The launch vehicle is ignited, and the rocket ascends to an altitude of 668 m (Open Rocket).

2 Deployment

- The CanSat separates from the launch vehicle.
- Subsequently, the CanSat deploys its parachute and undergoes descent at a rate of 15 ± 3 m/s after the rocket motor ejection charges fire.

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



3 Descent

- At 80% of the peak altitude (534.4 m), the payload shall separate from the container.
- The first camera shall record the deployment of the paraglider.
- The payload shall subsequently descend to the ground under a paraglider-based descent control system, maintaining a controlled descent rate of 5 ± 3 m/s until touchdown.

4 Deployment

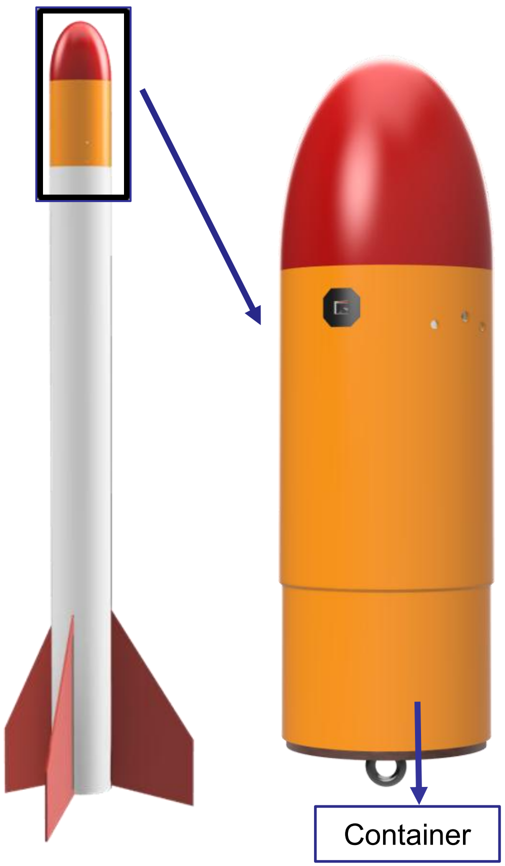
- The second camera shall record the deployment of the instrument deployment.
- The egg payload shall be deployed at an altitude of 2 m above the designated landmark.

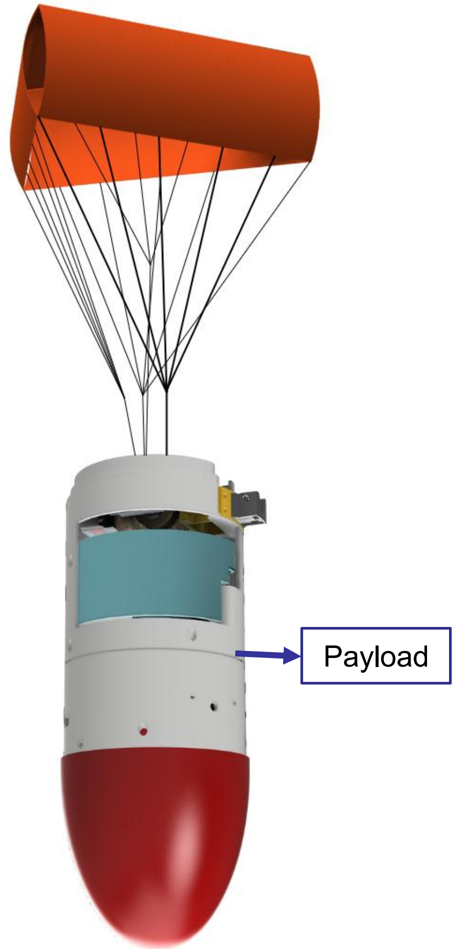
5 Landed

- The payload shall terminate all data transmission and camera recording operations.

CanSat Physical Layout (1/4)

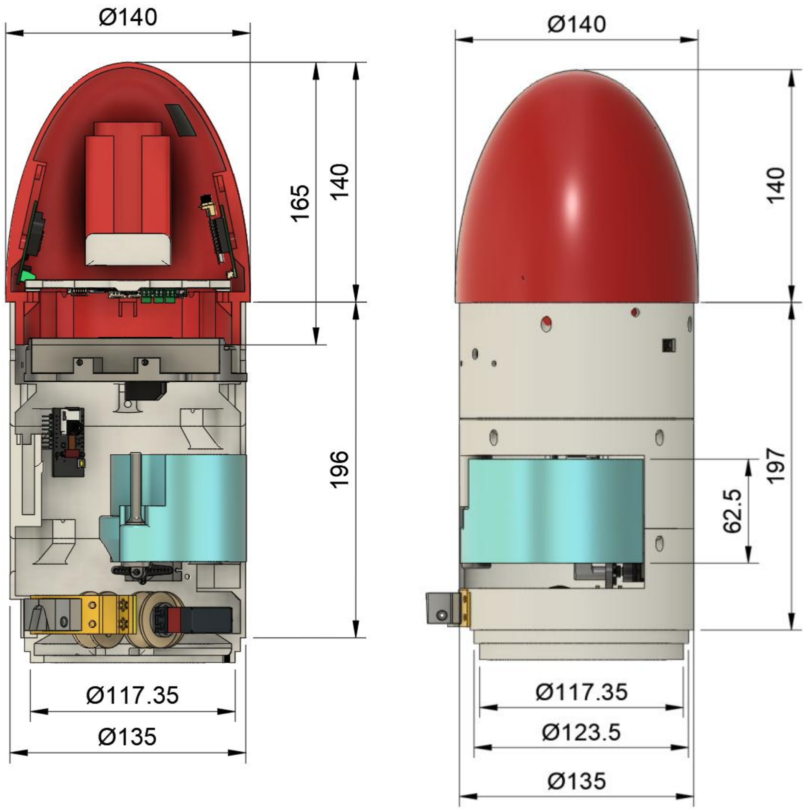
CanSat



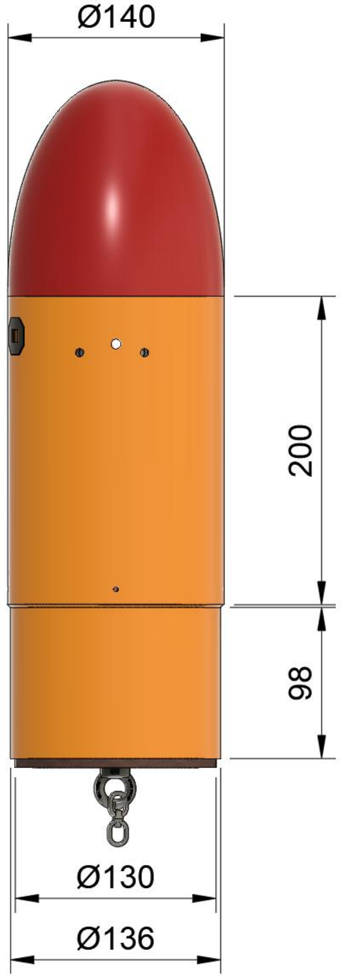


Launch Configuration | **Deployed Configuration** | **Instrument Deployment**

Dimensions



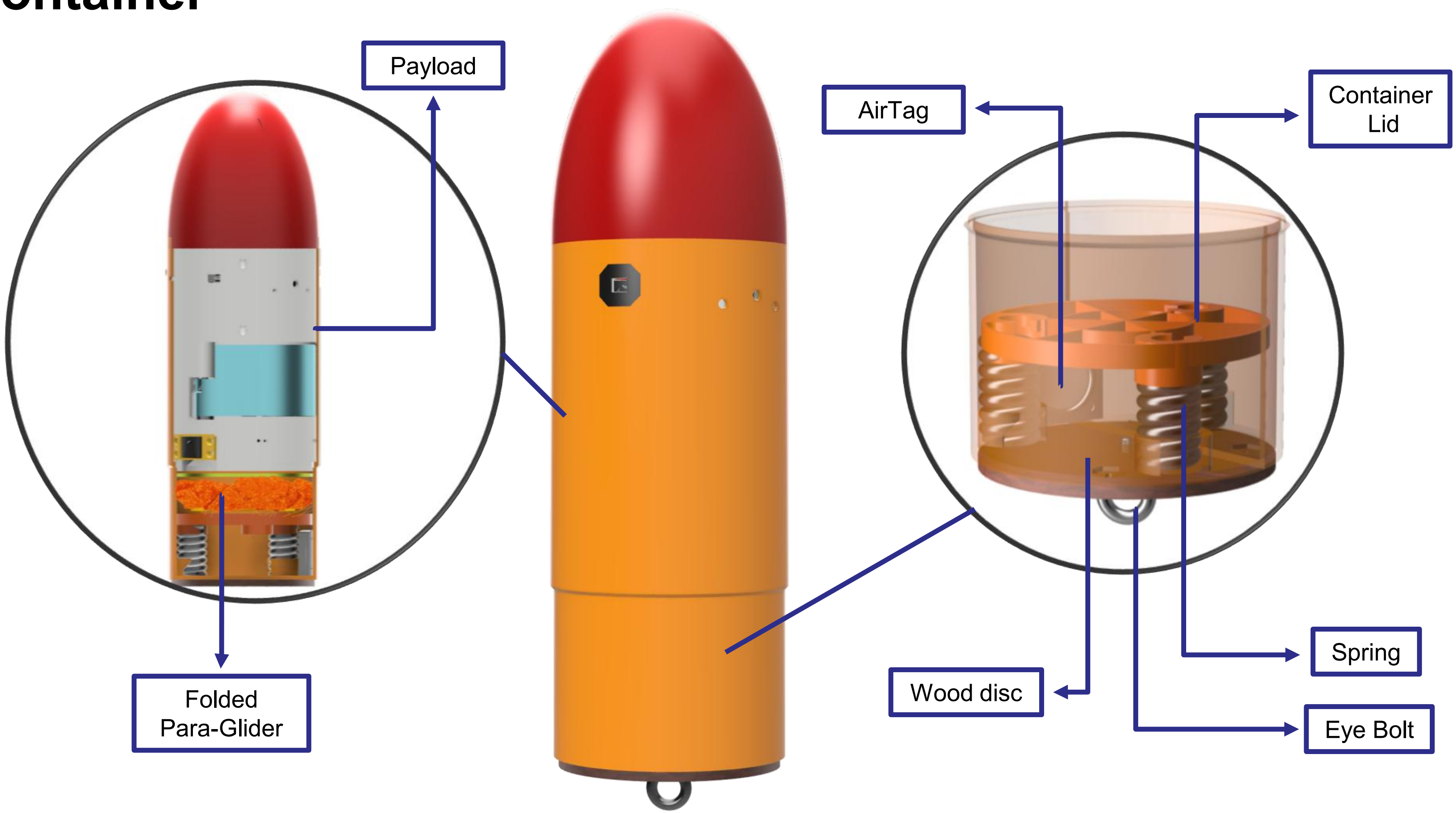
Payload Dimension



Container Dimension

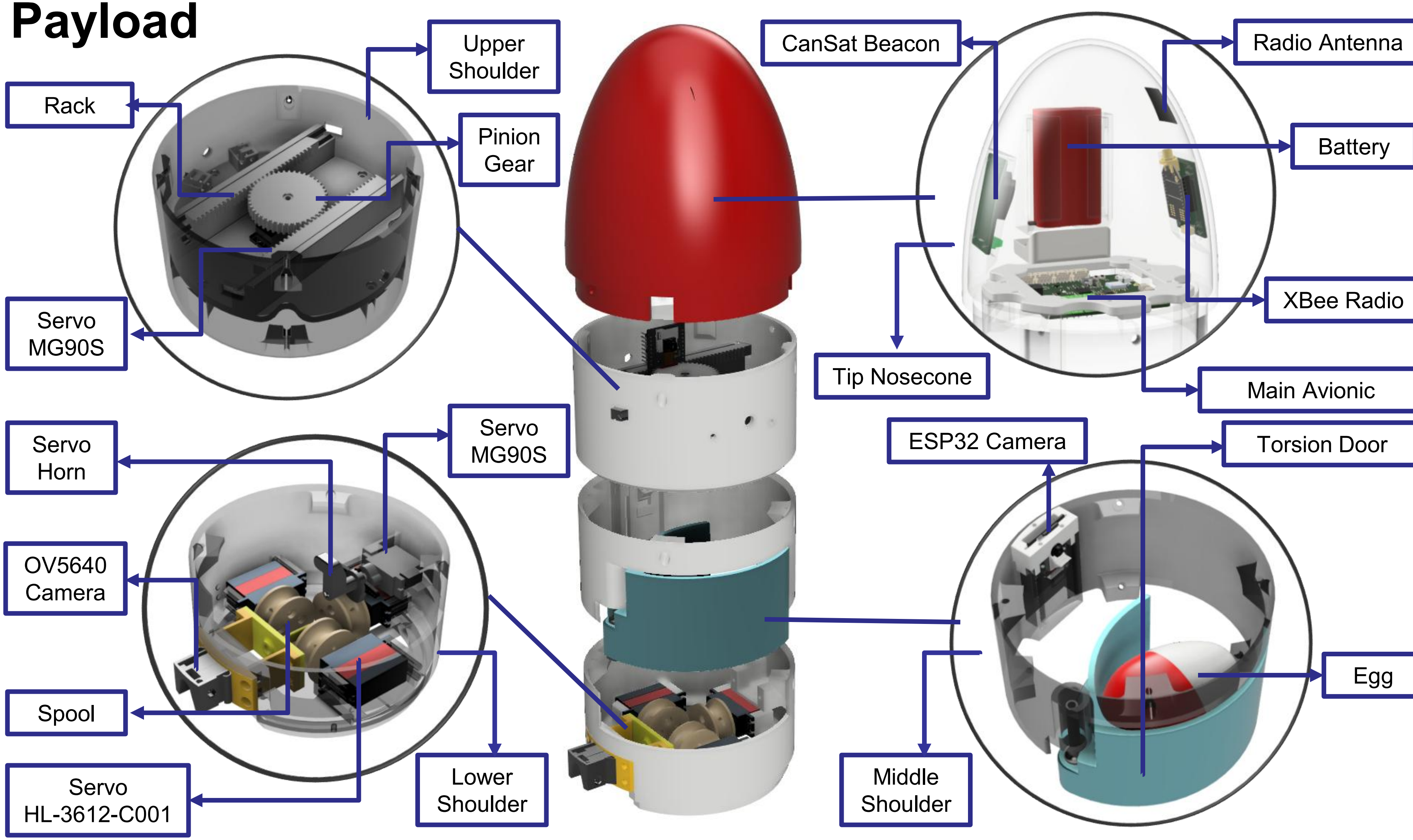
Unit : mm

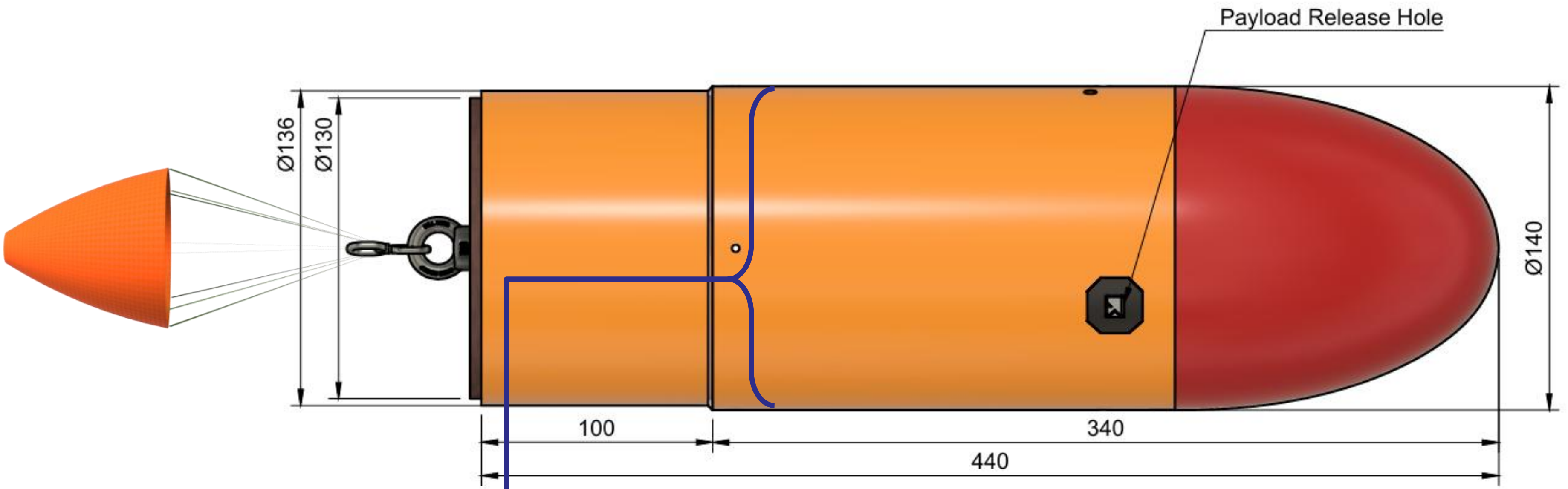
Container


Payload
Folded
Para-Glider
AirTag
Container
Lid
Spring
Wood disc
Eye Bolt

CanSat Physical Layout (4/4)

Payload





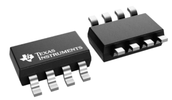
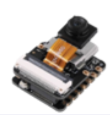
The container shall be wider at 140 mm diameter (above the shoulder).

Properties	Container Section Dimensions (mm)	Payload Dimensions (mm)	Nosecone (mm)
Diameter	140	135	140
Height	300	340	140
Clearance	3	5	0

Sensor Subsystem Design

Watcharawit Leksuwankun

Sensor Subsystem Overview

Sensor Type	Sensor Model	Function Overview
Air Pressure Sensor	BMP581 	Determine atmospheric pressure to estimate the altitude of the CanSat.
Air Temperature Sensor		Measure the internal temperature of the CanSat.
Battery Voltage and Current Sensor	INA236 	Measure battery voltage and current of payload.
GNSS Sensor	MAX-M10S 	Track the position of payload using GPS.
Acceleration Sensor	ISM6HG256X 	Measure the acceleration of payload.
Rotation Rate Sensor	BNO-086 	Measure the rotation rate of payload.
Release Camera	Seed Studio XIAOESP32S3 	Video recording of the deployment of paraglider at 80% peak altitude.
Instrument Release Sensor	VL53L1X BMP581  	Measure the altitude at 2 m for instrument deployment.
Ground Camera	Seed Studio XIAOESP32S3 	Video recording of the ground during descent.

Sensor Changes Since PDR (1/2)

Component	PDR	CDR	Rationales
Additional sensor	LIS3MDL (3-axis) (Magnetometer sensor)	BNO086 (9-axis) (Orientation sensor)	• real-time sensor fusion internally • more stable and accurate heading and orientation measurements • simplified calibration and system integration

*Note: This sensor is used for guiding the direction of the paraglider path control.

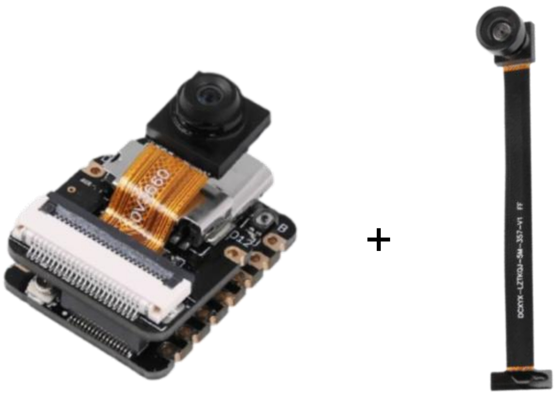
LIS3MDL
(3-axis)

BNO086
(9-axis)

Sensor Changes Since PDR (2/2)

Component	PDR	CDR	Rationales
Payload Release Camera Sensor	SQ11	Seed Studio XIAOESP32S3	• Allows the flight computer to trigger recording via software, eliminating unreliable manual button presses. • Operates on the regulated power rail, removing flight-failure risks from the SQ11's internal battery. • Smaller Size and Light Weight

Quelima SQ11 Camera

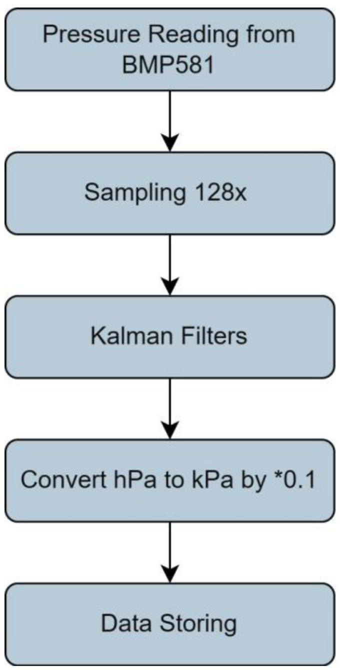


Seed Studio XIAO ESP32S3

Payload Air Pressure Sensor Summary

Model	Interfaces	Range (hPa)	Size (mm)	Mass (g)	Voltage (V)	Current (mA)	Cost (USD)
BMP581	I^2C, SPI	300 – 1250	2 x 2 x 0.8	0.2	1.71 - 3.6	0.26 mA	2.78

Data Processing



Formula

$$H = h_0 + \frac{T_0}{L}\left[\left(\frac{p}{P_0}\right)^{-\frac{R_d L}{g_0}} - 1\right]$$

Data Format	Accuracy (kPa)
Pressure = XXX.X kPa Altitude = XXX.X m	±0.006

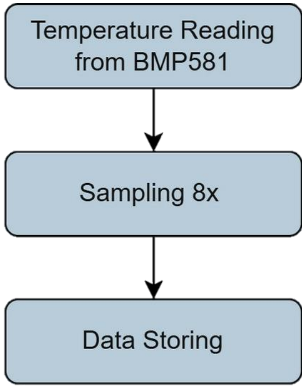
Note

- Uses the formula to transfer pressure to altitude
- Uses SPI communication

Payload Air Temperature Sensor Summary

Model	Interfaces	Range (°C)	Size (mm)	Mass (g)	Voltage (V)	Current (mA)	Cost (USD)
BMP581	I^2C, SPI	-40.0 – 85.0	2 x 2 x 0.8	0.2	1.71 - 3.6	0.26 mA	2.15

Data Processing



Formula

$$T\,[^\circ C] = \left(\frac{\text{TEMP\_DATA\_MSB,TEMP\_DATA\_XLSB,XLSB}}{2^{16}}\right)$$

Data Format	Accuracy (°C)
Temperature = XX.X °C	±0.5

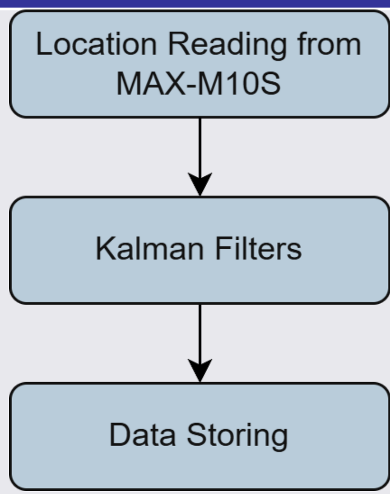
Note

- Uses the formula to transfer pressure to altitude
- Uses SPI communication

Payload GNSS Sensor Summary

Model	Interfaces	Update rate (Hz)	Start time (s)	Size (mm)	Mass (g)	Voltage (V)	Current (mA)	Cost (USD)
MAX-M10S	I^2C, UART	18	1	10.7 x 9.8 x 2.7	0.5	-0.3 – 3.6	10	21.11

Data Processing



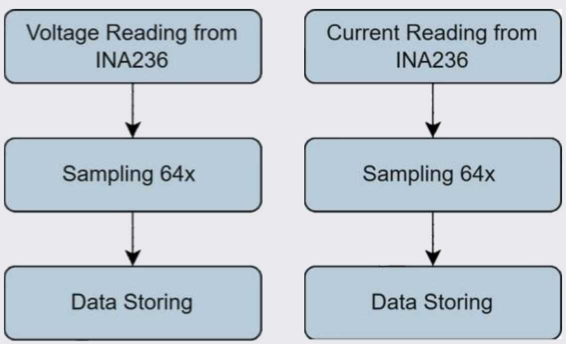
Uses I^2C communication
Max navigation update rate : 18 Hz

Data Format	Accuracy
GPS_TIME = XX:XX:XX hh:mm:ss	±60 ns
GPS_LATITUDE = XX.XXXX °	±1.5 m
GPS_LONGITUDE = XX.XXXX°	±1.5 m
GPS_SATS = XX	-

Payload Voltage and Current Sensor Summary

Model	Interfaces	Range (V)	Mass (g)	Resolution (mV/LSB)	Voltage (V)	Current (mA)	Cost (USD)
INA236	I^2C	-0.3 – 48	0.009	0.0025	-1.7 – 5.5	0.3	1.62

Data Processing

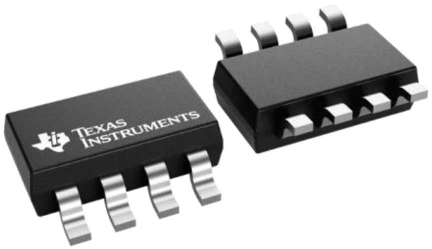


Uses I^2C communication

Formula

$$I_{load} = \frac{V_{shunt}}{R_{shunt}}$$

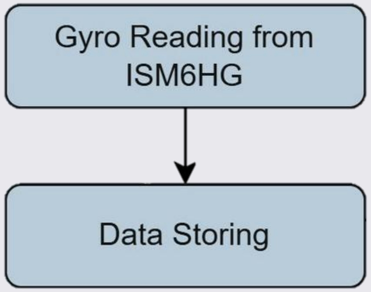
Data Format	Accuracy (%)
Voltage = XX.X V Current = XX.X A	±0.1%



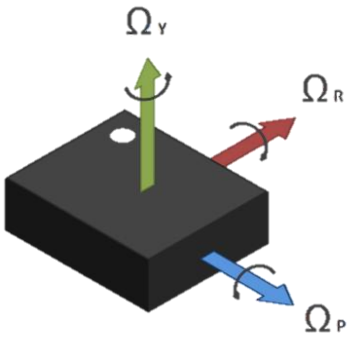
Rotation Rate Sensor Summary

Model	Interfaces	Range (dps)	Size (mm)	Mass (g)	Voltage (V)	Current (mA)	Cost (USD)
ISM6HG256X	I²C, SPI	±4000	2.5 x 3.0 x 0.83	0.05	1.71 - 3.6	0.8	7.17

Data Processing



Uses SPI communication



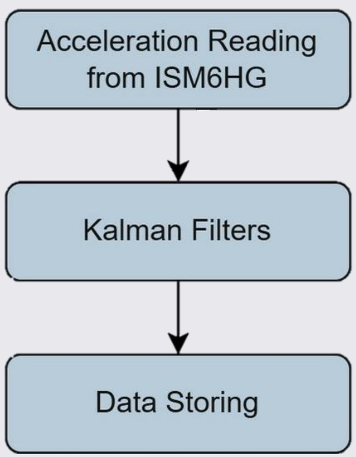
Direction

Data Format	Accuracy (dps)
GYRO_R = XX.X °/s GYRO_P = XX.X °/s GYRO_Y = XX.X °/s	±0.5

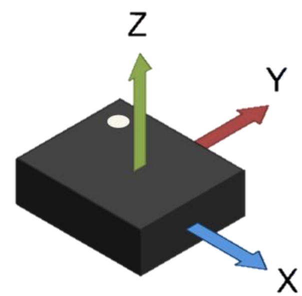
Payload Acceleration Sensor Summary

Model	Interfaces	Range (g)	Size (mm)	Mass (g)	Voltage (V)	Current (μA)	Cost (USD)
ISM6HG256X	I²C, SPI	Low-g channel ±2/±4/±8/±16 g High-g channel ±32/±64/±128/±256 g	2.5 x 3 x 0.83	0.05	1.71 - 3.6	0.8	8.24

Data Processing



Uses SPI communication



Direction

Data Format	Accuracy (g)
ACCEL_R = XX.X m/s² ACCEL_P = XX.X m/s² ACCEL_Y = XX.X m/s²	Low G: ±0.01 High G: ±0.25

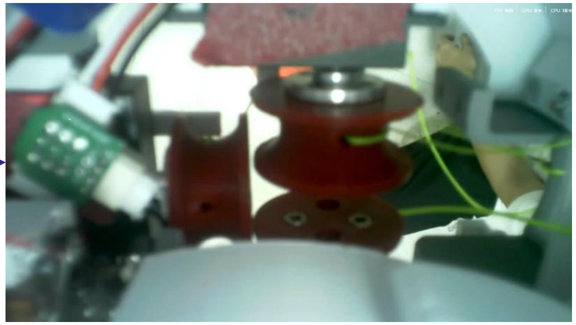
Payload Release Camera Sensor

Model	Interfaces	Resolution	FOV	FPS	Voltage (V)	Operating Current (mA)	Built-in Battery	Mass (g)	Size (mm)
Seed Studio XIAOESP32 S3	UART, SPI, I^2C,USB OTG,GPIO	1280 x 720	68°	30	3.7 - 5.0	150	No	5	21 x 17.5 x 15

Data Format	Rationales
• Video file type: AVI • Resolution: 1280 x 720 • Video: Color • Meet requirements of minimum 640x480 pixels with color	• Provides a superior field of view • Offers automatic image control functionality • Micro SD card for video storage • Readily available within the domestic market

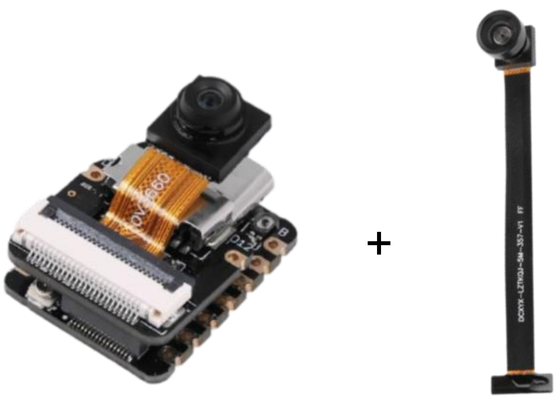
Sensor: OV5640 (1/4”) CMOS 60° FOV

Example of Camera View



Payload Ground Camera Sensor

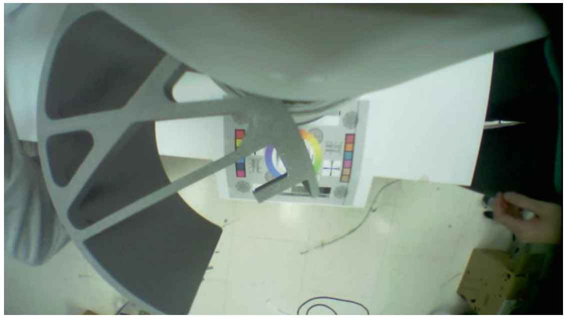
Model	Interfaces	Resolution	FOV	FPS	Voltage (V)	Operating Current (mA)	Built-in Battery	Mass (g)	Size (mm)
Seed Studio XIAOESP32 S3	UART, SPI, I^2C,USB OTG,GPIO	1280 x 720	160°	30	3.7 - 5.0	150	No	5	21 x 17.5 x 15



Sensor: OV5640 (1/4”) CMOS 160° FOV

Data Format	Rationales
• Video file type: AVI • Resolution: 1280 x 720 • Video: Color • Meet requirements of minimum 640x480 pixels with color	• Provides a superior field of view • Offers automatic image control functionality • Micro SD card for video storage • Readily available within the domestic market

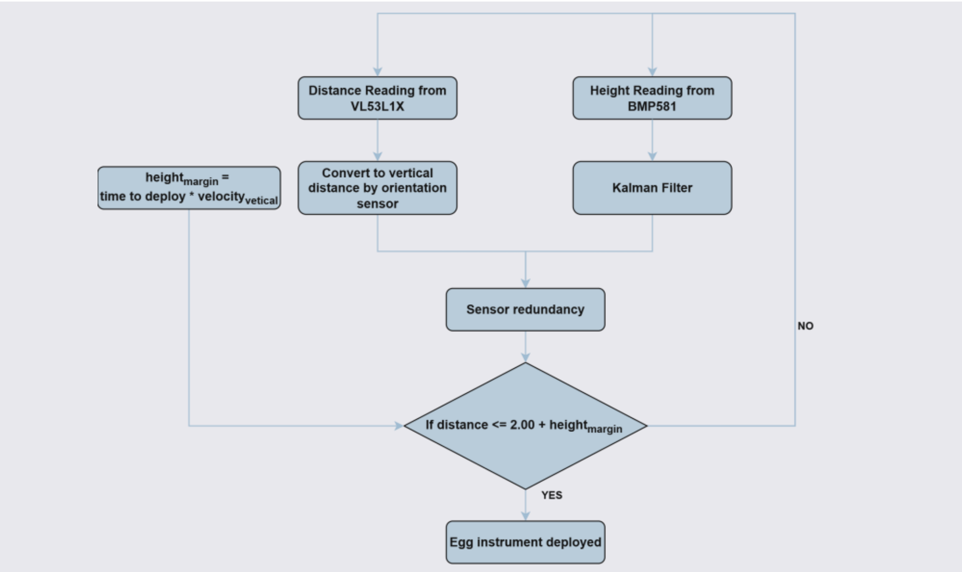
Example of Camera View



Egg Release Sensors

Model	Interfaces	Range	Size (mm)	Mass (g)	Voltage (V)	Current (mA)	Cost (USD)
VL53L1X (TOF sensor)	I²C	0.04 – 4 m	4.9 x 2.5 x 1.56	3	2.6-3.5	40	19.75
BMP581 (Air pressure sensor)	I²C, SPI	9,164 – -1,807 m	2 x 2 x 0.8	0.2	1.71 - 3.6	0.26	2.78

Logic to Release



VL53L1X

The VL53L1X uses I²C communication.

BMP581

The BMP581 uses SPI communication.

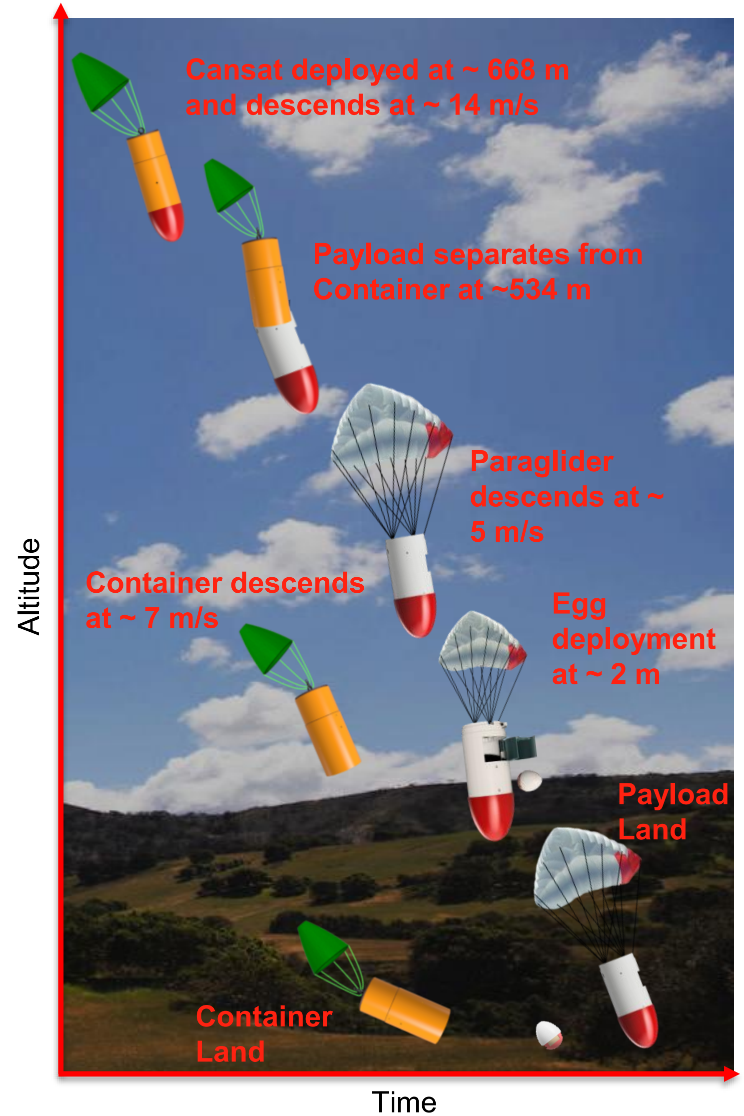
Descent Control Design

Watcharaphong Geeratayaporn
Nopparuch Ungpipattanapong

Descent Control Overview (1/2)

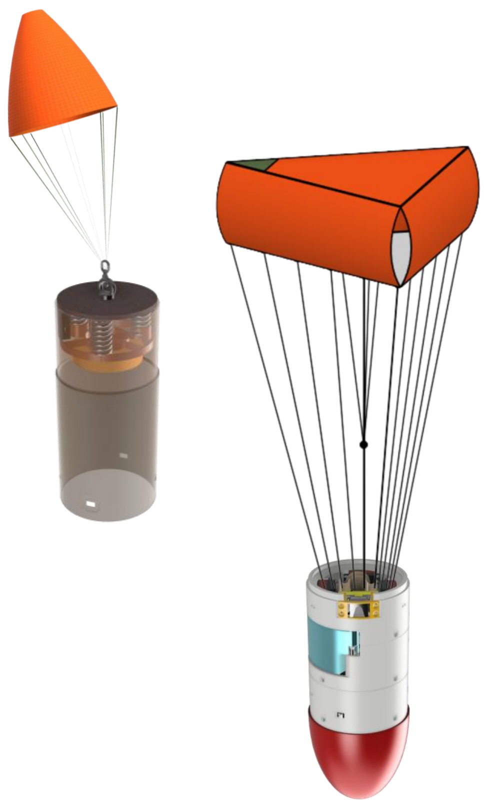
At the apogee (~668 m), the container and payload are separated from the rocket simultaneously, with the container parachute deployed, resulting in a descent velocity of approximately 14 m/s. At 80% of the apogee (~536 m), the payload and container are separated. The paraglider then descends at approximately 5 m/s, while the container descends separately at approximately 7 m/s.

States	Operational Time (s)	Final Altitude (m)	Velocity (m/s)
Open Rocket Time to Apogee	11	668	
Container Parachute Descent	9		~ 14 m/s
Container and Payload Separate		536	
Paraglider Descent	83	536	~ 5 m/s
Egg Deployment	0.4	2	
Total Flight	103.4		

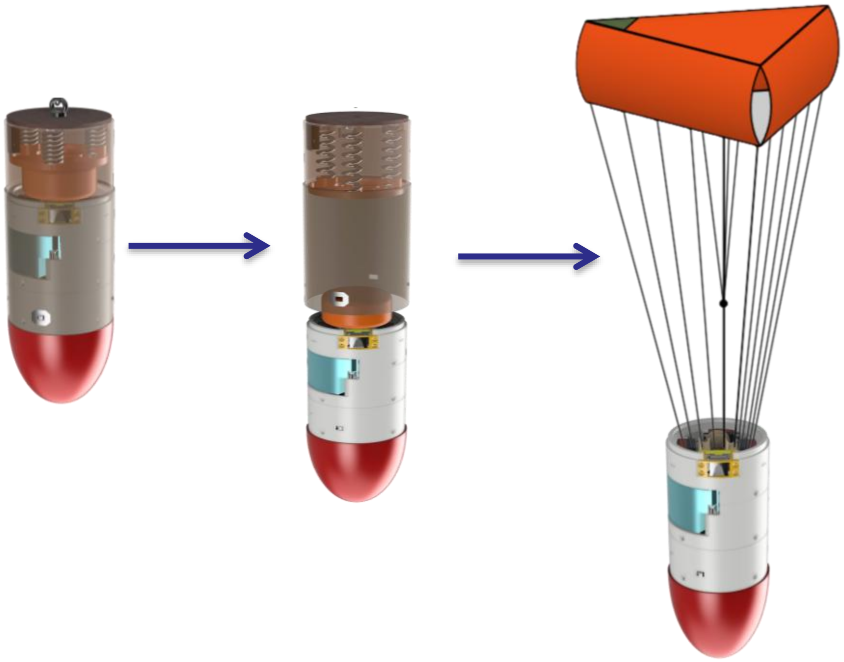


Container Descent Control system [Two-Stage]

1st Container Parachute



2nd Paraglider parachute



Detailed view on parachute deploy system

Descent Control Changes Since PDR (1/4)

Components	PDR	CDR	Rationales
Ripstop Nylon	Ripstop nylon 70d	Ripstop nylon 15d	Reduced weight and improved canopy deployment while maintaining sufficient strength.
Parachute Rope Color	Use the same color for the parachute.	The colors are different in each corner.	Easy to steer and observe.

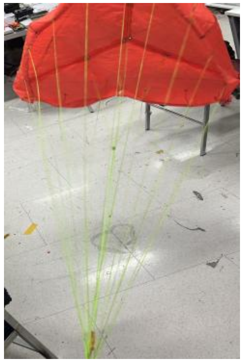
Ripstop Nylon

PDR

CDR

Parachute Rope Color

PDR

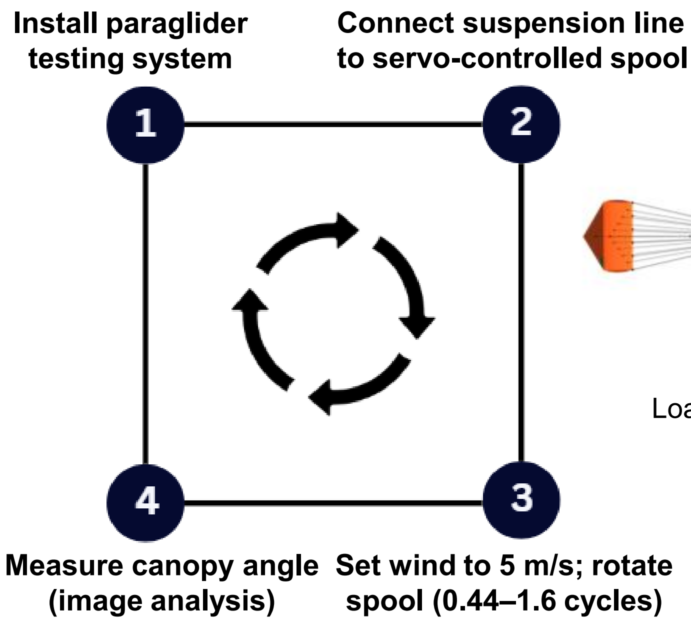


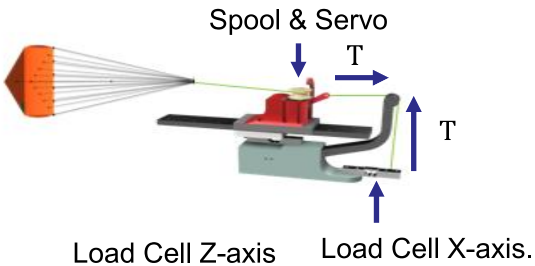
CDR

Prototype Testing : Paraglider Stability Test

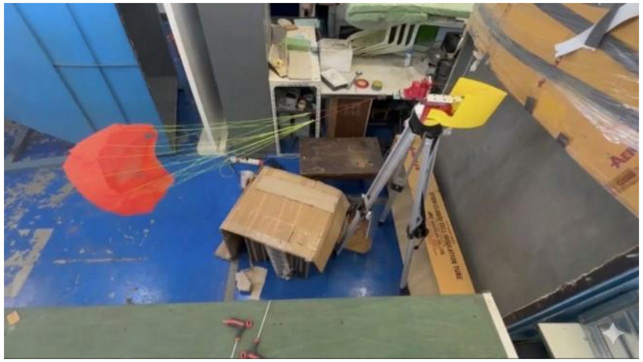
Objective: To analyze the relationship between spool rotation and payload movement angle along the X-axis.

Test Procedures

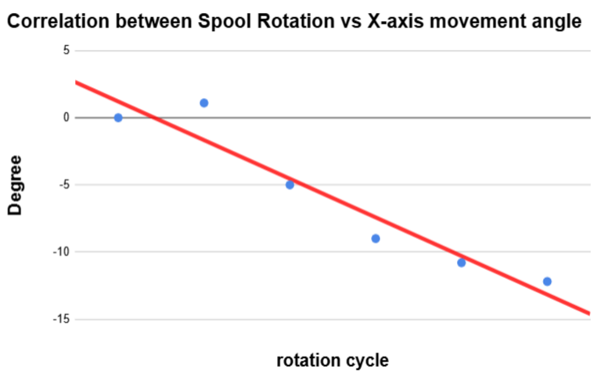




Experiment Setup



Testing in Wind Tunnel

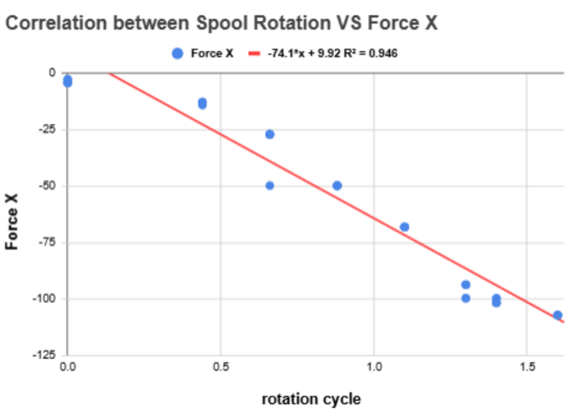


Linear Regression of Spool Rotation vs. X-axis Movement Graph

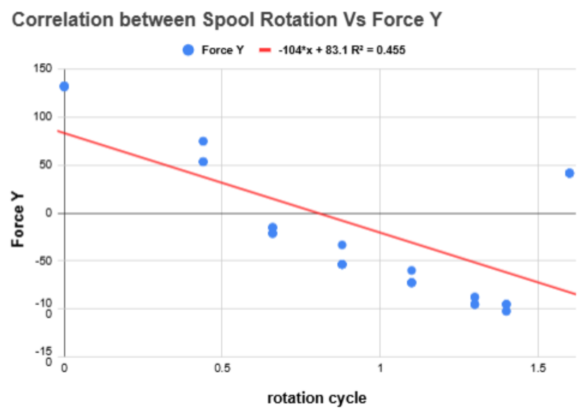
Results: Spool rotation correlates with parachute angle and motion, while variations may arise from aerodynamic and environmental factors.

Prototype Testing : Paraglider Rotation Effects on Aerodynamic Forces

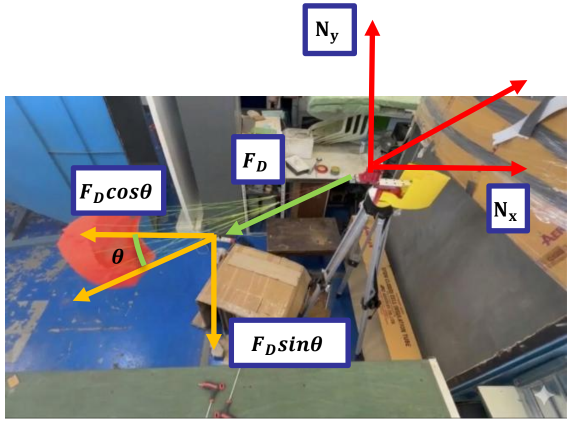
Objective: To evaluate descent stability and spool–aerodynamic force relationship



Linear Regression of Spool Rotation vs. Force in X-axis



Linear Regression of Spool Rotation vs. Force in Y-axis



Free Body Diagram

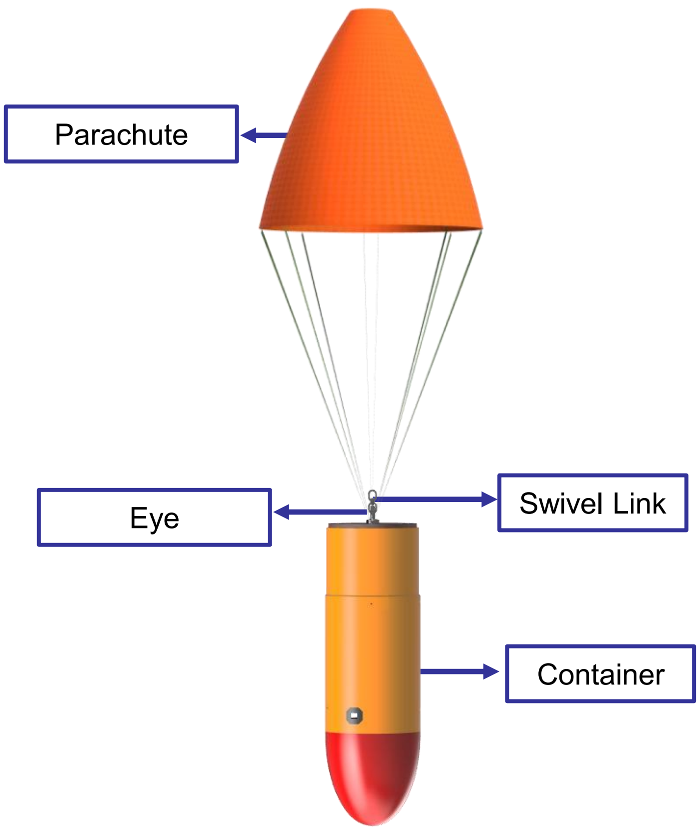
Results: The results show spool rotation correlates with X and Y forces, indicating effective control of parachute motion.

Note: This experiment follows the same procedures as the Paraglider Stability Test.

Wind Tunnel Test

Video: Wind Tunnel Test

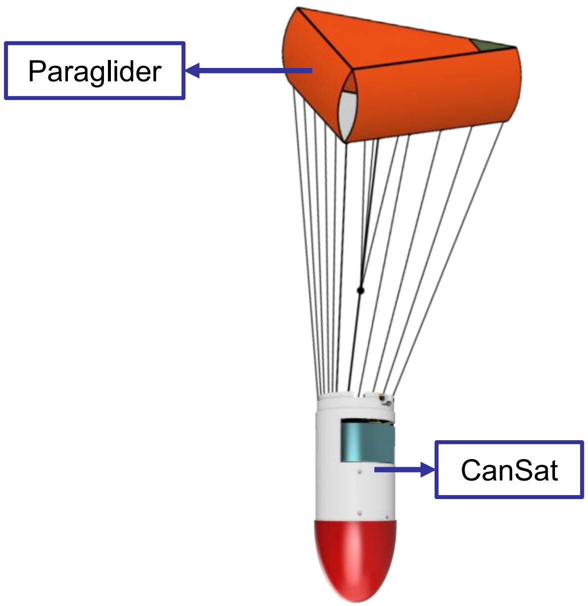
Parachute Container Design Characteristics



Container Parachute : Conical Parachute

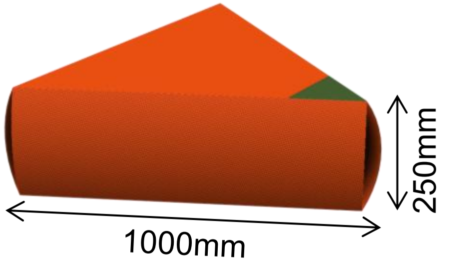
- The conical parachute is chosen as our first parachute because of its stability. It is incredibly stable compared with other types of parachutes.
- We used it in most of our past projects.
- The material is **Ripstop nylon 15D**, with a **Fluorescent orange color**, and it is lightweight, helping to reduce the overall system weight.
- The suspension lines are also made up of nylon and sewn to the top of the second parachute.

Paraglider Design Characteristics



Paraglider Parachute: Parachute X-Triangle

- The triangle parachute is chosen because it provides high stability, is easy to control, and can be maneuvered in three directions.
- The material is **Ripstop nylon 15D**, with a **Fluorescent Orange color**, and it is lightweight, helping to reduce the overall system weight.
- The suspension lines are also made up of nylon and sewn to the top of the second parachute.



Steerable Guide Parachute X-Triangle

Variables

$A = 0.43\ m^2 \qquad C_D = 1.25$

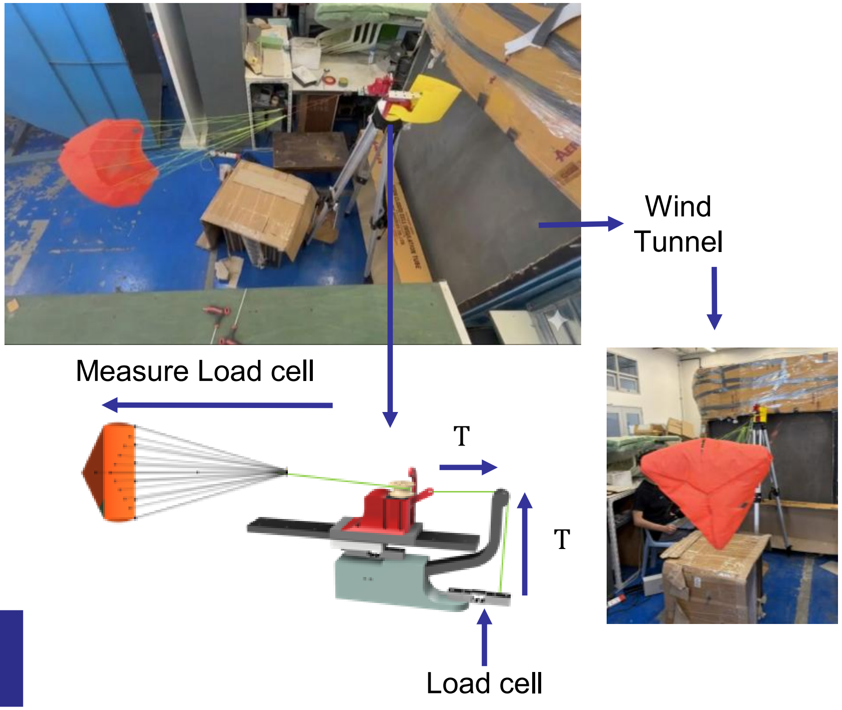
$\rho = 1.225\ kg/m^3 \qquad V = 5\ m/s$

Solution F_D(Force Drag)

$$F_D = \frac{1}{2}\rho C_D V^2 A\cos^3\theta$$

$$F_D = \frac{1}{2}(1.225)(1.25)(5)^2(0.43)\cos^3\theta$$

θ/Angle(Degree) ngle(Degree)3	F_D(N)(Calculation)	Measure load cell Wind tunnel
0	8.23	-0.0365 N
10	7.86	-0.1286 N
15	7.41	-0.3028 N
20	6.83	-0.4881 N
25	6.12	-0.6677 N
30	5.35	-0.9329 N
35	4.52	-0.9880 N

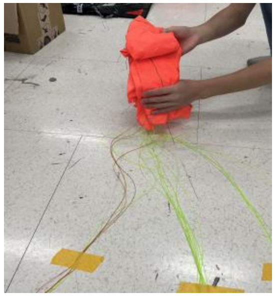
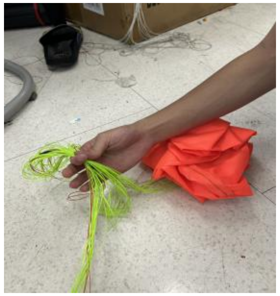


This analysis shows the correlation between X-Triangle parachute angle and drag force by comparing theoretical calculations with wind tunnel data, confirming consistency with aerodynamic principles and system design.

Para-Glider Descent Control Summary (3/4)

How to Fold Paraglider




Stage : 1

Spread the parachute flat and secure the suspension lines with tape to prevent tangling.

Stage : 2

Fold the fabric from both sides toward the center until the wide parachute becomes a long rectangular strip.

Stage : 3

Fold the opposite end of the fabric (away from the suspension lines) upward in a zigzag pattern.

Stage : 4

Gather all the suspension lines arranged earlier and fold them together in a zigzag pattern.

Stage : 5

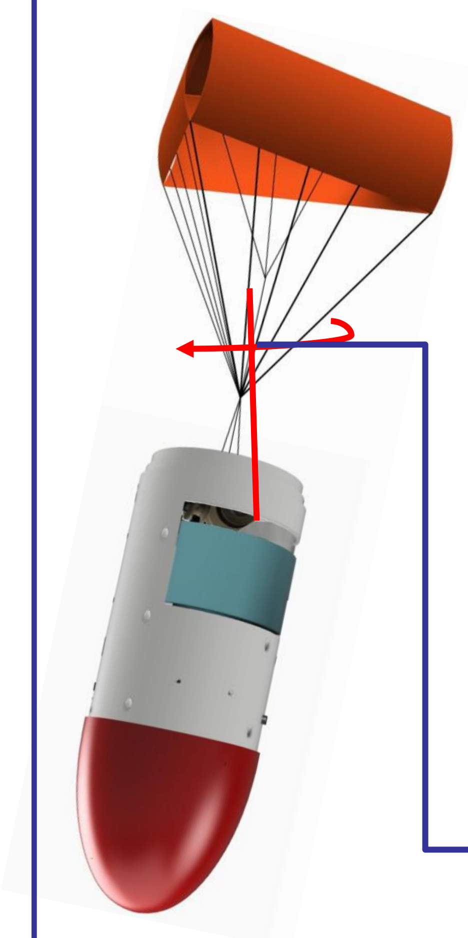
Keep the lines neatly contained inside the parachute, ready for integration into the para-glider system.

Release Folding Paraglider

Video : Release Paraglider Folding

Para-Glider Descent Speed Control Design (1/2)

Active stability control system



L = Maximum Retraction Length
R = radius of spool (cm)

- One full spool revolution corresponds to 10° of servo rotation, as determined from wind tunnel testing.

L = $2\pi R$
L = 2(3.14)(1.09)
L = 6.8 cm

- Maximum deflection angle: 30°
- Maximum spool rotation: 3 revolutions

L = 20.4 cm

30 degrees

Used Mechanism

- Spool mechanism connected to servo motors is implemented.
- The mechanism adjusts the length and tension of the suspension lines.
- Pulling both lines equally increases aerodynamic drag.
- Increased drag reduces forward speed.
- This results in a slower and more controlled descent.
- Releasing the lines decreases drag.
- Reduced drag allows the para-glider to glide more efficiently.
- This leads to a slightly higher descent rate.

Conical Parachute

$$Mg = \frac{1}{2}\rho\, C_D V^2 A$$

$$A_p = \frac{2Mg}{\rho \cdot C_D \cdot V_T^2}$$

$$A_p = \frac{2(1)(9.81)}{1.225 \cdot 0.6 \cdot 15^2}$$

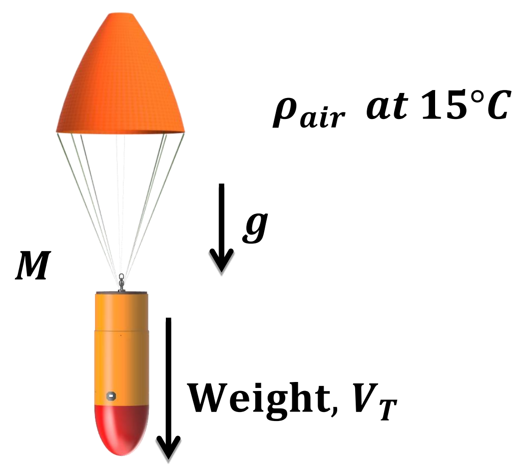
$$\Rightarrow A_p = 0.144\, m^2$$

$$\Rightarrow D_p = 0.288\, m\ (Container\ Parachute\ Diameter)$$

Variables

- A_p : Area of Parachute (m^2)
- C_D : Drag Coefficient (Assumed $C_{D,cone} = 0.6$)
- ρ : Air Density at 15 °C ($1.225\ kg/m^3$)
- V_T : Terminal Velocity ($15\ m/s$ by Requirements)
- D_p : Diameter of Parachute (m)
- M : Mass of Payload (kg)
- g : Acceleration due to gravity ($9.81\ m/s^2$)

Drag Force



Descent Rate Estimates (2/4)

Steerable Guide Parachute X-Triangle

Assumption

The following assumptions are made in the experimental determination of the drag coefficient (C_D), using 25 parachute drop tests conducted in four sets from a building.

Variables

$$A = 0.126\ m^2 \qquad h = 30\ m$$
$$\rho = 1.225\ kg/m^3 \qquad g = 9.81\ m/s^2$$

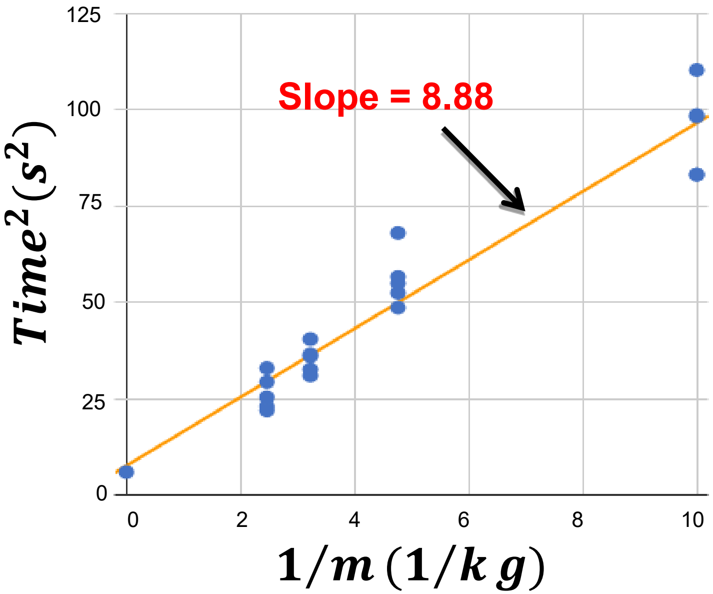
$$slope = \frac{1}{2g}\rho A h^2 C_D$$

$$C_D = \frac{2g(slope)}{\rho A h^2}$$

$$C_D = \frac{2(9.81)(8.88)}{1.225 \times 0.126 \times 30^2}$$

$$C_D \approx 1.25$$

Experimental Time² vs Inverse Mass Graph of the X-Triangle Steerable Guide Parachute



Descent Rate Estimates (3/4)

Steerable Guide Parachute X-Triangle

$$Mg = \frac{1}{2}\rho\, C_D V^2 A$$

$$(0.8)(9.8) = \frac{1}{2}(1.225)(1.25)(5^2)(\frac{\sqrt{3}}{4}\mathrm{L}^2)$$

$$\Rightarrow L \;= 1\; m\; (Side\; Length)$$

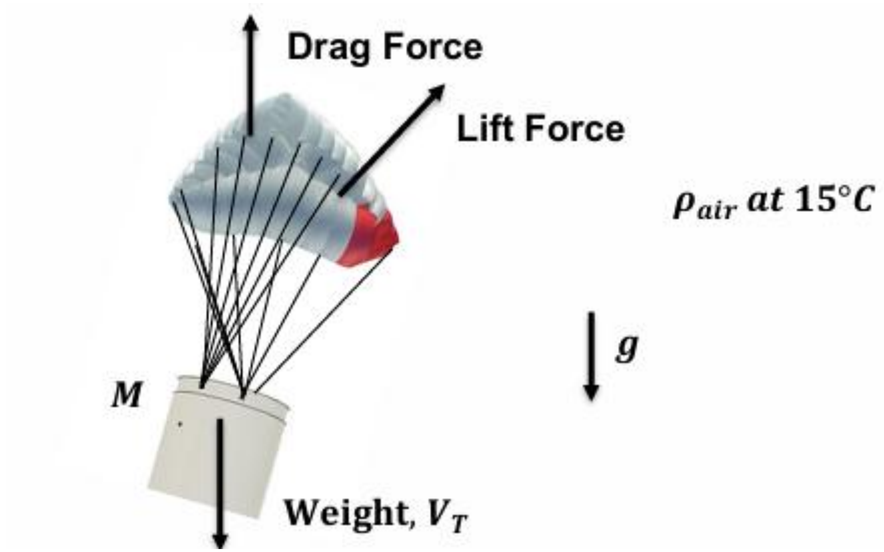
$$A_p = \frac{\sqrt{3}}{4}\mathrm{L}^2$$

$$A_p = \frac{\sqrt{3}}{4}1^2$$

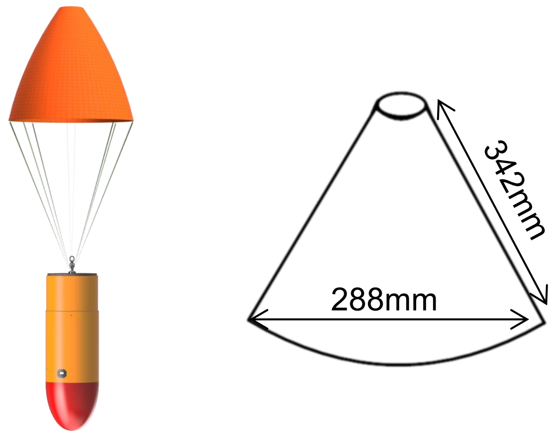
$$\Rightarrow A_p = 0.43\; m^2$$

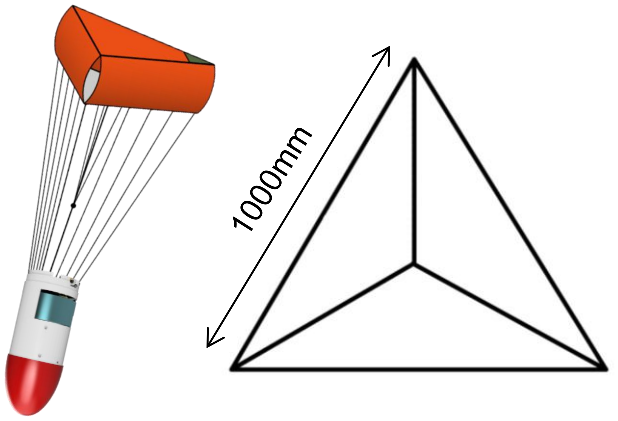
Variables

A_p	:	Area of Equilateral Triangle Parachute $(\frac{\sqrt{3}}{4}L^2)$
C_D	:	Drag Coefficient (Assumed $C_D = 1.25$)
ρ	:	Air Density at 15°C $(1.225\; kg/m^3)$
V_T	:	Terminal Velocity ($5\; m/s$ by requirements)
M	:	Payload Mass (kg)
g	:	Acceleration due to gravity $(9.81\; m/s^2)$
L	:	Side Length of the Parachute (m)



Descent Rate Estimates (4/4)



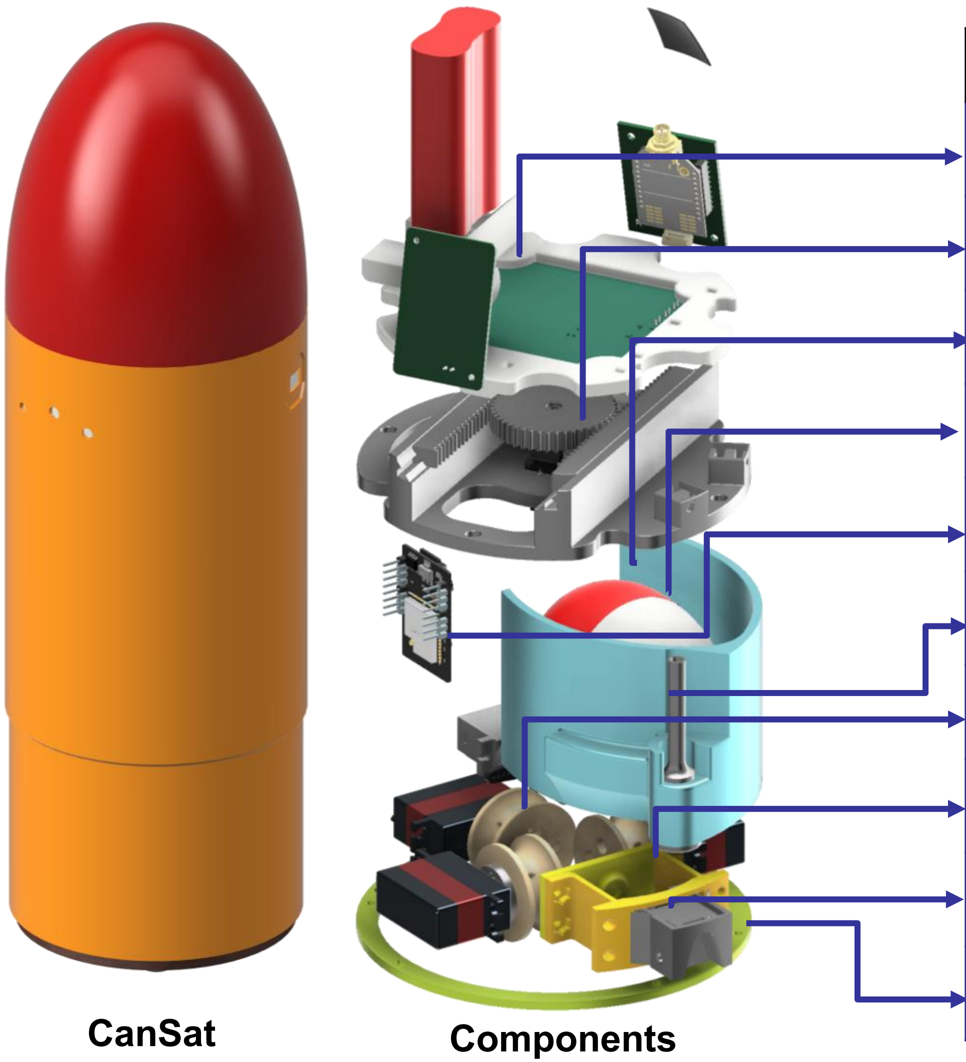


Parts	CanSat Container Parachute	Steerable Guide Parachute X-Triangle
Parachute Area	0.11 m²	0.43 m²
Payload Mass	1 kg	0.8 kg
Drag Coefficient	0.6	1.25
Parachute Diameter	0.288 m	N/A
Side Length	N/A	1 m
Descent Rate	≈ 14 m/s	≈ 5 m/s

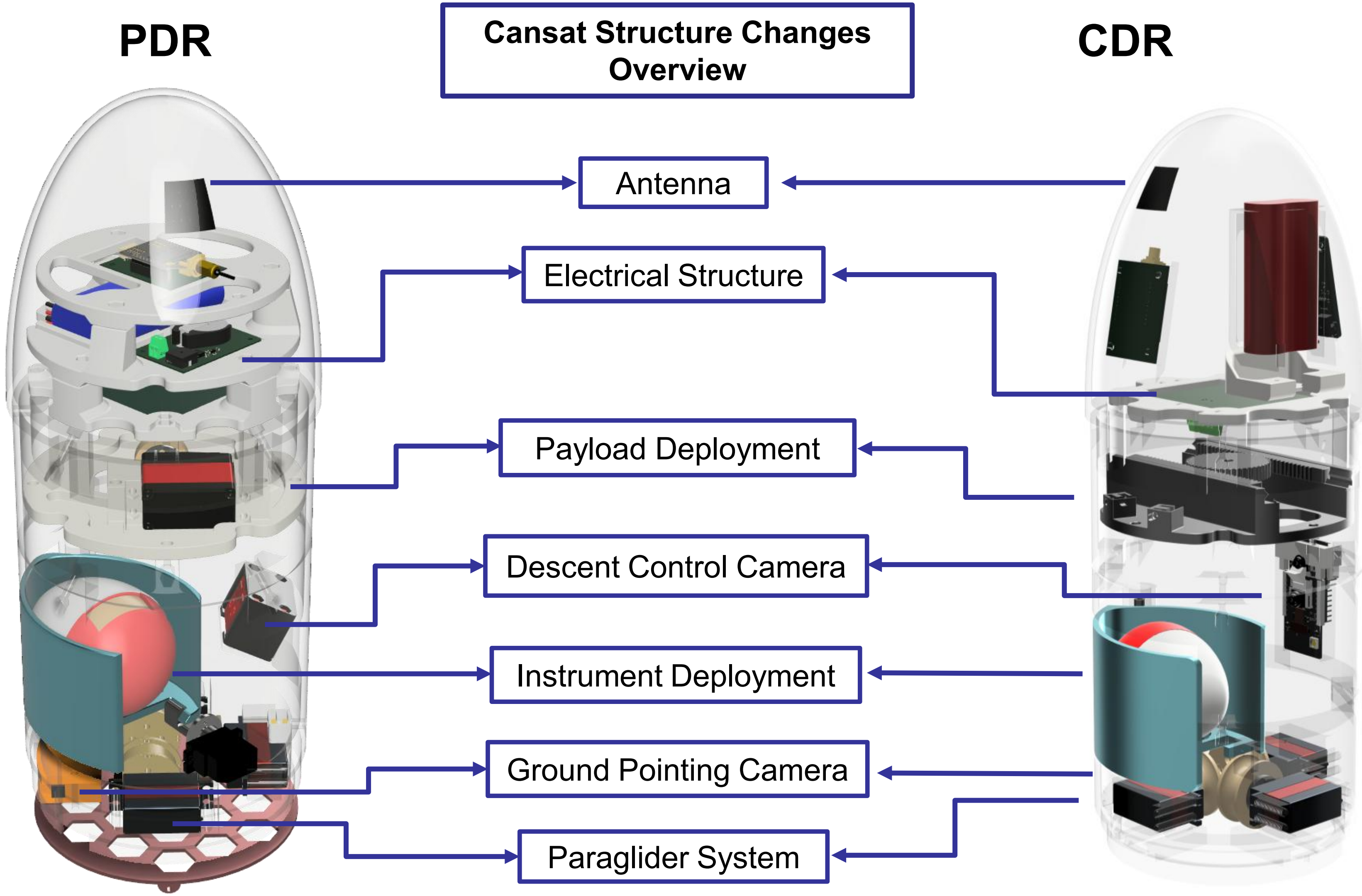
Mechanical Subsystem Design

Rapassakorn Leelarujawanich
Warithnun Kliesuwan
Pasin Thawornwiriyakul

Mechanical Subsystem Overview



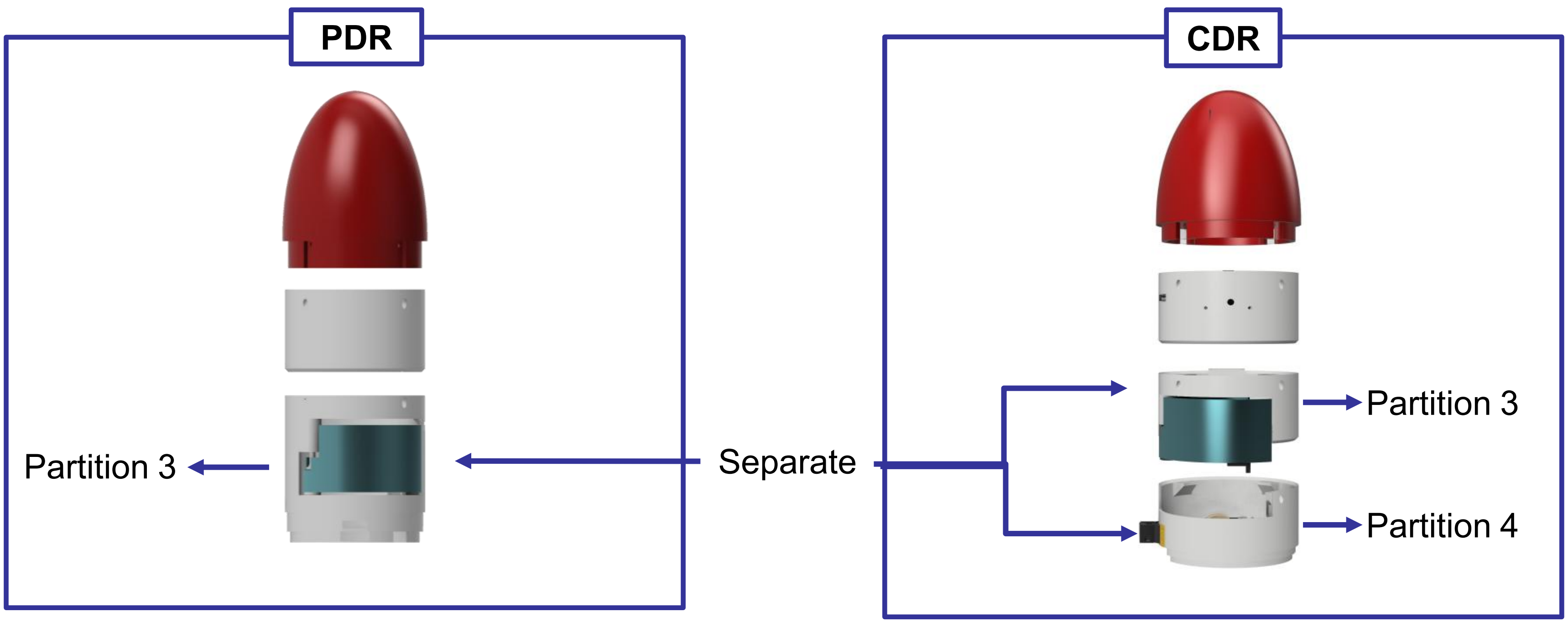
Parts	Materials
Electrical Structure	ASA-LW
Payload Deployment	ASA-LW
Instrument Deployment	ASA-LW
Egg Container	ABS
Ground Pointing Camera	ASA-LW
Spacer	ASA-LW
Paraglider Spools	ASA-LW
Descent Control Camera	ASA-LW
Camera Deployment	TPU-95A
Grid Plate	ASA-LW


PDR
Cansat Structure Changes Overview
CDR
Antenna
Electrical Structure
Payload Deployment
Descent Control Camera
Instrument Deployment
Ground Pointing Camera
Paraglider System

Mechanical Subsystem Changes Since PDR (2/6)

CanSat Structure

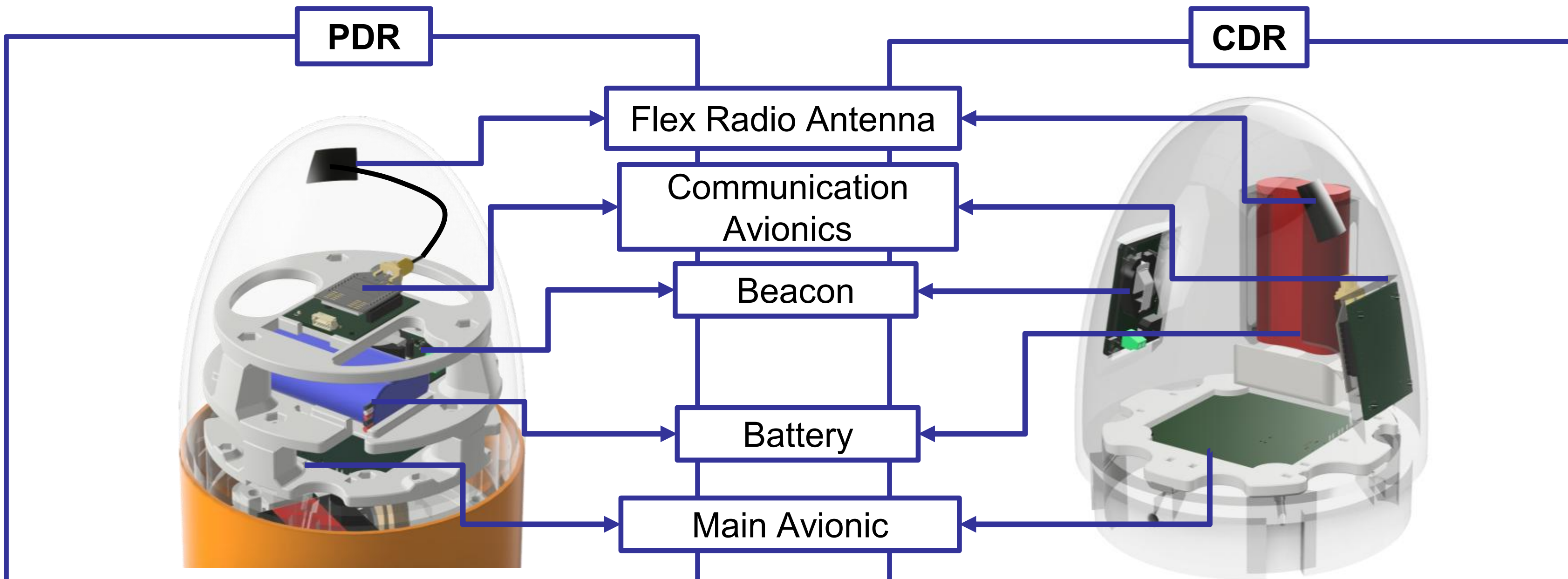
PDR	CDR	Rationales
• Three-Partition Layout	• Four-Partition Layout	• Ease of Assembly • Ease of Maintenance



Mechanical Subsystem Changes Since PDR (3/6)

Nosecone

PDR	CDR	Rationales
• Electrical Structure Stack Layout	• Nosecone Side Electrical Mounting Layout	• Less complex • Reduced mass



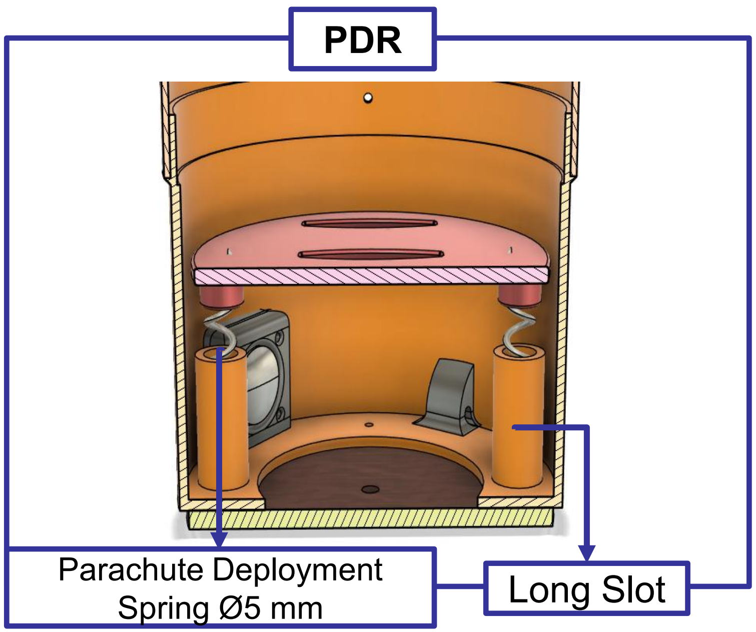
Stacked Electrical Structures

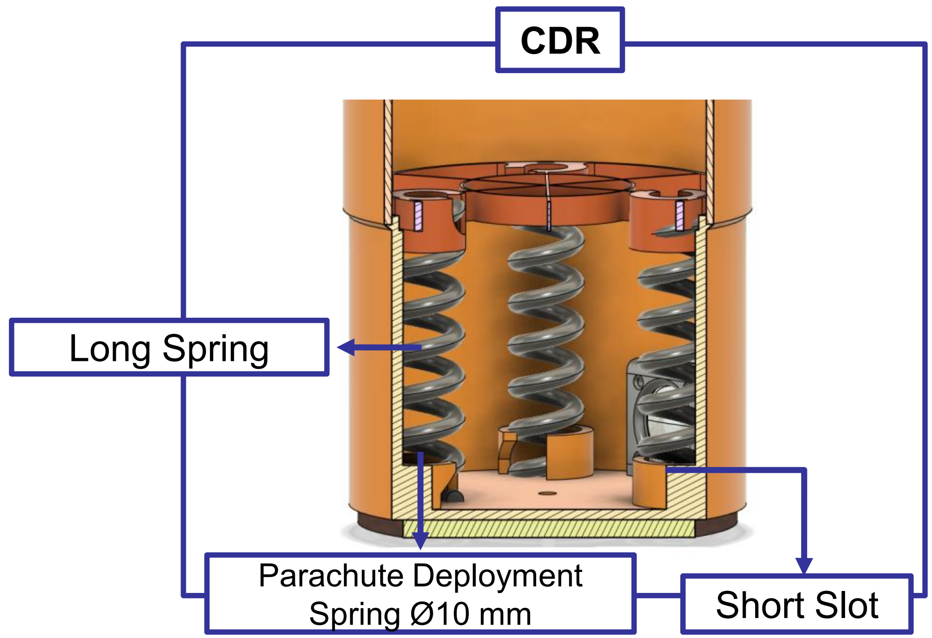
Nosecone Side Electrical Mount

Mechanical Subsystem Changes Since PDR (4/6)

Container

PDR	CDR	Rationales
• Spring Ø5 mm • Long-slot mount • 2 Spring	• Spring Ø10 mm • Short-slot mount • 3 Spring	• More stable • Better load distribution • Spring anti-blocking mechanism

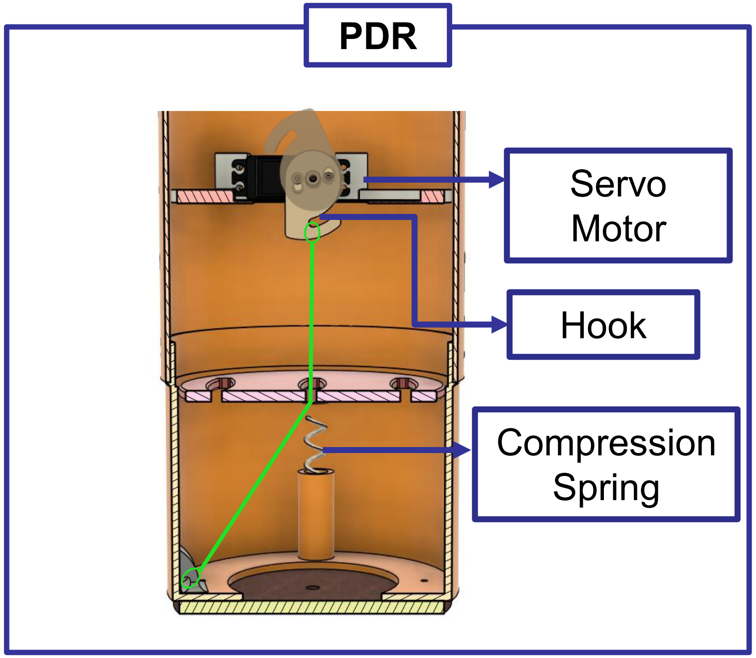


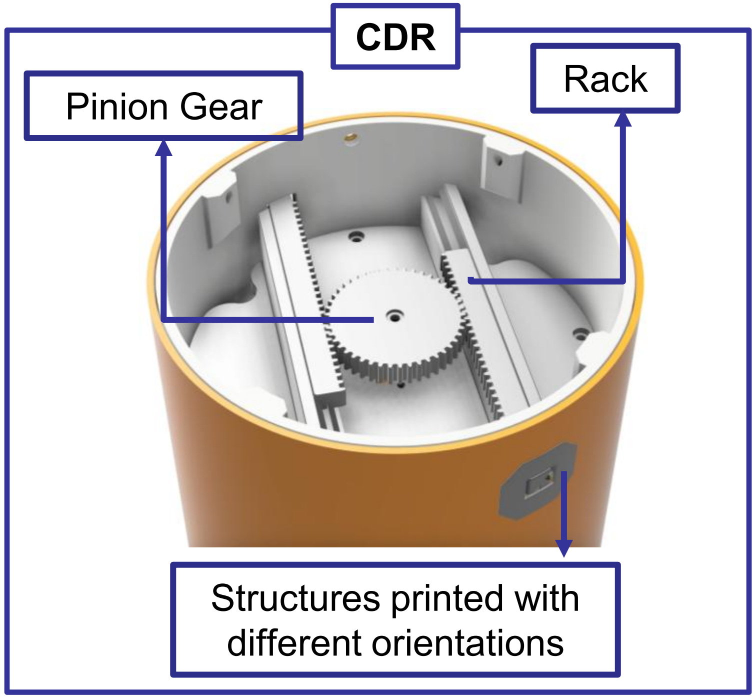


Mechanical Subsystem Changes Since PDR (5/6)

Payload Release

PDR	CDR	Rationales
• Restrain hook	• Rack and Pinion gear	• Lower Mass • Less Complex

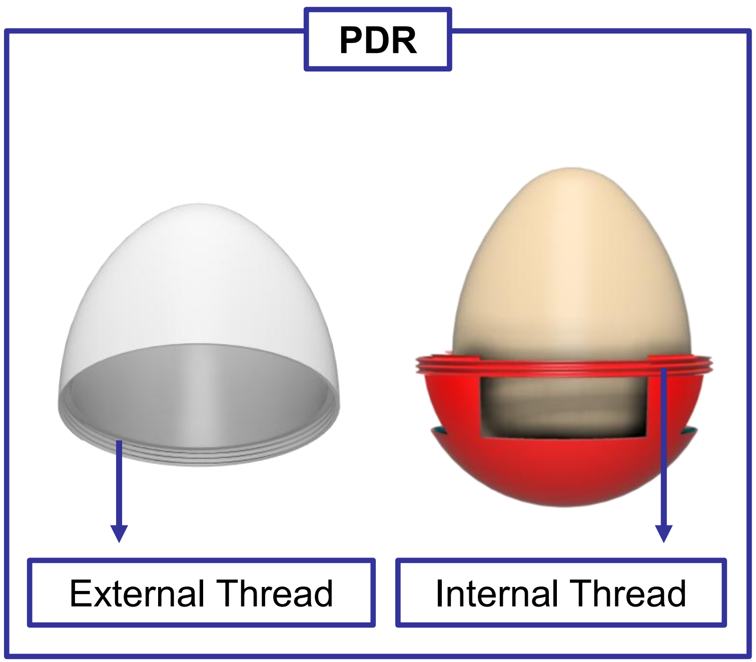


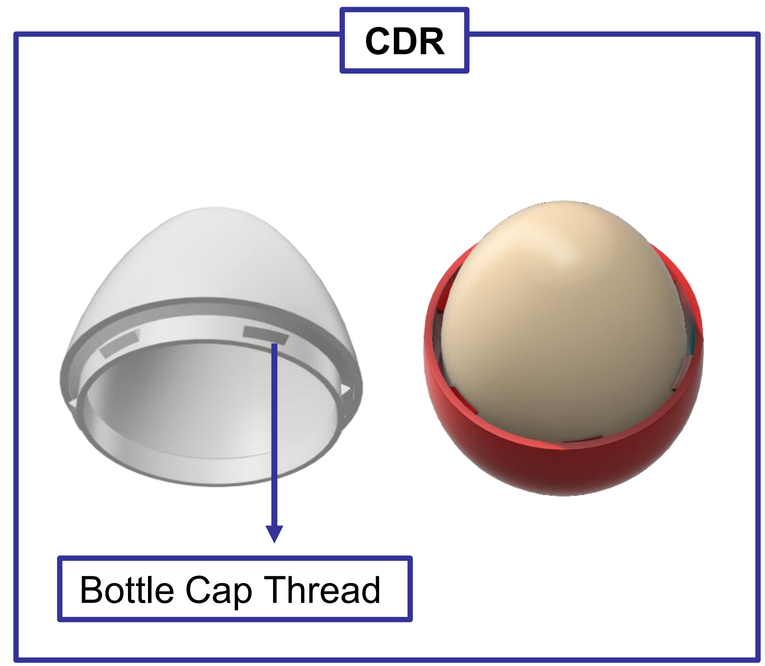


Mechanical Subsystem Changes Since PDR (6/6)

Egg Container

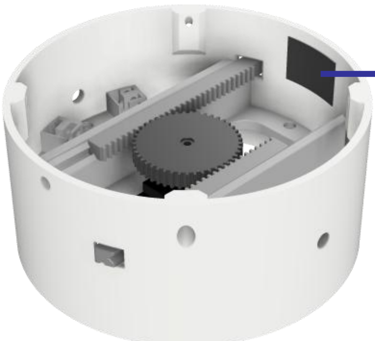
PDR	CDR	Rationales
• Internal–external threaded connection	• Bottle Cap Thread	• Manufacturing Efficiency • Tighter Sealing



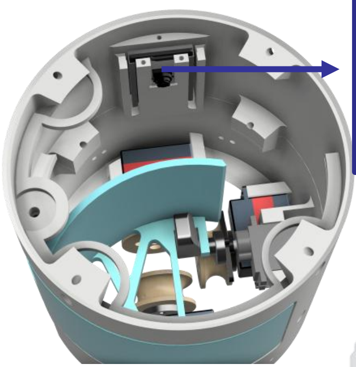


CanSat Mechanical Layout of Components (1/6)

Electrical Components



The flex GNSS Antenna is attached to the side of the payload shoulder using acrylic tape.

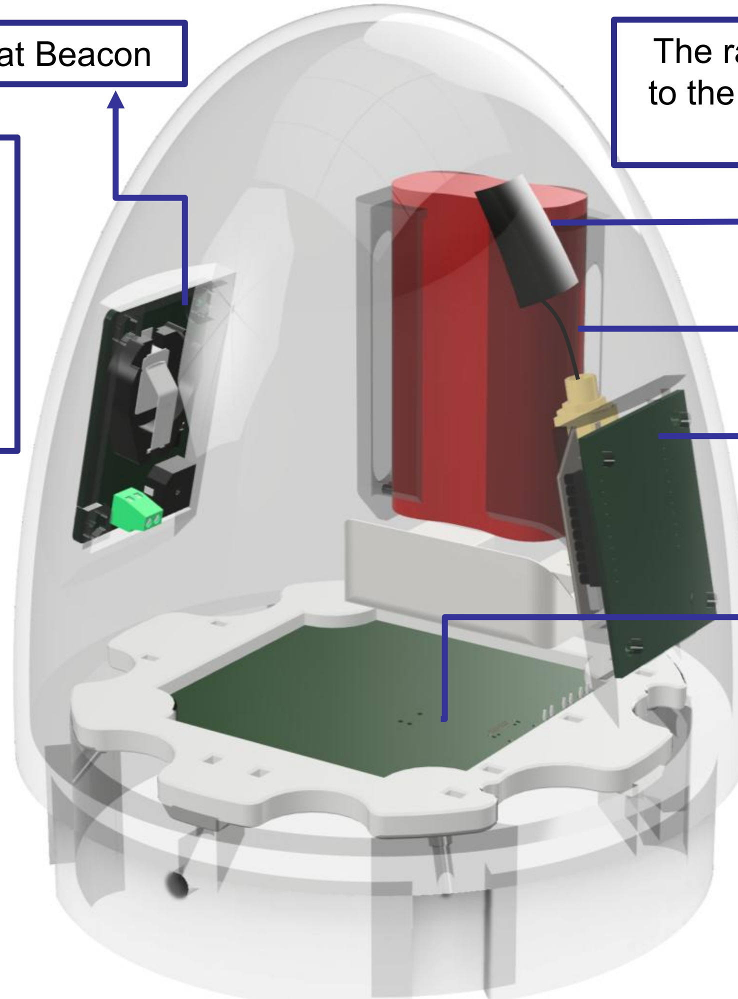


The release camera is mounted on partition 3 of the payload structure.

The ground camera is mounted and deployed in partition 4.

CanSat Beacon

The radio antenna is attached to the tip of the nose cone wall using acrylic tape.



Radio Antenna

2S1P 3800mAh Battery

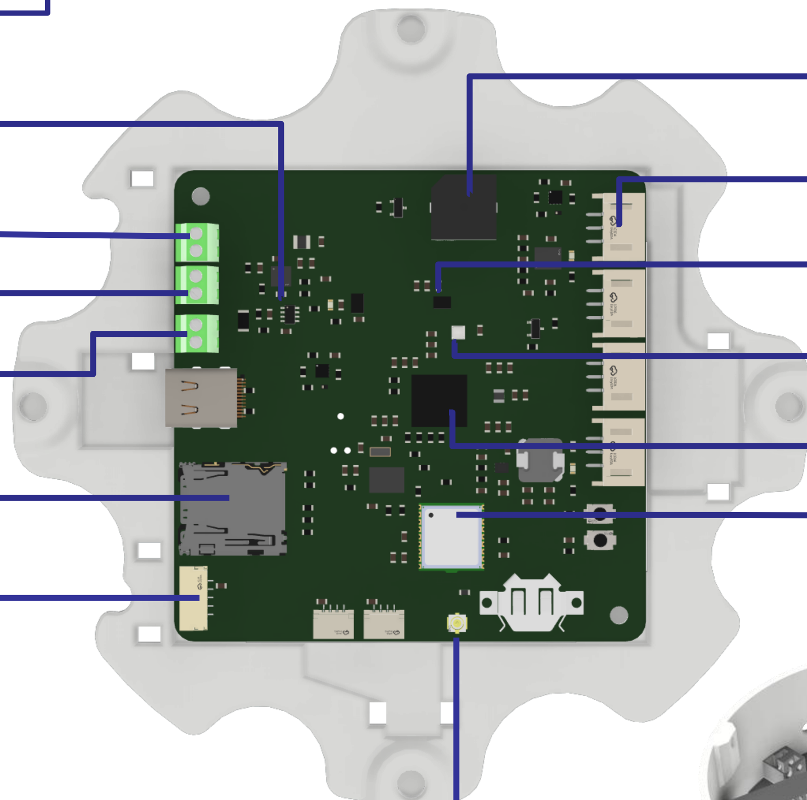
XBee Radio

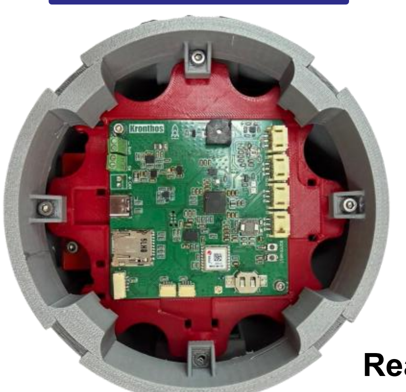
Main Avionic

Real Prototype

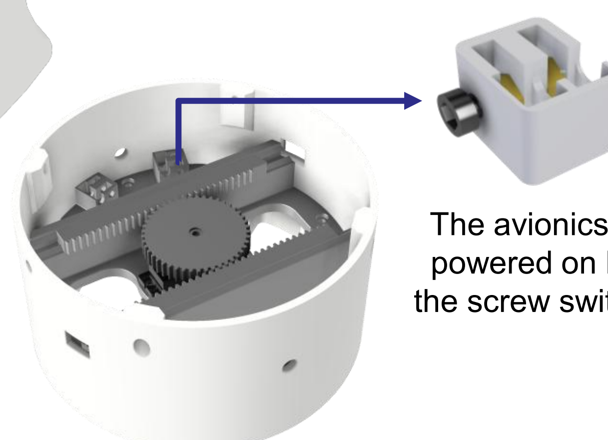
CanSat Mechanical Layout of Components (2/6)

Payload Avionic





Real Prototype



The avionics is powered on by the screw switch.

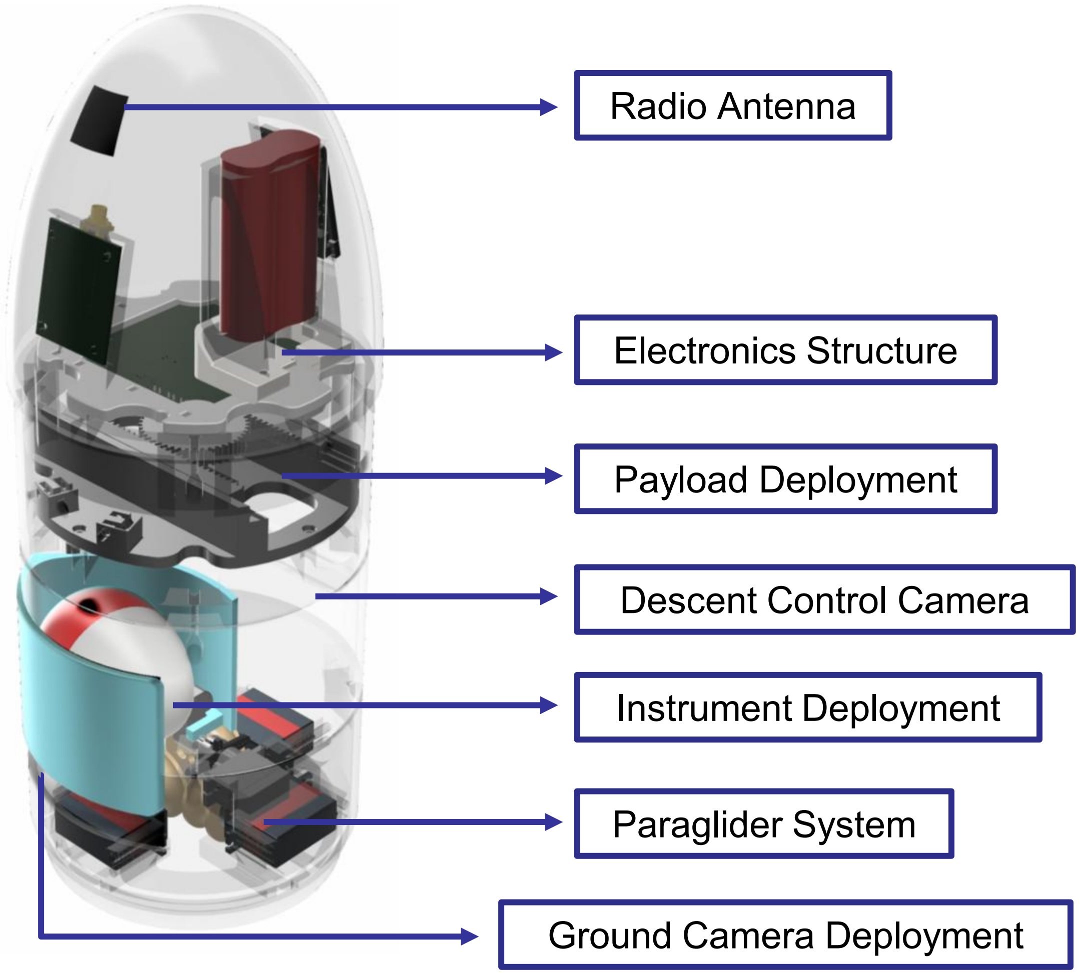
CanSat Mechanical Layout of Components (3/6)

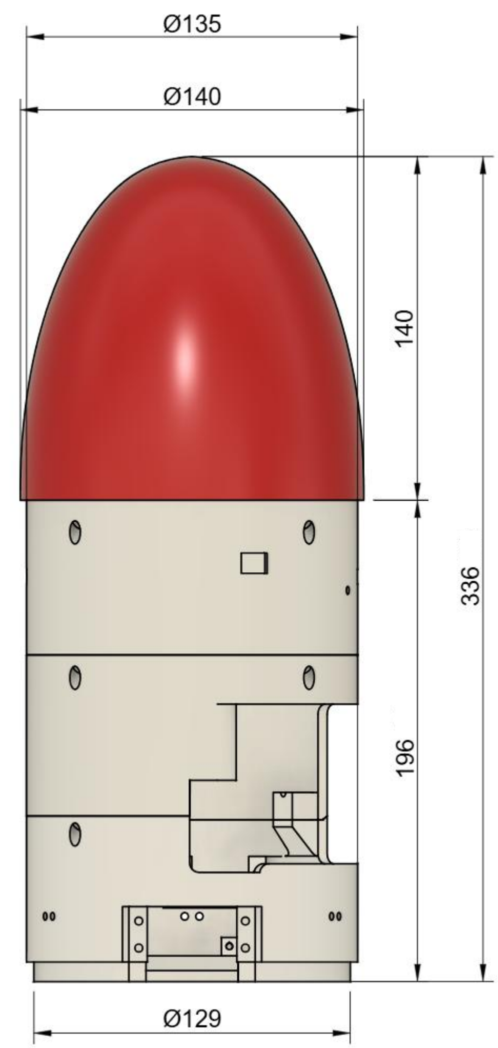
Material Trade & Selection (for 3D printing)

Materials	Advantages	Disadvantages	Density (g/cm^3)	Young's Modulus (MPa)	Ultimate Strength (MPa)
ASA-LW	• Ultra-lightweight • Excellent durability • Good impact strength	• Inconsistent printing results • More expensive than other filaments	0.6	970	9
ABS	• High strength & rigidity • Good heat resistance • Easy to post-process	• Warping during printing • Poor UV resistance	1.04	2,100	40
TPU-95A	• Highly flexible & elastic • Excellent abrasion resistance	• Lower rigidity	1.22	26	51

Part	Selected Material	Rationales
Egg Container	ABS	• High strength & rigidity • Perfect for protecting the egg
Ground Camera Deployment	TPU-95A	• Very elastic & flexible • Some parts need to be flexible in the mechanism
Other 3D-printed Parts	ASA-LW	• Perfect for reducing overall weight • Good durability and impact strength

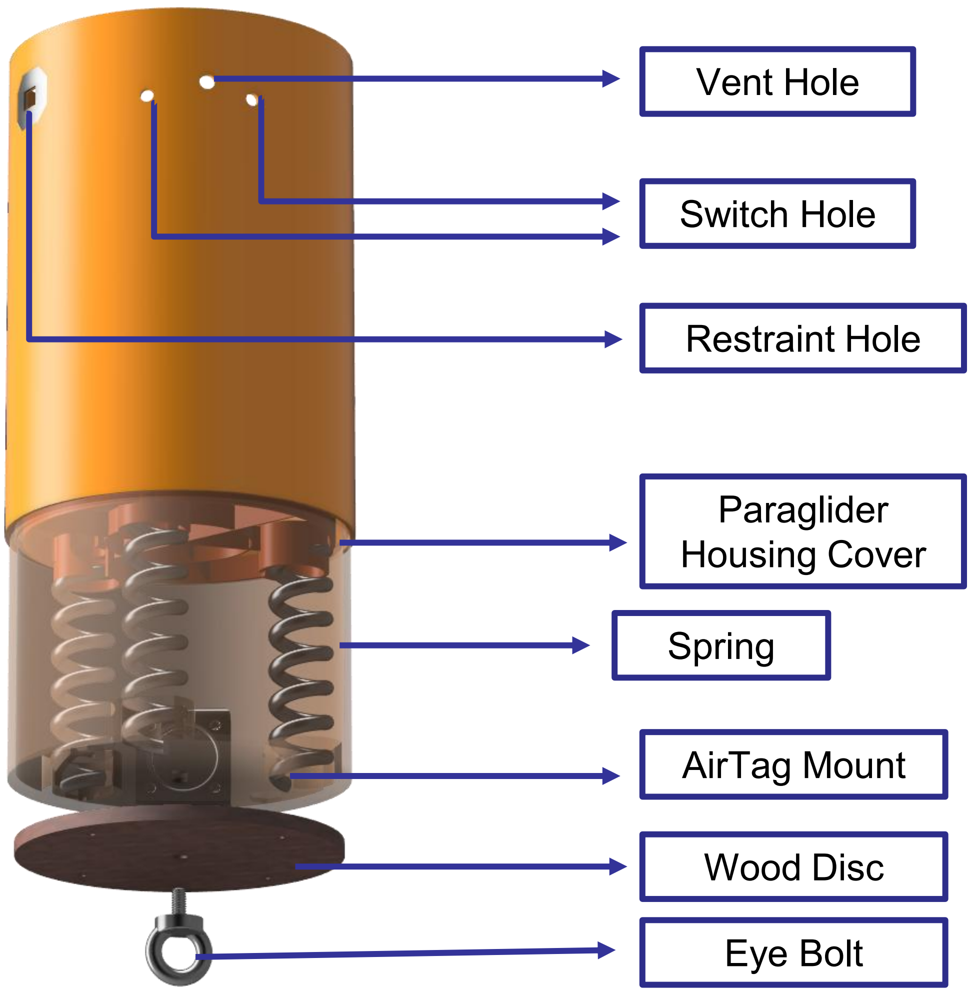
Payload

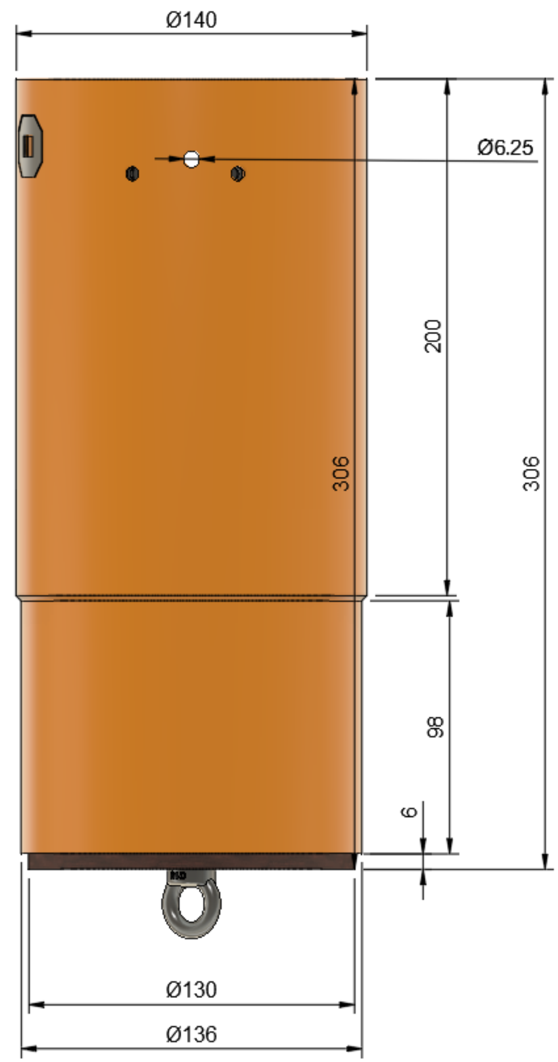

Radio Antenna
Electronics Structure
Payload Deployment
Descent Control Camera
Instrument Deployment
Paraglider System
Ground Camera Deployment


Ø135
Ø140
140
336
196
Ø129

CanSat Mechanical Layout of Components (5/6)

Container

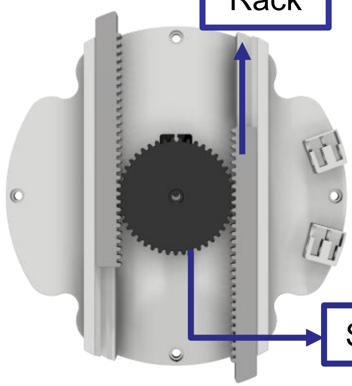




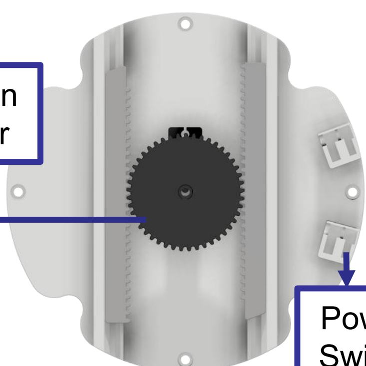
CanSat Mechanical Layout of Components (6/6)

Mechanisms

Payload Deployment

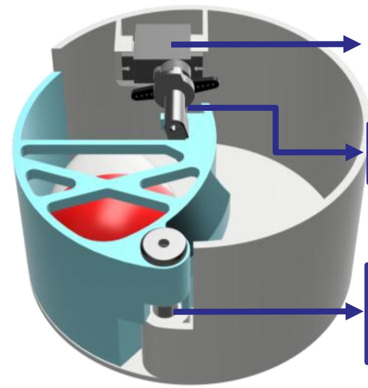


Lock Position

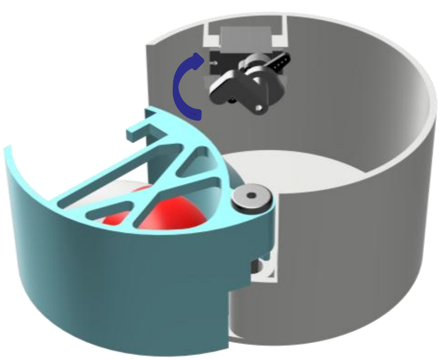


Deployed Position

Instrument Deployment

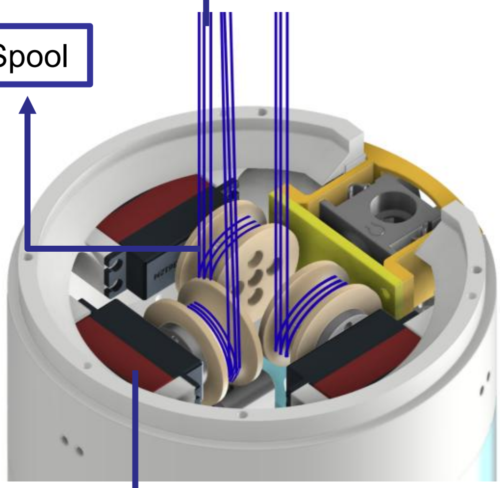


Lock Position



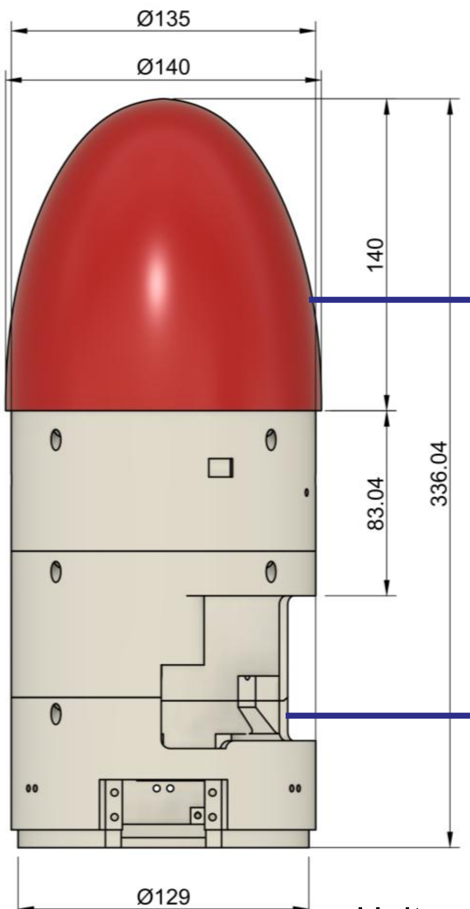
Deployed Position

Paraglider



Nose Cone Design (1/3)

Ellipsoid Design



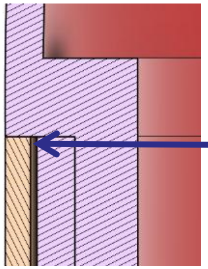
Nosecone

Both nosecone and shoulder uses ASA-LW material.

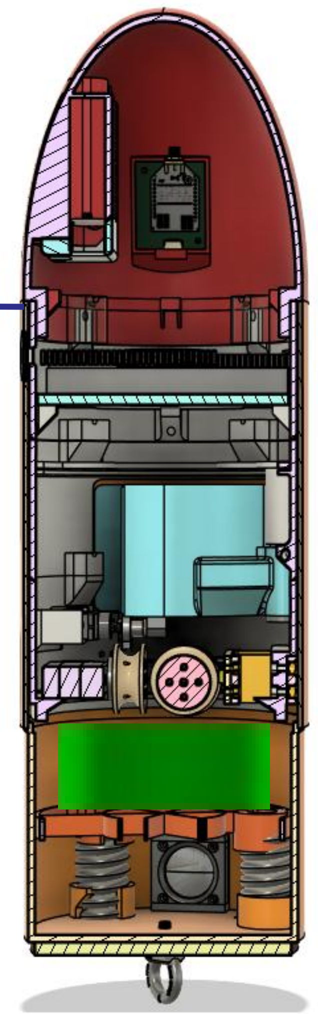
Shoulder

Unit : mm

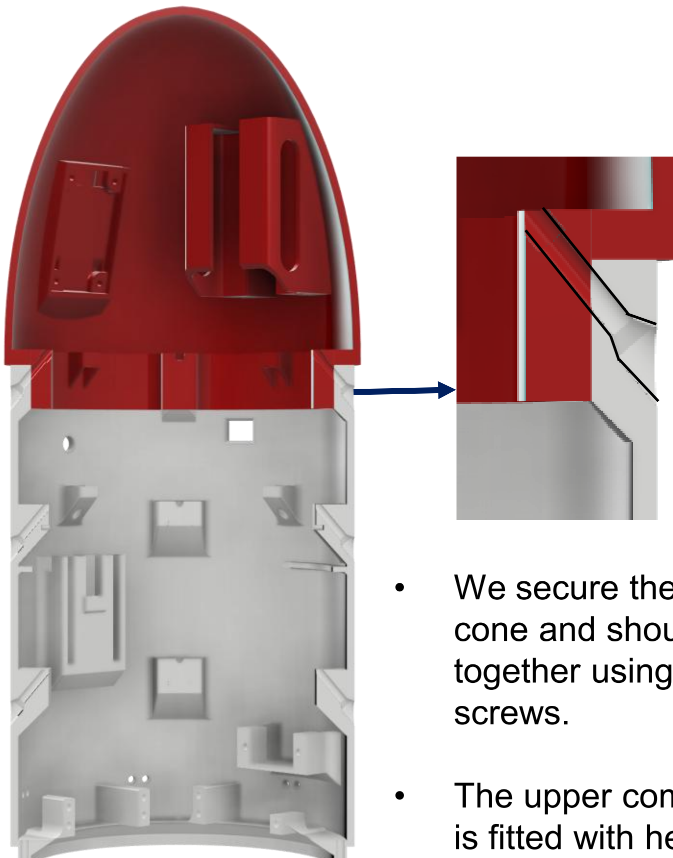
Nose Cone Dimension



- The clearance between payload and container is 0.5 mm
- The thickness of nosecone and shoulder is 3 mm



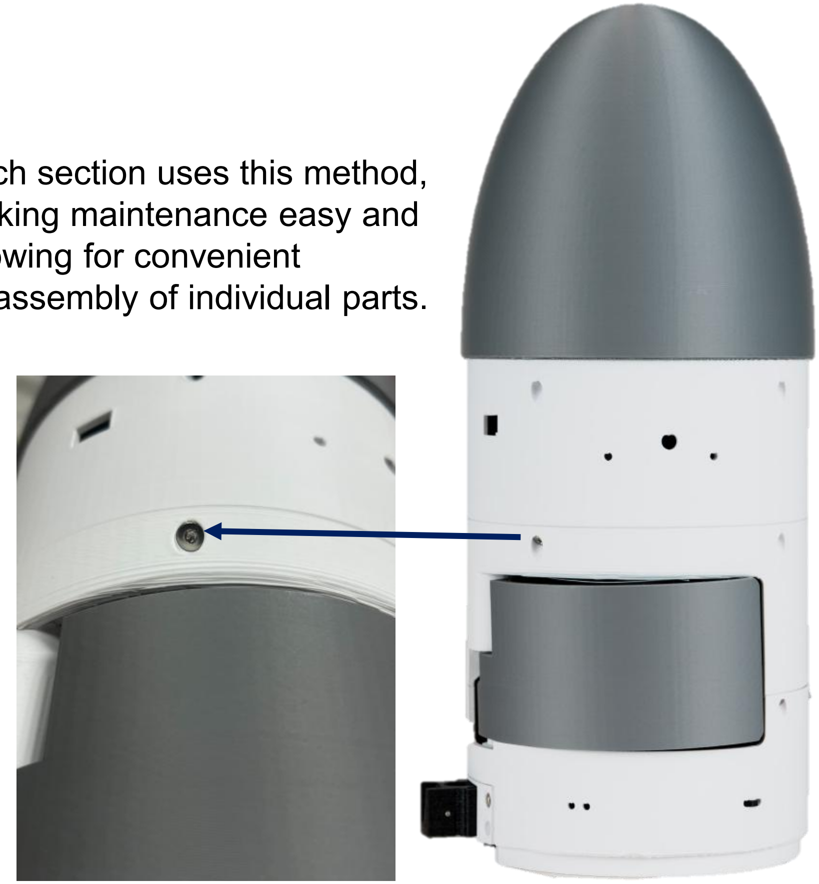
Sectional Analyzed Payload



- Each section uses this method, making maintenance easy and allowing for convenient disassembly of individual parts.

- We secure the nose cone and shoulder together using flat head screws.

- The upper component is fitted with heat-set inserts.

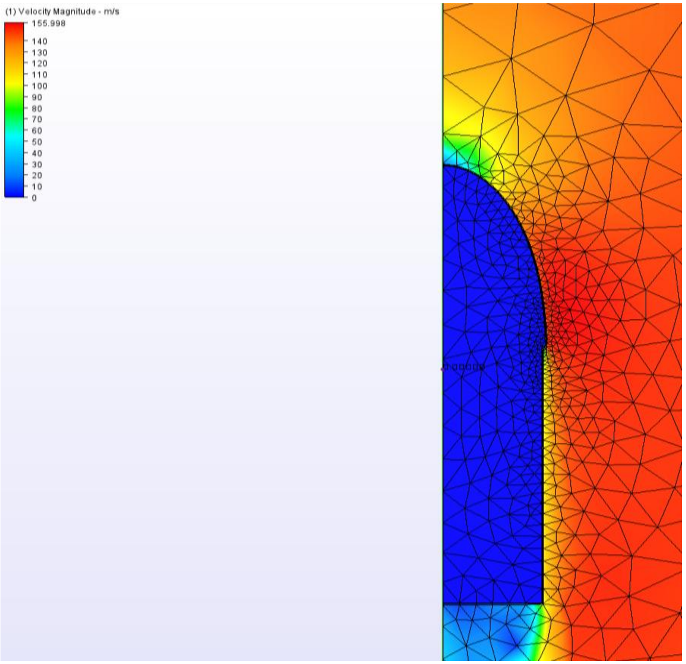


Sectional Analyzed Payload

Assembled Payload

Nose Cone Design (3/3)

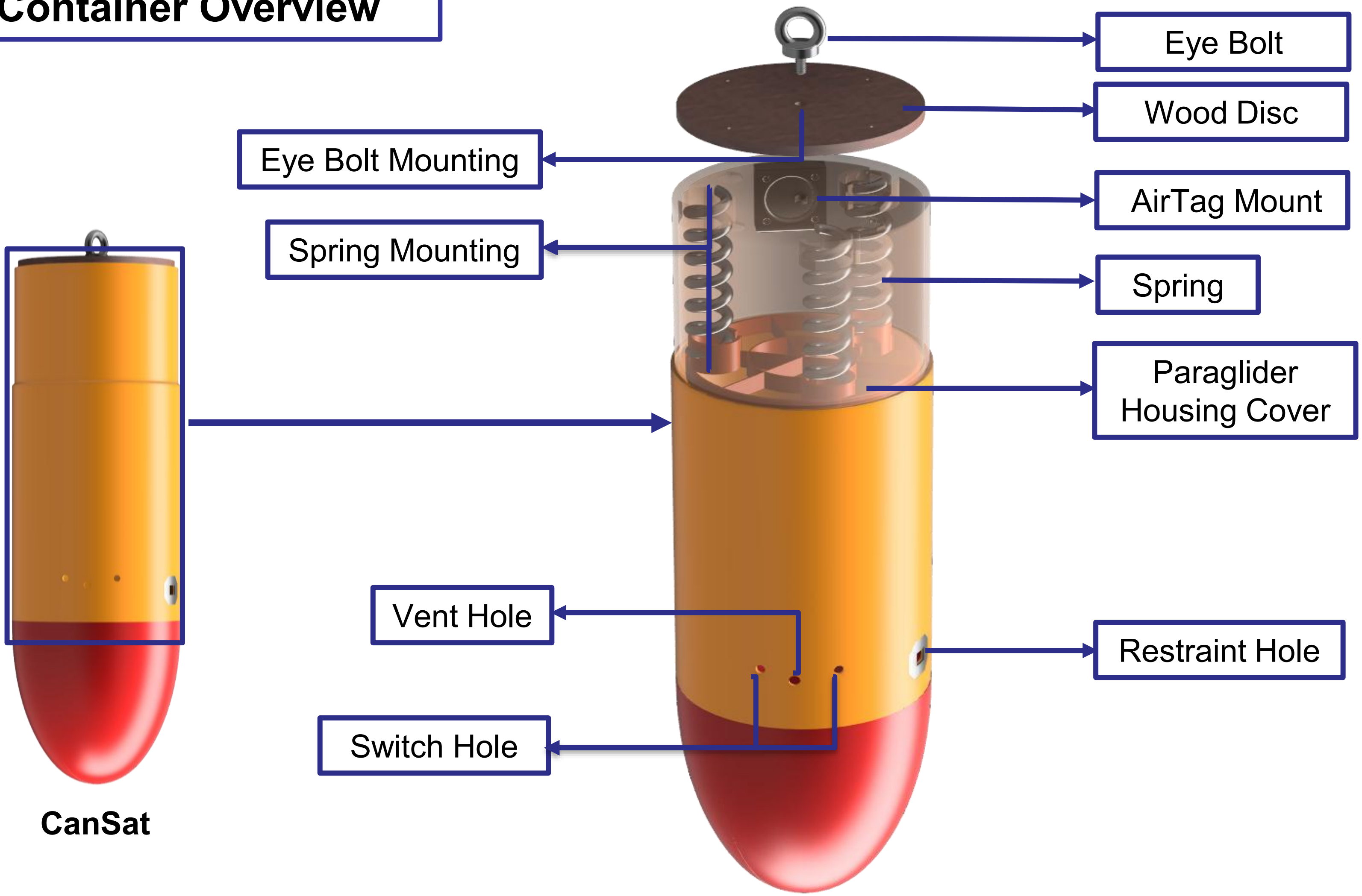
Aerodynamic Simulation in a Wind-Tunnel-Like Environment



Drag Coefficient 0.30
(Simulated by Autodesk CFD)

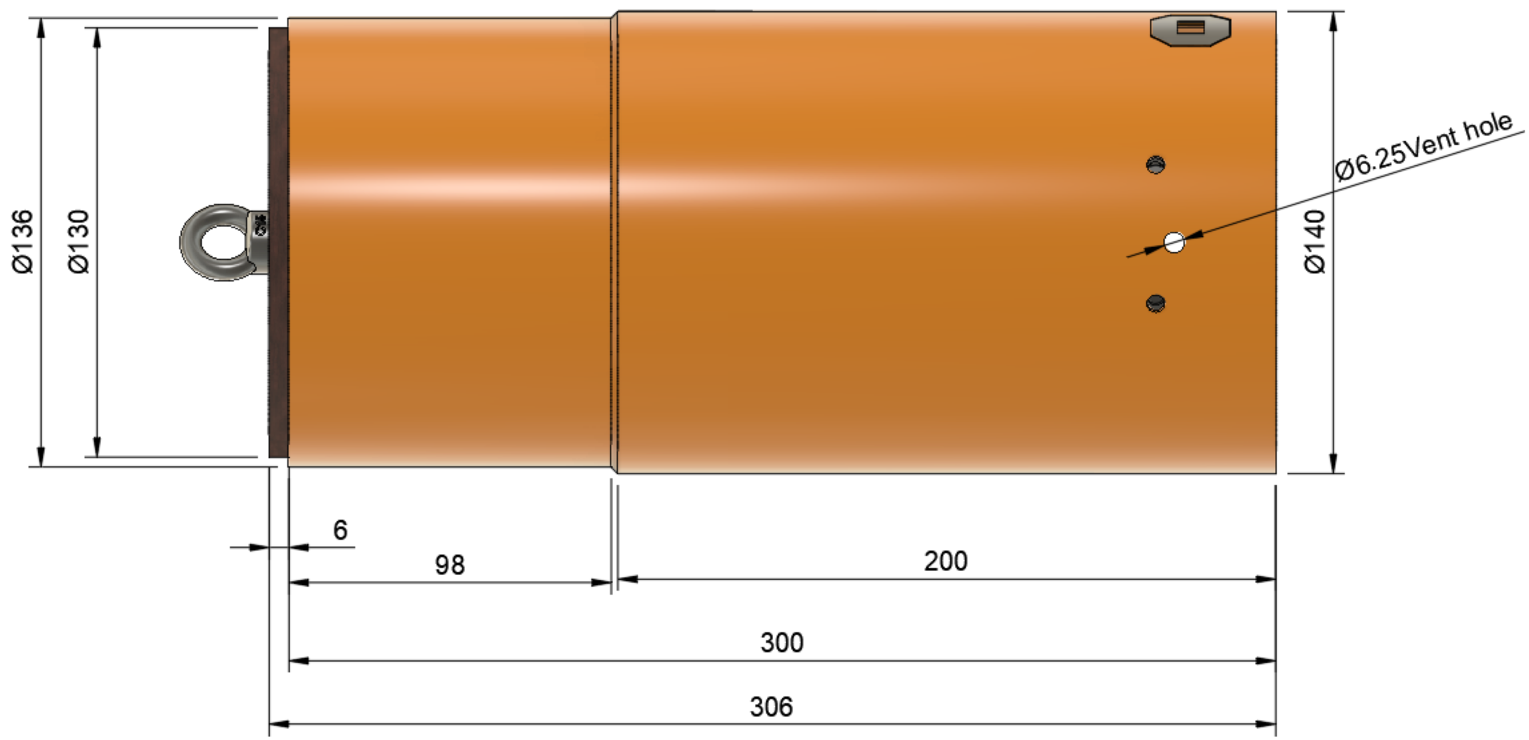
Container Design (1/2)

Container Overview



Container Design (2/2)

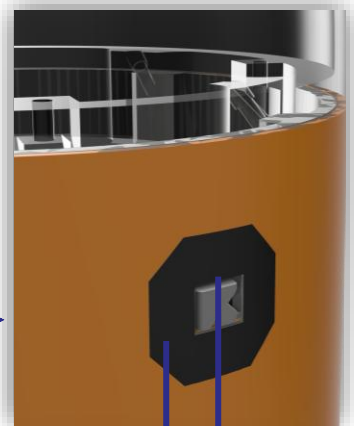
Dimensions will be carefully measured using a vernier caliper to ensure a proper fit in the launch vehicle. The container is 3D printed in a single piece without separation.



Wall thickness is 2mm throughout the whole container.

Payload Pre-Deployment Configuration (1/2)

CanSat



- The payload and container are secured by a mechanical latch to prevent separation during flight
- The container is reinforced with layered walls, with 3D print orientation perpendicular to the primary load direction for added strength
- The rack also functions as a structural component.

The actual printed sample for testing.

A rack when it locks

3D-Printed Structural Plate

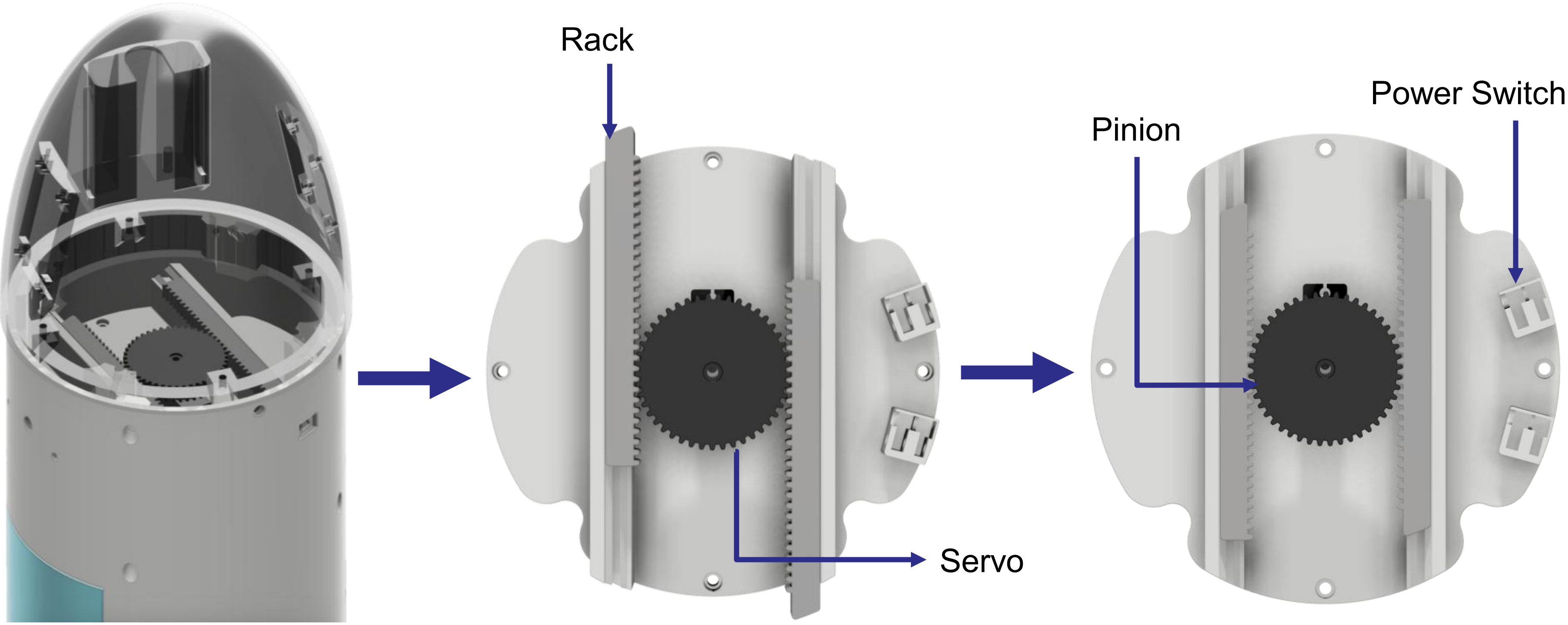
Payload Pre-Deployment

Payload Pre-Deployment Configuration (2/2)

Payload deployment

[Testing Video]

Payload Release

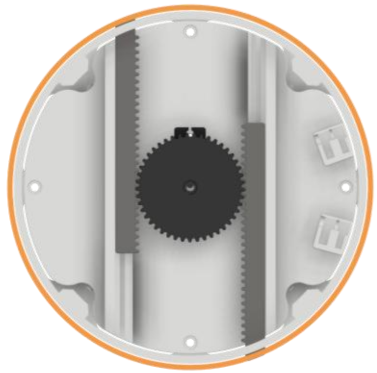


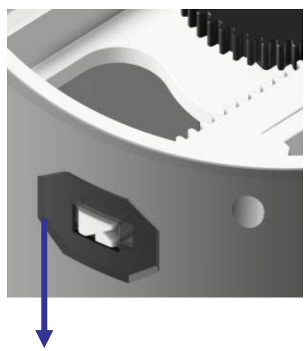
Payload Restraint Hole **Lock Position** **Deployed Position**

- The design has been revised from a Hook to a **Rack and Pinion system**
- The payload structure has been modified to include holes for restraint.
- This design ensures the payload remains mission-ready and capable of responding to mission requirements

Payload Deployment Configuration

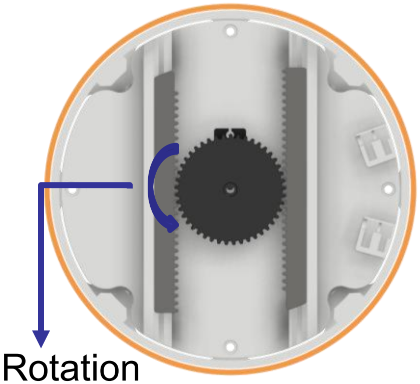
Pre-Deployment

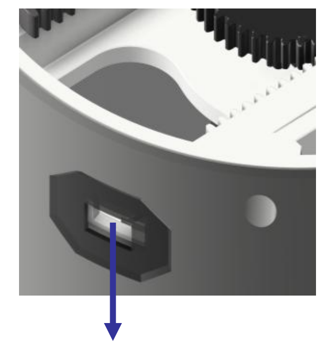




The structure is printed to withstand loads

Deployment





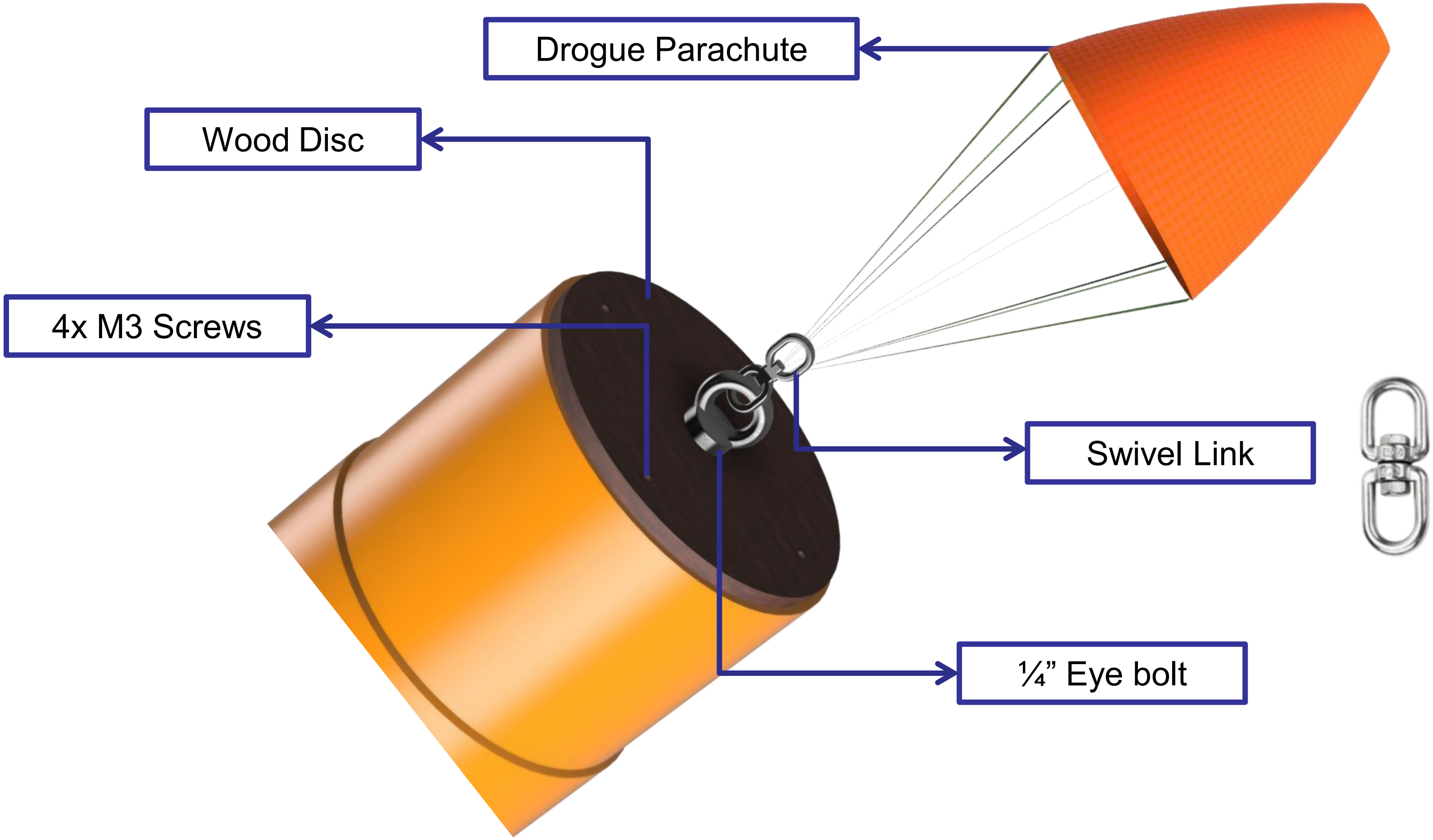
The rack rotates back into the payload to deploy

The rack mechanism prevents payload-container separation before reaching 80% altitude

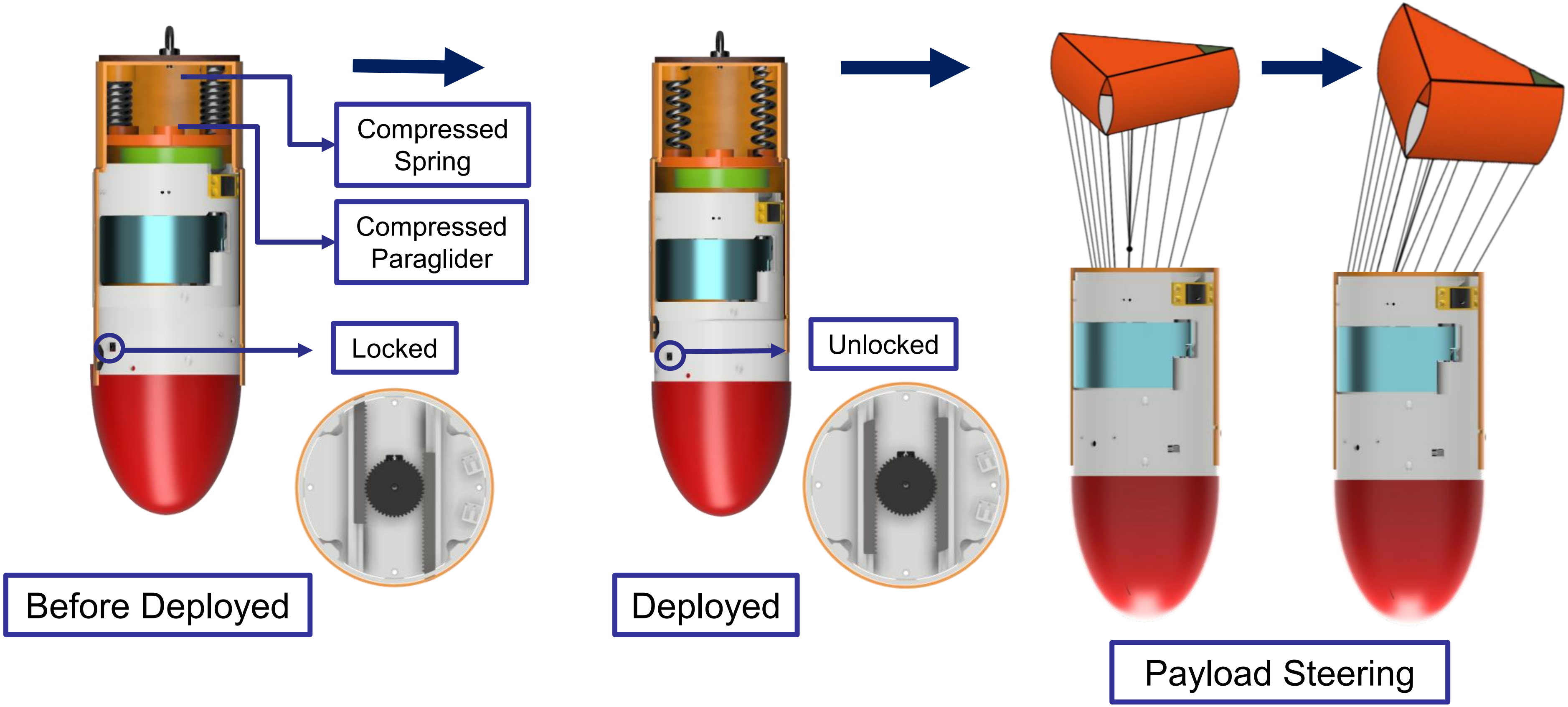
At 80% altitude, the latch rotates and disengages, enabling payload-container separation

Parachute Attachment to Container

The parachute is attached to the CanSat via an eye bolt, with a swivel link incorporated to prevent line entanglement during CanSat rotation. Four M3 screws are used to attach the wood disc to the container.



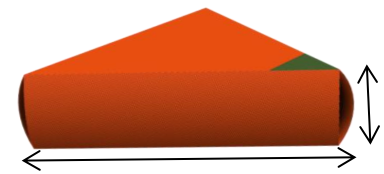
Para-Glider Deployment



- Passively deployed after the rack is unlocked and the payload is out of the container.
- The spring is compressed and held in place by the payload deployment system.
- The payload acts as the component that keeps the spring restrained.

Controlling System Overall Concept

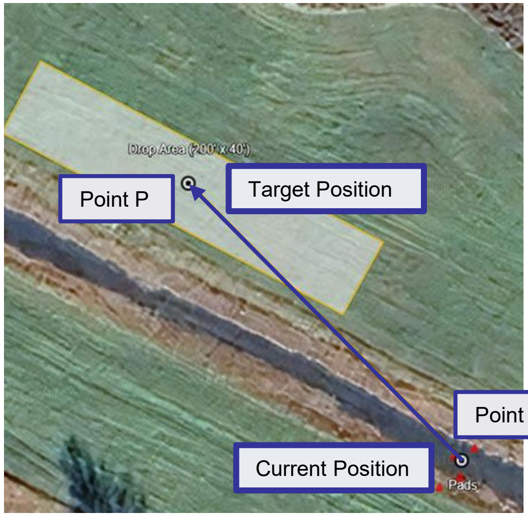
- From geometric shape, this parachute uses a delta-shaped paragliding design instead of conventional forms, enabling active directional control rather than passive stabilization.
- The problem can be formulated as a mapping from a two-dimensional Euclidean space to a three-dimensional control space, defined by a function in an **Omni Wheel Framework.**



Parachute X-Triangle

$$f : R^2 \rightarrow R^3, (x, y) \rightarrow (u_1, u_2, u_3)$$

- Where u_1, u_2 and u_3 represent the independent control inputs of the delta-shaped paragliding parachute, which are used to regulate and determine both direction and speed.
- To compute both direction and magnitude, the displacement vector $\overrightarrow{OP}$ is defined from the current position O to the landing point P. (We use latitude and longitude as coordinates on maps)



The Displacement Vector Example

Main Calculation

- From the map, point O represents the current position, and point P represents the target position.

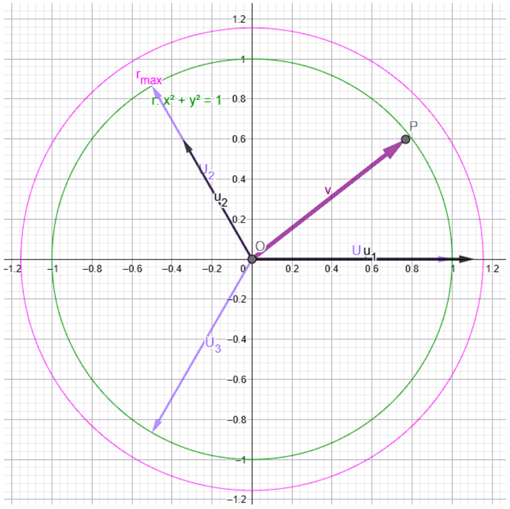
The displacement vector: $\vec{v} = \begin{bmatrix} x \\ y \end{bmatrix}$ defines the required motion from O to P.

- The parachute has three control lines, each with a fixed direction. By activating two lines at a time
- This allows us to model the system as a linear transformation:

$$\mathbf{v} = A\mathbf{u}$$

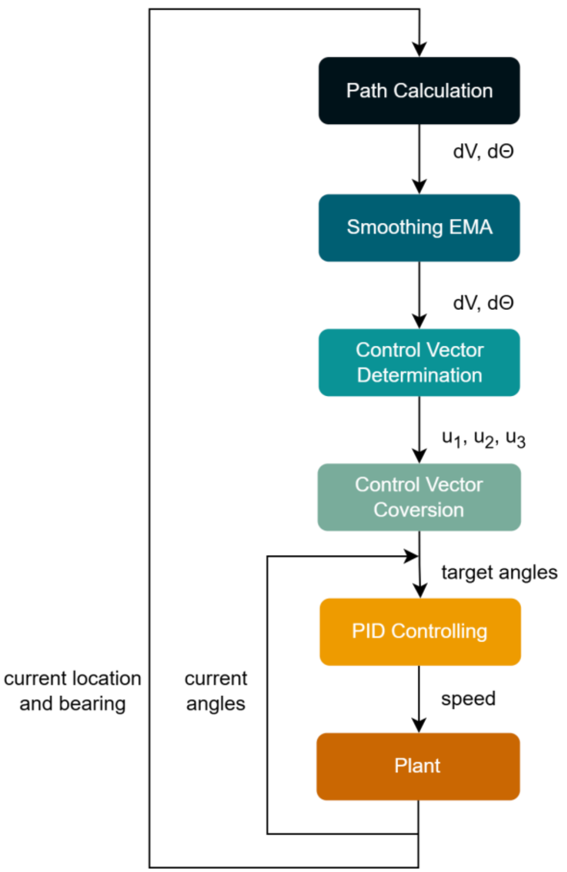
Where:

$$A^{-1} = \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}$$

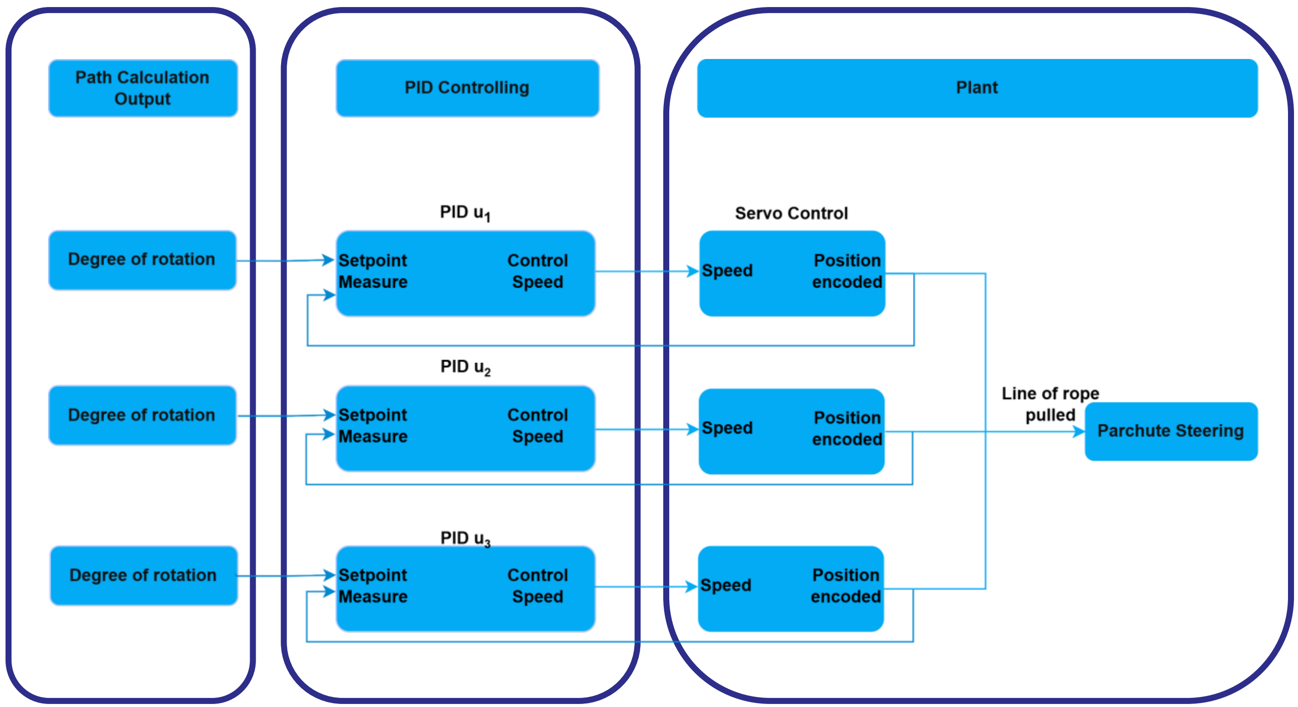


Example of Decomposing Resulting Vector

Controlling



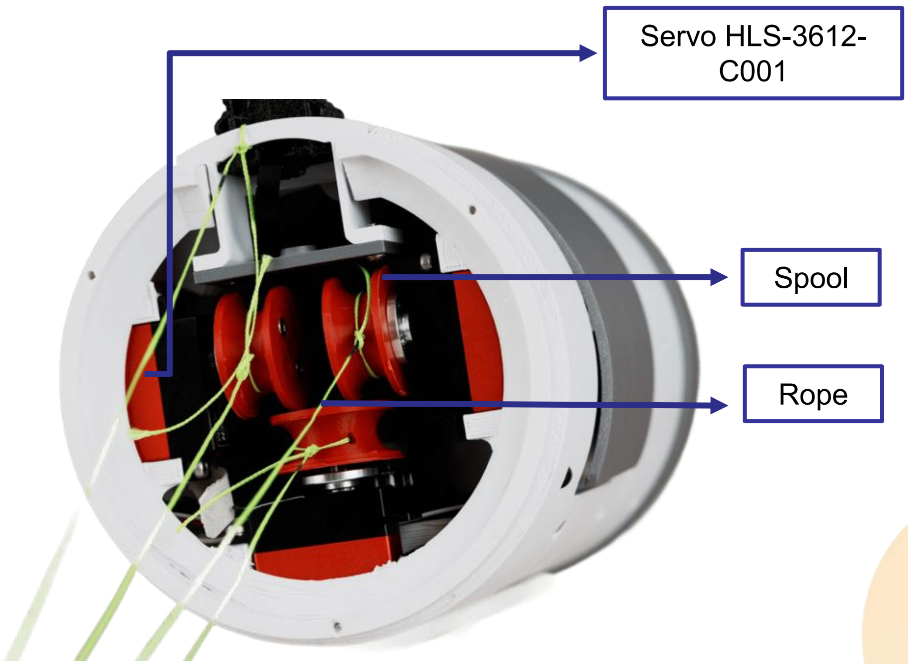
Control Diagram



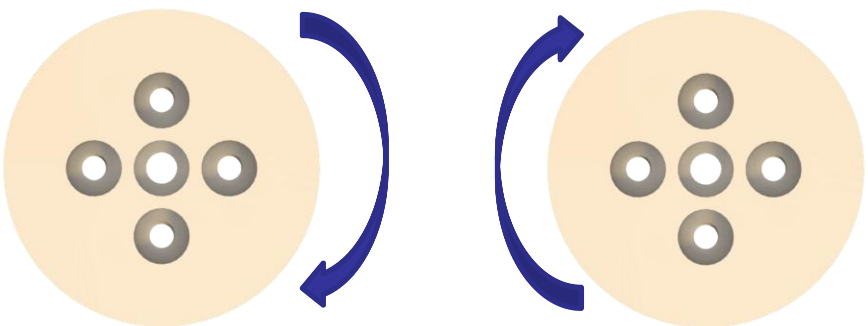
Actuators Control Diagram

Payload Steering (4/6)

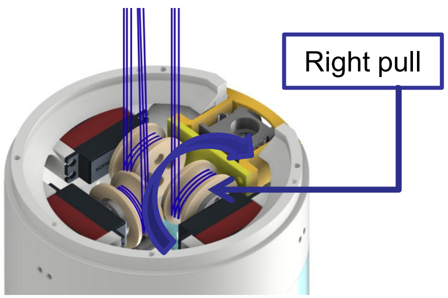
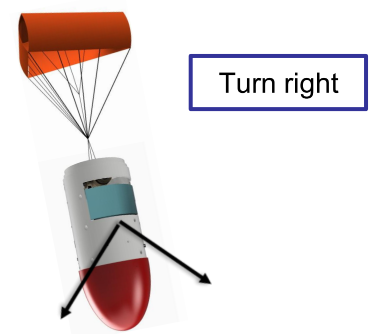
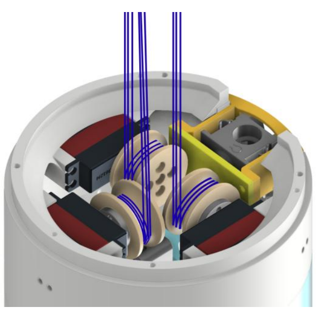
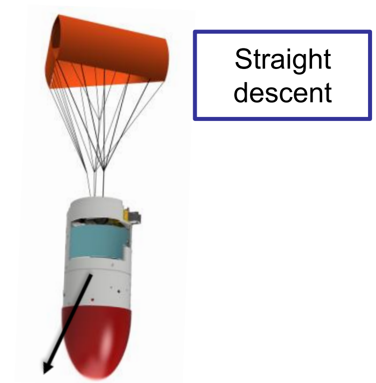
Mechanisms



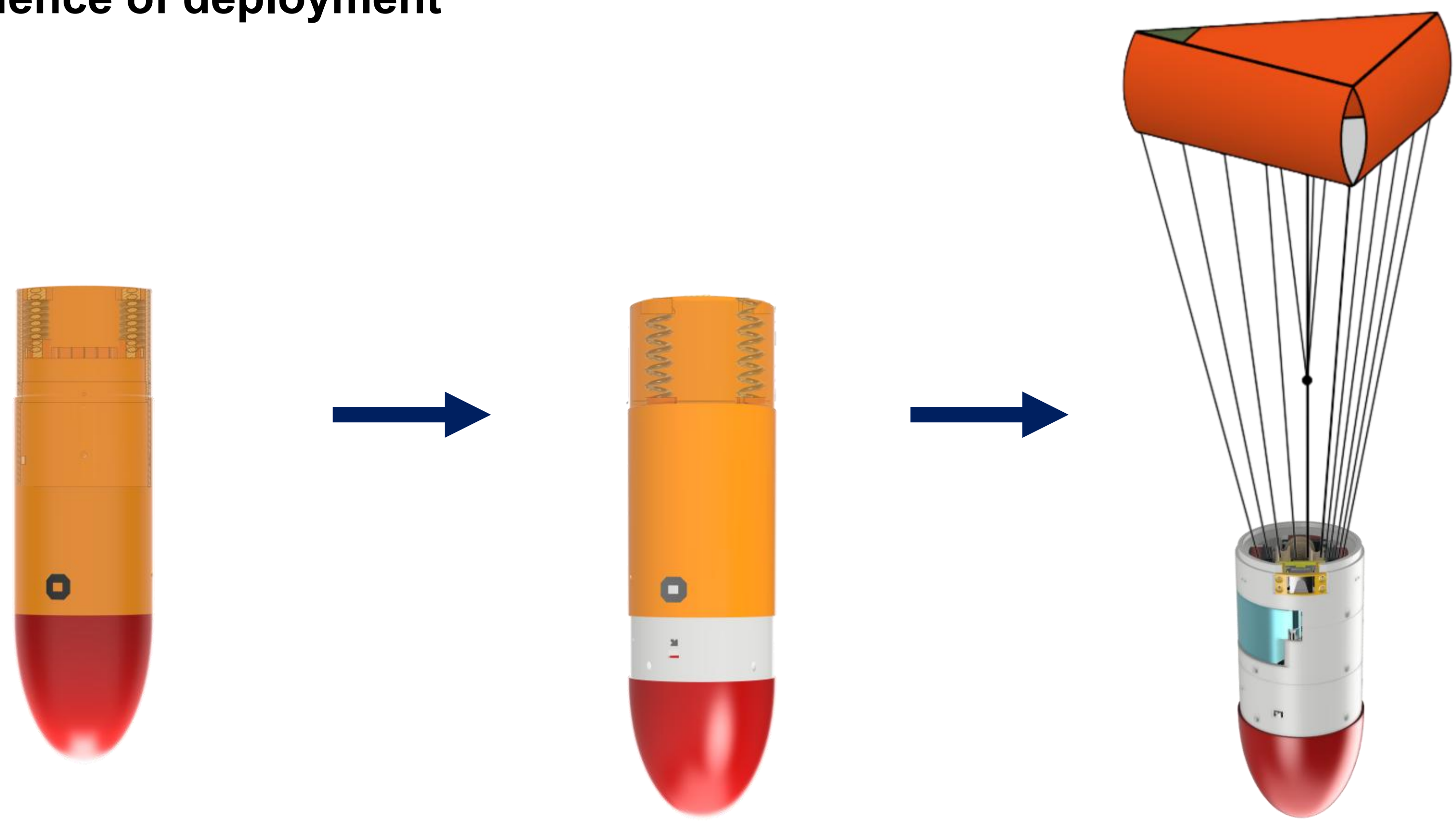
- Uses a spool-based mechanism to control steering line length
- Line length is precisely matched to the paraglider's steering angle
- Spool rotation reels in the line on one side
- Tilt results in steering toward the desired direction



Mechanisms

Steering Input	Mechanism	Payload Direction
Single-Side Pull 	• Spool rotates • One line shortened • Asymmetric drag • Turning moment generated	
Neutral 	• Spool centered • Equal line length • Symmetric canopy • Balanced drag	

Sequence of deployment



Payload Deployed

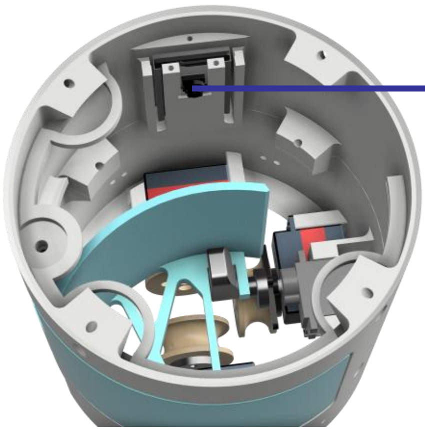
After Payload Deployed

Release Camera Pointing

Mounting Method

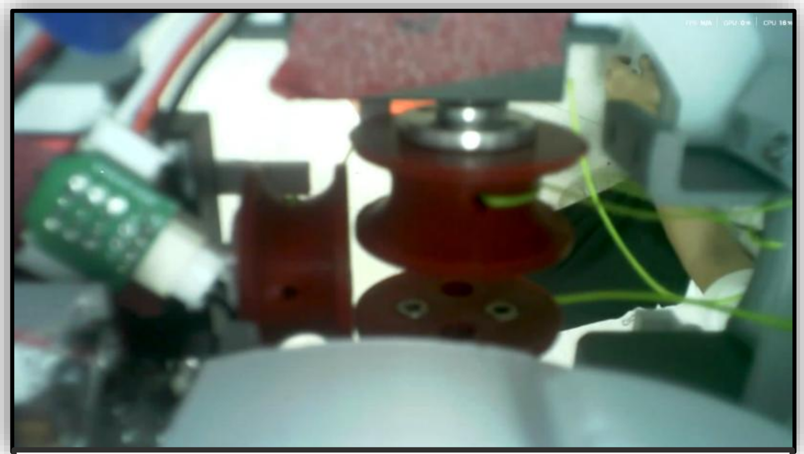
- Camera mount integrated into payload structure
- Dedicated insertion slot ensures fixed camera positioning
- Camera enclosed with protective lid
- Lid secured using M2 screws for reliable retention

Mounting Location



Expected Field Of View

- Camera shall capture paraglider deployment
- Field of view includes canopy and line expansion
- Unobstructed view during release and descent
- Alignment maintained for stable monitoring

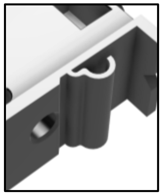


Example of Camera View

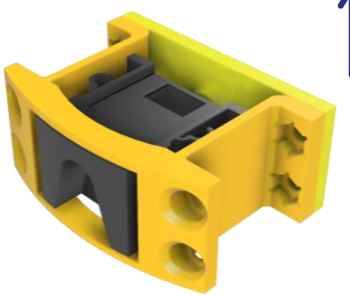
Ground Camera Pointing

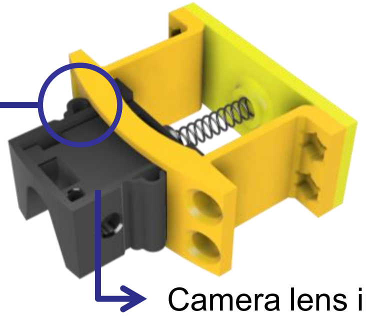
Mounting Method

- The camera is mounted inside a 3D-printed structure (TPU-95A).
- The structure is inserted into the payload and secured by fitting the payload into the container.
- When the container deploys, the camera deploys along with it.



The flexible section prevents the camera from sliding back in after deployment.





Stowed Configuration **Deployed Configuration**

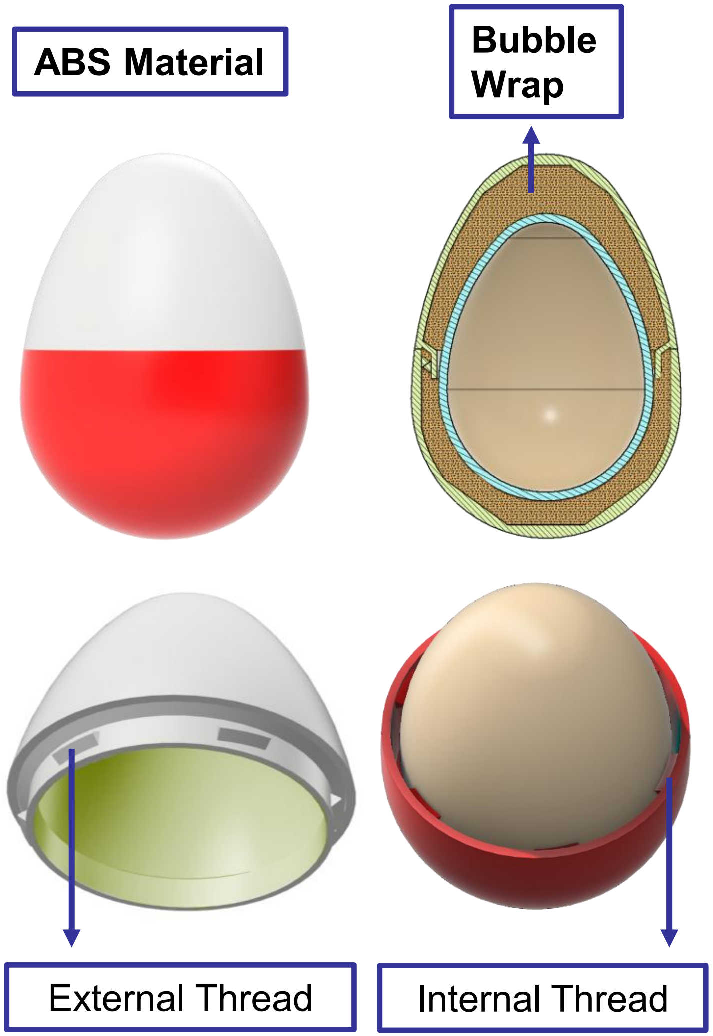
Mounting Location

Expected Field Of View

- View of the egg deploying
- View of the ground

Example of Camera View

Egg Container Design



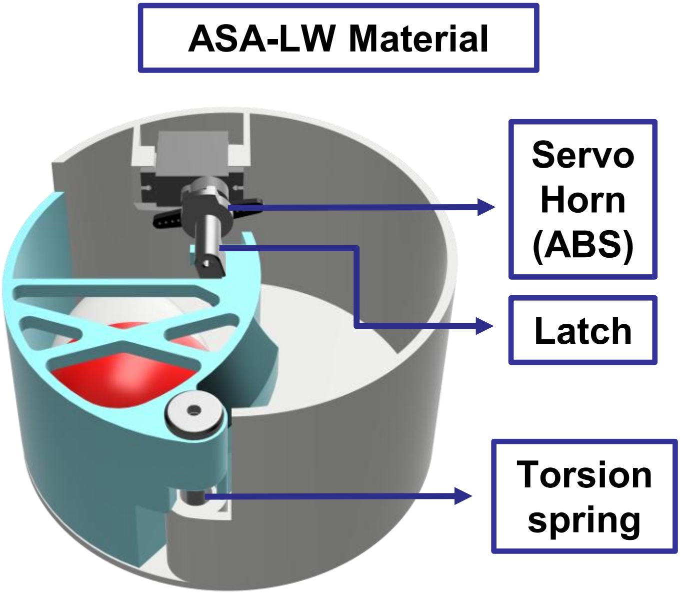
Protection Method

- Bubble wrap or soft foam padding is placed around the egg to absorb impact.
- Two-piece threaded shell keeps the egg securely enclosed.
- Rounded container shape helps distribute impact forces.
- Internal padding reduces vibration during launch and descent.
- Rigid outer shell protects against external damage.

Mounting Method

- Egg container uses a threaded connection between two halves.
- The container is secured by rotating the two halves together.
- This creates a tight and stable enclosure for the egg.
- The threaded design prevents accidental opening during launch and deployment.
- The container can be easily opened by unscrewing for egg installation or inspection.

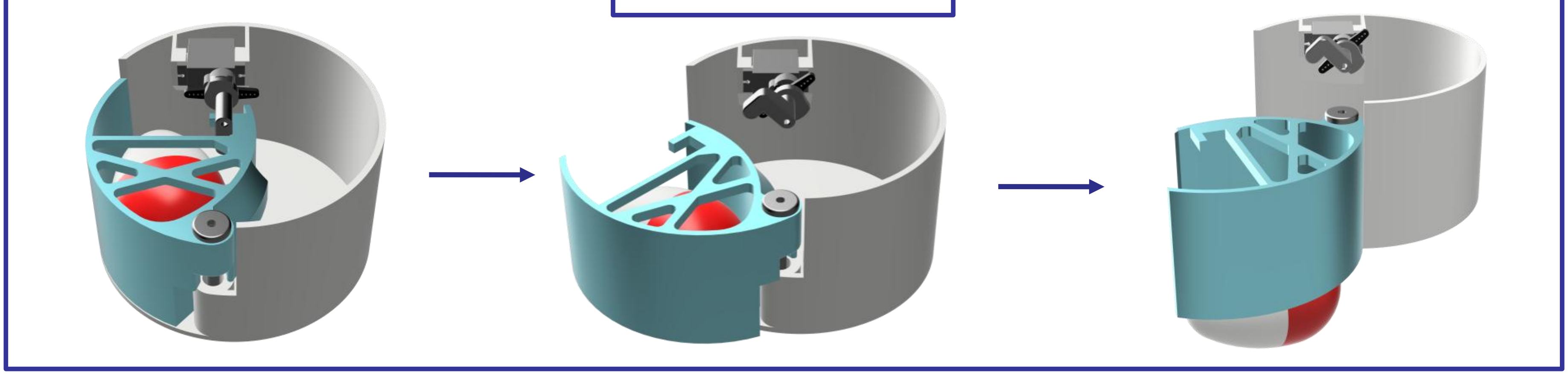
Egg Container Release Design (1/2)



Release Method

- Uses a torsion spring to generate deployment force
- The spring is preloaded to store rotational energy
- A servo motor with a servo horn restrains the mechanism before release
- The servo rotates to unlock the latch during deployment
- Once released, the torsion spring rotates the arm
- The rotating arm pushes the egg container out of the side opening

Release Mechanism



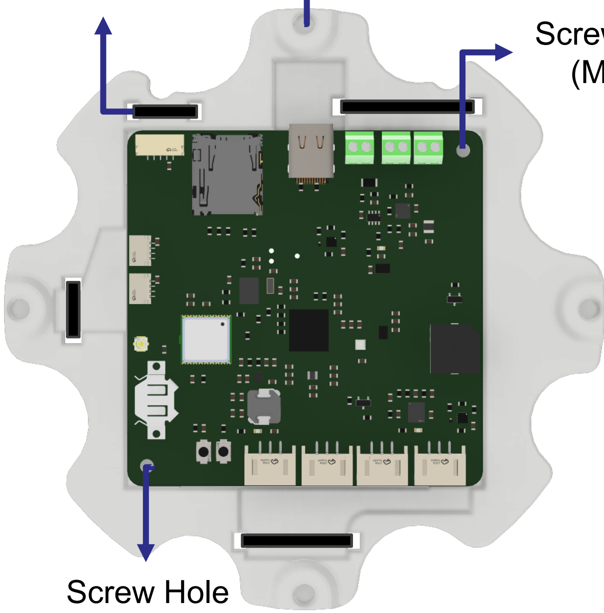
Egg Container Release Design (2/2)

Deployment Video

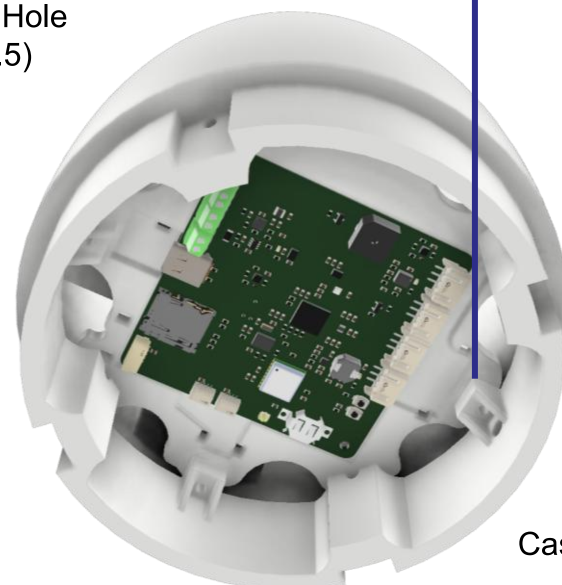
[Test Video]

Structure Survivability (1/3)

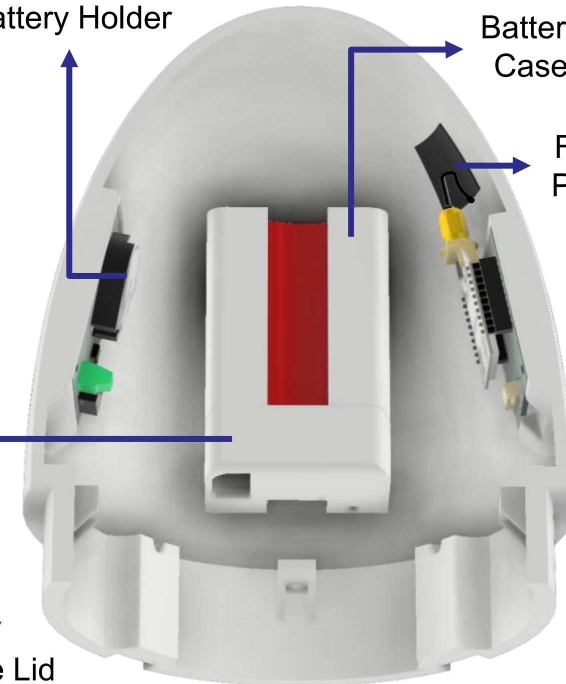
Mounting Methods & Electronics Enclosure



- The payload PCB is screwed to a payload structure using nuts and screws.
- Cable ties and acrylic tapes are used to secure wire connections in sockets.



- The payload structure is mounted with the nose cone using nut inserts and M3 screws.
- The nose cone will enclose the electronics structure.

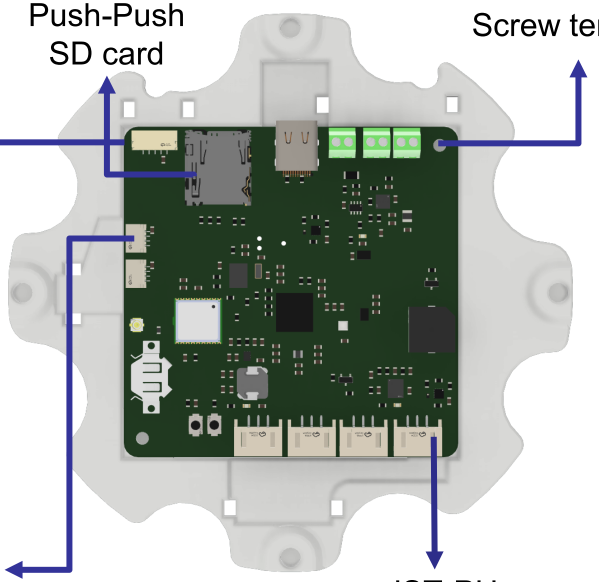


- The battery is placed in the case and is held with the case lid.
- A clipped battery holder mounts a coin cell for the RTC and beacon.
- The Communication avionic is screwed into a payload structure using nuts and screws.

Structure Survivability (2/3)

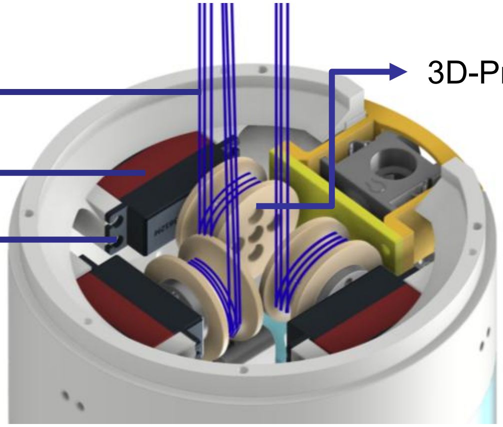
Securing Electrical Connections

- All connections and cables that don't require removal or disassembly will be soldered to ensure a strong connection and signal integrity.
- Peripherals will be connected to the main avionic using a JST connector and screw terminal.
- Any electronics that require insertion into sockets will be secured by cable ties and acrylic tape.
- Cable management using cable ties.

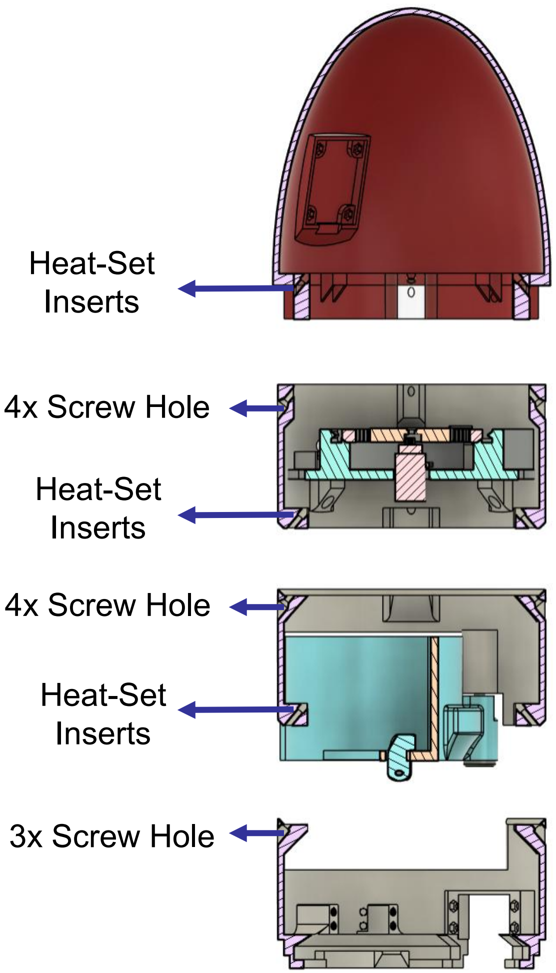


Descent Control Attachments

- The 3D-printed spool is attached to the servo horn using screws.
- The servo is mounted into the structure using screws.



Shock Force Requirements and Testing

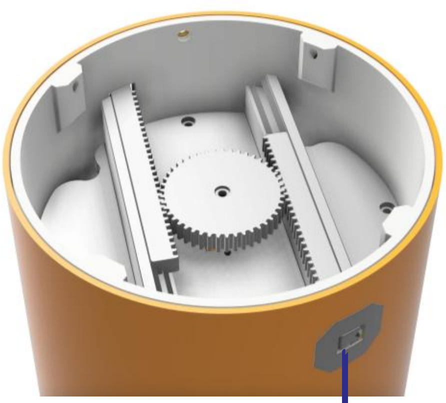


Structural Design for Survivability

- The CanSat has four partitions, joined using heat-set inserts in the upper structure, with the bottom secured by screws at a 45° angle (M3).
- The nose cone is tolerance-fitted into the CanSat structure.
- The container is reinforced with layered walls, using a 3D-printed part oriented perpendicular to the primary load direction for increased strength.

Shock Force Testing

- Non-critical parts simplified (hand calculation)
- Shock tested via 30g drop
- No real-world testing yet



Mass Budget (1/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Infill (%)	Source
Nose Cone	62 ± 2	1	62 ± 2	25	Software Estimated
Container	105 ± 2	1	105 ± 2	15	Software Estimated
Instrument Deployment	36 ± 1	1	36 ± 1	15	Software Estimated
Payload Deployment	35 ± 1	1	35 ± 1	30	Software Estimated
Electronic Structure	19 ± 1	1	19 ± 1	25	Software Estimated
Paraglider Spools	4± 0.2	3	12 ± 0.6	30	Software Estimated
Steerable Guide Parachute X-Triangle	90 ± 2	1	90 ± 2	N/A	Measurement
Parachutes	16 ± 1	1	16 ± 1	N/A	Measurement
Screw M2 × 15	0.20 ± 0.02	3	0.6 ± 0.06	N/A	Datasheet
Screw M2.5 x 5	0.20 ± 0.02	8	1.6 ± 0.16	N/A	Datasheet
Screw M2.5 x 10	0.30 ± 0.03	1	0.3 ± 0.03	N/A	Datasheet
Screw M2.5 x 25	0.50 ± 0.06	1	0.5 ± 0.06	N/A	Datasheet
Screw M3 x 8	0.30 ± 0.04	8	2.4 ± 0.32	N/A	Datasheet
Screw M3 x 10	0.40 ± 0.05	4	1.6 ± 0.20	N/A	Datasheet
Screw M3 x 15	0.50 ± 0.06	39	19.5 ± 2.34	N/A	Datasheet

Mass Budget (2/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Source
Screw M3 × 65	2.00 ± 0.23	1	4.50 ± 0.23	Datasheet
Nut M2.5	0.30 ± 0.001	5	1.5 ± 0.005	Datasheet
Nut M3	0.30 ± 0.001	9	2.7 ± 0.009	Datasheet
Heat Set Insert M2.5	0.15 ± 0.01	5	0.75 ± 0.05	Datasheet
Heat Set Insert M3	0.25 ± 0.01	20	5 ± 0.20	Datasheet
Eyebolt	30 ± 2	1	30 ± 2	Measurement
Wood Disc	52 ± 2	1	52 ± 2	Measurement
Egg Case	7.5 ± 0.5	1	7.50 ± 0.50	Software Estimate
Egg	59 ± 2	1	59 ± 2	Mission Guide
M3 Swivel Link	1.50 ± 0.1	1	1.50 ± 0.1	Datasheet
Compression Spring (ground pointing camera)	0.2 ± 0.01	1	3.0 ± 0.2	Datasheet
Compression Spring (paraglider deployment)	2.0 ± 0.1	3	6.0 ± 0.3	Datasheet
Torsion Spring	5 ± 0.5	1	5 ± 0.5	Datasheet
Mechanical Structure Subtotal (g)		566.7 ± 5.3		

Mass Budget (3/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Source
XBee Pro	20 ± 2	1	20 ± 2.0	Measurement
XBee Adapter	7 ± 0.1	1	7 ± 0.1	Measurement
Radio Antenna	8 ± 1	1	8 ± 1	Measurement
GPS Antenna	0.62 ± 0.1	1	0.62 ± 0.1	Datasheet
18650 Li-ion Battery	48 ± 0.2	2	96 ± 0.1	Datasheet
Coin Cell Battery	0.9 ± 0.01	2	1.8 ± 0.01	Datasheet
Screw switch	4 ± 0.5	2	8 ± 1.0	Measurement
Beacon avionic	30 ± 2	1	30 ± 2.0	Estimated
Servo HL-3612-C001	38.2 ± 0.2	3	114.6 ± 0.2	Datasheet
Servo MG90S	13.5 ± 0.1	2	27 ± 0.1	Datasheet
AirTag	11 ± 0.1	1	11 ± 0.1	Datasheet
Integrated PCB	27 ± 0.1	1	27 ± 0.1	Measurement
ESP32-S3-CAM with OV5640	10.7 ± 1	2	21.4 ± 2	Measurement
Electrical component Subtotal (g)		372.4 ± 8.8		

Mass Budget (4/4)

Total mass of all components and structural elements:

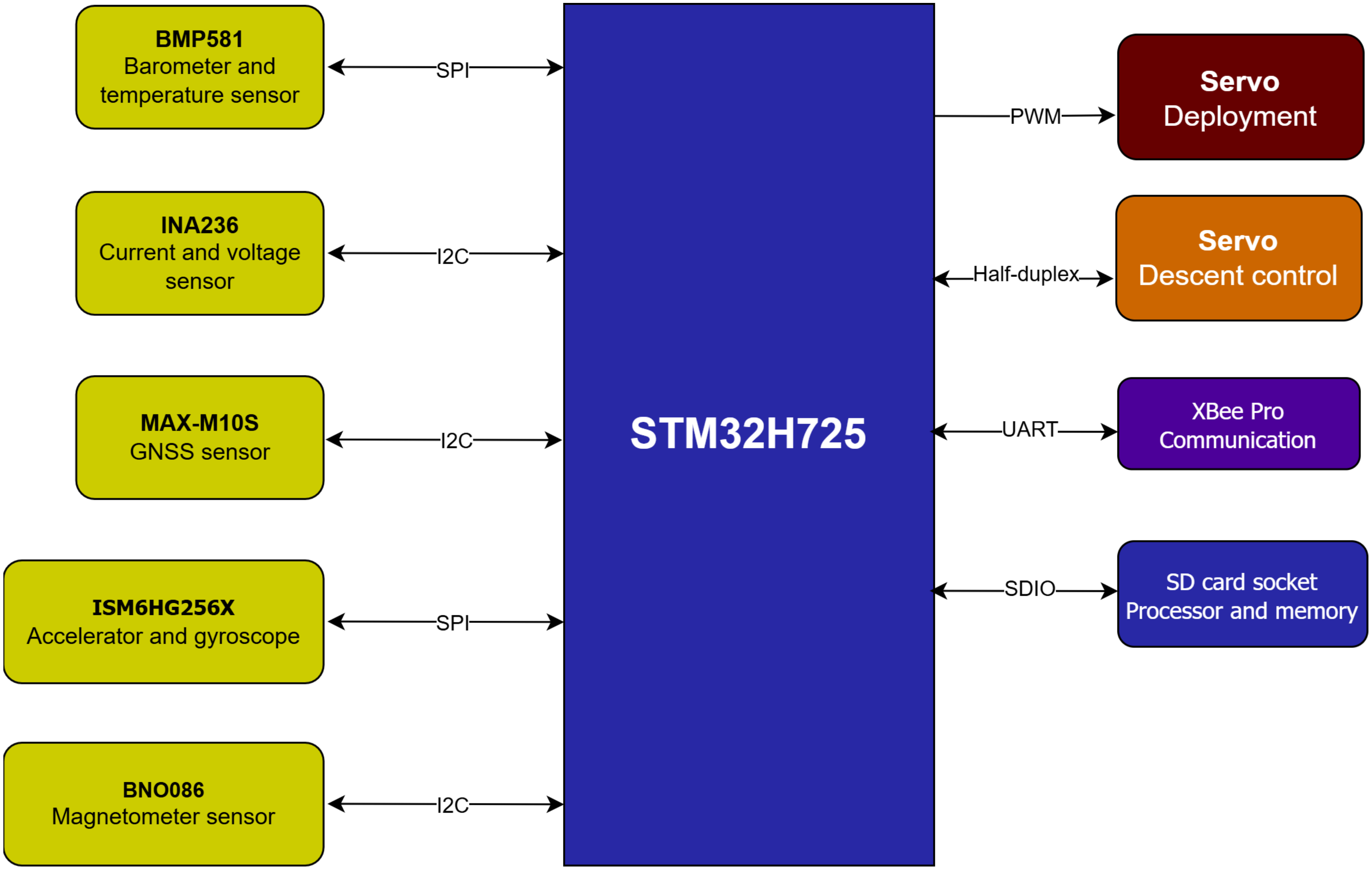
Total Mass Budget	
System	Mass(g)
Mechanical Structure	566.7 ± 20.4
Electrical Structure	372.4 ± 8.8
Subtotal	939.1 ± 29.1
Margin	1000.0 – 939.1 = 60.9 g

The margin can be adjusted by adding material and infill adjustment.

Communication and Data Handling (CDH) Subsystem Design

Watcharawit Leksuwankun
Trirayan Boontaganon

CDH Overview



CDH Changes Since PDR

Component	PDR	CDR	Rationales
Additional sensor	LIS3MDL (3-axis) (Magnetometer sensor)	BNO086 (9-axis) (Orientation sensor)	• real-time sensor fusion internally • more stable and accurate heading and orientation measurements • simplified calibration and system integration

*Note: This sensor is used for guiding the direction of the paraglider path control.

LIS3MDL
(3-axis)

BNO086
(9-axis)

Payload Processor & Memory Selection (1/2)

Modules	Boot Time (ms)	Clock Frequency (MHz)	Data interface	I/O Pins	Nonvolatile memory	Volatile memory (RAM)	Dimension (mm)	Cost (USD)
STM32H725 (SMD chip)	2	550	6*SPI 5*I²C, 5*UART 1*SDIO	50	1MB flash	564 KB	8x8	12.21

Data Bus Width (bits)	Current (mA)	Voltage (V)	Power Consumption (mW)
8-, 16-, 24-bit	100	3.3	330

Selected Processor	Rationales
 STM32H725	• Smaller physical size • Adequate processing capability for mission requirements • Fast boot time • Fast processor speed

Payload Processor & Memory Selection (2/2)

Models	Memory (GB)	Interface	Data Transfer Rate (MB/s)		Cost (USD)
			Read	Write	
SanDisk Ultra	32	SPI and SDIO	100	10	7.49

Selected Memory	Rationales
 SanDisk Ultra	• Low cost • Provides adequate storage capacity to support full-mission data recording

Payload Real-Time Clock

Modules	Reset Tolerance	Weight (g)	Dimensions (mm)	Cost (USD)
MAX-M10S built-in RTC	Unaffected due to external battery backup	Integrated in GPS	Integrated in GPS	0

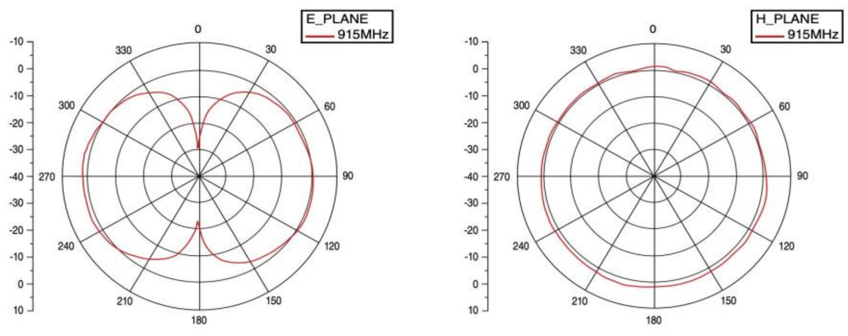
Selected Real-Time Clock	Rationales
 MAX-M10S built-in RTC	• Eliminate the need for additional hardware components • Built-in RTC support • Simplified PCB layout and reduced design complexity

External backup power for the RTC is provided by a CR927 coin cell, which is mounted in a clip-style battery holder.

Payload Antenna Selection

Antennas	Frequency Range (MHz)	Gain (dBi)	Electrical Design	Weight (g)	Dimension (mm)	Range (km)	Cost (USD)
RFDFLEX2 900MHz Flexible PCB	902-928	2.4	¼ wave	1.3	79 x 55 x 0.1	~12-18	26.50

Antenna Radiation Pattern



[E-Plane] [H-Plane]

Performance	Mass
• Frequency is 900Mhz • Gain is 2.4 • Impedance is 50Ω	• Length is 79 mm. • Weight is under 1.5 g

Selected Antenna	Rationales
RFDFLEX2 900MHz Flexible PCB	• Mass reduction • Improved gain performance • Flexible structure enabling precise conformity to the nose cone curvature

Payload Radio Configuration (1/2)

Model	RF Data Rate (Kbps)	Frequency Band (MHz)	Sensitivity (dBm)	Transmit Power (mW/dBm)	Operating Voltage (V)	Operating Current (mA)	Cost (USD)
XBee-PRO 900HP(S3P)	10 or 200	902 - 928	-101 @ 200 Kbps, -110 @ 10 Kbps	250/24	2.1 - 3.6	TX: 215 RX: 29	55.66

XBee Configuration

XBee Radio Selection: XBee Pro 900HP S3B

NETID: 1043

Transmission Method: Unicast mode

Transmission Control

1. The CanSat starts transmitting telemetry at 1 Hz when it receives a command "CMD,1043,CX,ON" from GCS.
2. The data transmission rate is gradually maintained at 1Hz throughout the entire mission.
3. When the CanSat lands and enters the LANDED state, it stops transmitting data.

Note

1. The UART protocol is employed because of its simplicity and high-speed communication capability.
2. Line-of-sight testing was conducted by placing the avionics on a high-altitude balloon, with healthy telemetry at distances reaching 3.3 km from the GCS.

Payload Radio Configuration (2/2)

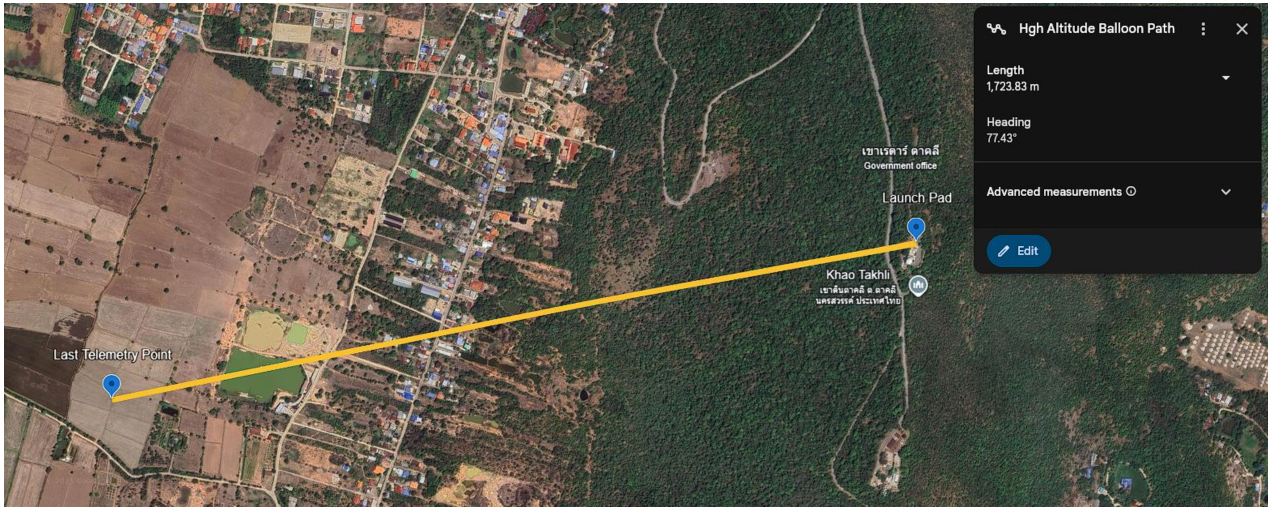
XBee Telemetry was clear and healthy until 3389.3 m far from GCS.

The balloon reached an altitude of 2918.2 m and was 1723.8 m from GCS.

$C^2 = A^2 + B^2$

$\text{Distance} = 2918.2^2 + 1723.8^2$

$\text{Distance} = 3389.3 \text{ m}$




```
1043,00:53:04,2385,F,STARTUP,2911.2,27.3,70.9,0.1,0.00,0.00,0.00,0.00,0.00,0.00,0.00,00:53:04,3053.3,15.2478,100.3213,32,,173.05
1043,00:53:05,2386,F,STARTUP,2918.2,27.3,70.9,0.1,0.00,0.00,0.00,0.00,0.00,0.00,0.00,00:53:05,3060.6,15.2478,100.3213,31,,-164.36
```

Payload Telemetry Format (1/4)

Given Telemetry Format

<TEAM_ID>, <MISSION_TIME>, <PACKET_COUNT>, <MODE>, <STATE>, <ALTITUDE>, <TEMPERATURE>, <PRESSURE>, <VOLTAGE>, <CURRENT>, <GYRO_R>, <GYRO_P>, <GYRO_Y>, <ACCEL_R>, <ACCEL_P>, <ACCEL_Y>, <GPS_TIME>, <GPS_ALTITUDE>, <GPS_LATITUDE>, <GPS_LONGITUDE>, <GPS_SATS>, <CMD_ECHO>, <HEADING>(OPTIONAL DATA)

Example Telemetry Format

1043,13:14:02,25,F,ASCENT,452.7,26.3,101.2,4.2,0.52,1.25,-0.80,0.15,0.02, -0.01,9.81,13:14:01,467.3,13.7564,100.5012,8,CXON,77.43

Each telemetry packet is formatted in ASCII, with individual telemetry fields separated by commas and terminated by a newline character. The telemetry data is transmitted at a rate of 1 Hz, with one complete packet generated and sent per second.

Payload Telemetry Format (2/4)

Data Field	Description	Example	Units	Resolution
TEAM_ID	The assigned four-digit team number	1043	N/A	N/A
MISSION_TIME	UTC timestamp	13:14:02	hh:mm:ss	1 s
PACKET_COUNT	Total count of transmitted packets since turn on increase every time transmitted	25	N/A	N/A
MODE	‘F’ for flight mode and ‘S’ for simulation mode	F	N/A	N/A
STATE	The operating state of the software	ASCENT	N/A	N/A
ALTITUDE	The altitude in meters relative to ground level at the launch site	452.7	m	0.1 m
TEMPERATURE	The internal temperature of CanSat	26.3	°C	0.1 °C
PRESSURE	The air pressure in atmosphere	101.2	kPa	0.1 kPa

Payload Telemetry Format (3/4)

Data Fields	Descriptions	Examples	Units	Resolution
VOLTAGE	The voltage of the CanSat power bus	4.2	Volt	0.1 V
CURRENT	The current measured from battery	0.52	A	0.01 A
GYRO_R	The gyro readings in degrees per second for the roll	1.25	°/s	0.01°/s
GYRO_P	The gyro readings in degrees per second for the pitch	-0.8	°/s	0.01°/s
GYRO_Y	The gyro readings in degrees per second for the yaw	0.15	°/s	0.01°/s
ACCEL_R	The accelerometer readings in meter per second squared for the roll	0.02	m/s^2	$0.01 m/s^2$
ACCEL_P	The accelerometer readings in meter per second squared for the pitch	-0.01	m/s^2	$0.01 m/s^2$

Payload Telemetry Format (4/4)

Data Fields	Descriptions	Examples	Units	Resolution
ACCEL_Y	The accelerometer readings in meter per second squared for the yaw	9.81	m/s^2	$0.01 m/s^2$
GPS_TIME	The time from the GPS receiver in UTC	13:14:01	hh:mm:ss	1 s
GPS_ALTITUDE	Altitude from the GPS receiver in meters above mean sea level	467.3	m	0.1 m
GPS_LATITUDE	The latitude from the GPS receiver in decimal degrees	13.7564	°	0.0001 ° N/S
GPS_LONGITUDE	The longitude from the GPS receiver in decimal degrees	100.5012	°	0.0001 ° W/E
GPS_SATS	The number of GPS satellites being tracked by the GPS receiver	8	Sats	1
CMD_ECHO	The text of the last command received and processed by the CanSat	CXON	N/A	N/A

Payload Command Formats (1/2)

DC	Team ID	CN	Option	Examples	Descriptions
CMD	1043	CX	ON	CMD,1043,CX,ON	Activates payload telemetry transmission
			OFF	CMD,1043,CX,OFF	Deactivates payload telemetry transmission
		ST	UTC_TIME	CMD,1043,ST,12:46:55	Sets the mission time to the value given
			GPS	CMD,1043,ST,GPS	Sets the time to the current GPS time
		SIM	ENABLE	CMD.1043,SIM,ENABLE	Enables the simulation mode
			ACTIVATE	CMD,1043,SIM,ACTIVATE	Activates the simulation mode after enable
			DISABLE	CMD,1043,SIM,DISABLE	To disables and deactivates the simulation mode
		SIMP	PRESSURE	CMD,1043,SIMP,101325	Provides a simulated pressure to the payload in sim mode

Payload Command Formats (2/2)

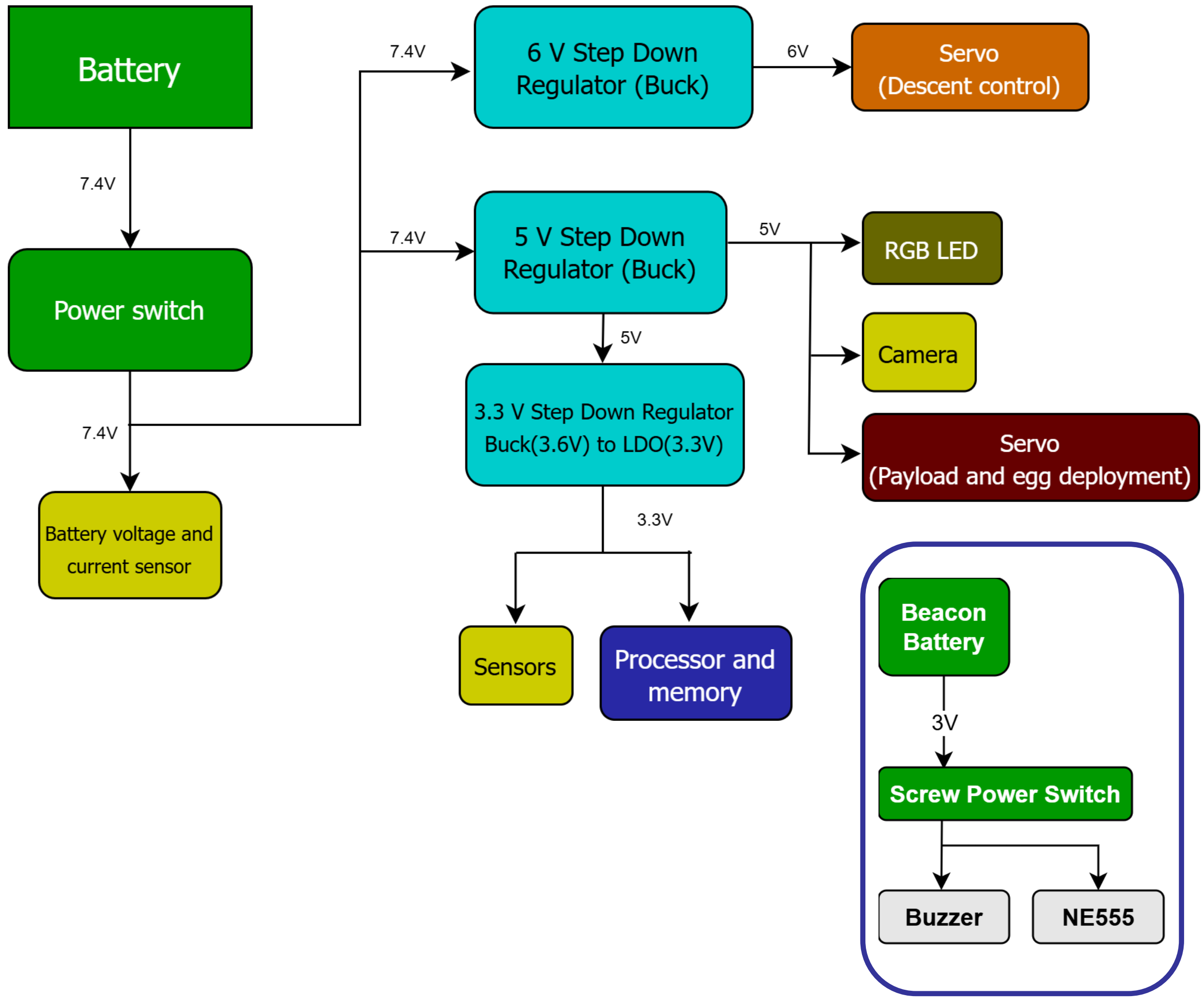
DC	Team ID	CN	Option		Examples	Descriptions
CMD	1043	CAL			CMD,1043,CAL	Calibrates telemetered altitude to 0 m when on the launch pad
		MEC	PL	ON	CMD,1043,MEC,PL,ON	Activates payload release system
				OFF	CMD,1043,MEC,PL,OFF	Deactivates payload release system
			INS	ON	CMD,1043,MEC,INS,ON	Activates instrument deployment system
				OFF	CMD,1043,MEC,INS,OFF	Deactivates instrument deployment system
			PAR	ON	CMD,1043,MEC,PAR,ON	Activates paraglider rotation system
				OFF	CMD,1043,MEC,PAR,OFF	Deactivates paraglider rotation system
		RESET			CMD,1043,RESET	Restarts the MCU and system

Electrical Power Subsystem Design

Watcharawit Leksuwankun

EPS Overview

Components	Purposes
Battery	Power Source
Sensors	Measuring Data
Actuators	Deployment And Descent Control
Voltage regulator	Converting The Voltage
Power switch	Controlling The Electric Current
LED	Indicated Power On
RGB LED	Indicating Percent Battery
MCU	Main Controlling



EPS Changes Since PDR (1/2)

- **Sensors are changed, causing the change in the power budget.**

Component	PDR	CDR
Magnetometer Sensor (Additional sensor)	LIS3MDL (3-axis)	BNO086 (9-axis)
Payload release camera	SQ11 camera	Seed StudioXIAO ESP32S3

LIS3MDL (3-axis)

BNO086 (9-axis)

SQ11 camera

Seed Studio XIAOESP32S3

- **Battery**

PDR	CDR	Rationale
Vapcell M35 (3500 mAh)	Vapcell F38 (3800 mAh)	• More suitable capacity • Offer more safety factor

Vapcell M35 (3500 mAh)

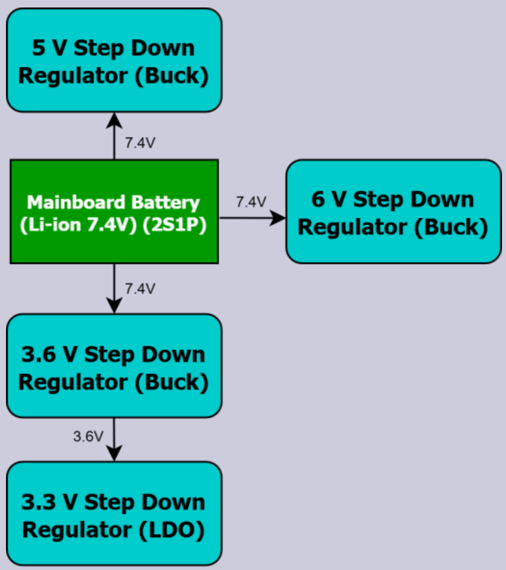
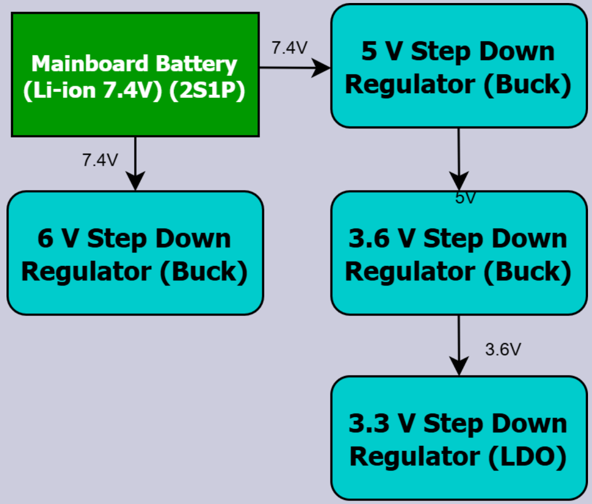
Vapcell F38 (3800 mAh)

- **Battery mounting**

PDR	CDR	Rationales
Battery is mounted on the electrical structure by a cable tie.	Battery is mounted to the side of nosecone by 3D printed slot.	• More reliable • Easier maintenance

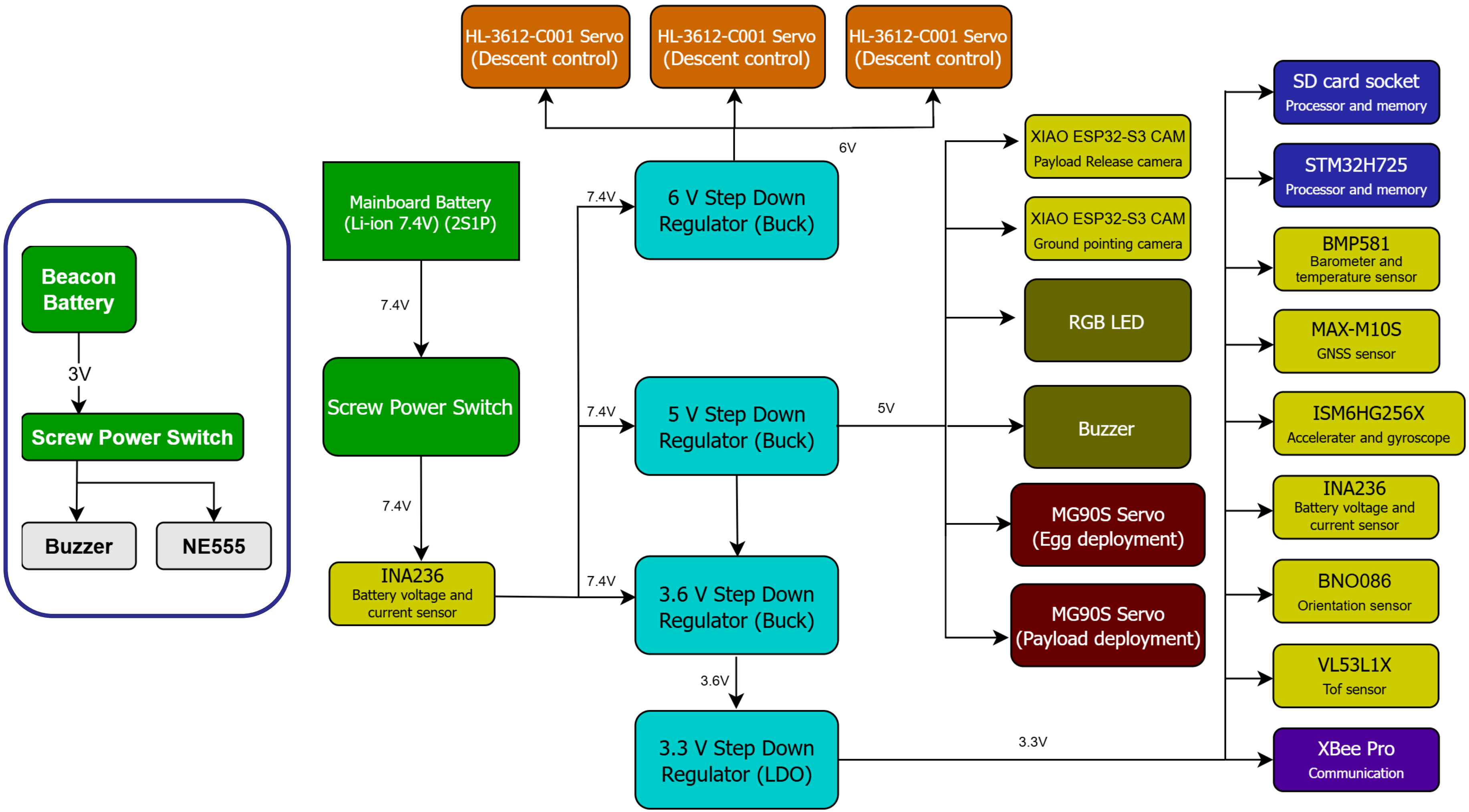
EPS Changes Since PDR (2/2)

- **Power system**

PDR	CDR
	

Rationales
• It can power 5V rail and 3.3 rail by the USBC • Debug from USBC

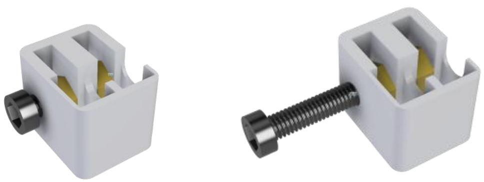
Payload Electrical Block Diagram (1/2)



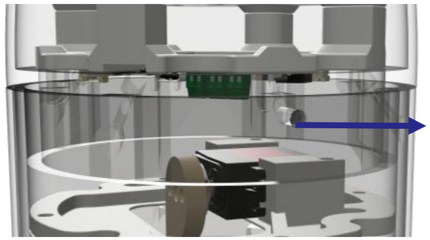
Payload Electrical Block Diagram (2/2)

Power Controlling

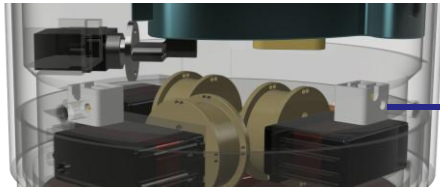
ON OFF



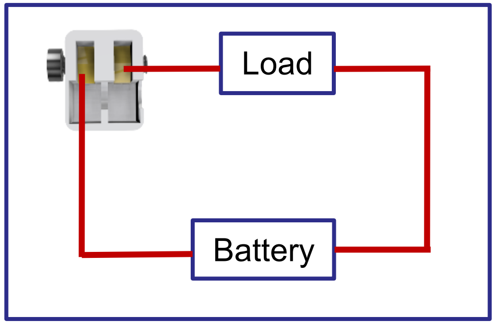
It is safer than slide switch because the screw switch tolerates the g force.



The Power Verification Hole Verified By LED



The Screw Switch

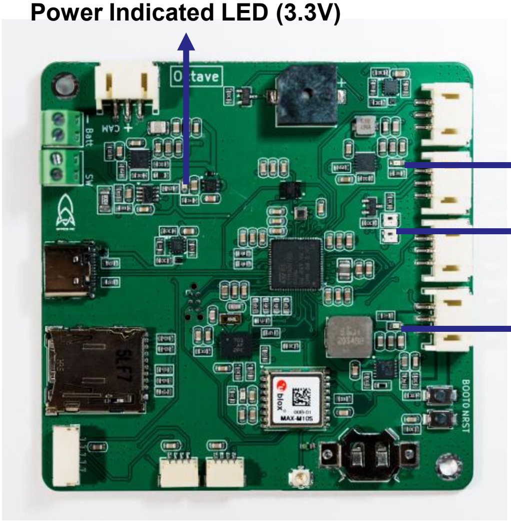


The switch is powered when the bolt is connected to the nuts.

Power Indicator

- The power indicates the LED will show up when powered on.
- The RGB LED is also used to indicate power status.

Power Indicated LED (3.3V)



Power Indicated LED (5V)

RGB LED

Power Indicated LED (6V)

Power Testing

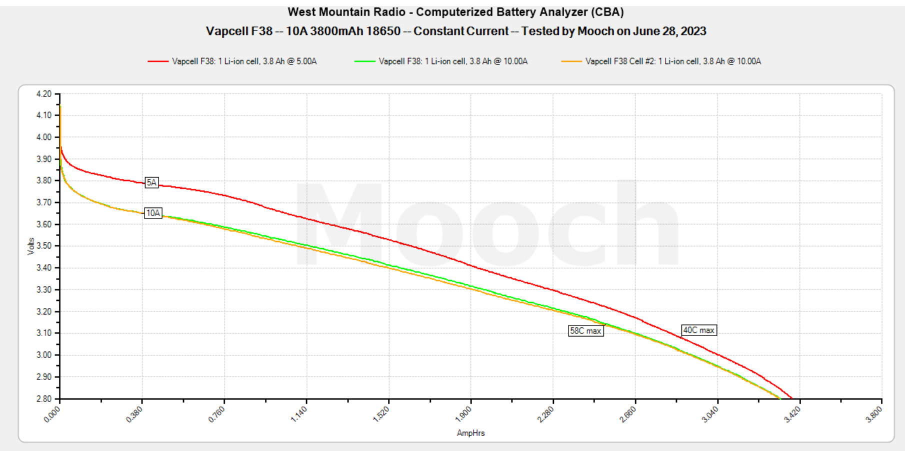
- The Avionics is safely tested by the stable power from power supply.

Payload Power Source

Modules	Types	Voltage (V)	Current Capacity (mAh)	Unit Weight (g)	Max Current (A)	Capacity (Wh)	Cost (USD)
Vapcell F38	18650 Lithium-ion Battery	3.6	3800	48	10	13.68	7.40

Power Source Information

- Batteries supply 7.2 volts.
- Single battery has a capacity of 3800mAh.
- The batteries can discharge up to 10A instantly.
- Two batteries are connected in series (2S1P) (7.2V) by spot welding.
- Battery is mounted to the side of the nosecone by a 3D printed slot.



The battery is tested by Mooch with the Computerized Battery Analyzer (CBA).

Source : https://www.e-cigarette-forum.com/threads/bench-test-results-vapcell-f38-10a-3800mah-18650.981475/

Payload Power Budget (1/2)

Models	Voltage (V)	Active Watt (mW)	Duty cycle (%)	Effective Watt (mW)	Source
STM32H725	3.3	330	100	330	Datasheet
BMP581	3.3	0.858	100	0.858	
INA236	3.3	0.99	100	0.99	
MAX-M10S	3.3	33	100	33	
ISM6HG256X	3.3	2.64	100	2.64	
BNO086	3.3	24.75	100	24.75	
VL53L1X	3.3	132	100	132	
SD card socket	3.3	660	100	660	
XBee Pro	3.3	825	100	825	
XIAO ESP32-S3 CAM	5	792	100	1200	
XIAO ESP32-S3 CAM	5	792	100	1200	
RGB LED	5	180	100	180	
RGB LED	5	180	100	180	
MG90S	5	2000	5	100	
MG90S	5	2000	5	100	
HLS3612M-C001	6	7800	20	1560	
HLS3612M-C001	6	7800	20	1560	
HLS3612M-C001	6	7800	20	1560	
Total Effective Watt (mW)			**9649.238**		

Payload Power Budget (2/2)

Beacon Staying Hour

Power Source: Beacon Battery	Energy
Total Energy Consumption (as the requirement)	0.068 Wh
Battery Energy (100% discharge depth)	0.27 Wh
Energy Margin	0.2 Wh
Operating Time (100% discharge depth)	10 hours

Avionic Staying Hour

Power Source: Avionic Battery	Energy
Total Energy Consumption (as the requirement)	24.12 Wh
Battery Energy (100% discharge depth)	28.12 Wh
Energy Margin	4 Wh
Operating Time (100% discharge depth)	2 hours and 54 minutes

Flight Software (FSW) Design

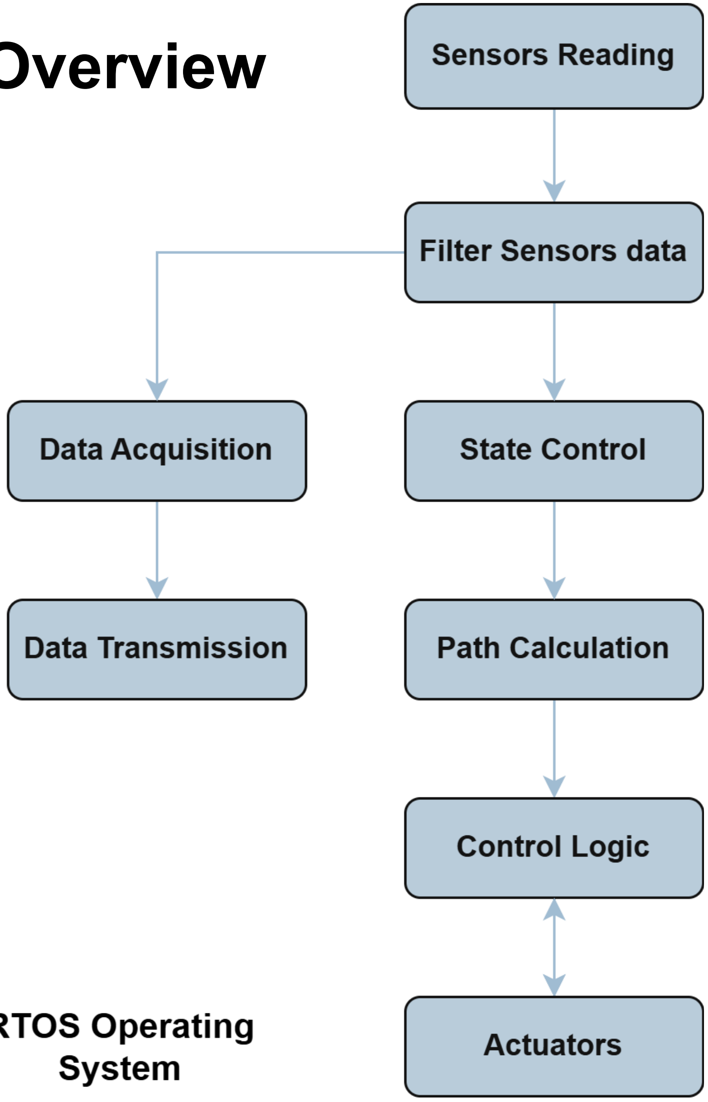
Trirayan Boontaganon

Functions

- To read sensor data and construct packets.
- To transmit the packet to GCS and save the packet in the onboard SD card.
- To receive the commands from GCS.
- To control payload release, instrument deployment, and paraglider. operation based on sensor-derived algorithms, or in response to activation commands received from the GCS.
- To save and retrieve the current system state from EEPROM in the event of an MCU reset.

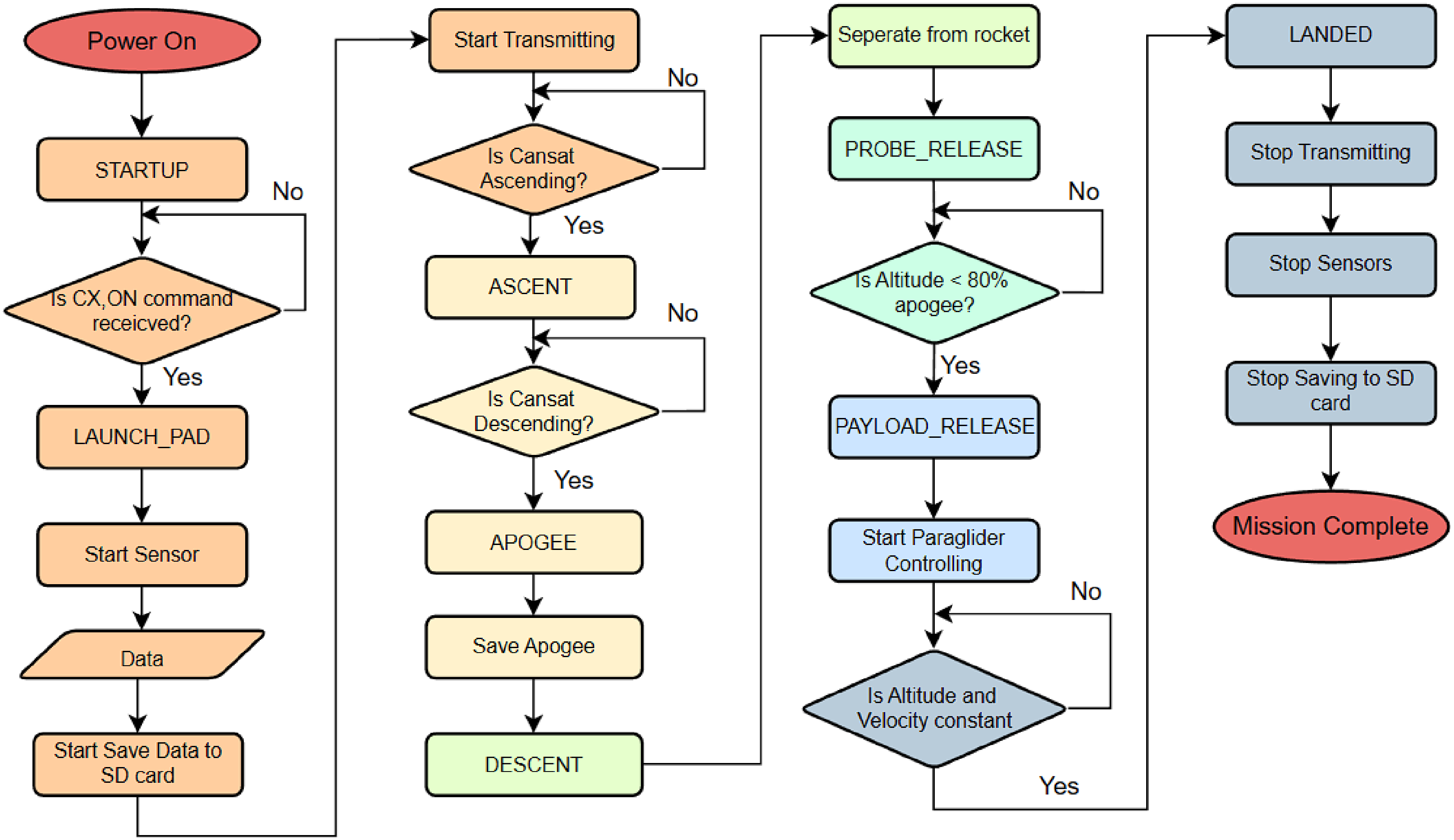
Languages	Framework	Development Environment	Libraries
C, C++	Arduino	PlatformIO, VSCode	STM32duino, Sparkfun, Adafruit

FSW Architecture Overview



RTOS Operating System

FSW Flowchart Overview



Flights Tasks in Each State (1/2)

States	Tasks
STARTUP	• Read the saved state. • Boot and configure all sensors. • Set the ground reference altitude. • Begin receiving commands. • Wait for CX,ON command.
LAUNCH_PAD	• Start Transmitting telemetry. • Wait for a launch detection.
ASCENT	• Wait for an apogee detection.
APOGEE	• Save apogee data into the SD card onboard. • Transfer state to Descent.

FSW Overview (5/5)

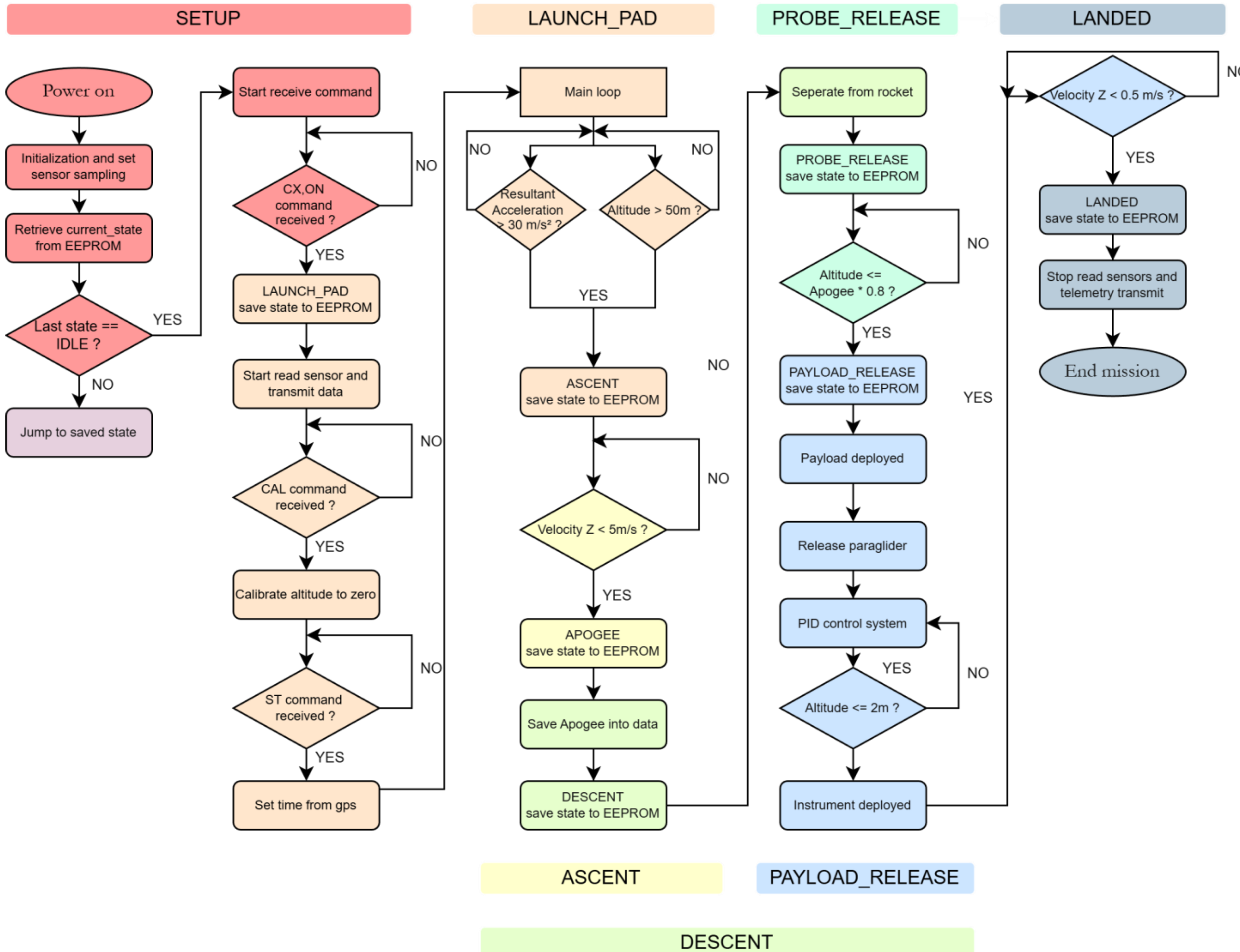
Flights Tasks in Each State (2/2)

States	Tasks
DESCENT	• Wait for a separation from the rocket.
PROBE_RELEASE	• Wait until 80% of apogee is detected, then activate the servo motor to release the payload.
PAYLOAD_RELEASE	• Activate the paraglider PID controlling navigation system to the target area. • Wait until a height of 2 m above ground is detected to activate the instrument deployment system.
LANDED	• Stop the telemetry transmission.
WHOLE FLIGHT	• Read all sensor data at the configured rate. • Save the acquired data to the onboard SD card.

FSW Changes Since PDR

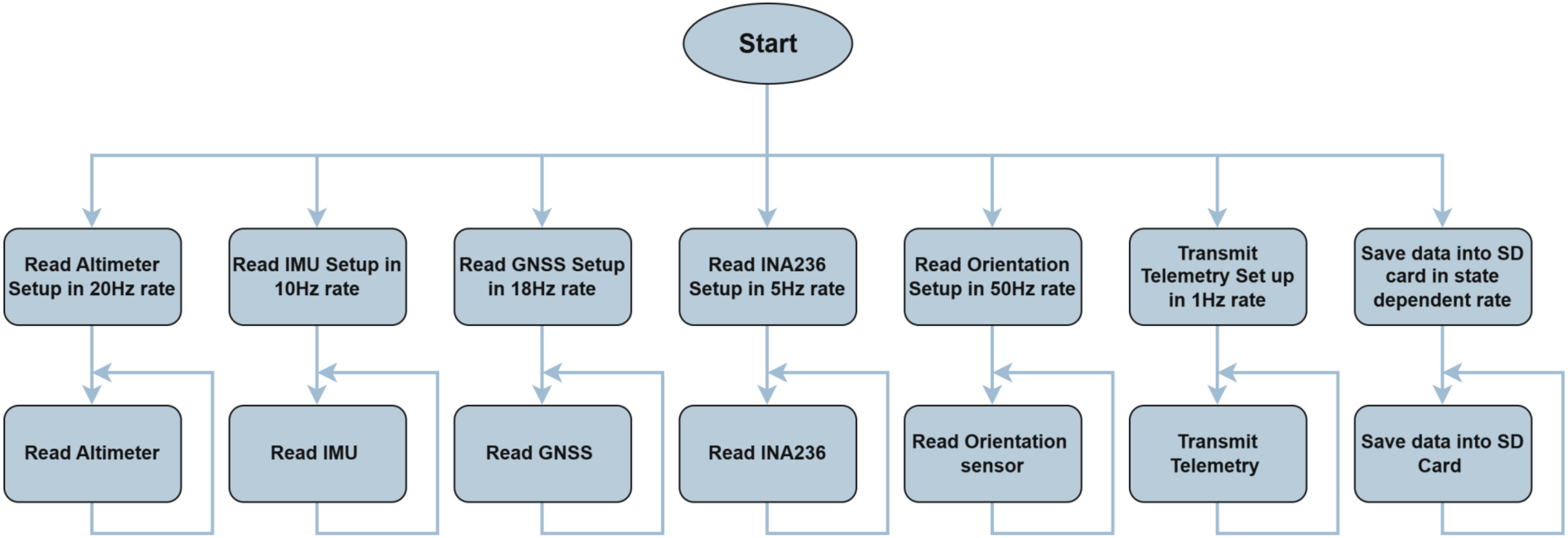
Components	PDR	CDR	Rationale
GNSS sampling frequency	5 Hz	18 Hz	• Improve computational efficiency and accuracy of path calculation • Optimize PID control performance for stability
Magnetometer sampling frequency	10 Hz	50 Hz	• Improve computational efficiency and accuracy of the path calculation system • Improve accuracy and stability of the PID control system
Calculate margin between target and current	PID	EMA	• Reduce noise and simplify signal processing using EMA smoothing • Utilize EMA for efficient smoothing with low computational cost • Apply PID for closed-loop control rather than signal filtering
EEPROM	Not included position of servos	Included position of servos	• Ensure normal paraglider operation after system reset • Prevent degradation in performance or functionality after reset

State Diagram



Link for GitHub

Sampling of Sensors/DAQ

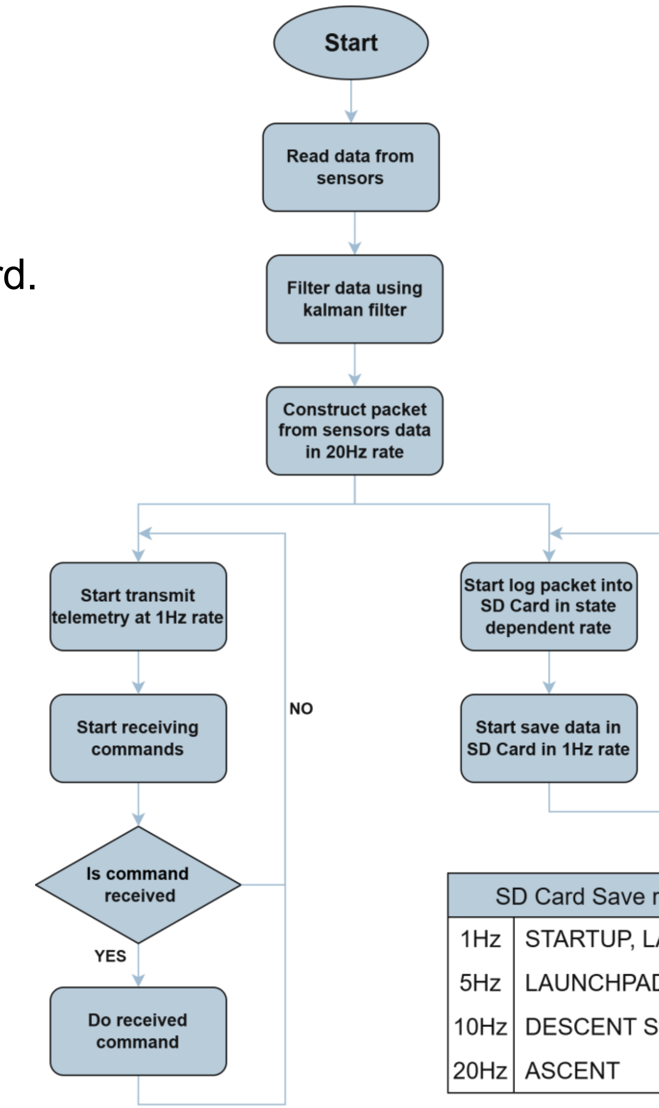


SD Card Save rate	
1Hz	STARTUP, LANDED
5Hz	LAUNCHPAD
10Hz	DESCENT States
20Hz	ASCENT

Payload FSW State Diagram (3/7)

Communications and Data Storage

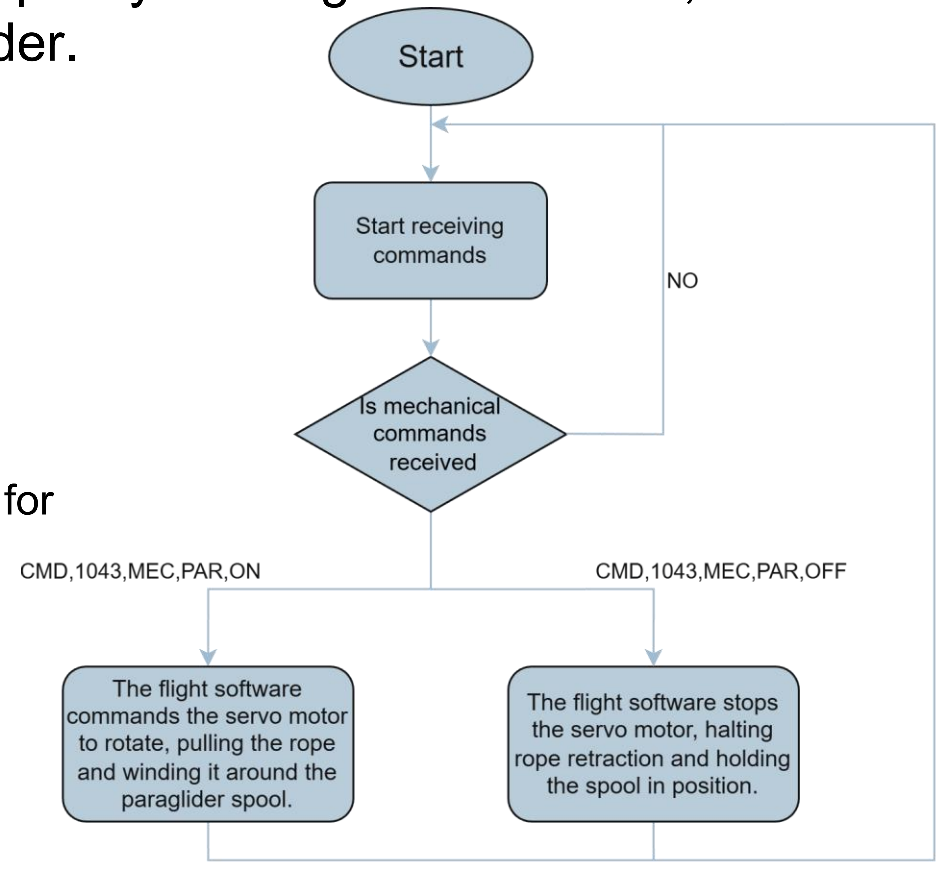
- Telemetry packets are transmitted via XBee at 1 Hz.
- Commands are received from GCS.
- All sensor and telemetry data are logged to an SD card.
- Logging continues even if communication is lost.



SD Card Save rate	
1Hz	STARTUP, LANDED
5Hz	LAUNCHPAD
10Hz	DESCENT States
20Hz	ASCENT

Mechanism Commands

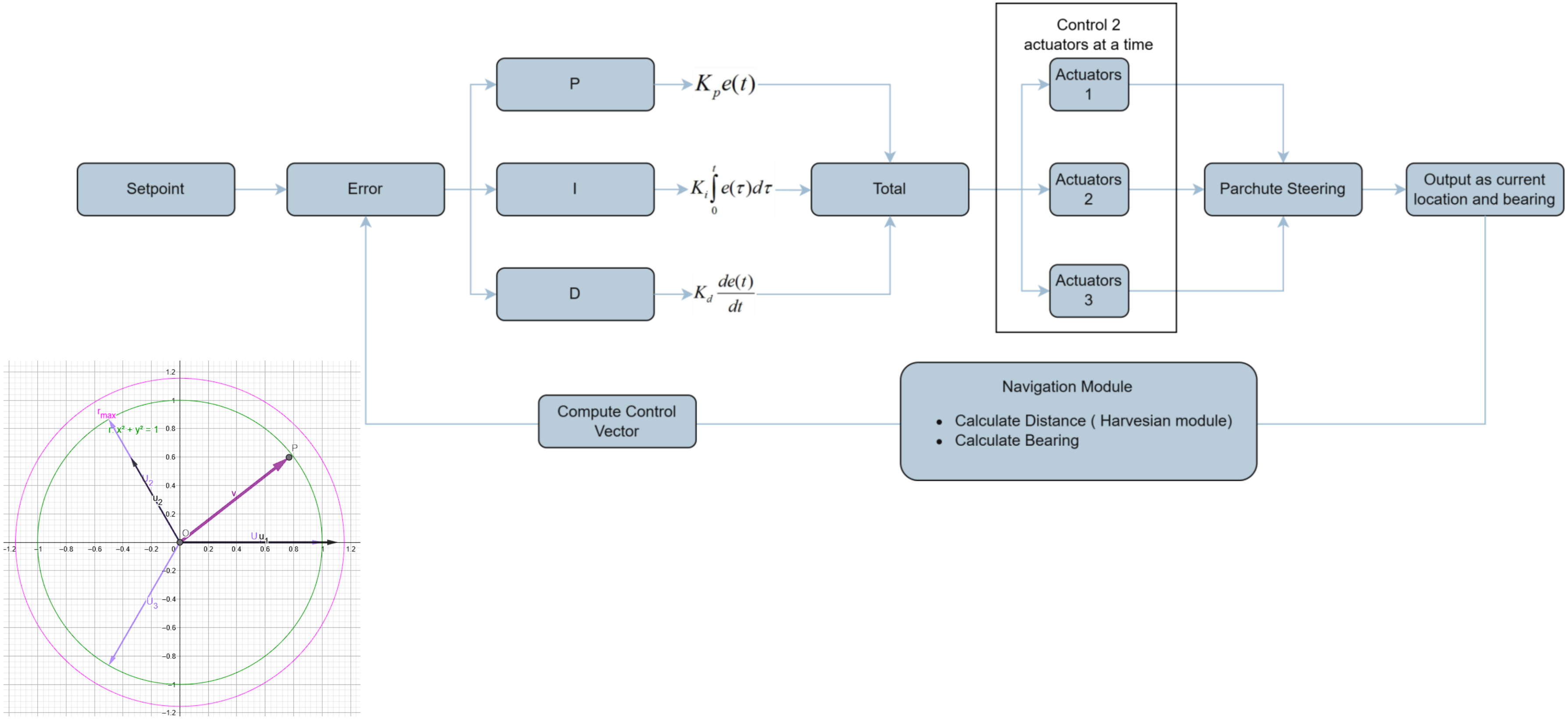
The MEC command is sent to activate a specific mechanism. The device identifier is defined by the team to specify the target mechanism; for example, PAR denotes the paraglider.



NOTE: The MEC command is not intended for use during flight unless an unexpected malfunction occurs. It is primarily used for testing and demonstration purposes.

PID Adaptive Algorithm

- PID will be used to control the paraglider to land on the target site.
- PID will be turned on to use after the release of the payload and the paraglider.



FSW Recovery (1/2)

The FSW stores the UTC, packet count, and state phase in the STM32H725RGV3 EEPROM during each loop iteration and stores the ground reference altitude in the EEPROM upon receiving a calibration command.

EEPROM	UTC time	Packet counts	State phase	Ground reference altitude	Position of paraglider servos

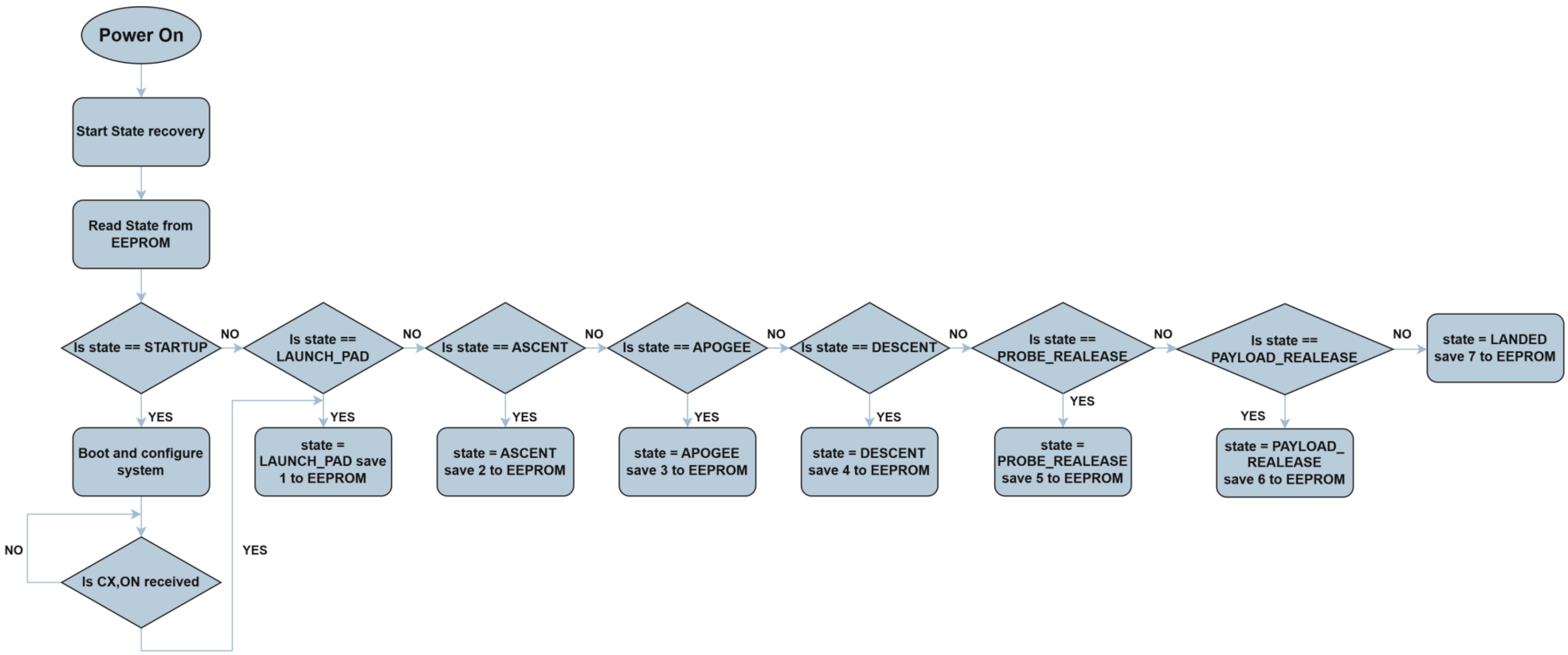
Reset conditions:

- Environment issues: shock, high acceleration.
- Power issues: voltage fluctuation, peak-voltage usage condition.
- OVP, OCP trigger.
- Reset command.

Recovery method:

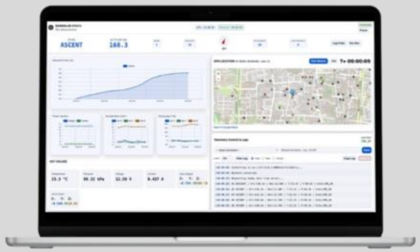
- When a reset occurs, the MCU retrieves previously stored data from EEPROM as initial values after restarting and resumes operation from the saved state.

FSW Recovery (2/2)



Simulation Mode Software

Ground Station



The Ground Station initiates simulation mode by unlinking the **SIM, ENABLE** command, which switches the telemetry **mode to ‘S’** and overrides onboard sensor inputs. It then streams pre-recorded pressure data from a CSV file at 1 Hz via **SIMP** commands to validate the flight logic in real time. The system remains in this mode until the SIM, DISABLE command is received, restoring normal operation.

CMD,1043,SIM,ENABLE →

CMD,1043,SIM,ACTIVATE →

CMD,1043,SIMP, <PRESSURE_VALUE>

← **Telemetry Packet**

CMD,1043,SIM,DISABLE →

CanSat

In simulation mode, the CanSat remains grounded but behaves as if in flight by substituting physical barometric **readings with ‘SIMP’ pressure data uplinked** from the Ground Station. This injected data is used for altitude calculation and state transitions, while other sensors continue to report real-time environmental values unaffected until the **‘DISABLE’** command restores normal operation.

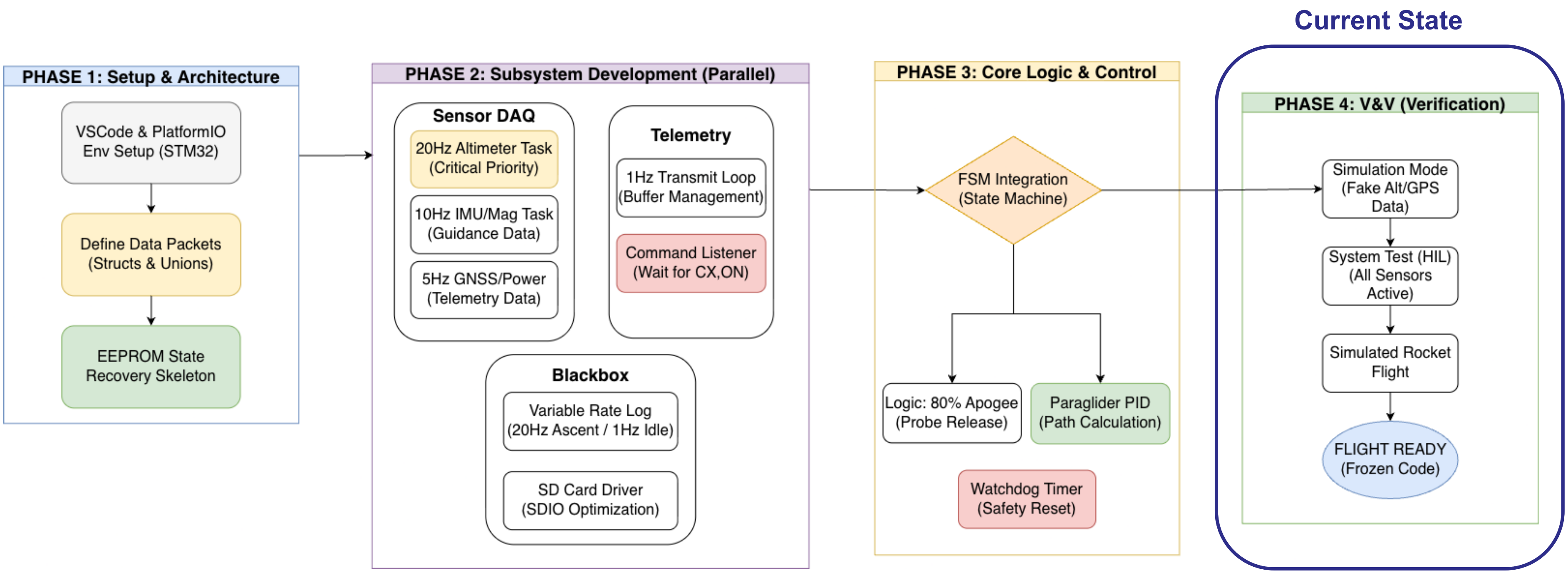
Risk Mitigation Plan for Late Software Development

A common challenge in CanSat projects is delayed software development, which can hinder system integration and testing. To mitigate this risk, the following plan is implemented:

- Early definition of software requirements to prevent late-stage design changes
- Modular and incremental development to enable parallel coding and early testing
- Use of simulation and hardware-in-the-loop testing before full system integration
- Regular progress reviews and defined milestones to identify delays at an early stage
- Early and continuous integration with subsystems to minimize last-minute debugging

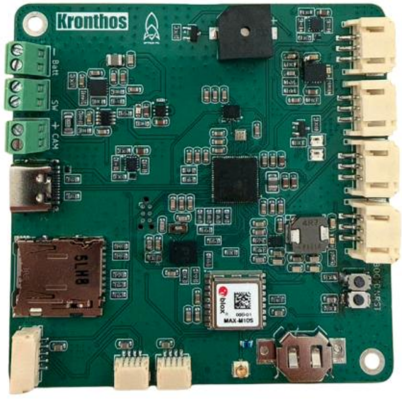
This approach helps ensure timely software completion and reduces schedule risk.

Software Development Life Cycle

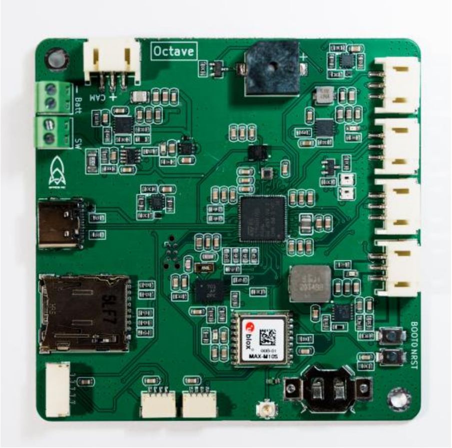


Prototyping

- FSW developed and tested using PCB Mk.1 representative of final flight hardware.
- Prototype enabled early validation of hardware–software integration.
- Verified software architecture, sensor processing, telemetry, data logging, and fault handling.
- Testing conducted in controlled environments with increasing realism.
- System behavior and flight algorithms validated prior to deployment.

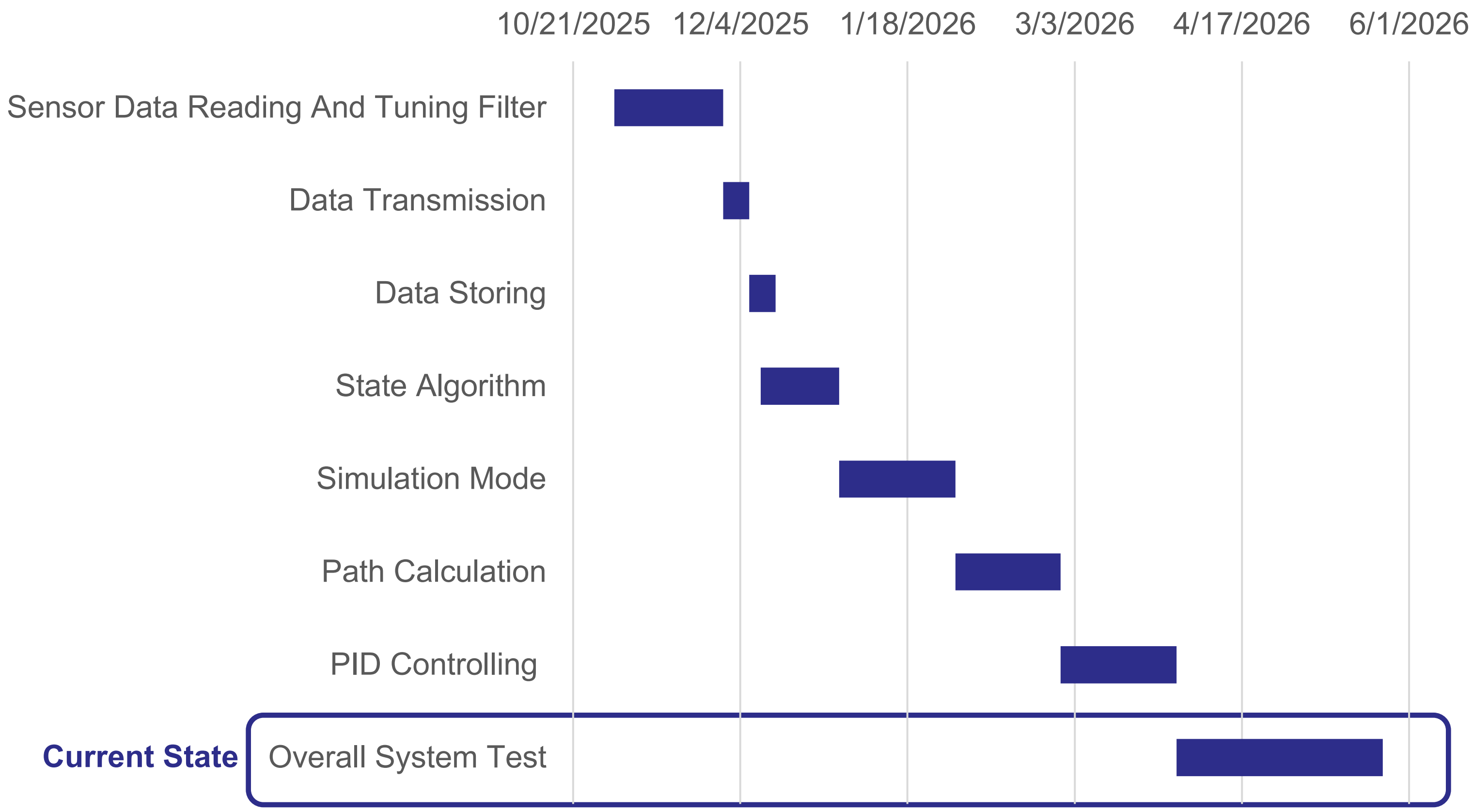


PCB Mk.1



PCB Mk.2

Subsystem Development Sequence



Software Development Plan (5/8)

Development Team

Jobs	Responsible Personnel
State Algorithm Sensor Data Reading Data Storing Data Transmission Actuator control Overall Test	Trirayan Boontaganon
PID Controlling Path Calculation Simulation Mode	Techit Monsakul

Test Methodology

A phased test methodology was implemented to progressively validate flight algorithms under increasing levels of environmental and operational realism.

Stage 1: Simulation-Based State Logic Verification Using Simulated Pressure Input

- Simulated pressure data was sent from the GCS and converted to altitude within the flight software.
- Mission state logic and state transitions were verified using predefined pressure profiles.
- This approach enabled rapid, repeatable validation of software behavior without reliance on physical sensors.

Stage 2: Algorithm Verification Using Vacuum Testing

- Initial altitude-based algorithms were verified using a vacuum tester to simulate atmospheric pressure variations corresponding to ascent and descent profiles.
- This testing confirmed accurate altitude change detection, correct mission state transitions, and reliable sensor data processing under controlled conditions.
- Vacuum testing provided a safe, repeatable environment for early-stage algorithm validation prior to outdoor or flight-level testing.

Stage 3: UAV-Based Flight Testing

- The system was integrated onto an Unmanned Aerial Vehicle (UAV) to evaluate algorithm performance under dynamic flight conditions.
- This testing introduced controlled vertical and horizontal motion, mechanical vibration, and variable ascent rates representative of flight operations.
- Sensor fusion performance, telemetry stability, and real-time algorithm execution were validated in a low-risk airborne environment.

Stage 4: Simulated Rocket Flight Using Sounding Rocket

- Final algorithm validation was conducted using a sounding rocket to replicate launch and ascent profiles representative of the competition environment.
- This testing subjected the system to high acceleration loads, rapid altitude changes, and launch-induced vibration.
- Critical mission events and state transitions were verified before final competition deployment.

Software Development Plan (8/8)

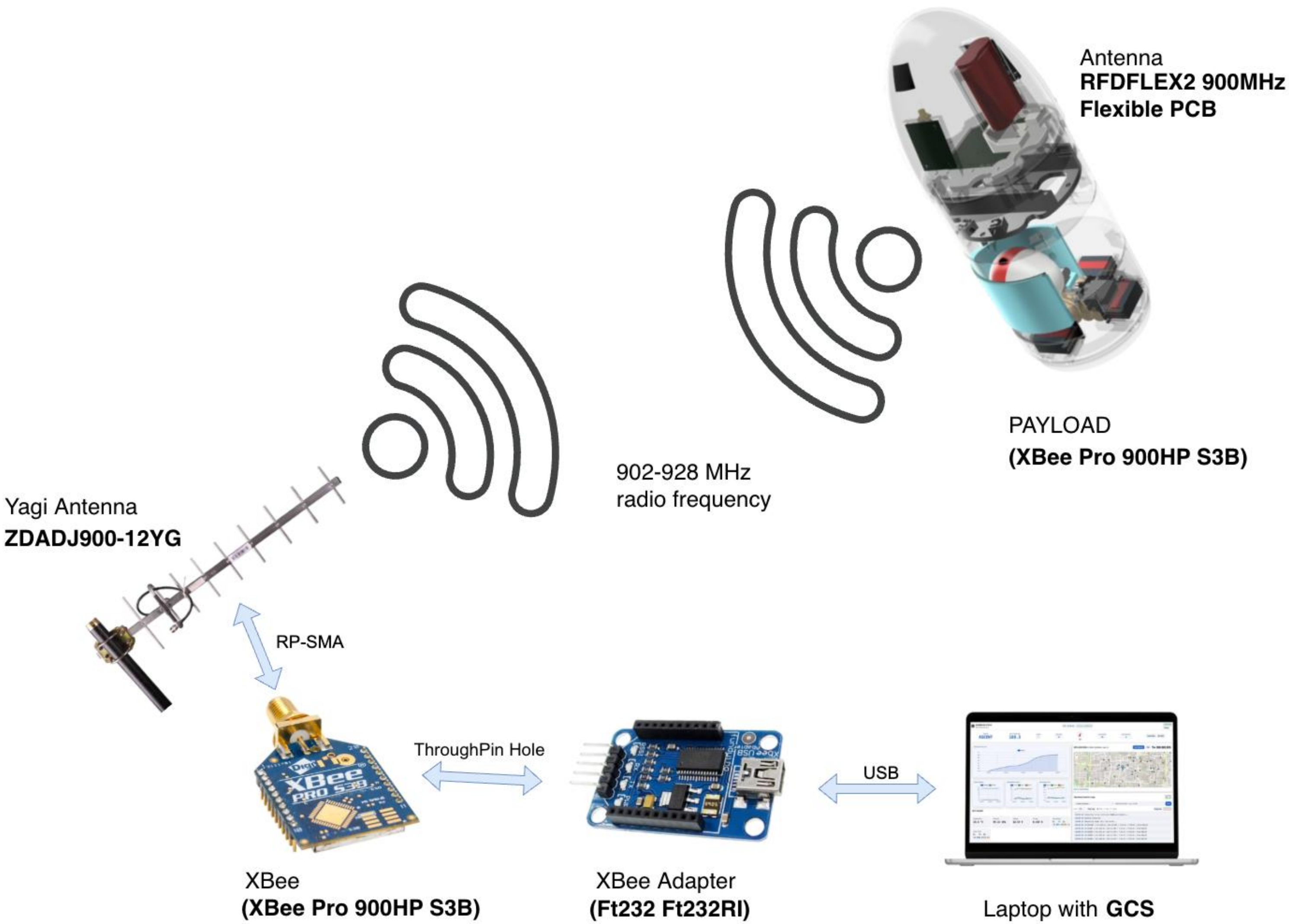
Progress since PDR

- The **state logic** module has been implemented to determine the current navigation state.
- The **path calculation algorithm** has been developed to compute the direction toward the target.
- The **PID control system** has been implemented and tested to generate actuator commands for steering control.
- Initial functional tests confirm correct integration between state estimation, path calculation, and control modules.
- **Integration testing confirmed proper interaction between state estimation, path planning, and control modules.**

Ground Control System (GCS) Design

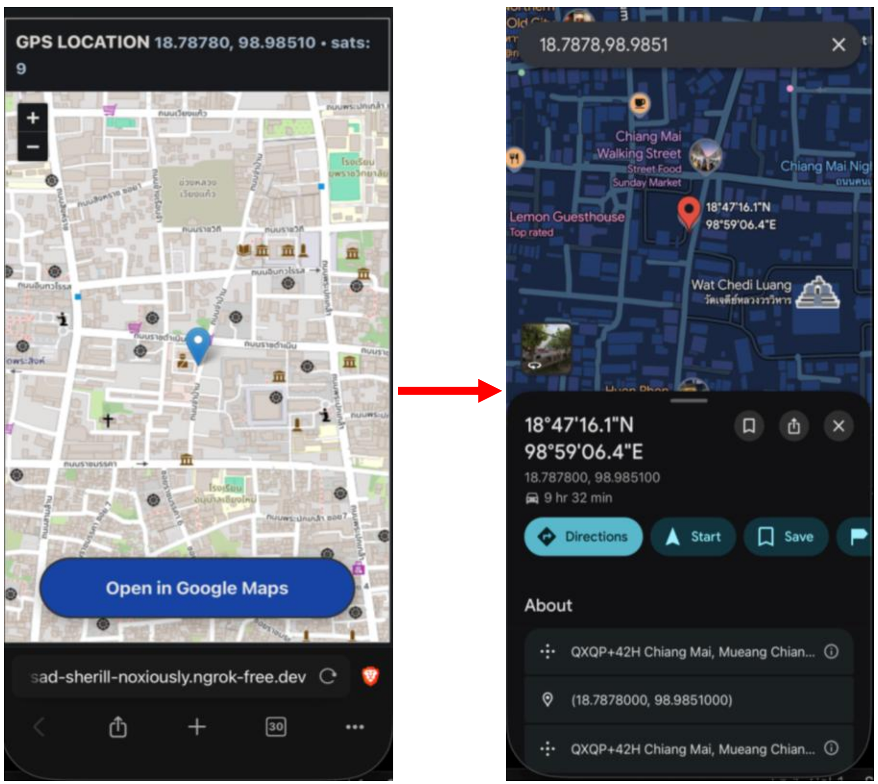
Techit Monsakul

GCS Overview



GCS Changes Since PDR (1/2)

Changes	PDR	CDR	Rationales
Remote Recovery Tracking	Not implemented	Used ngrok for secure public access to the GCS Map	Provides remote monitoring and real-time GPS tracking to assist CanSat recovery




```
Session Status                online
Account                       Techit Monsakul (Plan: Free)
Version                       3.37.1
Region                        Asia Pacific (ap)
Latency                       34ms
Web Interface                 http://127.0.0.1:4040
Forwarding                    https://dorsad-sherill-noxiously.ngrok-free.dev -> http://localhost:8080

Connections                   ttl     opn     rt1     rt5     p50     p90
                              37      0       0.03    0.05    0.55    22.23

HTTP Requests
```

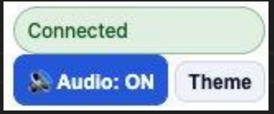
- Recovery team members can access the live dashboard on their smartphones via an **ngrok link** to monitor the CanSat's descent.
- They can use a one-click Google Maps button for instant turn-by-turn navigation directly to the landing coordinates.

GCS Changes Since PDR (2/2)

Changes	PDR	CDR	Rationales
Audio Telemetry Announcement	Not implemented	Implemented voice annunciation for critical flight events and telemetry	Delivers real-time audio updates on altitude and system states for operators

```
el.toggleAudio?.addEventListener('click', () => {
  st.audioEnabled = !st.audioEnabled;
  el.toggleAudio.textContent = `🔊 Audio: ${st.audioEnabled ? 'ON' : 'OFF'}`;
  if (st.audioEnabled) speak("Audio Assistant Enabled");
});

el.btnVoiceNav?.addEventListener('click', () => {
  st.voiceNavEnabled = !st.voiceNavEnabled;
  el.btnVoiceNav.textContent = `🔊 Voice Nav: ${st.voiceNavEnabled ? 'ON' : 'OFF'}`;
});
```



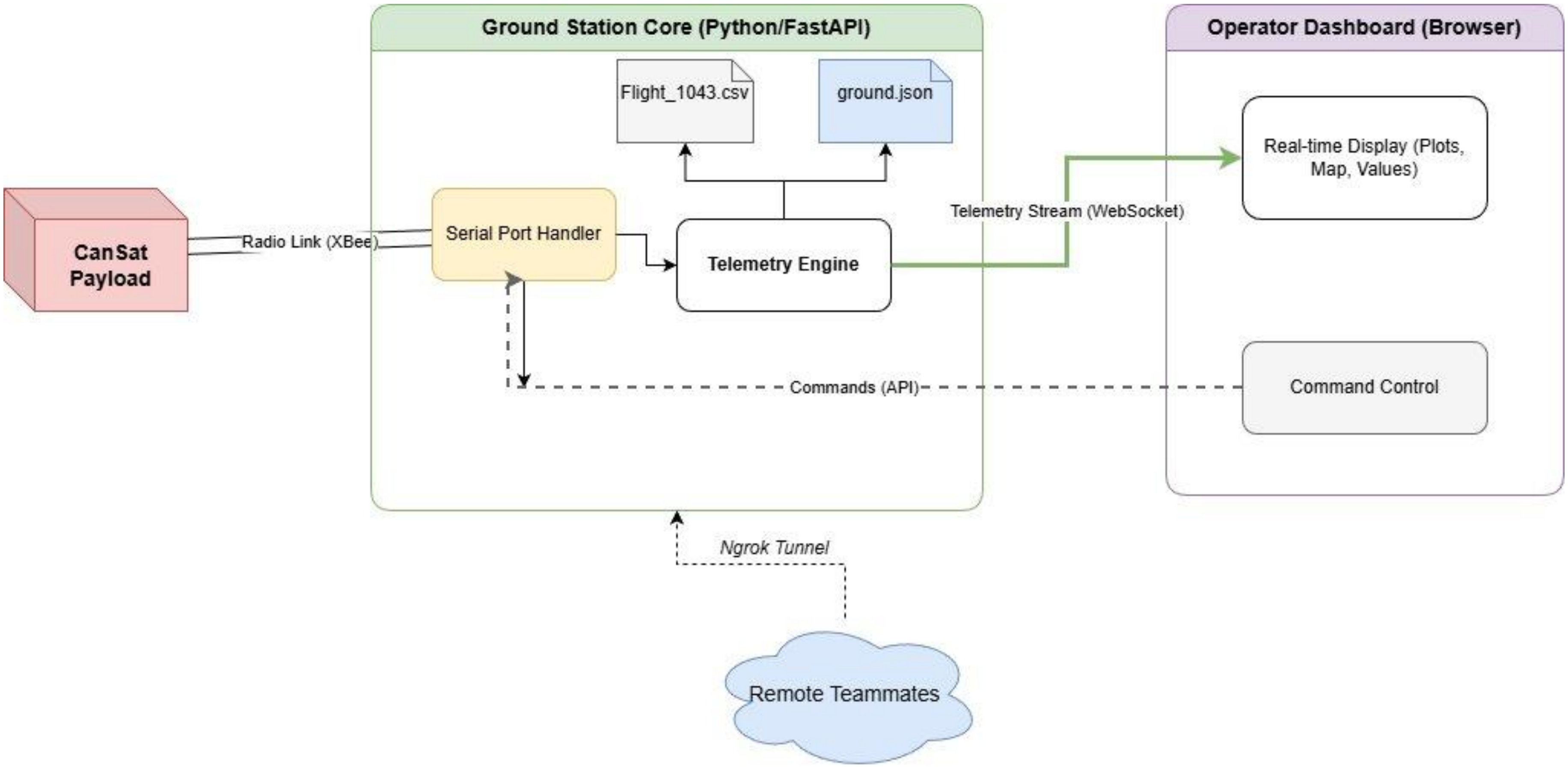

```
    if (st.voiceNavEnabled && dist > 5) {
      const now = Date.now();
      if (!st.lastNavSpeech || (now - st.lastNavSpeech > 15000)) { // Speak
        speak(`Payload is ${Math.round(dist)} meters away. Heading ${Math.r
        st.lastNavSpeech = now;
      }
    } else if (st.voiceNavEnabled && dist <= 5 && !st.arrivedSpoken) {
      speak("You have arrived at the payload.");
      st.arrivedSpoken = true;
    }
  }, err => console.warn("Geo error", err), { enableHighAccuracy: true });
} else {
  alert("Geolocation (External GPS) not supported or allowed.");
```

```
async function fetchDiagnosticText() {
  try {
    const res = await fetch('/api/health');
    if (res.ok) {
      const data = await res.json();
      if (!data.serial || !data.serial.port) {
        return "Warning: XBee port configuration not found.";
      } else {
        return `System initialized. Connected to Ground Station hardware on p
      }
    } else {
      return "System initialized with backend warnings.";
    }
  } catch (e) {
    return "Warning: Ground Station backend is offline.";
  }
}
```

The mission control software now uses **automated voice** announcements to call out critical state changes and live altitude readings, allowing the operator to maintain visual tracking of the CanSat without constantly looking at the screen.

GCS Design (1/4)

- **Ground Station Diagram**



GCS Design (2/4)

Our Portable Ground Station, fully functional meets all criteria: handheld, under ≈15 lbs, zero assembly, and single-switch operation.

Completed CDR Specs:

- **Hardware:** A **standalone** 3D-printed enclosure powered by an embedded Raspberry Pi 4 with a **built-in 10-inch display**.
- **Power & Comms:** 4+ hour internal battery and integrated XBee radio with external SMA antenna.
- **Software:** Auto-booting, fully offline architecture ready in seconds.
- **UI & Data:** Outdoor-optimized interface (high contrast, 14pt+) with one-click USB telemetry export.

GCS Design (3/4)

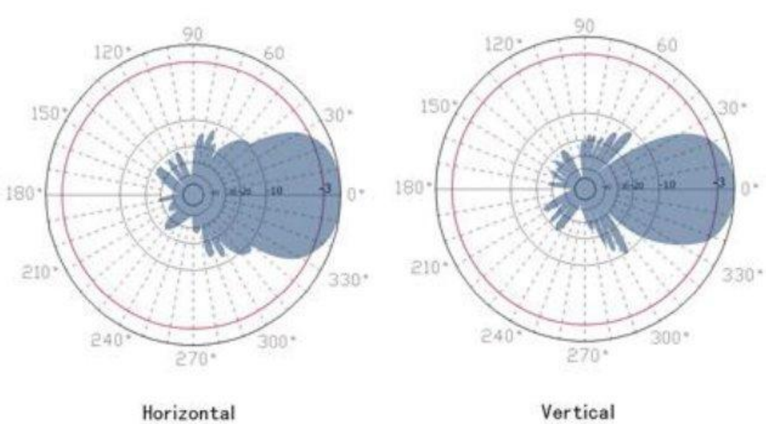
Mark Walker Portable Ground Station Design

GCS Design (4/4)

- **Specification**
  - Battery:
    - GCS is capable of operating continuously for a minimum of two hours. In the event of an emergency, a backup power bank will be available to provide additional charging for the laptop.
  - Overheating Mitigation:
    - GCS will be operated under umbrellas or other shading solution, minimizing thermal loading and prevent overheating. In addition, a secondary laptop with the GCS software preinstalled will be available as a backup system.
  - Auto Update Mitigation:
    - All automatic updates will be disabled on the GCS laptop to prevent unexpected interruptions during operation.

GCS Antenna (1/4)

Models	Frequency Range (MHz)	Gain	Direction	Polarization	Weight (KG)	Cost (USD)
ZDADJ900-12YG	824-960	12 dBi	Directional	Vertical and Horizontal	0.62	73.95



ZDADJ900-12YG Patterns

Selected GCS Antenna	Rationales
 ZDADJ900-12YG	• Higher gain compared to the alternative option • Wide frequency range • Rugged build for all weather conditions • Lower cost

A team member will **hold the antenna** and manually track the CanSat during the flight.

Antenna Length and Weight	0.81 m long and 0.62 kg weight
Antenna Construction	ZDADJ900-12YG is a detachable antenna.
Antenna Portability	Designed for easy transport, the antenna can be safely packed in luggage for international flights.

HAND-HELD

GCS Antenna (3/4)

Variables	Values
P_{TX}	24 dBm
G_{TX}	2.4 dBi
G_{RX}	12 dBi
L_{TX}	0.6 dB
L_{RX}	0.6 dB
L_M	0 dB
f	915 MHz
d	3 km

1. Free Space Path Loss (FSPL)

L_{FS} (dB) = 20·log10(d) + 20·log10(f) + 32.45

L_{FS} ≈ 9.54 + 59.23 + 32.45 ≈ **101.22dB**

2. Received Power Calculation

P_{RX} (dBm) = P_{TX} + G_{TX} - L_{TX} - L_{RX} - L_{FS} - L_M + G_{RX}

P_{TX} + G_{TX} + G_{RX} = 24 dBm + 2.4 dBi + 12 dBi = 38.4 dB

L_{TX} + L_{RX} + L_{FS} + L_M = 0.6 dB + 101.22 dB + 0 dB + 0.6 dB = 102.42 dB

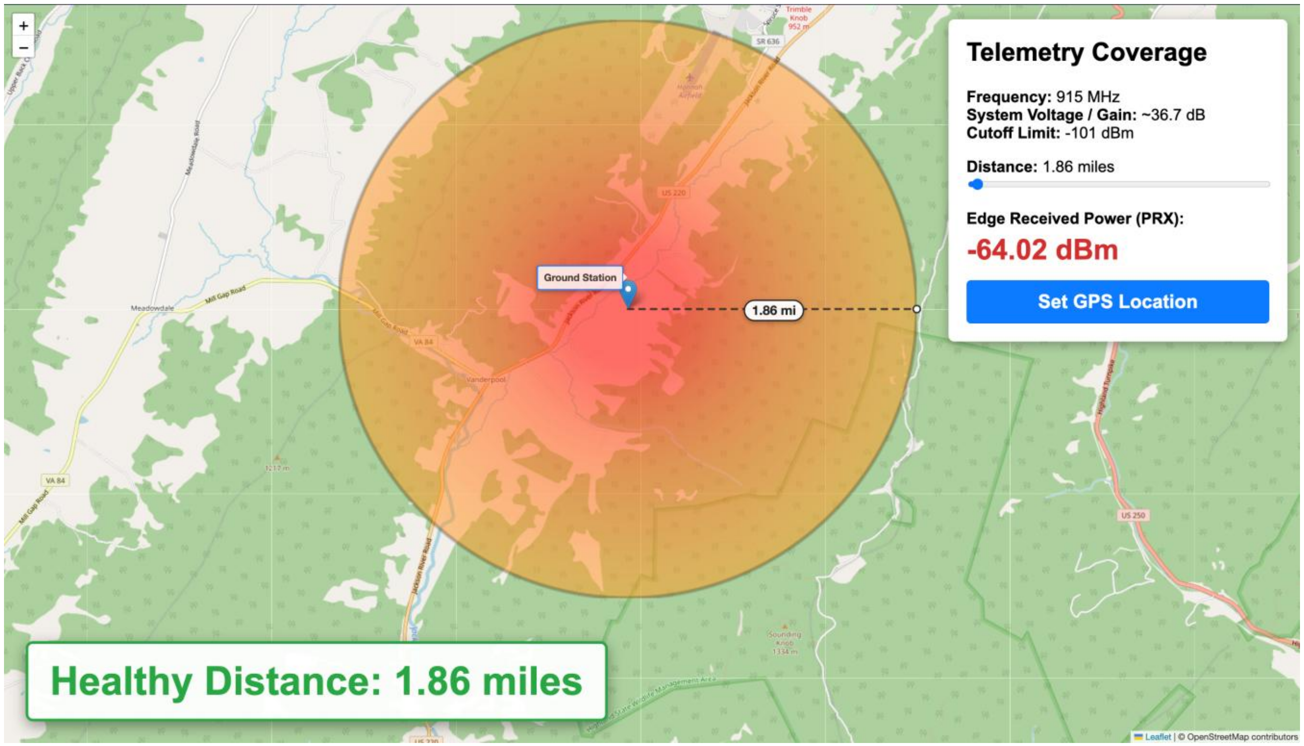
P_{RX} = 38.4 - 102.42 = **-64.02 dBm**

Variables	Calculated Values	3. Link Budget	4. Link Margin
L_{FS}	**101.22 dB**	**-64.02 dBm > -101.00 dBm**	-64.02 dBm - (-101.00 dBm) = **+36.98 dB**
P_{RX}	**-64.02 dBm**		

The signal strength at **3 km** confirms a resilient telemetry link that exceeds **safety standards**, ensuring data integrity against signal fading and antenna misalignment for continuous tracking from launch to recovery.

GCS Antenna (4/4)

ANTENNA COVERAGE AREA



Signal Strength Gradient:

🔴 **Red/Orange: High signal strength (Optimal data link).**

🟡 **Yellow/Green: Moderate signal strength (Reliable line-of-sight).**

🔵 **Blue/Edge: Approaching the receiver's absolute cutoff limit for about 3 km. (-101 dBm).**

GCS Software (1/6)

- **Telemetry display screen shots**

- **Real-Time Visualization:** Live telemetry rendering powered by ECharts.
- **Secure Data Logging:** Continuous `.csv` export via Python for post-flight analysis.
- **Interactive UI:** Hover-over tooltips provide precise timestamps and data values instantly.

Commercial off the shelf (COTS) software packages used

Backend (Python)

- FastAPI: High-performance web framework for building APIs.
- Uvicorn: Lightning-fast ASGI server implementation.
- PySerial: Python serial port access library for hardware communication.
- Pydantic: Data validation and settings management using Python type hints.
- Aiofiles: File support for asyncio.
- Python-Multipart: Streaming multipart parser for Python.

Frontend (JavaScript)

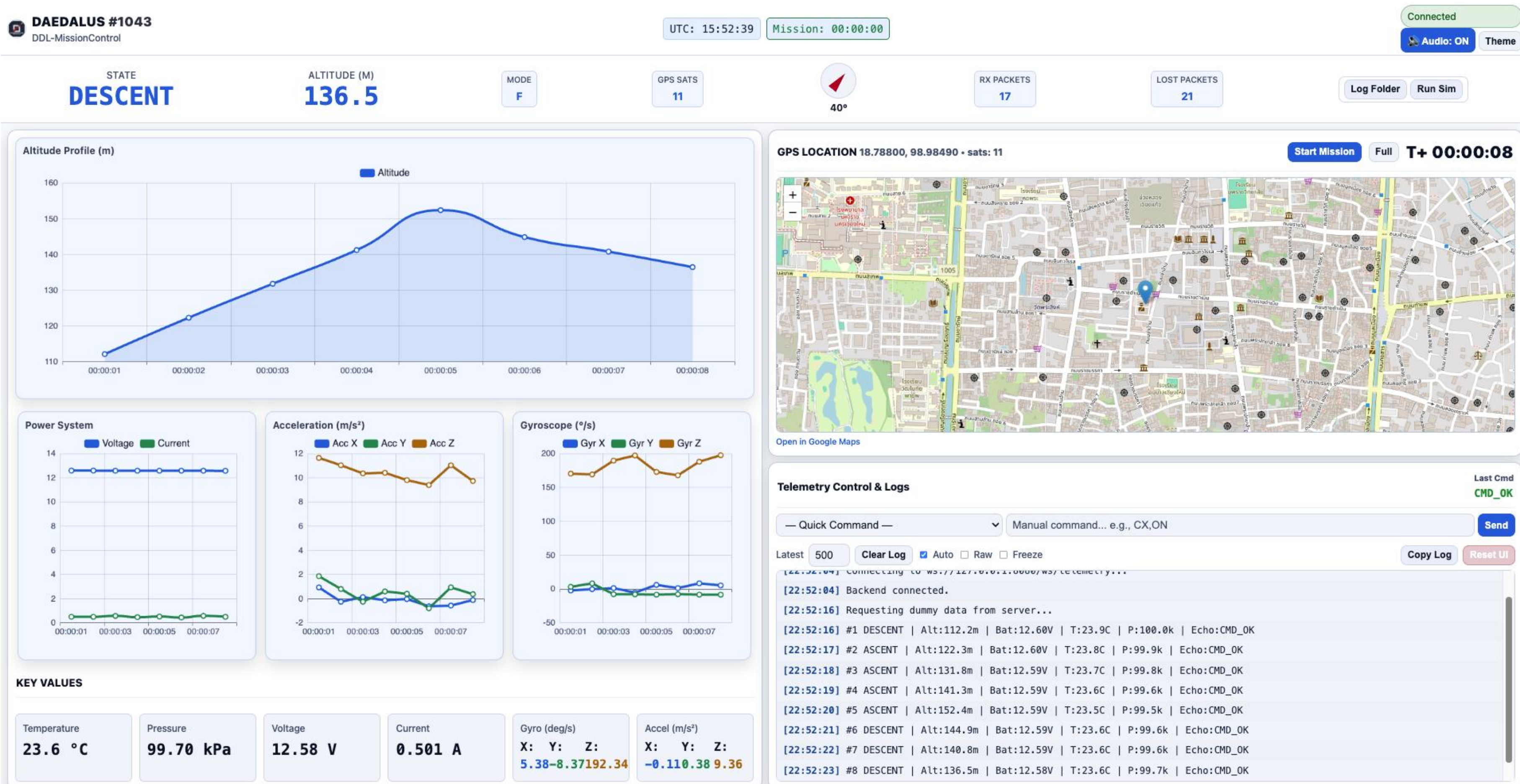
- ECharts: A powerful, interactive charting and visualization library.
- Leaflet.js: An open-source JavaScript library for mobile-friendly interactive maps.

External Tools

- Ngrok: A tool to expose a local web server to the internet (used for remote access).

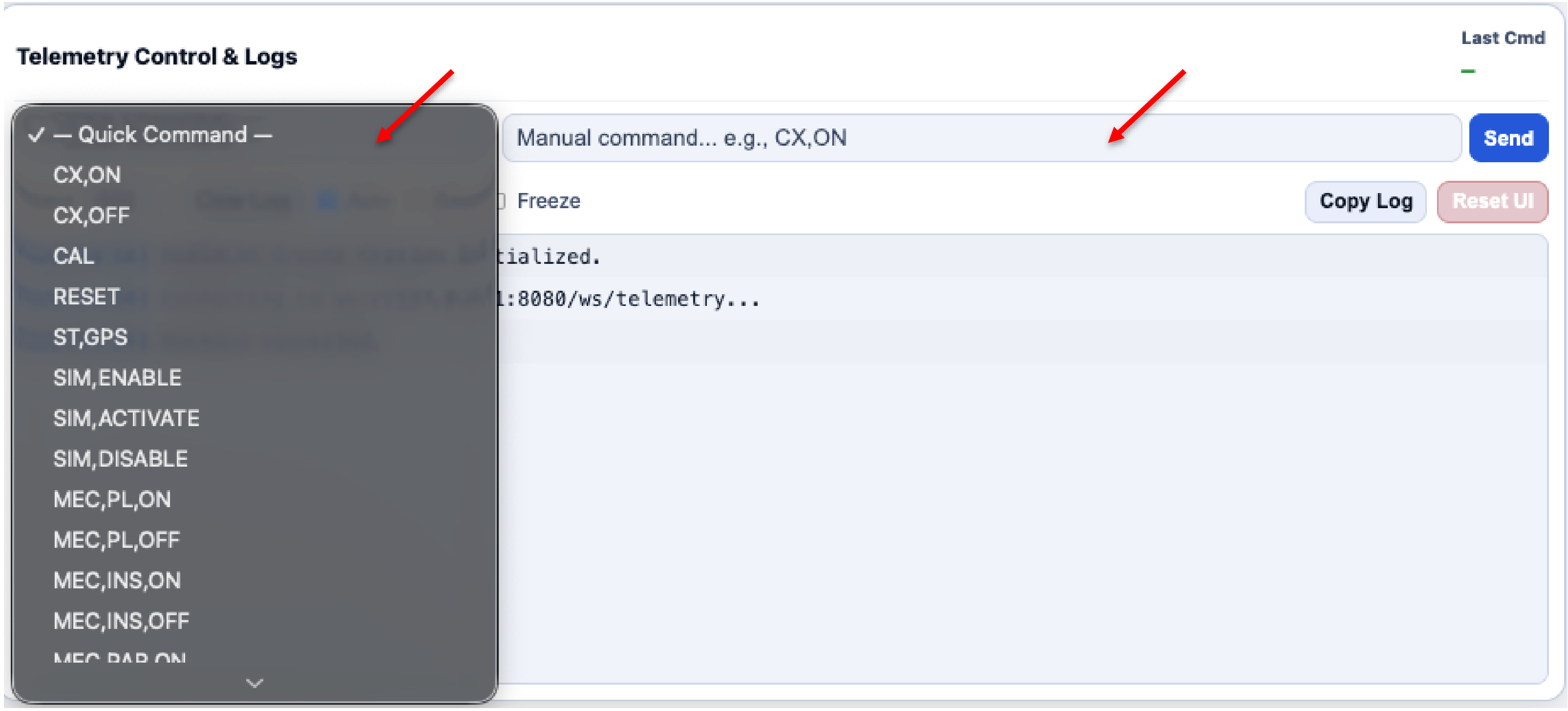
GCS Software (3/6)

Real-time plotting software design



Command software and interface

- The operator can send commands using **quick-action buttons** on the interface or by **typing commands manually** in the command line for debugging.
- The commands are then sent via a REST API to an asynchronous Python queue, which transmits them to the radio system while ensuring the user interface remains responsive and does not freeze during transmission.



Simulation mode

- Profile Reading: The ground station reads a pre-defined pressure profile (.csv) line-by-line.
- Transmission: A background task iterates through the file, wraps the pressure data into a command packet (CMD, 1043, SIMP,<value>), and transmits it via radio at a **1Hz** interval to emulate real-time descent rates.

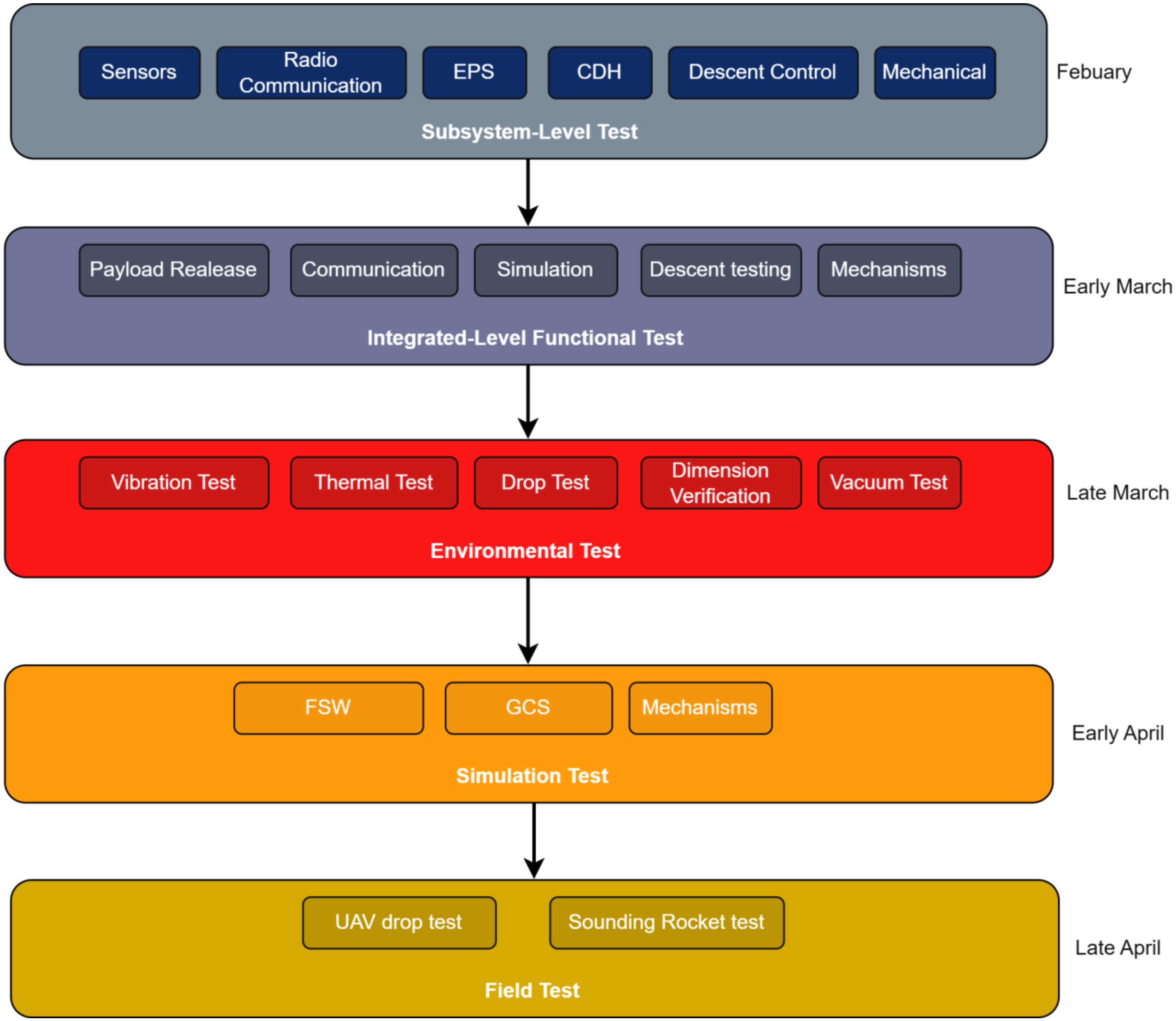
Progress Since PDR

Progress since PDR	
Telemetry & Data Handling	DONE
Command & Control	DONE
Simulation Mode	DONE
User Interface	DONE
GCS Laptop & XBee communication	DONE

CanSat Integration and Test

Kris Raungrit

CanSat Integration and Test Overview



Subsystem Level Testing Plan (1/5)

Subsystem	Components	Test Plans	Pass Requirement
Sensors	STM32H725 ISM6HG256X BMP581 MAX-M10S INA236 BNO086 ESP-CAM with OV5640	• Each subsystem was individually connected to the STM32H7 for basic functionality verification and calibration. • Calibration was performed to ensure sensor accuracy and correct actuator response. • After individual verification and calibration, all subsystems were integrated and tested as a complete system.	• Sensor outputs remain within specified accuracy and resolution limits. • Data is updated at the required sampling rate. • Continuous operation exhibits no data loss or communication errors. Tested to identify inaccurate readings, noise, calibration errors, and data dropouts under varying conditions.
CDH	STM32H725 SD card XBee Pro	• Verification of task scheduling and interrupt handling. • Data flow testing between sensors, storage, and communication subsystems. • Stress testing for timing, memory usage, and processor load.	• All tasks execute within defined timing constraints. • No data corruption or unexpected resets. • Stable operation under maximum processing load. Evaluated to detect data handling errors, timing faults, memory issues, and improper subsystem coordination.

Subsystem Level Testing Plan (2/5)

Subsystem	Components	Test Plans	Pass Requirement
EPS	Vapcell M35 Voltage Conversion	• Voltage and current conducted under nominal and peak load conditions. • Power cycling and brownout testing. • Endurance testing to verify mission-duration capability.	• Output voltages remain within allowable tolerance ranges. • No system reset or failure during load changes. • Power capacity supports full mission duration. Tested to identify voltage instability, current overloads, power losses, and regulator failures under different load conditions
Radio Comm.	STM32H725 XBee Pro S3B Ground Station Antenna	• Range testing conducted under open-field conditions. • Packet integrity and error-rate evaluation. • Continuous telemetry transmission testing.	• Telemetry received with acceptable packet loss rate and range. • Stable communication link throughout test duration. • Correct data formatting and timing. Assessed to detect packet loss, latency issues, signal degradation, and command reception failures.

Subsystem Level Testing Plan (3/5)

Subsystem	Components	Test Plans	Pass Requirement
FSW	Avionics Actuators Ground station	• Unit testing of individual software modules. • Deployment moment tests were conducted to verify correct triggering, timing, and system response during deployment events. • Simulation testing of state transitions and fault handling. • Hardware-in-the-loop testing with live sensor inputs. • Clean switching between Flight and Simulation mode.	• Correct mission state transitions under all defined operating conditions. • No absence of software crashes or undefined system states. • Accurate data handling and logging. • Check the algorithm’s behavior after running for a long time. Tested to identify logical errors, incorrect state transitions, fault-handling failures, and unexpected behavior during mission sequences.

Subsystem Level Testing Plan (4/5)

<table>
<tr><th>Subsystem</th><th colspan="2">Components</th><th>Test Plans</th><th>Pass Requirement</th></tr>
<tr><td rowspan="3">Mechanical</td><td colspan="2">Servo</td><td>• After being mounted on the CanSat, the servo functions as the actuator for the deployment mechanism.</td><td>• The servo operates properly with no interference.
• Survive 30G shock.</td></tr>
<tr><td rowspan="2">Payload</td><td>Deployment</td><td>• The container and egg release the payload at the scheduled moment.
• Ensure that the deployment operation does not adversely affect the performance of other subsystems, such as power distribution.</td><td>• The container and egg shall release the payload at the scheduled moment within ±1 second of the predefined deployment time.
• The deployment operation shall not cause any abnormal behavior, voltage drop, or reset in other subsystems, including power.</td></tr>
<tr><td>Camera</td><td>• Inspect and verify the tightness and mechanical stability of all camera mounting points to ensure the camera remains securely fixed during operation.</td><td>• All camera mounting points shall be secure and stable, with no looseness, movement, or vibration during normal operation.

Inspected to detect structural weaknesses, misalignments, fastening issues, and deployment interference.</td></tr>
</table>

Subsystem Level Testing Plan (5/5)

Subsystem	Components	Test Plans	Pass Requirement
Descent Control	Parachute	• The CanSat will be dropped from a high structure to evaluate the descent speed.	• The parachute descends at a speed of 15 m/s. • The egg shall remain intact with no cracks or breaks.
	Paraglider	• Repeat the drop test multiple times to ensure consistent performance. • Observe the gliding behavior of the paraglider. • Test the paraglider's ability to withstand wind forces. • Assess the paraglider's steering performance controlled by servos.	• Verify that the descent speed is approximately 5 m/s. • Verification that the payload is capable of returning to the designated landing landmark. • The egg shall remain intact with no cracks or breaks. Tested to identify instability, control inefficiencies, and failure to meet descent rate requirements.

Integrated Level Functional Test Plan (1/4)

Payload Release from Container

Test Component	Test Plans	Pass Requirement
Release Trigger	• Simulate payload release trigger at 534.4 m to verify proper activation • Integrate the CanSat system with a drone and lift to target altitude • Release the container and payload during flight	• Release at 450 m as intended • Successful separation of container and payload • No premature deployment • Mechanism works properly
Mechanisms	• Position the CanSat horizontally on a stable surface to simulate deployment conditions. • Ensure the system is properly secured before testing. • Trigger the release mechanism according to the designed activation method. • Test the servo under load to verify it can rotate and control	• The payload separates smoothly from the container • No jamming or structural damage occurs • The system remains functional after testing • Servo rotates under load without stalling
Payload Release	• Payload release at 80% of peak altitude • The parachute is properly connected and responds to the control system • Observe system response	• Payload is released at the 80% of peak altitude • Release mechanism activates correctly • Parachute responds correctly without malfunction.

Communication

Test Component	Test Plans	Pass Requirement
Ground Station Software	• Connect the ground station to the communication module and receive telemetry packets from the CanSat. • Verify that the software correctly parses ASCII telemetry fields, displays data in real time, and logs the data to a file.	• Ground station successfully receives, decodes, displays, and logs telemetry packets continuously without data corruption or software crash.
Telemetry	• Transmit telemetry packets from the CanSat at 1 Hz containing all required data fields (e.g., time, sensor data). • Verify packet format (ASCII, comma-separated, newline termination) and monitor data integrity during transmission.	• Telemetry packets are transmitted at 1 Hz, correctly formatted, and at least 95% of packets are received without errors during the test period.
Antennas	• Test communication between the CanSat and the ground station at increasing distances in an open field. • Monitor signal strength and packet reception while the antennas are properly oriented.	• Stable communication link is maintained and telemetry packets are successfully received at the required operational distance with minimal packet loss.

Mechanisms

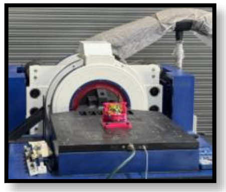
Test Component	Test Plans	Pass Requirement
Descent Test	• Verify that the system descends safely under parachute and parafoil • Measure descent rate during flight or controlled drop test • Observe stability and controlled descent behavior	• Descent rate is within acceptable margin • System descends stably without excessive oscillation • Parachute and parafoil deploy and function correctly
Simulation	• Simulate flight conditions using pressure (altitude) data • Trigger key such as payload release and deployment • Monitor system response and telemetry output	• All events are triggered at the correct conditions within acceptable margin • System responds correctly without malfunction • Telemetry data is accurate and continuously transmitted
Instrument Deployment	• Activate mechanism at 2 m height • Repeat test multiple times to check consistency • Observe release timing and landing condition	• Egg released at 2 m (±0.5 m) • Egg lands intact with no damage • Mechanism works reliably every test

Integrated Level Functional Test Plan (4/4)

Mechanisms

Test Component	Test Plans	Pass Requirement
Payload Release	• Simulate altitude using vacuum or simulation mode • Trigger release at 80% peak altitude • Observe separation and deployment behavior	• Payload releases at correct altitude condition • Separation is clean without obstruction • All deployment mechanisms function properly
Environmental Test	• Perform drop test (shock) • Perform vibration test • Perform thermal and vacuum tests	• No structural damage or loose components • System remains powered and functional • Telemetry and sensors operate normally
Camera System	• Record video during deployment and descent • Test both cameras (side + downward) • Review recorded footage	• Both cameras record successfully • Video clearly shows deployment and ground view • Resolution ≥ 640×480 and no data loss

Environmental Test Plan (1/3)

Test	Test Plan	Pass Requirement
Vibration Test	• Power on CanSat. • Mount the CanSat on a vibration testing machine (Electrodynamic shaker). • Apply vibration for 5 seconds per trial, repeated five times at 230Hz of vibration. • Monitor telemetry, power status, and sensor data during and after testing. • Cansat must survive 15 Gs vibration. • A three-level vibration test was conducted to evaluate structural integrity and system functionality under progressively increasing frequency conditions • Level 1 (Low): 5Gs 230Hz • Level 2 (Mid): 10Gs 80Hz • Level 3 (High): 15Gs 10Hz	• CanSat maintains continuous power during the vibration test. • Telemetry data is transmitted without interruption. • No internal components become loose or detached. • The structure shows no visible damage after the test. • All subsystems operate normally after the vibration exposure. 
Thermal Test	• Power on the CanSat. • Test the CanSat in a thermal chamber at 60°C for 2 hours (GE300)-STAINLESS STEEL. • Inspect 3D-printed and plastic components for warping or softening. • Verify stable operation of electronic boards and batteries. 	• CanSat maintains continuous power and telemetry during the test. • Internal temperature readings are transmitted correctly. • All electronic subsystems operate normally after the test. • No material deformation, warping, or component failure occurs.

Environmental Test Plan (2/3)

Test	Test Plan	Pass Requirement
Drop Test	• Power on CanSat. • Perform shock testing by dropping a CanSat using a rope that long 1Meter and hook first. • Visually inspect the structure after each test. • Mount CanSat on a shocking testing machine. • Apply a shock of 30G force • Monitor telemetry, power status, and sensor data during and after testing.	• CanSat maintains power on after test. • No interior or exterior damage is identified. • Telemetry are received continuously, and no error is identified.
Dimension Verification	• Insert the CanSat into the payload section • Verify proper mechanical fit • Ensure it meets dimensional requirements • Check that it can be installed and removed smoothly • Confirm no interference from structural or external components • Measured by using Vernier Caliper	• CanSat container fits within the rocket payload section. • The container slides in and out smoothly without obstruction. • No interference with the rocket structure or parachute system. • The CanSat remains structurally intact after installation and removal. • Shoulder diameter **136 mm** • Diameter above shoulder **140 mm** (S12) • Length above shoulder **200 mm ± 5%** • Wall thickness **≥ 2 mm**

Environmental Test Plan (3/3)

Test	Test Plan	Pass Requirement
Vacuum Test	• Power on CanSat. • Operate the CanSat under low-pressure conditions to simulate high-altitude flight. • Verify stage logic, flight software (FSW), barometer performance, and deployment. • Monitor telemetry and sensor data during and after testing.	• Telemetry continues to transmit during the vacuum test. • Pressure and altitude readings respond correctly to pressure changes. • All altitude-triggered mechanisms activate as expected. • The CanSat remains operational after the test.

Test Procedures Descriptions (1/7)

System	Test Proc	Test Description	Rqmts	Pass Fail Criteria	Status
Operational Requirements	1	**The Deployment Test:** The payload separates from the container and all systems, including deployment mechanisms and cameras, activate and operate correctly during descent.	C5, C6,C10 C11	The test passes if the payload separates successfully and all systems, including cameras, function as intended without failure	**Pass**
	2	**Descent Rate Test:** The parachute is dropped from a height to measure its descent velocity, using a ballast mass equivalent to the actual payload.	C4,C7	The velocity, descent rates and rotation should be within margin	**Pass**
	3	Conduct a controlled flight or field test Deploy payload with para-glider system Track trajectory using GPS data Compare actual path with target location	C8,C9 C12,C13	Payload shows **intentional steering behavior** Trajectory demonstrates **movement toward target location**	**Pass**
Structural Requirements	4	The container is inserted into a tube and the payload is placed inside to verify proper fit, while key dimensions are measured to ensure compliance with requirements.	S13 S15,S16 S20,S21	The test passes if the container and payload fit properly and all dimensions meet requirements	**Pass**

Test Procedures Descriptions (2/7)

System	Test Proc	Test Description	Rqmts	Pass Fail Criteria	Status
Environmental Test	5	**Drop Test:** The CanSat can withstand 30 G shock by releasing it using a 61 cm non-stretching cord attached to a fixed structure.	S9	The structure remains intact, all components stay secured, and the system maintains power and telemetry; otherwise, it fails.	**Pass**
	6	An orbital sander is used to simulate vibration on the CanSat	S8	All systems shall function as intended without any compromise to structural integrity.	**Pass**

Test Procedures Descriptions (4/7)

System	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Communications	7	**Telemetry Rate:** Connect CanSat to Ground Station. Log telemetry for 60 seconds and verify packet timestamps.	X4	Ground Station logs exactly one packet per second (1 Hz) with zero dropped packets.	**Pass**
	8	**Telemetry Content:** Capture telemetry via Ground Station software and inspect the parsed data string.	X5	Telemetry successfully displays readable values for altitude, pressure, temperature, battery voltage, command echo, and all GPS data (lat, long, alt, satellites tracked).	**Pass**
Ground Station	9	**UI & Telemetry Display:** Connect CanSat to Ground Station. Transmit telemetry and verify dashboard plots, text, and units.	G6,G7 G8	Software successfully displays all required real-time plots and text values (time, temp, GPS, packets, state). All data is strictly in explicitly labeled SI units.	**Pass**

Test Procedures Descriptions (5/7)

System	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Ground Station	10	Hardware & Portability: Assemble Ground Station (laptop, XBEE, antenna). Run continuously on laptop battery to simulate flight-line conditions.	G9,G10	Fully portable setup; operates for 2+ hours on laptop battery without AC power.	Pass
	11	Simulation Mode: Send simulation commands to CanSat via Ground Station software and initiate the CSV pressure data feed.	G11,G12	Transmits SIMULATION ENABLE and ACTIVATE commands, then streams CSV pressure data at 1 Hz.	Pass
	12	Received Packet Counter: Verify Ground Station packet counter during active telemetry transmission.	G16	Ground station accurately tracks and displays the total count of successfully received packets, completely independent of the CanSat's onboard transmitted count.	Pass
Flight Software	13	Resets & State: Transmit telemetry to establish packet count and calibration state. Force a processor reset and resume telemetry.	F1,F8	Post-reset: packet count continues from its previous value and zero-altitude calibration persists.	Pass
	14	Simulation Mode: Send SIMULATION ENABLE and ACTIVATE commands. Transmit 1 Hz pressure profile from Ground Station.	F4,F5,F6	Sim mode requires both commands. Altitude is calculated solely from uplinked 1 Hz pressure data.	Pass

Test Procedures Descriptions (6/7)

System	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Electrical Requirements	15	Power on the electronics board and confirm that all components can operate continuously for a minimum of 2 hours.	E6	The CanSat is capable of operating continuously for a minimum duration of 2 hours.	**Pass**
Sensor Requirement	16	The CanSat altitude measurement from pressure shall be verified by changing its height.	SN1	Altitude value changes consistently with height change.	**Pass**
	17	The internal temperature measurement shall be verified by operating the CanSat	SN2	Temperature data is transmitted and shows reasonable variation.	**Pass**
	18	The battery voltage measurement shall be verified by powering the CanSat.	SN3	Temperature data is transmitted and shows reasonable variation.	**Pass**
	19	The GPS tracking capability shall be verified by placing the CanSat outdoors.	SN4	Battery voltage is measured and decreases gradually during operation.	**Pass**
	20	The acceleration and rotation measurements shall be verified by moving and rotating the CanSat.	SN5	Valid latitude, longitude, and satellite data are received and updated.	**Pass**

Test Procedures Descriptions (7/7)

System	Test Proc	Test Description	Rqmts	Pass/Fail Criteria	Status
Sensor Requirements	21	The para-glider deployment recording shall be verified by triggering the deployment condition.	SN6	Deployment event is clearly visible in the recorded video at 80% peak altitude.	**Pass**
	22	The ground recording during descent shall be verified by performing a descent test.	SN7	Continuous video of the ground is recorded during descent.	**Pass**
	23	The instrument release recording shall be verified by releasing the instrument.	SN8	Release and landing of the instrument are visible in the video.	**Pass**
	24	The video performance requirement shall be verified by reviewing recorded footage.	SN9	Video is recorded in color with resolution	**Pass**
	25	The battery current measurement shall be verified by operating the CanSat.	SN10	Battery current data is transmitted and varies with system activity.	**Pass**

Simulation Test Plan (1/2)

Parts	Descriptions
FSW	• Correct reception and decoding of simulated pressure data. • Proper substitution of simulated data for real barometer readings. • Correct altitude computation from pressure input. • Correct execution of flight events at predefined simulated altitudes. • Robust handling of missing data or end-of-file conditions.
Mechanism	• Verification that the deployment mechanism activates the actuator at the predefined target altitude. • Evaluation of system robustness against sensor noise or fluctuating altitude data.
GCS	• Correct formatting and packaging of pressure data according to the defined telemetry/command protocol. • Reliable transmission of simulated pressure data to the payload. • Command timing and update rate consistency. • Communication link integrity between GCS and payload.
End-to-End System	• Correct synchronization between GCS pressure playback and FSW response. • Repeatable execution of flight logic using identical pressure datasets. • Validation of flight logic without reliance on physical pressure changes.

Simulation Test Plan (2/2)

Simulation Implementations

1. The GCS transmits SIM,ENABLE and SIM,ACTIVATE.
2. The GCS reads the pressure values sequentially from the text file.
3. Pressure values are transmitted to the payload at a fixed 1Hz rate.
4. The FSW receives the pressure data and treats it as barometer-sensor input.
5. Altitude is calculated onboard using the existing pressure-to-altitude conversion algorithm behavior.
6. Flight state transitions and events are triggered based on pressure-derived altitude thresholds.
7. The FSW logs and transmits telemetry using the simulated pressure data.

Mission Operations & Analysis

Warithnun Kliesuwan

Overview of Mission Sequence of Events (1/2)

Sequence of Event

Arrival

Pre-launch

Check-In
- Inspect CanSat and hardware
- Complete pre-launch checklist (MCO)
- Set up Ground Control Station (GCS)

Pre-launch Preparation
- Verify battery, power, and deployment systems (CC)
- Activate and check buzzer and control system (CC)
- Calibrate sensors and verify payload board (CC + GSC)
- Conduct communication and full system checks (CC + GSC)
- Perform safety checks and final CanSat assembly (Team)

Flight

Rocket Integration
- Perform final CanSat inspection (CC)
- Confirm telemetry and communication link (GSC)
- Integrate CanSat into the rocket (CC)

Launch
- Rocket is launched and CanSat is released
- Paraglider deploys automatically and control system activates
- Telemetry is received, displayed, and monitored in real time (GSC)

Post-flight

Recovery and Data Retrieve
- Track and locate CanSat via GPS and audio beacon (RC)
- Recover payload and return to launch site (RC)
- Retrieve flight and video data (GSC + RC)
- Submit telemetry data to field judge for review

Data Anyalysis
- Analyze telemetry and mission performance (GSC)
- Inspect hardware condition and document findings (CC + RC)
- Prepare and submit the Post-Flight Report (Whole Team)

Overview of Mission Sequence of Events (2/2)

Personnel Responsibilities

Team	Team Member(s)	Responsibilities
Mission Control Officer (MCO)	Trirayan Boontaganon	Responsible for coordinating the team during launch operations, verifying system readiness in coordination with the ground station crew, and conducting the final countdown from five to one prior to launch.
Ground Station Crew (GSC)	Techit Monsakul Watcharawit Leksuwankun Warithnun Kliesuwan	Responsible for monitoring telemetry reception at the ground station and issuing control commands to the CanSat during mission operations.
Recovery Crew (RC)	Kris Ruengrit Pasin Thawornwiriyakul	Responsible for tracking the CanSat throughout flight operations, conducting field recovery procedures, and returning the CanSat to the judges at check-in with all required payloads intact.
CanSat Crew (CC)	Rapassakorn Leelarujawanich Watcharawit Leksuwankun Warithnun Kliesuwan Nopparuch Ungpipatpong Watcharaphong Geeratayaporn	Responsible for preparing the CanSat, integrating it into the rocket, and verifying its operational status.

Field Safety Rules Compliance (1/2)

Mission Operation Manual	Content(s)
Introduction	• Overview of Team Member Roles and Responsibilities. • CanSat Hardware Components.
CanSat Safety Protocol	• Personnel Safety Procedures. • Hardware Handling and Assembly Safety. • Electrical and Power Safety. • Launch and Recovery Safety.
Ground Station Configuration	• Ground Station System Setup. • Antenna Alignment and Telemetry Reception. • Telemetry Monitoring and Command Operations.
CanSat Preparation	• Install and secure the battery and power system. • Avionics Activation and Communication Verification. • Pre-Flight System Inspection and Integration. • Test actuator functionality. • Final Readiness Inspection. • Launch Vehicle Integration and Pre-Launch Status Confirmation.
CanSat Integration	• Perform final CanSat system inspection. • Verify telemetry communication before integration. • Insert CanSat into the rocket payload bay. • Secure CanSat and ensure antenna/deployment clearance. • Perform final system check prior to launch.
Launch Preparation	• Document is provided by CanSat competition.
Launch Procedure	• Document is provided by CanSat competition.
Recovery Procedure	• Guide for Locating and Recovering the CanSat.

Field Safety Rules Compliance (2/2)

- The Mission Operations Manual is being developed to document procedures for all mission phases, including ground station setup, CanSat preparation, system integration, and flight operations.
- The manual includes operational checklists, system configuration procedures, communication protocols, and data handling procedures.
- Current development focuses on documenting procedures based on completed system testing and integration activities.
- Draft versions of the operational checklists and procedures have been completed.
- Remaining work includes refinement of procedures, validation through testing, and addition of contingency and safety protocols.
- The final Mission Operations Manual will be completed and assembled in a 3 ringed binder by the end of May before beginning flight rehearsals and submitted during the Flight Readiness Review (FRR) prior to launch.

CanSat Location and Recovery (1/2)

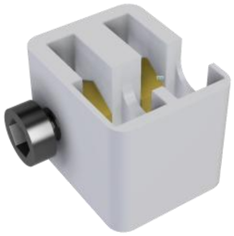
Recovery Strategy	Contents
Fluorescent Color	The CanSat uses a high-visibility color scheme, with a bright orange container and parachute and a red nose cone, to improve visual detection during descent and post-landing recovery.
Audio Beacon	An onboard buzzer emits a continuous beeping sound after power-up to assist the recovery team in locating the CanSat.
GPS Information	The GPS operates in airborne mode to help with accuracy when descending and provides the accurate landing location to the recovery crew in real time.
AirTag	The container can be tracked via an integrated AirTag when paired with an iPhone.
Exterior Label	A durable identification label is affixed to the exterior of the CanSat, displaying team and contact information for recovery identification.

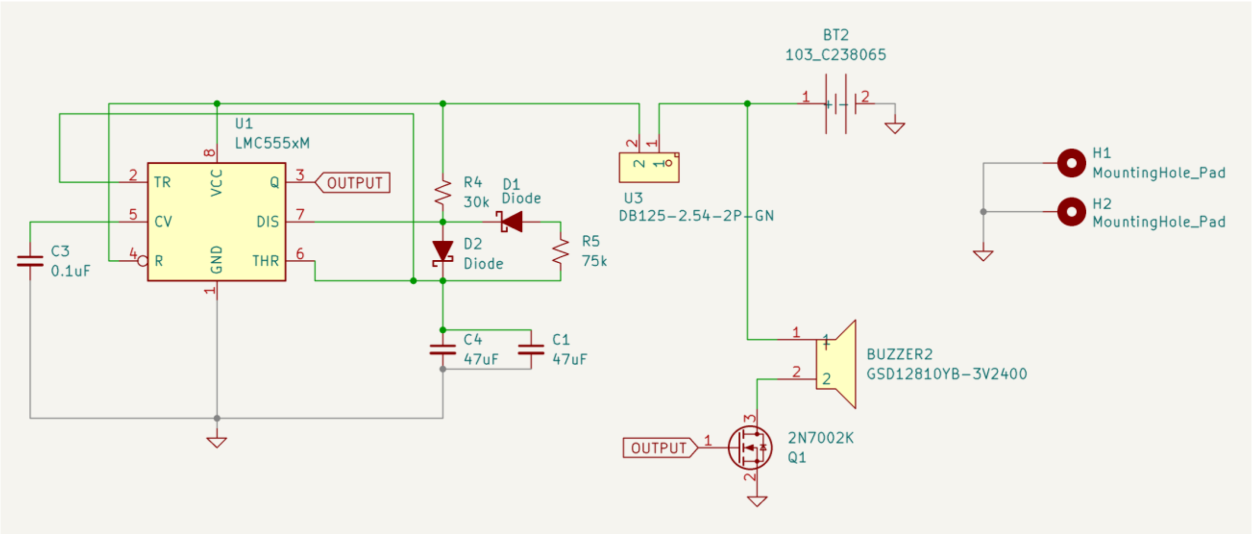
Exterior label:

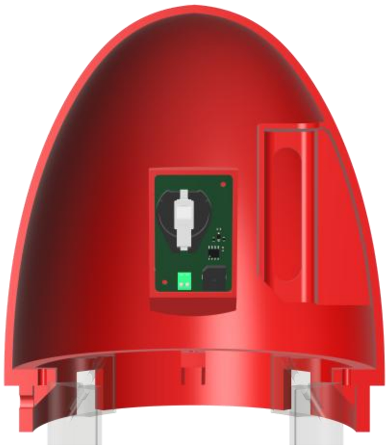
CanSat Location and Recovery (2/2)

- Beeps for 2000 milliseconds every 5 seconds.
- Safe power switch to prevent the beacon from turning off.
- Operating time: 8 hours 53 minutes.
- Mounted by nuts and screws (M2.5).
- The power is controlled by using the screw switch.
- Use an independent power supply, which is a coin cell isolated from the avionic.
- The audio beacon shall have an easily accessible power switch through the container.

Screw Switch







Placement of Beacon

Mission Rehearsal Activities (1/2)

Section	Rehearsal Date	Contents
Powering On & Off CanSat	4/10	1. Install the batteries into the CanSat electronics compartment. 2. Power on the CanSat system. 3. Verify that the power status indicator is active. 4. Power off the CanSat system. 5. Confirm that the power status indicator is inactive.
Ground System Radio Communication	4/10	1. Attach and connect the communication antenna to the ground station. 2. Power on the CanSat system. 3. Adjust the antenna orientation to optimize signal reception. 4. Verify that the ground station establishes a stable communication link. 5. Transmit the CX,ON command to initiate communication.
Launch Configuration Preparations	4/25-30	1. Inspect all structural connections and mechanical linkages for integrity. 2. Verify that all components are properly secured within the structure. 3. Fold and pack the CanSat parachute according to the deployment procedure. 4. Confirm that all servo actuators are positioned at their initial starting positions.

Mission Rehearsal Activities (2/2)

Section	Rehearsal Date	Contents
Telemetry Processing	4/10	1. Power on the CanSat system. 2. Confirm that the communication link with the ground station is established. 3. If the connection is successful, transmit the CXON command to enable telemetry transmission. 4. Verify that the ground station successfully receives telemetry data packets. 5. Confirm continuous and stable telemetry data reception.
Loading The CanSat in the launch vehicle	4/25-30	1. Perform a final inspection of the CanSat system. 2. Power on the CanSat. 3. Verify communication with the ground station. 4. Insert the CanSat into the launch vehicle payload tube. 5. Rotate the CanSat within the tube to verify smooth movement and proper clearance. 6. Reconfirm telemetry and communication link with the ground station.
Recovery	4/28-30	1. Visually track the CanSat during descent. 2. Monitor the latest GPS telemetry and AirTag data to estimate the landing location. 3. Recover the CanSat using the audio beacon and visual indicators to locate the payload.

Requirements Compliance

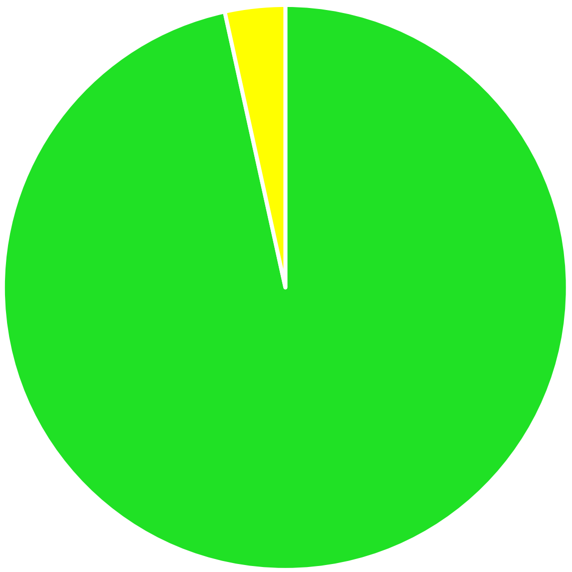
Trirayan Boontaganon

Requirements Compliance Overview

- The current design complies with most of the applicable missions and system requirements, as demonstrated through analysis, simulation, and testing.
- The following slides summarize the key design features, verification approaches, and test results that establish compliance with each requirement.
- While the design largely satisfies the stated mission and system requirements, a subset of requirements remains partially compliant pending final verification through fully integrated system testing.

  - 84 requirements are in compliance with the mission guide.
  - 3 requirements are partially in compliance with.
  - There are no requirements that are not in compliance.

Compliance



Requirements Compliance (1/11)

#	Requirements	Status	Ref. Slides	Notes
C1	The CanSat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	20	
C2	The CanSat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	20	
C3	The CanSat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	17, 18, 19	
C4	After deployment, the CanSat payload and container shall descend at 15 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	Comply	17, 18, 19	
C5	At 80% peak altitude, the payload shall be released from the container.	Comply	17, 18, 19	
C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Comply	17, 18, 19	
C7	The payload shall descend at 5 meters/second averaged over the entire descent within +/- 3 meters/sec with the para-glider descent control system.	Comply	17, 18, 19	
C8	The payload shall steer toward a target location.	Comply	50, 81, 82, 83, 84, 134	
C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	106, 108, 131, 132	

Requirements Compliance (2/11)

#	Requirements	Status	Ref. Slides	Notes
C10	The payload shall record video of the release of the payload from the container and the deployment of the para-glider descent control system.	Comply	35, 87	
C11	A second video camera shall point at the ground.	Comply	36, 88	
C12	The payload shall release a protected hen's egg when the payload is 2 meters +/- 0.5 m above the ground without breaking the egg.	Comply	19, 37, 89, 90, 91	
C13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat battery and electronics.	Comply	192	
C14	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	216	
S1	The CanSat and container mass shall be 1000 grams +/- 10 grams.	Comply	95, 96, 97, 98	
S2	The nose cone shall be symmetrical along the thrust axis.	Comply	70	
S3	Nose cone radius shall be exactly 70 mm.	Comply	70	
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	70	

Requirements Compliance (3/11)

#	Requirements	Status	Ref. Slides	Notes
S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	71	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	71	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	70	
S8	CanSat structure must survive 15 Gs vibration.	Partially Comply	175	Confirmed by vibration test
S9	CanSat shall survive 30 G shock.	Partially Comply	176	Confirmed by shock test
S10	The container shoulder length shall be 90 to 120 mm.	Comply	74	
S11	The container shoulder diameter shall be 136 mm.	Comply	74	
S12	Above the shoulder, the container diameter shall be 140 mm.	Comply	74	
S13	The container wall thickness shall be at least 2 mm when 3D printed and must not flex or be deformed when under stress.	Comply	74	

Requirements Compliance (4/11)

#	Requirements	Status	Ref. Slides	Notes
S14	The container length above the shoulder shall be 200 mm +/- 5%.	Comply	74	
S15	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	40	
S16	The CanSat container can be used to restrain any deployable parts of the CanSat payload but shall allow the CanSat to slide out of the payload section freely.	Comply	70, 75, 78	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	92, 93	
S18	The CanSat container shall meet all dimensions in section F.	Comply	74	
S19	The CanSat container materials shall meet all requirements in section F.	Comply	74	
S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Comply	N/A	We do not separate the nose cone.
S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Comply	N/A	We do not separate the nose cone.

Requirements Compliance (5/11)

#	Requirements	Status	Ref. Slides	Notes
M1	No pyrotechnical or chemical actuators are allowed.	Comply	N/A	We do not use nichrome wire.
M2	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	N/A	We do not use nichrome wire.
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partially Comply	72, 175	Confirmed by tests
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	92, 93	
E1	Lithium polymer batteries are not allowed.	Comply	120	
E2	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	120	
E3	An easily accessible power switch through the container is required.	Comply	119	
E4	The container shall have small access holes for power switches of no more than 10 mm.	Comply	119	
E5	Power indicator is required.	Comply	119	

Requirements Compliance (6/11)

#	Requirements	Status	Ref. Slides	Notes
E6	The CanSat shall operate for a minimum of two hours when integrated into the rocket.	Comply	122	
E7	The audio beacon shall operate on a separate battery.	Comply	192	
E8	The audio beacon shall have an easily accessible power switch through the container.	Comply	192	
X1	XBee radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBee radios are also allowed.	Comply	106	
X2	XBee radios shall have their NETID/PANID set to their team number.	Comply	106	
X3	XBee radios shall not use broadcast mode.	Comply	106	
X4	The CanSat shall transmit telemetry once per second.	Comply	106, 108, 131, 132	
X5	The CanSat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	108, 109, 110, 111	
SN1	CanSat payload shall measure its altitude using air pressure.	Comply	29	

Requirements Compliance (7/11)

#	Requirements	Status	Ref. Slides	Notes
SN2	CanSat payload shall measure its internal temperature.	Comply	30	
SN3	CanSat payload shall measure its battery voltage.	Comply	32	
SN4	CanSat payload shall track its position using GPS.	Comply	31	
SN5	CanSat payload shall measure its acceleration and rotation rates.	Comply	33, 34	
SN6	CanSat payload shall video record the deployment of the para-glider at 80% peak altitude.	Comply	35	
SN7	CanSat payload shall video record the ground during descent.	Comply	36	
SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Comply	36	
SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	35, 36	
SN10	CanSat payload shall measure its battery current.	Comply	32	

Requirements Compliance (8/11)

#	Requirements	Status	Ref. Slides	Notes
G1	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	113, 161	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	158	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	104, 109	
G4	Each team shall develop their own ground station.	Comply	147	
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Comply	158,160	
G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	160	
G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Comply	158,160	
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Comply	160	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and an antenna.	Comply	151, 153	

Requirements Compliance (9/11)

#	Requirements	Status	Ref. Slides	Notes
G10	The ground station must be portable so that 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	147, 151, 152, 153, 155	
G11	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	161, 162	
G12	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	162	
G13	The ground station shall use a table top or handheld antenna.	Comply	147, 155	
G14	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	151, 152, 160	
G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Comply	160	

Requirements Compliance (10/11)

#	Requirements	Status	Ref. Slides	Notes
G16	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	160	
G17	The ground station shall be able to activate all mechanisms on command.	Comply	161	
F1	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	109, 135	
F2	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	135	
F3	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	112, 132	
F4	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 file.	Comply	137, 162	
F5	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	137, 162	

Requirements Compliance (11/11)

#	Requirements	Status	Ref. Slides	Notes
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	112, 137	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	113, 133	
F8	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Comply	135, 136	

Management

Trirayan Boontaganon

Status of Procurements (1/3)

Component	Quantity	Status	Expected Arrival
Electrical Power and Sensor Subsystem Design			
PCB	3	Received	
Electronic Components	3 (sets)	Received	
Li-ion 18650 Battery	1	Received	
Coincell CR927 battery	5	Received	
Coincell CR2016 battery	5	Pending	6 April
MG90S Servo	2	Received	
HLS3612M-C001	3	Received	
Communication and Data Handling Subsystem Design			
Flexible GPS Antenna	1	Received	
Flexible XBee Antenna	1	Received	
Other components			
XT30 Connector	2	Received	
JST Connecter	7	Received	

Status of Procurements (2/3)

Component	Quantity	Status	Expected Arrival
Ground Station			
XBee pro s3b XBP9B-DMST-002	1	Received	
XBee adapter (Ft232 Ft232RI)	1	Received	
Raspberry Pi 4 (8GB RAM)	1	Received	
Geekworm Raspberry Pi X728	1	Pending	14 April
18650 Li-ion 3.7V Battery		Pending	7 April
ZDADJ900-12YG	1	Received	
RP-SMA Cable	1	Received	
52Pi 10.1-inch Touch Screen 1280X800	1	Pending	12 April
USB HUB HAT (B) for Raspberry Pi	1	Pending	10 April
VK-172 USB GPS	1	Pending	6 April

Status of Procurements (3/3)

Component	Quantity	Status	Expected Arrival
Mechanical and Subsystem Design			
Spring	12	Received	
Eye bolt	4	Received	
Threaded inserts	30	Received	
Screws	60	Received	
Torsion Spring	2	Received	
ASA LW, ABS, TPU	7	Received	
Descent control			
Nano cord	4	Received	
Ripstop Nilon	4(yard)	Received	

CanSat Budget – Hardware (1/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Mechanical Parts					
Filament ASA-LW	49.99 / 1 kg	457 g	22.85	Structure	Actual
Filament TPU-95A	29.99 / 1 kg	2 g	0.06	Structure	Actual
Filament ABS	15.99 / 1 kg	16 g	0.26	Structure	Actual
M2.5 × 5	0.2	2	0.4	Structure	Actual
M2.5 × 8	0.2	8	1.6	Structure	Actual
M3 × 5	0.2	4	0.8	Structure	Actual
M3 × 6	0.2	4	0.8	Structure	Actual
M3 × 8	0.3	8	2.4	Structure	Actual
M3 × 13	0.3	8	2.4	Structure	Actual
M3 × 18	0.35	12	4.2	Structure	Actual
M3 × 30	0.5	7	3.5	Structure	Actual
Nut M2.5	0.1	10	1	Structure	Actual
Nut M3	0.2	27	8.6	Structure	Actual
Heat Set Insert M2.5	0.16	4	0.64	Structure	Actual
Heat Set Insert M3	0.16	23	3.68	Structure	Actual

CanSat Budget – Hardware (2/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Mechanical Parts					
Swivel Link	1.5	1	1.5	Descent Control	Actual
Nylon Ripstop	2.45 / 1.37 m²	7.5 m²	13.41	Descent Control	Actual
Nano Cord	7 / spool	1	7	Descent Control	Actual
Torsion Spring	5.43	1	5.43	Deployment	Actual
Compression Spring	4	4	16	Deployment	Estimated
Acrylic Tape	3.79 / spool	1	3.79	Others	Actual
Cable tie	0.03	6	0.18	Others	Estimated
Wood disc	2.43	1	2.43	Others	Actual
¼” Eye Bolt	0.61	1	0.61	Others	Actual
Total (Mechanical) = 103.5 USD					

CanSat Budget – Hardware (3/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Electrical Parts					
STM32H725	12.21	1	12.21	Avionic	Actual
BMP581	2.78	1	2.78	Sensor	Actual
ISM6HG256X	8.24	1	8.24	Sensor	Actual
MAX-M10S	21.11	1	21.11	Sensor	Actual
INA236	1.62	1	1.62	Sensor	Actual
XBee PRO S3B XBP9B-DMST-002	55.66	1	55.66	Communication	Actual
VL53L1X (Tof sensor)	19.75	1	19.75	Sensor	Actual
GSD12810YB-3V2400 (Buzzer)	1.2	1	1.2	Beacon	Actual
Radio Antenna	61.16	1	61.16	Antenna	Actual
GNSS Antenna	3.6	1	3.6	Antenna	Actual
Avionic PCB	43.09	1	4309	Avionic	Actual
Communication PCB	3.12	1	3.12	Avionic	Actual
Beacon PCB	5.58	1	5.58	Avionic	Actual

CanSat Budget – Hardware (4/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Electrical Parts					
18650 Li-ion Battery	5.27	2	10.54	Power	Actual
CR2016 Coin Cell Battery	0.57	1	0.57	Power	Actual
CR927 Coin Cell Battery	0.88	1	0.88	Power	Actual
MG90S Servo	2.27	2	13.60	Actuator	Actual
HL-3612-C001 Servo	24.72	3	74.16	Actuator	Actual
SD Card 32 GB For Avionic	7.49	1	7.49	CDH	Actual
SD Card 32 GB For ESP 32 Camera	7.49	2	14.98	CDH	Actual
Seed Studio XIAOESP32S3	13.9	2	27.8	Camera	Actual
AirTag	31.72	1	31.72	Sensor	Actual
Total (Electronics) = 420.9 USD					

CanSat Budget – Hardware (5/5)

Total Hardware Budget	
System	**Cost (USD)**
Mechanic	103.5
Electronic	420.9
Subtotal	**524.4**
Margin	1000 – 524.4 = **475.6**

CanSat Budget – Other Costs (1/3)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Justification
Ground Station				
XBee pro s3b XBP9B-DMST-002	55.66	1	55.66	Actual
XBee adapter (Ft232 Ft232RI)	2.67	1	2.67	Actual
Raspberry Pi 4 (8GB RAM)	119	1	119	Actual
Geekworm Raspberry Pi X728	43	1	43	Actual
18650 Li-ion 3.7V Battery	0.76	2	1.52	Actual
ZDADJ900-12YG	73.95	1	73.95	Actual
RP-SMA Cable	32.51	1	32.51	Actual
52Pi 10.1-inch Touch Screen 1280X800	86	1	86	Actual
USB HUB HAT (B) for Raspberry Pi	8	1	8	Actual
Total (Ground Station) = 422.31 USD				

CanSat Budget – Other Costs (2/3)

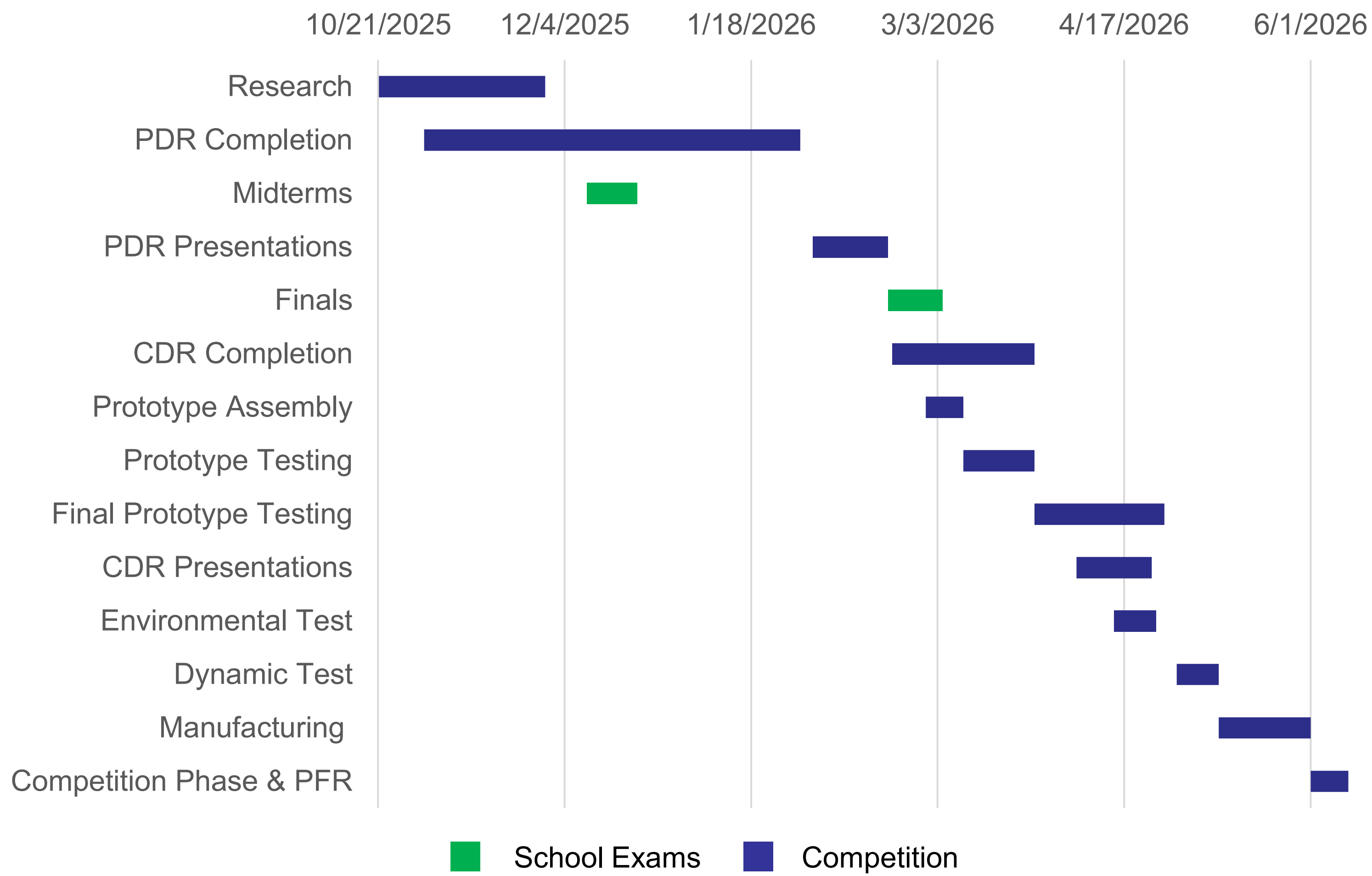
Expenses	Total Cost (USD)	Justification
Prototyping		
Mechanical	350	Actual
Electrical	400	Actual
Test facilities and equipment		
Spectrum Analyzer	203	Actual
Oscilloscope	450	Actual
Thermal Machine	1090	Actual
Travel (Per Person)		
Airfare	2000	Actual
Visa Cost	185	Actual
Food Expense	60 / day	Estimated
Travel (Whole Team)		
Accommodation	800 / day	Estimated
Van Rental	500 / day	Estimated

CanSat Budget – Other Costs (3/3)

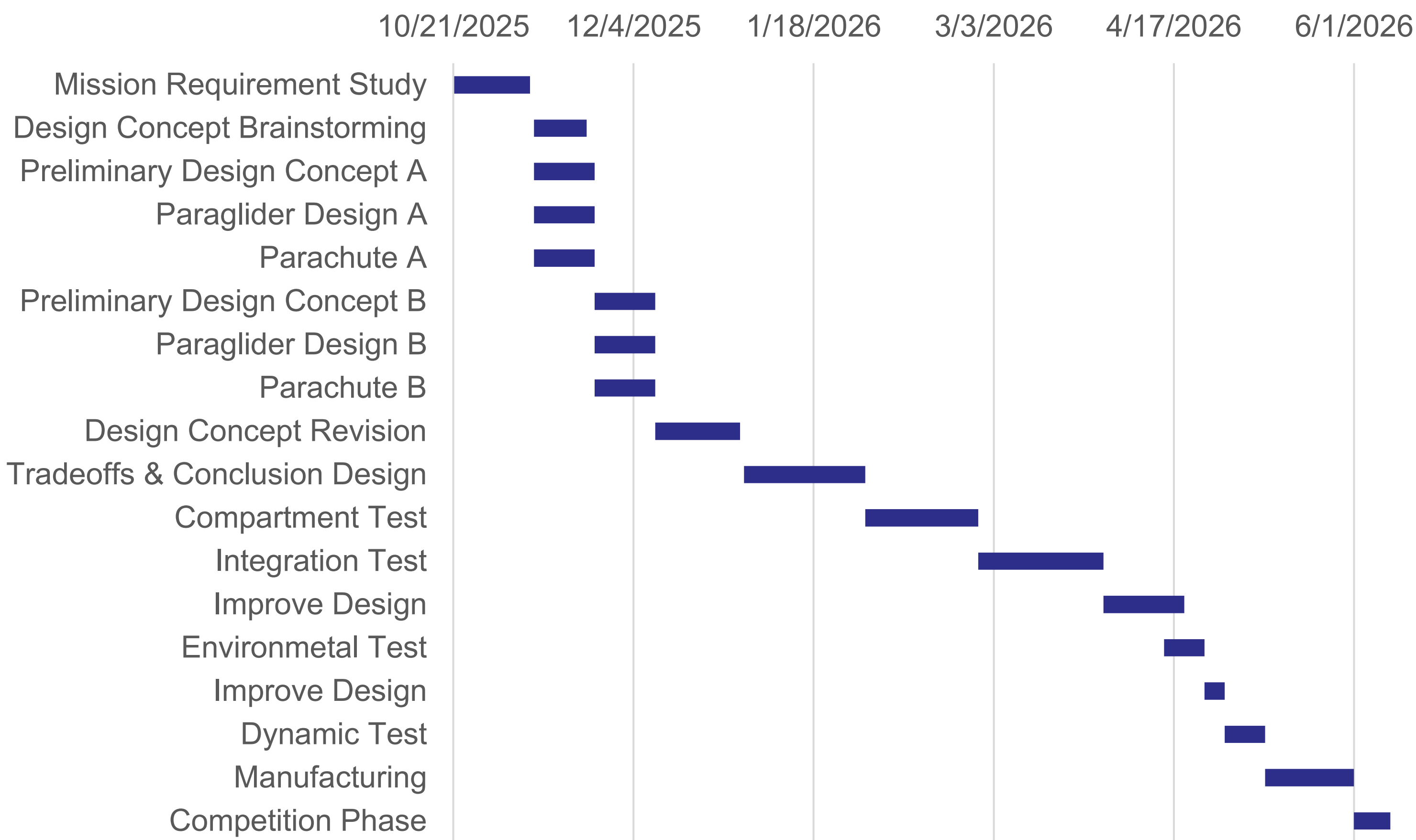
Incomes	Total Cost (USD)	Justification
Source of Income		
From School	60%	Actual
From Sponsors	30%	Estimated
From Parents	10%	Actual

- Our sponsors that have confirmed are such as Bangkok Bank, Central Group, Parents and Teachers Association AC, Thai Beverage Plc, and Sino Pacific Trading Thailand Co. Ltd.

Program Schedule Overview

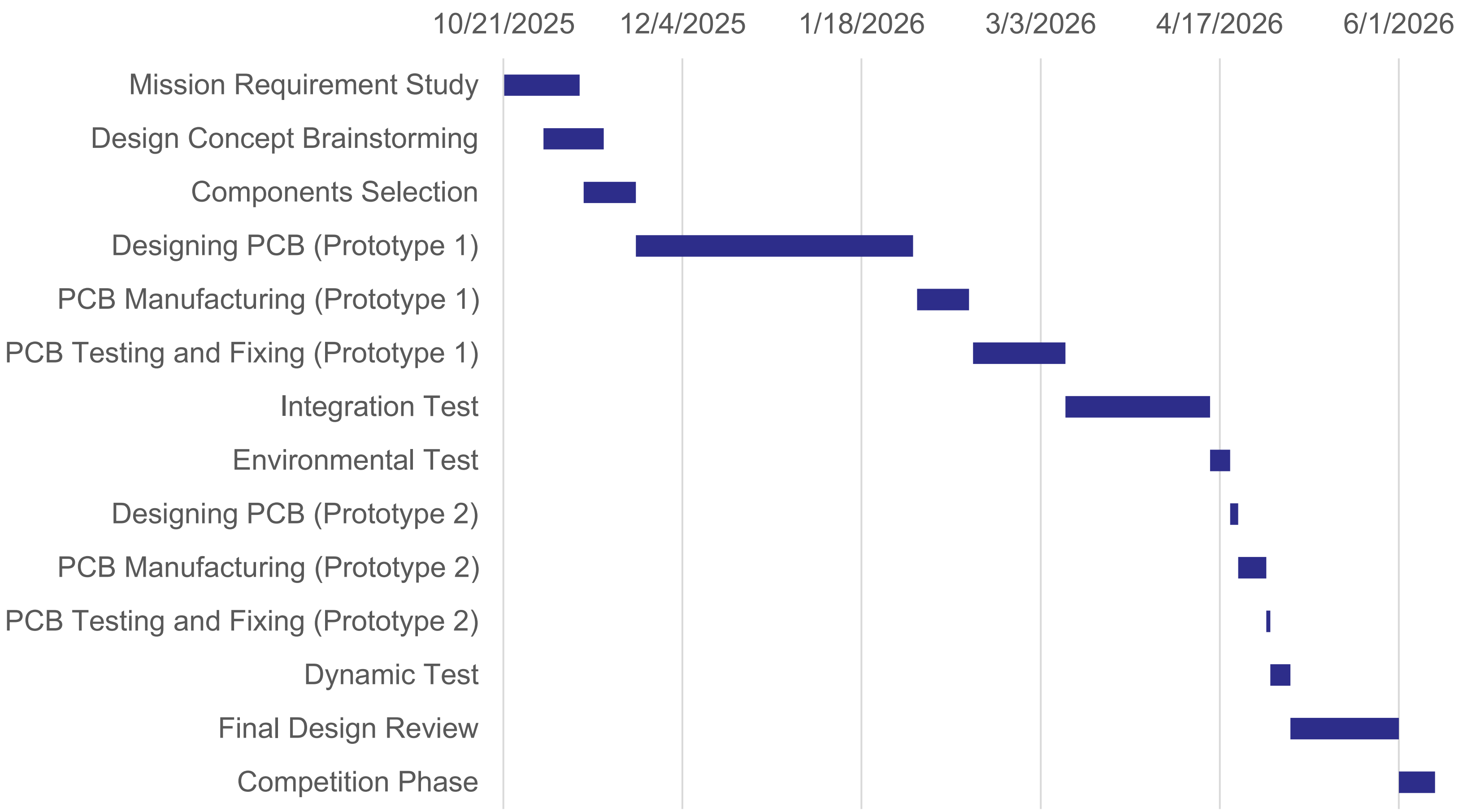


Mechanical Subsystem Schedule



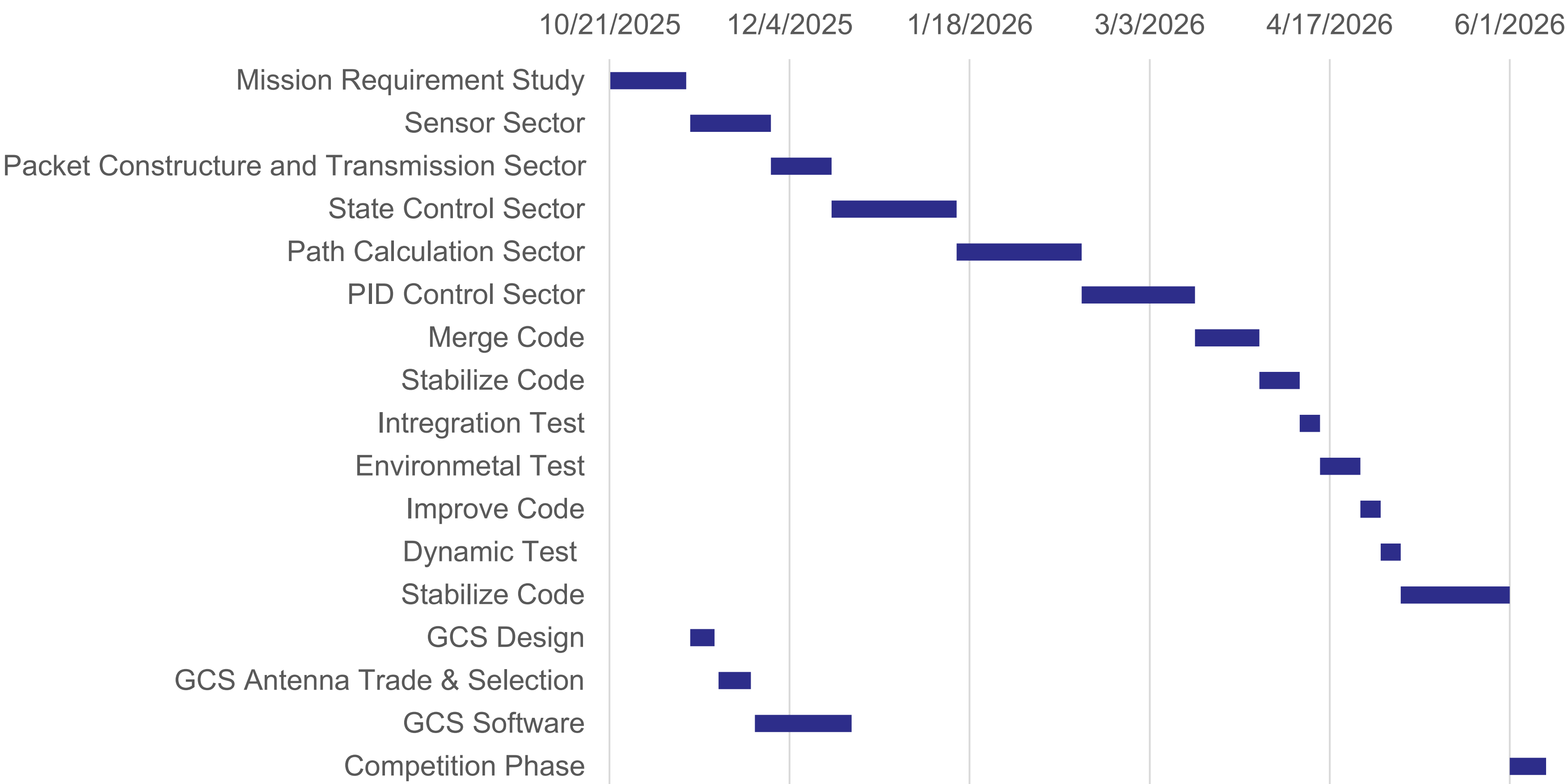
Responsible Member : Rapassakorn Leelarujawanich

Electrical Subsystem Schedule



Responsible Member : Watcharawit Leksuwankun

Software Subsystem Schedule



Responsible Member : Trirayan Boontaganon

Detailed Program Schedule (4/4)

Percentages

- To effectively assess our overall progress, the mission is organized into four subsystems: Mechanics, Electronics, Software & GCS, and Integration & Testing.
- The progress is calculated based on the Gantt chart of each unit, using the ratio of the completed task duration to the total task duration.

Subsystems	Estimated Progress
Mechanics	75 %
Electronics	67 %
Software & GCS	80 %
Integration & Testing	20 %

The overall progress: 60.5%

Shipping and Transportation

- The CanSat payload, including sensitive electronics, structure, and antennas, will be transported in protective Pelican cases with fitted foam to prevent damage.
- These cases will be carried as carry-on luggage whenever possible to minimize handling risks.
- Tools and non-sensitive equipment will be transported in checked luggage.
- In the United States, all equipment will be transported to the launch site using a rented vehicle.
- After arrival, the team will perform a visual inspection and system check to ensure the CanSat remains fully functional.

Conclusions (1/2)

Major Accomplishments

- Funding secured, budget finalized, and team roles defined
- Flight & ground software implemented (PID + path planning validated)
- Mechanical system prototyped and tested
- Electronics selected, schematics & PCB completed
- Full system integrated and tested (including sensors & SMD Board Mk.1 and Mk. 2)

Major Unfinished Work

- Hotel accommodation has not yet been booked.
- Minor modifications required after UAV drop test and dynamic testing.

Testing To Complete

- Environmental Test (drop, shock, vibration, thermal, fit check, vacuum)
- UAV Drop Test
- Dynamic Sounding Rocket Test

Flight Software Status

- FSW is already functional.

Conclusions (2/2)

We are ready to proceed to the next stage because

- Significant progress achieved across all subsystems, including successful system integration with fully prototyped mechanical structures, validated electronics, and implemented flight software
- Remaining work focuses on refinement and validation, including minor mechanical adjustments, further PCB verification, and PID tuning
- The system is approaching high readiness, with final efforts aimed at ensuring reliability under real operational conditions

WE ARE READY!