CanSat 2026
Preliminary Design Review (PDR)

Team # 1043
Daedalus

Presentation Outline

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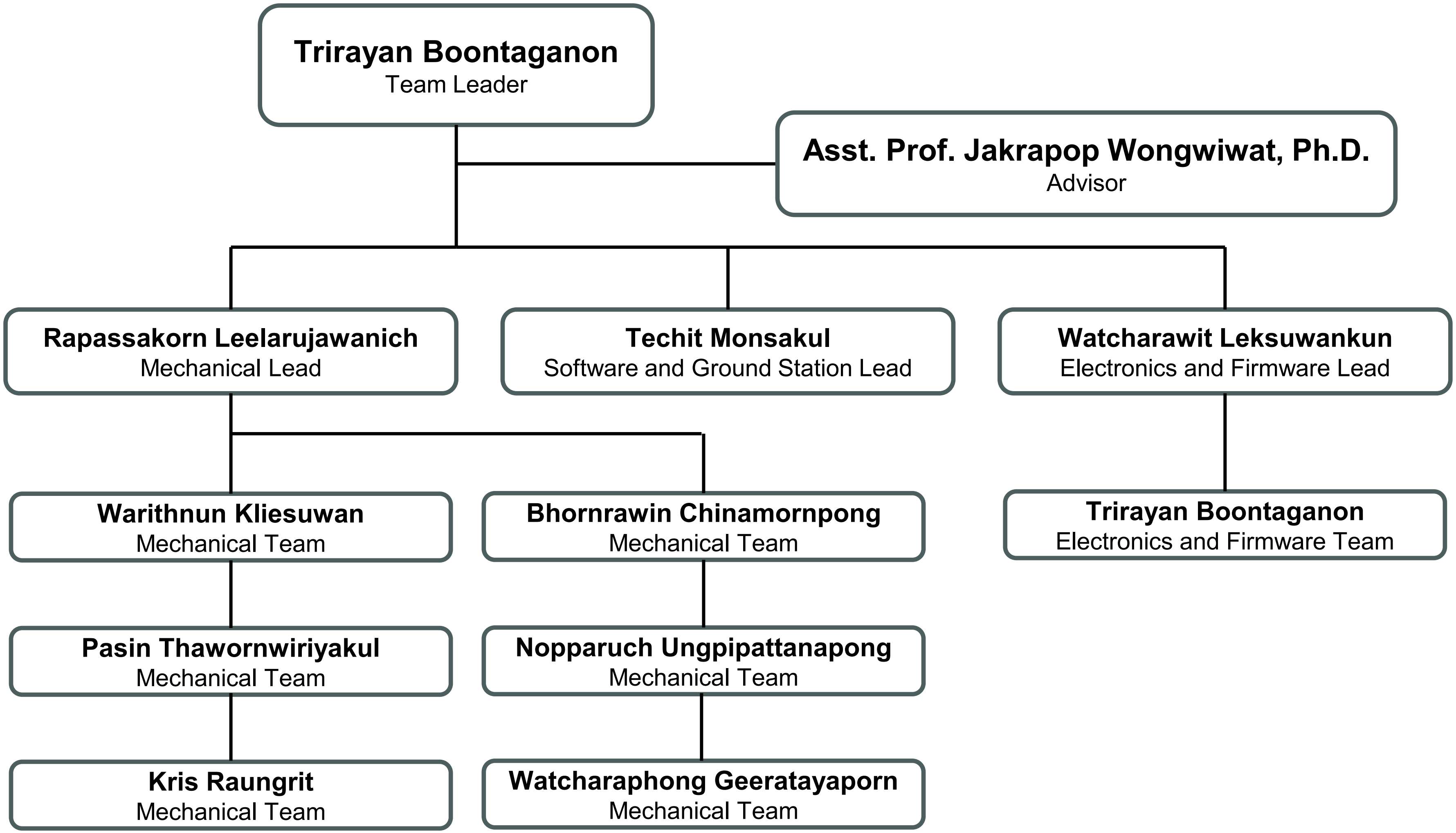
Team Organization



Acronyms (1/2)

Acronyms	Definition
ABS	Acrylonitrile Butadiene Styrene
ASA-LW	Lightweight Acrylonitrile Styrene Acrylate
CC	CanSat Crew
CF	Carbon-Fiber
CN	Command Name
CONOP	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

Systems Overview

Trirayan Boontaganon
Rapassakorn Leelarujawanich

Mission Objectives

- The CanSat consists of a payload and a container that mounts on the rocket, with the nose cone 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.

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 environment 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 Level CanSat Configuration Trade & Selection (1/2)

Nosecone & Container

Design A

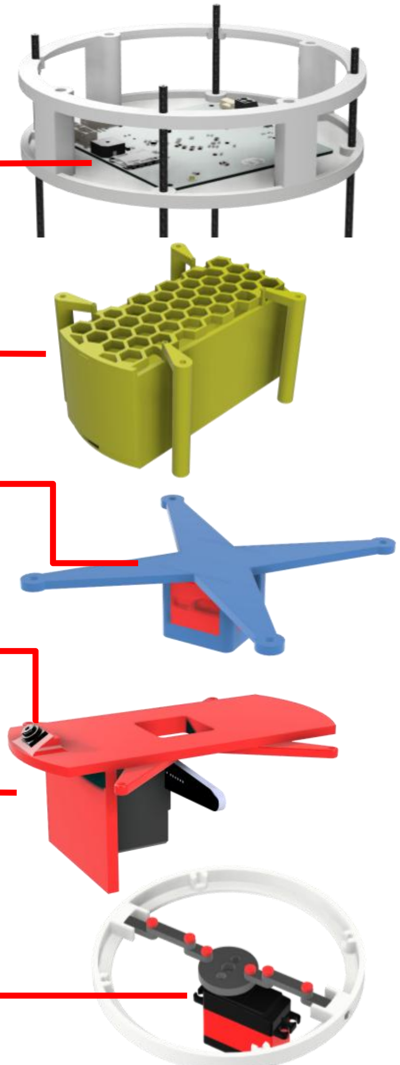
Carbon Rod Structure

Design B **(Selected)**

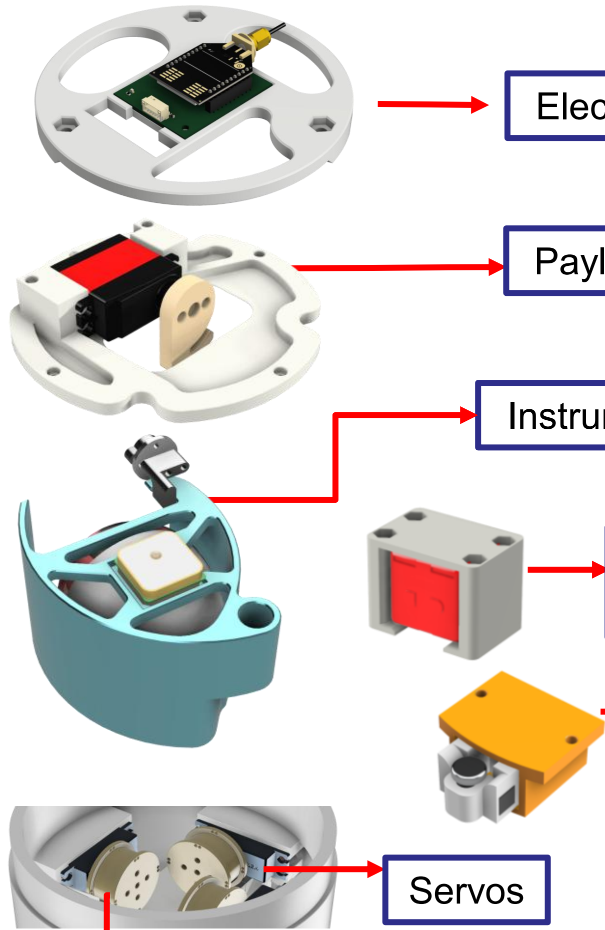
3D-printed Shoulder

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

Design A



Design B (Selected)



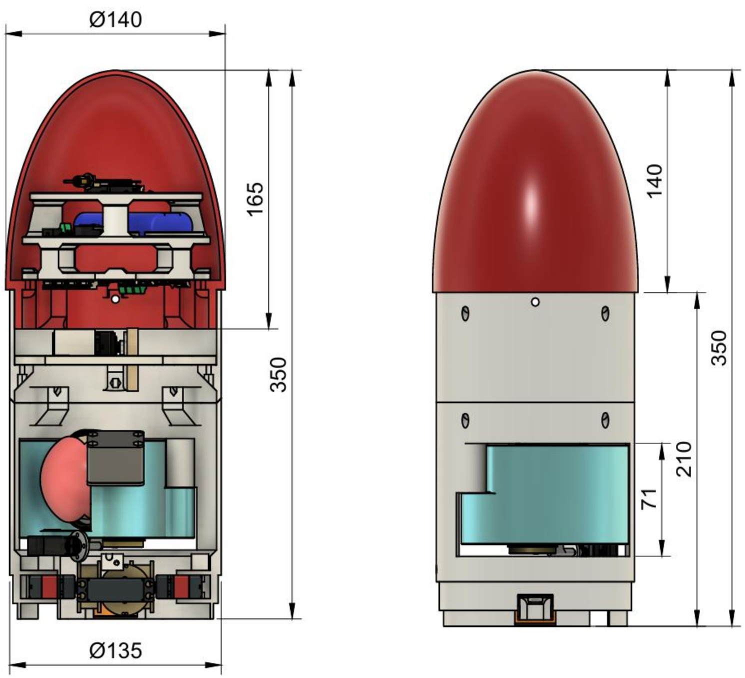
System Level Configuration Selection

Configurations	Advantages	Disadvantages
 Configuration A	• Simple assembly process • Lower air resistance	• Reduced strength and rigidity • Air may leak into the structure, causing internal pressure changes
 Configuration B	• More robust and rigid • Enhanced paraglider system reliability	• Higher overall mass • Higher air resistance

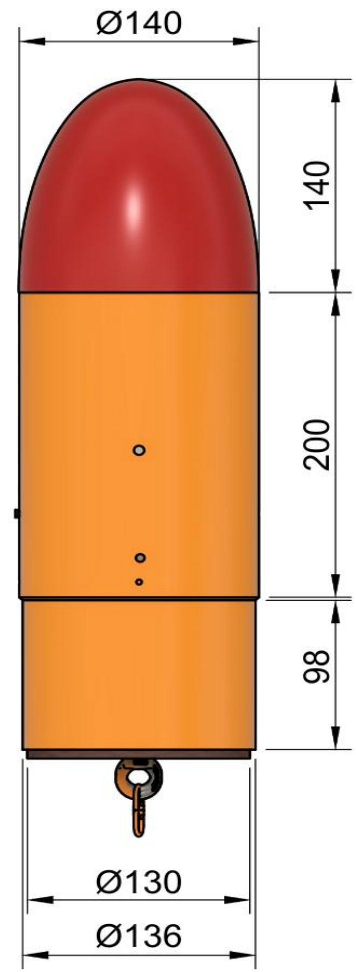
Selected Configuration	Rationales
Configuration B	Design B was chosen for its superior structural robustness and reliability. Although it increases mass and drag, the enhanced stability and three-servo configuration offer finer control and improved flight precision.

Physical Layout (1/3)

Payload and Container Dimensions



Payload

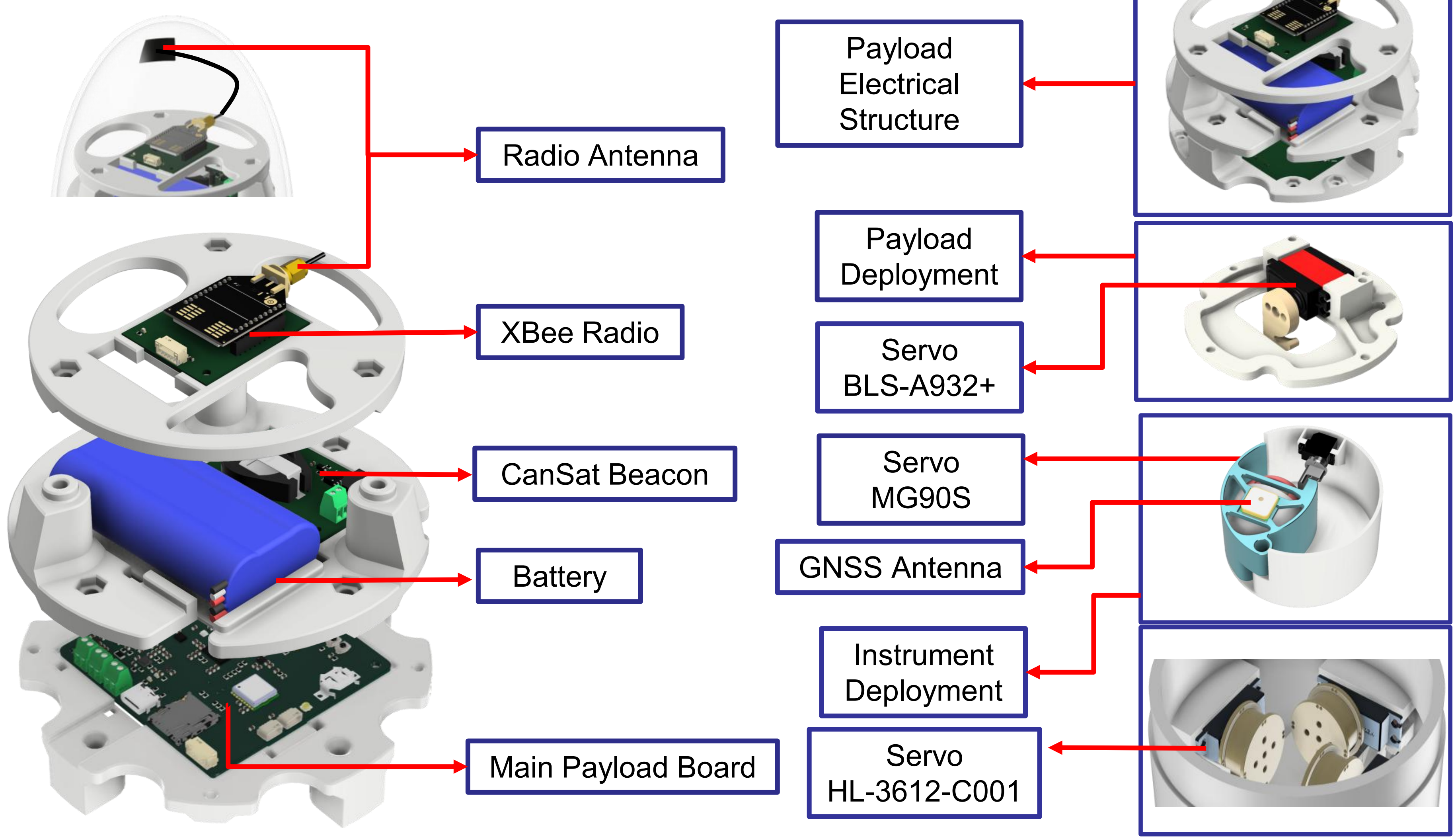


Container

Unit : mm

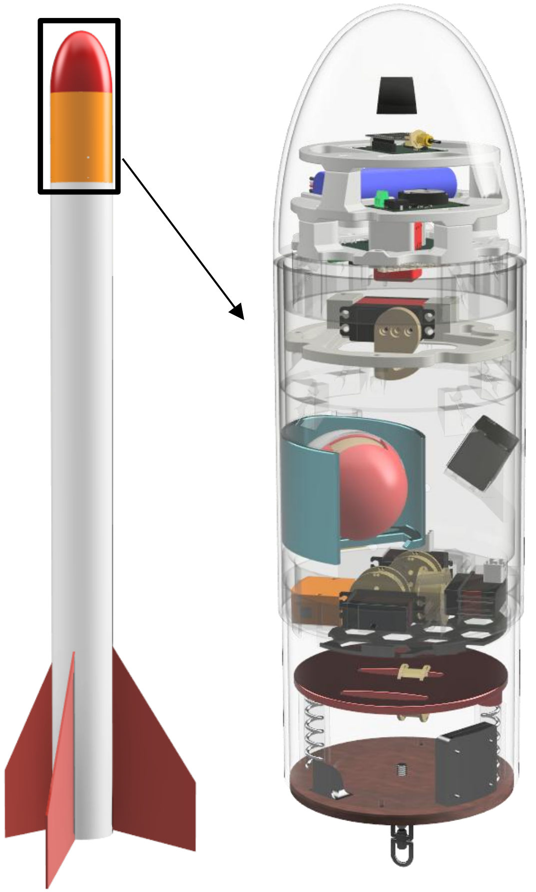
Physical Layout (2/3)

Placements of Major Components

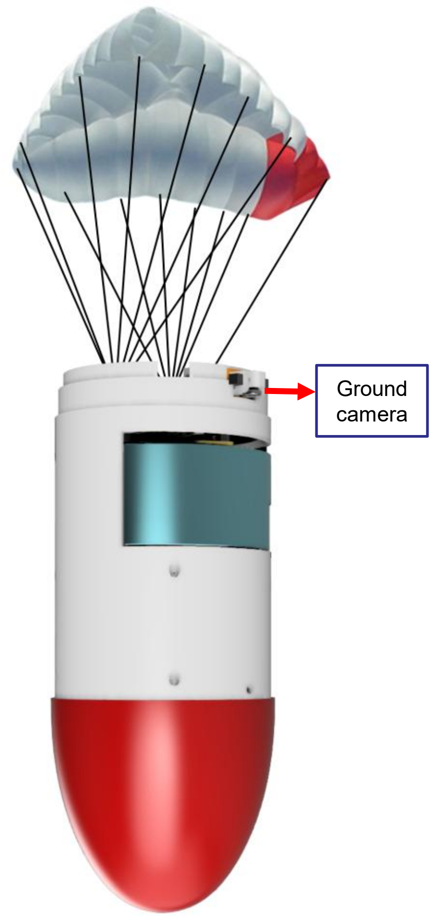


Physical Layout (3/3)

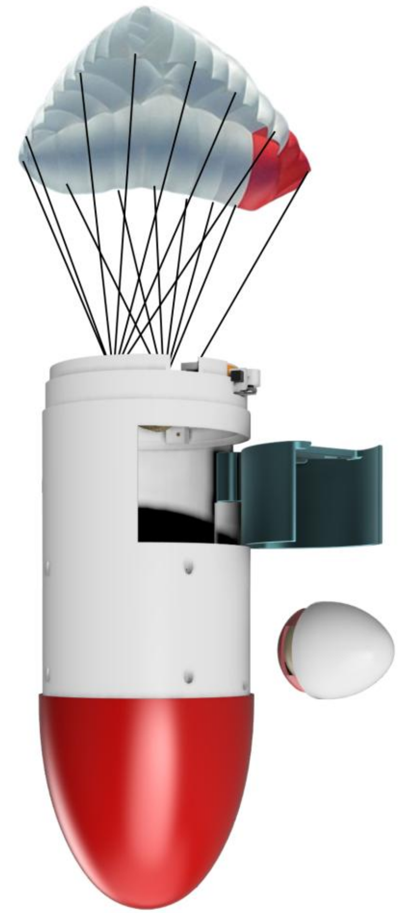
Launch Configuration
(mounted in the rocket)



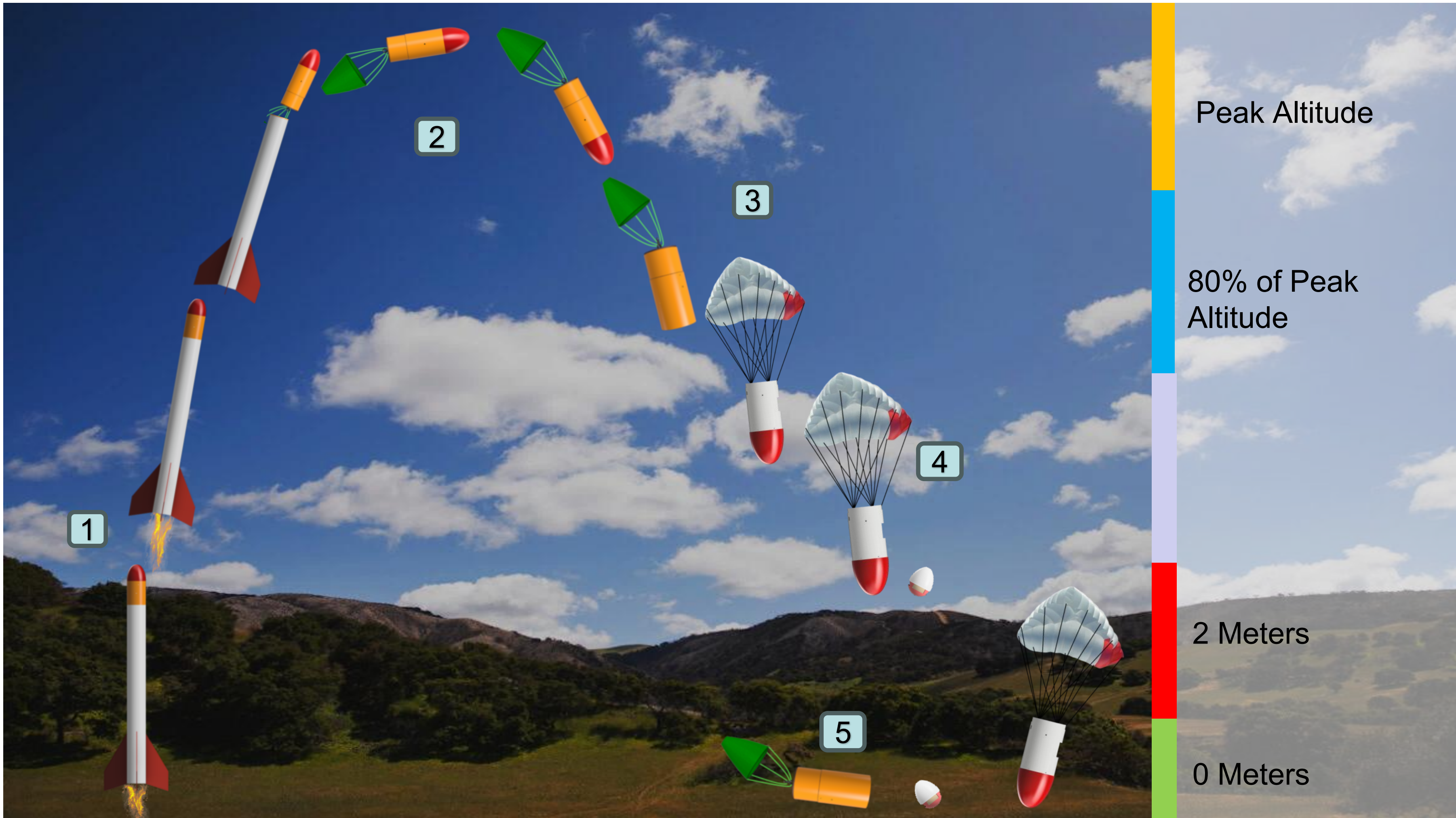
Deployed Configuration



Instrument Deployment



System Concept of Operations (1/2)



Timeline: Launch | Deployment | Descent With Parachute | Paraglider | Deploy Egg | End Of The Mission

System Concept of Operations (2/2)

Phase 1: Launch Phase
- 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).

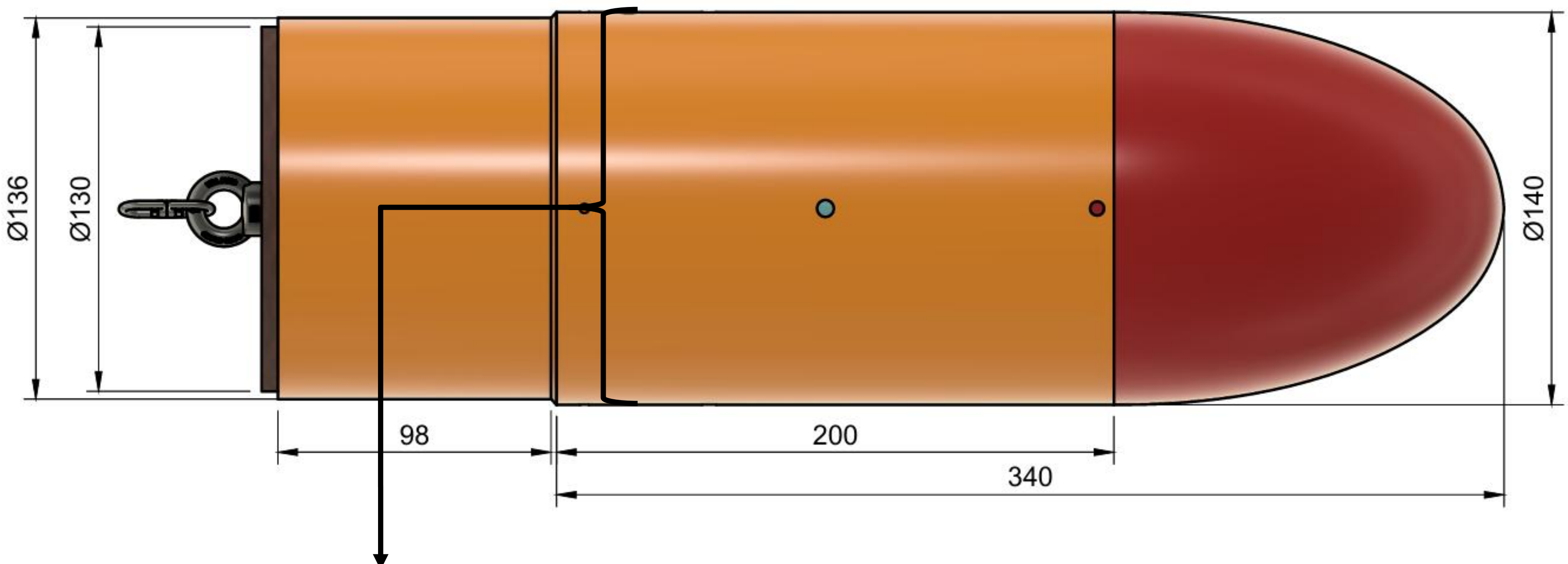
Phase 2: Deployment
- The CanSat separates from the launch vehicle.
- Subsequently, the CanSat deploys its parachute and undergoes descent at a rate of 15 ± 3 m/s after the rocket motor ejection charges fire.

Phase 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.

Phase 4: Egg Release
- 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.

Phase 5: Landed
- The payload shall terminate all data transmission and camera recording operations.

Launch Vehicle Compatibility



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

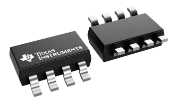
Properties	Container section dimensions (mm)	Payload dimensions (mm)	Nosecone (mm)
Diameter	140	135	140
Height	300	340	140
Clearance	3	5	0

Sensor Subsystem Design

Watcharawit Leksuwankun

Techit Monsakul

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		Measure the rotation rate of payload.
Release Camera	Quelima SQ11 Camera 	Video recording of the deployment of paraglider at 80% peak altitude.
Instrument Release Sensor	VL53L1X (TOF Sensor) 	Measure the altitude at 2 m for instrument deployment.
Ground Camera	ESP32-S3-CAM with OV5640 	Video recording of the ground during descent.

Payload Air Pressure Sensor Trade & Selection

Model	Interfaces	Range (hPa)	Accuracy (hPa)	Size (mm)	Mass (g)	Current	Cost (USD)
BMP581	I^2C, SPI	300 – 1250	±0.06	2 x 2 x 0.8	0.2	0.26 mA	2.78
BME280	I^2C, SPI	300 – 1100	±0.12	15.5 x 11.5 x 3	1	3.6 μA	3.06
MS5607	I^2C, SPI	10 – 2000	±1.5	5 x 3 x 1	0.39	1.4 μA	3.09

Selected Payload Air Pressure Sensor		Rationales
BMP581		• Higher accuracy compared to alternative models • Lower cost • Reduced physical size

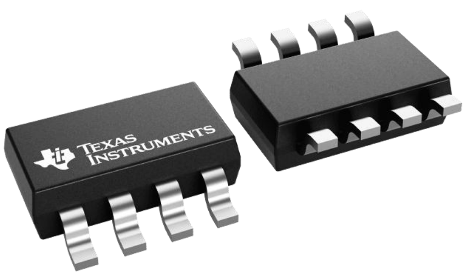
Payload Air Temperature Sensor Trade & Selection

Model	Interfaces	Range (°C)	Accuracy (°C)	Size (mm)	Mass (g)	Current	Cost (USD)
BMP581	I^2C, SPI	-40.0 – 85.0	±0.5	2 x 2 x 0.8	0.2	0.26 mA	2.15
BME280	I^2C, SPI	-40.0 – 85.0	±0.5	15.5 x 11.5 x 3	1	3.6 μA	3.06
MS5607	I^2C, SPI	-40.0 – 125.0	±0.5	5 x 3 x 1	0.39	1.4 μA	3.09

Selected Payload Air Temperature Sensor	Rationales
BMP581 	• Already utilized for payload air-pressure measurement • Lower cost • Compact size

Payload Battery Voltage and Current Sensor Trade & Selection

Model	Interfaces	Range (V)	Accuracy (%)	Mass (g)	Resolution (mV/LSB)	Cost (USD)
ADC Pin + Voltage Divider	Analog	0 – 8.25	±1%	0.004	2	0.2
INA236	I^2C	-0.3 – 48	±0.1%	0.009	0.0025	1.62

Selected Payload Battery Voltage & Current Sensor	Rationales
INA236 	• Higher accuracy in both voltage and current sensing • Digital interface, which reduces noise susceptibility and improves measurement reliability • Integrated amplifier and ADC, enhancing overall measurement performance

Payload GNSS Sensor Trade & Selection

Model	Interfaces	Accuracy (m)	Update rate (Hz)	Start time (s)	Size (mm)	Mass (g)	Current (μA)	Cost (USD)
MAX-M10S	I^2C, UART	±1.5	18	1	10.7 x 9.8 x 2.7	0.5	25	21.11
NEO-M9N	I^2C, UART	±2	25	2	16.1 x 12.3 x 2.6	1	43	16.18
NEO-6M	I^2C, UART	±2.5	5	1	16 x 12.2 x 2.4	1	40	10.90

Selected Payload GNSS Sensor	Rationales
MAX-M10S 	• More compact • Reduced current consumption, improving overall power efficiency • Higher accuracy with sufficient start time compared with alternative solutions

Payload Acceleration Sensor Trade & Selection

Model	Interfaces	Range (g)	Accuracy (g)	Size (mm)	Mass (g)	Current (μA)	Cost (USD)
ICM42688	I^2C, SPI	± 2/4/8/16	±0.02	3 x 2.5 x 0.1	0.09	0.8	4.53
ISM6HG256X	I^2C, SPI	Low-g channel ±2/±4/±8/±16 g High-g channel ±32/±64/±128/±256 g	Low : ±0.01 High : ±0.25	2.5 x 3 x 0.83	0.05	0.8	8.24

Selected Payload Acceleration Sensor	Rationales
ISM6HG256X 	• Capable of measuring g-force during launch • Supports a significantly broader measurement range • Achieves superior accuracy compared with alternative sensors

Payload Rotation Rate Sensor Trade & Selection

Model	Interfaces	Range (dps)	Accuracy (dps)	Size (mm)	Mass (g)	Current (μA)	Cost (USD)
ICM42688	I^2C, SPI	±2000	±0.5	3 x 2.5 x 0.1	0.09	0.8	4.53
ISM6HG256X	I^2C, SPI	±4000	±0.5	2.5 x 3.0 x 0.83	0.05	0.8	7.17

Selected Payload Rotation Rate Sensor	Rationales
ISM6HG256X 	• Provides a significantly wider measurement range • Lower overall mass than comparable models

Payload Release Camera Trade & Selection

Model	Interfaces	Resolution	FOV	FPS	Maximum Memory (GB)	Mass (g)	Size (mm)	Cost (USD)
OV7670	SCCB +	640 x 480	25°	30	32	10	35 x 34 x 25	2.79
Quelima SQ11 Camera	Mini USB	1280 x 720	140°	30	64	15	23 x 23 x 23	3.99
RunCam 5 Orange	Micro USB	1980 x 1080	145°	120	128	56	38 x 38 x 36	110

Selected Payload Release Camera	Rationales
Quelima SQ11 Camera 	• Onboard SD card for recording • Standalone video recording capability • High-resolution imaging with a wide FOV compared to size and weight • Low cost and lightweight design • Built-in battery

Instrument Release Sensor Trade and Selection

Model	Supply Voltage (V)	Interfaces	Range	Accuracy	Size (mm)	Mass (g)	Current	Cost (USD)
VL53L1X (TOF sensor)	3.3	I²C	0.04 – 4 m	±25 mm	4.9 x 2.5 x 1.56	3	40 mA	19.75
HC-SR04 (Ultrasonic)	5	GPIO	0.02 – 4 m	±30 mm	45 x 20 x 15	10	15 mA	6.77
BMP581 (Barometer)	3.3	I²C, SPI	-1.9– 9.2 km	±0.5 m	2 x 2 x 0.8	0.3	0.26 uA	2.15

Selected Instrument Release Sensor	Rationales
VL53L1X (TOF sensor) 	• Highest accuracy • More compact than HC-SR04

Ground Camera Trade and Selection

Model	Interfaces	Resolution	FOV	FPS	Voltage (V)	Mass (g)	Size (mm)	Cost (USD)
ESP32-S3-CAM with OV5640	UART, SPI, I2C	1920 x 1080	160°	30	3.3	10.7	8.5 x 8.5 x 5.12	17.86
Adafruit 3202	PVP, UVC	640 x 480	62°	30	3.3	2.8	28.5 x 17 x 4.2	12
Turbowing Cyclops v3	CUBS	1280 x 720	120°	30	3.5 - 5.5	4.8	18 x 18 x 8	20

Selected Ground Camera	Rationales
ESP32-S3-CAM  OV5640 Selected Sensor: OV5640 (1/4”) CMOS	• Provides a superior field of view • Offers automatic image control functionality • Readily available within the domestic market

Descent Control Design

Bhornrawin Chinamornpong
Watcharaphong Geeratayaporn

Descent Control Overview

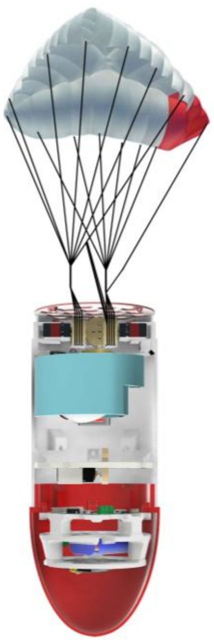
Parachute

- At the peak altitude, the ejection system deploys the CanSat from the rocket.
- The paraglider is stowed in the payload container.
- Triple servo spool steering system.

Release

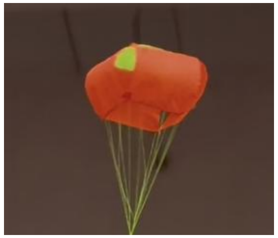
- At 80 % of Apogee, the payload separates from the container.
- Paraglider canopy, suspension lines, triple servo spool system.
- The paraglider deploys after payload separation.

Paraglider



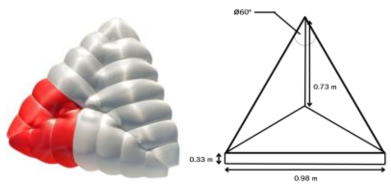
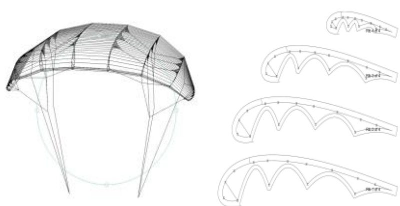
- The paraglider becomes fully inflated.
- The servo-driven spools enable directional control.
- A controlled glide phase is initiated.

Container Parachute Descent Control Strategy Selection and Trade

Parachute	Advantages	Disadvantages
 Conical Parachute ($C_D = 0.6$)	• Simple manufacturing process • Minimal interaction with lateral airflow, thereby reducing horizontal displacement	• Lacks directional control, with drift governed entirely by ambient wind conditions • Manufacturing imperfections may increase oscillation and slightly increase the drift rate
 Cube Parachute ($C_D = 0.9$)	• Well suited for low-altitude deployment scenarios that require rapid drag generation	• Highly asymmetric airflow induces oscillatory motion and rotational behavior

Selected Parachute	Rationales
Conical Parachute	The conical parachute was chosen for its lightweight design and simple manufacturing, allowing for a stable, near-vertical descent that minimizes lateral airflow effects. While it lacks active directional control and is affected by wind and manufacturing flaws, it usually lands close to the release point.

Payload Steering Control Strategy Selection and Trade

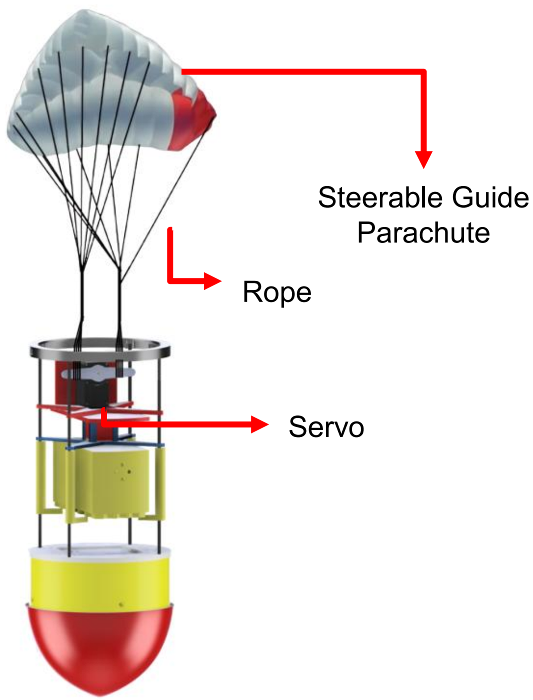
Parachute	Dimensions	Advantages	Disadvantages
 Steerable guide parachute x-triangle	• Flat Area = 0.42 m² • Sweep Angle = 60° • Span Length = 0.98 m • Chord Length = 0.73 m • Glide Ratio $Vy : Vx$ = 9 : 1 (Low)	• Simple manufacturing process • High reliability of deployment • Low mass and cost	• Lower aerodynamic efficiency • Limited steering authority and high descent rate
 Parafoil	• Flat Area = 0.7 m² • Average Bridle Angle = 70.56° • Wingspan = 1.44 m • Chord Length = 0.57 m • Glide Ratio $Vy : Vx$ = 5 : 2 (High)	• High aerodynamic efficiency • Good descent rate control and high steering authority • Stable glide performance	• High manufacturing cost and complex fabrication process • Higher mass and packing volume

Selected Paraglider	Rationales
Steerable X-Triangle	The steerable X-triangle parachute was chosen for its ease of manufacture, light weight, and reliable deployment. Despite reduced aerodynamic efficiency and limited steering, it provides an affordable, dependable descent system that meets mission needs.

Para-Glider Descent Speed Control Strategy Selection and Trade (1/4)

Design A

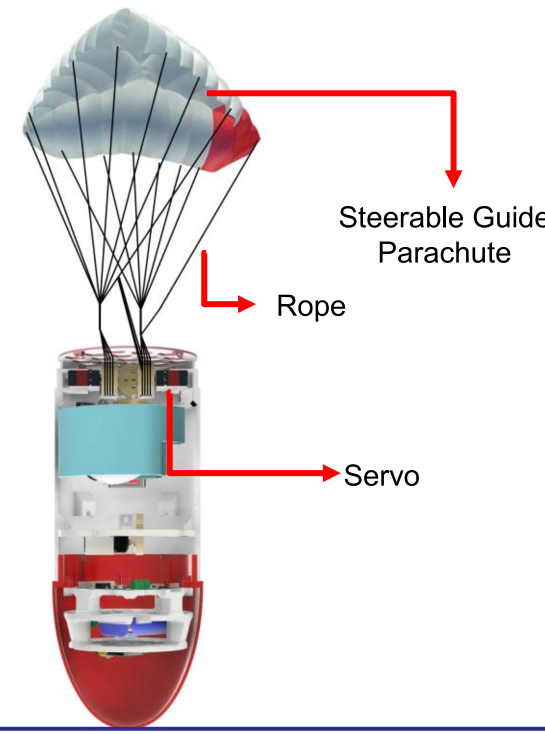
Servo-Arm Line Control



How it works:
- Suspension lines are directly connected to servo arms.
- Servo rotation pulls or releases the lines tot for the creation of differential tension.
- Active control with limited authority, partially relying on passive stability.

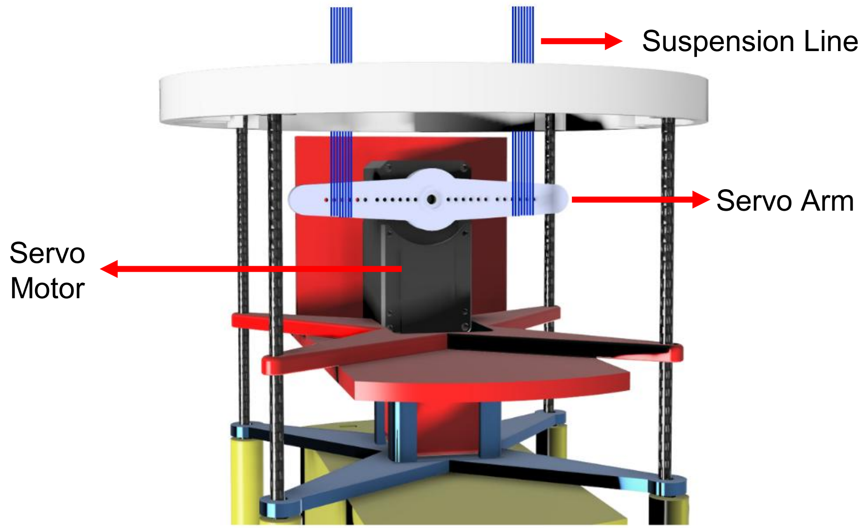
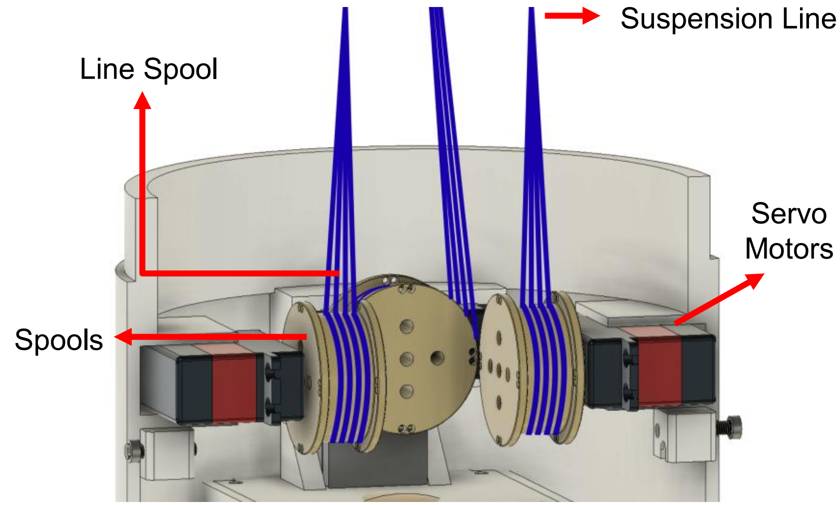
Design B

Spool-Based Line Control



How it works:
- Each suspension line is wrapped around a servo-driven spool.
- Differential line length between left, right, and front spools produces steering control.
- The system does not rely solely on passive aerodynamic stability.

Para-Glider Descent Speed Control Strategy Selection and Trade (2/4)

Design A	Design B
Servo-Arm Line Control (Active)	**Spool-Based Line Control (Active)**
	
Advantages: • Simple and lightweight mechanical design • Easy to manufacture and integrate into the payload structure • Minimal risk of line overlap or entanglement	**Advantages:** • Provides continuous and precise control over line length • Allows a large line displacement with multiple spool rotations • Reduces the continuous holding torque required from the servo
Disadvantages: • Limited line travel because of servo rotation constraints • Higher continuous torque demand on the servo motor	**Disadvantages:** • Mechanically more complex than a simple servo arm • Requires line guides to prevent tangling or uneven winding

Conclusion: The spool-based line control mechanism was selected for its continuous, precise control and large line displacement with reduced servo torque. Although it is mechanically more complex and requires line guides, its performance advantages enable reliable and accurate directional control, outweighing the drawbacks. This approach implements an active stability and steering control strategy.

Para-Glider Descent Speed Control Strategy Selection and Trade (3/4)

Servo Torque Calculation

Assumption – Given Parameters if:

$\Delta\theta = 2\pi\ rad \qquad \Delta T = 0.91\ s$

$S = 9\ cm \qquad R = 1.39\ cm$

Servo's Angular Velocity

$$\omega = \frac{\Delta\theta}{\Delta T}$$

Velocity of Rotation

$$V = \omega \times R$$

Time per Revolution

$$V = \frac{S}{T}$$

Variables

S	:	Rope Length (cm)
T	:	Time per One Rotation (s)
R	:	Pulley Radius (cm)
V	:	Rope Pulling Speed (cm/s)
ω	:	Angular Velocity (rad/s)
$\Delta\theta$	:	Angle (rad)

Final Design Requirement

$\omega \approx 7.12$ rad/s

$V \approx 9$ cm/s

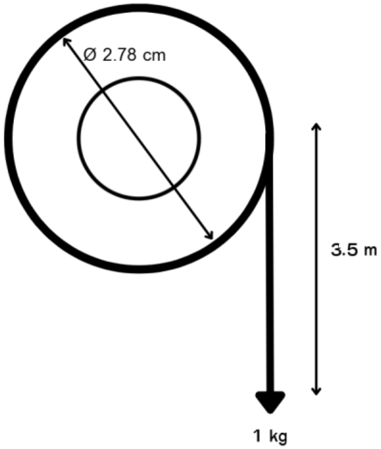
$T \approx 0.91$ s

This ensures reliable payload release under worst-case deployment conditions.

Para-Glider Descent Speed Control Strategy Selection and Trade (4/4)

Assumption – Given Parameters if:

M = 1 kg
S = 3.5 m
R = 1.39 cm
$g \approx 9.81 m/s^2$
ΔT = 0.91 s



Variables

M	:	Mass of Payload (kg)
S	:	Free-fall Distance (m)
ΔT	:	Deceleration time (s)
R	:	Pulley Radius (cm)
V	:	Rope Pulling Speed (m/s)
g	:	Acceleration due to gravity $(9.81\ m/s^2)$
ΣF	:	Pulling Force (N)
T	:	Torque $(kg \cdot cm)$

Payload Velocity before tension

$$V = \sqrt{2gS}$$

Required Pulling Force

$$\sum F = \frac{M \times \Delta V}{\Delta T}$$

Required Servo Torque

$$T = F \times R$$

Safety Factor

- A safety factor of 2 is applied

$$T_{Design} = T \times 2$$

Final Design Requirement

$V \approx 8.3$ m/s
$\Sigma F = 41.5$ N
$T \approx 5.76$ kg·cm

Total required actuation torque (three servos combined) is 11.52 kg·cm.

The required torque per servo is ≥ 3.84 kg·cm.

This ensures reliable payload release under worst-case deployment conditions.

Descent Rate Estimates (1/4)

Conical Parachute

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

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

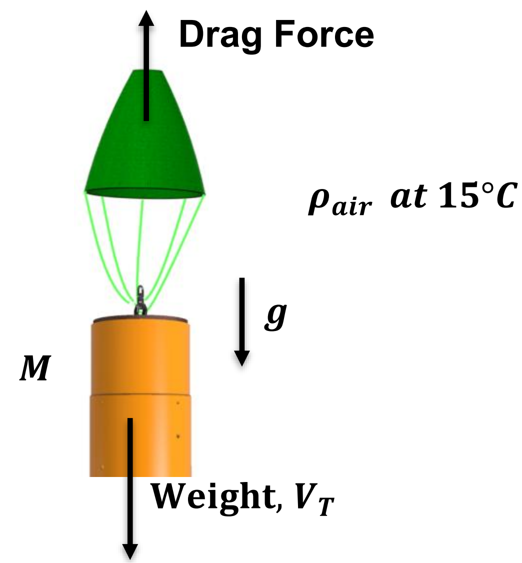
$$A_p = \frac{2(1)(9.81)}{1.225 \cdot 0.6 \cdot 15^2}$$

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

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

Variables

- A_p : Area of Parachute (m^2)
- C_D : Drag Coefficient (Assumed $C_{D,cone} = 0.6$)
- ρ : Air Density at 15 ℃ $(1.225\ kg/m^3)$
- 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 $(9.81\ m/s^2)$



Steerable Guide Parachute X-Triangle

Assumption

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

Variables

$A = 0.126\ m^2$ $\qquad h = 30\ m$

$\rho = 1.225\ kg/m^3$ $\qquad g = 9.81\ m/s^2$

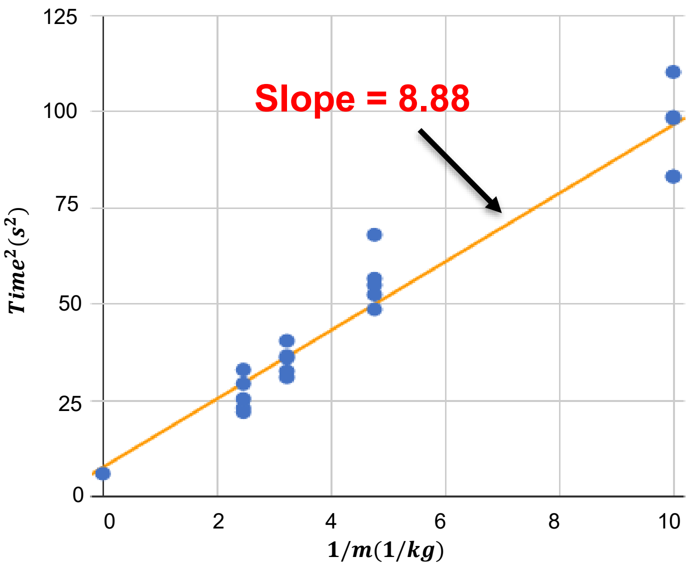
$$slope = \frac{1}{2g}\rho A h^2 C_D$$

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

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

$$C_D \approx 1.25$$

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



Descent Rate Estimates (3/4)

Steerable Guide Parachute X-Triangle

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

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

$$\Rightarrow L \;\; = 1.09\, m\; (Side\ Length)$$

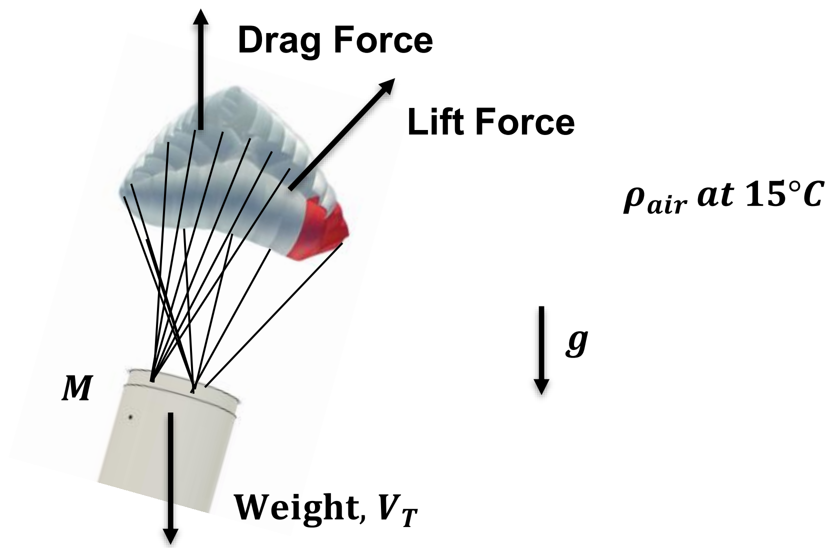
$$A_p = \frac{\sqrt{3}}{4}\mathrm{L}^2$$

$$A_p = \frac{\sqrt{3}}{4}1.09^2$$

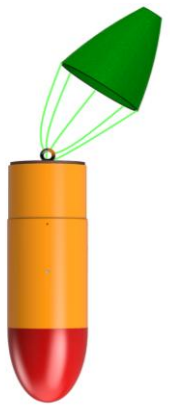
$$\Rightarrow A_p = 0.51\, m^2$$

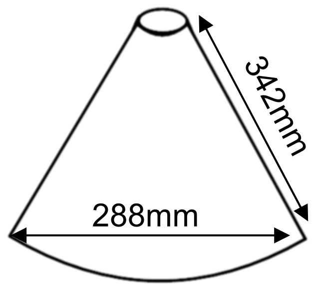
Variables

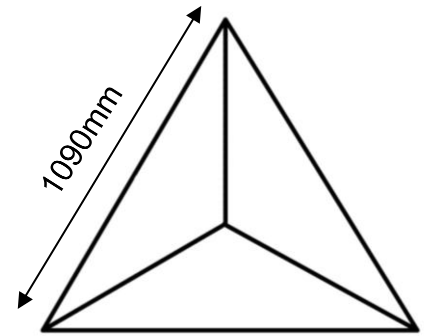
A_p	:	Area of Equilateral Triangle Parachute $(\frac{\sqrt{3}}{4}L^2)$
C_D	:	Drag Coefficient (Assumed $C_D = 1.25$)
ρ	:	Air Density at $15^{\circ}\mathrm{C}$ $(1.225\ kg/m^3)$
V_T	:	Terminal Velocity ($5\ m/s$ by requirements)
M	:	Payload Mass (kg)
g	:	Acceleration due to gravity $(9.81\ m/s^2)$
L	: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



Descent Rate Estimates (4/4)





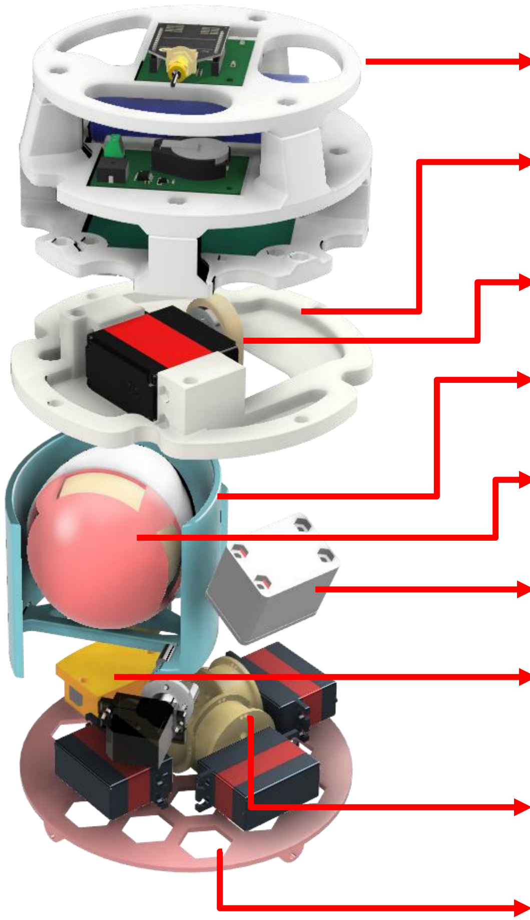


Parts	CanSat Container Parachute	Steerable Guide Parachute X-Triangle
Parachute Area	0.11 m^2	0.38 m^2
Payload Mass	1 kg	0.8 kg
Drag Coefficient	0.6	1.25
Parachute Diameter	0.288 m	N/A
Side Length	N/A	1.09 m
Descent Rate	≈ 13.64 m/s	≈ 5 m/s

Mechanical Subsystem Design

Rapassakorn Leelarujawanich
Nopparuch Ungpipattanapong
Pasin Thawornwiriyakul

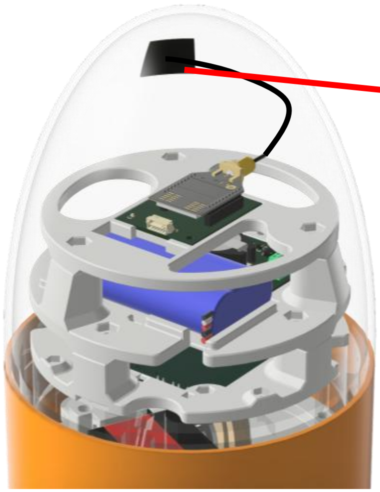
Mechanical Subsystem Overview



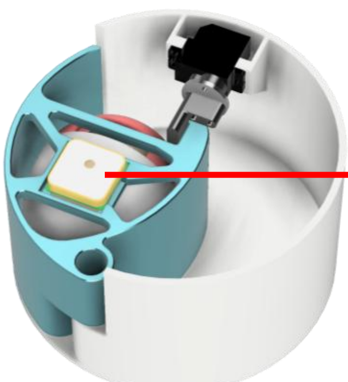
Parts	Materials
Electrical Structure	ASA-LW
Payload Deployment	ASA-LW
Hook	PPA-CF
Instrument Deployment	ASA-LW
Egg Case	ASA-LW
Descent Control Camera Case	ASA-LW
Ground Pointing Camera Case	ASA-LW
Paraglider Spools	ASA-LW
Grid Plate	ASA-LW

CanSat Mechanical Layout of Components Trade & Selection (1/6)

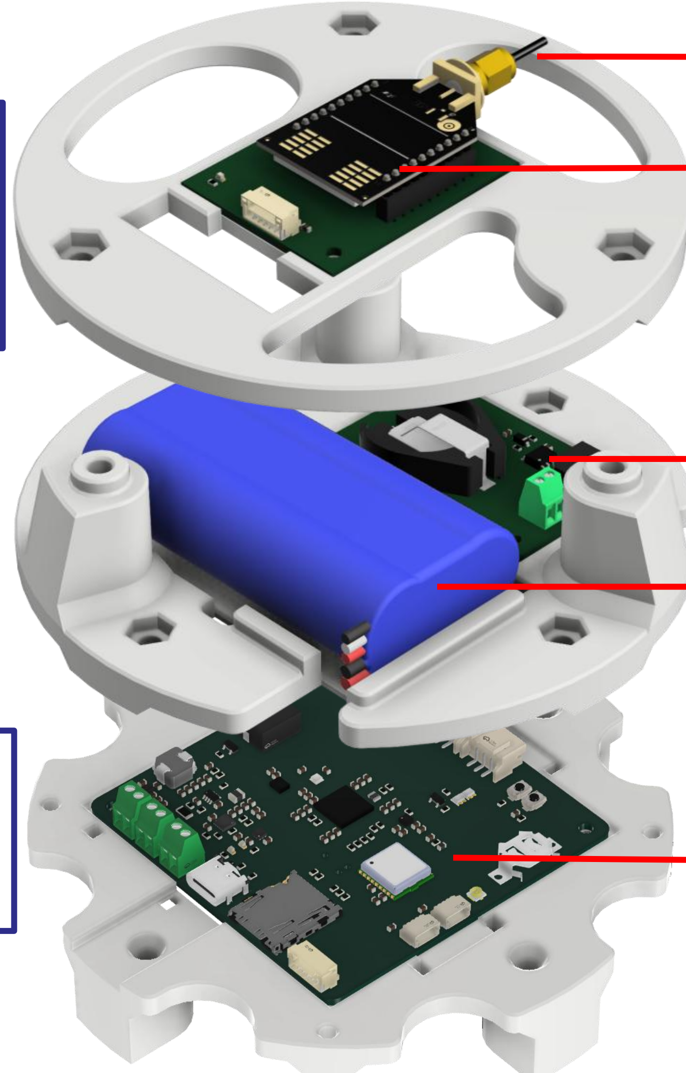
Electrical Components



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

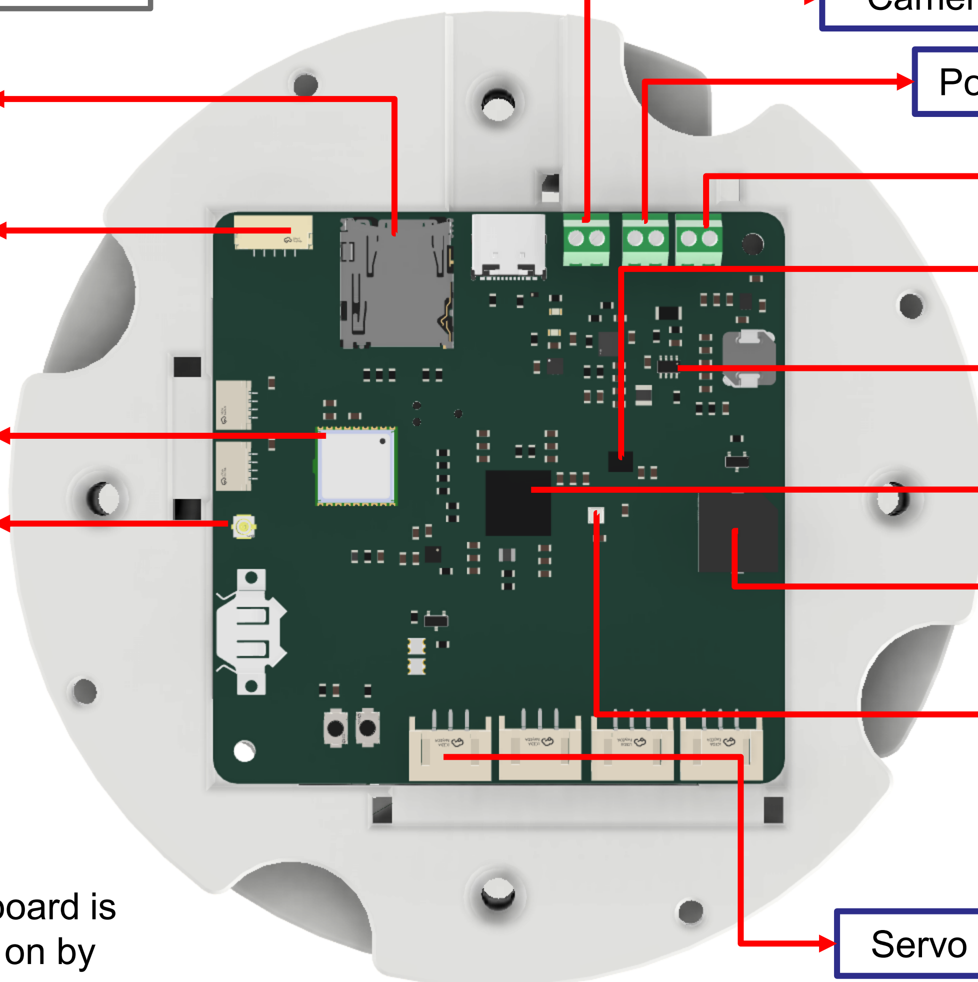


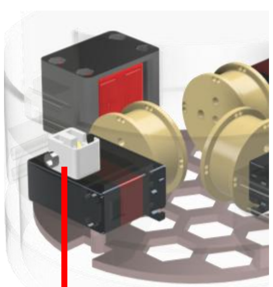
The GNSS Antenna is attached to the top of the instrument deployment.



CanSat Mechanical Layout of Components Trade & Selection (2/6)

Payload Mainboard





The mainboard is powered on by the screw switch.

CanSat Mechanical Layout of Components Trade & Selection (3/6)

Material Trade & Selection (for 3D printing)

Materials	Advantages	Disadvantages	Density (g/cm^3)	Young's Modulus (MPa)	Ultimate Strength (MPa)
PPA-CF	• Excellent durability • Great thermal resistant	• Difficult to print • More expensive than other filaments	1.25	9860	168
ASA-LW	• Ultra-lightweight • Excellent durability • Good impact strength	• Inconsistent printing results • More expensive than other filaments	0.6	970	9

Part	Selected Material	Rationales
Payload Deployment Hook	PPA-CF	• Fit for structural strength overload • Excellent durability and impact strength
Electronics Structure	ASA-LW	• Perfect for reducing overall weight • Good durability and impact strength
Deployment Structure	ASA-LW	• Perfect for reducing overall weight • Good durability and impact strength
Descent Control	ASA-LW	• Perfect for reducing overall weight • Good durability and impact strength

CanSat Mechanical Layout of Components Trade & Selection (4/6)

Payload

Design A

Electronics Structure

Instrument Deployment

Descent control Camera

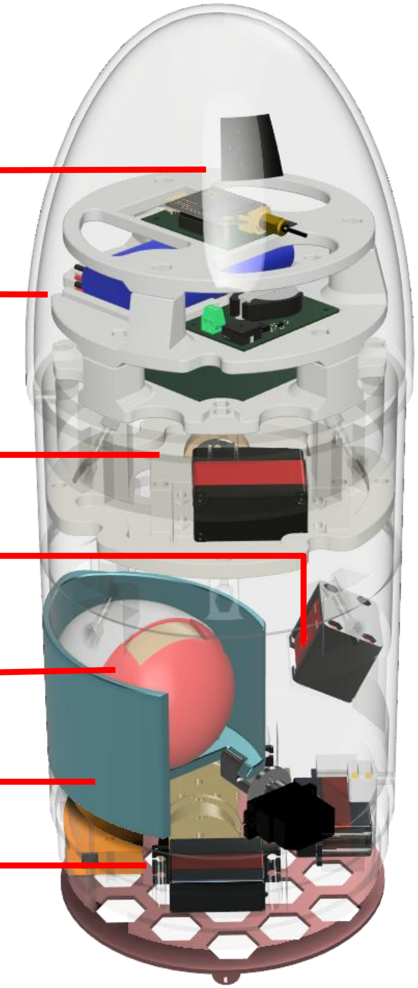
Ground pointing Camera

Paraglider System

Payload Deployment

Design B

(Selected)



Radio Antenna

Electronics Structure

Payload Deployment

Descent Control Camera

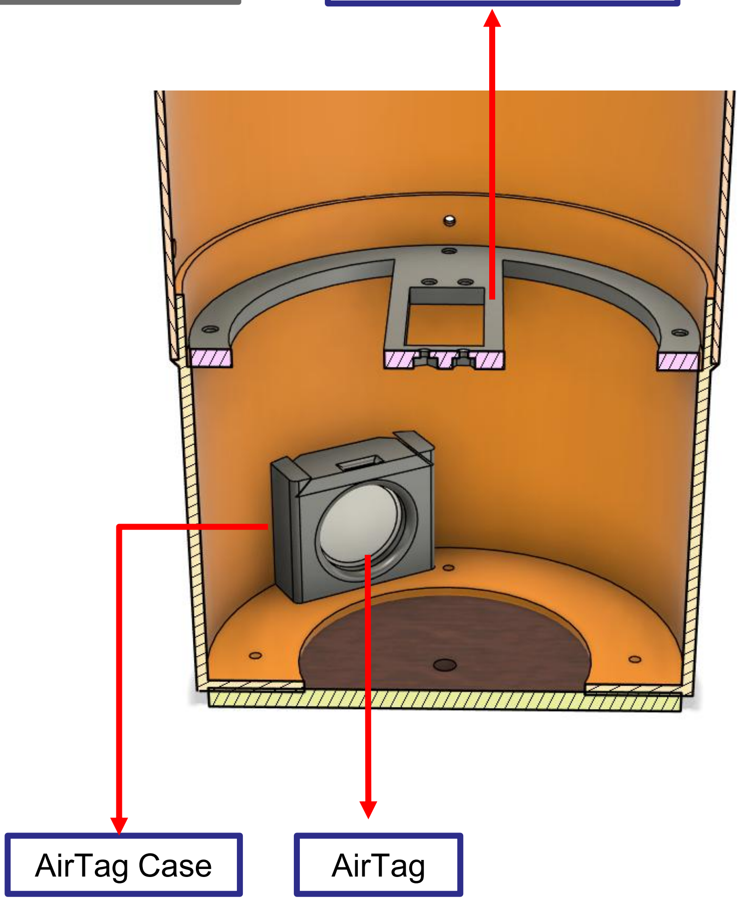
Instrument Deployment

Ground Pointing Camera

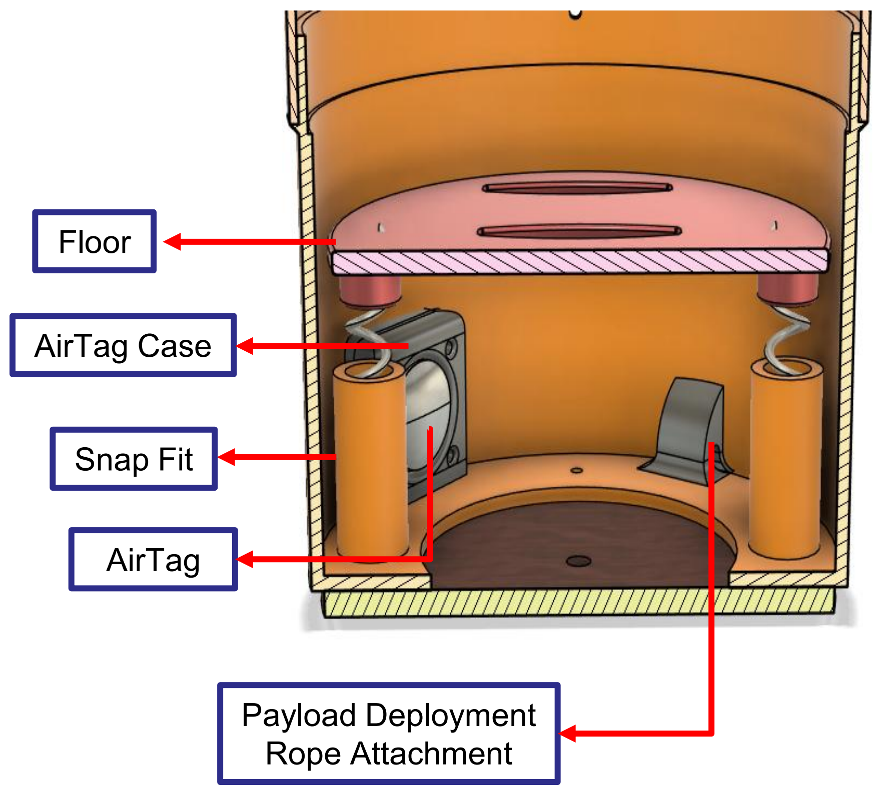
Paraglider System

Container

Design A



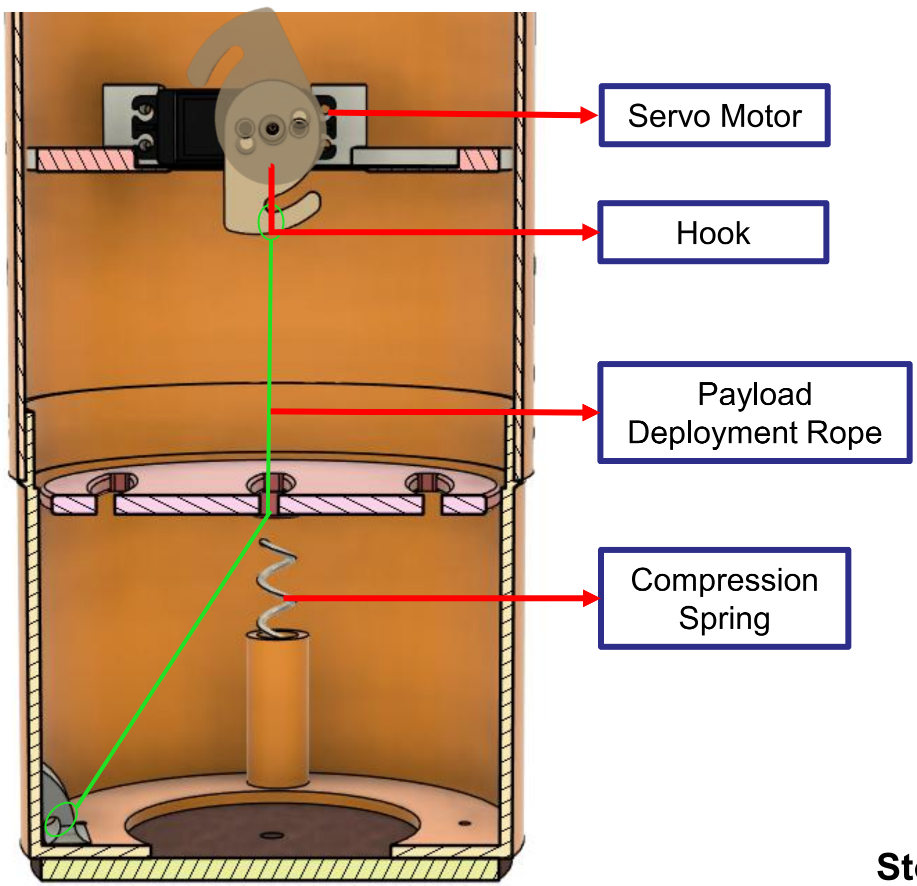
Design B (Selected)



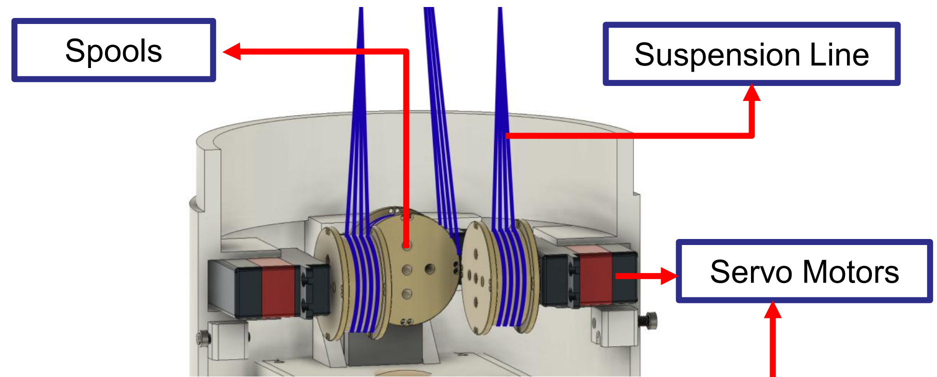
CanSat Mechanical Layout of Components Trade & Selection (5/6)

Mechanisms

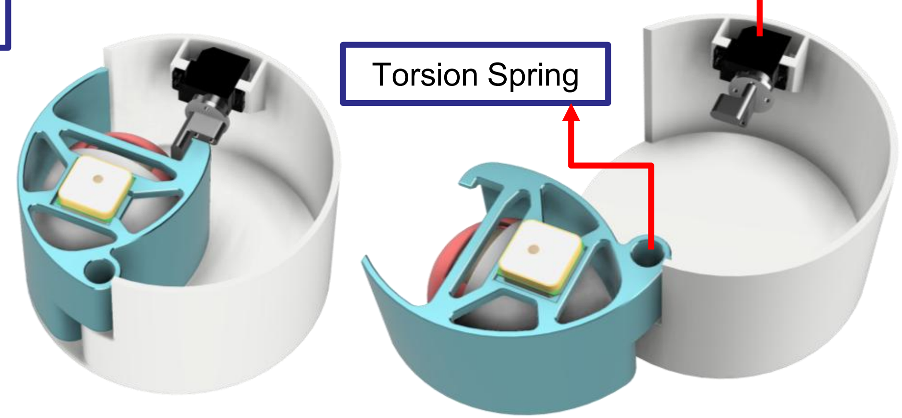
Payload Deployment



Paraglider



Egg Deployment



Stowed Configuration **Deployed Configuration**

CanSat Mechanical Layout of Components Trade & Selection (6/6)

Design	Advantages	Disadvantages
 Design A	• Lightweight • Less complex assembly process	• Potential concerns regarding the structural reliability of the rod
 Design B	• Enhanced rigidity and overall reliability • Less moving parts	• Heavyweight • More complex assembly process

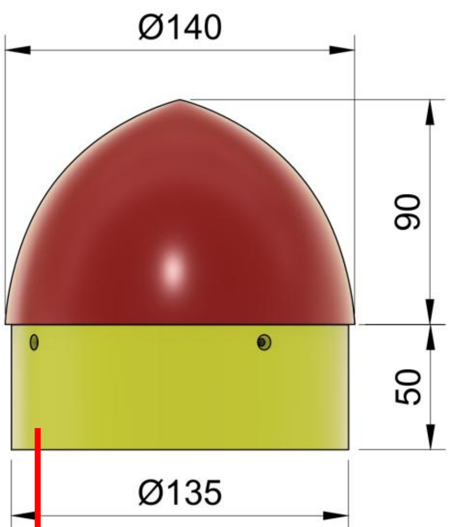
Selected Design	Rationales
Design B	Design B was selected for its enhanced rigidity and overall stability, with fewer moving parts that improve structural reliability under operational loads. Although it is heavier and involves a more complex assembly process, the increased reliability and payload protection justify these trade-offs.

Nose Cone Design Trade & Selection (1/4)

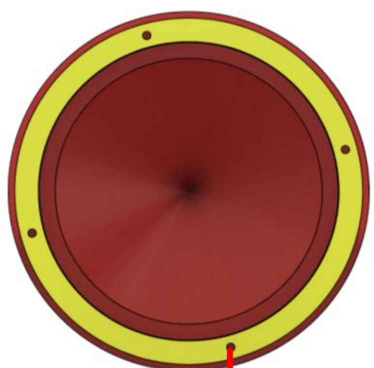
Properties

Design A

Ogive Design



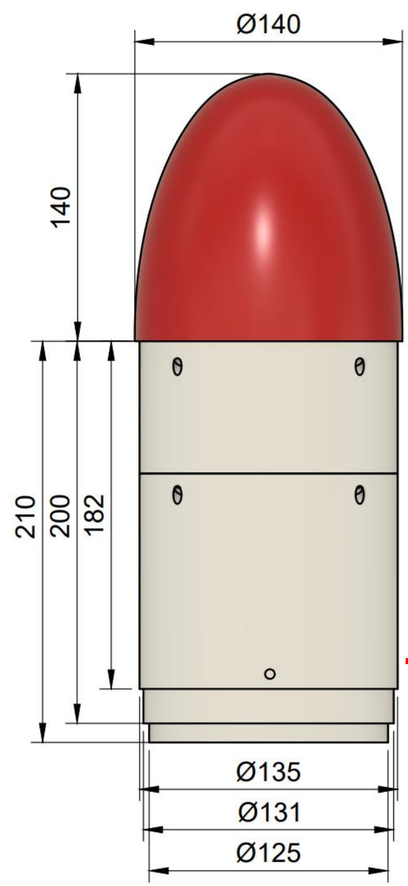
PETG Material



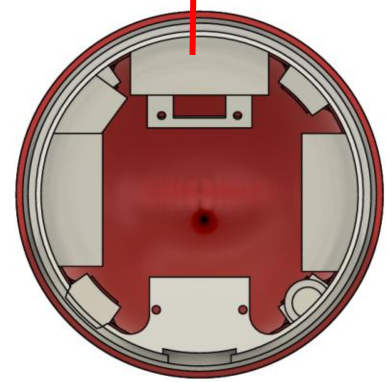
Insert hole for the carbon fiber rod.

Design B **(Selected)**

Ellipsoid Design



The Placement for SQ11 Camera



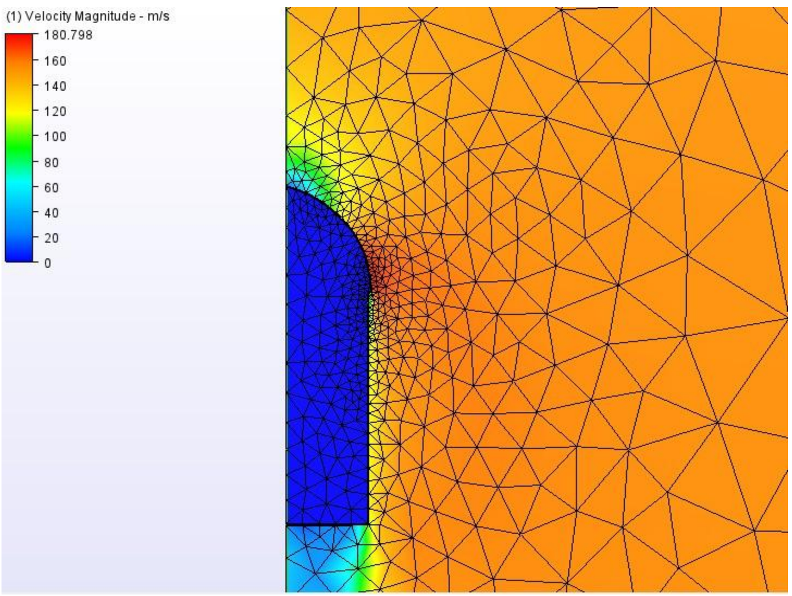
ASA-LW Material

Unit : mm

Aerodynamic Simulation in a Wind-Tunnel-Like Environment

Design A

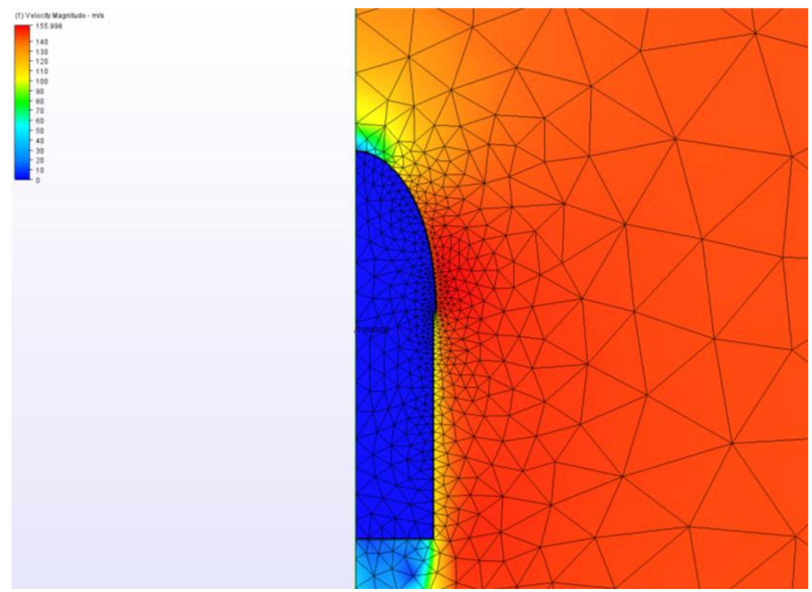
Ogive Design



Drag Coefficient 0.17
(Simulated by Autodesk CFD)

Design B **(Selected)**

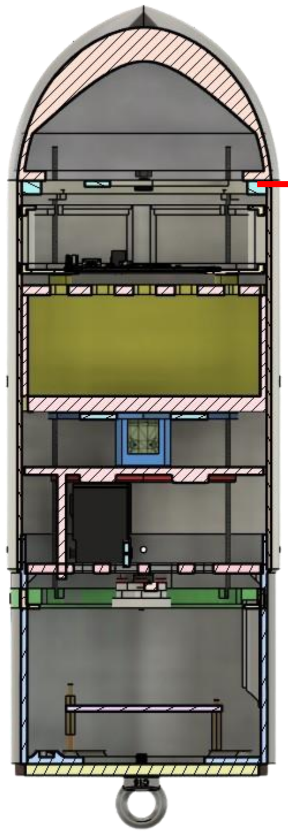
Ellipsoid Design

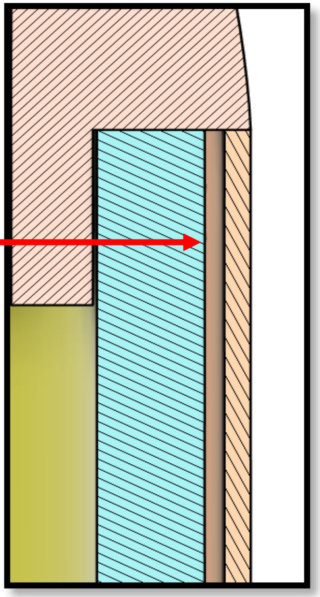


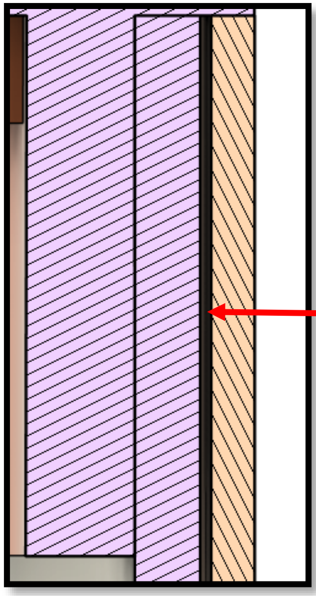
Drag Coefficient 0.30
(Simulated by Autodesk CFD)

Nose Cone Shoulder & Container Fitting

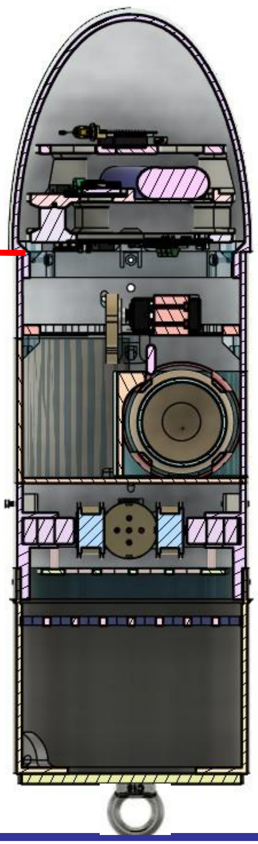
Design A







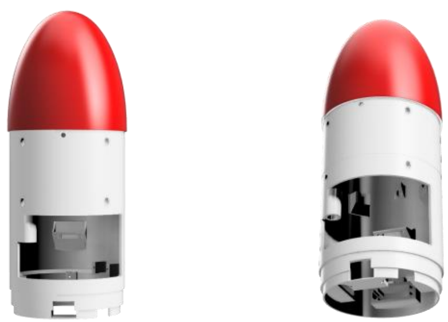
Design B



The two designs are distinguished by the spacing between the nosecone and the container.

Design A and Design B have slightly different container spacing, with Design A at 1.5 mm and Design B at 0.5 mm.

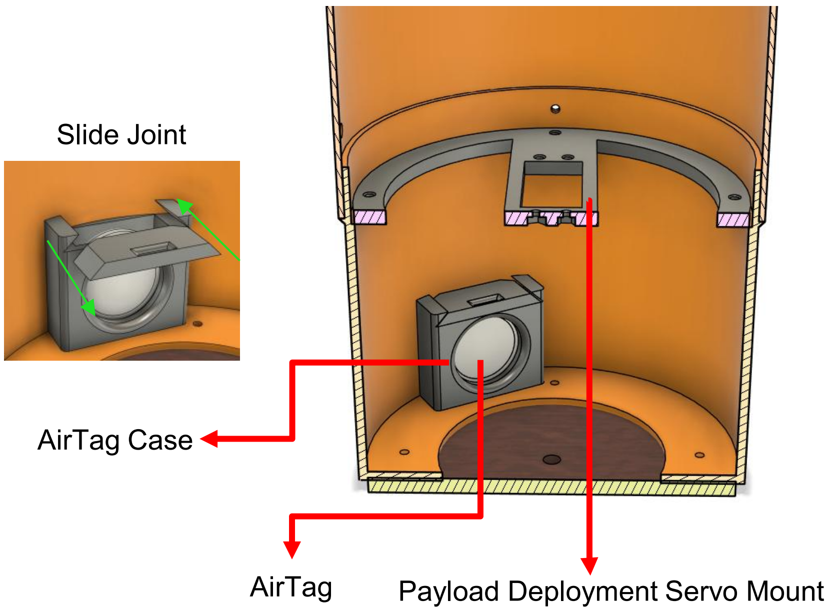
Nose Cone Design Trade & Selection (4/4)

Designs	Advantages	Disadvantages
 Design A	• Simple manufacturing process • Optical transparency enabling unobstructed video capture through the nose cone	• Restricted internal volume, limiting storage and integration capability
 Design B	• Provides adequate internal volume to support multiple mission applications • Allows more system functions	• Challenging manufacturing and printing due to structural complexity • Heavyweight • High aerodynamic drag

Selected Design	Rationales
Design B	Design B was selected for its ample internal volume, allowing for multiple mission functions and flexible component integration. Despite its higher mass, aerodynamic drag, and manufacturing complexity, its structural capacity and versatility outweigh these drawbacks.

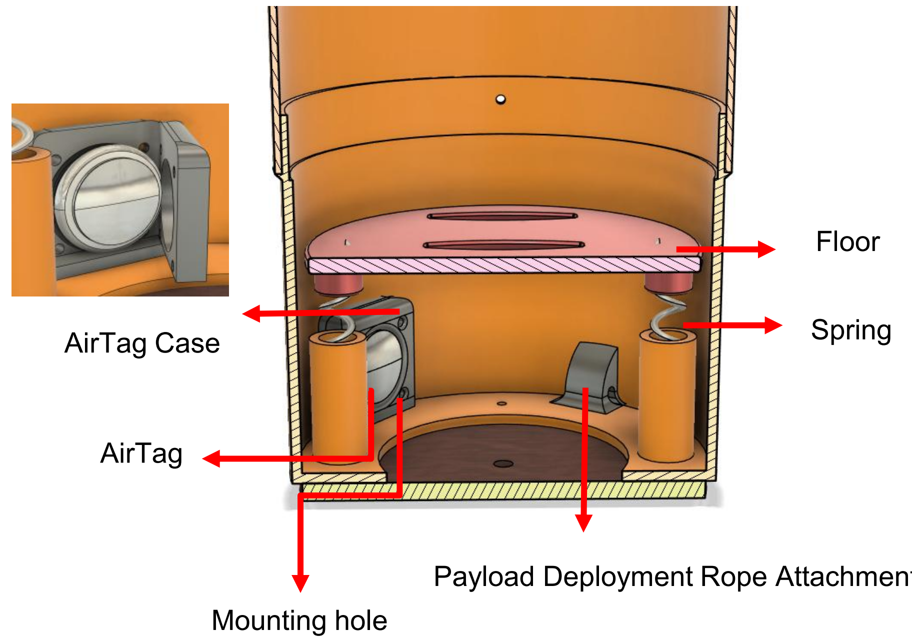
Container Design and Configuration Trade & Selection (1/3)

Design A



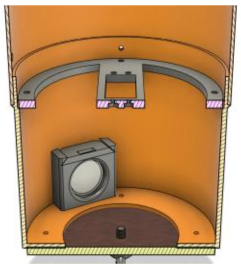
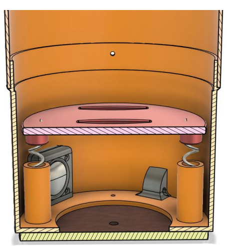
- The AirTag is housed within a snap-fit enclosure, ensuring secure retention.
- The payload deployment servo is mounted on top using screws.

Design B (Selected)



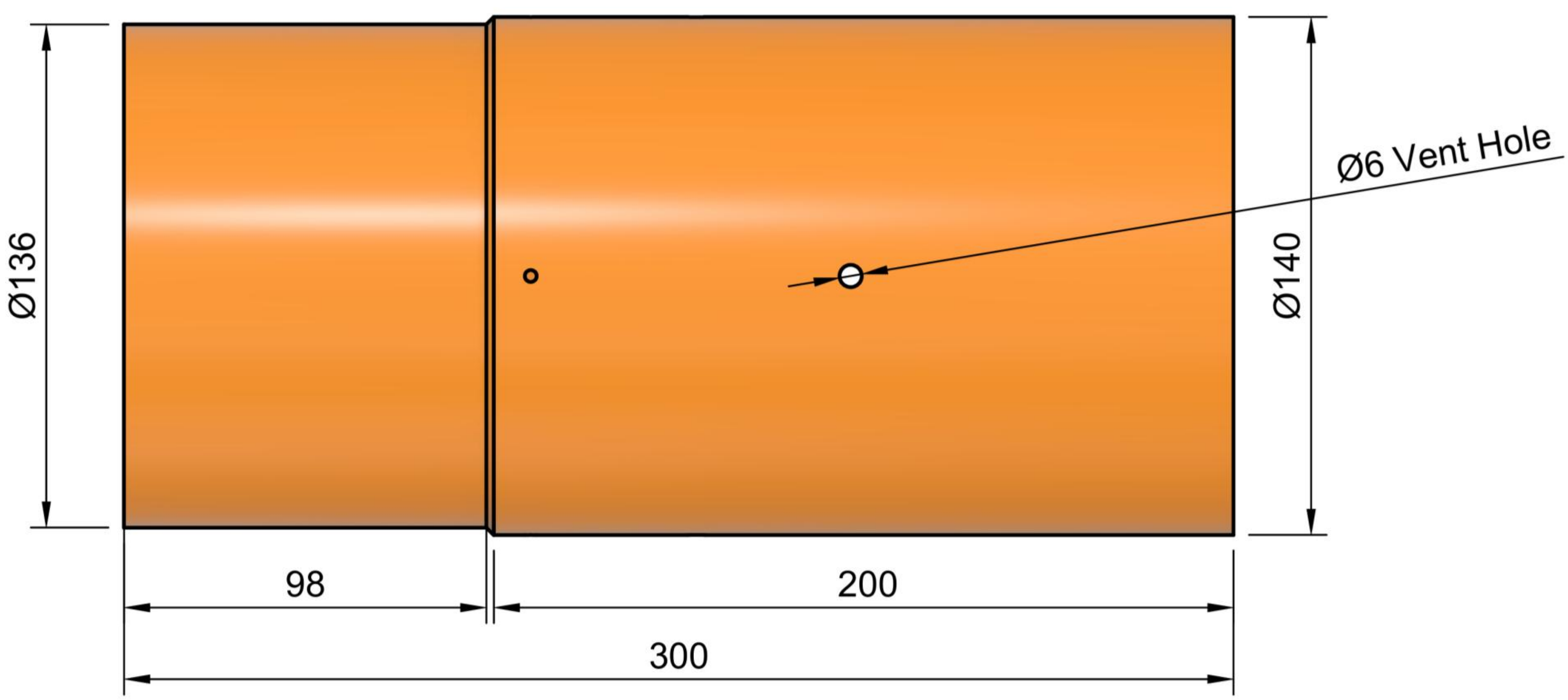
- The AirTag is mounted in a case with a screw-secured door.
- The payload deployment rope is attached to the attachment point.
- A spring-loaded mechanism used for paraglider deployment.

Container Design and Configuration Trade & Selection (2/3)

Designs	Advantages	Disadvantages
 Design A	• Provides strong structural support for the servo	• Consumes a substantial amount of internal volume • Involves a complex assembly process
 Design B	• The AirTag mount is strong and secure • More space for the parachute • Dedicated attachment point for a payload deployment	• Additional installation time is required for integrating the AirTag

Selected Design	Rationales
Design B	Design B was selected for its robust AirTag mount, added parachute space, and dedicated payload attachment, improving system functionality. The extra installation time is acceptable given the structural and operational benefits.

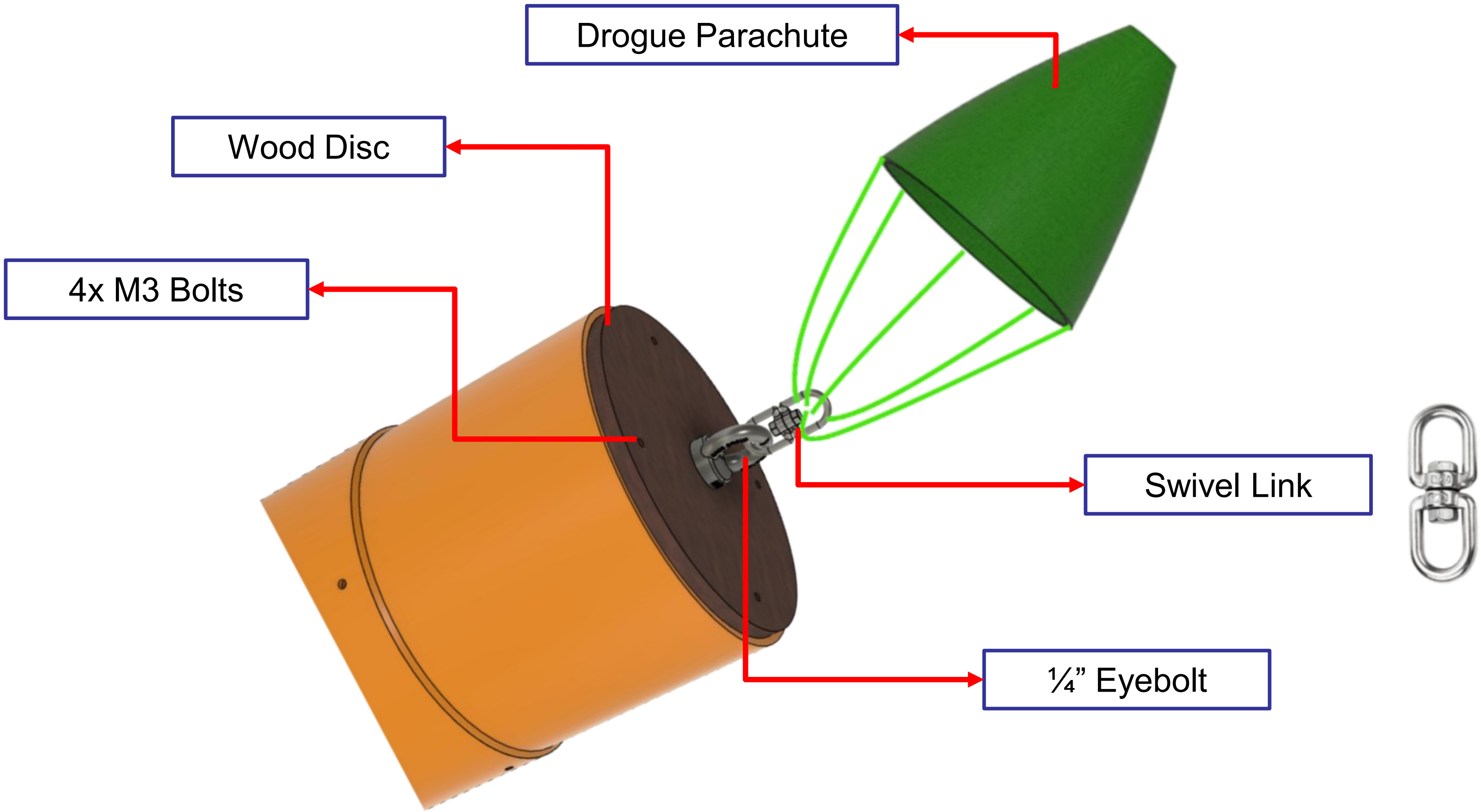
Container Design and Configuration Trade & Selection (3/3)



Dimensions are the same for both designs.
Wall thickness is 2mm throughout the whole container.

Container Parachute Attachment

The parachute is attached to the CanSat via an eyebolt, 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.

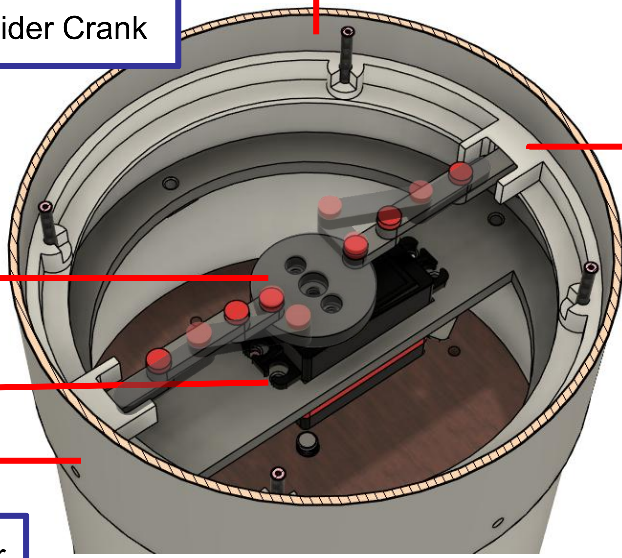


Payload Release Trade & Selection (1/2)

Design A

Rotary Slider Crank

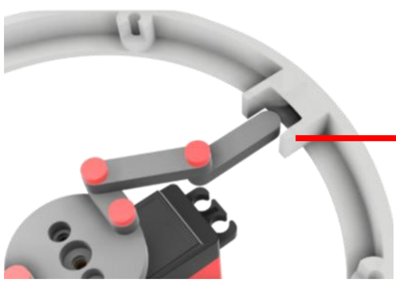
Insert hole for CF rod



Servo

Container

Payload Structure

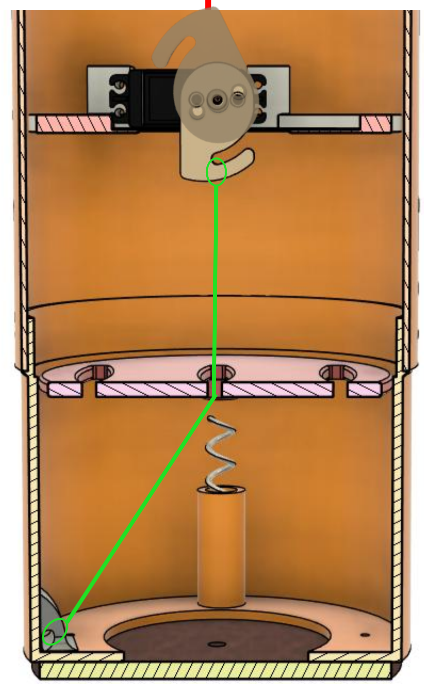


Deployed position with payload structure

* Controlled by Avionics in the container

Design B **(Selected)**

Restrain hook

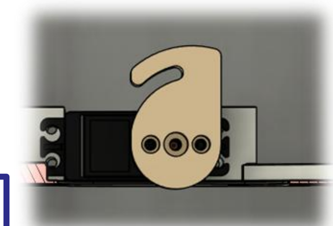


Servo mounting base

Servo

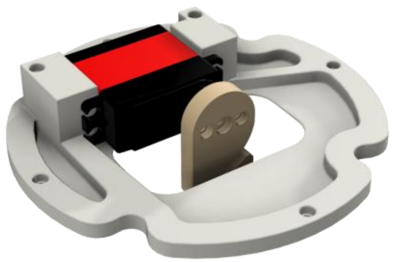
Picture of Testing

Deployed Position



* Controlled by Avionics in the payload

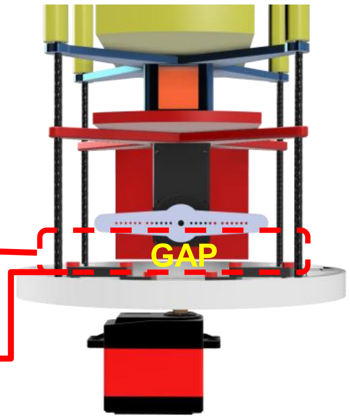
Payload Release Trade & Selection (2/2)

Designs	Advantages	Disadvantages
 Design A	• Simple and efficient assembly process • The mechanism is simple in structure.	• Consumes a significant amount of space • Degraded operational reliability • High friction losses during rotational motion
 Design B	• Greater structural strength • Reduced space usage • Improved overall mechanical reliability	• Increased assembly difficulty • Elevated mechanism complexity

Selected Design	Rationales
Design B	Design B was chosen based on the fact that its rotational motion enhances stability during the container–payload separation process.

Para-Glider Stow Configuration Trade & Selection

Design A

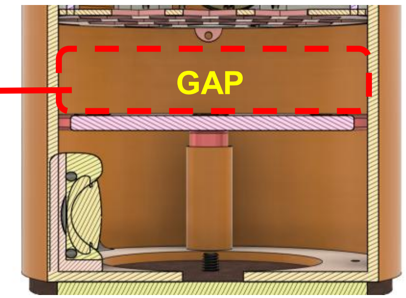


Parachute Integration

Before the container deploys.

Design B **(Selected)**

Parachute Integration

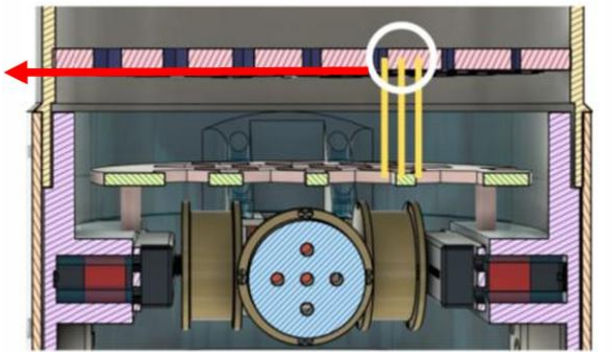


The parachute is stowed within the 17 mm gap between the servo arm and the payload deployment assembly.

The parachute will be stowed in the container by placing it on the floor. The gap between these two components is 35 mm.

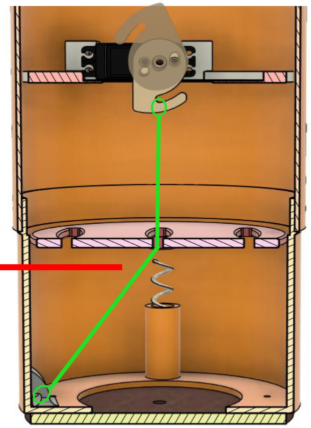
Selected Design	Rationales
Design B	Design B was selected a larger parachute storage compartment reduces parachute compression. Excessive compression may lead to parachute deployment failure due to jamming.

Design A



"In this design, the parachute rests on a mesh and is extracted by a loosely attached tether during payload deployment. The tether then releases, allowing full parachute deployment.

Design B (Selected)



The parachute is ejected by two compression springs mounted on guide rods and held by the payload deployment servo. When released, the springs push the parachute out of the container.

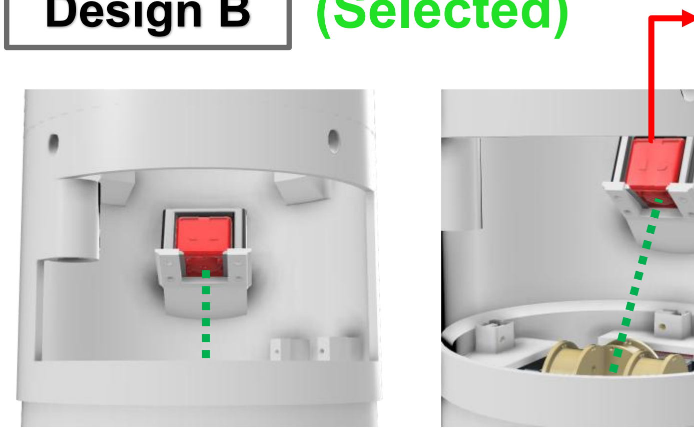
Selected Design	Rationales
Design B	Design B is preferred because its spring-driven ejection mechanism provides a controlled and reliable parachute deployment. The guided compression springs actively push the parachute out of the container, ensuring consistent performance and reducing the risk of deployment failure.

Descent Control Pointing Camera Mount Trade & Selection

Design A

- **Faces downwards towards the paraglider.**
- Designed as a separate piece to assemble with the payload structure.
- Mounted at the center of the support, which is inserted into the carbon fiber rod.

Design B (Selected)

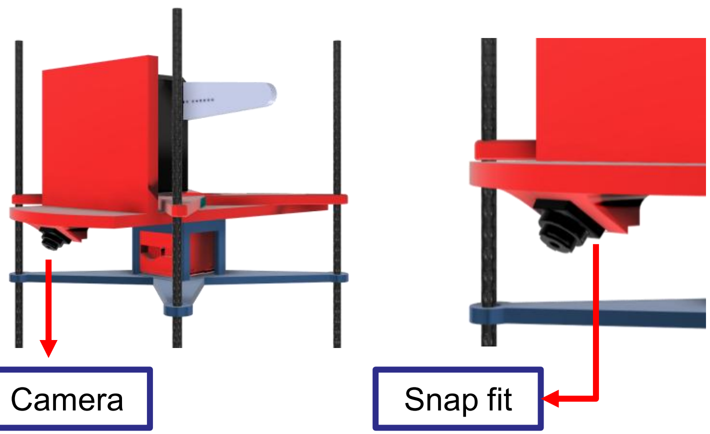


- **The camera is mounted at the edge of the nose cone shoulder, facing the paraglider.**
- It is housed within a protective enclosure, which is mounted to the protruding structure using mechanical fasteners (bolts).

Selected Design	Rationales
Design B	Design B was selected for its simple installation, bolted structural stability, and unobstructed viewing angle. The camera placement ensures a clear view of the paraglider while maintaining durability through a mechanically secured protective enclosure.

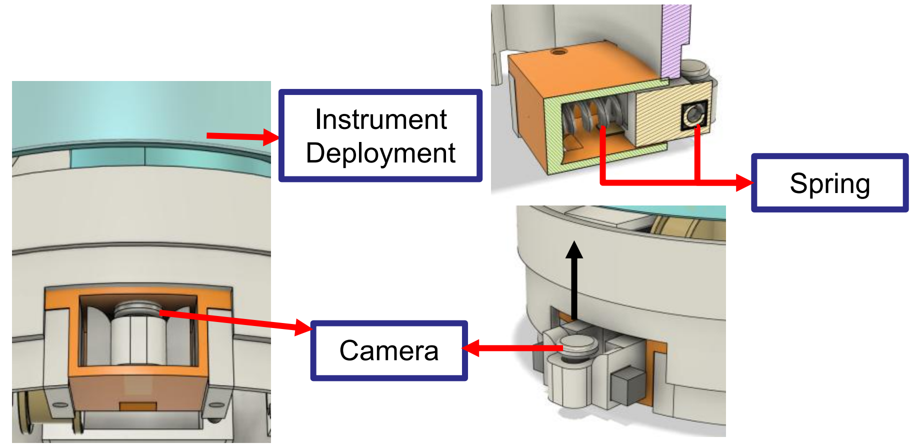
Ground Pointing Camera Mount Trade & Selection

Design A



- The camera is mounted on a sloped 3D-printed plane on the paraglider control platform and is tilted 60° toward the wall, with an opening provided for the lens.

Design B (Selected)



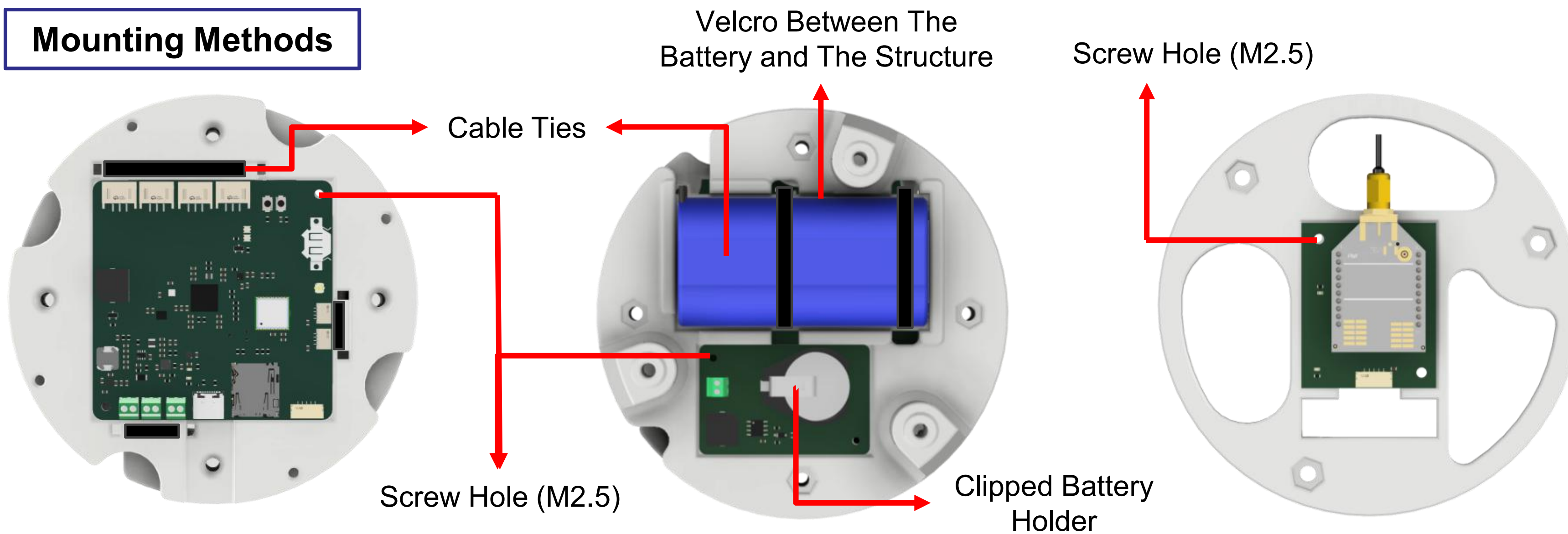
Stowed **Deployed**

- The camera is mounted on the payload via a spring-loaded mechanism that activates upon the payload’s release from the container.

Selected Design	Rationales
Design B	Design B was selected for its unobstructed field of view and reliable ground imaging during descent, with higher installation complexity considered an acceptable trade-off.

Electronics Structural Integrity (1/2)

Mounting Methods



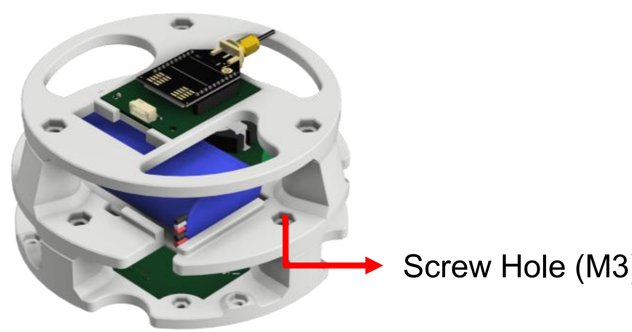
- The payload PCB is screwed to a payload structure using nuts and screws.
- Cable ties are used to secure wire connections in sockets.

- The battery is placed in the battery mount and is additionally secured with velcro and cable ties.
- A clipped battery holder mounts a coin cell for the RTC and beacon.

- The Communication Board is screwed into a payload structure using nuts and screws.

Electronics Enclosures

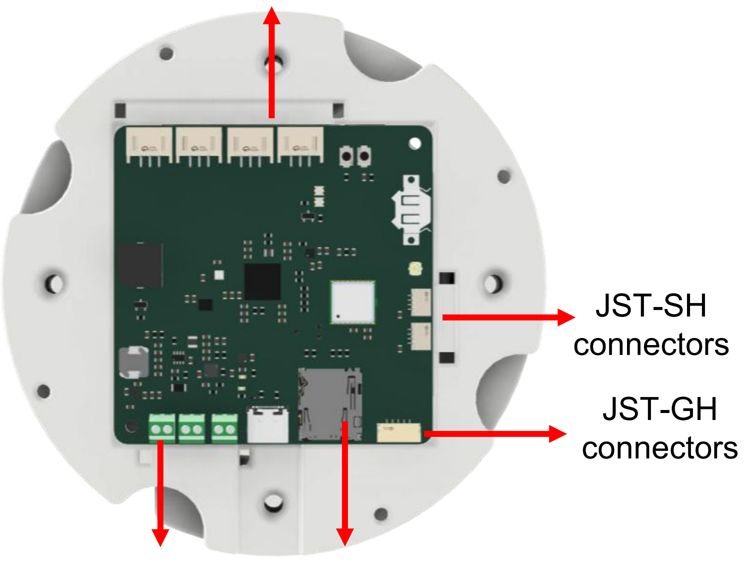
- A 3D-printed structure will enclose electronic components (ASA-LW Material).
- The structure has three parts and will be assembled using M3 nuts and screws.



Electronics Structural Integrity (2/2)

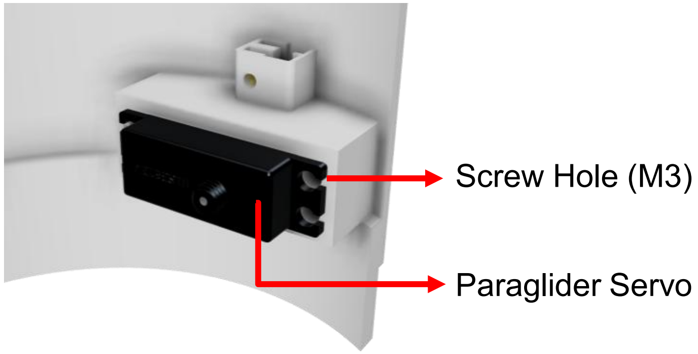
Securing Electrical Connections

- 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 board 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.



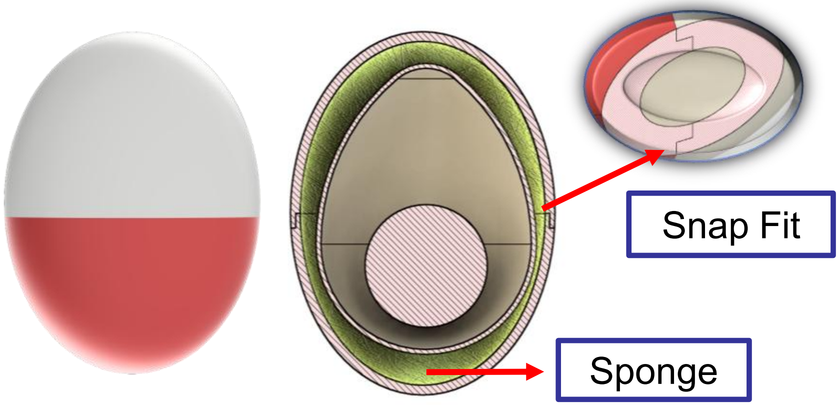
Descent Control Attachments

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



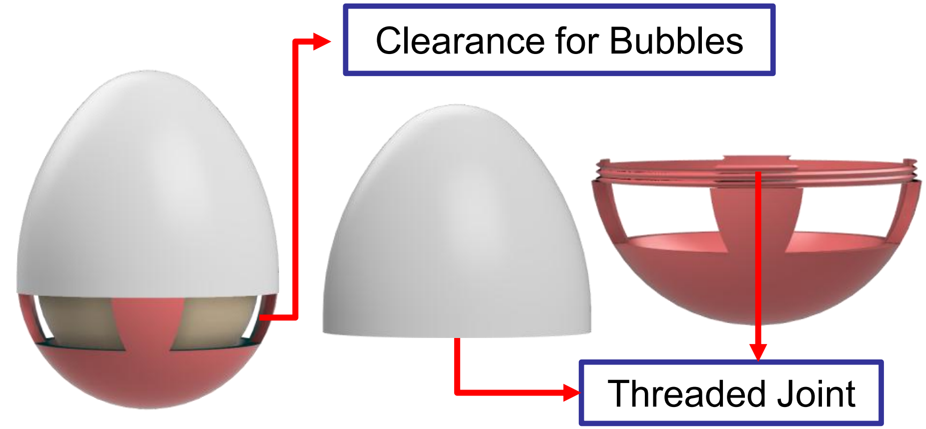
Egg Instrument Design Trade & Selection

Design A



- Restricted internal volume
- Lack of flexibility
- Inadequate structural attachment

Design B (Selected)



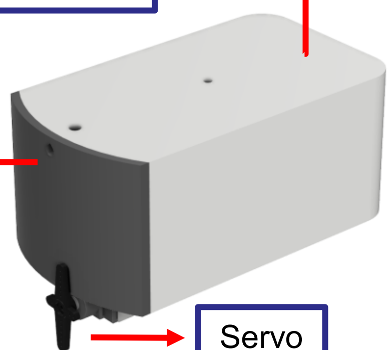
- Exhibits elastic deformation characteristics
- Allows increased impact-absorbing padding

Selected Design	Rationales
Design B	Design B was selected because it offers superior overall performance by combining elastic deformation capability, and improved impact absorption, effectively addressing the limitations of Design A related to volume constraints, excessive rigidity, and insufficient structural attachment.

Egg Instrument Release Trade & Selection (1/2)

Design A

Stowed Configuration



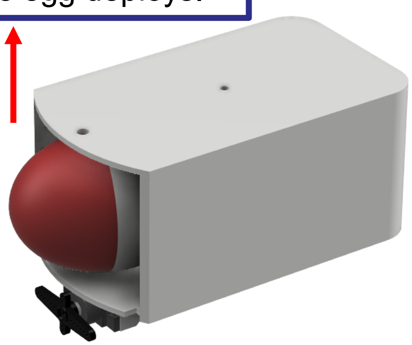
Spring inside

Door

Servo

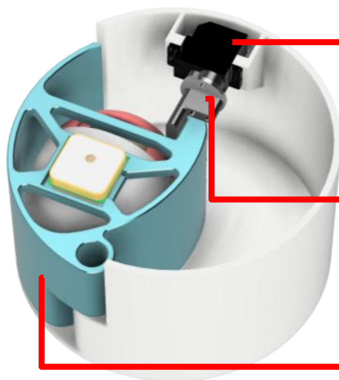
Deployed Configuration

The egg deploys.



Design B (Selected)

Stowed Configuration



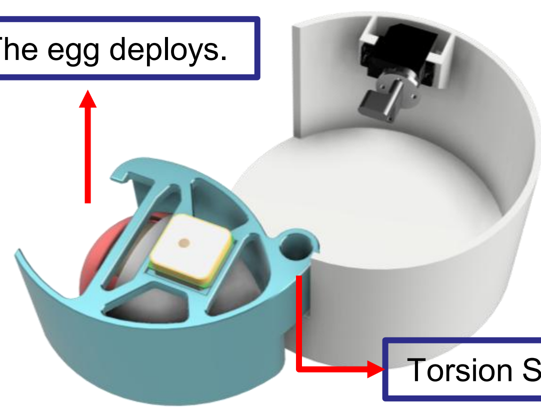
Servo

The door is restrained by the servo arm.

Door

Deployed Configuration

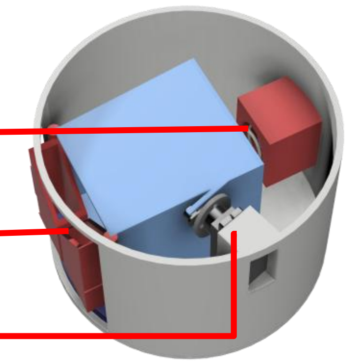
The egg deploys.



Torsion Spring

Design C

Stowed Configuration



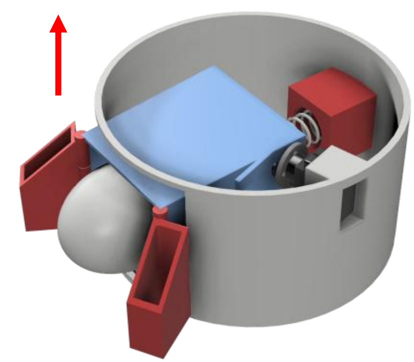
Spring

Door

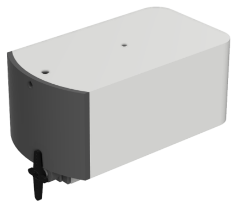
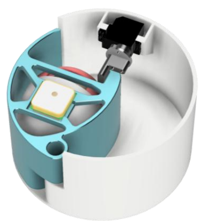
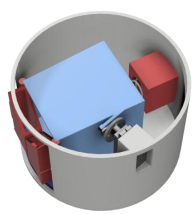
Servo

Deployed Configuration

The egg deploys.



Egg Instrument Release Trade & Selection (2/2)

Designs	Advantages	Disadvantages
Design A 	• Fewer moving components • Rigid structural configuration • Low assembly complexity	• Occupies a large amount of space • Potential for door tilting
Design B 	• Provides reliable deployment • High mechanical advantage enables effective spring restraint	• High assembly complexity
Design C 	• Low assembly complexity • Space-efficient design	• High mechanism complexity • Lower reliability during operation • Poor structural integrity

Selected Design	Rationales
Design B	Design B was selected for its dependable deployment and strong mechanical advantage, which ensure effective spring restraint. Although assembly is more complex, the increased reliability make the design preferable.

Mass Budget (1/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Infill (%)	Source
Nose Cone	108 ± 2	1	108 ± 2	30	Software Estimated
Container	104 ± 2	1	104 ± 2	15	Software Estimated
Instrument Deployment	35 ± 1	1	35 ± 1	15	Software Estimated
Payload Deployment	18 ± 0.5	1	18 ± 0.5	40	Software Estimated
Electronic Structure	34 ± 1	1	34 ± 1	25	Software Estimated
Paraglider Spools	3.2 ± 0.2	3	9.6 ± 0.6	30	Software Estimated
Steerable Guide Parachute X-Triangle	49 ± 2	1	49 ± 2	N/A	Measurement
Parachutes	13.5 ± 1	1	13.5 ± 1	N/A	Measurement
Bolt M2.5 × 5	0.08 ± 0.004	2	0.16 ± 0.008	N/A	Datasheet
Bolt M2.5 × 8	0.13 ± 0.04	8	1.04 ± 0.32	N/A	Datasheet
Bolt M3 × 5	0.15 ± 0.02	4	0.60 ± 0.08	N/A	Datasheet
Bolt M3 × 6	0.15 ± 0.02	4	0.60 ± 0.08	N/A	Datasheet
Bolt M3 × 8	0.20 ± 0.02	8	1.60 ± 0.16	N/A	Datasheet
Bolt M3 × 13	0.25 ± 0.04	8	2 ± 0.32	N/A	Datasheet
Bolt M3 x 18	0.30 ± 0.06	12	3.60 ± 0.72	N/A	Datasheet

Mass Budget (2/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Infill (%)	Source
Bolt M3 × 30	0.70 ± 0.10	7	4.9 ± 0.70	N/A	Datasheet
Nut M2.5	0.30 ± 0.001	10	3 ± 0.01	N/A	Software Estimate
Nut M3	0.30 ± 0.001	27	8.10 ± 0.027	N/A	Software Estimate
Eyebolt	30 ± 2	1	30 ± 2	N/A	Measurement
Wood Disc	52 ± 2	1	52 ± 2	N/A	Measurement
Egg Case	7.5 ± 0.5	1	7.50 ± 0.50	N/A	Software Estimate
Egg	59 ± 2	1	59 ± 2	N/A	Mission Guide
M3 Swivel Link	1.50 ± 0.1	1	1.50 ± 0.1	N/A	Datasheet
Compression Spring	4 ± 0.25	3	12 ± 0.75	N/A	Datasheet
Torsion Spring	8 ± 0.5	1	8 ± 0.5	N/A	Datasheet
Mechanical Structure Subtotal (g)		**566.70 ± 20.37**			

Mass Budget (3/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Source
STM32H725	0.2 ± 0.0	1	0.2 ± 0.0	Datasheet
BMP581	0.2 ± 0.0	1	0.2 ± 0.0	Datasheet
INA236	0.009 ± 0.0	1	0.009 ± 0.0	Datasheet
ISM6HG256X	0.05 ± 0.0	1	0.05 ± 0.0	Datasheet
MAX-M10S	0.5 ± 0.0	1	0.5 ± 0.0	Datasheet
VL53L1X	3 ± 0.1	1	3 ± 0.1	Datasheet
SD Card	0.01 ± 0.0	3	0.03 ± 0.0	Datasheet
XBee Pro	20 ± 2	1	20 ± 2.0	Measurement
Radio Antenna	1.3 ± 0.0	1	1.3 ± 0.0	Datasheet
GPS Antenna	7 ± 0.0	1	7 ± 0.0	Datasheet
18650 Li-ion Battery	48 ± 0.0	2	96 ± 0.0	Datasheet
Coin Cell Battery	0.9 ± 0.0	2	1.8 ± 0.0	Datasheet
Screw switch	4 ± 0.5	2	8 ± 1.0	Measurement
Beacon board	30 ± 2	1	30 ± 2.0	Estimated
Servo HL-3612-C001	38.2 ± 0.0	3	114.6 ± 0.0	Datasheet
Servo BLS-A932+	35.5 ± 0.0	1	35.5 ± 0.0	Datasheet
Servo MG90S	13.5 ± 0.0	1	13.5 ± 0.0	Datasheet
AirTag	11 ± 0.0	1	11 ± 0.0	Datasheet
Empty PCB	28 ± 0.0	1	28 ± 0.0	Manufacturer

Mass Budget (4/4)

Components	Mass Per Unit (g)	Quantity	Total Mass (g)	Uncertainty (g)	Source
Quelima SQ11 Camera	15	1	15 ±0.5		Measurement
ESP32-S3-CAM with OV5640	10.7	1	10.7 ±0.0		Datasheet
Electrical Structure Subtotal (g)		**396.39 ± 5.60**			

Total mass of all components and structural elements:

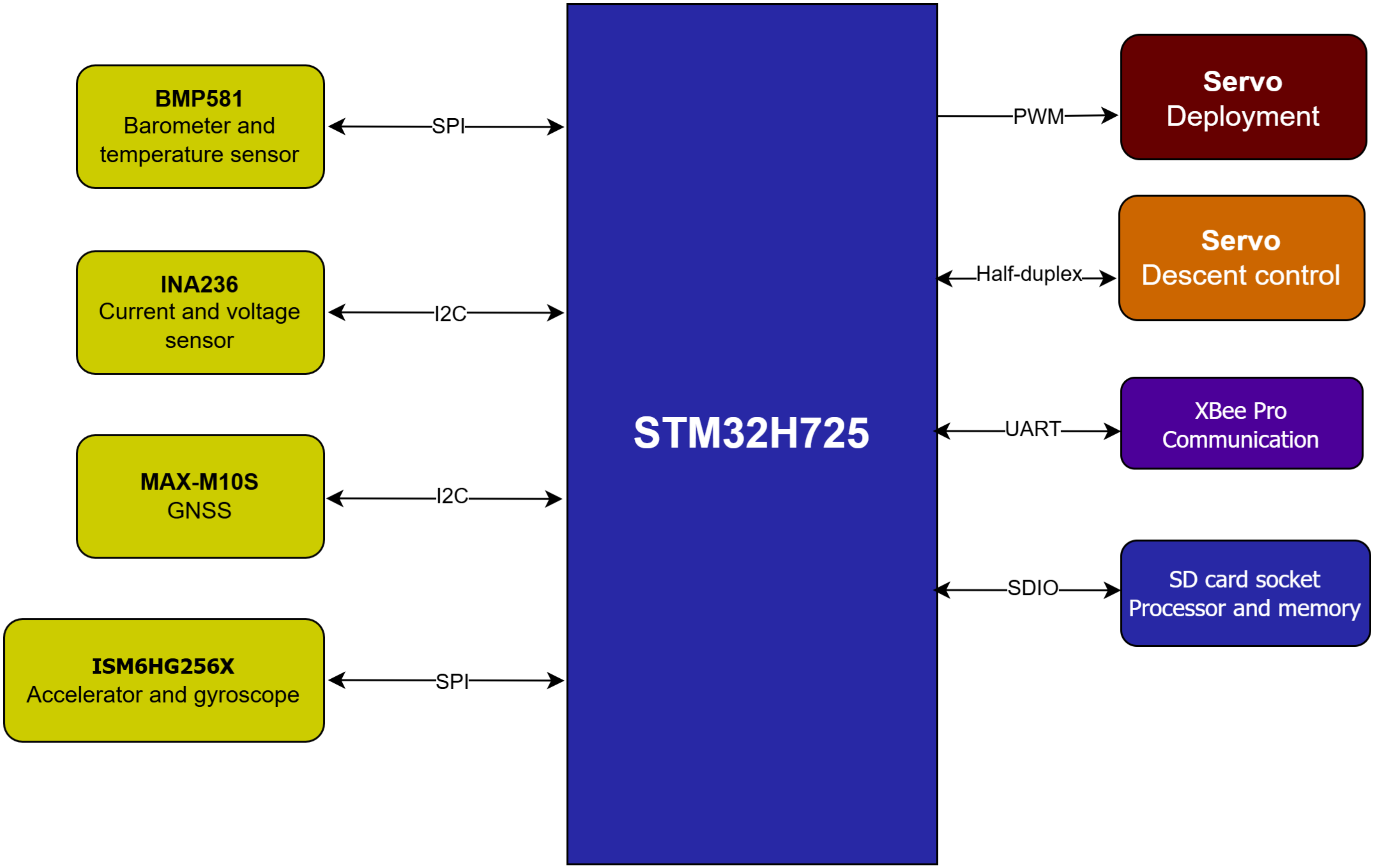
Total Mass Budget	
System	Mass(g)
Mechanical Structure	566.70 ± 20.37
Electrical Structure	396.39 ± 5.60
Subtotal	963 ± 26
Margin	1000 – (963 + 26) = 11 g

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

Communication and Data Handling (CDH) Subsystem Design

Trirayan Boontaganon

Payload Communication Data Handling (CDH) Overview



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

Modules	Boot Time (ms)	Clock Frequency (MHz)	Data interface	I/O Pins	Nonvolatile memory	Volatile memory (RAM)	Dimension (mm)	Cost ()
Teensy 4.1 (module)	4	600	3*SPI 3*I²C 8*UART	54	7MB flash	1023 KB	75x21	63.87
STM32F411 (SMD chip)	2	100	5*SPI 3*I²C, 3*UART 1*SDIO	51	0.5MB flash	128 KB	10x10	6.41
STM32H725 (SMD chip)	2	550	6*SPI 5*I²C, 5*UART 1*SDIO	50	1MB flash	564 KB	8x8	12.21

Selected Processor	Rationales
 STM32H725	• Lower cost compared to the Teensy 4.1 • Smaller physical size • Adequate processing capability for mission requirements • Faster boot time than Teensy 4.1.

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

Models	Memory (GB)	Interface	Data Transfer Rate (MB/s)		Cost ()
			Read	Write	
SanDisk Ultra	32	SPI and SDIO	100	10	7.49
SanDisk Extreme Pro	32	SPI and SDIO	100	90	15.81
BLACKBERRY BBR-MSD-UL	16	SPI and SDIO	80	10	4.68

Selected Memory	Rationales
 SanDisk Ultra	• Lower cost compared to the SanDisk Extreme Pro • Provides adequate storage capacity to support full-mission data recording

Payload Real-Time Clock

Modules	Reset Tolerance	Weight (g)	Dimensions (mm)	Cost ()
MAX-M10S built-in RTC	Unaffected due to external battery backup	Integrated in GPS	Integrated in GPS	0
Adafruit DS3231 Precision RTC	Unaffected due to external battery backup	2.3	38 x 22 x 14	14.42
PCF8563	Unaffected due to external battery backup	3	55 x 16 x 5	7.16

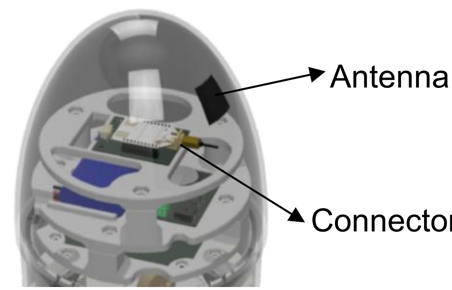
Selected Real-Time Clock	Rationales
 MAX-M10S built-in RTC	• Eliminates the need for additional hardware components • Built-in RTC support • Simplified PCB layout and reduced design complexity

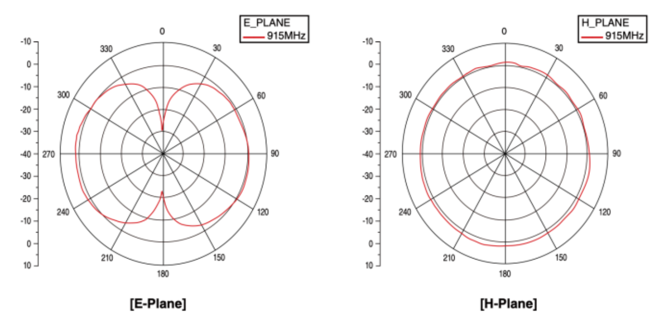
External backup power for the RTC is provided by a CR927 coin cell, which is mounted in a clip-style battery holder.

Payload Antenna Trade & Selection

Antennas	Frequency Range (MHz)	Gain (dBi)	Electrical Design	Weight (g)	Length (mm)	Range (km)	Cost (USD)
RFDesign 900MHz Right Angle	900-928	2.1	¼ wave	7.4	52.2	~10 - 14	5.30
RFDFLEX2 900MHz Flexible PCB	902-928	2.4	¼ wave	1.3	79	~12-18	26.50

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





Radiation Patterns

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)

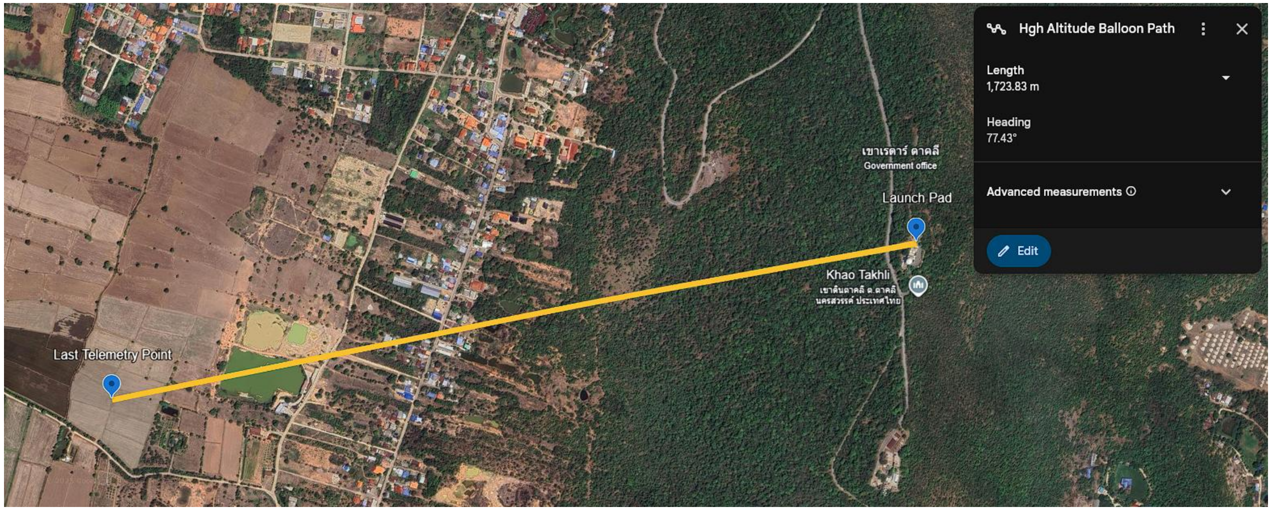
XBee Telemetry was clear and healthy until 3389.3 m far from GCS.

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 will be formatted as ASCII, and each telemetry field will be delimited by a comma and terminated with a newline. A packet will be sent at a rate of 1 Hz during transmission.

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)

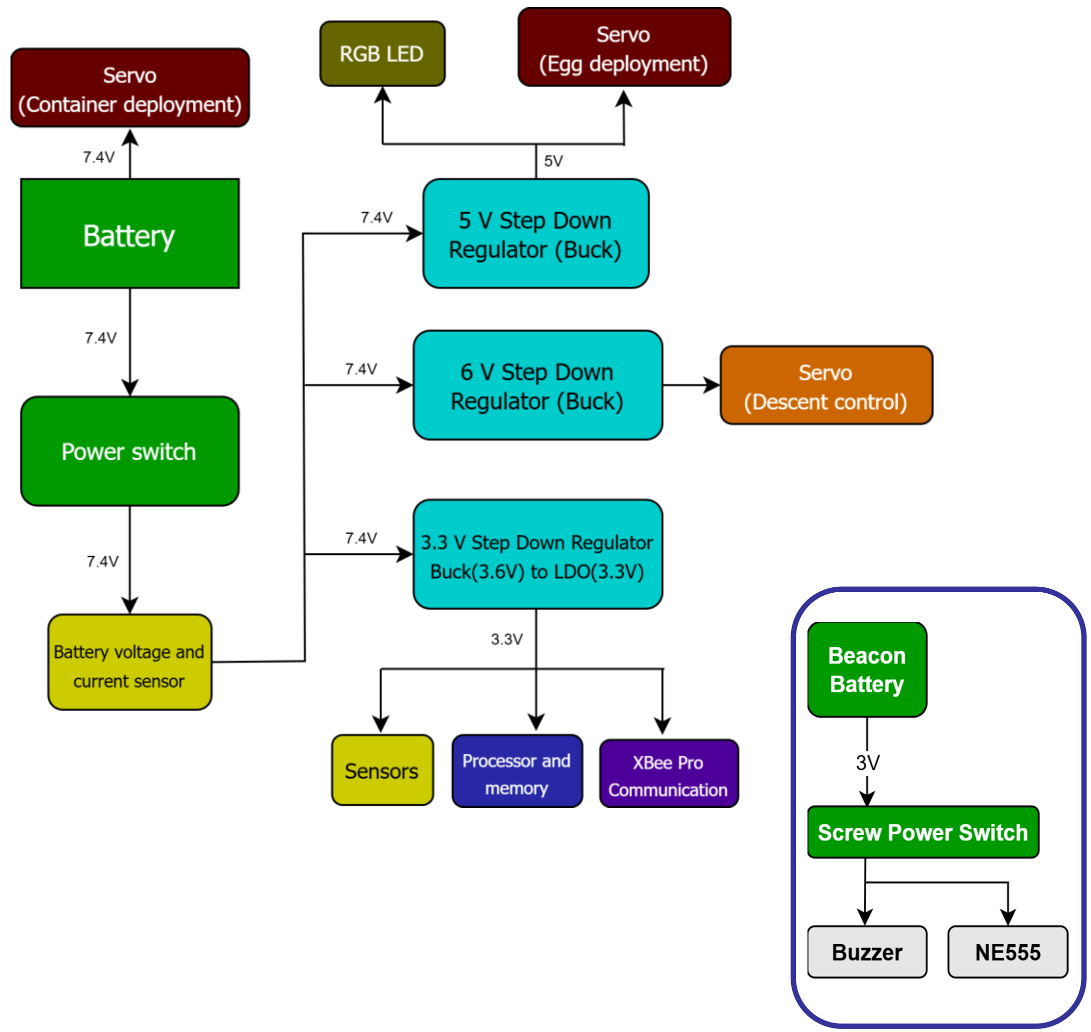
DC	Team ID	CN	Option		Examples	Descriptions
CMD	1043	CAL			CMD,1043,CAL	Calibrates telemetered altitude to 0 m when on the launch pad
		MEC	PL	ON	CMD,1043,MEC,PL,ON	Activates payload release system
				OFF	CMD,1043,MEC,PL,OFF	Deactivates payload release system
			INS	ON	CMD,1043,MEC,INS,ON	Activates 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 (EPS) Design

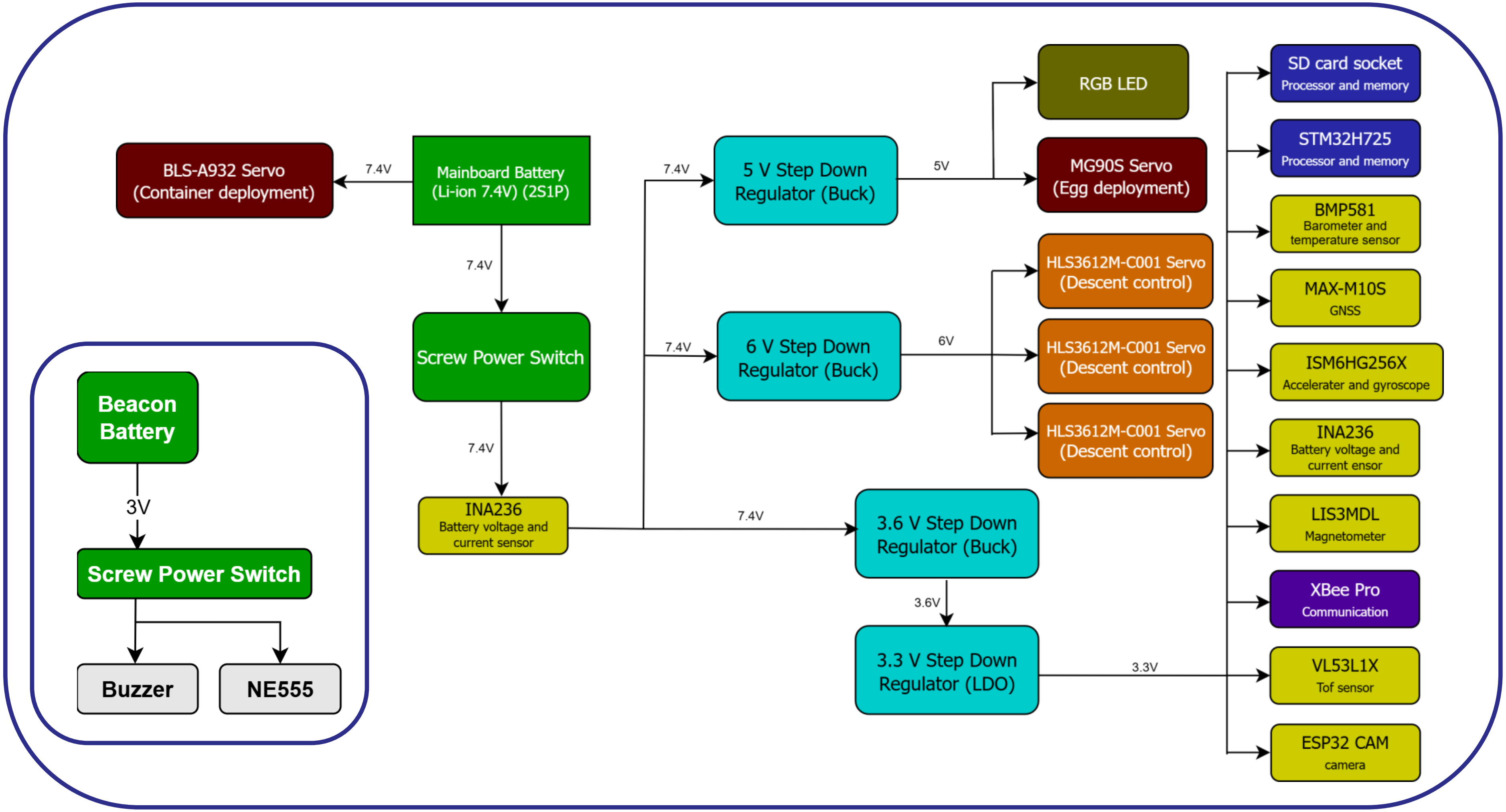
Watcharawit Leksuwankun

EPS Overview

Components	Purposes
Battery	Power Sourse
Sensors	Mesuring 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



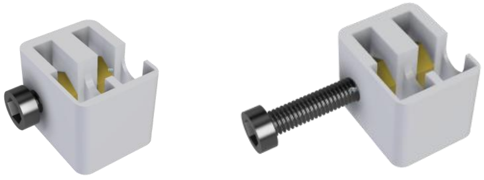
Mainboard and Beacon Electrical Block Diagram



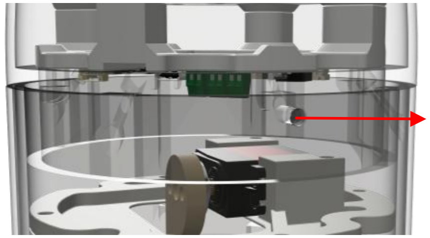
Payload Electrical Block Diagram (2/2)

Power Controlling

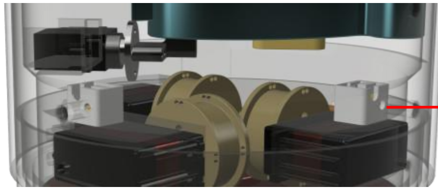
ON OFF



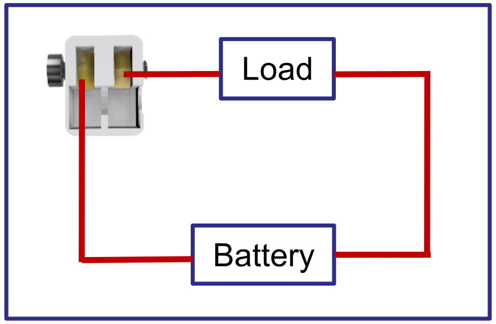
The switch is cut off when the bolt disconnects both nuts.



The power verification hole verified by LED



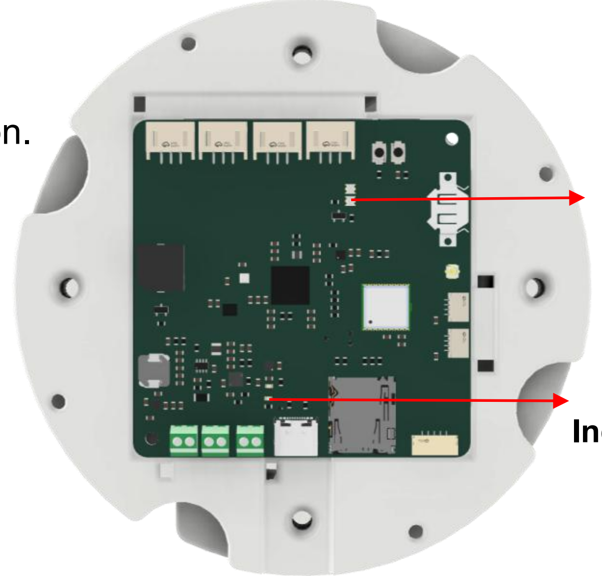
The Screw Switch



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.



RGB LED

Power Indicated LED

Power Testing

- The Avionics is safely tested by the power supply.

Payload Power Trade & Selection

Modules	Types	Voltage (V)	Capacity (mAh)	Unit Weight (g)	Max Current (A)	Capacity (Wh)	Cost (USD)
Vapcell M35	18650 Lithium-ion Battery	3.7	3500	48	10	12.95	5.27
Vapcell K25	18650 Lithium-ion Battery	3.7	2500	48	10	9.25	3.50
Sanyo UR18650 ZM2	18650 Lithium-ion Battery	3.7	2600	48	10	9.62	3.22

Selected Processor & Memory	Rationales
Vapcell M35 	• Capacity is sufficient for the mission requirement. • Its package complies with the competition rules.

Note

1. Two batteries are connected in series (2S1P) (7.4V) by spot welding.
2. Welded battery is wrapped around using Kapton tape for insulation.
3. Battery is mounted by a cable tie.
4. The battery is connected to the mainboard using an XT30 connector.

Payload Power Budget (1/2)

Note : Quelima SQ11 Camera uses a built-in battery

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	82.5	100	82.5	
ISM6HG256X	3.3	2.64	100	2.64	
LIS3MDL	3.3	0.891	100	0.891	
VL53L1X	3.3	132	100	132	
SD card socket	3.3	660	100	660	
XBee Pro	3.3	825	100	825	
ESP32-S3-CAM	3.3	792	100	792	
RGB LED	5	180	100	180	
RGB LED	5	180	100	180	
MG90S	5	2000	5	100	
HLS3612M-C001	6	7800	20	1560	
HLS3612M-C001	6	7800	20	1560	
HLS3612M-C001	6	7800	20	1560	
BLS-A932 (Servo)	7.4	22200	5	1110	
Total Effective Watt (mW)			**9076.88**		

Payload Power Budget (2/2)

Beacon Staying Hour

Power Source: Beacon Battery	Energy
Total Energy Consumption	0.15 Wh
Battery Energy (100% discharge depth)	0.66 Wh
Energy Margin	0.51 Wh
Operating Time (100% discharge depth)	8 hours 53 minutes

Mainboard Staying Hour

Power Source: Mainboard Battery	Energy
Total Energy Consumption	18.51 Wh
Battery Energy (100% discharge depth)	26 Wh
Energy Margin	8 Wh
Operating Time (100% discharge depth)	2 hours 48 minutes

Flight Software (FSW) Design

Trirayan Boontaganon

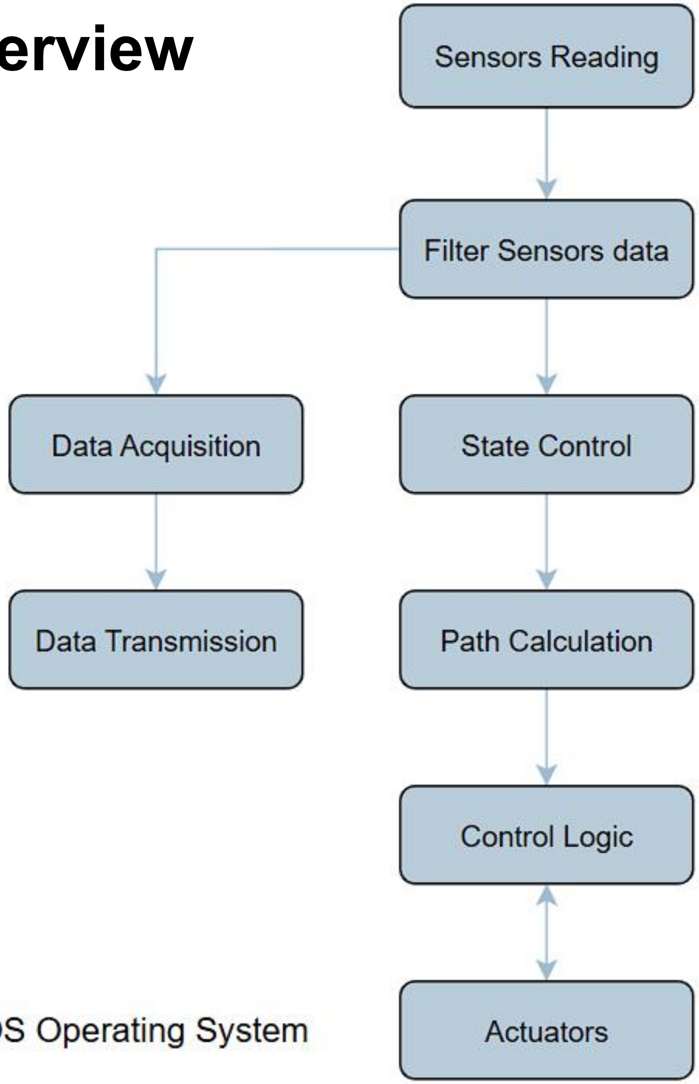
FSW Overview (1/5)

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

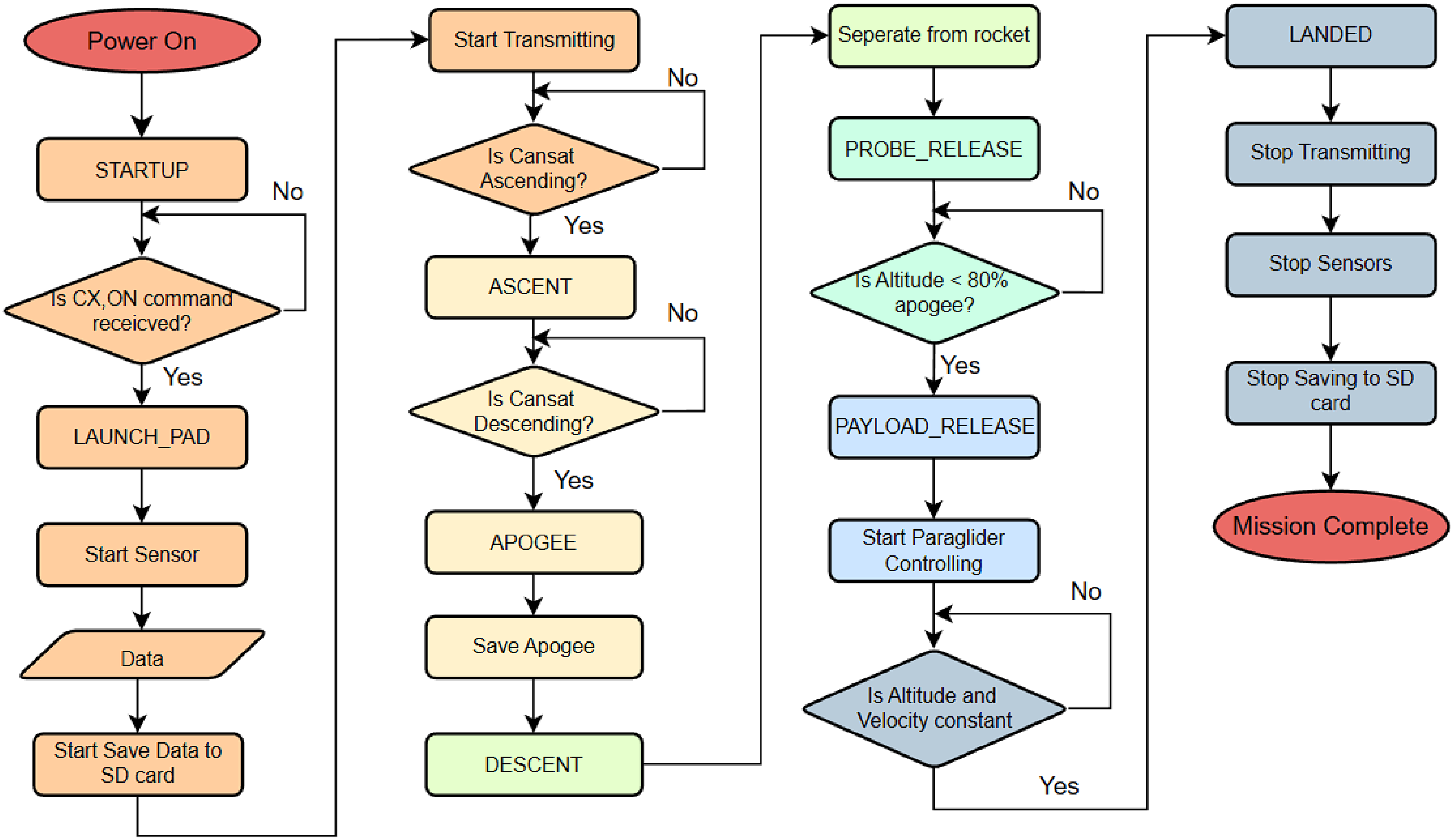
Languages	Framework	Development Environment	Libraries
C, C++	Arduino	PlatformIO, VSCode	STM32duino, Sparkfun, Adafruit

FSW Architecture Overview



RTOS Operating System

FSW Flowchart Overview



Flights Tasks in Each State (1/2)

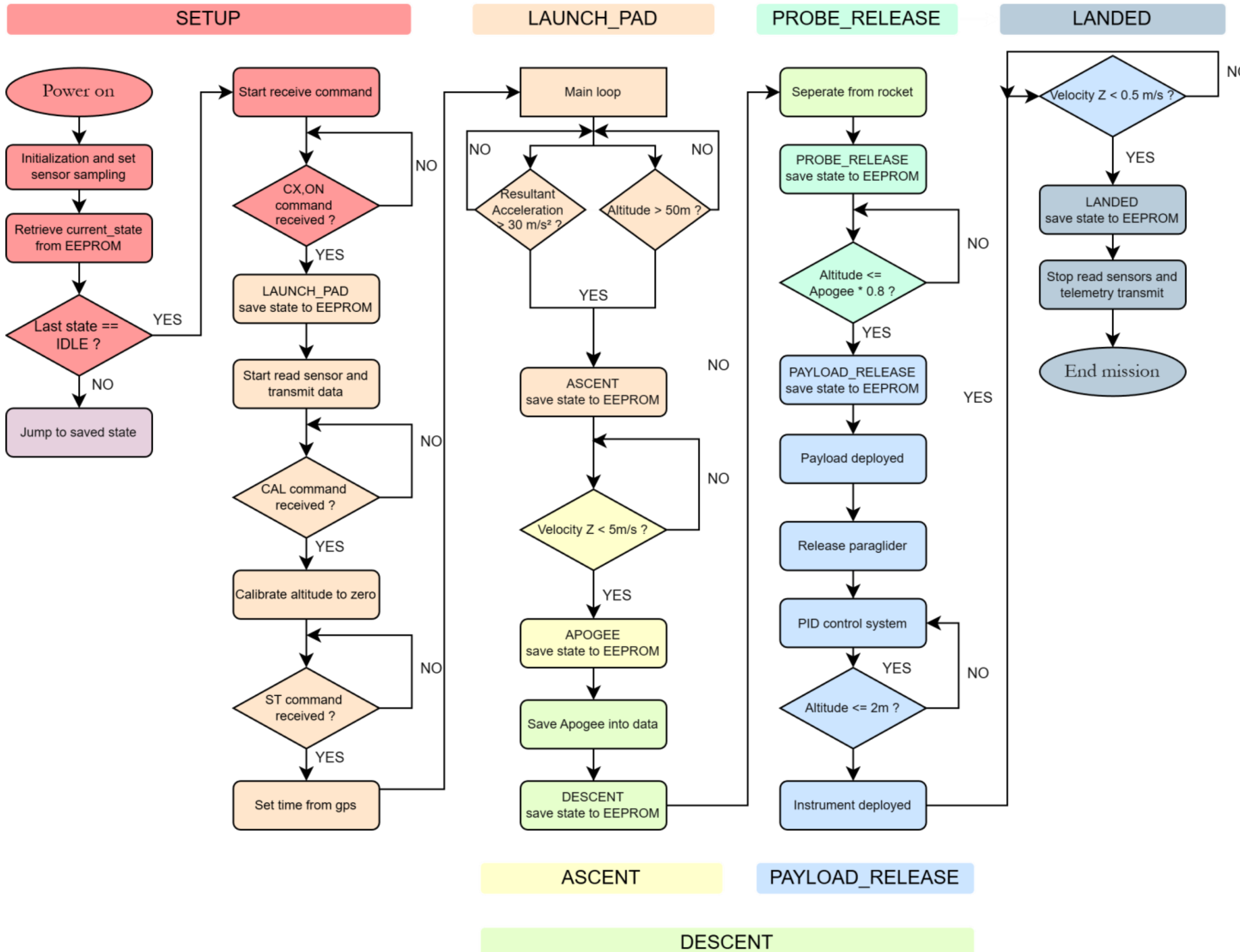
States	Tasks
STARTUP	• Read the saved state. • Boot and configure all sensors. • Set the ground reference altitude. • Begin receiving commands. • Wait for CX,ON command.
LAUNCH_PAD	• Start Transmitting telemetry. • Wait for a launch detection.
ASCENT	• Wait for an apogee detection.
APOGEE	• Save apogee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

Flights Tasks in Each State (2/2)

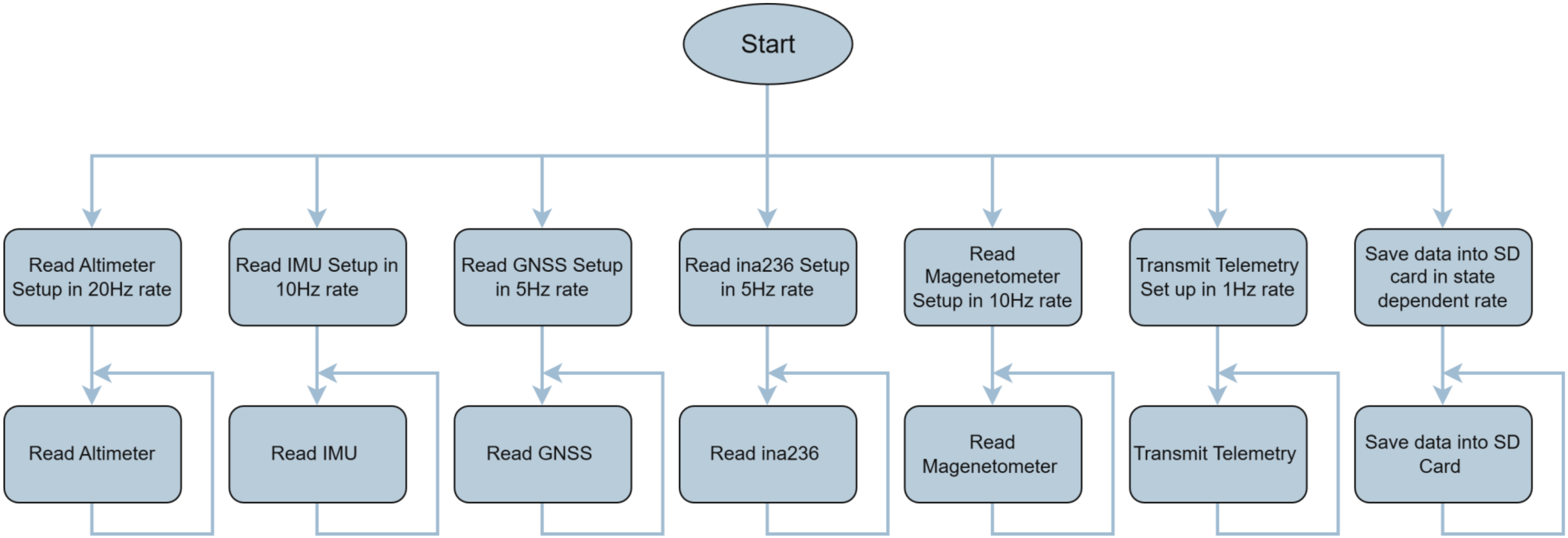
States	Tasks
DESCENT	• Wait for a separation from the rocket.
PROBE_RELEASE	• Wait until 80% of apogee is detected, then activate the servo motor to release the payload.
PAYLOAD_RELEASE	• Activate the paraglider PID controlling navigation system to the target area. • Wait until a height of 2 m above 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.

Payload FSW State Diagram (1/7)

State Diagram



Sampling of Sensors/DAQ

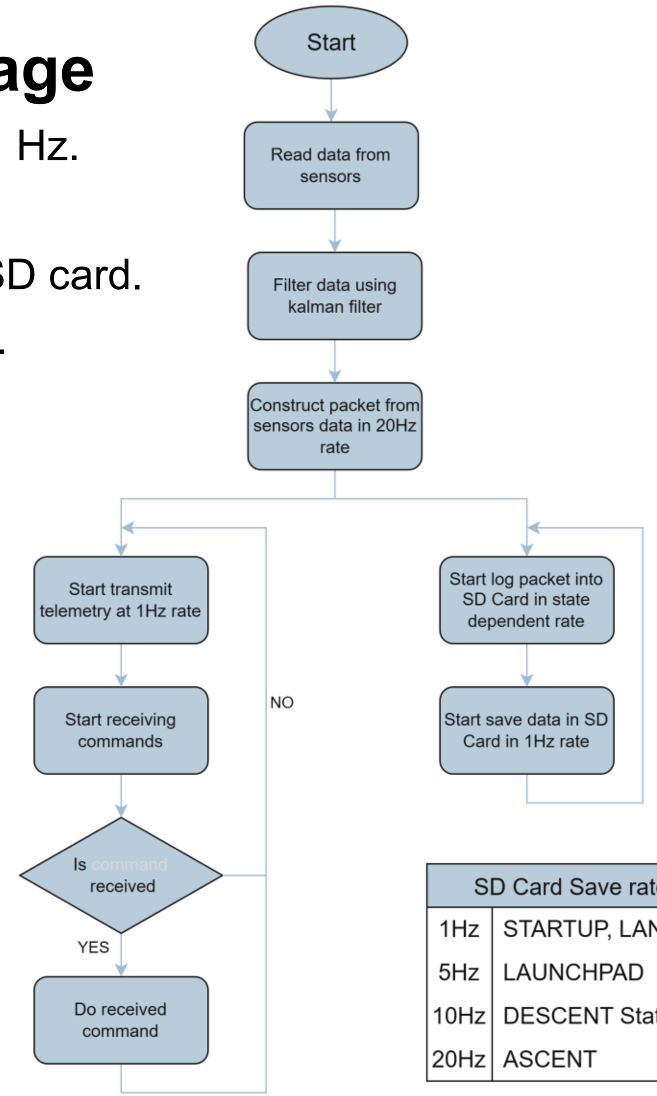


SD Card Save rate	
1Hz	STARTUP, LANDED
5Hz	LAUNCHPAD
10Hz	DESCENT States
20Hz	ASCENT

Payload FSW State Diagram (3/7)

Communications and Data Storage

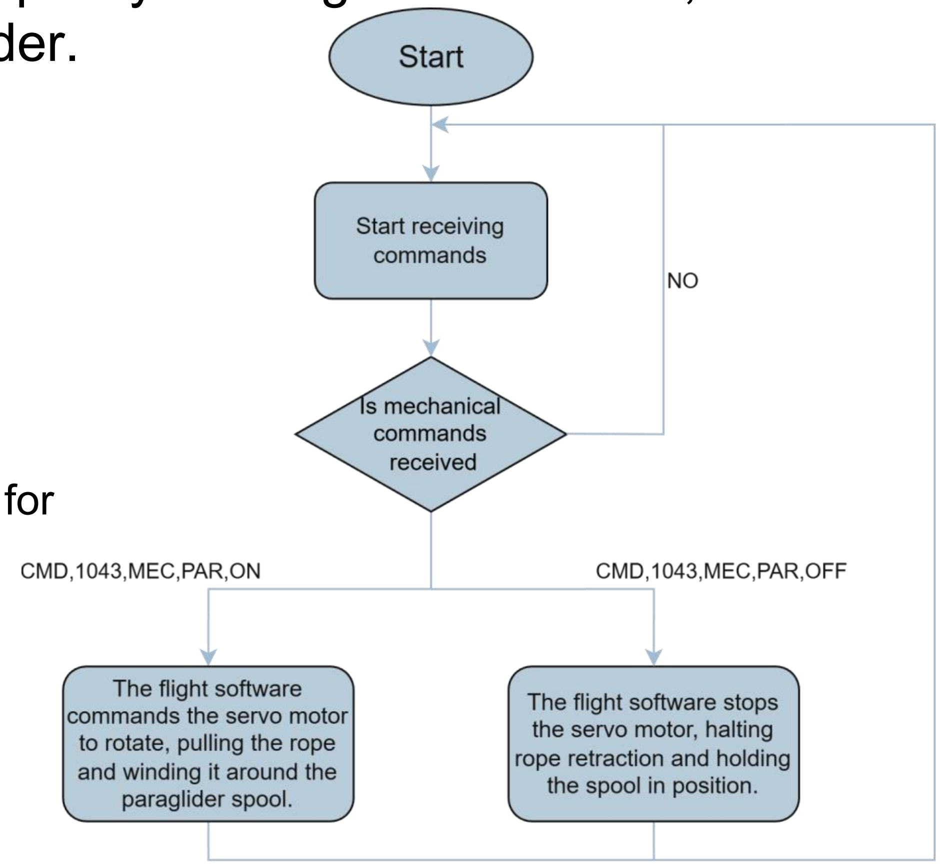
- Telemetry packets are transmitted via XBee at 1 Hz.
- Commands are received from GCS.
- All sensor and telemetry data are logged to an SD card.
- Logging continues even if communication is lost.



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

Mechanism Commands

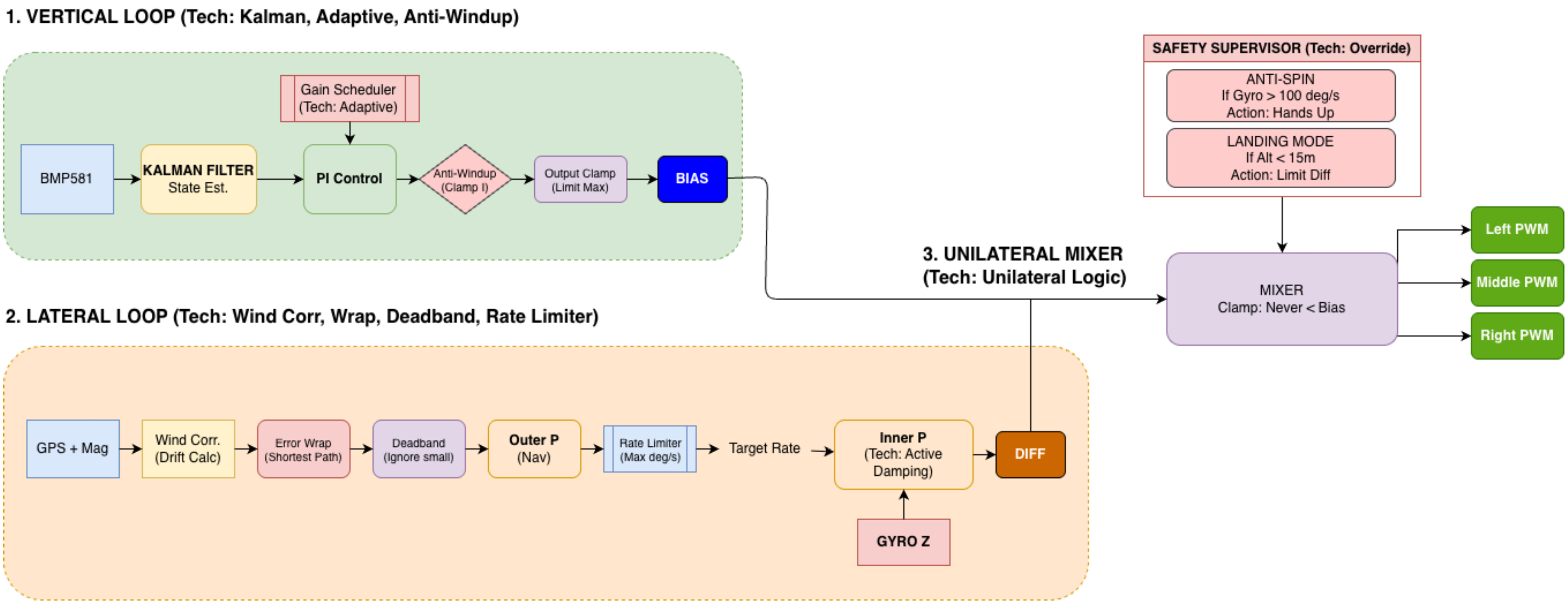
The MEC command is sent to activate a specific mechanism. The device identifier is defined by the team to specify the target mechanism; for example, PAR denotes the paraglider.



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

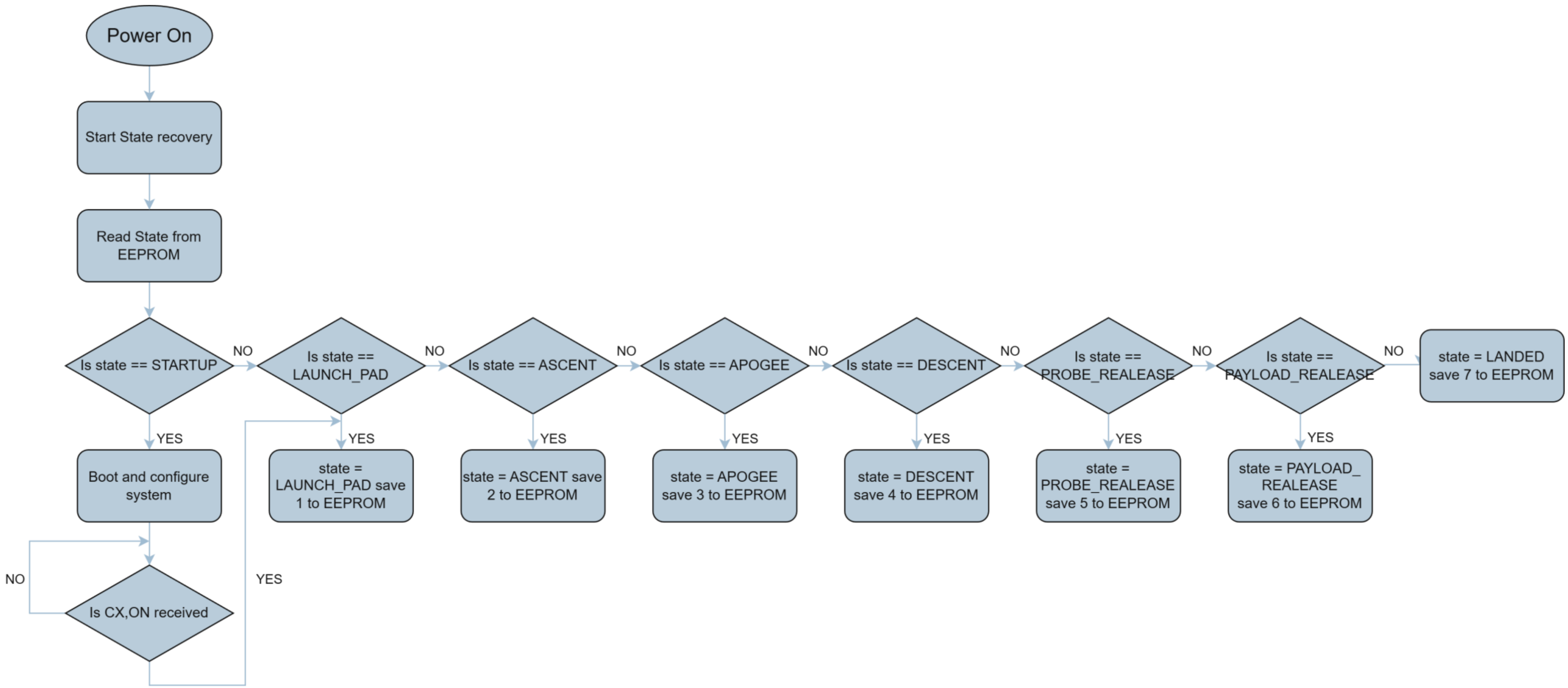
Reset conditions:

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

Recovery method:

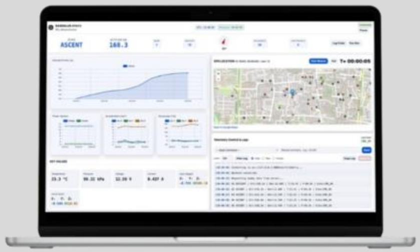
- When a reset occurs, the MCU retrieves previously stored data from EEPROM as initial values after restarting and resumes operation from the saved state.

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

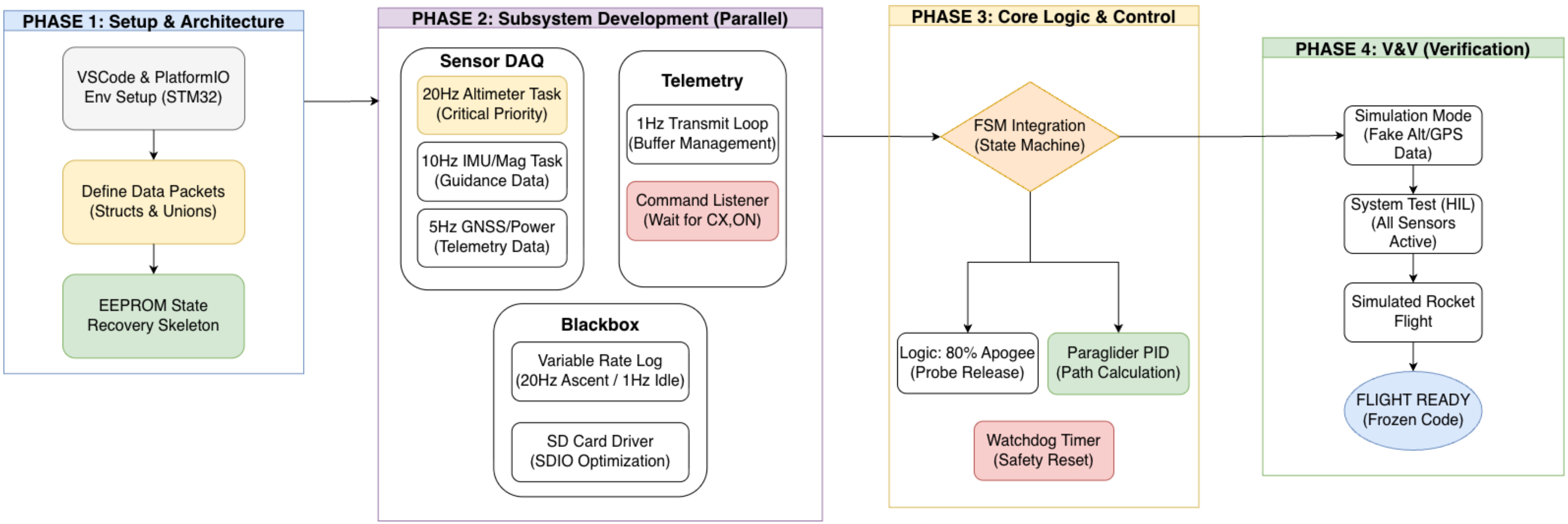
A common challenge in CanSat projects is delayed software development, which can hinder system integration and testing. To mitigate this risk, the following plan is implemented:

- 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 Plan (2/7)

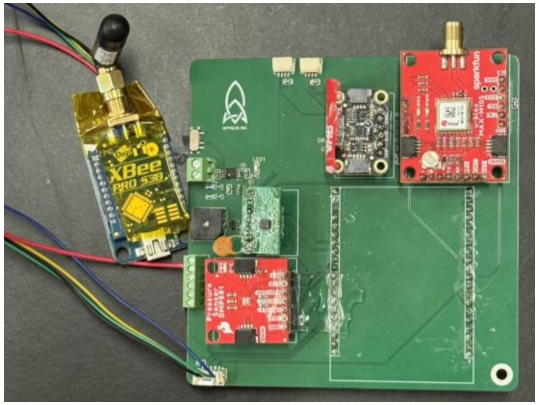
Software Development Life Cycle

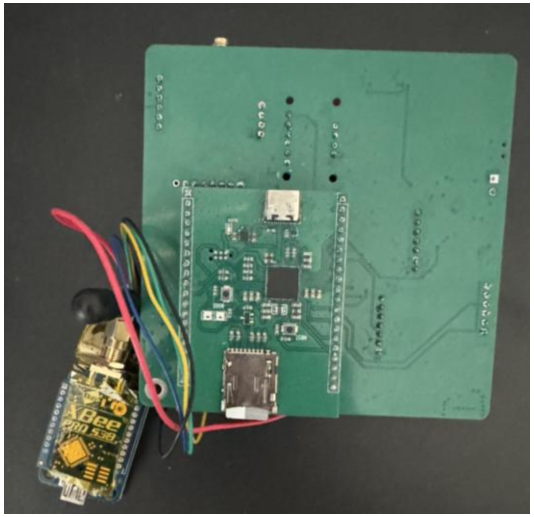


Software Development Plan (3/7)

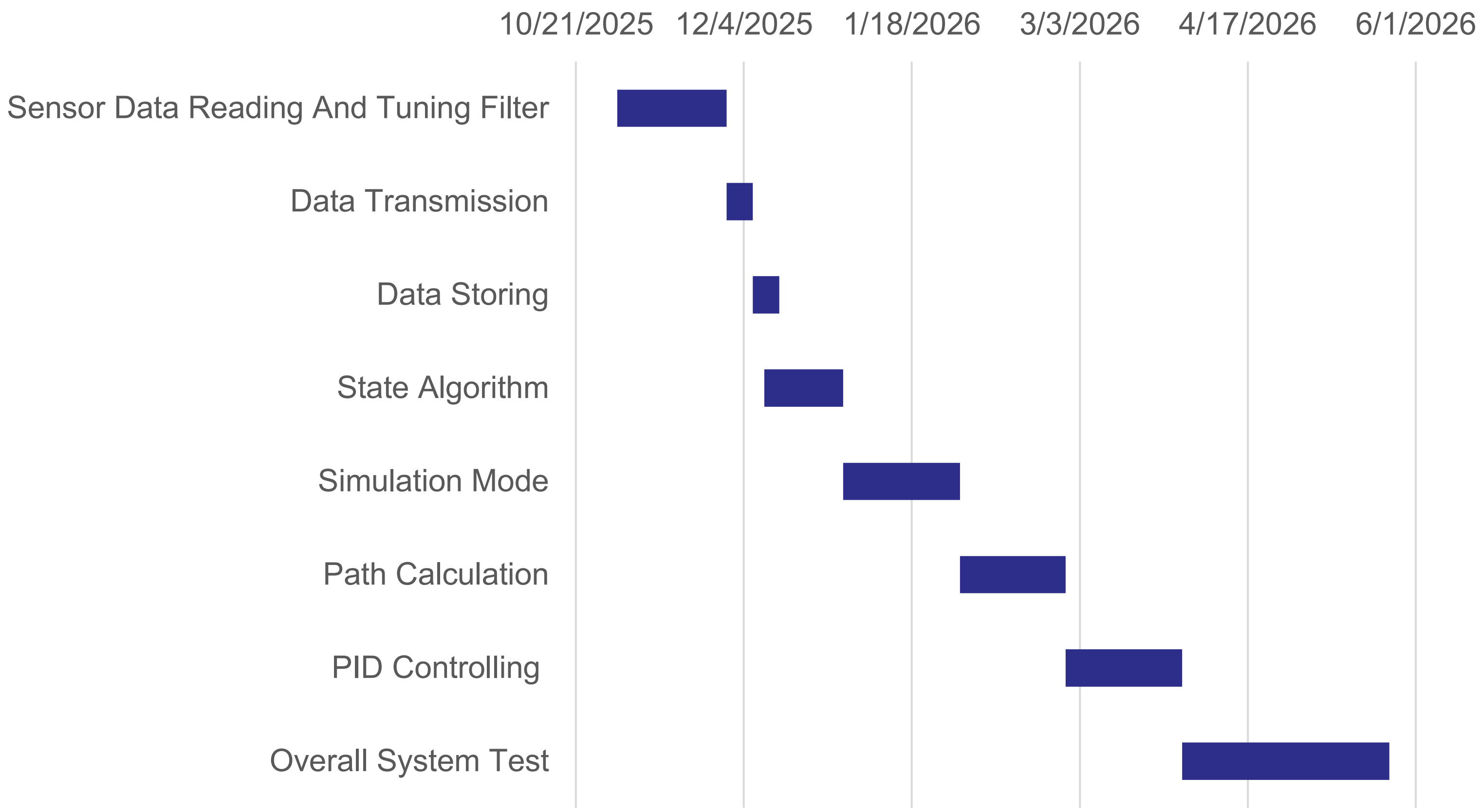
Prototyping

- The Flight Software (FSW) was developed and prototyped using a simulated full-system Printed Circuit Board (PCB) that closely represents the final flight hardware configuration.
- The prototype PCB integrates all critical subsystems, allowing early verification of hardware–software interfaces in a representative environment.
- FSW testing was conducted in a controlled prototype environment to validate:
  - Software architecture and task execution.
  - Sensor data acquisition and processing.
  - Telemetry generation and transmission.
  - Onboard data logging.
  - System state transitions and fault handling.
- Flight Software (FSW) prototyping and validation were performed using hardware representative of the final flight system.
- These environments provided progressively increasing levels of realism for validating system behavior and flight algorithms before final deployment.





Subsystem Development Sequence



Software Development Plan (5/7)

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.

Software Development Plan (7/7)

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.

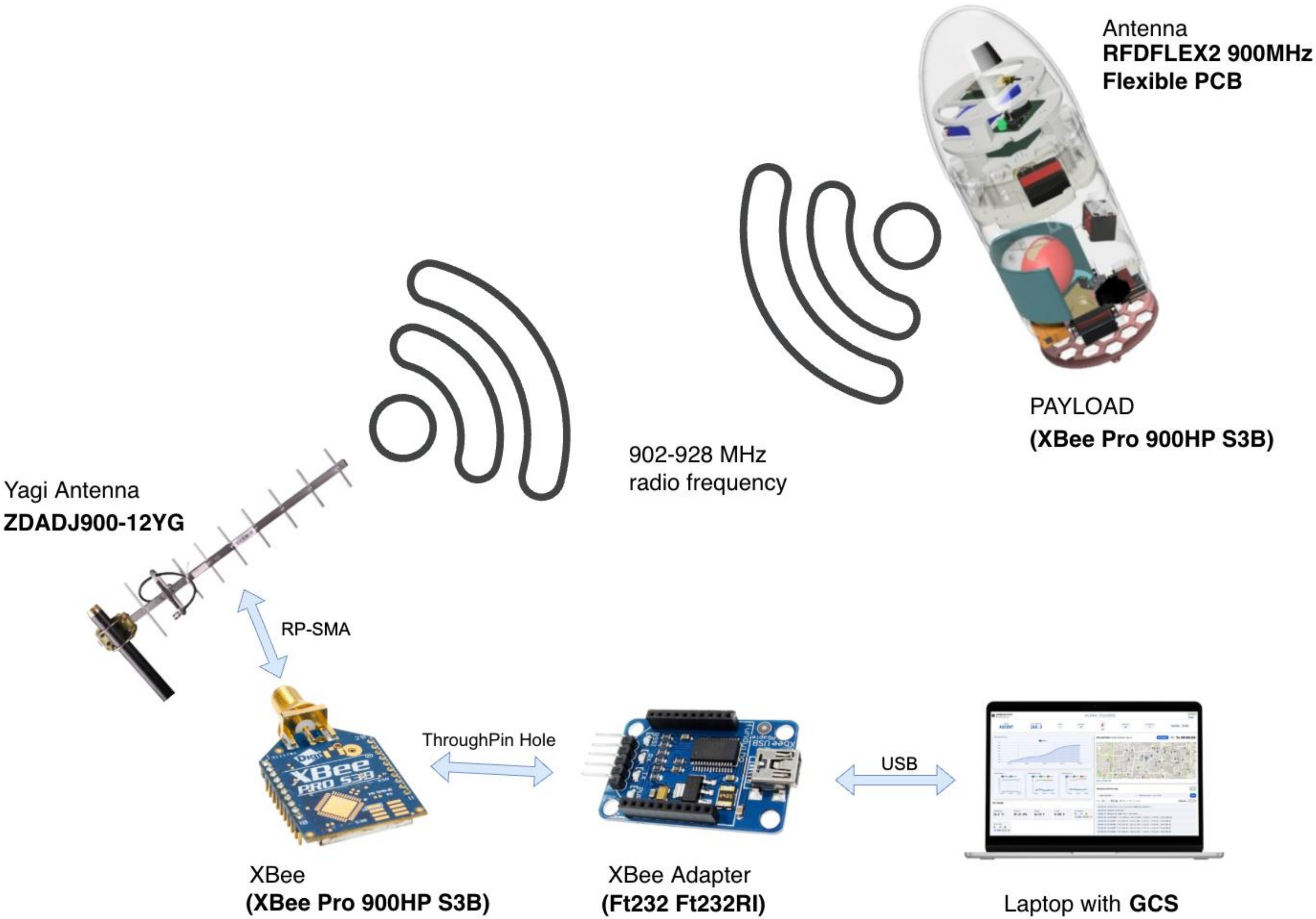
Stage 4: Simulated Rocket Flight Using Sounding Rocket

- 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.

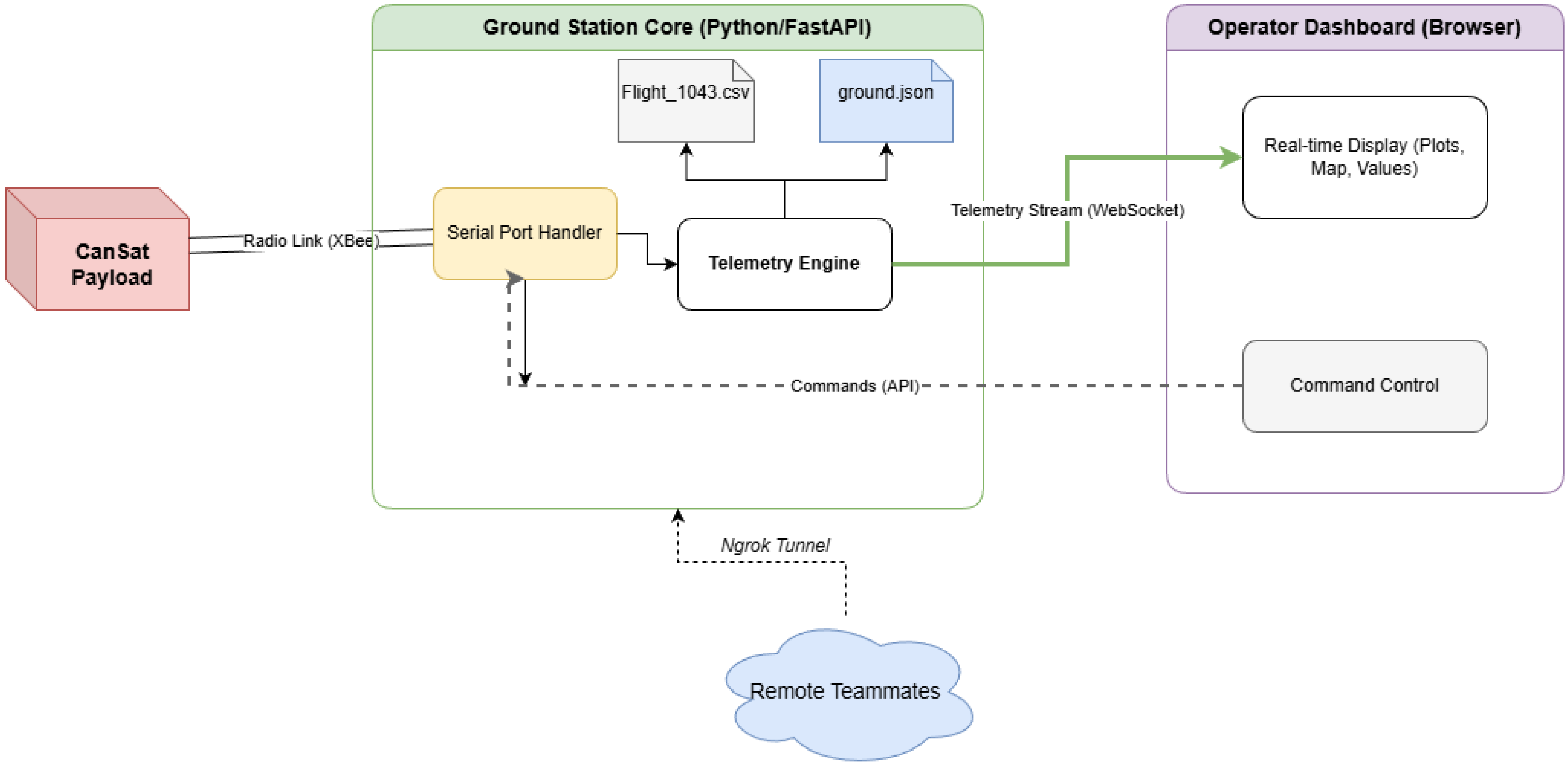
Ground Control System (GCS) Design

Techit Monsakul

GCS Overview



GCS Design (1/4)



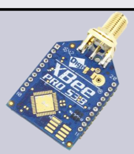
GCS Design (2/4)

We plan to attend the Mark Walker Portable Ground Station Design Award.

This award recognizes teams that design the best custom, fully functional portable ground station — a single handheld device under 15 lbs that requires no assembly and operates with a single power switch.

- Our Approach:
  - **Custom 3D printed enclosure** designed specifically for CanSat operations.
  - **Raspberry Pi 4** embedded system (not a laptop).
  - **Auto-start software** — ready to operate in seconds.
  - **Outdoor-optimized UI** — High contrast, 14pt+ fonts.
  - **Internal battery** — 4+ hours runtime, no AC power needed.
  - **Integrated radio** — XBee module with external SMA antenna.
  - **One-click data export** — USB port for telemetry backup.
  - **Fully offline** — No internet connection required.

GCS Design (3/4)

Component		Specification
Compute		Raspberry Pi 4 (8GB RAM)
Display		WaveShare 4.3" LCD (800×480)
Input		Rii K01X1 Mini Wireless Keyboard
Power		Geekworm x728 UPS
Radio		XBee pro s3b XBP9B-DMST-002
Enclosure		Custom 3D Printed Case

This is our idea.

GCS Design (4/4)

Specification

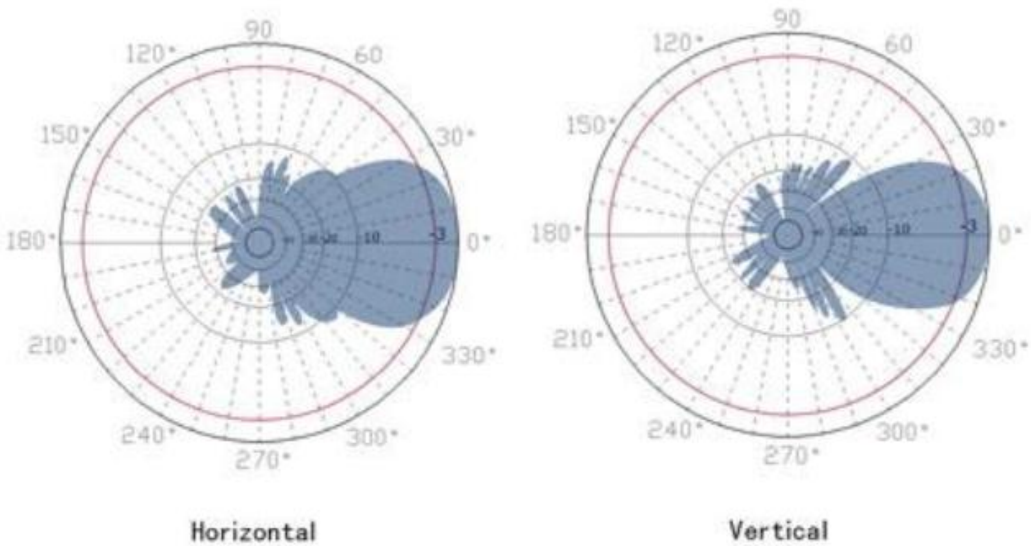
- Battery:
  - GCS is capable of operating continuously for a minimum of two hours. In the event of an emergency, a backup power bank will be available to provide additional charging for the laptop.
- Overheating Mitigation:
  - GCS will be operated under umbrellas or other shading solutions to minimize 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 Trade & Selection (1/2)

Models	Frequency Range (MHz)	Gain	Direction	Polarization	Weight (kg)	Cost (USD)
ZDADJ900-12YG	824-960	12 dBi	Directional	Vertical and Horizontal	0.78	73.95
OMB.915.BOSF21	902-928	5.9 dBi	Omnidirectional	Linear	0.5	117.92

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.



ZDADJ900-12YG Patterns

Benefits to CanSat Mission

- High Directionality
- Focused Beam
- Noise Rejection
- Symmetric Design

- **Telemetry Display Prototypes**
  - Plot using Echarts.
  - The graph will expand when it receives more data.
  - We use a rolling window to maintain constant performance regardless of mission duration.

Commercial off-the-shelf (COTS) software packages are 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.

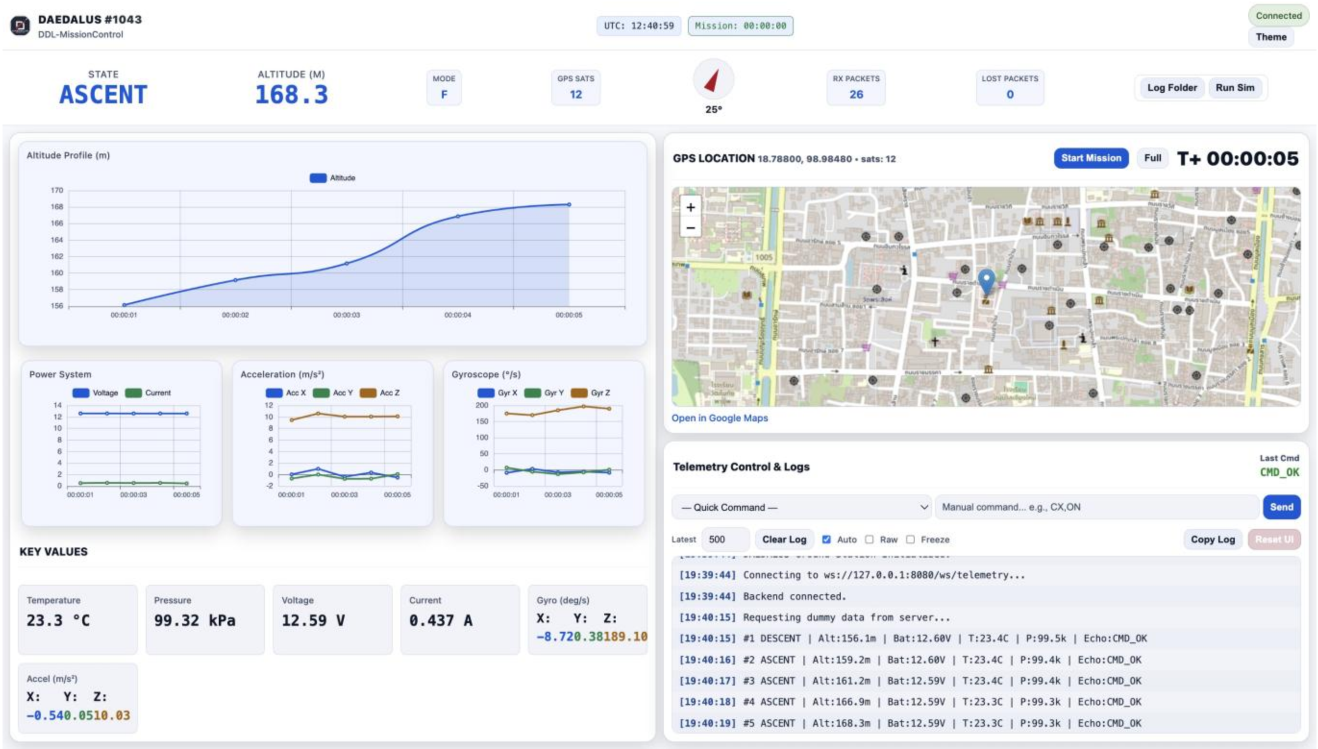
Frontend (JavaScript)

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

External Tools

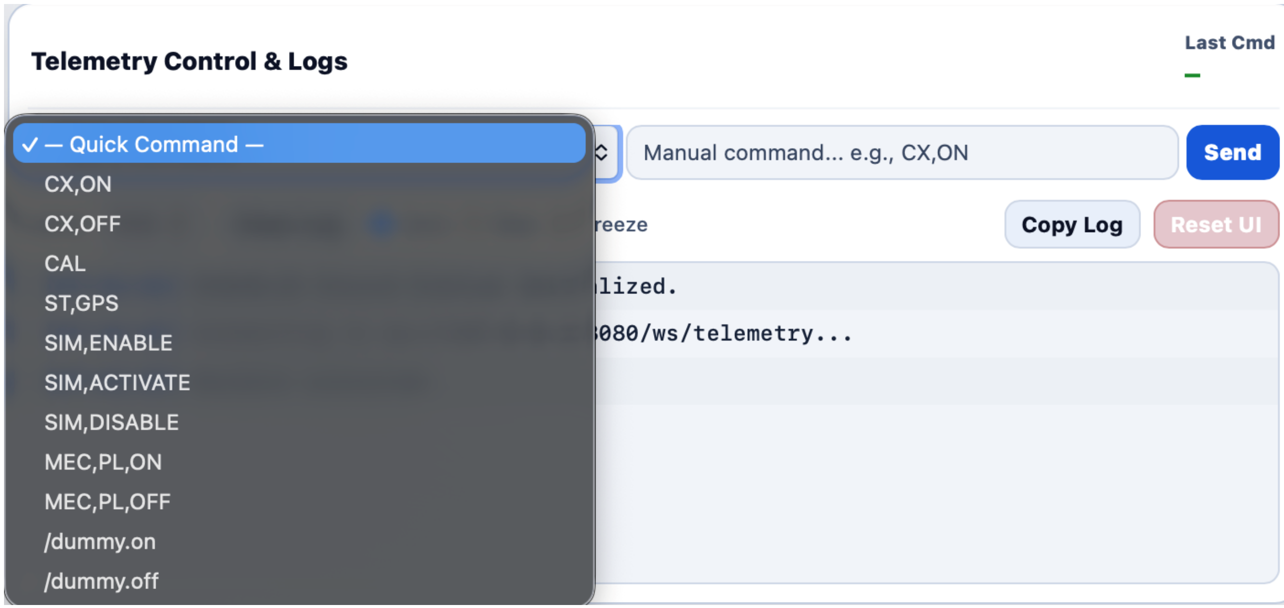
- Ngrok: A tool to expose a local web server to the internet (used for remote access).

Real-time Plotting Software Design



- Utilizes Apache Charts to render high-frequency sensor data.
- Implements a FIFO (First-In-First-Out) rolling window to maintain browser performance over long mission durations.
- Dynamic UI updates via JavaScript DOM manipulation for non-graphical data.

Command Software and Interface



- Hybrid Control: Features a "Quick-Action" dropdown for critical commands (e.g., CX,ON, SIM, ACTIVATE) and a manual text input for debugging.
- Async Queuing: Commands are sent via REST API to an asynchronous Python queue, ensuring the UI never freezes while waiting for radio transmission.

GCS Software (5/9)

Calibration Command Description

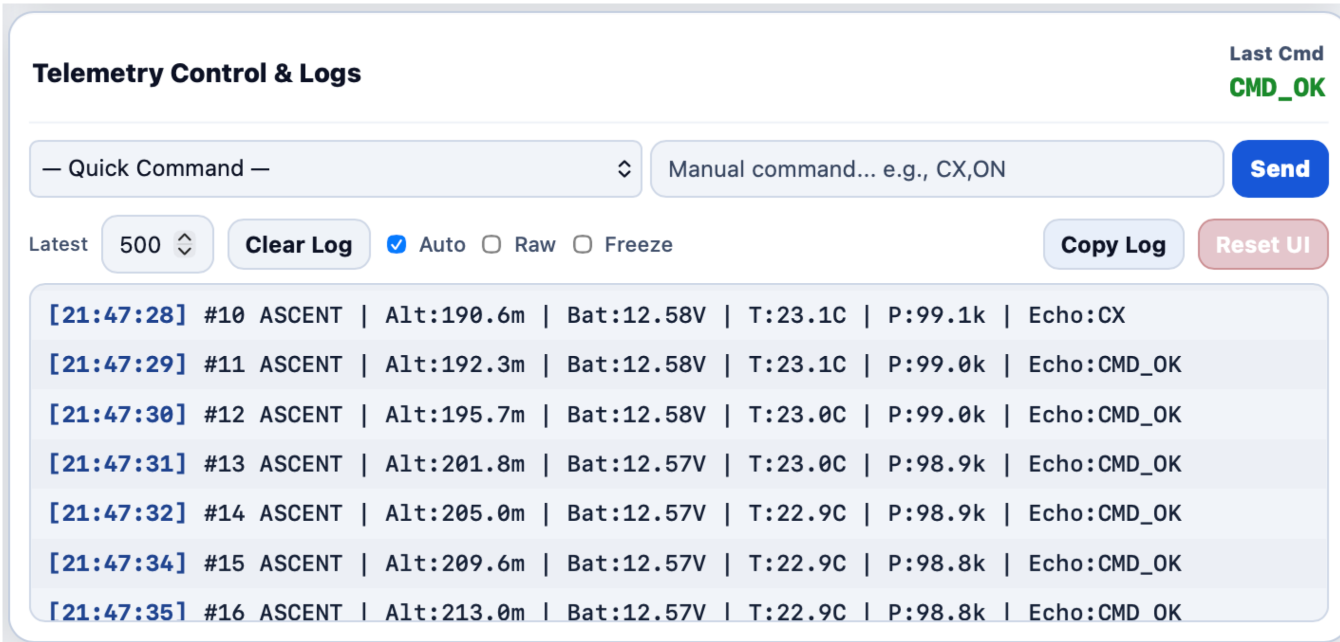
- The command is clicked manually, and the GCS sends the calibration command to the CanSat for calibration.
- After reception, the flight software establishes the 0-meter altitude reference using current pressure and simultaneously zeros the IMU's Roll and Pitch angles.

Safety:

* Enables Processor Reset Recovery (Flag set to "Launch Pad" state).

GCS Software (6/9)

Telemetry Data Recording and Media Presentation to Judges for Inspection (1/2)



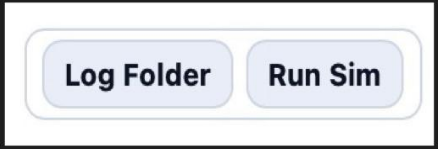
- Dual-Logging: System records raw serial strings (for debugging and parsed CSV data (for scoring) simultaneously.

- Visual Logs: On-screen scrolling text log provides immediate verification of command receipts (CMD_ECHO) and packet loss stats.

GCS Software (7/9)

Telemetry Data Recording and Media Presentation to Judges for Inspection (2/2)

```python
# These lines set up where the program looks for files.
# It creates folders for 'data' (CSV files), 'logs', and 'ui' (website files) if they don't exist.
ROOT_DIR = Path(__file__).resolve().parent
DATA_DIR = ROOT_DIR / "data"
LOG_DIR = ROOT_DIR / "logs"
UI_DIR = ROOT_DIR / "ui"
DATA_DIR.mkdir(parents=True, exist_ok=True)
LOG_DIR.mkdir(parents=True, exist_ok=True)
UI_DIR.mkdir(parents=True, exist_ok=True)
```



Live Inspection:

"Log Folder" button in UI instantly opens the OS file directory for judges.

```
DDL-JS/
├── main.py                 # Core backend logic (Server, Serial, Logging)
├── requirements.txt        # Python dependencies
├── telemetry_config.json   # Telemetry parsing configuration
├── data/                   # Stores flight CSV data
├── logs/                   # Stores system operation logs
├── scripts/                # Deployment scripts (raspberry-pi branch only)
│   ├── setup-pi.sh         # One-time Pi setup script
│   └── autostart/
│       ├── groundstation.service  # Systemd service for backend
│       └── kiosk.sh               # Chromium kiosk launcher
└── ui/                     # Web frontend source code
    ├── index.html          # Main dashboard layout
    ├── app.js              # Frontend logic
    ├── styles.css          # Styling (includes 800x480 responsive rules)
    └── assets/             # Images and icons
```

This is the overall project file structure

Describe .csv Telemetry File Creation for Judges

```
#function checks if the file exists. If it doesn't, it creates the file and writes the top row (headers).
def ensure_csv_header():
    """Checks if the CSV file exists. If not, creates it and adds the header row."""
    if not CSV_CURRENT.exists():
        CSV_CURRENT.write_text(CSV_HEADER + "\r\n", encoding="utf-8", newline="\r\n")
    state.csv_ready = True

ensure_csv_header()
```

Dynamic Generation: CSV headers are built automatically from telemetry_config.json, ensuring the file structure always matches the packet definition.

```
#the program asynchronously appends every new "clean" telemetry line to the CSV file as it arrives.
if state.csv_ready:
    async with aiofiles.open(CSV_CURRENT, "a", encoding="utf-8", newline="") as f:
        await f.write(clean_csv + "\r\n")
```

Reliability: The file is created upon application startup (Flight_1043.csv). Data is flushed to disk immediately after every packet reception to prevent data loss in case of a power failure.

GCS Software (9/9)

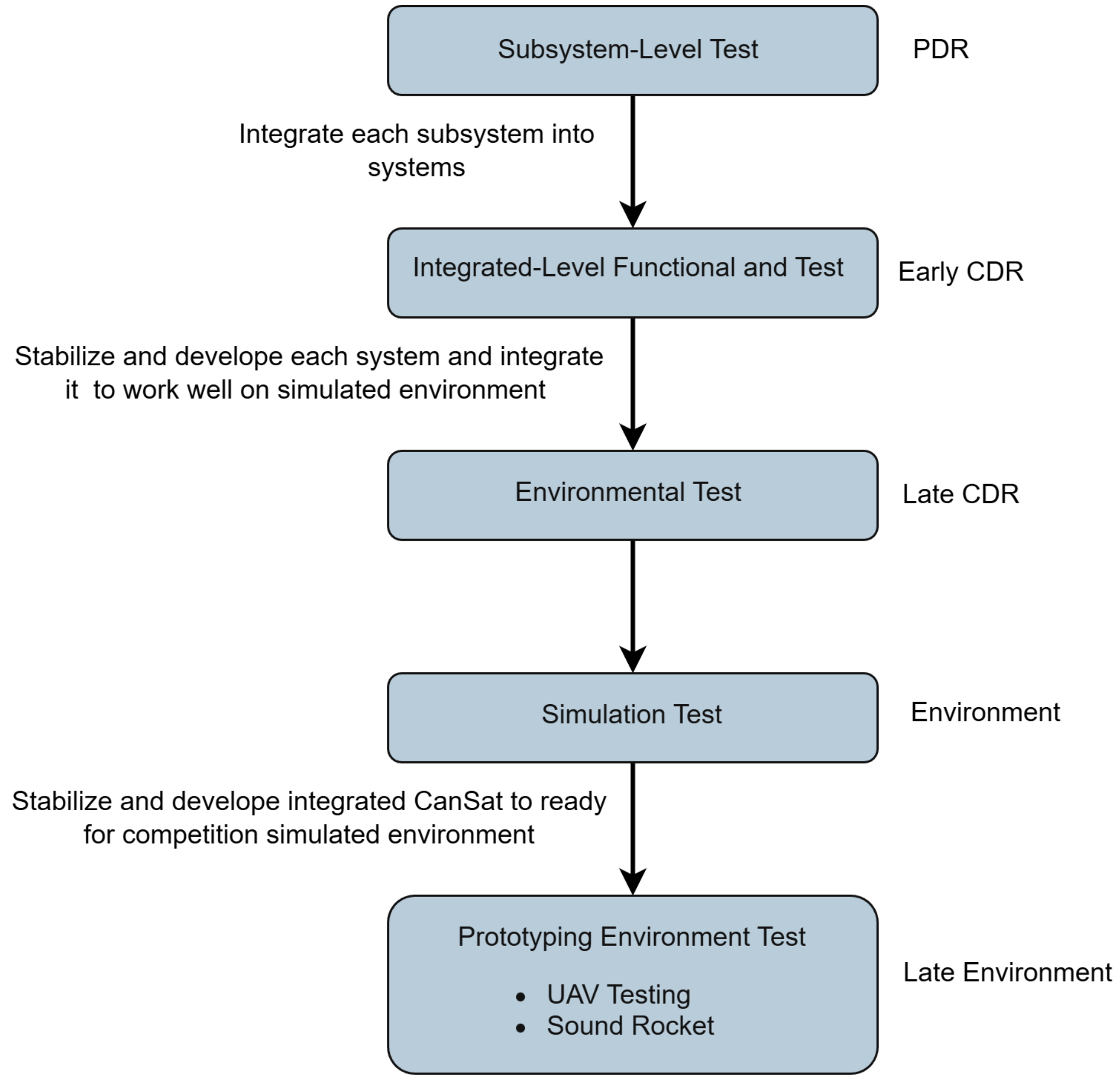
Simulation Mode Descriptions

- 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.

CanSat Integration and Test

Kris Raungrit

CanSat Integration and Test Overview (1/2)



CanSat Integration and Test Overview (2/2)

Subsystem-Level Test
A series of evaluations was carried out to verify the functionality, stability, and design compliance of each individual subsystem prior to system integration. Subsystems including sensors, Command and Data Handling (CDH), Electrical Power System (EPS), radio communication, Flight Software (FSW), mechanical structure, and the descent control system were assessed independently to ensure all requirements were satisfied.

Integrated-Level Functional Test
System-level interactions were examined to confirm proper interoperability among all subsystems. This process verified sensor data flow through the flight software, correct execution of control commands, reliable communication with the ground station, and accurate mission state transitions.

Environmental Test
System performance was examined under conditions representative of the mission environment. The test campaign included drop, thermal, vibration, vacuum, and fit check procedures to evaluate structural integrity, operational reliability, and mechanical compatibility prior to flight.

Simulation Test
Flight software behaviour and mission logic were verified through software-based simulations. Simulated sensor inputs were used to validate state transitions, data processing, and mission sequencing before and during hardware testing.

Prototyping Environment Test Plans

A phased testing approach was implemented to progressively increase test realism and systematically reduce mission risk.

Subsystem Level Testing Plan (1/5)

Subsystem	Components	Test Plans	Pass Requirement
Sensors	STM32H725 ISM6HG256X BMP581 MAX-M10S INA236 SQ11 Camera 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 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)

<table>
<tr><th>Subsystem</th><th>Components</th><th>Test Plans</th><th>Pass Requirement</th></tr>
<tr><td rowspan="3">FSW</td><td>Avionics</td><td rowspan="3">• 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.</td><td rowspan="3">• 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.</td></tr>
<tr><td>Actuators</td></tr>
<tr><td>Ground station</td></tr>
</table>

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 Plans (1/2)

Test	Test Plans	Pass Requirement
Mechanisms	• Assemble all mechanical components as specified in the system integration drawing, ensuring precise alignment and proper fit through a detailed visual inspection. • Trigger the payload release mechanism electrically and measure release timing using a stopwatch. • Pack the paraglider and suspension lines following the standard packing procedure, then inspect for correct stowage. • Activate the deployment sequence and record video to verify the camera's field of view during all phases. • Apply manual shaking and low-level vibration to verify secure camera mounting.	• Mechanical integration matches the design configuration. • Payload releases at the intended time without jamming. • Paraglider and lines remain properly stowed prior to deployment. • Camera field of view is clear throughout deployment. • Camera mount remains secure with no movement.
Descent System	• Verify stable and controlled descent behavior of the CanSat. • Confirm reliable and timely deployment of the paraglider under nominal conditions. • Verify that suspension lines do not entangle or interfere with the spool or structure. • Verify secure restraint and controlled release of the egg container during descent. • Measure parachute-assisted descent rate.	• Descent is stable with no excessive spinning. • The paraglider is controlled to navigate and land near the designated target. • Paraglider deploys fully and on time. • Suspension lines do not tangle. • Descent rate meets mission requirements.

Integrated Level Functional Test Plans (2/2)

Test	Test Plans	Pass Requirement
Deployment	• Perform ground deployment tests by activating the deployment mechanism multiple times. • Use simulated pressure data to simulate apogee detection and verify deployment trigger. • Inspect structural components after deployment for cracks, deformation, or loosening.	• Deployment occurs smoothly without excessive shock. • Container and instrument deploy at the intended altitude and timing. • No structural or functional damage is observed after deployment.
Communication	• Power on the CanSat and GCS and verify automatic XBee link establishment. • Transmit telemetry data continuously and monitor the real-time display on the GCS. • Compare transmitted data logs with received data logs to check data integrity. • Measure packet rate and latency using timestamped telemetry packets. • Send commands from the GCS and observe system response. • Increase distance and introduce motion to evaluate link stability. • Temporarily disable the communication link and observe reconnection behavior.	• Communication link is established and maintained reliably. • Telemetry is received and displayed correctly in real time. • Data packets are complete, correctly formatted, and in sequence. • Communication rate and latency meet mission requirements. • Commands from GCS are executed correctly. • System recovers from temporary link loss without failure.

Environmental Test Plan (1/2)

Test	Test Plans	Pass Requirement
Drop Test	• Power on CanSat. • Perform shock testing by dropping a CanSat using a rope 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.	• No cracks, fractures, or permanent deformation are observed. • System remains functional after testing.
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 • The (opm) ranging from 12,000 to 14,000 (according to mission guide) and translates to 200 to 233 Hz. • Monitor telemetry, power status, and sensor data during and after testing. • Cansat must survive 15 Gs vibration	• All components and connections remain securely fixed. • No data loss, power interruption, or malfunction is observed. • System remains operational after vibration testing. 

Environmental Test Plan (2/2)

Test	Test Plans	Pass Requirement
Thermal Test	• Power on 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. 	• Electronic systems operate normally during and after thermal exposure. • No visible deformation or material degradation occurs. • Battery performance remains stable.
Fit Check	• Insert the CanSat into the payload section to verify mechanical fit.	• All components fit correctly within the payload volume. • No interference or misalignment is observed.
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.	• All subsystems operate correctly under low-pressure conditions. • Flight software sequencing functions as designed. • Barometer provides accurate and stable pressure readings.

Simulation Test Plan (1/2)

Parts	Responsibilities
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.
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 Events

1. ARRIVAL

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

2. PRE-LAUNCH PREPARATION

- Verify battery levels, power systems, and deployment mechanisms *(CC)*
- Activate and verify buzzer and paraglider control system *(CC)*
- Calibrate onboard sensors and verify payload board operation *(CC + GSC)*
- Conduct communication tests and full system checks *(CC + GSC)*
- Perform safety checks and final CanSat assembly *(Whole Team)*

3. ROCKET INTEGRATION

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

4. 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)*

5. RECOVERY and DATA RETRIEVE

- Track and locate the CanSat using GPS and onboard audio beacon *(RC)*
- Recover the payload and return it to the launch site *(RC)*
- Retrieve flight and video data from onboard storage *(GSC + RC)*

6. DATA ANALYSIS

- 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.

Mission Operations Manual Development Plan

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 Assembly and Pre-Launch Preparation	• Overall Assembly Guide and System Integration. • Avionics Activation and Communication Verification. • Pre-Flight System Inspection and Integration. • Final Readiness Inspection. • Launch Vehicle Integration and Pre-Launch Status Confirmation.
Launch Preparation and Launch Procedure	• Document is provided by CanSat competition.
Recovery Procedure	• Document is provided by CanSat competition. • Guide for Locating and Recovering the CanSat.

- A mission operations manual will be created to support safe and successful CanSat pre-launch, launch, recovery, and post-flight procedures through structured checklists and operational instructions and will be reviewed and approved by all team members.

CanSat Location and Recovery

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:


AAS CANSAT COMPETITION 2026

TEAM DAEDALUS#1043

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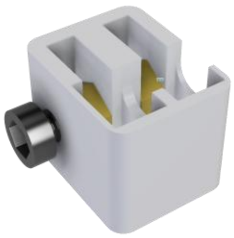
TEL: +66 82-149-5924

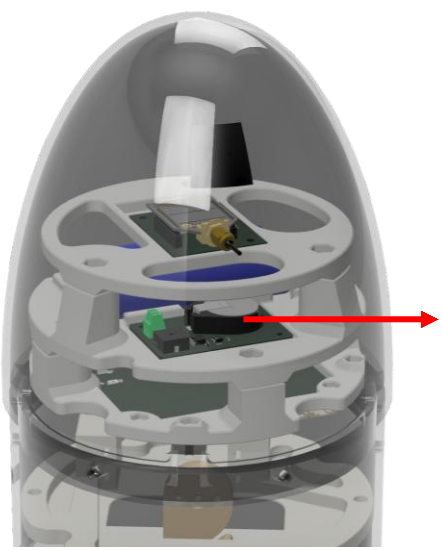
MAIL:TRIRAYAN@GMAIL.COM

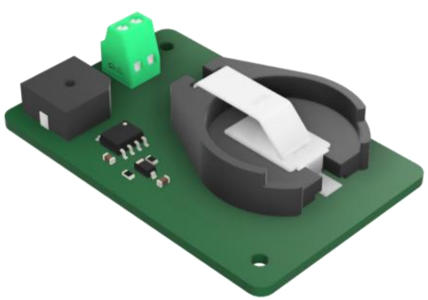
CanSat Beacon Design

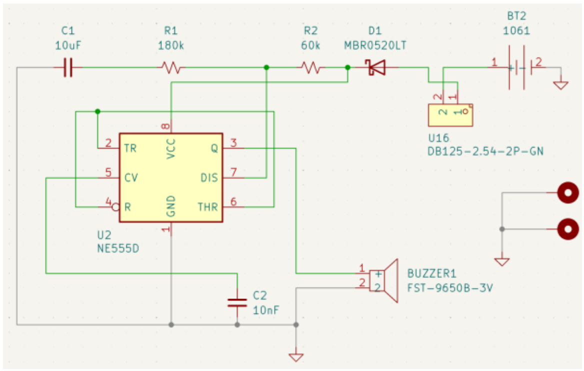
- Beeps for 250 milliseconds every 1 second.
- Safe power switch to prevent the beacon from turning off.
- Operating time 8 hours 53 minutes.
- Mounted by nuts and screws (M2.5).
- The power is controlled by using the screw switch.
- Use an independent power supply, which is a coin cell isolated from the main board.
- The audio beacon shall have an easily accessible power switch through the container

Screw Switch









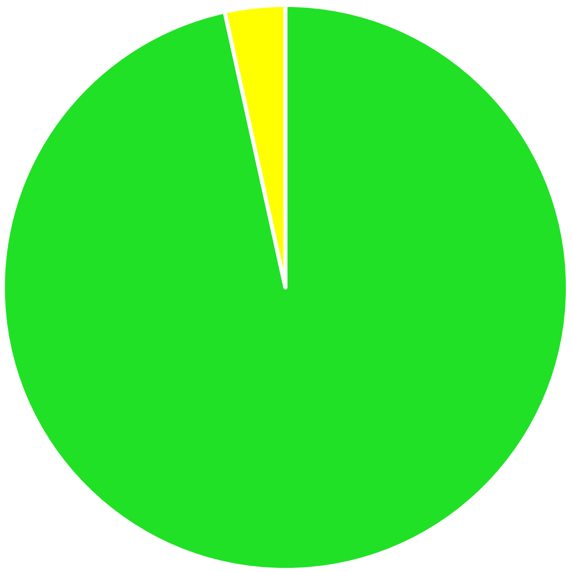
Requirements Compliance

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.



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	22	
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	22, 46	
C5	At 80% peak altitude, the payload shall be released from the container.	Comply	22, 64, 65	
C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Comply	22, 67	
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	22, 46	
C8	The payload shall steer toward a target location.	Comply	39, 40, 110	
C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	85, 107, 108	

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	68	
C11	A second video camera shall point at the ground.	Comply	69	
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	22, 33, 72, 73, 74	
C13	The CanSat payload shall include an audible beacon that is turned on separately and is independent of the CanSat battery and electronics.	Comply	157	
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	176	
S1	The CanSat and container mass shall be 1000 grams +/- 10 grams.	Comply	78	
S2	The nose cone shall be symmetrical along the thrust axis.	Comply	20, 55	
S3	Nose cone radius shall be exactly 70 mm.	Comply	18, 55	
S4	Nose cone shoulder length shall be a minimum of 50 mm.	Comply	18, 55	

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	55	
S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	55	
S7	The nose cone height shall be a minimum of 76 mm.	Comply	18, 55	
S8	CanSat structure must survive 15 Gs vibration.	Partially Comply	148	Confirmed by vibration test
S9	CanSat shall survive 30 G shock.	Partially Comply	148	Confirmed by shock test
S10	The container shoulder length shall be 90 to 120 mm.	Comply	18, 23	
S11	The container shoulder diameter shall be 136 mm.	Comply	18, 23	
S12	Above the shoulder, the container diameter shall be 140 mm.	Comply	18, 23	
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	62, 148	

Requirements Compliance (4/11)

#	Requirements	Status	Ref. Slides	Notes
S14	The container length above the shoulder shall be 200 mm +/- 5%.	Comply	23	
S15	The CanSat shall perform the function of the nose cone during rocket ascent.	Comply	20	
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	56, 64	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	70, 71	
S18	The CanSat container shall meet all dimensions in section F.	Comply	62	
S19	The CanSat container materials shall meet all requirements in section F.	Comply	62	
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	64, 65, 71, 72	
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	57, 148	Confirmed by tests
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	71, 97	
E1	Lithium polymer batteries are not allowed.	Comply	97	
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	97	
E3	An easily accessible power switch through the container is required.	Comply	96	
E4	The container shall have small access holes for power switches of no more than 10 mm.	Comply	96	
E5	Power indicator is required.	Comply	96	

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	99	
E7	The audio beacon shall operate on a separate battery.	Comply	157	
E8	The audio beacon shall have an easily accessible power switch through the container.	Comply	96	
X1	XBee radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBee radios are also allowed.	Comply	85	
X2	XBee radios shall have their NETID/PANID set to their team number.	Comply	85	
X3	XBee radios shall not use broadcast mode.	Comply	85	
X4	The CanSat shall transmit telemetry once per second.	Comply	85, 107, 108	
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	87	
SN1	CanSat payload shall measure its altitude using air pressure.	Comply	26	

Requirements Compliance (7/11)

#	Requirements	Status	Ref. Slides	Notes
SN2	CanSat payload shall measure its internal temperature.	Comply	27	
SN3	CanSat payload shall measure its battery voltage.	Comply	28	
SN4	CanSat payload shall track its position using GPS.	Comply	29	
SN5	CanSat payload shall measure its acceleration and rotation rates.	Comply	30, 31	
SN6	CanSat payload shall video record the deployment of the para-glider at 80% peak altitude.	Comply	32, 67	
SN7	CanSat payload shall video record the ground during descent.	Comply	34, 68	
SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Comply	34, 68	
SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	32, 34	
SN10	CanSat payload shall measure its battery current.	Comply	28	

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	132, 133	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	87, 136	
G3	Telemetry shall include mission time with 1 second resolution.	Comply	87, 88	
G4	Each team shall develop their own ground station.	Comply	131	
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Comply	134	
G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	134	
G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Comply	129	
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Comply	131	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and an antenna.	Comply	126	

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	125,126	
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	137	
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	137	
G13	The ground station shall use a table top or handheld antenna.	Comply	128	
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	131	
G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Comply	131	

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	131	
G17	The ground station shall be able to activate all mechanisms on command.	Comply	131, 132	
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	88, 111	
F2	The CanSat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	111	
F3	The CanSat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	91, 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	113	
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	113	

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	91, 113	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	92, 109	
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	111, 112	

Management

Trirayan Boontaganon

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	389.5 g	19.47	Structure	Actual
Filament PPA-CF	150 / 0.75 kg	10 g	2	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
Swivel Link	1.5	1	1.5	Descent Control	Estimated
Nylon Ripstop	2.45 / 1.37 m²	7.5 m²	13.41	Descent Control	Actual

CanSat Budget – Hardware (2/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Mechanical Parts					
Nano Cord	7	1	7	Descent Control	Actual
Tactical cord	11	1	11	Descent Control	Estimated
Torsion Spring	5.43	2	10.86	Deployment	Actual
Compression Spring	4	2	8	Deployment	Estimated
Tape	1	1	1	Others	Estimated
Glue	2.6	1	2.6	Others	Estimated
Cable tie	3	2	6	Others	Estimated
Total (Mechanical) = 108.54 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	Board	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
FUET-9652B (Buzzer)	0.60	1	0.60	Beacon	Actual
Radio Antenna	26.50	1	26.50	Antenna	Actual
GNSS Antenna	9.08	1	9.08	Antenna	Actual
Components	18.54	1	18.54	Board	Estimated
PCB	8	1	8	Board	Actual
18650 Li-ion Battery	5.27	2	10.54	Power	Actual

CanSat Budget – Hardware (4/5)

Components	Cost per Unit (USD)	Quantity	Total Cost (USD)	Types	Justification
Electrical Parts					
CR2032 Coin Cell Battery	1.61	1	1.61	Power	Actual
CR927 Coin Cell Battery	0.88	1	0.88	Power	Actual
Servo BLS-A932+	13.60	1	13.60	Actuator	Actual
Servo HL-3612-C001	24.72	3	74.16	Actuator	Actual
Servo MG90S	4.05	1	4.05	Actuator	Actual
SD Card 32 GB For Mainboard	7.49	1	7.49	CDH	Actual
SD Card 64 GB For Quelima SQ11 Camera	8.67	1	8.67	CDH	Actual
SD Card 128 GB For ESP 32 Camera	11.64	1	11.64	CDH	Actual
Quelima SQ11 Camera	4.47	1	4.47	Camera	Actual
ESP 32 CAM With OV5640 160º FOV	17.86	1	17.86	Camera	Actual
AirTag	31.72	1	31.72	Sensor	Actual
Total (Electronics) = 370.78 USD					

CanSat Budget – Hardware (5/5)

Total Hardware Budget	
System	**Cost (USD)**
Mechanic	108.54
Electronic	370.78
Subtotal	**479.32**
Margin	1000 – 479.32 = **520.68**

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
SunShader Pro 5	29.9	1	29.9	Actual
ZDADJ900-12YG	73.95	1	73.95	Actual
RP-SMA Cable	32.51	1	32.51	Actual
Rii K01X1 Mini Wireless Keyboard	16.99	1	16.99	Actual
GeekWorm x728 UPS	43	1	43	Actual
WaveShare 4.3inch LCD 800x480	51	1	51	Actual
Total (Ground Station) = 424.68 USD				

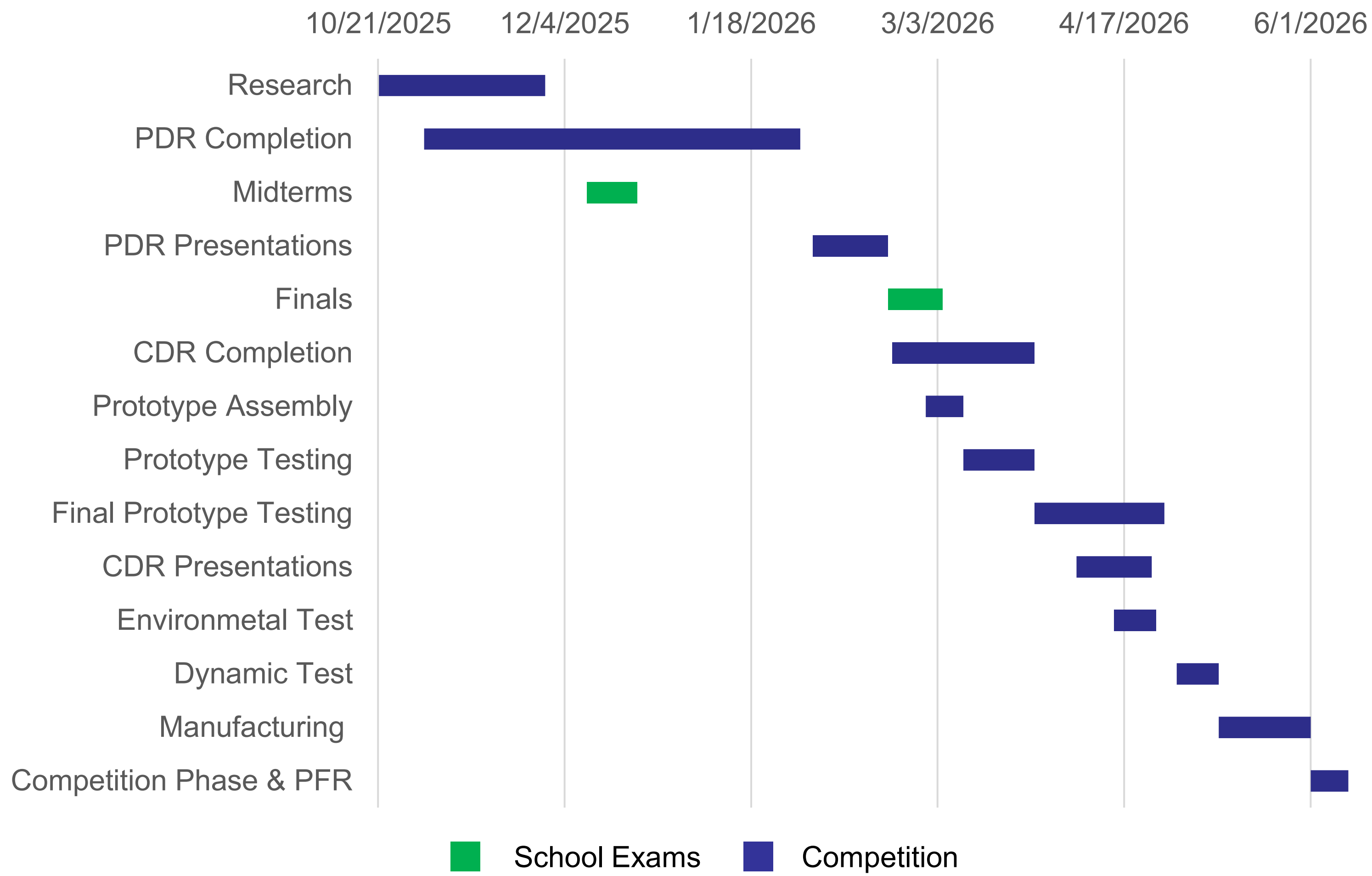
CanSat Budget – Other Costs (2/3)

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)

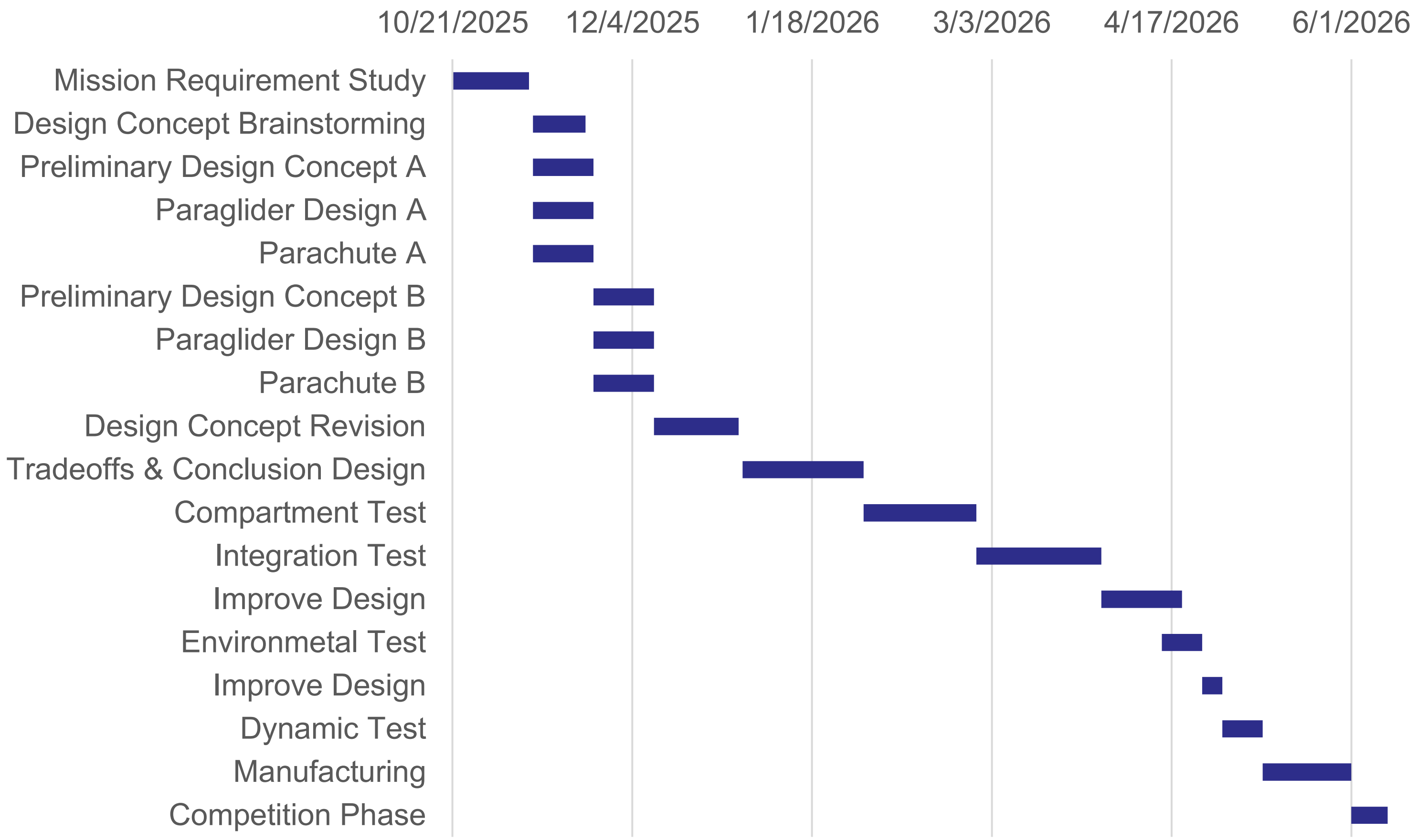
Incomes	Total Cost (USD)	Justification
Source of Income		
From School	60%	Actual
From Sponsors	30%	Estimated
From Parents	10%	Actual

Program Schedule Overview



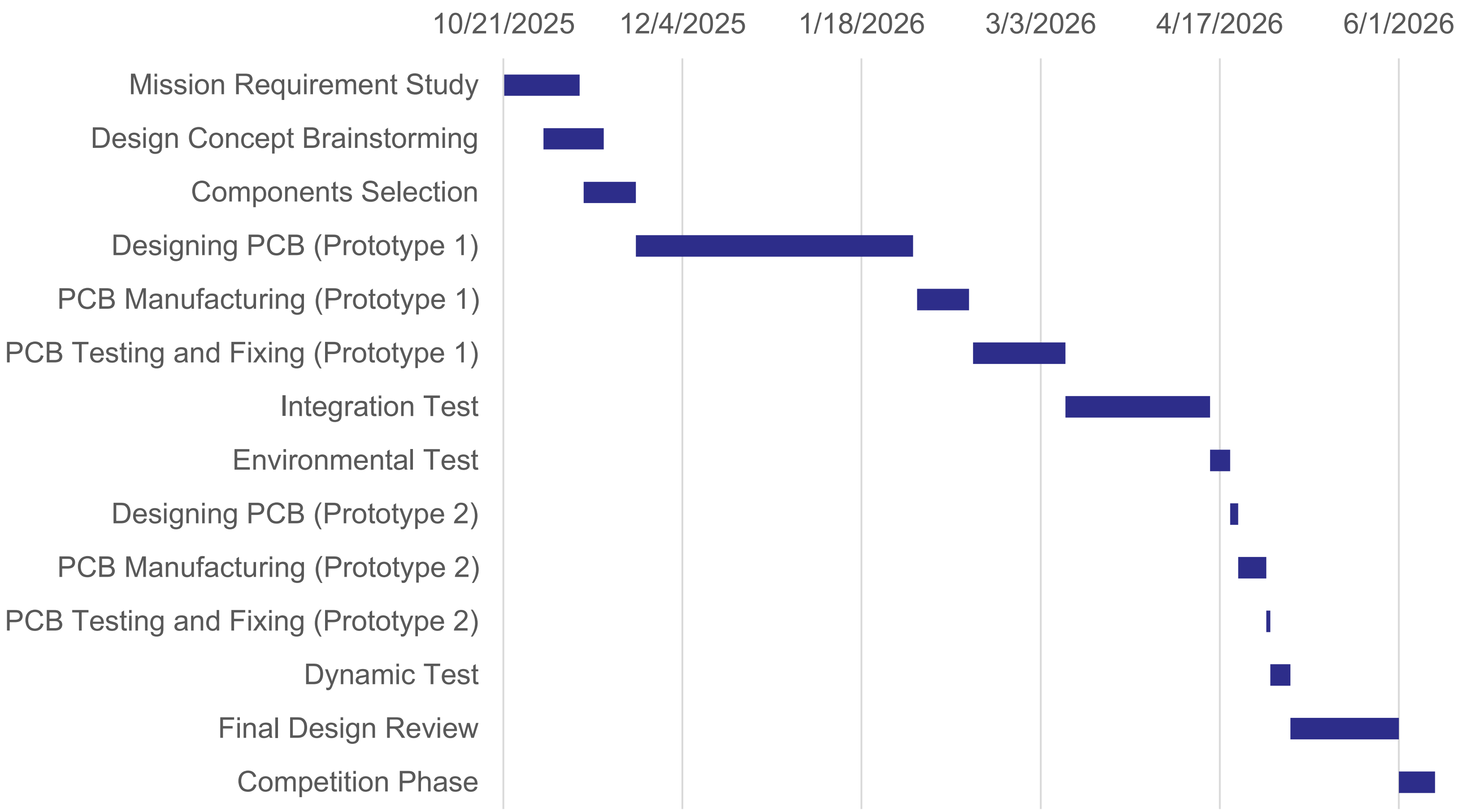
Detailed Program Schedule (1/3)

Mechanical Subsystem Schedule



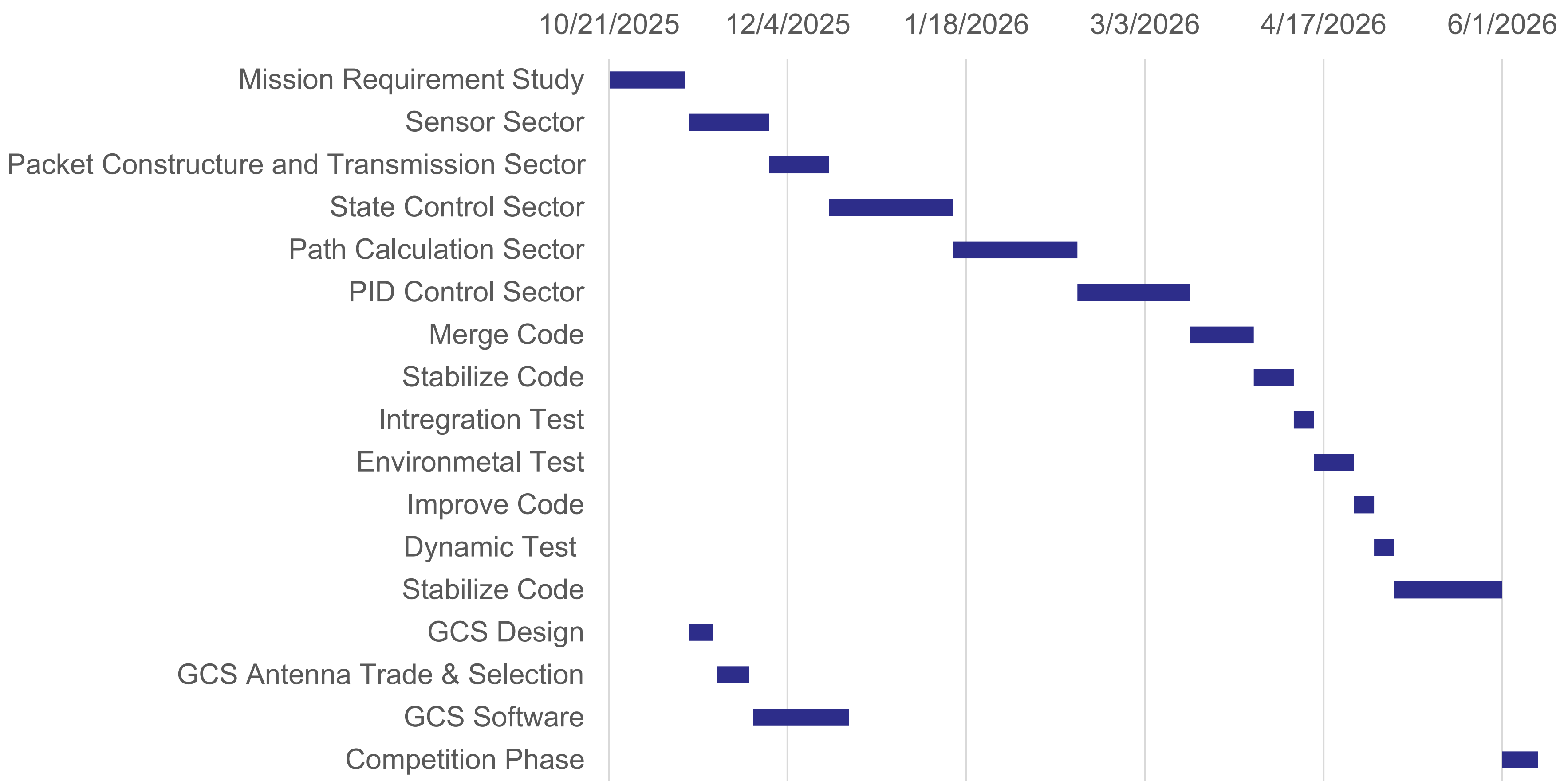
Detailed Program Schedule (2/3)

Electrical Subsystem Schedule



Detailed Program Schedule (3/3)

Software Subsystem Schedule



Conclusions (1/2)

Management

Major Accomplishments
- Strong partnerships established with major sponsors.
- Budget planning completed based on secured funding.
- Team roles clearly defined.

Major Unfinished Work
- Some of member Visas have not been applied for yet.

Mechanical

Major Accomplishments
- All compartment design completed and discussed.
- Some compartments have been prototyped and tested.

Major Unfinished Work
- Full system integration will be tested after PDR completion.

Electrical

Major Accomplishments
- All electronic components are chosen.
- Electrical schematics and PCB design completed.
- Sensors tested at the integration level.

Major Unfinished Work
- The new PCB will be tested after the PDR.

Software

Major Accomplishments
- Core flight and ground software implemented.
- Initial functionality validated through simulation and subsystem testing.

Major Unfinished Work
- Extended testing with integrated hardware.
- Remain implementation of and PID controlling.

Conclusions (2/2)

We are ready to proceed to next stage because

The team is fully prepared to advance to the next testing phase. All preliminary mechanical, electrical, and software designs are complete, and the project has entered prototyping with CDR preparation underway. With strong organization and funding support, the project is ready to proceed confidently toward full system testing and mission deployment.

WE ARE READY!