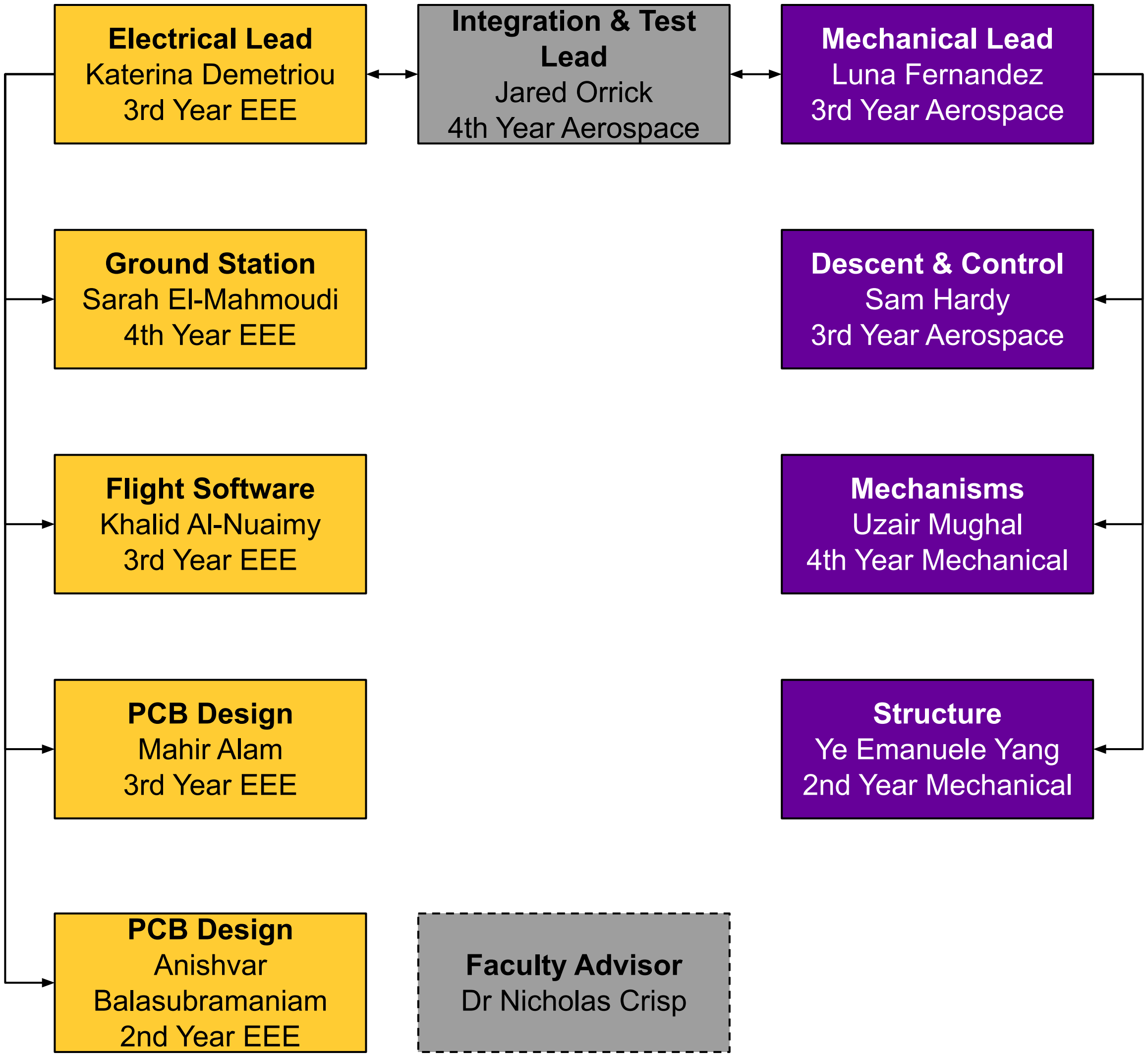
CanSat 2026
Preliminary Design Review (PDR)

Your Team 1079
Manchester Satellite Development Group

Presentation Outline

Team Organization



Team Member	Initials
Jared Orrick	JO
Luna Fernandez	LF
Katerina Demetriou	KD
Sarah El-Mahmoudi	SE
Khalid Al-Nuaimy	KA
Mahir Alam	MA
Anishvar Bala	AB
Sam Hardy	SH
Uzair Mughal	UM
Ye Emanuele Yang	YEY

Systems Overview

Luna Fernandez

Mission Summary

Objectives:

1. Design a Cansat that contains electronics, a paraglider, has a stabilized camera mechanism and can send and receive telemetry. The CanSat shall functional as a nose cone during the assent in a rocket. Once it reaches appogee it will be deployed, it therefore must be able to survive the shock and vibrational forces involved with launch and ejection. This point will be recorded as the peak altitude by the pressure sensor.
2. Once ejected, the CanSat will immediately deploy a parachute passively. This will enable the Cansat to descend at a rate no more than 15 m/s.
3. The CanSat will compare its current altitude with the altitude at apogee. Once this gets to 80% of the peak altitude the CanSat will release the payload. This payload will release a para-glider descent control system and descend at a rate of 5 m/s.
4. Once again, the CanSat will compare its current altitude with the initial altitude on the ground, and once it indicates 2m, the payload shall release a protected hens egg without breaking it.
5. Throughout the pre-flight, flight and post flight the CanSat will contain a buzzer that will be isolated and sound at a 1 Hz rate.

External Objectives:

- Further the work of the UK University CanSat competition through weekly workshops for, not only University of Manchester students, but all university students participating in the UK competition.
- Promote STEM through our outreach projects.
- Represent The University of Manchester, and our sponsor: RS.

System Requirement Summary

#	Requirement	Understanding	Verification
C5	At 80% flight peak altitude, the payload shall be released from the container.	At 80% of the total apogee altitude the payload shall separate from the container and simultaneously deploy a mechanism to control the descent of the payload which includes a paraglider.	Test
C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.		Test
C8	The payload shall steer toward a target location	Self explanatory.	Test
E6	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	The CanSat shall have sufficient battery supply so that it stays operational for a minimum of 2 hours in the rocket and in the arm state.	Test
X4	The Cansat shall transmit telemetry once per second.	The telemetry transmission rate shall be 1 Hz.	Test

System Requirement Summary

#	Requirement	Understanding	Verification
X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, battery current, command echo, and GPS coordinates that include latitude, longitude, altitude and **number of satellites tracked**.	Self explanatory.	Demonstration
S1	The Cansat and container mass shall be 1000 grams +/- 10 grams.	The CanSat shall have a total all up mass of no less than 990 grams and no more than 1010 grams.	Inspection
S15	The Cansat shall perform the function of the nose cone during rocket ascent.	The CanSat shall sit inside the rocket payload bay with the nose cone facing the sky, the nose cone shall be sufficiently shaped to minimise drag, and be structurally sound to avoid any deformation which may cause the rocket to divert.	Demonstration
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.	There shall be sufficient tolerances and no obstructions between the payload and the container walls to allow for the payload to be released from the container. Passive mechanisms which rely on components such as springs should not obtrude the payload from sliding out of the container.	Demonstration
S18	The Cansat container shall meet all dimensions in section F.	Self explanatory.	Inspection

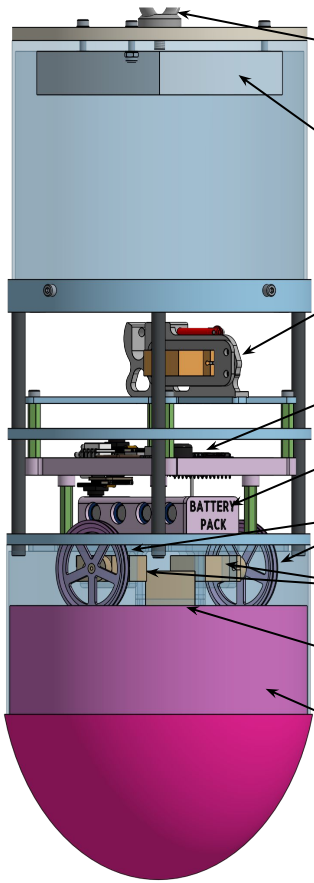
System Requirement Summary

#	Requirement	Understanding	Verification
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Mechanisms shall not deform under heat, wind, or other external conditions.	Test
SN6	Cansat payload shall video record the deployment of the para-glider at 80% peak altitude.	Self explanatory.	Test
SN7	Cansat payload shall video record the ground during descent.	The CanSat payload shall have a camera onboard that will be pointed at the ground during descent.	Demonstration
SN8	The ground pointing camera shall capture video of the instrument being released and reaching the ground.	The ground camera shall be able to capture a video of the egg being released from the payload and it touching the ground.	Demonstration
G4	Each team shall develop their own ground station.	Self explanatory.	Inspection

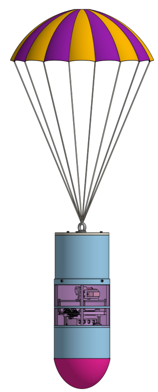
System Requirement Summary

#	Requirement	Understanding	Verification
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Self explanatory.	Demonstration
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.	Self explanatory.	Test
G17	The ground station shall be able to activate all mechanisms on command.	The ground station shall be able to send messages that actuate the mechanisms.	Test

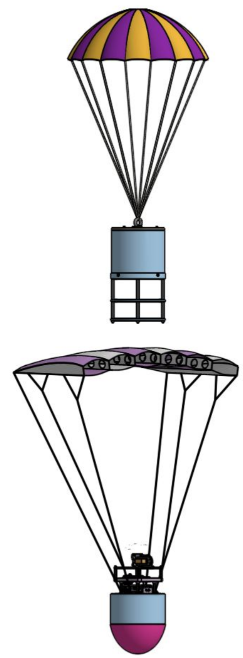
Concept 1 Overview



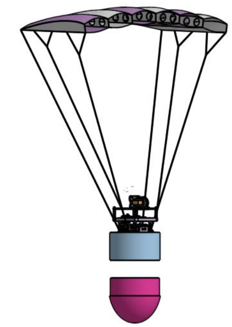
Stage 1: Container Separation Phase

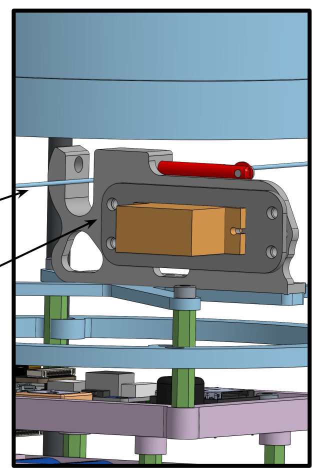


Stage 2: Payload Deployment Phase

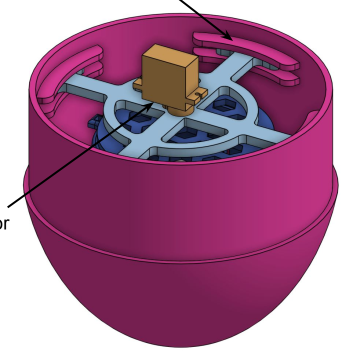


Stage 3: Egg Release Phase



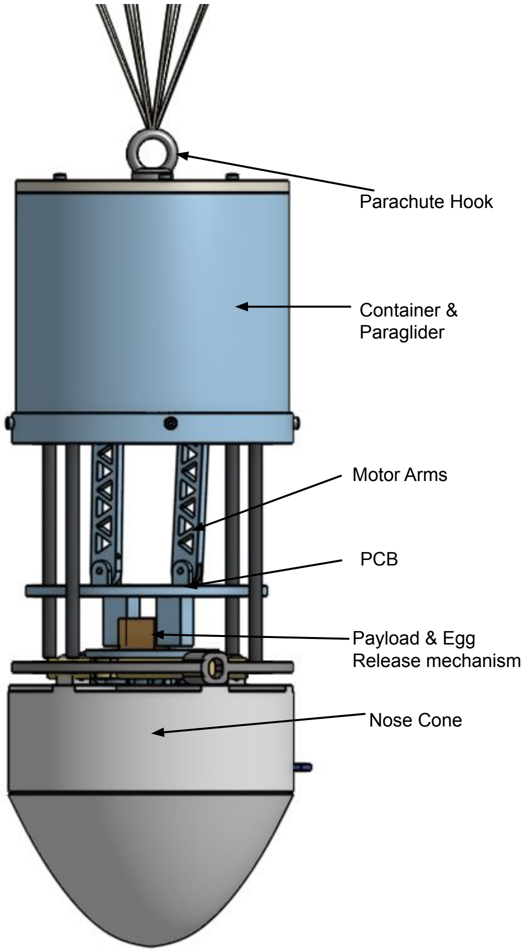


Payload Release Mechanism

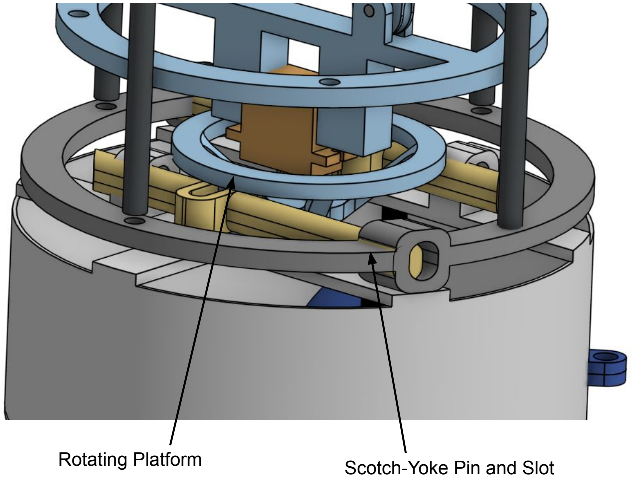


Egg Release Mechanism

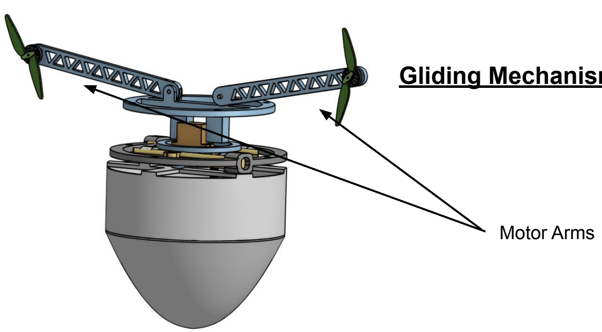
Concept 2 Overview



Payload & Egg Release Mechanism



Gliding Mechanism

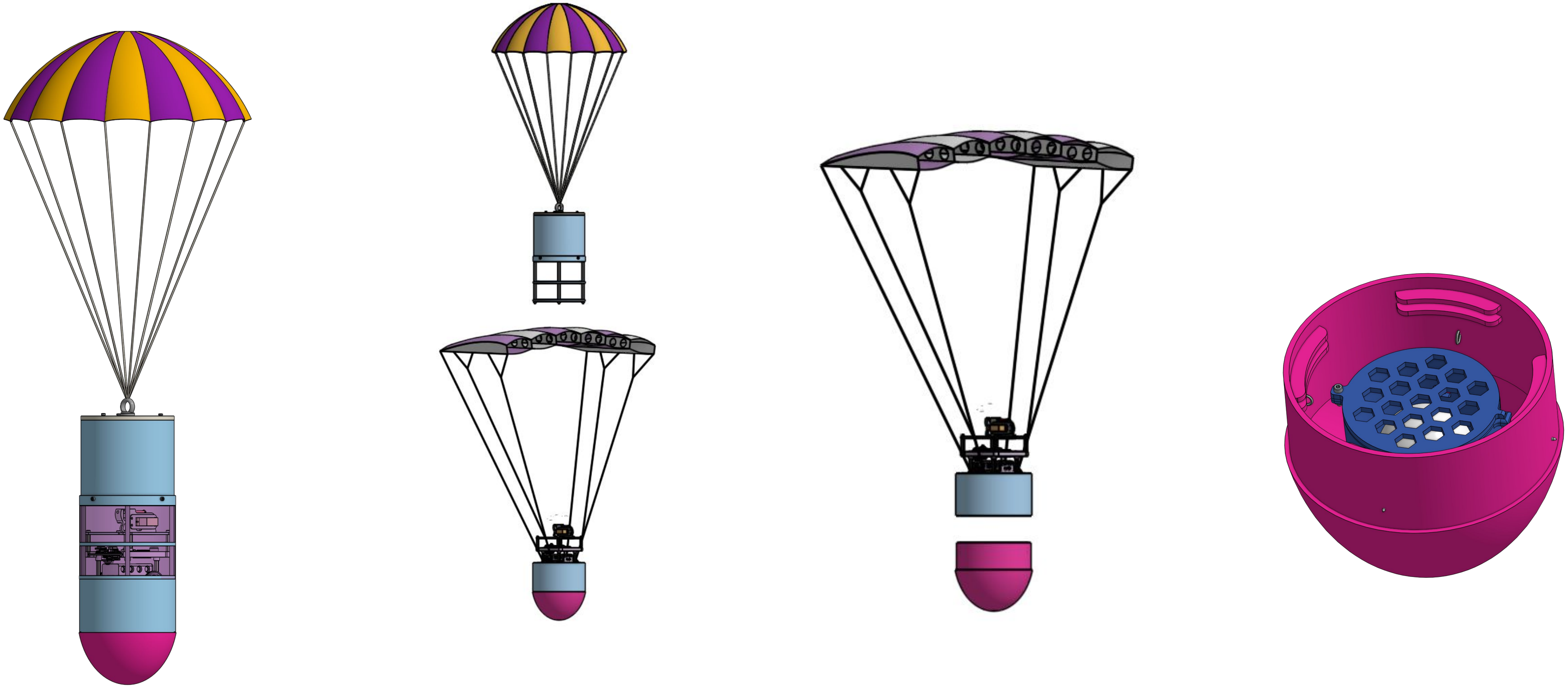


System Level Configuration Selection

Concept 1	Concept 2
The payload is released from the container through the activation of a pin that releases nylon strings attached to the roof of the container. These strings are routed through guides and are freed when the pin retracts. The paraglider is stowed in a backpack at the top of the container, with its opening triggered by the container release mechanism.	The container is released using a lock-pin mechanism actuated by a servo motor. This mechanisms rests on a plate in the middle of the payload. The servo rotates in two directions, with each direction releasing a different section of the CanSat. The first rotation releases the container from the payload and simultaneously triggers the deployment of the paraglider.
Two main suspension lines tether the paraglider to the payload. Steering is achieved via servo-actuated brake lines, which are routed through pulleys on either side to modulate drag and effect turns.	As the payload separates from the container, it simultaneously deploys the paraglider and two folding control arms. These arms are equipped with terminal motors and 3-inch propellers, which utilize thrust vectoring to steer the CanSat while the paraglider governs the vertical descent velocity.
The cargo is released through the rotation of a 4-leg plate that rests on internal ledges within the nose cone wall. This rotation is actuated by a servo motor, allowing the cargo to be released.	A second servo rotation releases the cargo from the payload.
An elliptical nose cone is used to minimise aerodynamic drag.	A conical nose is used.

Concept Chosen	Rationale
Concept 1	Concept 1 is selected due to its simple and reliable design. It requires less electrical power, as it uses fewer motors. The concept incorporates a pin-release mechanism, a brake-line steering mechanism for the paraglider, a rotating release plate, and an aerodynamically efficient elliptical nose cone.

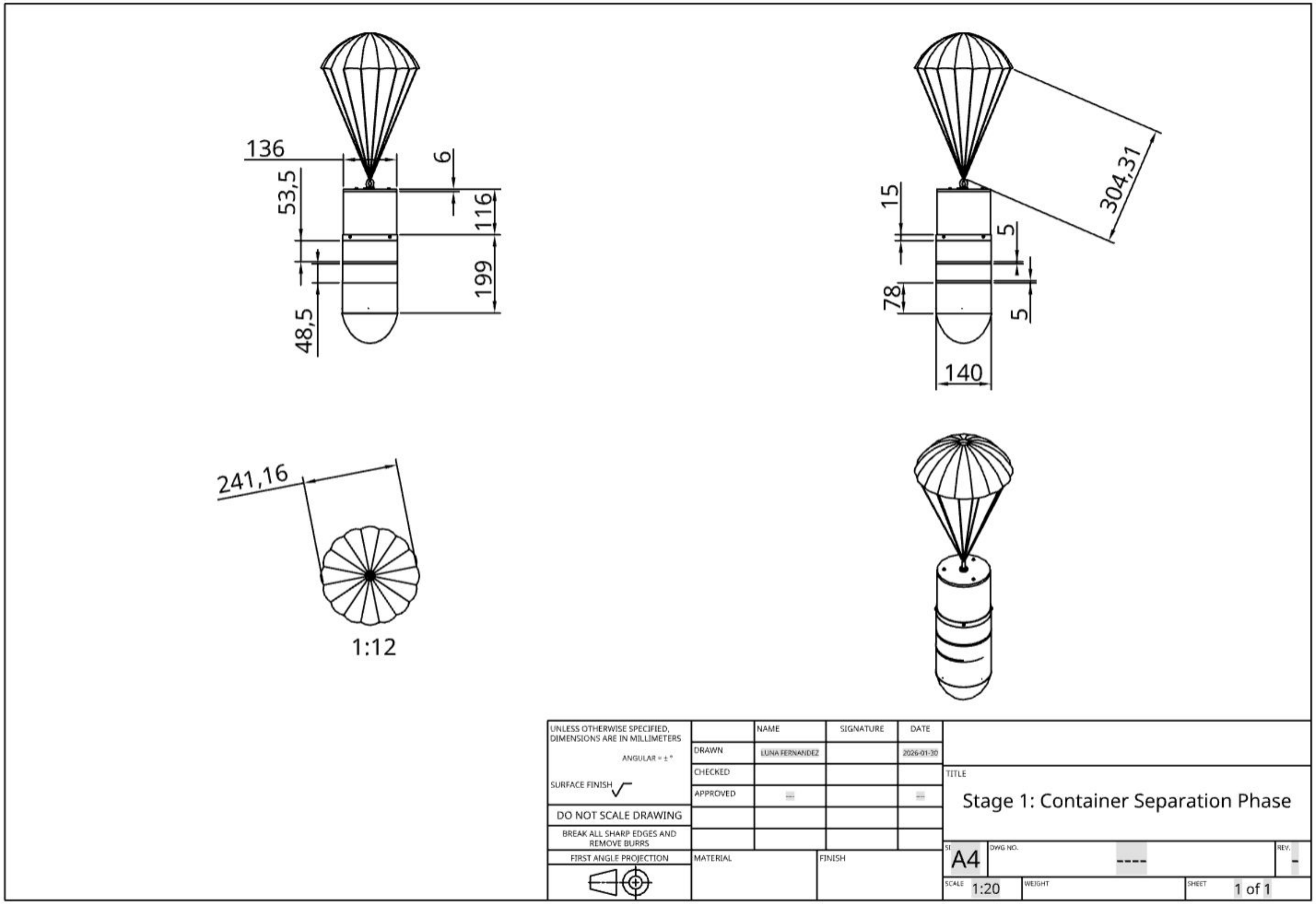
Physical Layout- Configurations



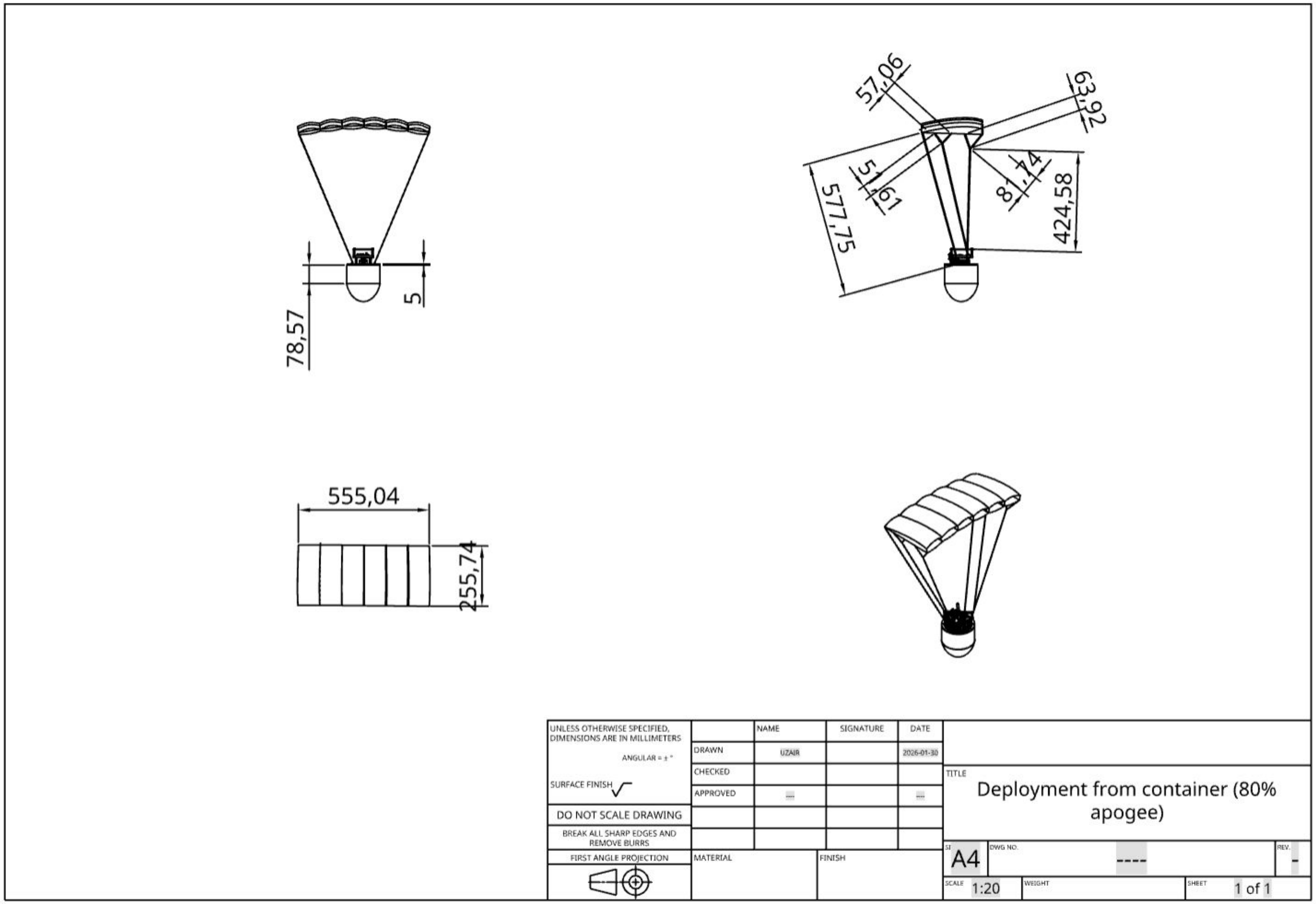
1 2 3 4

1. Launch configuration
2. Deployment from container (80% apogee)
3. Deployment of cargo (2m above the ground)
4. Cargo touchdown

Physical Layout- Drawings



Physical Layout- Drawings



System Concept of Operations

1. Pre Launch

CanSat sat on launch pad.

CX, CAL, ST, ARM, commands sent.

The CanSat's time is synchronised to UTC

2. Launch

The CanSat is launched in a rocket.

The CanSat is in communication with the GCS.

3. Deployment from Rocket

Apogee is reached.

The CanSat is ejected from the rocket.

Parachute passively deployed.

4. At 80% Altitude

The Payload and Container separate.

The Paraglider and steering mechanism deploys.

5. Touchdown

The CanSat container, payload, and egg lands.

6. Recovery

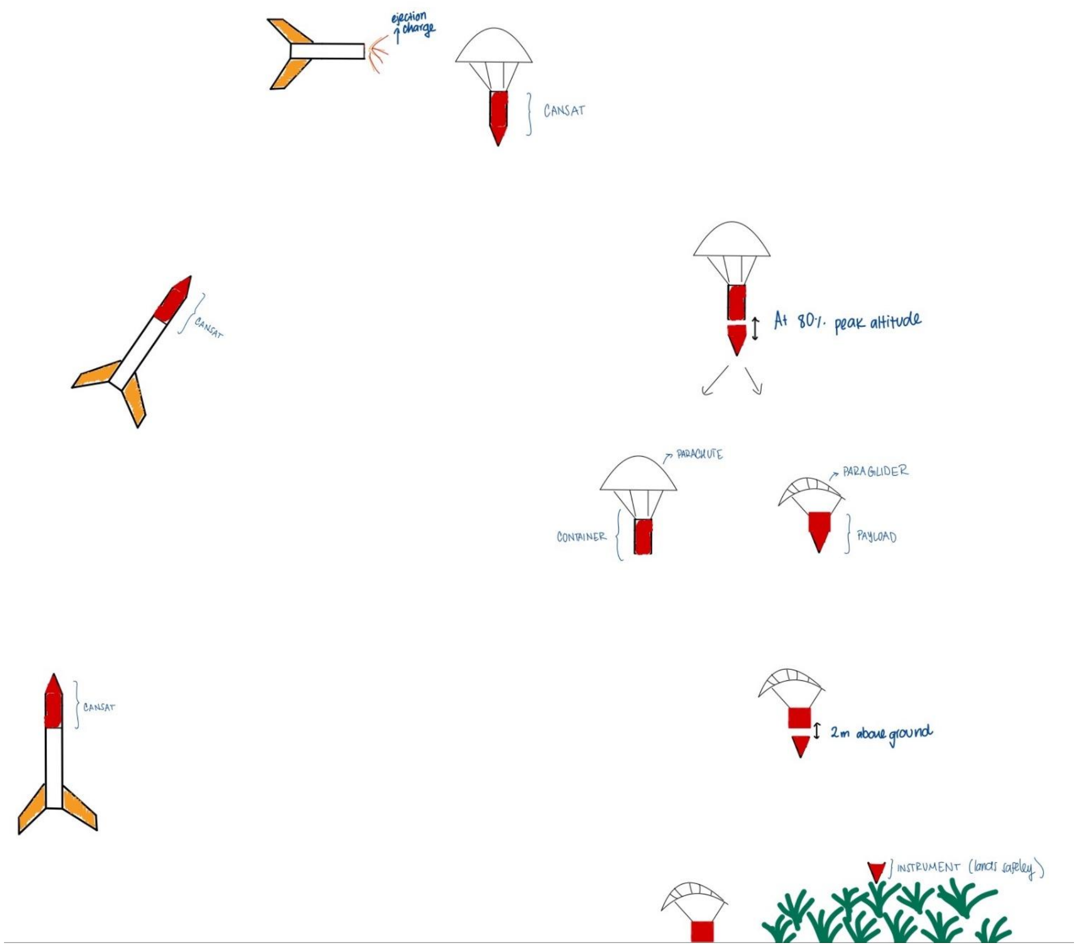
The recovery crew collect the CanSat components.

7. Data Handover

Data sent from the CanSat during the launch is handed over to the judges.

System Concept of Operations

The ConOps shown on the previous slide can be seen here in diagrammatic form



Launch Vehicle Compatibility

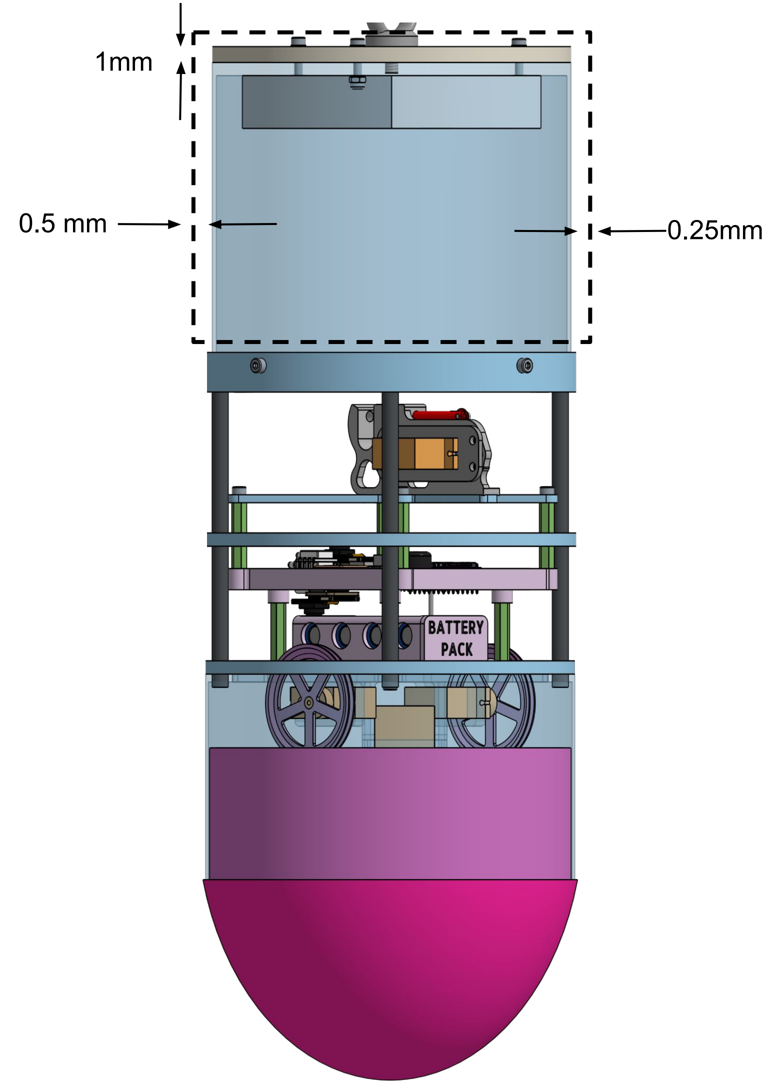
Dimensional constraints (as per Requirements):

- Diameter- 140mm
- Height (without the nose cone)- 320mm

Dimensional constraints of current design:

- Diameter-136mm
- Height (without the nose cone)- 244mm
- Diameter clearance- **0.5mm on each side**
- Height clearance – **1mm at the top**

Dimensions were selected to ensure compatibility to fit and deploy



Basic dimensions:
1 - 140mm (Container Outer dia)
2 - 136mm (Payload outer dia)
3 - 76mm (Nose cone height)
4 - 110mm (Shoulder Height)

Sensor Subsystem Design

Katerina Demetriou

Sensor Subsystem Overview

Flight Controller F405-miniTE

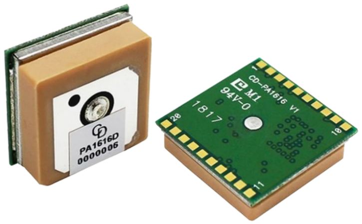
- Air Pressure (SPL06-001)
- Rotation Rate & Accelerometer (ICM-20948)

INA260

Battery Voltage Sensor

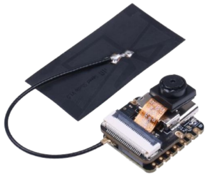
CD-PA1616D

GNSS



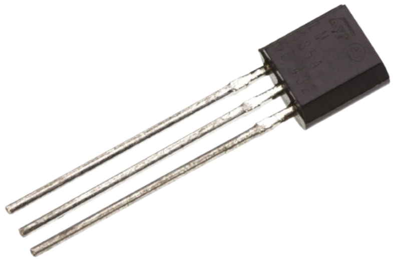
Seeed XIAO ESP32S3

Camera Sensor



LM335AZ

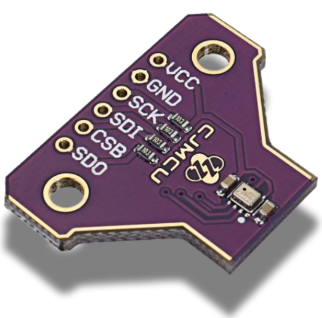
Temperature Sensor



Payload Air Pressure Sensor Trade & Selection

Name	Operating Voltage (V)	Current (uA)	Pressure Resolution (Pa)	Absolute Accuracy (pressure, Pa)	Interface	Mass (g)	Dimensions(mm)	Cost (GBP)
F405-miniTE (SPL06-001)	**1.7 - 3.6**	**400**	**0.06**	**100**	**I²C or SPI**	**<1**	**2.5 x 2.0 x 0.95**	**51.08**
BME280	1.71 - 3.6	0.16	0.0763	300	I²C	<1	2.5 x 2.3	5.99
BMP581	1.71 - 3.6	260	0.015625	75	I²C, I³C, SPI	<1	2 x 2	2.18
Fermion: ICP-10111	3.3 -5.5	＜2000	0.4	100	I²C	<1	16.5 x 12.5	5.88

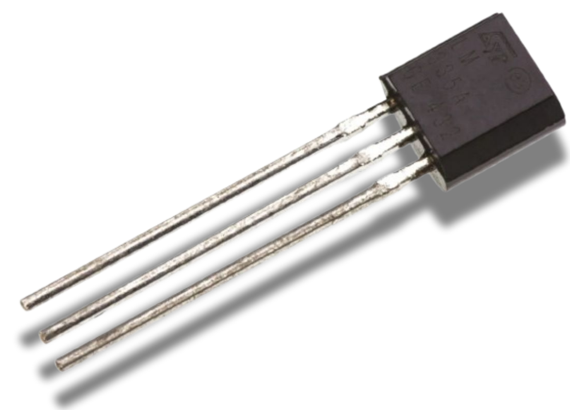
Requirements	Selected Sensor	Reasons
Pressure resolution: 0.1 ℃	**F405-miniTE (SPL06-001)**	• **High resolution** • **High accuracy** • **Small form factor** • **2 in 1 with temperature and pressure sensor which provides correction to the pressure reading**



Payload Air Temperature Sensor Trade & Selection

Name	Operating Voltage (V)	Current (uA)	Temperature Resolution (°C)	Accuracy (temp,°C)	Interface	Mass (g)	Dimensions(mm)	Cost (GBP)
LM335AZ	**3 - 30**	**140**	**0.01**	**0.5**	**I²C**	**<1**	**4.3 x 4.3 x 1.75**	**0.45**
DHT20	3.3 - 5.5	980	0.01	0.5	I²C	<1	170 x 190 x 5.8	4.25
TMP117M	1.7 -5.5	240	0.0078	0.1	I²C	<1	180 x 8.4 x 2.3	5.24

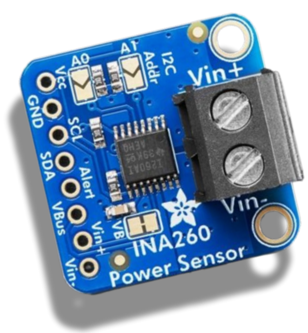
Requirements	Selected Sensor	Reasons
Temperature resolution: 0.1	**LM335AZ**	**• High resolution • High accuracy • Small current current consumption • Small form factor • Lowest cost**



Payload Battery Voltage Sensor Trade & Selection

Name	Operating Voltage (V)	Current (uA)	Range (V)	Resolution (mV)	Interface	Mass (g)	Dimensions (mm)	Cost (GBP)
INA260	**2.7 - 5.5**	**310**	**0 - 36**	**0.36**	**I²C, SMBus**	**2**	**22.9 x 22.8 x 2.7**	**7.57**
LTC2943	2.7 - 5.5	700	3.6 - 20	1.44	I²C, SMBus	4.5	3 x 3 x 0.75	6.72
PAC1931	2.7 - 5.5	585	0.2 - 32	0.488	I²C	3.2	4 x 4 x 0.5	0.58
INA226	2.7 - 5.5	420	0 -36	0.36	I²C	23.7	20 x 27 x 1	1.97

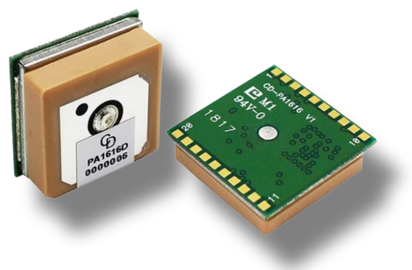
Requirements	Selected Sensor	Reasons
Voltage resolution: 0.1V	**INA260**	• **The only sensor on the list with an internal resistor - reduces design complexity** • **High resolution** • **High accuracy** • **Lightest weight**



Payload GNSS Sensor Trade & Selection

Name	Voltage (V)	Current (mA)	Update Rate (Hz)	Sensitivity (dBm)	Position accuracy (m)	Antenna	Interface	Mass (g)	Dimensions (mm)	Cost (GBP)
CDPA1616D	**2 - 4.3**	**34**	**10**	**-165**	**3**	**Internal**	**UART, I2C**	**6**	**16 x 15 x 2**	**11.30**
ADAFRUIT INDUSTRIES 746 GPS Module (V3)	3.0 - 5.5	20	10	-165	1.8	internal + u.fl	I2C	8.5	25.5 x 35 x 6.5	39.31
u-blox MAX-M10S	1.76 - 3.3	10	10	-167	1.5	NA	UART I2C	0.5	10.1 x 9.7 x 2.5	15.35
STMicroelectronics TESEO-LIV4FTR GNSS	3.0 - 3.63	48.8	1	-162	<1	NA	UART I2C	0.175	9.7 x 9.2 x 0.8	13.5

Requirements	Selected Sensor	Reasons
• **Time resolution (s): 1** • **Altitude resolution (m): 0.1** • **Longitude resolution (degrees): 0.0001** • **Latitude resolution (degrees): 0.0001**	**Adafruit PA1616D**	• **Strong library support (Adafruit)** • **Wide range for voltage** • **Low power usage** • **Small form factor** • **Cost effective** • **Highest position accuracy**



Payload Acceleration Sensor Trade & Selection

Name	Operating Voltage (V)	Current (mA)	Resolution (ADC bits)	Interface	Mass (g)	Dimensions (mm)	Cost (GBP)
F405-miniTE (ICM-20948)	**1.7-3.6**	**2.5 mA**	**16,16**	**I2C, SPI**	**<1**	**3 x 3 x 1**	**6.5**
BNO085	2.0 - 3.6	14 mA	14, 14	I²C, SPI, UART	2.5	25.6 x 22.7 x 4.6	6.45
BNO055	2.4 - 3.6	12.3 mA	14,16,13	I2C, UART	<1	3.8 x 5.2 x 1.1	9.24

Requirements	Selected Sensor	Reasons
• Resolution (bits): 16 • Interface: I2C • DMP • Lightweight • Measures acceleration	F405-miniTE (ICM-20948)	• Small dimensions • Low power usage • Cost effective

Payload Rotation Rate Sensor Trade & Selection

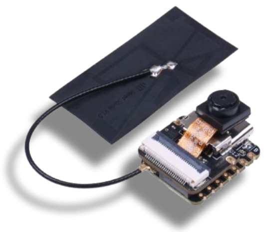
Name	Operating Voltage (V)	Current (mA)	Resolution (ADC bits)	Interface	Mass (g)	Dimensions (mm)	Features	Cost (GBP)
F405-miniTE (ICM-20948)	**1.7-3.6**	**2.5 mA**	**16,16**	**I2C, SPI**	**<1**	**3 x 3 x 1**	**Has DMP**	**6.5**
LSM9DS1	1.9 - 3.6	4.3 mA	16, 16, 16	I²C, SPI	<1	3.5 x 3 x 1.0	No DMP	20.36
BHI260	0.3 - 4.25	1.4 mA	16,16	I²C, SPI	<1	3.6 x 4.1 x 0.83	Supports DMP but no internal Magnetometer	6.5
BMI270	1.7-3.6	2 mA	16,16	I2C, SPI	<1	2.5 x3 x 0.83	No DMP	2.8

Requirements	Selected Sensor	Reasons
• Resolution (bits): 16 • Interface: I2C • DMP • Lightweight • Measures acceleration	F405-miniTE (ICM-20948)	• Low power usage • Cost effective

Payload Release Camera Trade & Selection

Name	Operating Voltage (V)	Current (mA)	Resolution (pixels)	Field of view (degrees)	Frames per second	Micro SD card	Interface	Mass (g)	Dimensions(mm)	Cost (GBP)
Seeed XIAO ESP32S3	**3.0-5.0**	**138**	**1600 x 1200**	**65**	**30**	**Yes**	**UART, SPI, I²C, GPIO**	**5**	**21 X 17.8 X 15**	**14.5**
Adafruit 3202	3.7 - 5.0	110	640 x 480	120	30	Yes	GPIO	2.8	29 x 17 x 5	18.06
OV5640	3.8 - 5.0	200	1280 x 720	120	60	Yes	Analog	6	8 x 8 x 13	30.73

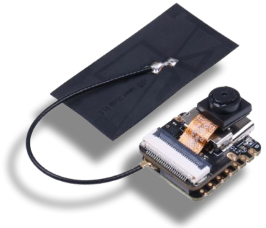
Requirements	Selected Sensor	Reasons
Resolution: 640 x 480	**Seeed XIAO ESP32S3**	• **Lightweight** • **Low power usage** • **Cost effective** • **Multiple interface types**



Ground Camera Trade and Selection

Name	Operating Voltage (V)	Current (mA)	Resolution (pixels)	Field of view (degrees)	Frames per second	Micro SD card	Interface	Mass (g)	Dimensions(mm)	Cost (GBP)
Seeed XIAO ESP32S3	**3.0-5.0**	**138**	**1600 x 1200**	**65**	**30**	**Yes**	**UART, SPI, I²C, GPIO**	**5**	**21 X 17.8 X 15**	**14.5**
M5Stack Unit Cam U109	3.3 - 5.0	380	640 x 480	66.5	30	No	Wifi, UART	4.7	45 x 20 x 12	12.19
OV5640	3.8 - 5.0	200	1920 x 1080 1280 x 720	120	30 60	Yes	Analog	6	8 x 8 x 13	30.73

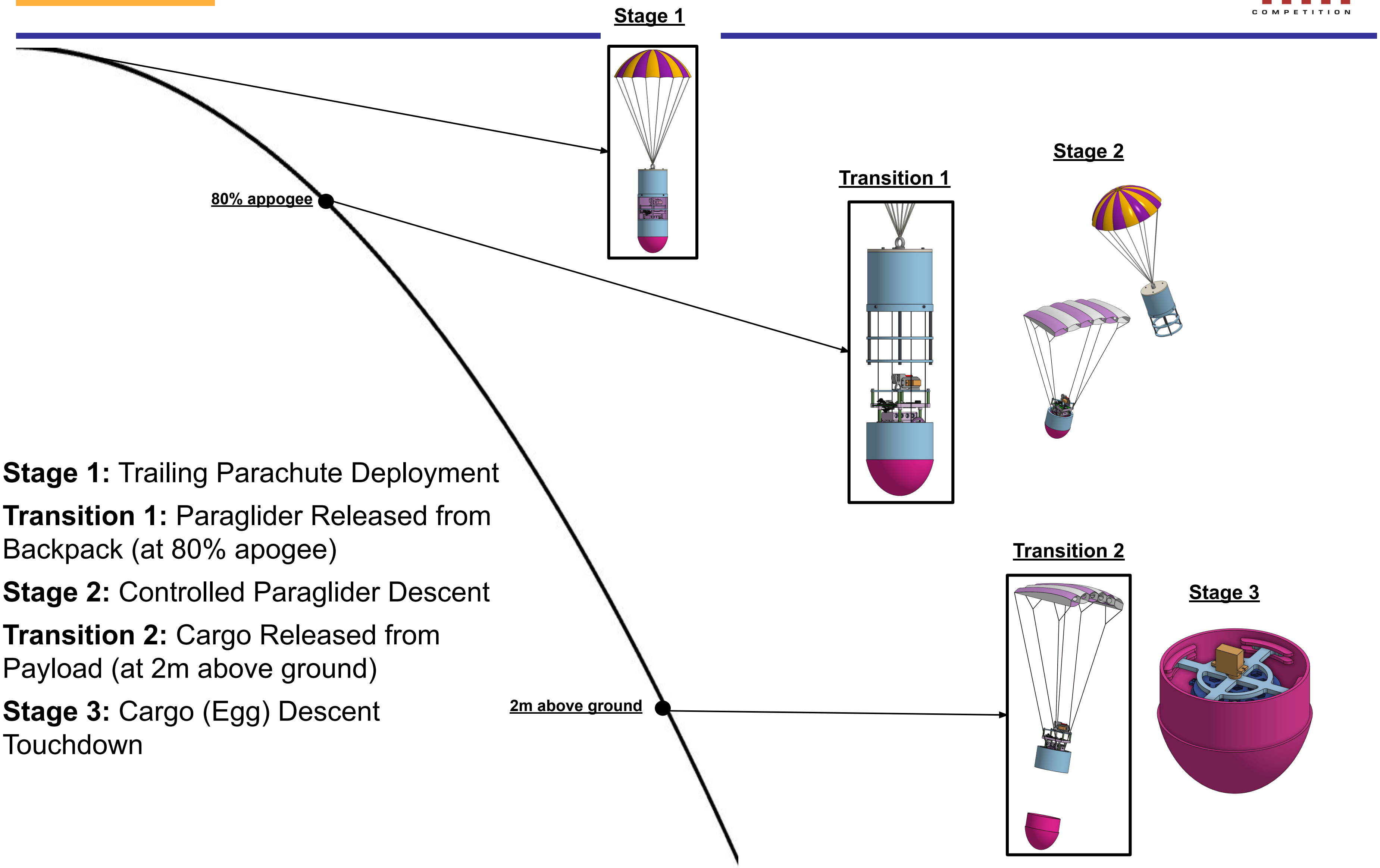
Requirements	Selected Sensor	Reasons
Resolution: 640 x 480	**Seeed XIAO ESP32S3**	• **Lightweight** • **Low power usage** • **Cost effective** • **Multiple interface types**



Descent Control Design

Jared Orrick & Luna Fernandez

Descent Control Overview



Stage 1: Trailing Parachute Deployment

Transition 1: Paraglider Released from Backpack (at 80% apogee)

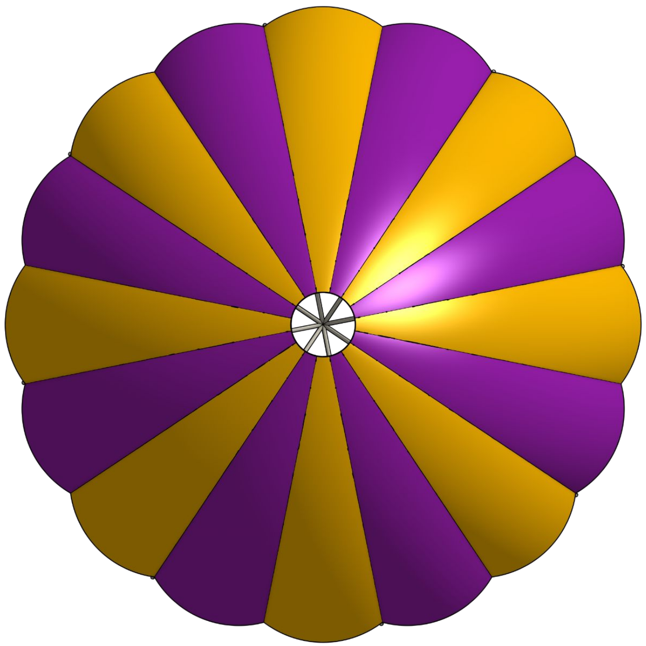
Stage 2: Controlled Paraglider Descent

Transition 2: Cargo Released from Payload (at 2m above ground)

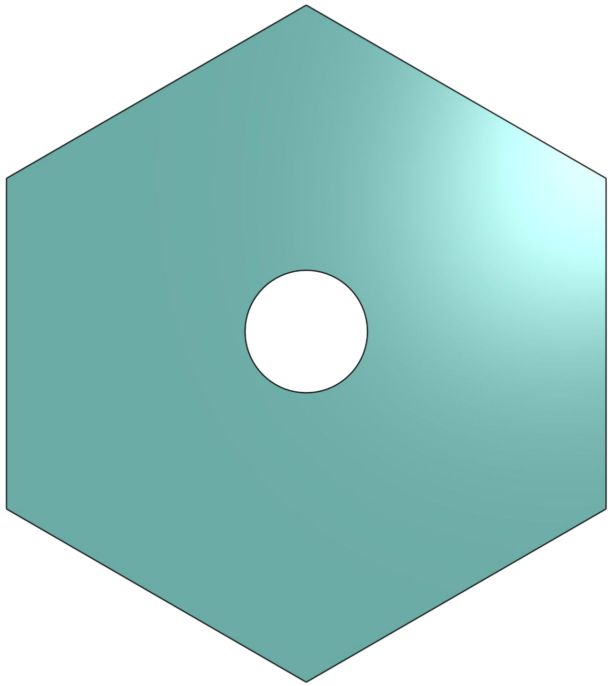
Stage 3: Cargo (Egg) Descent Touchdown

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

Hemispherical



Hexagonal



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

Parachute Type	Advantage	Disadvantage
Hemispherical	Ability to carry heavy loads Simplest Design Uniform drag distribution ensures more stability Chord number flexibility	Lack of steerability Increased mass
Hexagonal	Simple manufacturing High performance Commonly used in model rockets	Need for multiple shroud lines Uneven inflation due to airflow variations

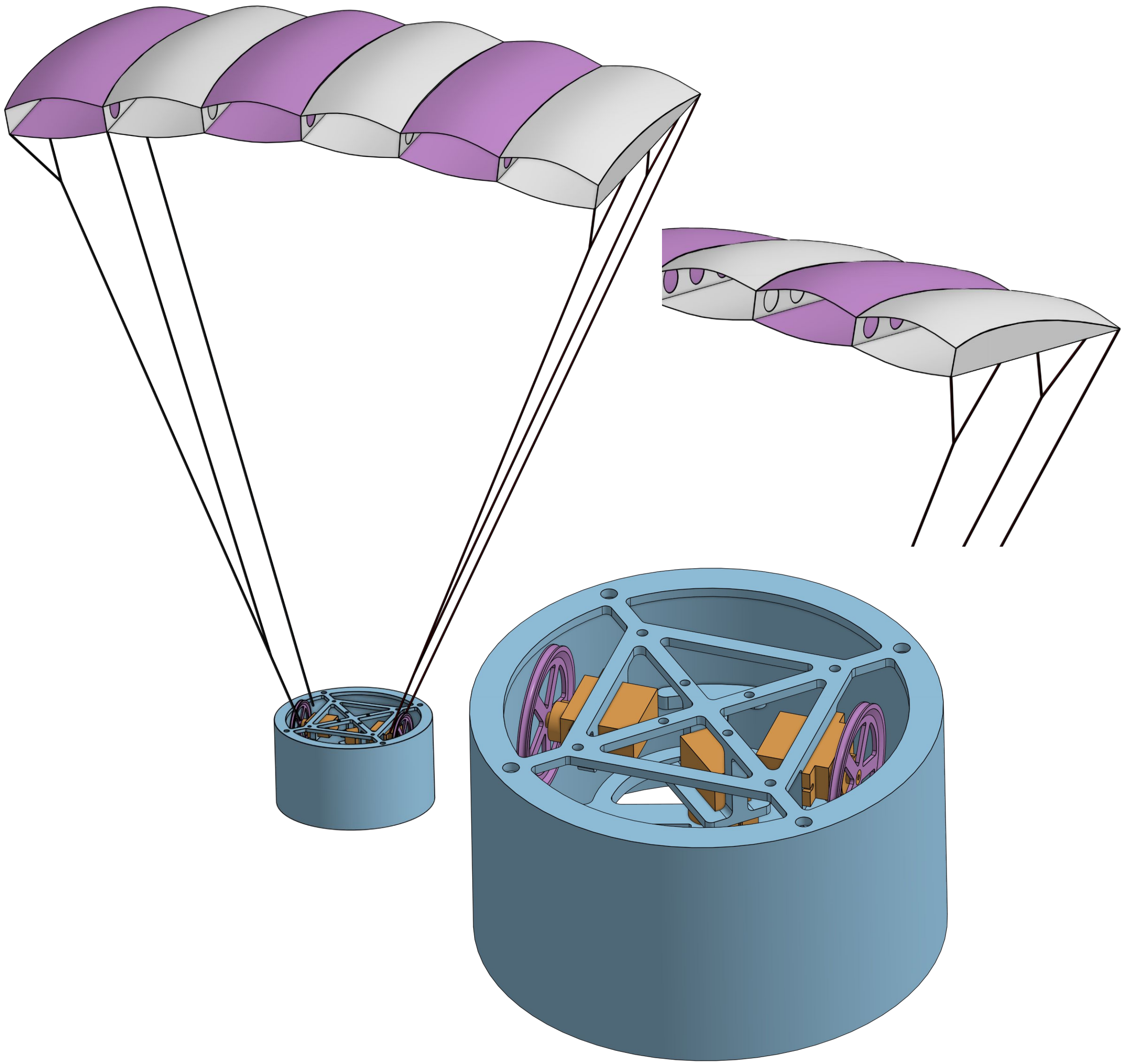
Chosen Type	Rationale
Hemispherical	**The hemispherical parachute was chosen given its high stability and uniform drag distribution due to its axial symmetry. This provides a slow and control descent rate for a simpler design. It also allows design adaptations thanks chord number flexibility.**

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

Parachute Material	Advantage	Disadvantage
Nylon	Good elastic properties Very strong Most common and affordable material	Melts at high temperatures Requires care when handling
Dacron	Low weight and volume Low porosity Temperature resistant	Requires treatment for stability before using Poor elastic properties
Spectra	One of the strongest materials Low density Low friction	No fibre elongation Difficult handling

Chosen Type	Rationale
Nylon	**Nylon was chosen due to its good elastic properties and high strength-to-weight ratio. It is an easily acquired and economical material, which helps ensure improved parachute performance during descent.**

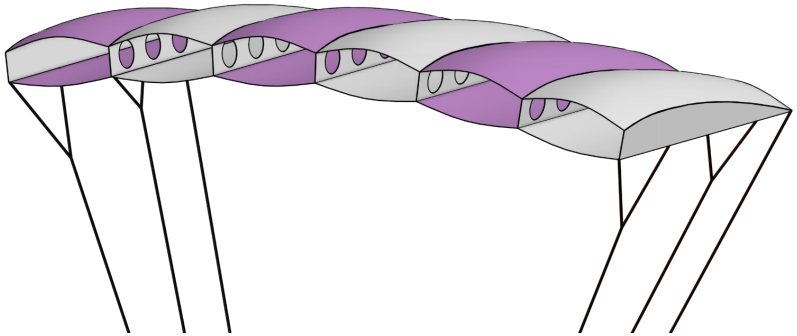
Payload Descent Control Strategy Selection and Trade (1/3)

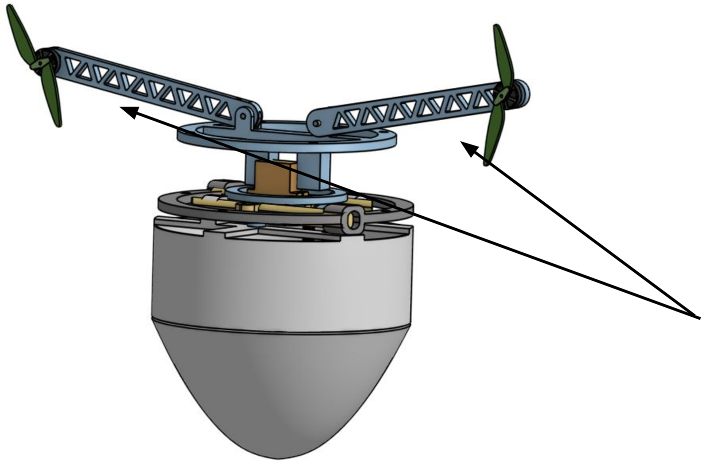


Concept 1:
- The main suspension lines are attached to the front of the payload.
- The brake lines are fed into servo-actuated pulleys on either side of the payload

Paraglider Design:
- 7 cell Rectangular design based off of a ram-air parachute
- Chord: 0.255m
- span: 0.562 m
- angle of attack: 7deg
- average line length: 61cm

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





Concept 2: Motor-Arm Guided Descent

- Once the nose cone is released, the motor arms deploy outward from the top plate to their locked position.
- The propellers then provide controlled lateral thrust to steer the egg module toward the target area.
- Increase thrust on one side allows the turning in the opposite direction
- Thrust commands are generated from onboard navigation data and updated continuously during descent.

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

Concept	Advantage	Disadvantage
Servo-actuated pulley mechanism	**Aerodynamic Efficiency:** Uses the wing's massive surface area for highly responsive turning with minimal energy. **Weight & Simplicity:** Extremely lightweight (just servos and string) and compact, leaving mass budget for other systems. **Proven Design:** Standard industry method for all steerable parachutes. C	**Tangle Risk:** High risk of lines tangling during deployment (riser twist), which can disable steering. **Shock Load:** High-speed deployment can transmit shock waves that strip servo gears.
Motor and propellor steering mechanism	**Line Independence:** Steering remains possible even if suspension lines are twisted or tangled. **Zero-Speed Control:** Can generate steering force even with low forward airspeed.	**Physics Flaw (The Swivel):** Without a rigid link to the wing, the payload may just spin in circles underneath while the wing flies straight. **Structural Fragility:** Rigid arms are likely to snap upon landing impact or transfer shock that breaks the egg. **High Complexity:** Adds weight and failure points (hinges, motors, ESCs, extra batteries).

Chosen Concept	Rationale
Servo-actuated pulley mechanism	We selected Concept A primarily because it applies control forces directly to the lifting surface (the wing), ensuring a predictable aerodynamic response. Concept B was rejected due to the "pendulum effect"; since the payload is connected to the wing via flexible lines, applying torque to the payload would likely cause it to spin independently or twist the risers without effectively turning the glider.

Para-Glider Descent Speed Control Strategy Selection and Trade

Chosen Concept	Rationale
Ram Air Parachute	A ram-air parachute is a simple mechanism that allows for easily controllable descent speed, which is why it was chosen. The suspension lines (chords) act as brake lines, and when pulled simultaneously they slow or stop the forward motion of the payload. The tension in the lines controls the descent speed of the paraglider.

Descent Rate Estimates - Parachute

Assumptions:

- Drag coefficient for a hemispherical parachute = 1.5
- Average density during descent = 1.17 kg/m^3
- Target descent rate of 15 m/s (Requirement C4)

$$D = \sqrt{\frac{8\,m\,g}{\pi\,\rho\,C_d V^2}} \cong 0.246 \text{ m}$$

Descent Rate Estimates - Paraglider

Main Assumptions

- **Equilibrium Flight:** The sizing calculations assume "Steady State" equilibrium where Weight equals the Aerodynamic Resultant Force (Lift + Drag vector sum).
- **Blunt Body Payload:** The CanSat payload is modeled as a blunt cylinder (Cd = 1.2)
- **Linear Aerodynamics:** The wing's lift is calculated using a linear lift slope approximation valid for low angles of attack before stall.

$$C_L = C_{L0} + C_{L\alpha} \cdot \alpha$$

- **Inflation Dynamics:** The transition from freefall to gliding (Phase 2 opening) is modeled as a linear increase in Drag Area over 2.0 seconds.

Core Equations

- **Total Drag Coefficient:**

$$C_{D,total} = C_{D,profile} + \frac{C_L^2}{\pi \cdot e \cdot AR} + C_{D,lines} + \frac{(C_{D,sat} \cdot A_{sat})}{S_{wing}}$$

- **Glide Ratio (L/D):**

$$GR = \frac{C_L}{C_{D,total}}$$

- **Glide Angle (theta):**

$$\theta = \tan^{-1}\left(\frac{1}{GR}\right)$$

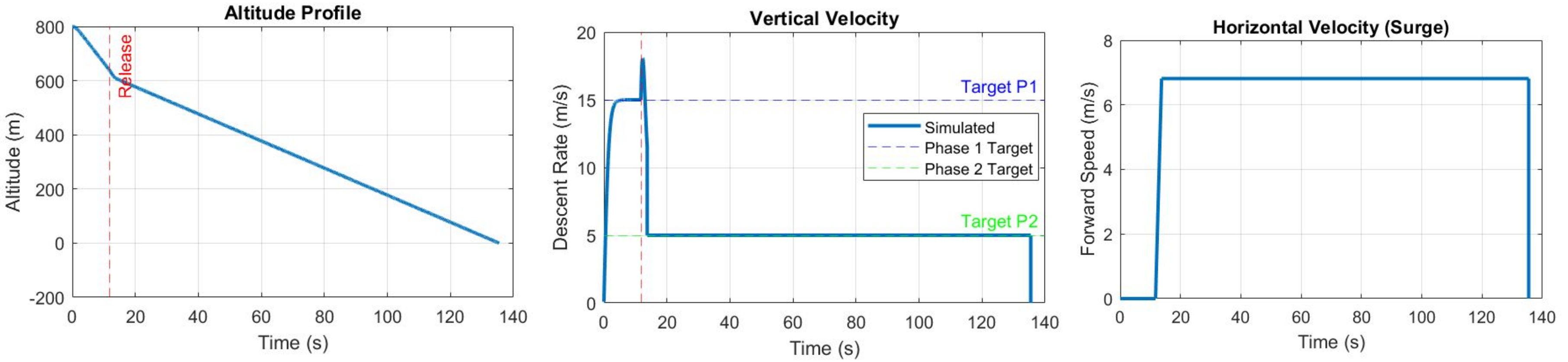
- **Equilibrium Velocity:**

$$V_{eq} = \sqrt{\frac{2 \cdot m \cdot g}{\rho \cdot S_{wing} \cdot C_R}}$$

Explanation of Calculation Method

To determine the optimal wing dimensions, we employed an iterative numerical solver in MATLAB rather than a direct algebraic solution. This approach was necessitated by the circular dependency between the wing area and the system's total drag coefficient; specifically, the payloads effective drag contribution (Cd_payload) is inversely proportional to the wing reference area (S), which is the variable being solved for. The algorithm models the complete lift and drag polar, accounting for induced drag, line drag, and the payload's blunt-body aerodynamics and initiates with an estimated wing area. By comparing the calculated equilibrium descent rate against the 5.0m/s target, the solver dynamically adjusts the wing area in a convergence loop until the flight velocity matches the requirement within a tolerance of $0.0001m/s, ensuring a precise match between the aerodynamic design and the mission requirements.

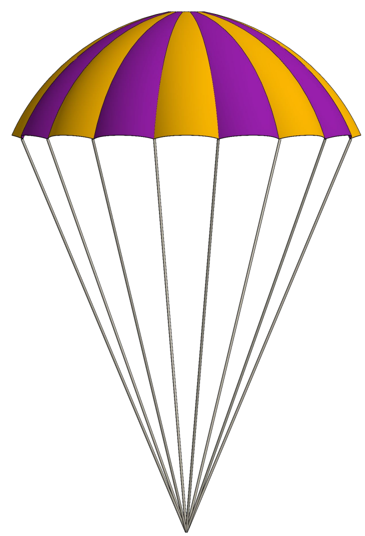
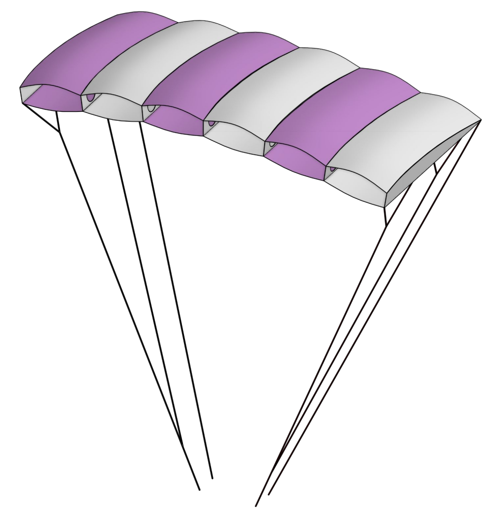
Descent Rate Estimates - Paraglider



RAM-AIR AERODYNAMIC DESIGN	
Rigging Angle	7.0 deg
Payload Drag Area	0.0529 m^2
Sat. Cd Contribution	+0.368 (Added to Wing Cd)
Total System Cd	0.785
Glide Ratio	1.36 : 1
Forward Speed	6.81 m/s

REQUIRED DIMENSIONS	
Wing Area	0.1436 m^2
Span	0.562 m
Chord	0.255 m
Circ. Para Dia	0.246 m

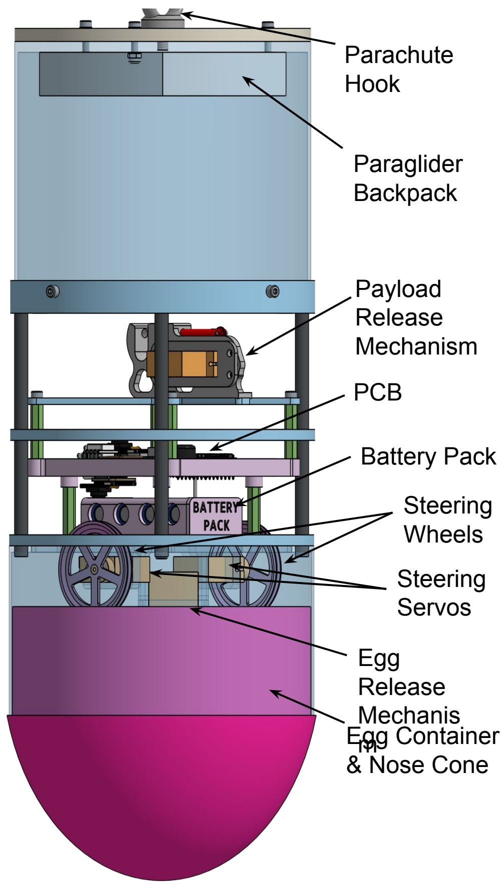
Descent Rate Estimates - Summary

	Container Parachute	Payload Paraglider
Size	0.25 m diameter	6 cells with a total chord length of 25.5cm
Descent Rate	15 m/s	5 m/s
Image		

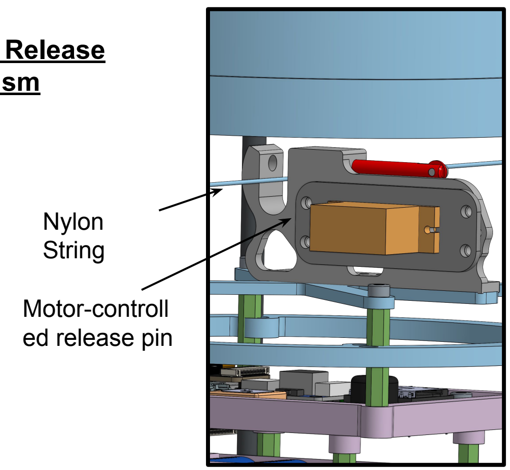
Mechanical Subsystem Design

Jared Orrick & Luna Fernandez

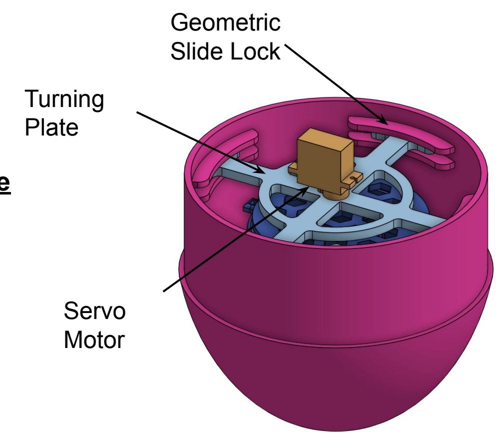
Mechanical Subsystem Overview



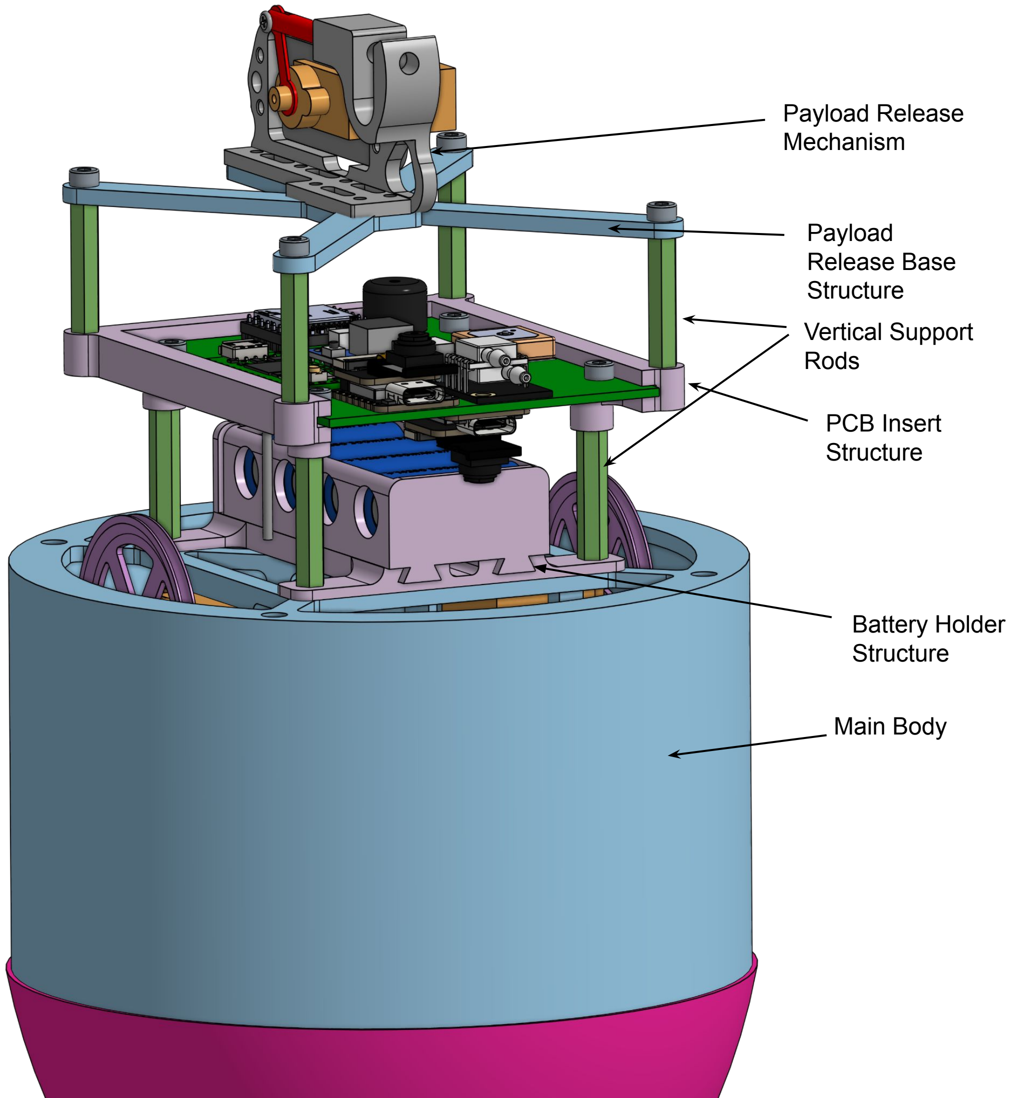
Payload Release Mechanism



Egg Release Mechanism



Payload Structural Layout of Components Trade & Selection



Structural Description:

The structure of the payload of the chosen design consists of 3 superficial platforms & a main body. Each layer is divided by vertical supports fixed using screws on the top side and geometric locks on the bottom side. The 3 superficial platforms contains the payload release mechanism, the PCB, and the battery pack and holder respectively.

1) The top platform consists of a cross shaped base structure fixing the payload release mechanism using screws.

2) The middle platform mainly consists of the body of the PCB that is inserted into a geometric lock, providing top fixtures for vertical supports for the top platform, while the vertical supports of the bottom structure are screwed to the PCB.

3) The bottom platform is geometrically fixed to the main body of the payload.

Payload Structural Layout of Components Trade & Selection

Structure Material Trade-Off 1/3					
Section	**Material**	**Density**	**Manufacturing**	**Advantages**	**Disadvantages**
Payload Release mechanism - Structure	**Aluminum**	**2.70 g/cm^3**	**CNC Machining**	**Tough, easily machined, good heat resistance**	**Heavy**
	ABS	1 g/cm^3	3D Printing	Lightweight, tough	Difficult to print, toxic fumes
	PLA	1.25 g/cm^3	3D Printing	Easy to print, inexpensive	Not as tough, poor heat resistance
Payload Release base Structure	**PLA**	**1.25 g/cm^3**	**3D Printing**	**Easy to print, inexpensive**	**Not as tough, poor heat resistance**
	ABS Printed Structure	1 g/cm^3	3D Printing	Any kind of shape is supported	Heavy, not as tough as carbon, toxic fumes
	Foam cored Carbon Fibre Plate	0.27 g/cm^3	CNC Router	Very light, strong	Expensive, reliant on external manufacturers

Payload Structural Layout of Components Trade & Selection

Structure Material Trade-Off 2/3					
Section	**Material**	**Density**	**Manufacturing**	**Advantages**	**Disadvantages**
Vertical Support Rods	**PLA**	**1.25 g/cm^3**	**3D Printing**	**Easy to print, inexpensive**	**Not as tough, poor heat resistance**
	ABS Printed Structure	1 g/cm^3	3D Printing	Any kind of shape is supported	Heavy, not as tough as carbon, toxic fumes
	Carbon Fibre Tubes	0.025 g/cm^3	Dremel, filling	Very strong, lightweight	Difficult to manufacture
PCB Insert Structure	**PLA**	**1.25 g/cm^3**	**3D Printing**	**Easy to print, inexpensive**	**Not as tough, poor heat resistance**
	ABS	1 g/cm^3	3D Printing	Lightweight, tough	Difficult to print, toxic fumes
	PETG	1.27 g/cm^3	3D Printing	Tough, easy to print, good heat resistance	Heavy

Payload Structural Layout of Components Trade & Selection

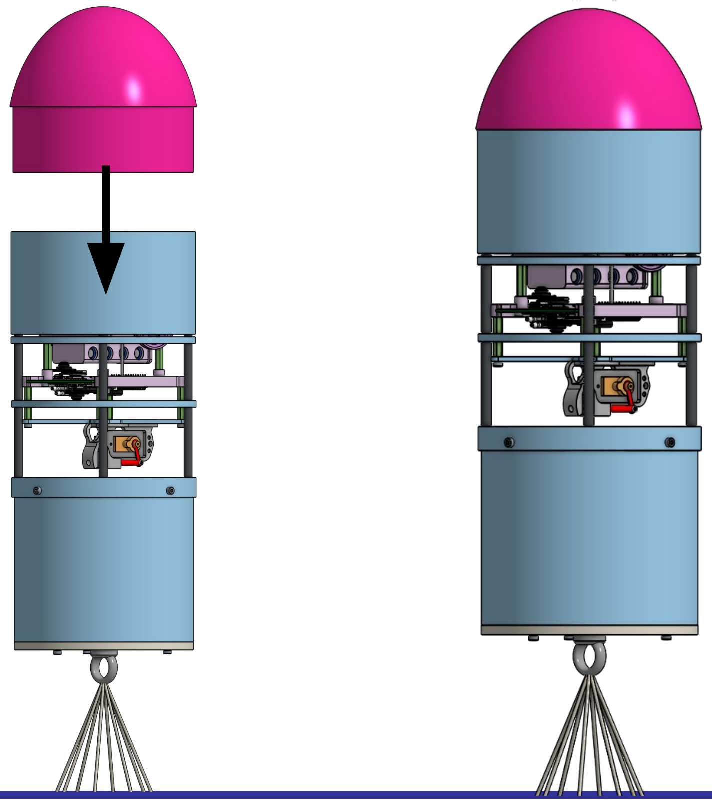
Structure Material Trade-Off 3/3					
Section	**Material**	**Density**	**Manufacturing**	**Advantages**	**Disadvantages**
Battery Holder Structure	**PLA**	**1.25 g/cm^3**	**3D Printing**	**Easy to print, inexpensive**	**Not as tough, poor heat resistance**
	ABS	1 g/cm^3	3D Printing	Lightweight, tough	Difficult to print, toxic fumes
	PETG	1.27 g/cm^3	3D Printing	Tough, easy to print, good heat resistance	Heavy
Main Body	**PLA**	**1.25 g/cm^3**	**3D Printing**	**Easy to print, inexpensive**	**Not as tough, poor heat resistance**
	ABS	1 g/cm^3	3D Printing	Lightweight, tough	Difficult to print, toxic fumes
	PETG	1.27 g/cm^3	3D Printing	Tough, easy to print, good heat resistance	Heavy

Nose Cone Design Trade & Selection

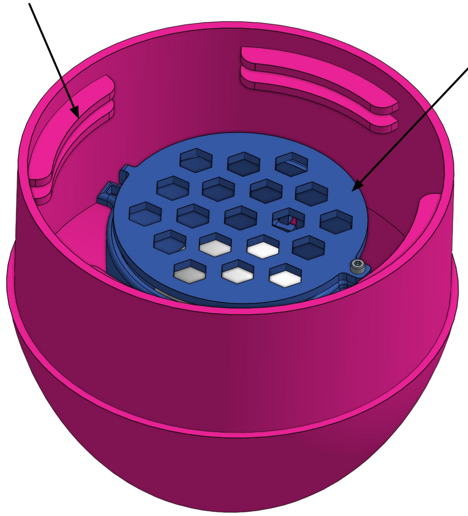
Concept 1: Elliptical Nose Cone

The nose cone uses a single piece elliptical cross section. It is geometrically locked to the egg release mechanism. The nose cone acts as the main egg container, and it is released with the egg. This is succeeded through a geometrical lock mechanism. The nose cone fits into the container as its dimensions are defined such that the shoulder fits seamlessly into the container, as the diameter of the nose cone above the shoulder is equal to the diameter of the container.

Detached **Attached**



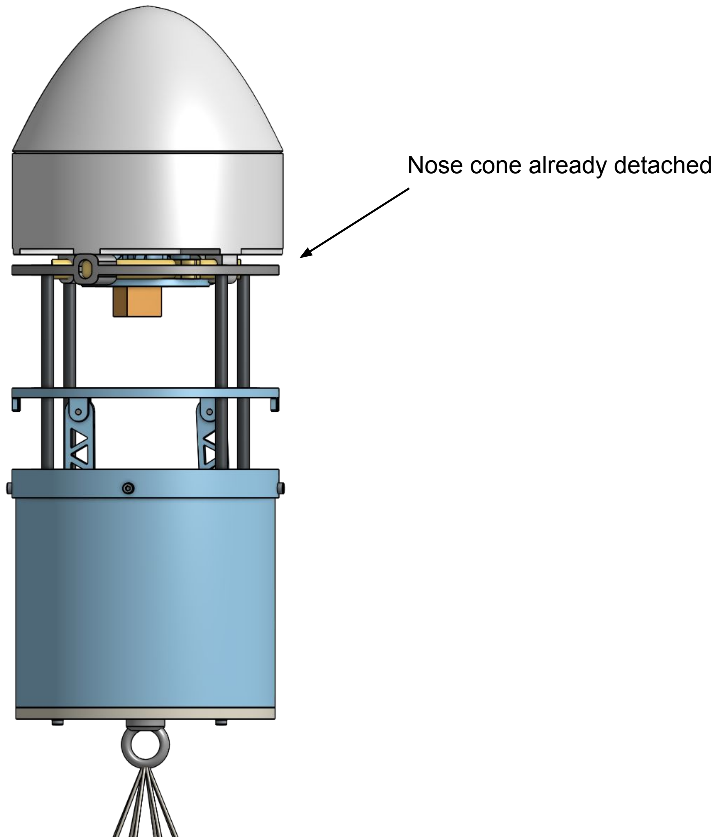
Nose cone dimensions:
Radius: 71 mm
Nose cone height: 76mm

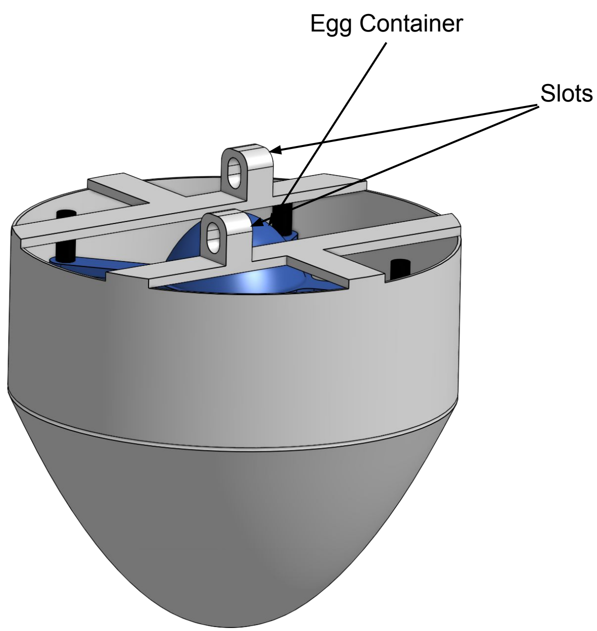


Nose Cone Design Trade & Selection

Concept 2: Conical Nose Cone

The nose cone uses a single piece conical cross section. It is locked onto the egg release mechanism using geometric slots. Similarly, it acts as the egg container, so it is released with the egg during the egg release phase. There are no slotting as it would get in between the slots, which causes risks for it getting stuck during the egg release phase.





Nose Cone Design Trade & Selection

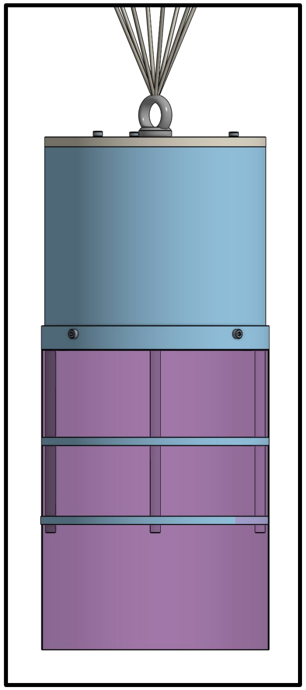
Design	Advantages	Disadvantages	Drag Coefficient
Concept 1: elliptical nose cone	**Minimises drag at subsonic speeds** **Air flows smoothly around nose cone without creating turbulence or separation**	**Larger surface area that can experience drag** **More mass intensive**	**≈ 0.05 to 0.2**
Concept 2: conical nose cone	Less mass intensive	Geometrically pointier, being less impact resistance Can't stand vertically on the ground	≈ 0.5 to 0.8

Chosen Concept	Rationale
Concept 1	**Concept 1 is more suited to the task for its aerodynamic shape, which generates more predictable motion and less drag force. It also has the advantage of standing on itself when the nose cone and egg falls together on the ground.**

Container Design and Configuration Trade & Selection

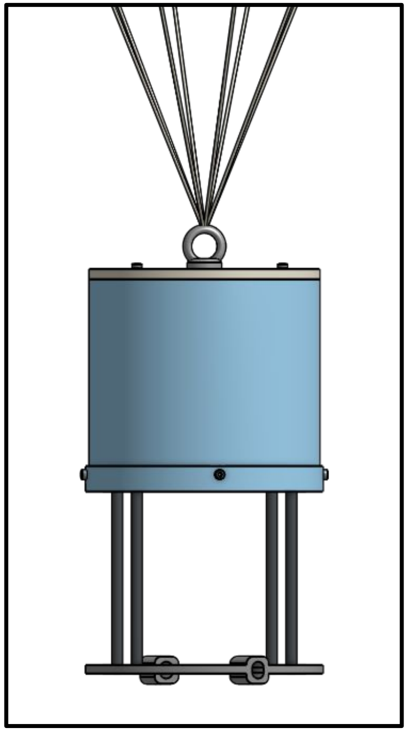
Concept 1: Rods and Rings

The container has 4 vertical supporting rods that minimises weight, while using 2 circular rings to keep them in place, allowing better structural integrity. The container is them wrapped in film to cover the components located inside.



Concept 2: Rods

The container is made out of 4 vertical supporting rods that extend all the way to the end of the payload, achieving least amount of material usage.

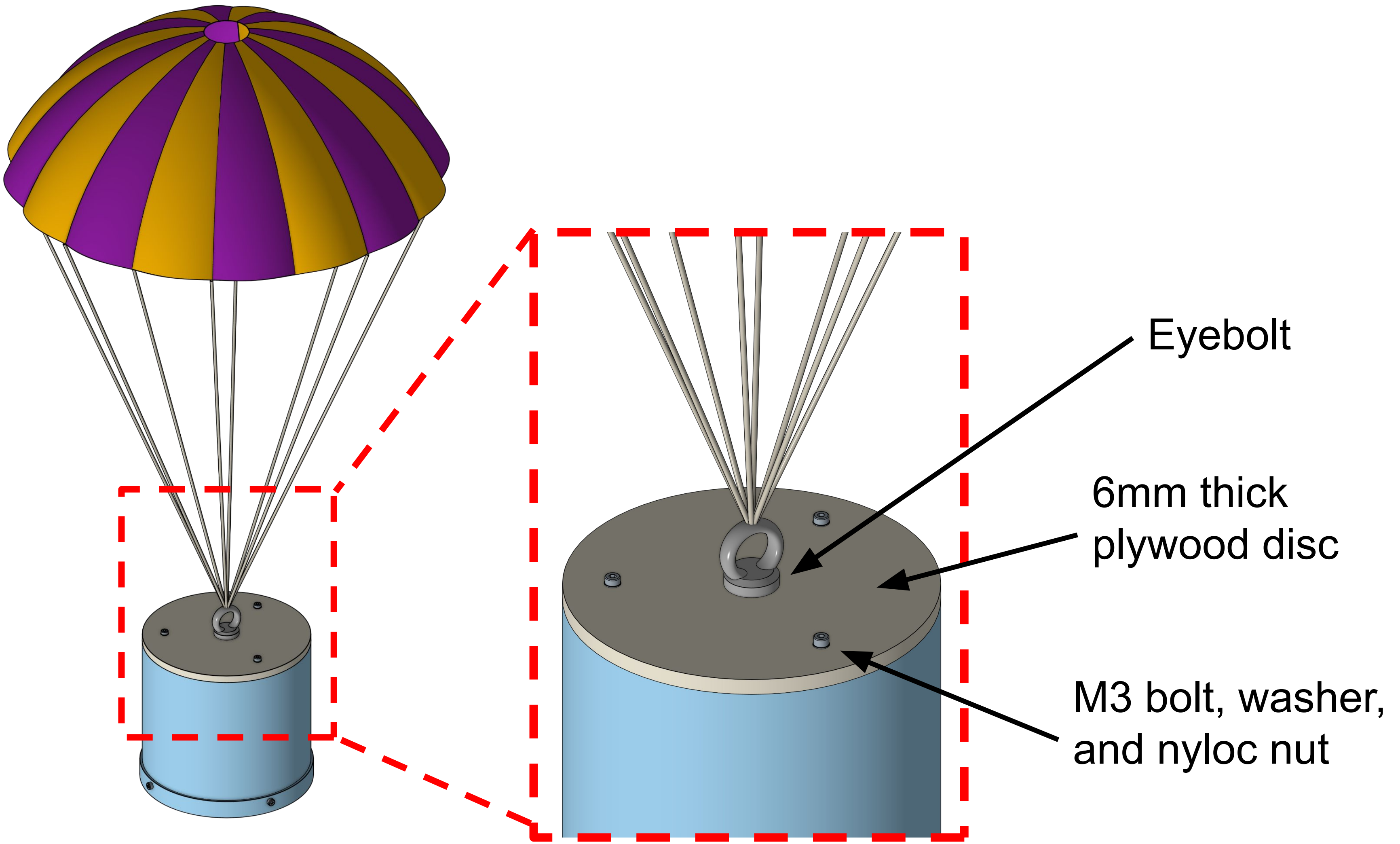


Container Design and Configuration Trade & Selection

Design	Advantages	Disadvantages
Concept 1: Rods and Rings	Structural stable if rod material chosen correctly Very light compared to solid bodies	Less aerodynamic, may cause turbulence
Concept 2: Rods	Very light	high requirements for rod material empty, allowing flow within the system

Chosen Concept	Rationale
Concept 1: Rods and Rings	**Concept 1 ensures a structural stable container, which is only important when the whole body falls from the rocket. This design saves a lot of weight, being one of the most weight consuming parts and only critical during the very first part of the mission,**

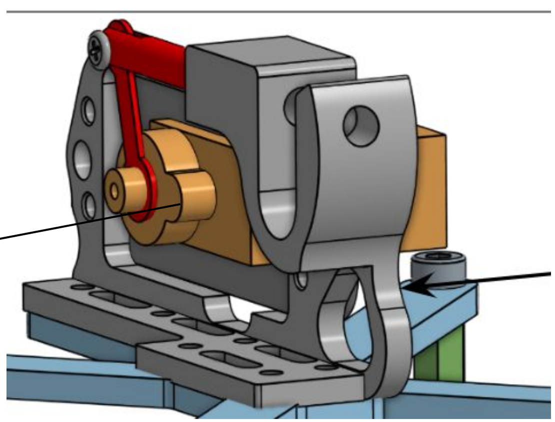
Container Parachute Attachment



Payload Release Trade & Selection

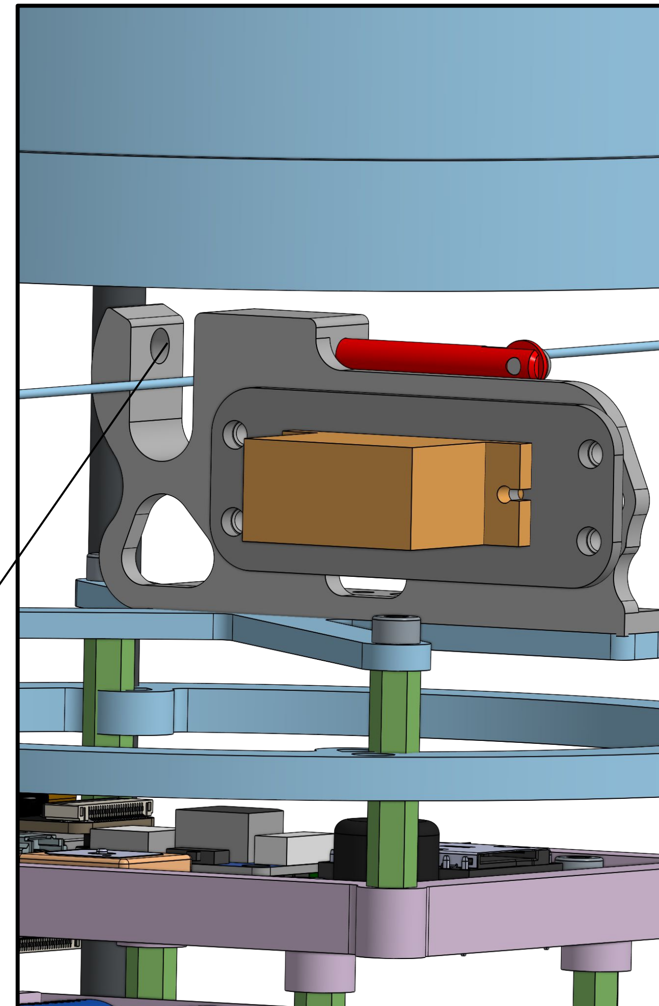
Concept 1: Nylon string release with linear actuator

This payload release mechanism uses a servo-driven sliding pin to act as a string retainer. In the locked state, the pin passes through a small channel, trapping a nylon line that holds the payload in place under tension. When release is commanded, the servo retracts the pin linearly, allowing the nylon line to slip free. Once the line is released, the restraint is removed and the payload separates from the container under gravity and airflow.



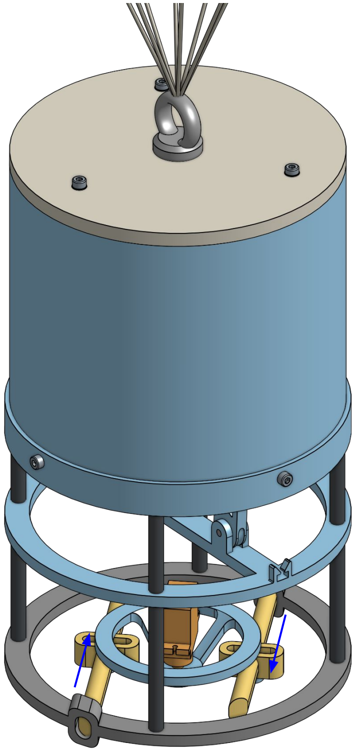
Servo

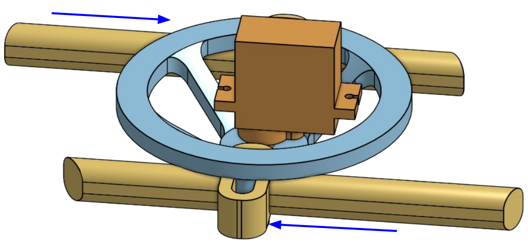
Slide pin

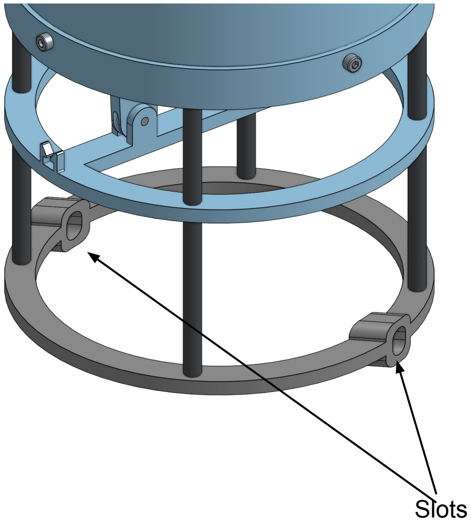


Concept 2: Double sided Scotch-Yoke locking mechanism

Similarly, this is a single-servo driven mechanism that acts like pins and slots, actuated by the rotational motion generated by the motor. The mechanism is comprised of two Scotch-Yoke mechanisms that act on both sides. Opposite slots are located for the two mechanism, so a rotational motion causes the two pins to slide to opposite direction, which retrieves on one end, achieving unlocking of one of the two locked components, which are the container and the nose cone. The opposite rotation cause the release of the other component.







Payload Release Trade & Selection

Design	Advantages	Disadvantages
Concept 1:	Very simple and lightweight mechanism Low friction release Easy to manufacture, inspect, and bench-test Release force mainly set by string tension, so servo load is predictable	Single-point failure: string can knot / fray, preventing release Depends on string routing and tension consistency Potential for premature release if line slips or stretches under vibration Requires careful choice of line material and wear points
Concept 2:	Positive mechanical locking using pins-in-slots Bidirectional operation enables two independent releases from one actuator Symmetric layout can reduce unbalanced loads and improve stability	More moving interfaces Higher actuation load due to sliding contact in yoke/slots More complex to design and manufacture; requires tight alignment of both sides If one side binds, it may prevent full motion

Chosen Concept	Rationale
Concept 1:	**Concept 1 was selected because it is a lightweight, low-complexity release mechanism with few moving parts, making it easier to manufacture, test, and validate for reliable payload separation compared to the more alignment-sensitive Scotch-Yoke design.**

Para-Glider Stow Configuration Trade & Selection

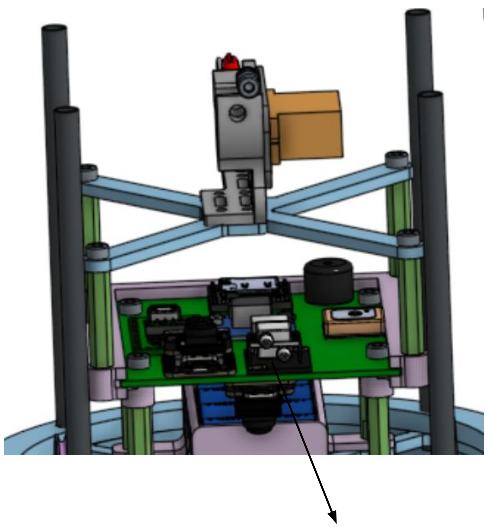
Design	Advantages	Disadvantages
"Backpack" with latch openes from the bottom	Simple Common mechanism used in skydiving Paraglider is pulled out of bag with payload	Paraglider may not stay fully stowed after vigorous vibrations
"Backpack" with latch openes from the top	lower risk of lines breaking	paraglider is left to unfurl its self

Chosen Concept	Rationale
"Backpack" with latch openes from the bottom	Concept 1 was selected because it is a reliable mechanism that has been tested before in a larger scale. It is a simple mechanism that can be easily assembled and mounted on to the container.

Descent Control Pointing Camera Mount Trade & Selection

Concept 1

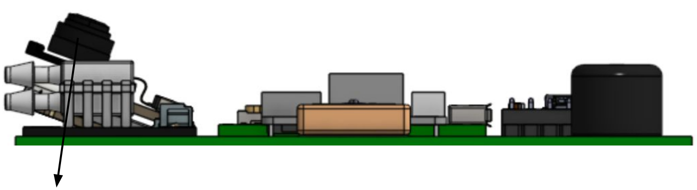
The up-facing camera is rigidly mounted on the internal electronics deck using a fixed bracket/standoff, with its lens oriented vertically toward the release mechanism so it can continuously capture the moment the retaining pin retracts and the payload separates from the container.



Up Facing Camera

Concept 2

The up-facing camera is mounted on the electronics deck using a rigid bracket and set at a 20° upward incline, positioning its field of view toward the payload release mechanism so it can capture the moment the latch disengages and the payload separates.



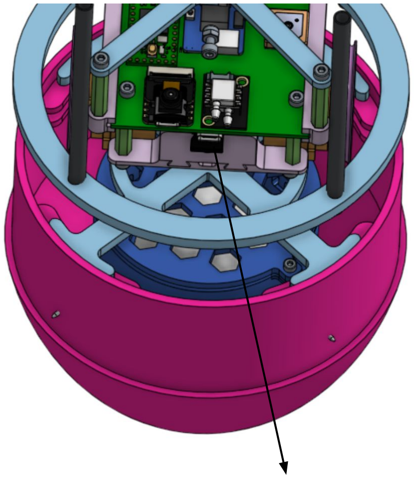
Up Facing Camera

The first mounting configuration was chosen because it provides the most direct, unobstructed view of the release area with minimal alignment sensitivity, making the footage more repeatable and reliable than the 20° inclined setup.

Ground Pointing Camera Mount Trade & Selection

Concept 1

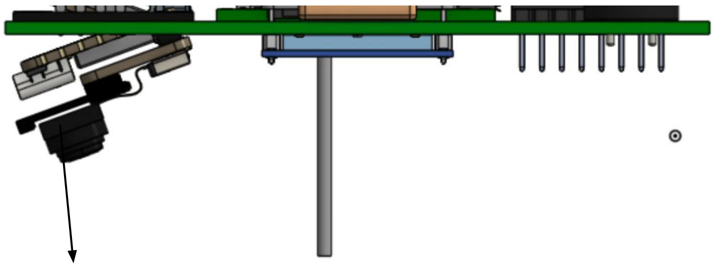
The down-facing camera is mounted to the lower internal deck on a rigid bracket/standoff and aligned vertically through the base opening, giving a clear view of the egg release area and allowing it to record the moment when the nose cone is released and the egg module is deployed



Down Facing Camera

Concept 2

The up-facing camera is mounted on the electronics deck using a rigid bracket and set at a 20° upward incline, positioning its field of view toward the payload release mechanism so it can capture the moment the latch disengages and the payload separates.



Down Facing Camera

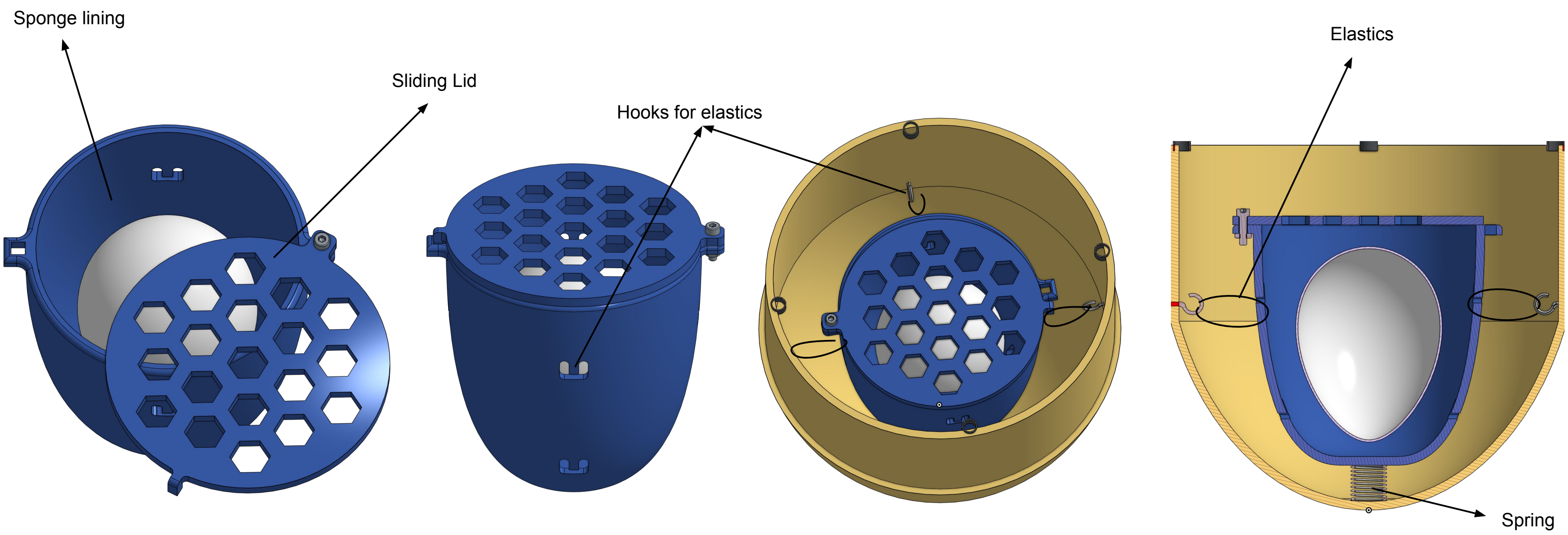
The first mounting configuration was chosen because it provides the most direct, unobstructed view of the release area with minimal alignment sensitivity, making the footage more repeatable and reliable than the 20° inclined setup.

Egg Instrument Design Trade & Selection

Concept 1: Egg Protective Basket:

The cargo (egg) will be housed in a 3D-printed container. The container features a sliding lid that allows easy insertion and removal of the egg and is secured with a screw. The interior of the basket will be lined with sponge material (not shown bellow) to provide an additional layer of soft protection.

The basket will be suspended using elastic braces attached to the nose cone, ensuring it is not in direct contact with rigid surfaces. This suspension system helps reduce the risk of impact-induced damage. Additionally, a spring will be installed at the base of the basket to act as a damper, mitigating vibrations during descent and absorbing impact forces upon landing.

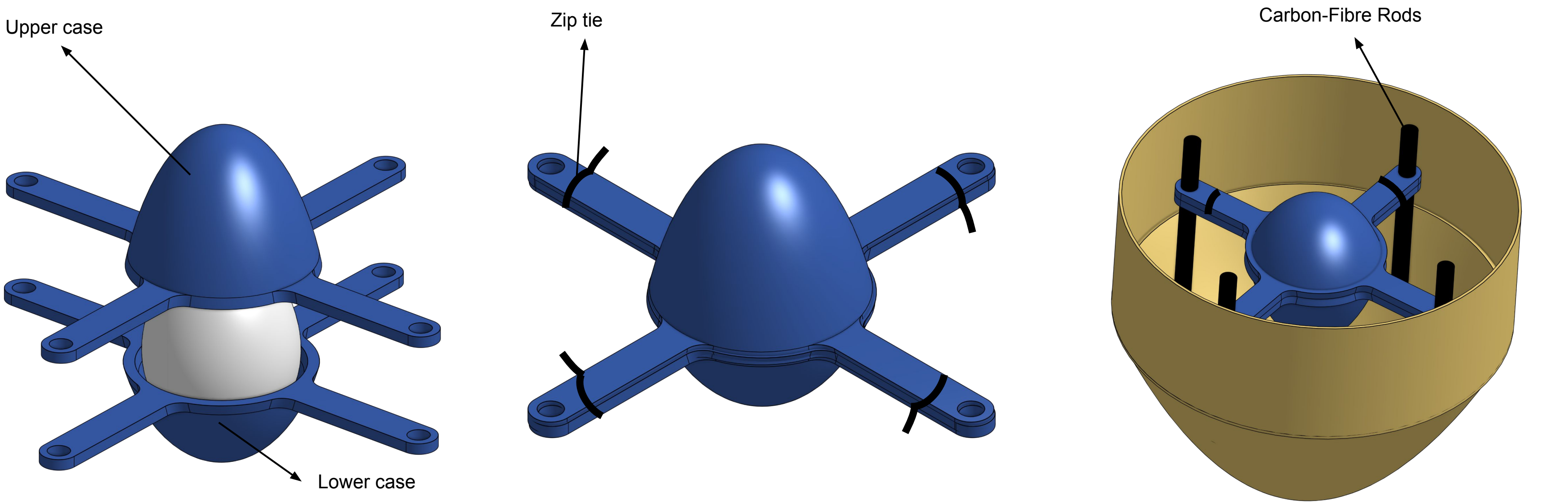


Egg Instrument Design Trade & Selection

Concept 2: Egg-shaped Protective Case:

The cargo (egg) will be housed in a 3D-printed, egg-shaped container. The container will be lined with bubble wrap to provide an additional layer of protection. It is composed of two detachable parts to allow easy insertion of the egg.

The container is supported by four carbon-fibre rods attached to the nose cone, which also help reduce vibrations transmitted to the egg. The rods are press-fitted into the container, as the tolerance between the rod diameter and the container holes is small. This allows the container halves to be separated with applied force during assembly. Once the egg is inserted, zip ties are used on each arm to secure the upper and lower sections of the case together.



Egg Instrument Design Trade & Selection

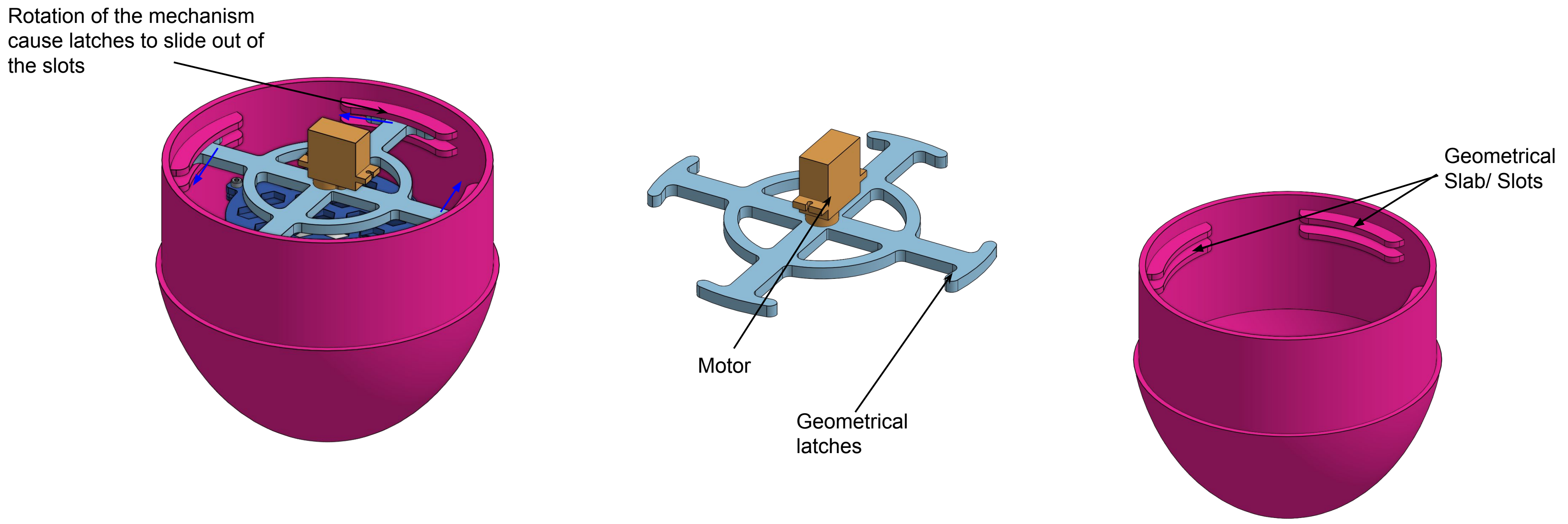
Design	Advantages	Disadvantages
Concept 1: Egg Protective Basket	**Easier access to egg** **More stable damping** **More secured to nosecone** **Easily manufactured**	**Need access to screwdriver to access egg** **Risks of elastics breaking**
Concept 2: Egg-shaped Protective Case	Less parts to manufacture Easy to assemble	Requires specific tolerance otherwise case will slide More complex manufacturing

Chosen Concept	Rationale
Concept 1: Egg Protective Basket	**Concept 1 features a more reliable damping mechanism, ensuring the safety of the egg throughout the flight. It is securely attached to the nose cone using elastic supports and a spring, while remaining easy to manufacture. The design also allows flexibility for modifications if changes are required. The egg can be accessed easily by unscrewing the lid.**

Egg Instrument Release Trade & Selection

Concept 1: Rotational geometrical lock and release mechanism

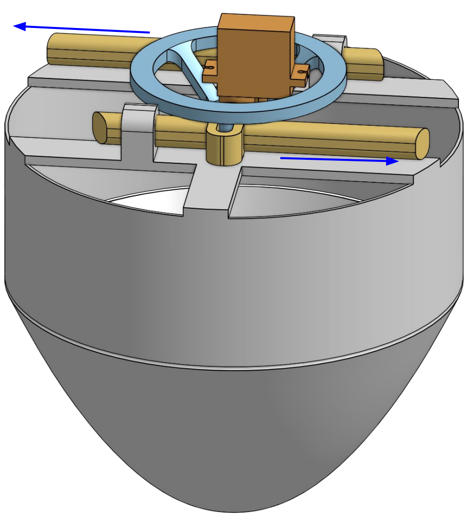
This is a single-servo driven mechanism that acts like latches and slots, actuated by the rotational motion generated by the motor. The mechanism is comprised of a crossed plate with 4 latches at its tips which slide rotationally into 4 slots at the sides of the nose cone, and rotational motion causes the latches to slide out of the slots, disengaging the geometrical lock, separating the nose cone and the payload.



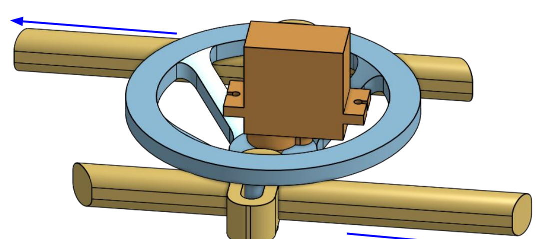
Egg Instrument Release Trade & Selection

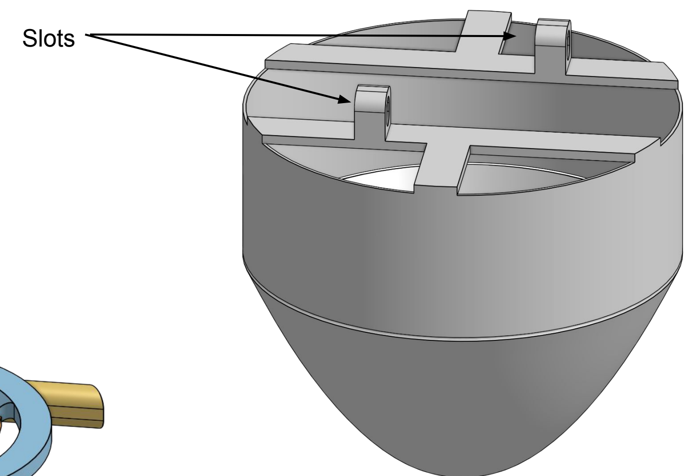
Concept 2: Double sided Scotch-Yoke locking mechanism

Similarly, this is a single-servo driven mechanism that acts like pins and slots, actuated by the rotational motion generated by the motor. The mechanism is comprised of two Scotch-Yoke mechanisms that act on both sides. Opposite slots are located for the two mechanism, so a rotational motion causes the two pins to slide to opposite direction, which retrieves on one end, achieving unlocking of one of the two locked components, which are the container and the nose cone. The opposite rotation cause the release of the other component.



Acting in one direction for the release of the nose cone





Egg Instrument Release Trade & Selection

Design	Advantages	Disadvantages
Concept 1: Rotational geometrical lock and release mechanism	Only 1 moving component, minimizing risks to get stuck Easy to manufacture	Only use for 1 mechanism
Concept 2: Double sided Scotch-Yoke locking mechanism	Can be used for both release mechanisms	High mechanical requirements for pins and slots Multiple moving components

Chosen Concept	Rationale
Concept 1: Rack & Pinion	**Concept 1 is much simpler and is more convincing using only 1 moving component. Having 4 latches, it allows more even stress distribution, more options for material choices, which allows easier manufacturing.**

Electronics Structural Integrity

Container Electronics Mounting Methods		
Method	**Advantages**	**Disadvantages**
Metal Standoffs	Very strong, Off-the-shelf	Large mass
Nylon Standoffs	Off-the-shelf options, strong enough	Hygroscopic - shouldn't be exposed to elements
3D Printed Mounts	**Cheap, lightweight**	**Not strong, difficult to include screw thread**
PCB	**All in one, simple integration into the container and payload, small probability of short-circuiting.**	**Manufacturing required**
Screws	**Very secure and strong, many sizes, non-permanent**	**Can be heavy**
Bolts & Nuts	Numerous sizes, can be unscrewed	Heavy

Electronics Structural Integrity

Securing Electrical Connections		
Method	**Advantages**	**Disadvantages**
Tape	Lighter, easy application	Less reliable adhesion
Hot Glue	Strong, rigid and permanent	Increased mass (very minimal) Susceptible to melting
Epoxy	**Very strong and light**	**Permanent**

Electrical Equipment Enclosure Methods		
Method	**Advantages**	**Disadvantages**
Fiberglass	Very strong	Heavy, difficult to manufacture
Plastic cover	Very light	Relatively difficult to manufacture
PE container cover	**Very light, can be formed easily**	**Relatively weak**
3D printed plastic	**Easy to manufacture, strong**	**Can be heavy depending on slicing**

Electronics Structural Integrity

Descent Control Attachments		
Method	**Advantages**	**Disadvantages**
Nylon cord	Strong tensile strength	Poor UV resistance, knotting
Epoxy	Strong	Relatively heavy

Mass Budget

	Item	Individual mass* (g)	Uncertainty	Quantity	Total (g)
Main PCB	PCB 1 weight	25	0.01	1	25.01
	Camera (ESP32S3)	10	0.01	1	10.01
	Turnig TR-1160A Mini Servo	16	0.1	2	32.2
	Radio(XBEE)	3.27	0.01	1	3.28
	PA1616D (GNSS)	5.66	0.01	1	5.67
	Teensy 4.1	15	0.01	1	15.01
	Power switch (screw switch)	2.785	0.005	1	2.79
	Temperature sensor (LM335AZ)	0.71525	0.001	1	0.71625
	Flight controller (Matek F405 minite)	5	0.01	1	5.01
	Airspeed sensor (MS4525DO)	4	0.01	1	4.01
	Board-to-board connectors	1	0.01	1	1.01
	Solder paste	1	0.1	1	1.1
	SMD Components	1	0.1	1	1.1
	Battery (Li-Ion 3.7V 14280)	12	0.1	4	48.4
	Camera(ESP32S3)	10	0.01	1	10.01
	Battery connector	1.807.1	0.01	1	1.107
	Solder paste	1	0.1	1	1.1
	Buzzer (KXG1203c)	1.37	0.01	1	1.38
	Buzzer Battery (CR2032)	3	0.1	1	3.1
	Micro Servo	9	0.1	1	9.1
	5V Voltage Regulator (L7805CV)	1.6	0.01	1	1.61
Payload release	Micro Servo	9	0.1	1	9.1
*All masses are sourced from their respective datasheets				**Electrical Total:**	**191.8**

Mass Budget

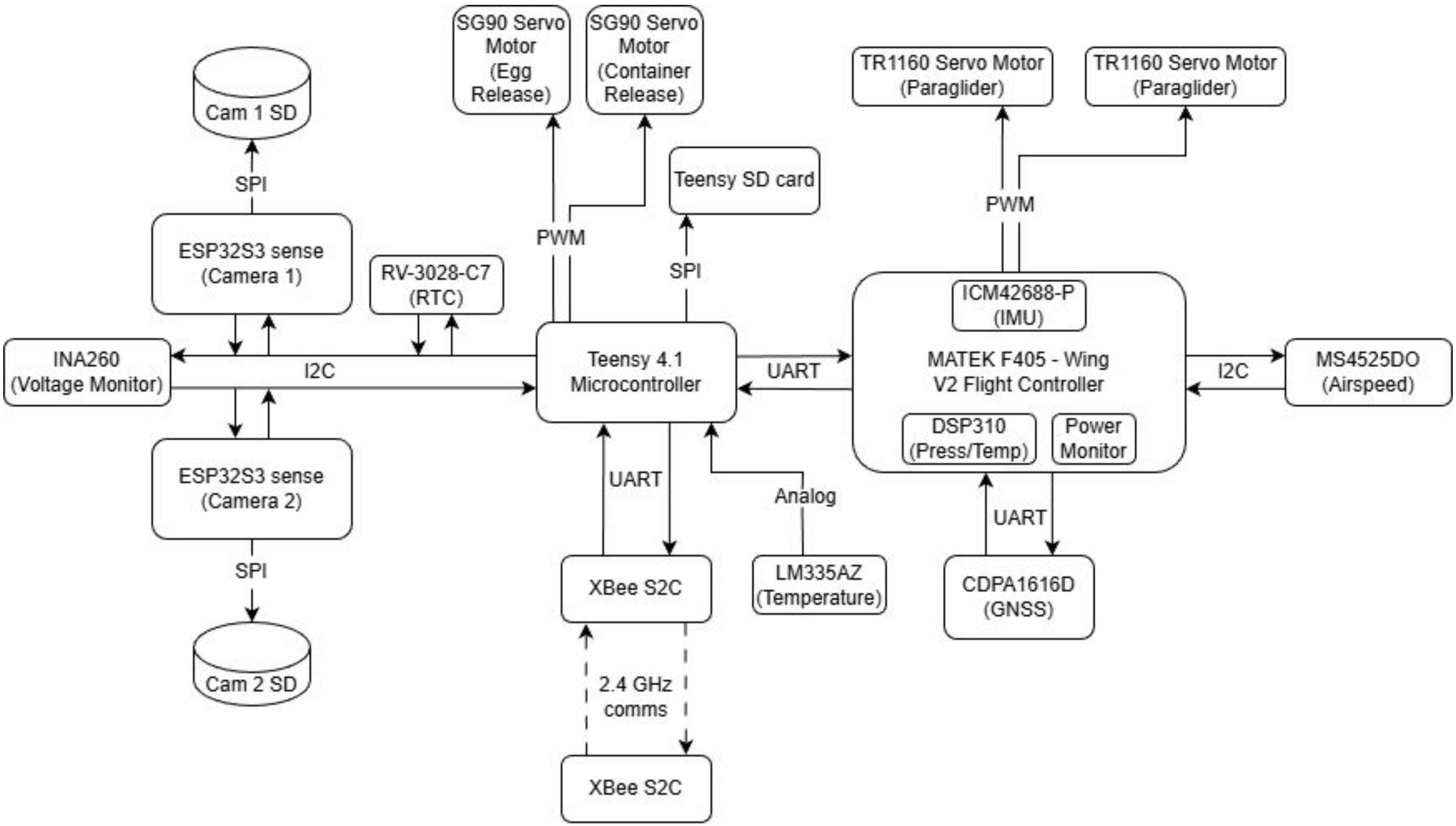
Component	Quantity	Mass (g)	Total (g)
Nose cone	1	135	135
Nose cone release servo plate	1	15	15
Egg container	1	30	30
Egg	1	68	68
Carbon fibre rods	4	12	48
Paraglider steering mechanism wheels	2	4	8
Paraglider steering mechanism plate	1	42	42
Middle container support ring	1	15	15
Battery pack tray	1	42	42
PCB shelf	1	25	25
Payload deployment servo mount plate	1	3	3
Payload release mechanism	1	80	80
Paraglider	1	10	10
Nylon cord	4	4	16
Paraglider backpack	1	15	15
Lower container	1	86	98
Parachute	1	30	30
Plywood plate	1	53	53
Eyebolt	1	17	17
M3 bolt	20	1	20
M3 washer	6	0.12	0.72
M3 nyloc nut	20	0.46	9.2
M3 standoff	8	3	24
Elastic (rubber) bands	4	0.5	2
Screw hook	4	1	4
		Overall total	**809.92**

Mass of 3D printed components estimated from PLA density and area given from CAD and assumed 10% infill. Mass of other components acquired from specifications.

Communication and Data Handling (CDH) Subsystem Design

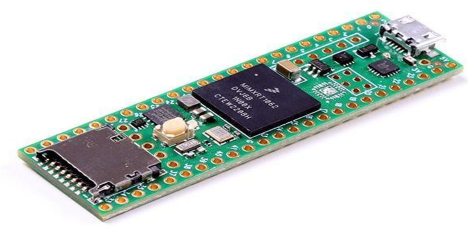
Katerina Demetriou

Payload Command Data Handler (CDH) Overview



Payload Processor & Memory Trade & Selection

Micro controller	Processor Speed (MHz)	Storage		Memory (KiB)	Current (mA @ 5V)	Dimensions (mm)	Mass (g)	Cost (GBP)	Data Interfaces			Boot Time (s)	micro SD Slot
		Flash (KiB)	EEPROM (Kbit)						UART	I2C	SPI		
Teensy 4.0	600	1984	8*	1024	100	36x18	4.8	23.28	7	3	3	1	0
Teensy 4.1	**600**	**7936**	**32***	**1024**	**100**	**61x18**	**10**	**33.9**	**8**	**3**	**3**	**1**	**1**
ESP8266 DevKitC	160	2048	0*	50	128	39x25	11	9.60	3	1	1	1	0
Arduino Nano	16	32	8	2	19	43x19	7	10.68	1	1	1	1.46	0



The Teensy 4.0 and the Teensy 4.1 are both very viable options, boasting the highest processor speeds, largest memories, and highest number of interfaces, and a low boot time. However between the two, the Teensy 4.1 was chosen due to having more flash memory and the inclusion of an SD card slot built in.

Chosen MCU: **Teensy 4.1**

*These microcontrollers have no EEPROM storage, but provide means of emulation using the flash storage.

Payload Real-Time Clock

Option	Component	Interface	Power Usage	Expected Runtime	Weight (g)
1	RS PRO CR2032 Button Batteries, 3V (Internal RTC)	VBAT	675 mWh	7.2 h	3.1
2	150 uF Capacitor Circuit (Internal RTC)	VBAT	675 mWh	24 s (check)	0.05
3	**RV-3028-C7 with 3V with 300uF Capacitor (External RTC)**	**I2C**	**3.92 mWh**	**4.2 h**	**1**

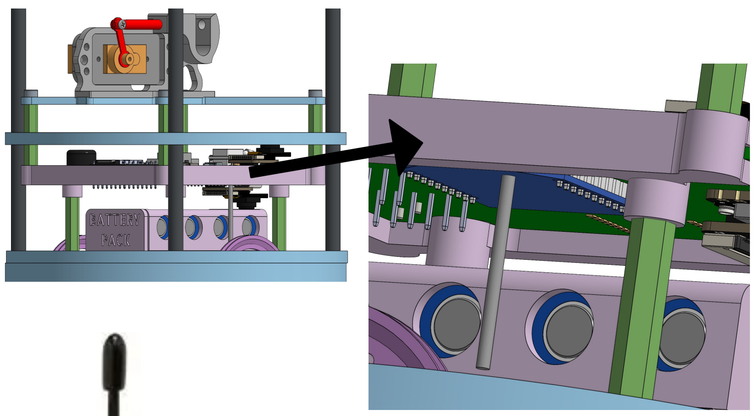
Option 3 is the superior choice because it offers the highest energy efficiency and vastly longer runtime. Option 3 utilizes a capacitor to store sufficient energy for maintaining RTC activity during power transients, offering a lighter and more compact alternative to a dedicated coin cell.

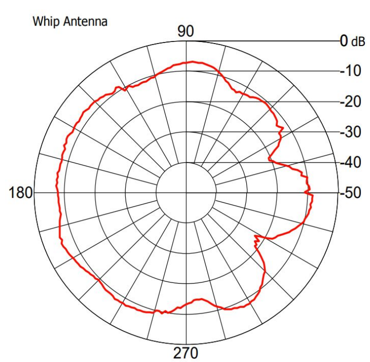
This capacitor charges through a Schottky diode, which isolates the backup energy from the main 3.3V bus to prevent discharging while leveraging its inherent 0.2V forward voltage drop to limit the capacitor to ~3.1V, effectively simulating the voltage levels of a standard coin cell.

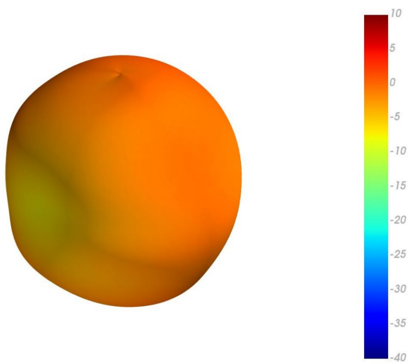
Payload Antenna Trade & Selection

Option	Component	Connection	Gain (dBi)	Type	Distance	Mass (g)	Size
1	Xbee S2C Pro PCB Antenna	-	-	PCB	1268 m	-	-
2	Molex 212860-0001 Whip	SMA	5.3	Monopole	-	0	108.4 mm
3	**Xbee S2C Pro Whip Antenna**	**Soldered**	**1.5**	**Monopole**	**3200 m**	**9.25**	**26.3 mm**

Whip antenna provides higher gain than PCB antenna. Although other whip antennas provide higher gain, Soldered quarter wave antenna was selected as it’s lightweight and compact. The antenna is positioned right before the nose cone to prevent EMI from other circuits.







Xbee Pro S2C Antenna Location

Payload Radio Configuration

Option	Component	TX Power (mW)	TX Current (mA)	RX Current (mA)	Freq (Hz)	Max LOS Range (km)	Weight	Size
1	Xbee S2C	6.3 mW (+8dBm)	45	31	2.4GHz	1.2	5g	27.61 x 24.38 x 6.85 mm
2	**Xbee S2C Pro**	**63 mW (+18dBm)**	**120**	**31**	**2.4GHz**	**3.2**	**5g**	**32.94 x 24.38 x 6.85 mm**
3	XBee-PRO ® SX 900	1000 mW (+30 dBm)	900	40	900Mhz	105	3g	33.8 x 22.1 x 12.9 mm

Reasoning:

- Higher TX power = Higher probability of a reliable connection to the ground station
- Lower frequency = Greater radio wave propagation therefore higher probability of a reliable connection to ground station

Payload Radio Configuration

Best option for reliable long range transmission would have been **XBee-PRO® SX 900 -** since 900MHz is not an ISM band in the UK, prior testing would not be possible.

Xbee S2C Pro selected instead:
NETID: 1079

- At 1Hz with small packet size average power is low, even at maximum TX power
- Remains in receive mode 99.9% of the time after launch.
- Set to sleep mode outside active states

Payload Telemetry Format

Field	Description	Resolution	Example
TEAM_ID	Assigned four digit team identification number	-	1059
MISSION_TIME	UTC time in format hh:mm:ss, where hh is hours, mm is minutes, and ss is seconds.	-	13:14:02
PACKET_COUNT	Total count of transmitted telemetry packets since turn on.	-	1025
MODE	'F' for flight mode, 'S' for simulation mode	-	F
STATE	Operating state used in flight software state machine, as human-readable ASCII text	-	ASCENT

Payload Telemetry Format

Field	Description	Resolution	Example
ALTITUDE	Altitude in meters, relative to ground level	0.1 m	427.3
TEMPERATURE	Temperature in degrees Celsius	0.1 C	21.3
PRESSURE	Air pressure in kPa	0.1 kPa	101.3
VOLTAGE	Voltage of the CanSat power bus in volts	0.1 V	3.7
CURRENT	Current from the battery	0.01 A	1.31

Payload Telemetry Format

Field	Description	Resolution	Example
GYRO_R, GYRO_P, GYRO_Y	Gyroscope reading for roll, pitch and yaw	1 $°s^{-1}$	186
ACCEL_R, ACCEL_P, ACCEL_Y	Accelerometer reading for roll, pitch and yaw	0.1 $°s^{-2}$	2.0
GPS_TIME	Time from the GPS receiver in UTC	1 s	21:49:53
GPS_ALTITUDE	Altitude from the GPS receiver in meters above mean sea level	0.1 m	558.0
GPS_LATITUDE	Latitude from the GPS receiver in decimal degrees North	0.0001°	63.4451
GPS_LONGITUDE	Longitude from the GPS receiver in decimal degrees West	0.0001°	10.9050
GPS_SATS	Number of GPS satellites being tracked by the GPS receiver	-	8
CMD_ECHO	Text of the last command received and processed	-	CXON

Payload Telemetry Format

Optional Fields	Description	Resolution	Example
SUBSTATE	Operating substate of FSW, as human-readable ASCII text	-	ARMED
MAIN_SOC	Main Battery state of charge as a percentage	1 %	45
BUS_POWER	Power draw on the main bus in Watts	0.001 W	0.377
AIR_SPEED	Pressure from wind speed measured in Pa	10 Pa	65310
ACTIVE_MECHS	Indicates which servo mechanisms are active	-	1234
ACTIVE_CAMERA	Indicates which camera is active	-	1
MATEK	Indicates the state of the MATEK ardupilot controller	-	GLIDER

Full data packet

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, SUBSTATE, MAIN_SOC, BUS_POWER, ACTIVE_MECHS, ACTIVE_CAMERA, MATEK

Example data packet

1059, 13:14:02, 1025, F, ASCENT, 427.3, 21.3, 101.3, 3.7, 1.31, 186, 2.0, 21:49:53, 558.0, 63.4451, 10.9050, 8, CXON, ARMED, 45, 0.377, 1234, 1, GLIDER

Payload Command Formats

CX - Payload Telemetry On/Off Command

Command string	**CMD,<TEAM_ID>,CX,<ON_OFF>**	
Meaning	Activate or deactivate telemetry transmission.	
Example	CMD,1059,CX,ON	
Arguments	**<ON_OFF>**	
	ON	Activate payload telemetry transmission
	OFF	Deactivate payload telemetry transmission

ST - Set Time

Command string	**CMD, <TEAM_ID>,ST,<UTC_TIME>|GPS**	
Meaning	Sets the mission time	
Example	CMD,1000,ST,13:35:59	
Arguments	**<UTC_TIME>|GPS**	
	<UTC_TIME>	UTC time in the format hh:mm:ss
	GPS	Current time read from the GPS module.

Payload Command Formats

SIM - Simulation Mode Control Command

Command string	**CMD,<TEAM_ID>, SIM, <MODE>**	
Meaning	Enable or disable simulation mode.	
Example	CMD,1000,SIM,ENABLE	
Arguments	**<MODE>**	
	ENABLE	Enable simulation mode
	ACTIVE	Activate simulation mode
	DISABLE	Enable simulation mode

SIMP - Simulated Pressure Data

Command string	**CMD,<TEAM_ID>,SIMP,<PRESSURE>**	
Meaning	Sends simulated pressure data	
Example	CMD,1000,SIMP,101325	
Arguments	**<PRESSURE>**	UTC time in the format hh:mm:ss

CAL - Calibrate Altitude to Zero

Command string	**CMD,<TEAM_ID>,CAL**
Meaning	Calibrate Altitude to zero
Example	CMD,1000,CAL

Payload Command Formats

MEC - Mechanism actuation command

Command string	**CMD, <TEAM ID> ,MEC, <DEVICE>,<ON_OFF>**	
Meaning	The MEC command is to be sent to activate a specific mechanism.	
Example	**CMD,<TEAM_ID>,MEC,<0004>,<ON>**	
Arguments	**<DEVICE>**	
	1000	Servo 1 - Payload release servo
	0200	Servo 2 - Port steering servo
	0030	Servo 3 - Starboard steering servo
	0004	Servo 4 - Egg release servo
	<ON_OFF>	
	ON	Activate the selected mechanism
	OFF	Deactivate the selected mechanism

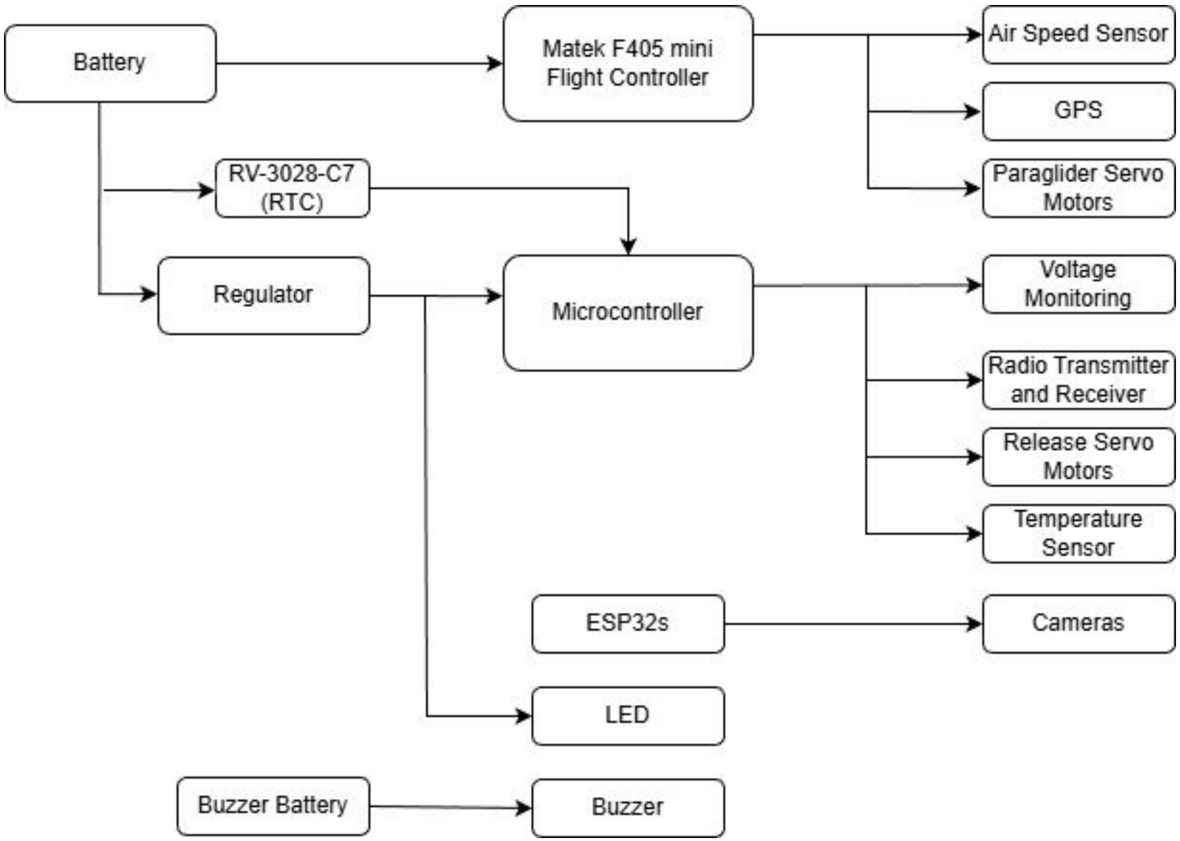
ARM - Activates the CANSAT's ARM state prior to launch (optional)

Command string	**CMD,<TEAM_ID>,ARM,<ON_OFF>**	
Meaning	Arm or disarm the CanSat	
Example	CMD,1000,ARM,ON	
Arguments	**<ON_OFF>**	
	ON	Arm the CanSat
	OFF	Disarm the CanSat

Electrical Power Subsystem (EPS) Design

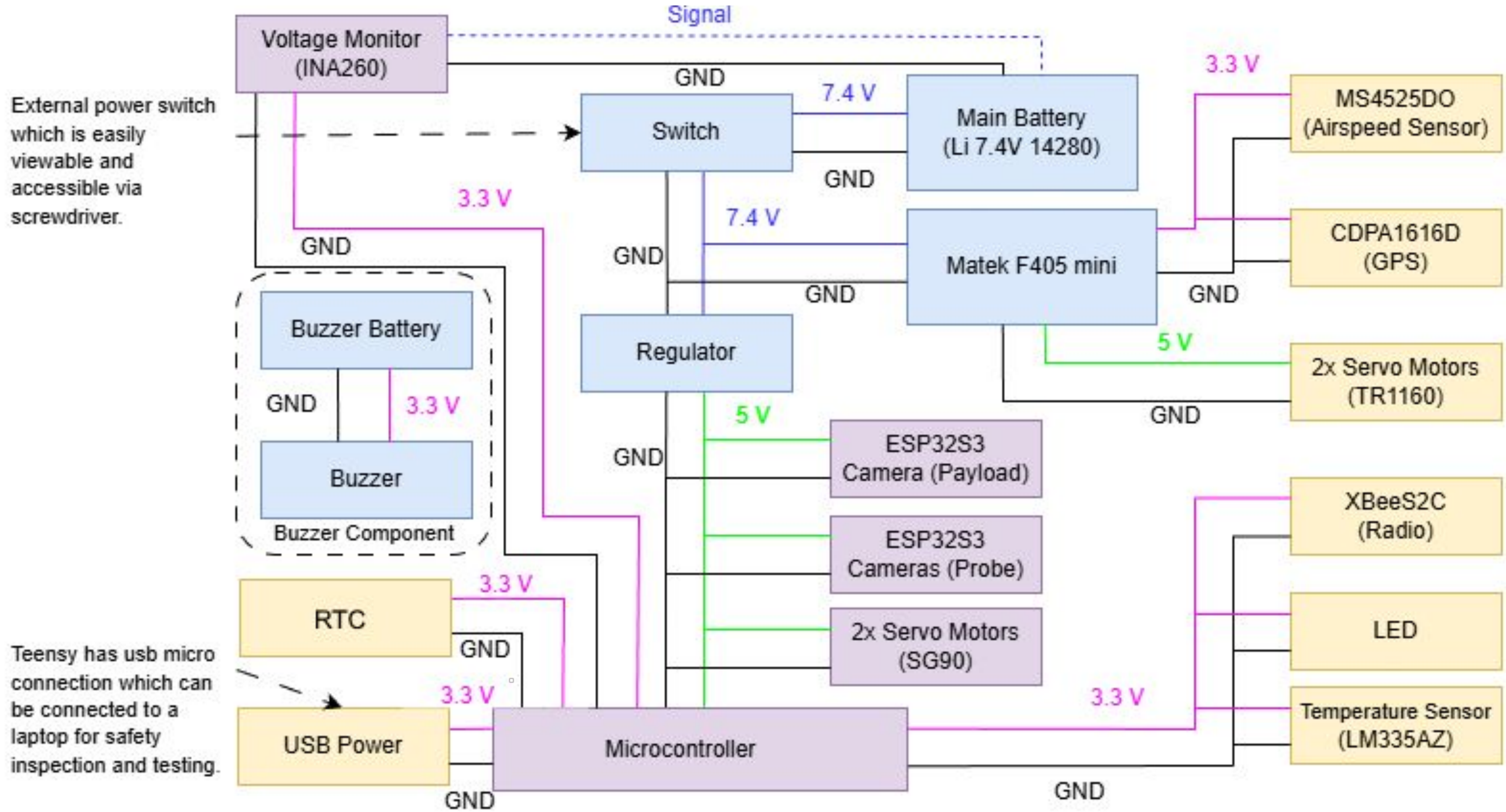
Katerina Demetriou

EPS Overview



Role	Component
Battery	Li-Ion 3.7V 14280
Flight controller	Matek f405 minite
Air Speed Sensor	MS4525DO
GPS	PA1616D
Paraglider Servo Motors	Turnig TR-1160A
Radio Transmitter & Receiver	XBEE Pro S2C
Release Servo Motors	SG90
Temperature Sensor	LM335AZ
Cameras	ESP32S3
LED	Indication LEDs
Buzzer	KXG1203c
Buzzer Battery	CR2032
5V Regulator	L7805CV
RTC (Real-Time Clock)	RV-3028-C7
Microcontroller	Teensy 4.1

Payload Electrical Block Diagram



Payload Power Trade & Selection

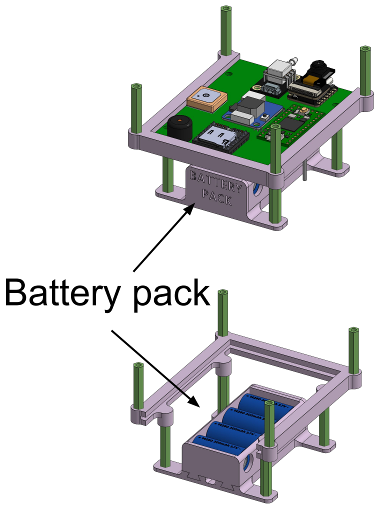
Main Battery

Option	Component	Configuration	Nominal Voltage (V)	Max Current Draw (A)	Rated Capacity (Wh)	Weight (g)
1	**Lithium Li-Ion 3.7V 14280 300mAh 2/3AA Rechargeable Battery**	**2s2p**	**7.4**	**1.800 (3C)**	**13.32**	**48**
2	Lithium-Ion 3.7V 14500 Rechargeable Battery 820mAh	2s2p	7.4	1.640 (1C)	12.1	81.2
3	Lithium-Ion 3.7V 14500 Rechargeable Battery 820mAh	2s1p	7.4	0.820 (1C)	6.1	57

The power system is required to operate for 2 hours, supply an energy capacity of 1.398 Wh, a minimum input voltage of 6.28 V to the main power bus and support a peak current of 1.398 A. All of these options satisfy the voltage requirement without the need for a boost converter. A series cell configuration was selected to provide a higher nominal voltage.

Option 1 was selected as it provides sufficient energy capacity while maintaining a low overall mass. Although Option 3 is the lightest option, it was not chosen as it provides inferior energy capacity compared to Option 1. Option 2 was rejected due to its larger mass.

Option 1's battery configuration provides an additional 11.922 Wh of energy for a 89% margin, and is capable of supplying up to 1.8 A, resulting in a current margin of approximately 402 mA.



Payload Power Trade & Selection

Buzzer Battery

Option	Component	Configuration	Nominal Voltage (V)	Max Current Draw (A)	Rated Capacity (Wh)	Weight (g)
1	**Panasonic CR2045, 3V**	**1s1p**	**3**	**0.0002**	**0.675**	**2.8**
2	LIR2450 3.6V Lithium Button Rechargeable Battery, 120mAh	1s1p	3.6	0.120 (1C)	0.432	5.6

Reasoning:

Option 1 has been selected as the buzzer's battery source. The buzzer requires 0.222 Wh and choosing Option 1 gives a power margin of 0.453 Wh. Option 1 is also the lightest option.

Payload Power Budget

Main Power Bus

Component	Qty	Duty Cycle	Voltage (V)	Average Current (A)	Power consumption (Wh)	Source
ESP32 sense (Recording)		0.04	3.7	0.104	0.015392	Datasheet
ESP32 sense (Idle)	2	0.96	3.7	0.001	0.003552	Datasheet
Xbee S2C Pro (TX)		0.001	3.3	0.12	0.000396	Datasheet
Xbee S2C Pro (RX)	1	0.999	3.3	0.031	0.1021977	Datasheet
Teensy 4.1	1	1	5	0.15	0.75	Estimate
Temperature sensor (IM335AZ)	1	1	3.3	0.015	0.0495	Datasheet
Flight controller (Matek F405 miniTE)	1	1	5	0.05	0.25	Datasheet
Airspeed sensor (MS4525DO)	1	0.5	3.3	0.003	0.00495	Datasheet
Voltage regulator	1	1	5	0.0025	0.0125	Datasheet
Power Indicator LED	1	1	3.3	0.01	0.033	Estimate
INA260	1	1	3.3	0.0003	0.00099	Datasheet
Turnigy Servo	2	0.25	5	0.1375	0.171875	Datasheet
SG90 Servo	2	0.001	5	0.73	0.00365	Datasheet
Total Active Power Consumption for Main Power Bus:					**1.319W**	

Payload Power Budget

Main Power Bus

Component	Qty	Duty Cycle	Capacity (mAh)	Voltage (V)	Current (A)	Power Source (Wh)	Source
Battery (Li-Ion 3.7V 14280)	4	1	300	7.4	1.8	2.22	Datasheet
					Total	**8.88 Wh**	

Main Power Bus Margin

2s2p Battery pack: 7.4 V, 1200 mAh

Capacity = 7.4×1.2=8.88 Wh

Main Power Bus Margin =Power Bus Consumption - Power Bus Source = 8.88 Wh - (2 x1.398 Wh) = **6.084 Wh or 68.5%**

Payload Power Budget

Buzzer Power Bus

Component	Qty	Duty Cycle	Voltage (V)	Current (A)	Power consumption (Wh)	Source
Buzzer	1	1	3.7	0.030	0.222	Datasheet
				Total	**0.222 Wh**	

Component	Qty	Duty Cycle	Voltage (V)	Current (A)	Power Source (Wh)	Source
Buzzer Battery (CR2032)	1	1	3	0.22	0.66	Datasheet
				Total	**0.66 Wh**	

Buzzer Power Bus Margin

Buzzer Power Bus Margin = Buzzer Power Bus Consumption - Buzzer Power Bus Source
= 0.66 Wh - 0.222 Wh
= **0.435 Wh or 65.9% Margin**

Flight Software (FSW) Design

Katerina Demetriou

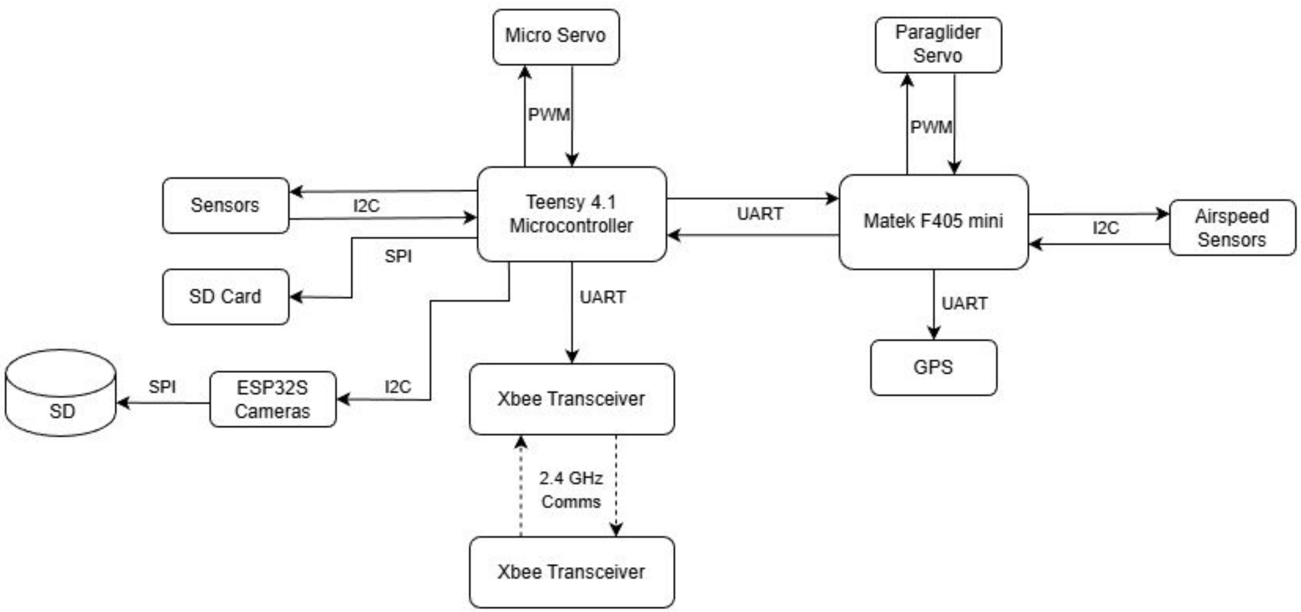
FSW Overview

Basic FSW Architecture

The Flight Software (FSW) manages internal data flow within the CanSat and makes mission decisions based on sensor inputs and command data.

Its primary responsibilities include:

- Controlling servo positions for camera orientation and probe release
- Activating camera modules and ensuring captured data is stored correctly
- Transmitting telemetry and receiving commands via the XBee transceiver
- Logging sensor and mission data to the SD card as a backup in case of transmission failure
- Managing processor resets and restoring required operational states
- Acquiring and processing data from onboard sensors as required for mission logic.



FSW Overview

Summary of FSW tasks

Pre flight task:

On power up, telemetry will be turned on to receive commands. The beacon is activated for the duration of operation as it is electrically isolated. Sensors are activated and calibrated, and the UTC time is set in the RTC to within 1s on the launchpad. Altitude sensors are calibrated to zero and the ground level readings are taken. These are done using the set time (ST) and calibration (CAL) commands from the ground control station

In flight tasks: The altitude and IMU sensors are used to detect whether the Cansat hast left the launchpad. Sensor data is sent to the ground control station at a rate of 1Hz while also being stored on an SD in case of telemetry failure or packet loss during flight. In case of a processor reset, certain data like the current state will be stored in EEPROM.

Ascent: The payload release camera is activated. The altitude is monitored using the pressure and temperature sensor during ascent and the apogee is detected. An apogee flag is set and this height will be stored in the EEPROM to be used to detect 80% during descent.

Descent: The payload release camera is deactivated and the probe release camera is activated. At 80% of peak altitude, the payload release mechanism is activated to detach the payload from the container. Then the Cansat checks for height to the ground. When it is at 2m, the probe release mechanism is activated.

Grounded: The Cansat turns off all sensor polling and only listens for GCS commands.

Power loss and processor reset: Upon power loss or processor reset, the FSW restores the CanSat's last recorded state from EEPROM and updates the mission time.

Note: The Cansat is ready to receive a command to activate all mechanisms at any time.

FSW Overview

Programming language choice

The flight software will be written in C++ specifically the embedded C++ subset creates by arduino. This language was chosen because:

- It is open source and free reducing the overall cost for the CanSat development.
- It has a large selection of libraries, the majority of which are also open source, reducing the overall workload.
- The Teensy 4.1, the microcontroller used, offers direct hardware support for the arduino code framework.
- Members of the team have experience working under this framework further reducing the time required to create the FSW.
- Despite some of the features of standard C++ being unavailable, the relative simplicity of the flight software means this drawback is negligible.

Development environment choice

The flight software will be developed in Microsoft Visual Studio Code with the Platformio extension. This development environment was chosen because:

- Members of the team are familiar with its use.
- It can provide inbuilt github support for version control.
- Visual Studio Code is a lightweight program meaning it can be reasonably installed on personal devices enabling work from home.
- The Platformio provides a number of useful features.
  - Inbuilt library management.
  - Unit test support
  - multi-device compilation.

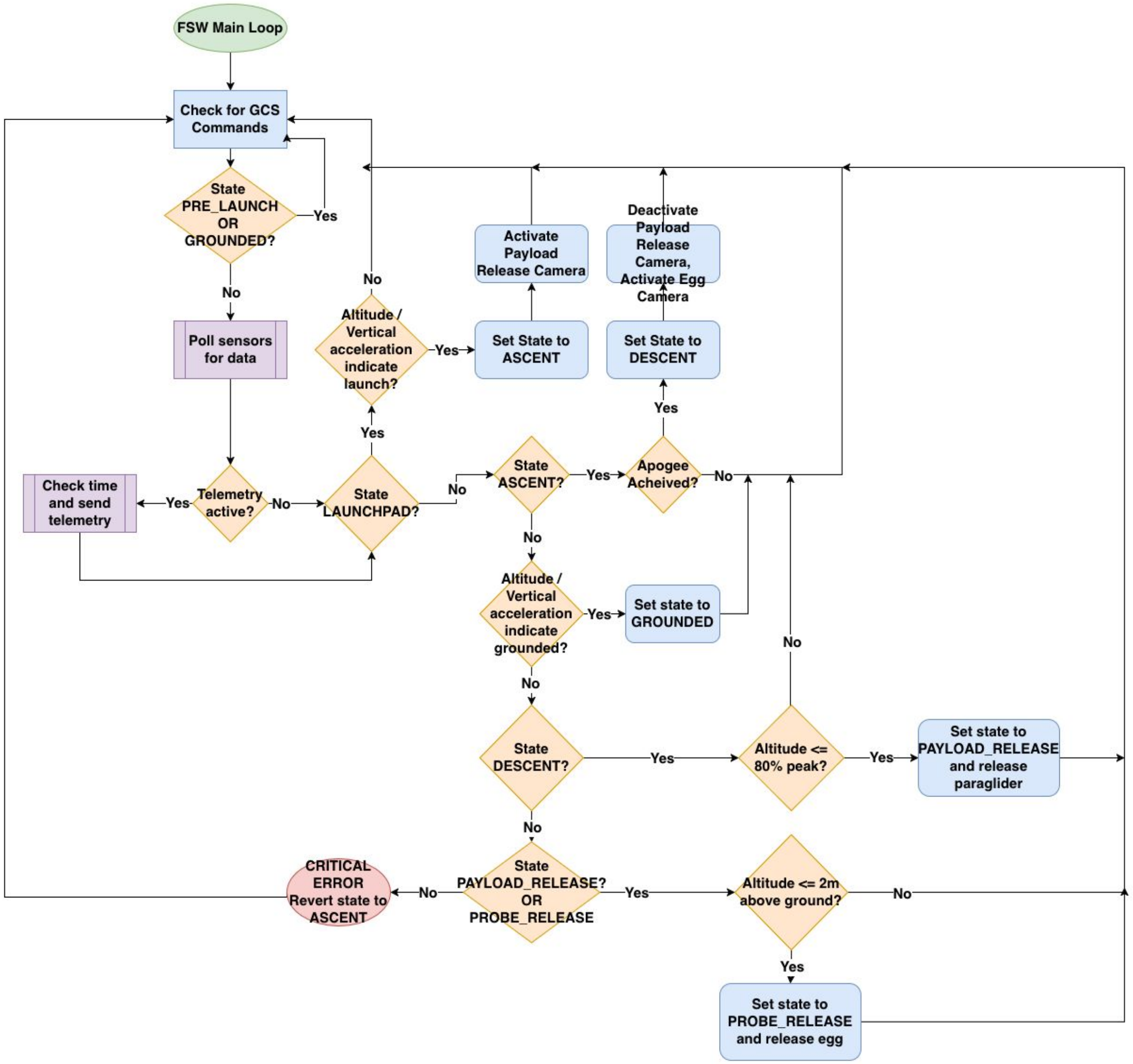
The VisualMicro extension for Microsoft visual studio was also consider however it was not chosen because

- It is prone to errors during compilation.
- It is a proprietary software which would cost the team money.

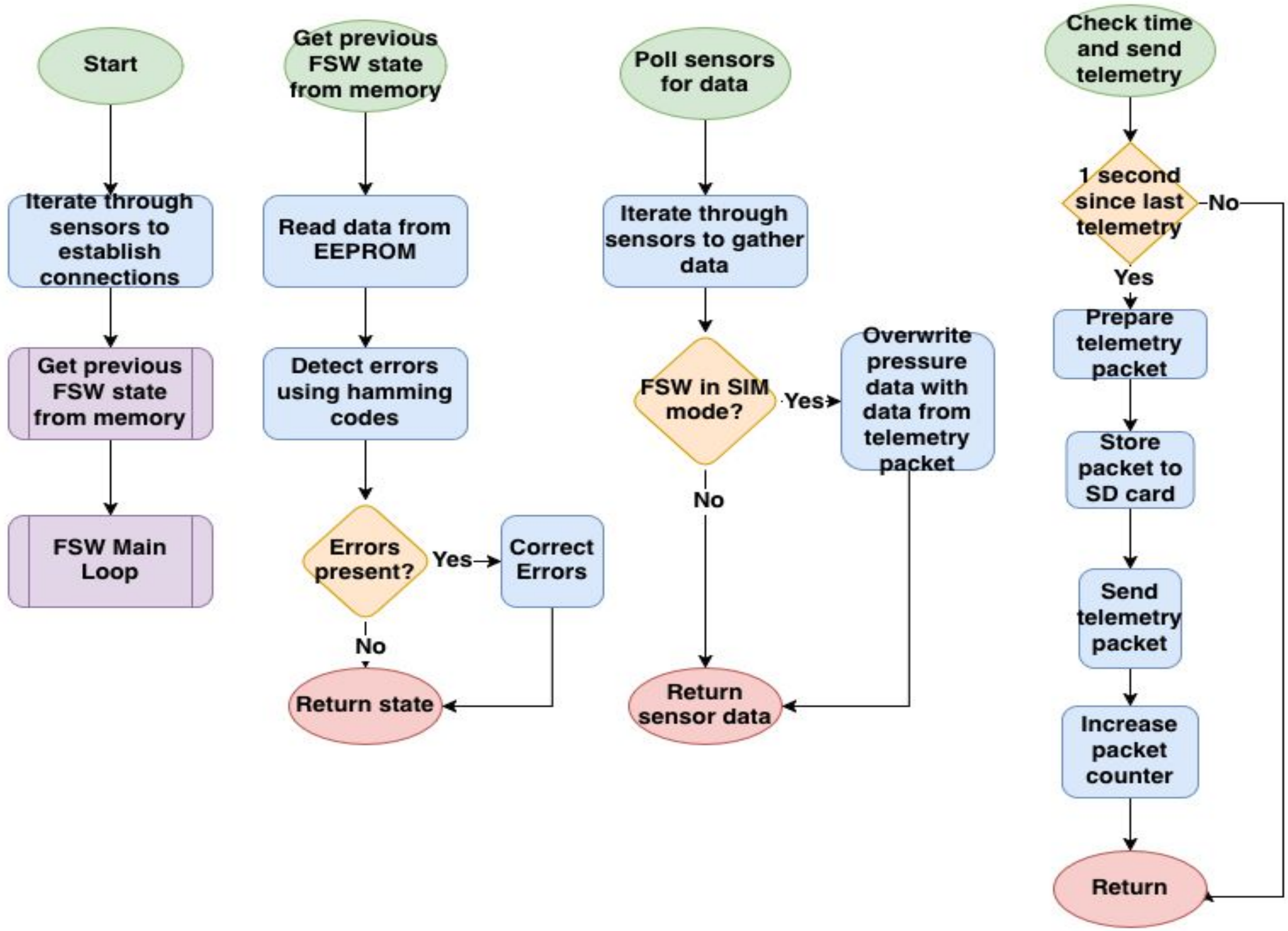
Payload FSW State Diagram

Key points of state diagram

- Telemetry is transmitted at 1 Hz to comply with competition requirements.
- Sensors are polled continuously within the main loop. The polling rate is therefore limited only by processor execution speed, as introducing a fixed polling delay would unnecessarily reduce responsiveness.
- Control actions are calculated using a **variable time step**, allowing the system to respond dynamically based on loop execution timing.
- The system does not implement a dedicated recovery state. Upon reset, the FSW restores previously stored mission states from non-volatile memory and resumes operation automatically.
- Additional ground commands are required for full system functionality, including commands to exit the **pre-launch safe state** and enable mission progression.
- The referenced subroutines are detailed in the following slides.



Payload FSW State Diagram



Payload FSW State Diagram

FSW recovery

Several variables will be needed to be saved to non-volatile EEPROM memory:

- **STATE:** current state used for the main state machine (hamming encoded byte)
- **APPOGEE_HEIGHT:** the recorded height of the reach appogee, zero by default, set during flight.
- **START_TIME:** mission start time in UTC.
- **PACKET_COUNT:** how many telemetry packets have been sent so far.
- **GROUND_ALTITUDE:** altitude of the launch pad from sea level.
- **REQUIRED_MODES:** current simulation mode and camera activation mode represented by a single hamming encoded byte.

Reasons for reset include:

- Short circuits.
- Cosmic rays.
- Excessive current draw from motors or cameras.
- Glitches in software.

Whenever the mission state changes, the new state is written to non-volatile memory. Key recovery variables transmitted in telemetry are also periodically saved to non-volatile storage.
On boot, these values are restored so that the CanSat can resume operation without requiring a dedicated recovery mode. In the event of a catastrophic state machine failure, the flight software will default to the ASCENT state. From there, normal descent detection logic will still function, ensuring that probe deployment can occur safely if required.

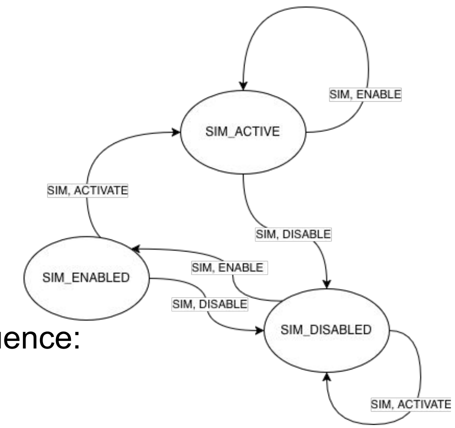
Mission time is not stored as a recovery variable, as it is maintained using the onboard real-time clock. Instead, only essential calibration data (such as altitude zero reference) is stored at launch to minimise write cycles to non-volatile memory.

Simulation Mode Software

The flight software includes a simulation mode that allows a complete mission profile to be executed without physical launch. In this mode, simulated barometric pressure values are transmitted from the Ground Control Station (GCS) at 1 Hz using SIMP packets derived from the provided pressure profile file. These values are sent via XBee and received by the CanSat during operation.

Simulation mode is controlled using a three-state configuration:

- **SIM_DISABLED** – Simulation inactive (default state)
- **SIM_ENABLED** – Simulation permitted but not yet active
- **SIM_ACTIVE** – Simulated pressure replaces real sensor data



To prevent accidental activation during live flight, simulation requires a two-step command sequence:

1. **SIM,ENABLE** – Allows simulation mode
2. **SIM,ACTIVATE** – Begins simulation

SIM,ACTIVATE is ignored unless the system is already in **SIM_ENABLED**. Simulation can be exited using **SIM,DISABLE**.

When in **SIM_ACTIVE**, incoming **SIMP** pressure values (in Pascals, 1 Pa resolution) **override the barometric sensor readings**. These substituted values are used for altitude calculation, state transitions, and deployment logic. Telemetry reports the simulated pressure values while in this mode.

Simulation configuration is stored in non-volatile memory to ensure robustness against processor resets.

Software Development Plan

Prototyping and prototyping environment

- Breadboards will be used to allow testing of elements of flight software with individual hardware components, without the need to test on the completed PCB.
- The flight software will be written using the Visual Studio Code development environment.
- The flight software will run on the Matek F405 flight controller.
- The team will use Git and GitHub for version control to allow easy file sharing and backups

Software subsystem development

- In order of soonest to latest in time, the following subsystems will be developed.
- Develop and test the sensor subsystem to poll all onboard sensors (IMU, barometer, GNSS, airspeed, power monitor).
- Simultaneously implement and validate the apogee detection algorithm, PWM control for the paraglider and release servos with safe actuation logic, and XBee communications including command parsing and 1 Hz telemetry.
- Once mechanical systems are complete, integrate camera control and servo logic into a state-based mission controller.
- Finally, integrate sensing, control, communications, and logging onto the completed PCB and finalise the state machine.

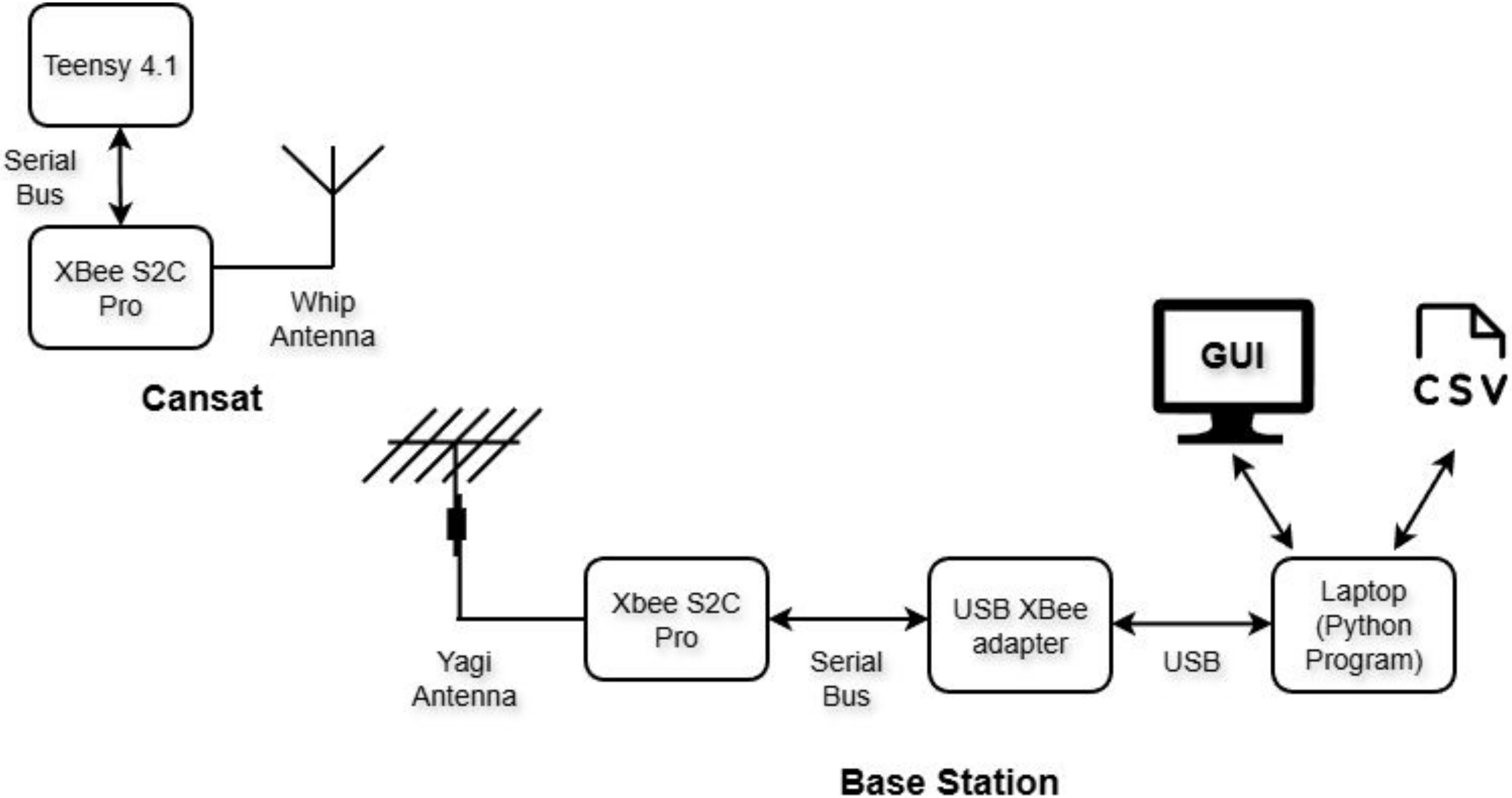
Software subsystem development

- Code will never be directly, or for the first time, run on the integrated CanSat. Instead, a test version of each subsystem will be created and validated independently.
- Code will be tested with values across the full operating range of available sensors and in all mission states.
- Power loss and reset during operation will be simulated, and recovery mode will be tested in all states of the flight software

Ground Control System (GCS) Design

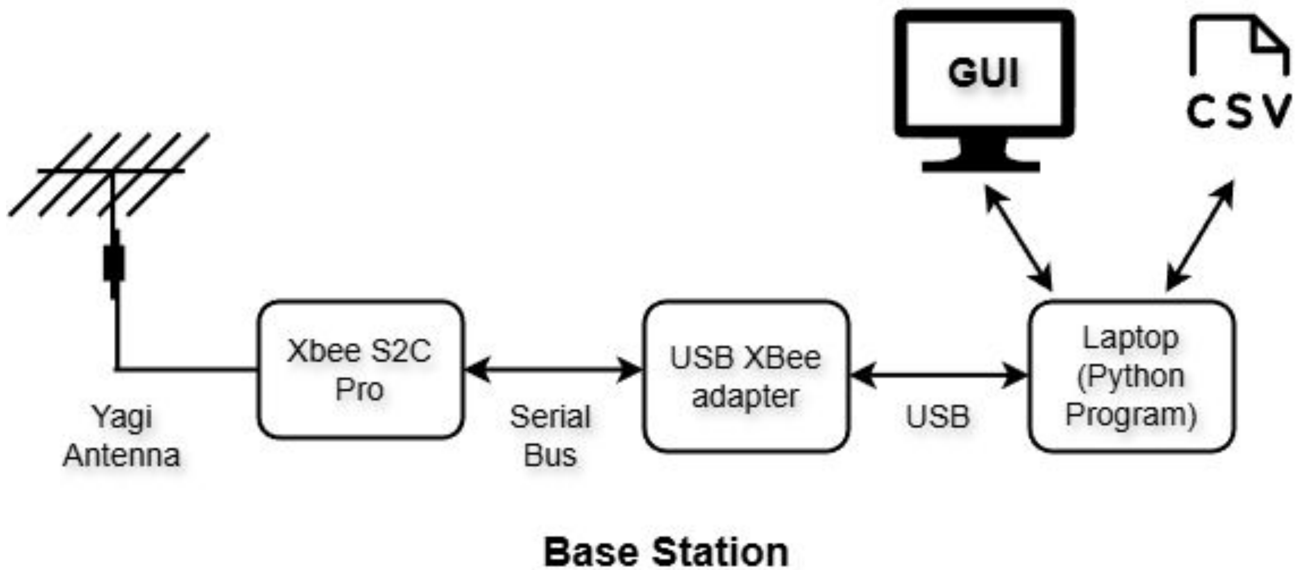
Katerina Demetriou

GCS Overview



GCS Design

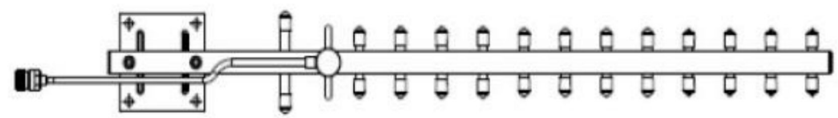
Specification	Risk Mitigation
Ground station must operate for at least 2 hours without external power	Ensure the ground station laptop has a battery life of at least two hours. A portable power bank will also be available to charge the laptop if needed.
Ground station must operate in hot conditions without overheating	A UV protection umbrella will be used to shield the laptop from sunlight
Auto update mitigation	Windows updates will be disabled from settings for periods of up to 5 weeks, which will ensure no updates take place.



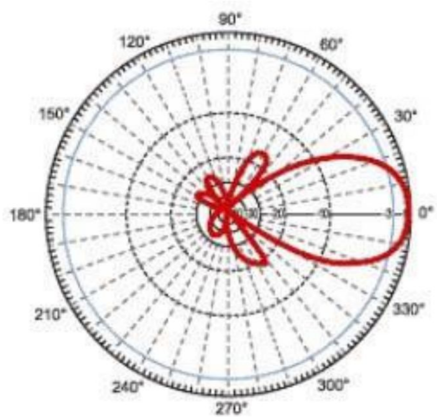
GCS Antenna Trade & Selection

Option	Component	Connection	Gain (dBi)	Beam Width H x V	Mass (g)	Cost (£)
1	ANT-2YAG16	SMA	16	23 x 23	260	49.30
2	**LPRS YAGI-14-2.4G**	**SMA Male**	**14**	**36° x 35°**	**320**	**34.49**
3	HG2420EG-1-NF	Type N Female	20	12 x 16	2400	**100.47**

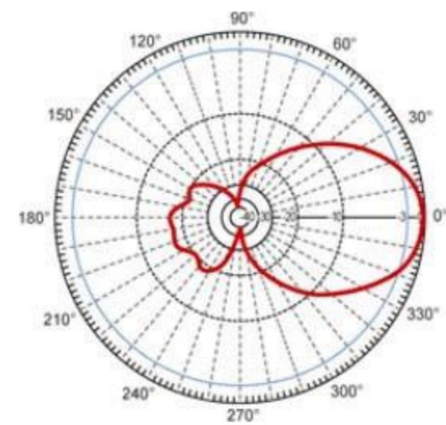
- Lightweight
- Inexpensive
- High gain
- Handheld selected better manual directional orientation towards CANSAT's
- Orrentiation is significant due to narrow beam



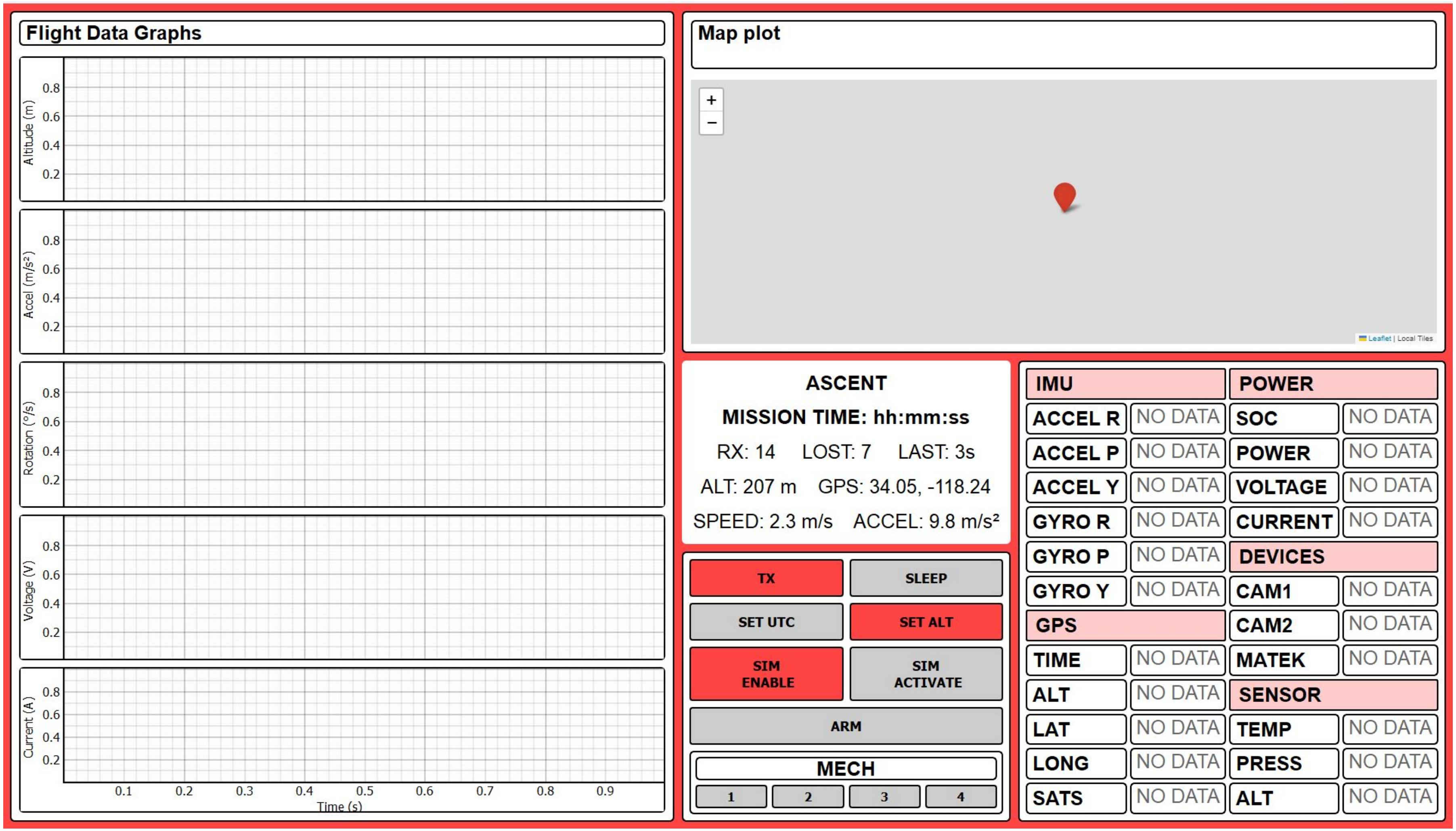
Vertical



Horizontal



GCS Software



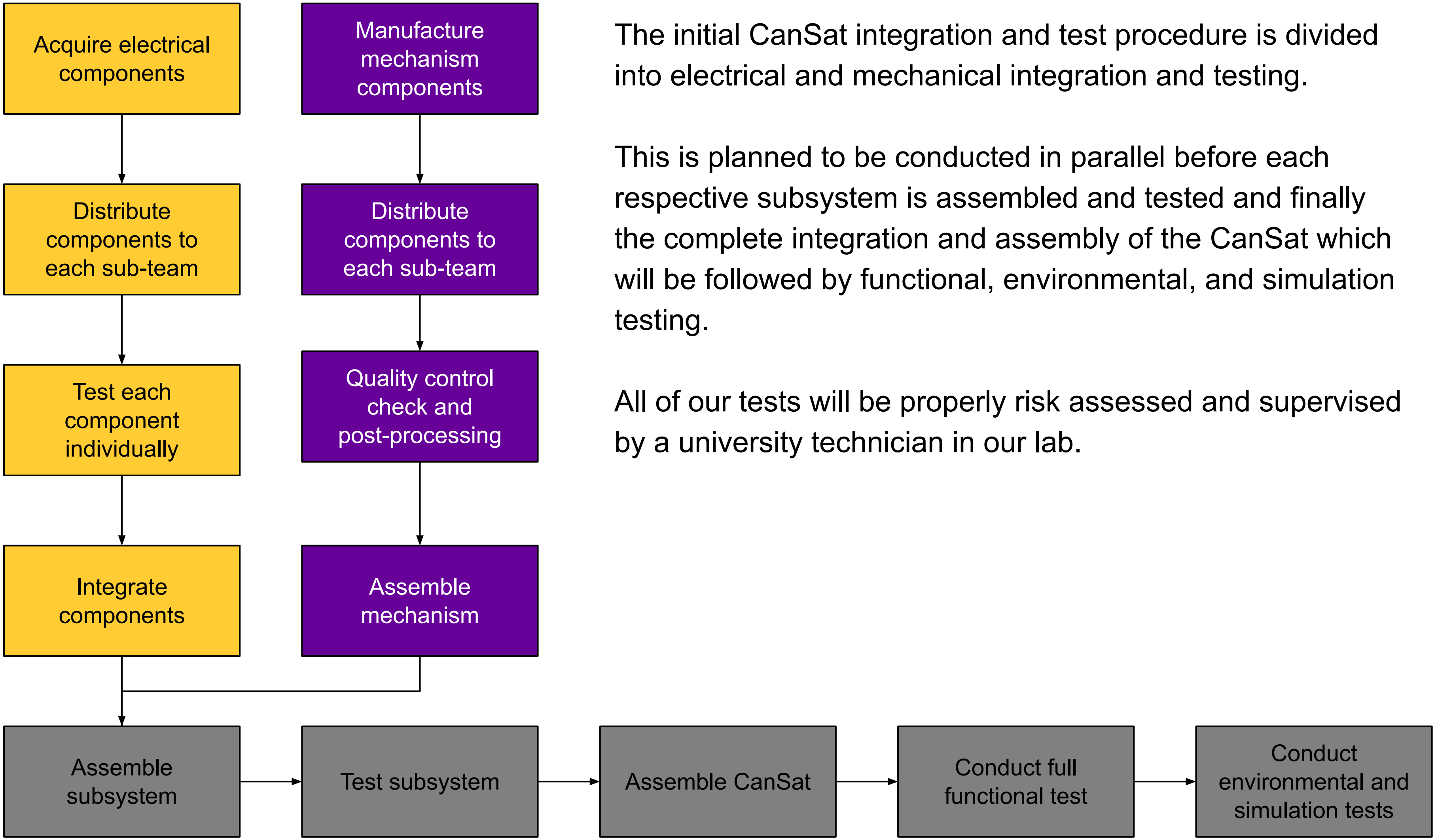
GCS Software

- Python dashboard made using PyQt as it’s easy to configure the layout and has wide library support.
- CSV file is created at the beginning of the programme, the dashboard and CSV file are updated at 1 Hz.
- Command panel used to enable/disable telemetry,enter low power sleep mode, set UTC time, zero altitude, enable simulation mode and activate simulated pressure data stream from the simulation CSV file. Individual mechanisms can also be tested using dashboard.
- Central panel displays key data points and all other telemetry data is displayed on the side panel.
- A map widget is used to display the GPS location of the Cansat and various real-time graphs are displayed on the left panel.

CanSat Integration and Test

Jared Orrick

CanSat Integration and Test Overview



The initial CanSat integration and test procedure is divided into electrical and mechanical integration and testing.

This is planned to be conducted in parallel before each respective subsystem is assembled and tested and finally the complete integration and assembly of the CanSat which will be followed by functional, environmental, and simulation testing.

All of our tests will be properly risk assessed and supervised by a university technician in our lab.

Subsystem Level Testing Plan

Subsystem	Component Level	Subsystem Level	System Level
Sensors	-Test sensors can be read from. -Test sensor readings are accurate. -Test servos can spin. -Test camera can be triggered .	-Test that all the sensors can be polled at the same time. -Test that the paraglider steering servos can correctly respond to changes in the flight controller orientation.	-Ensure data can be transmitted and stored. -Ensure sensor data is plotted in real-time. -Ensure the servos are fully integrated with the mechanical system.
CDH	-Test XBee's can parse data. -Test XBees can programmatically change its NETID.	-Test XBee can communicate between each other, the Cansat XBee and the GCS XBee. -Test the correct UTC time is maintained through processor resets.	-Ensure GCS commands are correctly forwarded to FSW. -Ensure the system correctly enters and leaves simulation mode. -Ensure correct packet transmissions.

Subsystem Level Testing Plan

Subsystem	Component Level	Subsystem Level	System Level
EPS	-Test the voltage of each battery. -Test the maximum current draw from each battery. -Test the continuity of each trace on the PCB. -Test the converter steps the voltage up correctly.	-Test that batteries can supply the correct voltage to each component on the PCB. -Test that current draw from all the components at stall current is capable from the batteries.	-Ensure that the batteries can supply the entire electrical system for 2 hours.
Radio Communication	-Test that the XBees can communicated between each other, by sending random data. -Test that the real time plotting plots data in real time. -Test that the antenna meets the required range.	-Test that communication can occur over the required range.	-Verify that data can be transmitted uninterrupted and accurately over the required range.

Subsystem Level Testing Plan

Subsystem	Component Level	Subsystem Level	System Level
FSW	-Verify that the flight control software is correctly flashed onto the flight controller	-Test that the software moves between states correctly. -Test the control code for the payload steering mechanism. -Test the motor motors can move to the required position.	-Test that the software runs correctly. -Test that the software can perform all functions set out in the requirements.

Subsystem Level Testing Plan

Subsystem	Component Level	Subsystem Level	System Level
Mechanical	-Test that the payload release mechanism can sufficiently hold the payload within the CanSat container -Test that the nose cone ledges and egg release mechanism plate can sufficiently keep the nose cone attached -Test that all components fit properly.	-Test the egg release servo plate spins properly and does not get stuck on the nose cone ledges. -Test that the wheels used for the payload steering mechanism can effectively tighten or loosen the nylon cord. -Test mechanisms do not interfere with cables and placements of other electrical components.	
Descent Control	-Stress/strain test on the parachute and paraglider fabric -Tensile strength test on the nylon cord	-Drop test parachute and paraglider to verify proper deployment and correct descent rate.	-Test that the payload steering mechanism can effectively induce a turn, breaking, and glide.

Integrated Level Functional Test Plan

Functional Test	Description
Descent Testing	Parachute: A drop test will be conducted to verify the ability of the parachute to successfully deploy and to descent at the required rate. This will involve dropping the CanSat from the upper level of the lab into a designated drop zone.
	Paraglider: A drop test will be conducted to verify the ability of the paraglider to successfully deploy when the payload is released from the CanSat container. This will involve dropping the CanSat from the upper level of the lab into a designated drop zone. The paraglider steering mechanism will be tested by simulating a variety of maneuvers to complete. For example: a sharp turn, a gradual turn, breaking, diving, and steady glide. Each test will be recorded from multiple angles using a mobile phone so the footage can later be analysed and used to verify the effectiveness of the payload steering mechanism for each test case. Subject to satisfactory results a test combining multiple maneuvers will be conducted to emulate the actual trajectory of the mission.

Integrated Level Functional Test Plan

Functional Test	Description
Communications	To test the CanSat's ability to communicate with the groundstation, the EPS will first be tested to verify that power can be supplied to the XBEEs. The fully assembled electrical system will be tested with the groundstation to check that the cansat will be able to send telemetry and receive commands.
Mechanism	To test the mechanisms are operational the EPS will first be tested to check that it can supply power to the mechanisms. The mechanisms will be tested when connected to the batteries and the sensing system to verify that the maximum current draw is high enough for the servos to supply sufficient torque to the mechanisms. The control of the mechanisms will then be tested.
Deployment	To test that the CanSat is able to be deployed a fit check will be performed to check for sufficient clearance. This will involve actuating the payload release and egg drop mechanisms, respectively, and verifying that they can successfully deploy.

Environmental Test Plan

Environmental Test	Description
Drop Test	The drop test is to assess the CanSat's survivability. The CanSat will be dropped from a tort rope from a height above 61 cm. The team will hold parachute material below the CanSat to protect the CanSat in the event the rope breaks.
Thermal Test	Thermal test will be performed in an insulated styrofoam chamber with foil sides and heated up to 60 degrees using a hair dryer. It will be heated for 2 hours. This is to test the CanSats ability to operate in higher temperature conditions.
Vibration Test	Vibration test will be performed to evaluate the overall structural integrity of the system, including mounting connections, battery connections and electrical connections. The CanSat will be attached to a rotary sander to conduct the test.This will test it can survive vibration and shock.
Fit Check	A laser cut jig will be used to assess that the CanSat will be compatible with the rocket and the correct size for launch.
Vacuum Test	Vacuum test will be performed by placing the CanSat in a vacuum bag and using a vacuum cleaner to simulate higher altitudes. This is to assess pressure readings, battery safety and integrity of epoxied connections.

Simulation Test Plan

Tests	Description
Test that the software start the simulation upon GCS command.	Two consecutives commands from GCS are sent to the CanSat which should trigger simulation mode.
Test that the software swap real pressure in pascals with simulated data in simulation mode.	GCS will send air pressure every second once in simulation mode. The test looks to see that the simulated data is used instead of measured data from the pressure sensor.
Test that telemetry is sent to GCS in simulation mode.	Test that telemetry is still sent to the GCS by the CanSat when in simulation mode.
Test that the CanSat is capable of recovery.	While transmitting data to the GCS in simulation mode, turn off/on the CanSat to check its recovery works against power loss.
Test that sensor data is still read while the CanSat is in simulation modes.	Test that while the cansat is transmitting data to the GCS in simulation mode, the other sensor data is still read and transmitted to the GCS.

Mission Operations & Analysis

Jared Orrick and Luna Fernandez

Overview of Mission Sequence of Events

Recap of outline of launch day activities from pre-launch to post launch and team member roles:

Roles and Responsibilities

Mission Control Officer: **LF**
Ground Station Crew: **SE**
Recovery Crew: **KA, SH**
CanSat Crew: **JO, YEY**

SE will be responsible for handing over the telemetry data file to the judges for review.

Final Integration and Testing

- The final I&T will be carried out between 8:00-12:00.
- The whole team will be present, this is to ensure all systems are operating correctly. This will be lead by **JO** and performed by the CanSat Crew.
- The GCS and Antenna setup will be carried out by the Ground Station Crew. Both GCS and Antenna are plug and play and selected for their ease of set-up.
- The I&T plan (set out in the mission operations manual) will be followed throughout this process to ensure that all procedures have been carried out correctly and efficiently.

Mission Operations Manual Development Plan

Mission Operation Overview

The Mission Operations Manual will contain:

- Pre-launch Procedure
- Ground Station Configurations
- Integrating the CanSat with the rocket
- Removal procedure
- Systems Overviews (Electrical Hardware)

All mandatory sections have been completed. The Mission Operation Manual will also contain an overview of the Mechanical Subsystem. Each section contains a checklist for all tests and procedures.

The Mission Manual will be completed in late **February** to begin launch testing.

CanSat Location and Recovery

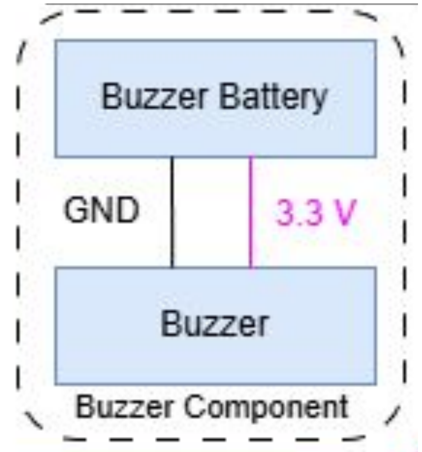
CanSat Recovery Plan:
Once the CanSat is confirmed to have landed, this will be verified by analysing the live telemetry data from the air pressure sensor, which provides altitude information. GPS tracking data will then be used to determine the precise landing location to facilitate recovery. Once recovery is authorised by the AAS team, two designated members of the MSDG team will retrieve the CanSat, wearing appropriate fieldwear and footwear.

Colour Selection:
The CanSat will be assembled using bright, high-visibility colours to ensure it can be easily identified in a field environment. The nose cone will be bright pink, while the parachute will be bright purple and yellow, improving visibility during descent and after landing. The payload bases will be turquoise, further enhancing detectability.

CanSat Labelling:
The CanSat will be clearly labelled with the team number, contact email address, and phone number. This ensures that, in the event the CanSat is not recovered by the team, anyone who finds it can easily contact us.

Buzzer (KXG1203C)

- 85dB 2300Hz continuous buzzer
- Loud and can be heard from far



Buzzer Battery (CR2450)

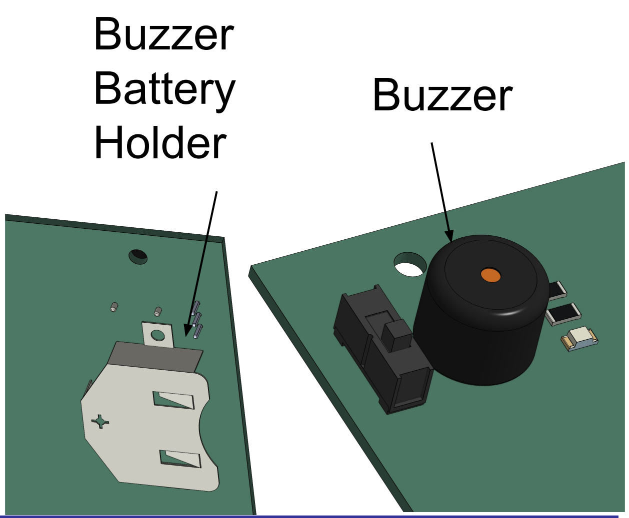
- Independent 3V 630mAh battery coil cell
- Can last for +20hrs

Slider Switch

ON/OFF switch to disconnect coin battery.

Location

Located near the edge of the PCB for easy access.



The purpose of this section is to summarize and cross reference the compliance to the CanSat Competition Mission Guide requirements.

Requirements Compliance

Jared Orrick

Requirements Compliance

RE#	Requirement	Compliance	Reference Slides	Notes
C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.		11,12	
C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.		19	
C3	The Cansat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.		11,12	
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.		39,42	
C5	At 80% flight peak altitude, the payload shall be released from the container.		54,55	
C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.		34,35	
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.		38,39	
C8	The payload shall steer toward a target location		35,36	
C9	The sensor telemetry shall be transmitted at a 1 Hz rate.		96	
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.		59	
C11	A second video camera shall point at the ground.		60	
C12	The payload shall release a protected hens egg when the payload is 2 meters +/- 0.5 m above the ground without breaking the egg.		61	
C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat battery and electronics.		122	
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.		132, 134	
S1	The Cansat and container mass shall be 1000 grams +/- 10 grams.		71	
S2	The nose cone shall be symmetrical along the thrust axis.		48,49	

Requirements Compliance

RE#	Requirement	Compliance	Reference Slides	Notes
S3	Nose cone radius shall be exactly 71 mm		48	
S4	Nose cone shoulder length shall be a minimum of 50 mm		18	
S5	The nose cone shall be made as a single piece. Segments are not allowed.		48,49	
S6	The nose cone shall not have any openings allowing air flow to enter		10,52	
S7	The nose cone height shall be a minimum of 76 mm.		48	
S8	Cansat structure must survive 15 Gs vibration		116	
S9	Cansat shall survive 30 G shock.		116	
S10	The container shoulder length shall be 90 to 120 mm.		18	
S11	The container shoulder diameter shall be 136 mm.		18	
S12	Above the shoulder, the container diameter shall be 142 mm		18	
S13	The container wall thickness shall be at least 2 mm when 3D printed and must not flex or be deformed when under stress.		18	
S14	The container length above the shoulder shall be 200 mm +/- 5%.		18	
S15	The Cansat shall perform the function of the nose cone during rocket ascent.		13	
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.		10	
S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.		67,68	
S18	The Cansat container shall meet all dimensions in section F.		18,14,15	

Requirements Compliance

RE#	Requirement	Compliance	Reference Slides	Notes
S19	The Cansat container materials shall meet all requirements in section F.		44,45,46	
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.		38,39,40	
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.		58, 63	
M1	No pyrotechnical or chemical actuators are allowed.		N/A	
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.		N/A	
M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.		116	
M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.		88	
E1	Lithium polymer batteries are not allowed.		88	
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.		88	
E3	An easily accessible power switch through the container is required.		87	
E4	The container shall have small access holes for power switches of no more than 10 mm.		87	
E5	Power indicator is required.		87	
E6	The Cansat shall operate for a minimum of two hours when integrated into the rocket.		91	
E7	The audio beacon shall operate on a separate battery.		122	
E8	The audio beacon shall have an easily accessible power switch through the container.		122	
X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.		76	

Requirements Compliance

RE#	Requirement	Compliance	Reference Slides	Notes
X2	XBEE radios shall have their NETID/PANID set to their team number.		77	
X3	XBEE radios shall not use broadcast mode.		98	
X4	The Cansat shall transmit telemetry once per second.		98	
X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, battery current, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.		78-80	
SN1	Cansat payload shall measure its altitude using air pressure.		21	
SN2	Cansat payload shall measure its internal temperature.		22	
SN3	Cansat payload shall measure its battery voltage.		23	
SN4	Cansat payload shall track its position using GPS.		24	
SN5	Cansat payload shall measure its acceleration and rotation rates.		26	
SN6	Cansat payload shall video record the deployment of the para-glider at 80% peak altitude.		27	
SN7	Cansat payload shall video record the ground during descent.		28	
SN8	The ground pointing camera shall capture video of the instrument being released and reaching the ground.		27	
SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.		28	
SN10	Cansat payload shall measure its battery current.		23	
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.		83	
G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.		107	

G1

RE#	Requirement	Compliance	Reference Slides	Notes
G3	Telemetry shall include mission time with 1 second resolution.		74	
G4	Each team shall develop their own ground station.		95	
G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.		106	
G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.		106	
G7	The payload shall descend at 5 meters/second averaged over the entire descent within +/- 3 meters/sec with the para-glider descent control system.		34,39	
G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.		106	
G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.		104	
G10	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.		104	
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.		106	
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.		107	
G13	The ground station shall use a table top or handheld antenna.		105	
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.		106	
G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.		106	
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.		106	
G17	The ground station shall be able to activate all mechanisms on command.		106	
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.		98, 95	

RE#	Requirement	Compliance	Reference Slides	Notes
F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.		74	
F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.		82	
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.		100	
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.		100	
F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.		100	
F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.		95	
F8	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.		95	

Management

Jared Orrick

CanSat Budget – Overview

Costs	Amount
Mechanical components	£83.27
Electrical components	£230.52
Other costs (travel, accommodation, Visas)	*£9461.04*
Total	**£9774.83**

Note: *italicised* text denotes estimated costs

CanSat Budget – Hardware

Mechanical					
Component Name	**Description/Use**	**Quantity**	**Unit Cost**	**Total Cost**	**Reused**
PLA+/PLA professional 3D printing filament	CanSat structure and mechanisms	1	£13.99 per kg	£13.99	No
Carbon fibre rod	CanSat structure	4	£6.37	£25.48	
Acrylic sheeting	CanSat structure	1	*£0.50*	*£0.50*	
Parachute	CanSat descent and control	1	£9.95	£9.95	
Ripstop nylon fabric	Paraglider	1	£4.39	£4.39	
Nylon thread	Paraglider	1	£1.99	£1.99	
Nylon cord	Paraglider	1	£0.2592 per m	£0.21	
M3 machine screw/bolt	CanSat structure and mechanisms	20	£0.1340	£2.68	
M3 washer	CanSat structure and mechanisms	6	£0.006	£0.04	
M3 nyloc nut	CanSat structure and mechanisms	20	£0.112	£2.24	
M3 standoff	CanSat structure and mechanisms	8	£0.49	£3.92	
Spring	Egg protection mechanism	1	£0.30	£0.30	
Servo-Powered Payload Release System Mount	Payload release mechanism	1	£3.47	£3.47	
Epoxy	CanSat structure	1	£7.99	£7.99	
Glue	CanSat structure	1	£2.95	£2.95	
Screw hook	Egg protection mechanism	4	£0.02	£0.09	
Elastic (rubber) band	CanSat mechanisms	8	*£0.01*	*£0.08*	
Cloth tape	Paraglider	1	£3.01	£3.01	
			Overall Total Cost	**£83.27**	

Note: *italicised* text denotes estimated costs

CanSat Budget – Hardware

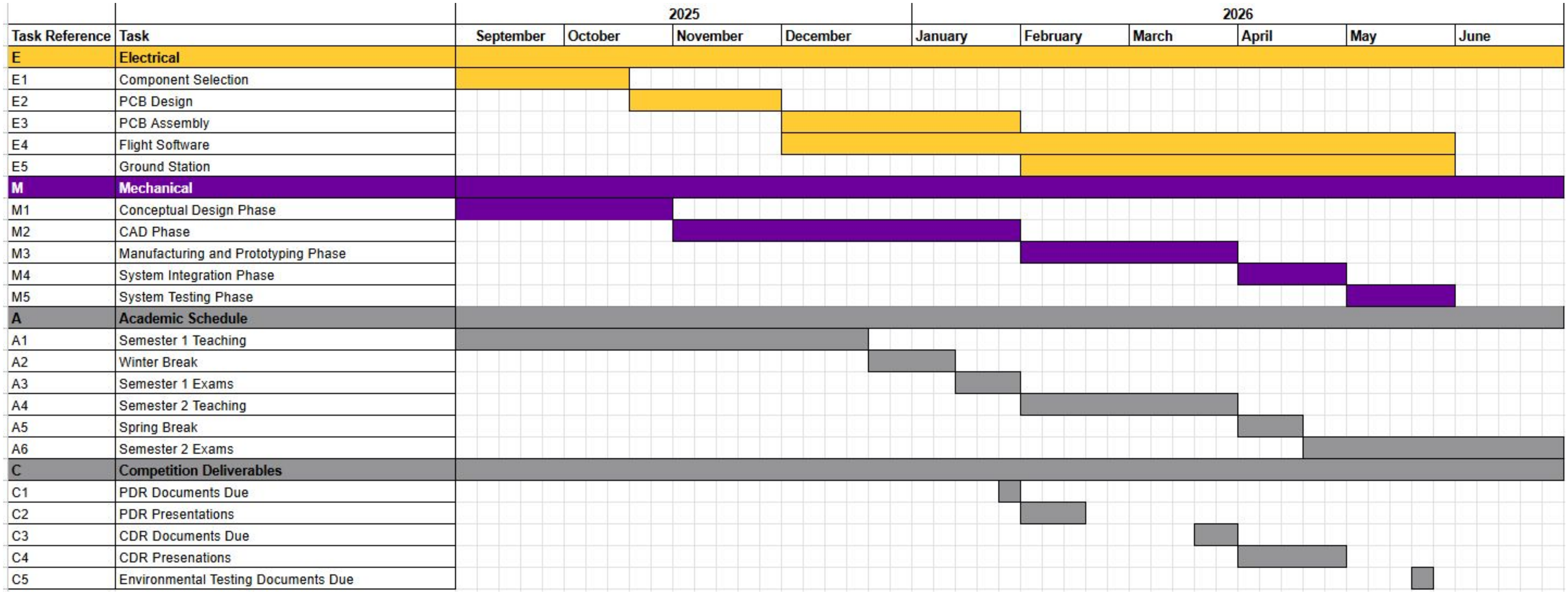
Electrical					
Component Name	**Description/Use**	**Quantity**	**Unit Cost**	**Total Cost**	**Reused**
Seeed XIAO ESP32S3 Sense	Camera	2	£13.50	£27.00	No
Turnigy™ TR-1160A Mini Servo 25T 3.0kg / 0.11sec / 16g	Paraglider steering servo	2	£4.75	£9.50	
Emax ES08A II Micro Servo	Egg release servo	1	£3.95	£3.95	
	Payload release servo	1	£3.95	£3.95	
XBEE S2C Pro	Radio	1	£50.81	£50.81	
PA1616D (GNSS)	GNSS sensor	1	£8.89	£8.89	
Buzzer (KXG1203c)	Buzzer	1	£4.30	£4.30	
Teensy 4.1	Microcontroller	1	£30.30	£30.30	
Matek F405-miniTE	Flight controller	1	£50.70	£50.70	
MS4525DO	Airspeed sensor	1	£15.99	£15.99	
Power switch (screw switch)	Buzzer switch	1	£1.50	£1.50	
32 GB MicroSDHC	Micro SD card for video logging	1	£8.32	£8.32	
LM335AZ	Temperature sensor	1	£0.89	£0.89	
14280 3.7 V Li-Ion Battery	Batteries for main power supply	4	£2.95	£11.80	
CR2450	Buzzer battery	1	£2.62	£2.62	
Keystone battery holder 3008	Buzzer battery holder	1	£0.30	£0.30	
L7805CV	Voltage regulator	1	£0.45	£0.45	
			Overall Total Cost	**£230.52**	

CanSat Budget – Other Costs

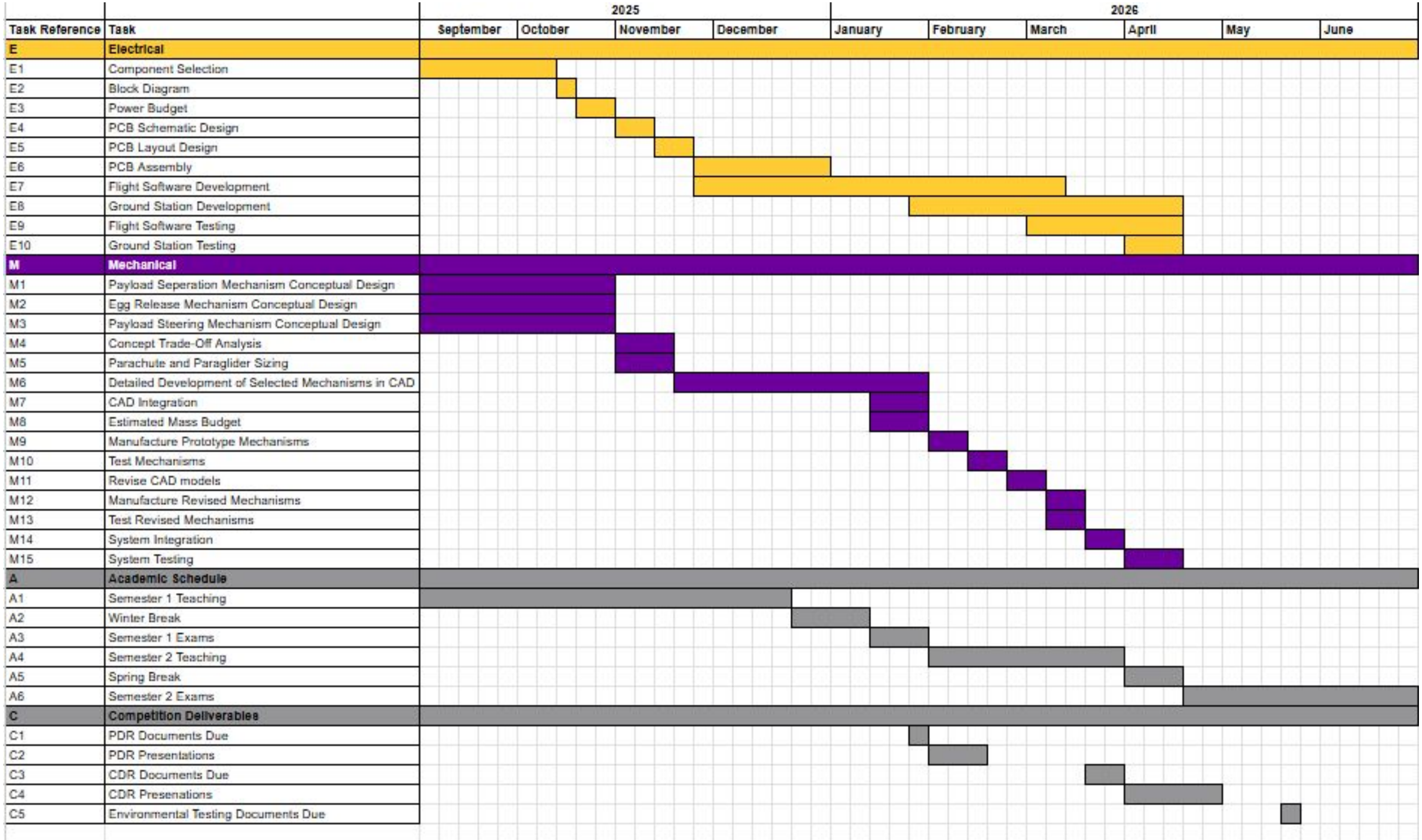
Cost Overview	Description	Quantity	Unit Cost	Total Cost
Travel	Return flights from Manchester to JFK	10	£543.00	£5,430.00
	Rental car for 6 days	2	£199.00	£398.00
Accomodation	Accomodation for 6 nights	10	*£300.00*	*£3,000.00*
Tourist Visa and Electronic Travel Authorisation applications	ESTA	8	£29.23	£233.84
	Visa applications for non-ESTA applicable team members	2	£127.00	£254.00
GCS hardware	Laptop provided by team member for GCS display	1	N/A	N/A
	Telemetry	1	£34.99	£34.99
Competition entry fee	N/A	1	£145.20	£145.20
			Overall Total Cost	**£9,461.04**

Sources of Income	Description	Amount
Society funding	Funding provided to the Manchester Satellite Development Group Society and assigned to the AAS CanSat competition.	£9,500.00
Sponsorship	RS grant provided for purchasing of equipment and components from the RS Industrial Solutions and Electronics store.	£500.00

Program Schedule Overview



Detailed Program Schedule



Conclusions

Major accomplishments:

- Fully developed CAD model of chosen concepts
- £500 sponsorship awarded from RS
- Team building sessions (potluck dinners, bowling, karaoke)

Major unfinished work:

- PCB design

Conclusions

Why we are ready!

- Secured society funding to support CanSat development and trip to the US
- Fully developed chosen concept which is in initial manufacturing stages
- Flight software development is underway
- Team motivation is high

Presentation Scoring & Information

Do Not Include the Following Charts in the Presentations

The following slides provide additional information regarding presentation scoring, as well as recommendations for the presentations and slides

Presentation Scoring

- **Each slide in this template is scored on a scale of 0 to 2 points**
  - 0 = missing or no compliance to the intent of the requirement
  - 1 = topic incomplete or partial compliance to requirement(s)
  - 2 = complete and demonstrates requirement(s) met
- **Each section of the presentation (System Overview, Sensor Subsystems, etc.) is weighted according to the table**
- **Each team will receive a link to a summary score sheet that will contain all their competition scores**

PPT Template Use

- **All teams shall use this presentation template**
- **Team logos**
  - A team logo can be inserted into the placeholder location (and size) on the master slide
  - If no logo is to be used, remove the placeholder from the master slide
- **Team number and name must be in the footer of each slide**
- **On each slide, replace the “Name goes here” in the bottom left corner with the name of the person(s) presenting that slide**
  - This will allow the judges to know the person to address any questions or comments to

Trade Studies

- **Recommendations for trade studies:**
  - Tabular format
  - Discuss criteria for selection
    - Studied configurations
    - Assessment criteria and ranking
- **Be clear on final component/configuration selections**
- **When using hardware from previous years, do the same**
- **Be consistent with trade study presentations**

- **Refer to past year presentations for examples of effective trade study presentation formats**

Presentation Template Update Log (Do not include in presentation)

- **1.0 Initial version for 2026**