



CanSat 2026

Critical Design Review (CDR)

Outline

Version 1.1

Team 1081
SEDs ITBA



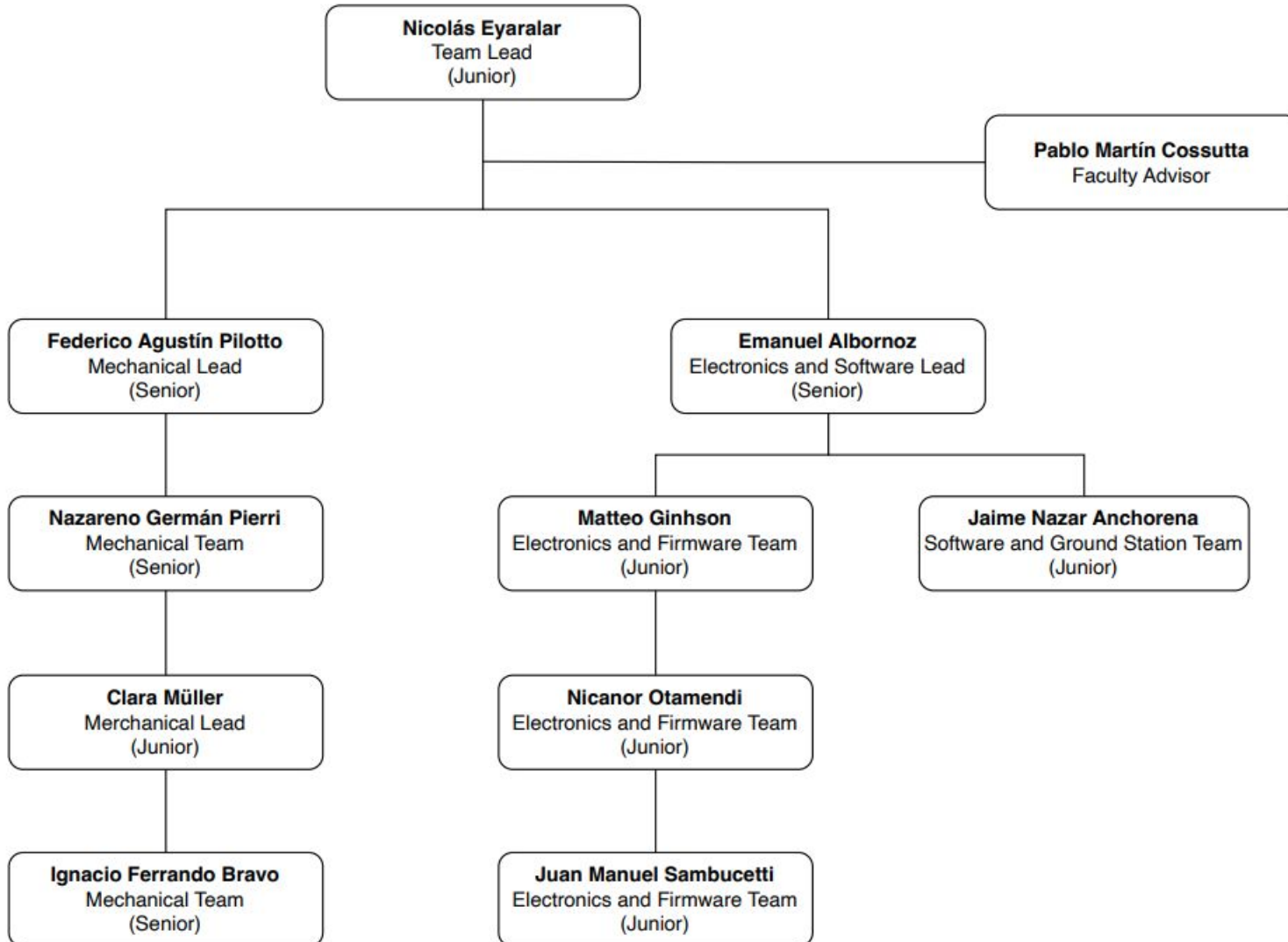
Presentation Outline



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Team Organization





Acronyms



Acronym	Explanation
FSW	Flight Software
m	Mass
g	Gravitational Acceleration
ρ	Density of the Air
v	Terminal Velocity
Cd	Drag Coefficient
A	Area
GCS	Ground Control System
MCU	Micro Controller Unit
RTC	Real Time Clock
MECH	Mechanical

Acronym	Explanation
ADC	Analog-Digital Converter
PCB	Printed Circuit Board
SMD	Surface Mount Devicema
T&S	Trade & Selection
GPS	Global Positioning System
ODR	Output Data Rate
LED	Light Emitting Diode
COTS	Commercial Off-The-Shelf
NEGL	Negligible
FOV	Field of View
LSB	Least Significant Bitep



System Overview

Nicolás Eyaralar
Federico Agustín Pilotto



Mission Summary



Design a Cansat that consists of a payload and a container that mounts on top of the rocket. The payload rests inside the container at launch and includes the nose cone as part of the payload. The container with the payload shall deploy from the rocket when the rocket reaches peak altitude and the rocket motor ejection forces a separation. The container with the payload shall descend at a rate of no more than 15 meters/second using a parachute that automatically deploys at separation. At 80% peak altitude, the payload shall separate from the container and descend using a para-glider descent control system until landing. The descent rate shall be an average of 5 meters/second. The payload shall steer toward a specified position to deposit an instrument. At 2 meters above the ground, the instrument shall be released and land intact. A video camera shall show the separation of the payload from the container and the para-glider descent control system functioning. A second video camera shall be pointing downwards and show the ground during descent and the instrument being released. The instrument will be simulated using a large hens egg with a mass ranging from 54 grams to 64 grams. The Cansat shall collect sensor data during ascent and descent and transmit the data to a ground station at a 1 Hz rate. The sensor data shall include interior temperature, battery voltage, battery current, altitude, tilt angle, rotation rate, and GPS position.

External objectives:

- Apply class concepts to real practice and gain more experience on the aerospace field
- Contribute to the recognition and prestige of our university
- Motivate students from different careers and ages to join SEDS-ITBA



Summary of Changes Since PDR



Subsystem	Element	Changes	Rationale
Descent control	Pulley	Pulley's diameter has been increased to 34mm	To fit 270° degree rotation of servo
Descent control	Shaft	New model includes a spline for torque transmission	Redesign
Descent control	Winch Floor	Slots were made to facilitate the assembly of the components and holes due to the enlargement of the pulleys.	Redesign
MECH	Batteries floor	Batteries floor is now also the camera support and rod positioner	Weight
MECH	Electronics floor	Electronics floor has been eliminated, resting only the PCB on the batteries floor	Weight
MECH	Ground camera	Ground camera support has been amplified	Protection during payload landing
MECH	Upper Floor	New design is thinner and has a two inclined planes to place the two LiDARs	Better view of paraglider deployment and LiDAR positioning
CDH	No changes	No changes	No changes
EPS	Battery	Beacon and main payload battery sizes were modified.	Weight/availability
FSW	No changes	No changes	No changes
GCS	UI	Moved the plots section to the upper-right corner.	Higher hierarchy section.



System Requirement Summary (1/3)



#	code	Requirement Description	Subsystem
1	C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.	Operational
2	C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Operational
3	C4	After deployment, the Cansat payload and container shall descend at 15 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	Operational
4	C5	At 80% flight peak altitude, the payload shall be released from the container.	Operational
5	C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Operational
6	C7	The payload shall descend at 5 meters/second averaged over the entire descent within +/- 3 meters/sec with the para-glider descent control system.	Operational
7	C8	The payload shall steer toward a target location.	Operational
8	C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Operational
9	C10	The payload shall record video of the release of the payload from the container and the deployment of the para-glider descent control system.	Operational
10	C11	A second video camera shall point at the ground.	Operational
11	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.	Operational



System Requirement Summary (2/3)



#	code	Requirement Description	Subsystem
12	C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat battery and electronics.	Operational
13	S1	The Cansat and container mass shall be 1000 grams +/- 10 grams.	Structural
14	S2	The nose cone shall be symmetrical along the thrust axis.	Structural
15	S8	Cansat structure must survive 15 Gs vibration	Structural
16	S9	Cansat shall survive 30 G shock.	Structural
17	S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Structural
18	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.	Operational
19	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.	Operational
20	E3	An easily accessible power switch through the container is required.	Electrical
21	E5	Power indicator is required.	Electrical
22	X4	The Cansat shall transmit telemetry once per second.	Communications



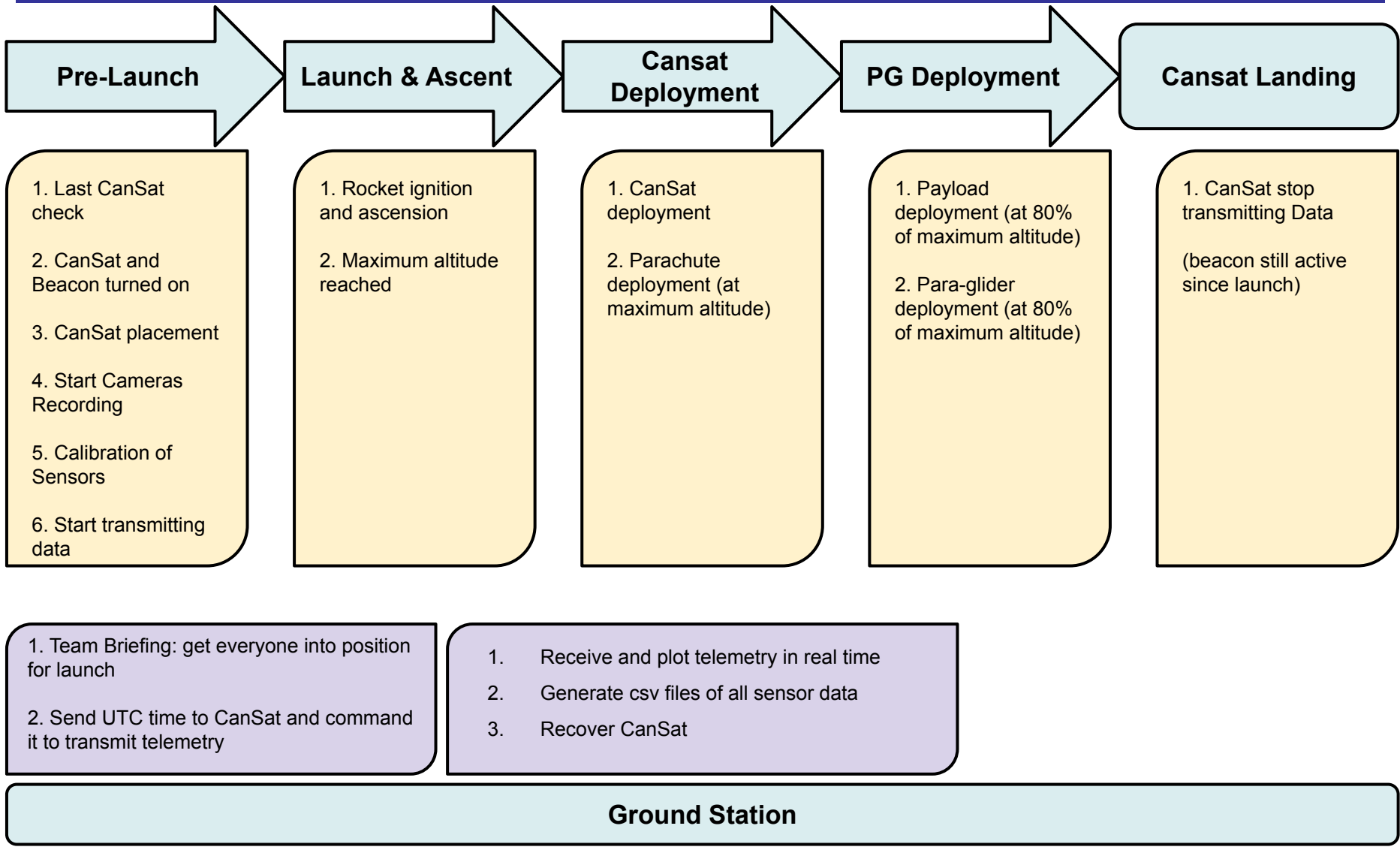
System Requirement Summary (3/3)



#	code	Requirement Description	Subsystem
23	X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Communications
24	SN6	Cansat payload shall video record the deployment of the para-glider at 80% peak altitude.	Sensors
25	G4	Each team shall develop their own ground station.	Ground Station
26	G17	The ground station shall be able to activate al mechanisms on command.	Ground Station



System Concept of Operations (CONOPS) (1/2)



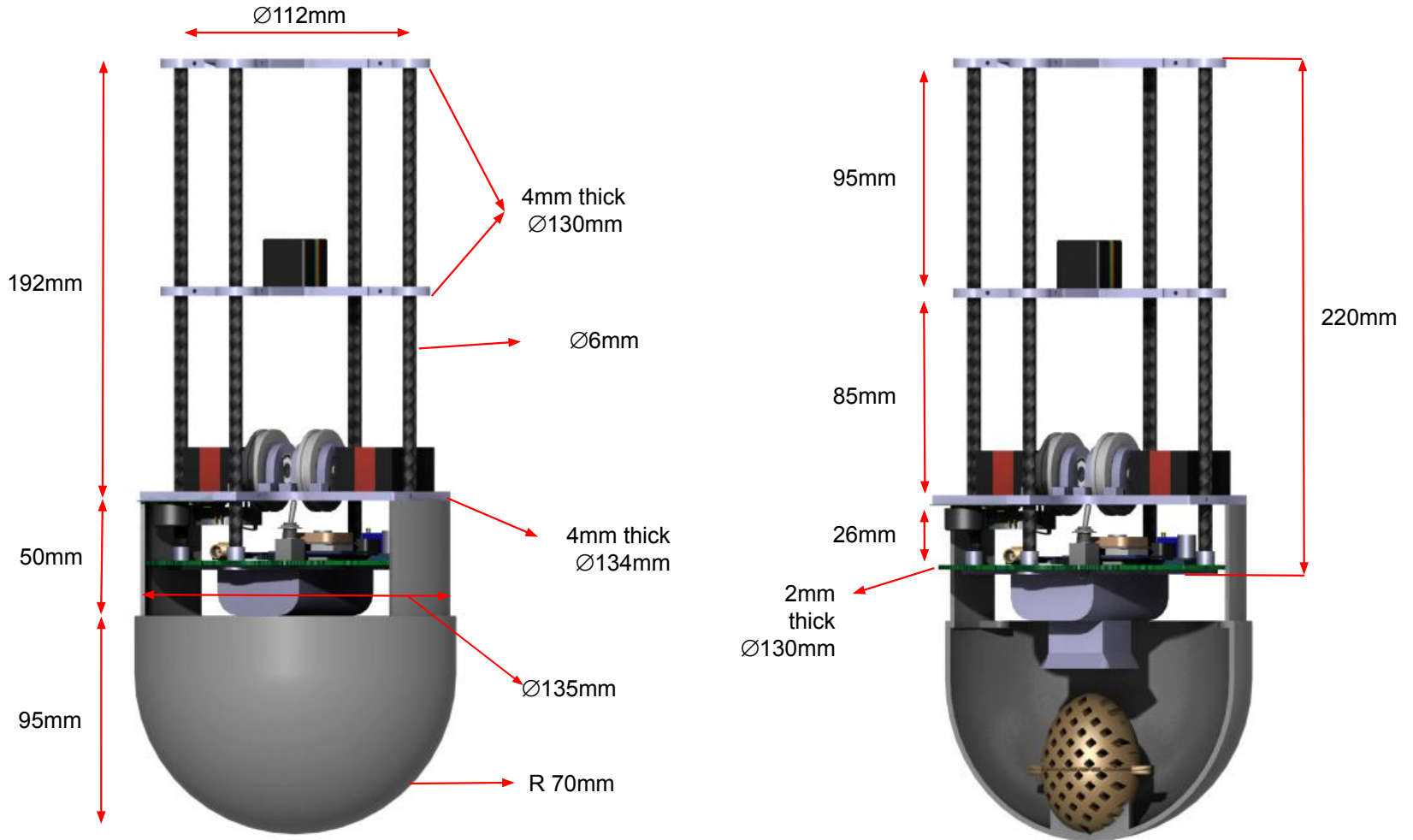


System Concept of Operations (CONOPS) (2/2)

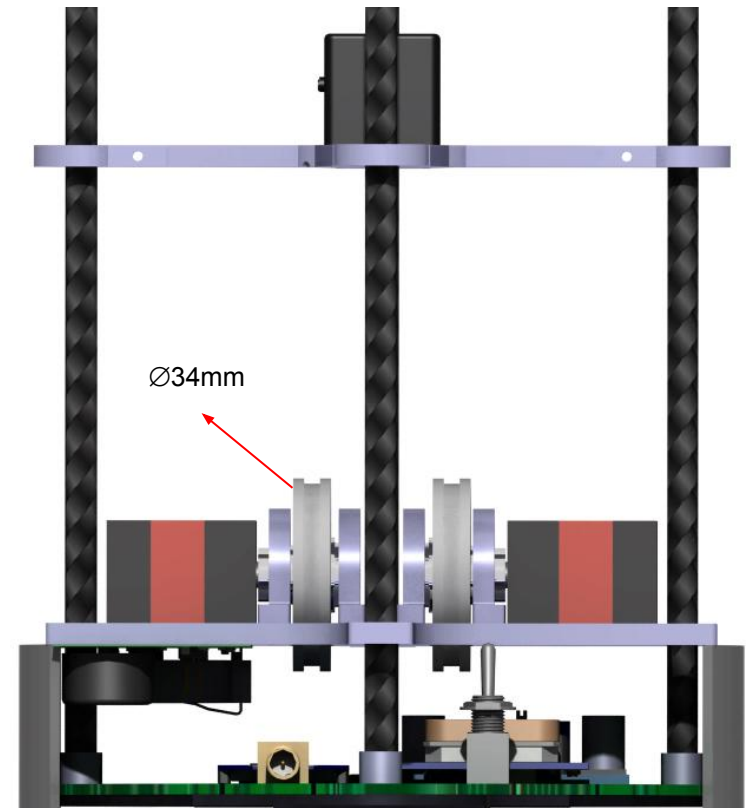
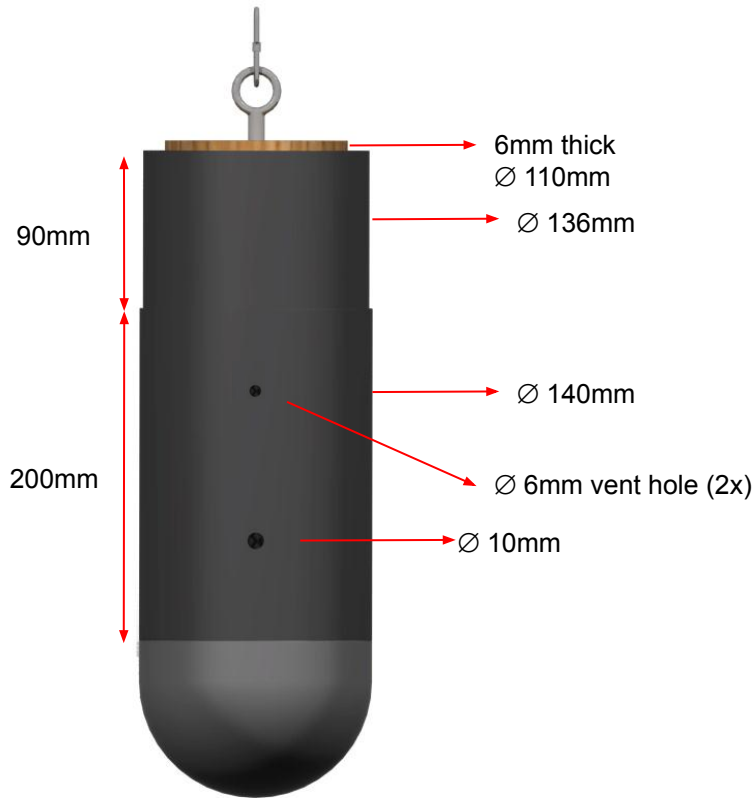


Position	Tasks	Members
Mission Control Officer	<ul style="list-style-type: none">• Manages the Team Launch• Verifies that everything is ready with The Ground Station Crew• Executes the launch procedure with flight coordinator oversight	<ul style="list-style-type: none">• Nicolás Eyaralar
Ground Station Crew	<ul style="list-style-type: none">• Monitor the ground station for telemetry reception• Issue commands to the CanSat.• Performs all required flight operations	<ul style="list-style-type: none">• Matteo Ginhson• Emanuel Agustin Albornoz• Jaime Nazar Anchorena
Recovery Crew	<ul style="list-style-type: none">• Track and recover the CanSat• Interact with field judges• Make sure all field scores are filled in	<ul style="list-style-type: none">• Federico Agustín Pilotto• Ignacio Ferrando Bravo• Nicanor Otamendi
CanSat Crew	<ul style="list-style-type: none">• Prepare the CanSat and integrate it into the rocket• Verifying status before launching	<ul style="list-style-type: none">• Clara Müller• Nazareno German Pierri• Juan Manuel Sambucetti

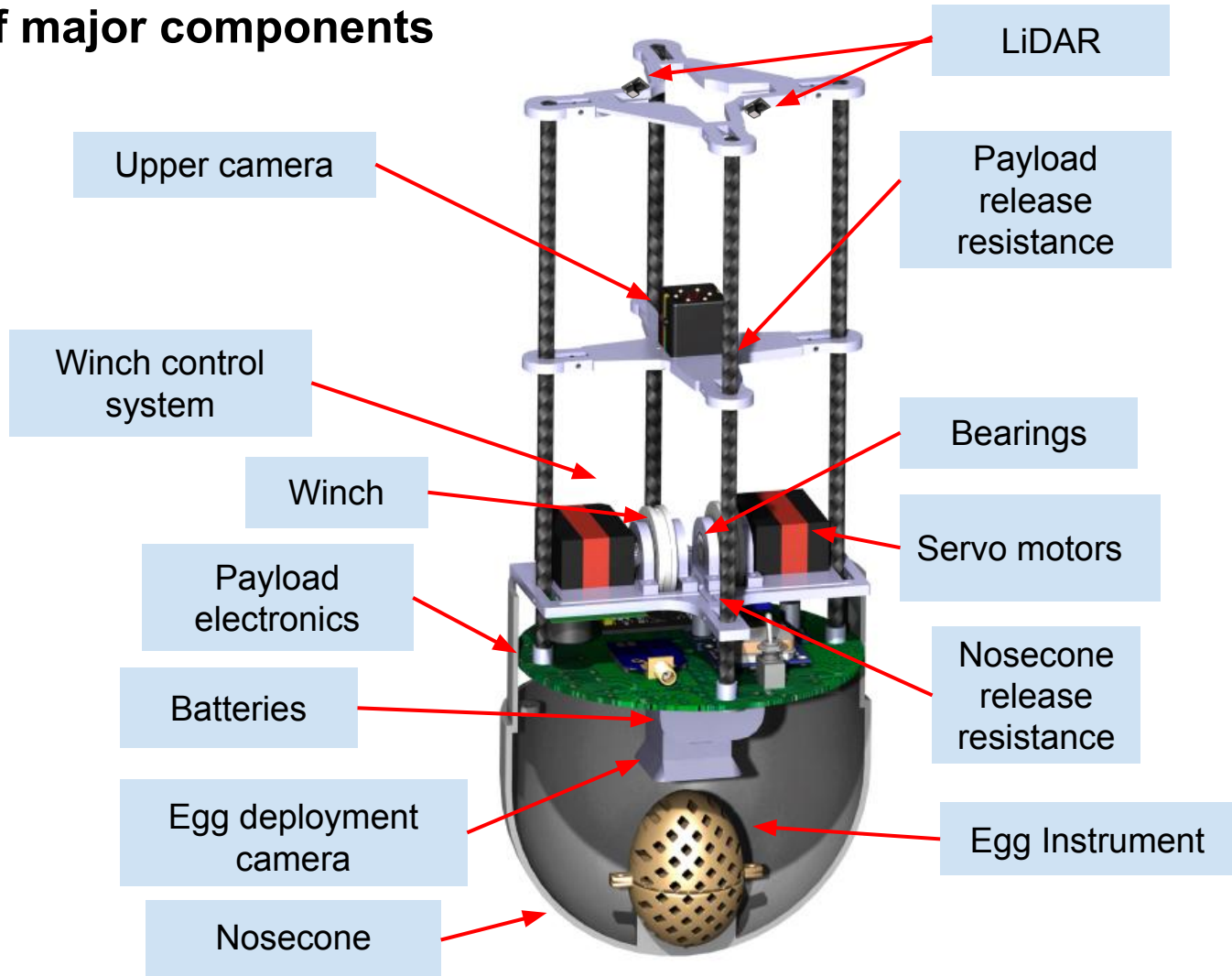
Payload dimensions



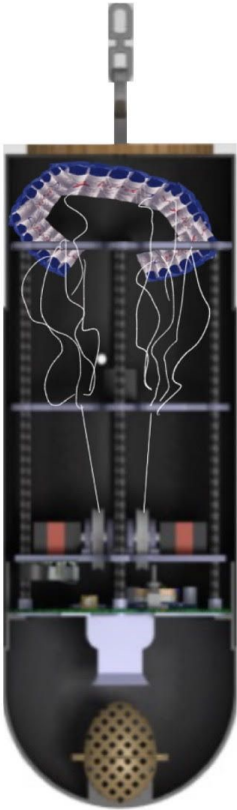
Winch and container dimensions



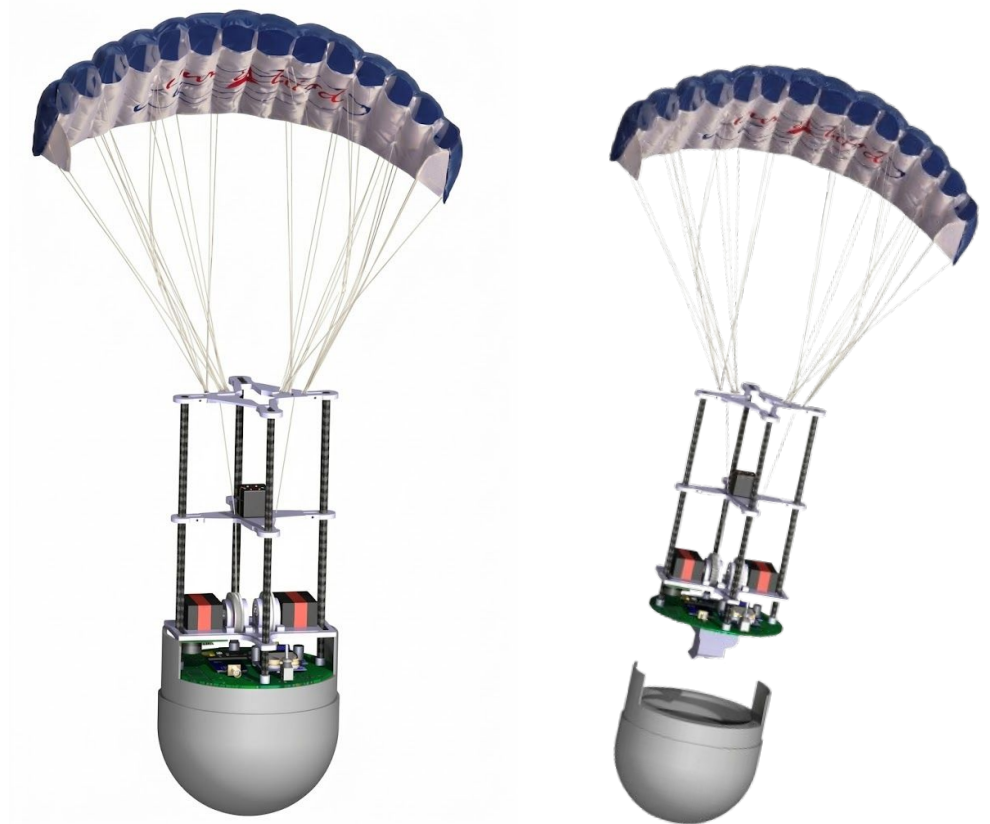
Placement of major components



Launch Configuration (as mounted in the rocket)



Deployed Configuration

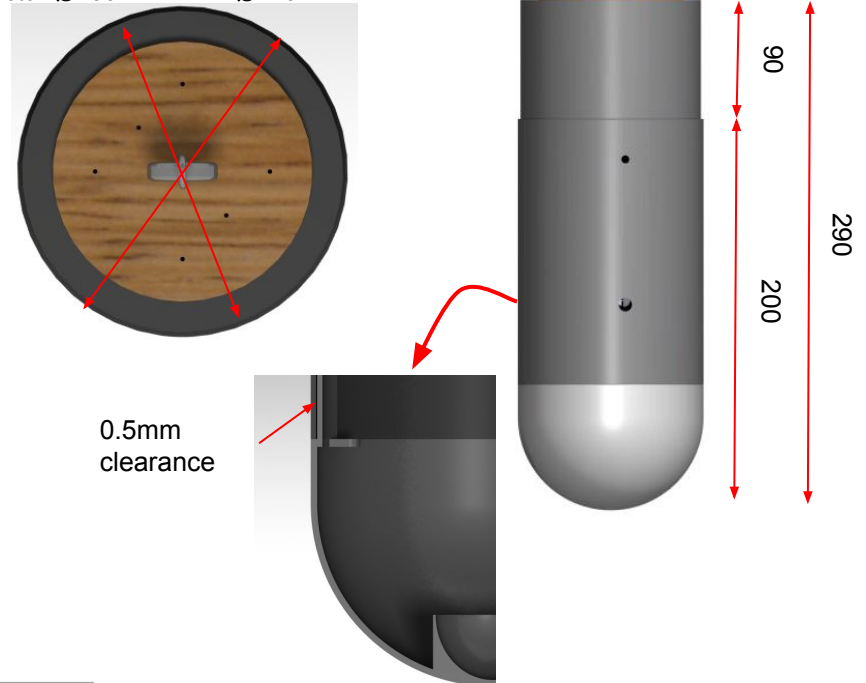


Container and nose cone dimensions and its clearance with the payload

Floors	Container/Nosecone internal diameter	Floor diameter	Clearance
Top	132mm	130mm	2mm
Camera	136mm	130mm	6mm
Winch	136mm	134mm	2mm
Electronics	131mm	130mm	1mm

Internal Container diameter	External shoulder nose cone diameter	Clearance
136mm	135mm	1mm
Container height	Payload height from nosecone shoulder	Clearance
288mm	242mm	46mm

Container Shoulder Diameter $\varnothing 136\text{mm}$ Container Diameter $\varnothing 140\text{mm}$



Dimensions required for launch vehicle compatibility

container shoulder length 90 to 120 mm.

container shoulder diameter 136 mm.

Above the shoulder, container diameter 140 mm

Container shoulder dimension is as required $\varnothing 136\text{mm}$, to fit correctly into the launch vehicle



Sensor Subsystem Design

Emanuel Albornoz
Matteo Ginhson

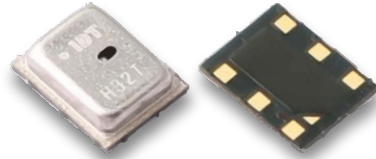
BNO055

Acceleration and rotation rate (IMU)



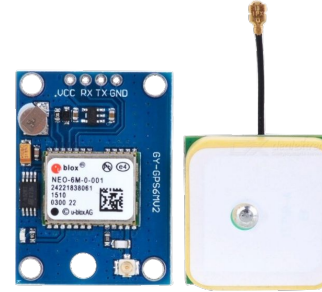
HS3003

Air temperature



Ublox Neo-6M

GNSS receiver



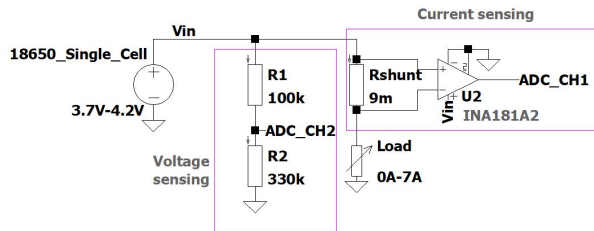
TFS 20-L

LiDar Sensor (Floor detection)



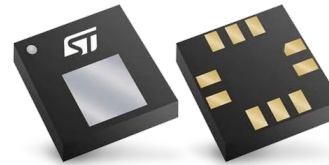
Resistor divider + Shunt + ADC

Battery voltage and current



LPS22HB

Air pressure



Quelima SQ11

Cameras





Sensor Changes Since PDR

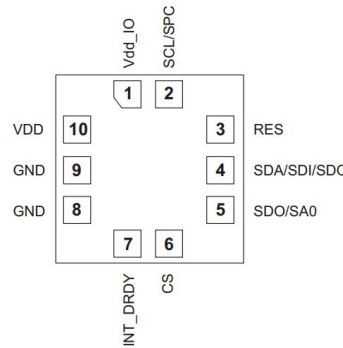
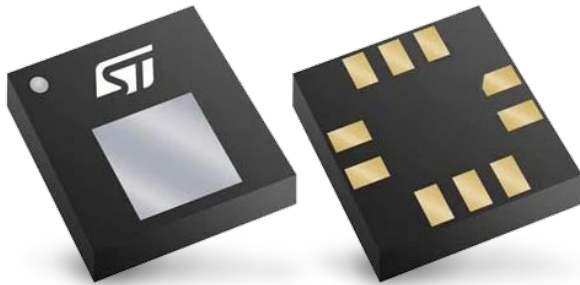


- The Operational Amplifier used for current sensing was changed, and all the values of the resistors calculated based on the EPS.

LPS22HB



MEMS nano pressure sensor: 260-1260 hPa absolute digital output barometer



2mm × 2mm Footprint

[Datasheet](#)

- 260 to 1260 hPa absolute **pressure range**
- ±0.10 hPa **relative accuracy**
- **Current consumption** down to 3 µA
- 4096 LSB/hPa **pressure sensitivity**
- 24-bit pressure **data output format** (in hPa)
- **Supply voltage:** 1.7 to 3.6 V
- **SPI and I2C interfaces**
- **Negligible mass**
- High overpressure capability: 20x full-scale
- Embedded temperature compensation
- Output Data Rate up to 75 Hz
- High **shock survivability:** 22,000 g
- **Negligible mass**

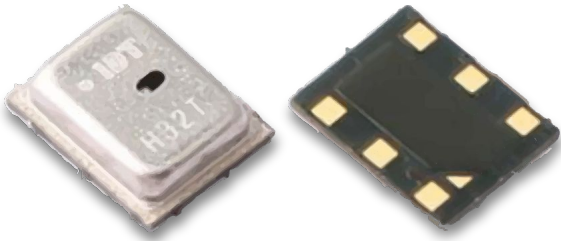
With this standard physics formula, we can convert the pressure reading into a height reference. Where "H" stands for altitude in meters, "P" for the measured pressure (hPa) from the sensor, and "p0" is the reference pressure at sea level (1013.25 hPa).

$$H = 44330 \cdot \left[1 - \left(\frac{P}{p_0} \right)^{\frac{1}{5.25588}} \right]$$

HS3003

RENESAS

High Performance Relative Humidity and Temperature Sensor



[HS300x Datasheet](#)

3mm × 2.41mm Footprint

- -40 to +125 °C **temperature range**
- ±0.25 °C **relative accuracy**
- Average **current consumption** of 24.4 µA
- ±0.015 °C **temperature sensitivity**
- 14-bit temperature **data output format** (in °C)
- **Supply voltage**: 3.3 to 5.5 V
- **I2C interface**
- Negligible **mass**
- Response time¹ constant: 2 sec
- Highly robust protection from harsh environmental conditions and mechanical shock

7.7 Calculating Humidity and Temperature Output

The entire output of the HS3xxx is 4 bytes.

The relative humidity (in percent) and the temperature (in degrees Celsius) are calculated with Equation 1 and Equation 2, respectively.

Equation 2
$$Temperature [^{\circ}C] = \left(\frac{Temperature [15:2]}{2^{14} - 1} \right) * 165 - 40$$

Notes:

1. Response time depends on system thermal mass and air flow
2. Formula retrieved from datasheet

```
if (HAL_OK != HAL_I2C_Mem_Read_IT(&hi2c2, HS3003_ADDRESS << 1,
                                   HS3003_DATA_FETCH,
                                   I2C_MEMADD_SIZE_8BIT, buffer, 4))
{
    error_handler(HS3003_NOT_RESPONDING);
}
```

NEO-6M



Versatile u-blox 6 GPS modules



16mm × 12.2mm Footprint

[NEO-6 Product Summary](#)

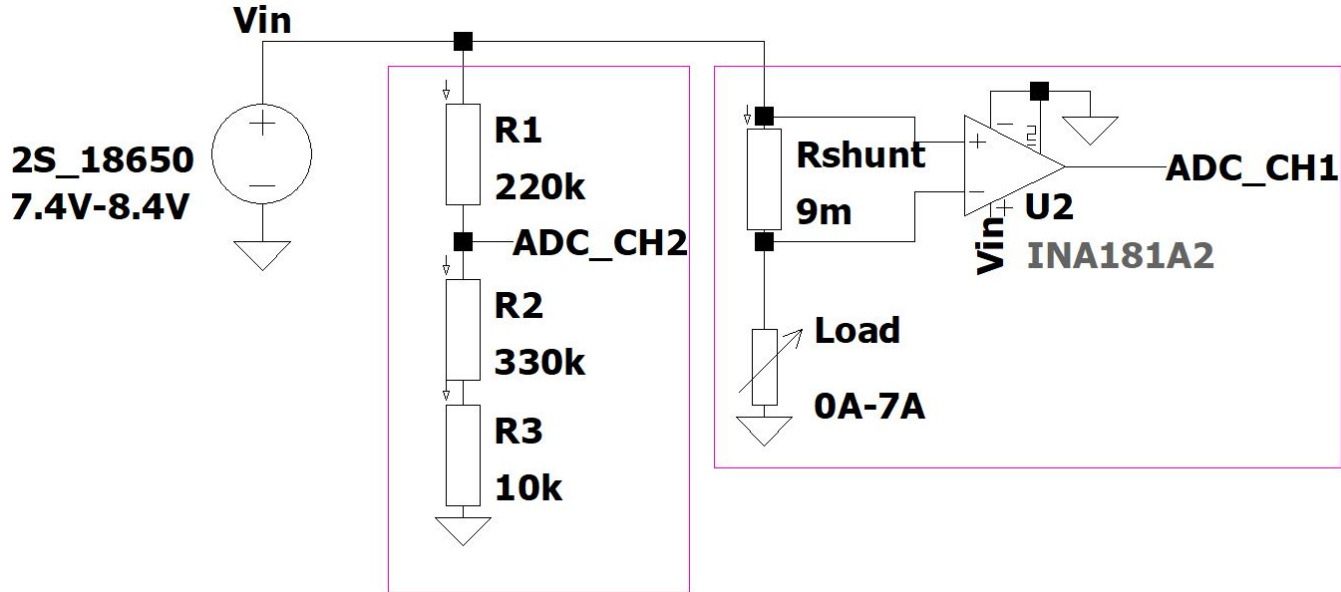
[NEO-6 u-blox 6 GPS Module Datasheet](#)

- UART, USB, DDC (I2C compliant) and SPI **interfaces**
- Based on GPS chips qualified according to AEC-Q100
- Position **accuracy**: 2.5 m CEP and 2 m SBAS
- Average **current consumption** of 37 mA
- **Sensitivity** up to -161 dBm (tracking mode)
- NMEA, UBX binary and RTCM **data output format**
- **Supply voltage**: 2.7 V to 3.6 V
- Navigation **update rate** up to 5 Hz
- Total **weight** 16g (module + antenna)

No data processing is needed on our side:

- We use an NMEA parsing tool called TinyGPSPlus.
- The data is already obtained in the desired format.

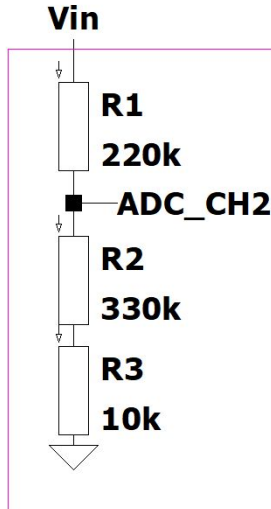
ADC (2 channels) + Voltage divider + Shunt Resistor + Instrumentation OpAmp



For both readings, the μC ADC will be used. It has a resolution of 12 bits, and a range of 0V to 3V3. In both cases, the components values were selected in order to utilize as much of this range as possible.

Voltage sensing

100kΩ and 330kΩ resistors were selected to be used as a voltage divider, in order to adapt the maximum 2S configuration battery voltage (8V4) to the maximum value that can be read by the μC ADC channel (3V3).



As it is seen, the solution can measure the battery's voltage with an accuracy of 2.05mV/LSbit

$$ADC : 0V \rightarrow 0, 3V3 \rightarrow 2^{12} - 1 = 4095$$

$$V_{ADC} = \frac{330k\Omega}{330k\Omega + 100k\Omega + 10k\Omega} V_{bat}$$

$$V_{ADC} = \frac{11}{28} V_{bat}$$

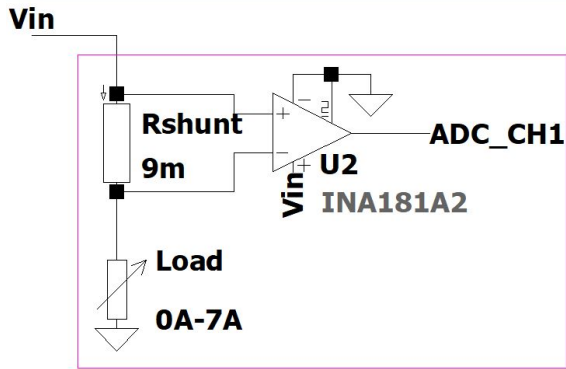
$$V_{bat} = 8V4 \Rightarrow V_{ADC} = 3.3V$$

$$V_{bat} = 7V4 \Rightarrow V_{ADC} = 2.907V$$

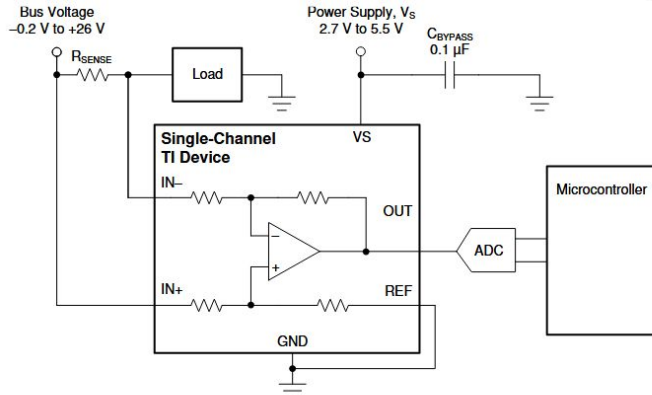
$$3.3V \rightarrow 4095, 2.907V \rightarrow 3608$$

$$\frac{8V4 - 7V4}{4095 - 3608} = 2.05 \frac{mV}{LSbit}$$

Current sensing



The INA181A2 was selected. It is an Instrumentation Operational Amplifier meant for Current Sensing. It has a fixed gain of 50 times. Based on the calculations, the solution gets an accuracy of 3.224mA/LSbit, and the selected Shunt resistor is a 5mΩ 2W 1%. That will allow us to monitor the full current range that can be demanded by the CanSat.



Texas Instrument's recommended implementation

$$ADC : 0V \rightarrow 0, 3V3 \rightarrow 2^{12} - 1 = 4095$$

$$0A \leq I_{load} \leq 7A$$

$$\frac{3V3}{50} = 66mV \Rightarrow \text{At } 7A \text{ we want } (V_{in+} - V_{in-}) = 66mV$$

$$(V_{in+} - V_{in-}) = I_{load} R_{shunt} \Rightarrow 66mV = 7A \cdot R_{shunt}$$

$$\Rightarrow R_{shunt} = 9.42m\Omega \approx 9m\Omega \text{ (Standard value)}$$

$$P_{shunt_{max}} = 9m\Omega \cdot (7A)^2 = 441mW$$

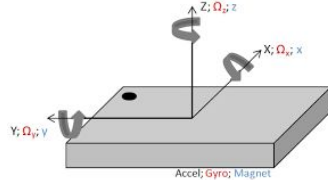
$$9m\Omega \cdot 7A \cdot 50 = 3.15V \rightarrow ADC : 3909$$

$$\frac{7A - 0A}{3909 - 0} = 1.8 \frac{mA}{LSbit}$$

BNO055



6-axis Inertial Measurement Unit for high-performance applications



3mm × 2.4mm Footprint [BNO055 Datasheet](#)
Example code:

```
typedef struct{
    struct {
        unsigned ready : 1;
        unsigned updated : 1;
    }; //Flags as anonymous struct

    //4.3.58
    enum{
        //4.3.59
        enum{
            BNO055_Vector3_t lia;
            BNO055_Vector3_t acceleration;
            BNO055_Vector3_t gyro;
            uint8_t id;
        }BNO055_t;
```

3.3.3.1 IMU (Inertial Measurement Unit)

In the IMU mode the relative orientation of the BNO055 in space is calculated from the accelerometer and gyroscope data. The calculation is fast (i.e. high output data rate).

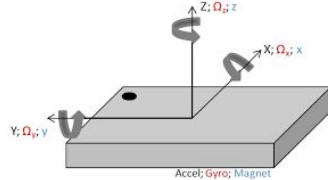
```
if (HAL_OK != HAL_I2C_Mem_Read_IT(&hi2c2, BNO055_ADDRESS << 1,
                                   BNO055_GYRO_DATA_X_LSB_ADDR,
                                   I2C_MEMADD_SIZE_8BIT,
                                   buffer, 6))
{
    error_handler(ERROR_IMU_NOT_RESPONDING);
}
```

- 16-bit triaxial accelerometer, gyroscope, and geomagnetic sensor
- **Ease of use:** Features a **Cortex M0+ microcontroller with Bosch's Sensortec Software**. It implements the calibration and filtering of the raw data, and outputs in either absolute orientation mode (Euler angles, Quaternions) and gravity vectors directly, eliminating the need for complex data processing on our side. **Fusion's IMU Mode will be used.**
- **From ±2g to ±16g accelerometer range.**
- **1024 LSB/g acceleration resolution.**
- **100 Hz acceleration output data rate** (in Fusion's IMU mode)
- **Average current consumption of 12.3 mA** (normal operation)
- **Supply voltage: 2.4 to 3.6 V**
- **HID-I2C, I2C, and UART interfaces, I2C will be used.**
- **Negligible mass**

BNO055



6-axis Inertial Measurement Unit for high-performance applications



3mm × 2.4mm Footprint [BNO055 Datasheet](#)

Example code:

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    struct {
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    //4.3.58
    enum{[]

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    enum{[]
    BNO055_Vector3_t lia;
    BNO055_Vector3_t acceleration;
    BNO055_Vector3_t gyro;
    uint8_t id;
}BNO055_t;
```

```
if (HAL_OK != HAL_I2C_Mem_Read_IT(&hi2c2, BNO055_ADDRESS << 1,
    BNO055_LINEAR_ACCEL_DATA_X_LSB_ADDR,
    I2C_MEMADD_SIZE_8BIT,
    buffer, 6))
{
    error_handler(ERROR_IMU_NOT_RESPONDING);
}
```

- 16-bit triaxial accelerometer, gyroscope, and geomagnetic sensor
- **Ease of use:** Features a **Cortex M0+ microcontroller with Bosch's Sensortec Software**. It implements the calibration and filtering of the raw data, and outputs in either absolute orientation mode (Euler angles, Quaternions) and gravity vectors directly, eliminating the need for complex data processing on our side. **Fusion's IMU Mode will be used.**
- **From ±125 to ±2000 dps gyroscope range**, adjustable based on the required rotation speed.
- **16 LSB/dps gyro sensitivity** (fixed in Fusion's IMU mode)
- **100 Hz gyro output data rate** (in Fusion's IMU mode)
- **0.0625° angular resolution** when outputting Euler Angles.
- **±3° dynamic accuracy**, typical error margin under motion conditions for the rotation vector.
- **Average current consumption of 12.3 mA** (normal operation):
- **Supply voltage: 2.4 to 3.6 V.**
- **HID-I2C, I2C, and UART interfaces, I2C will be used.**
- **Negligible mass**

Quelima SQ11

Mini spy camera



- **Supply voltage:** 3.3V
- **Current consumption:** 120 mA (average)
- **Output format:** MP4 video file
- **Storage:** Internal, 64 GB (SD card)
- **Resolution:** 1280 x 720p
- **Field of View:** 140°
- **Framerate:** 60 FPS
- **Control interface:** Digital (pulses sent from microcontroller)
- **Weight:** 15 g
- **Size:** 23 x 23 x 23 mm
- **Video:** Color

No data processing is needed on our side.

Quelima SQ11

Mini spy camera

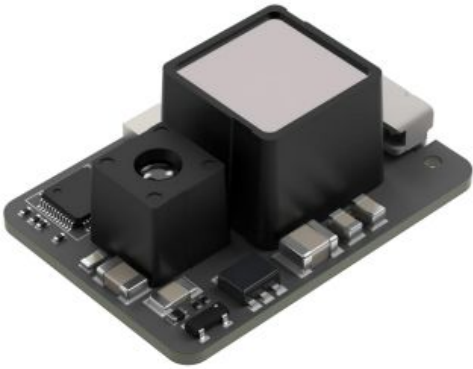


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- **Video:** Color

No data processing is needed on our side.

TFS20-L

LiDar Sensor



- Detection range of 0.2-20m@90% reflectivity@0Klux // 0.2-15m@90% reflectivity@100Klux
- Accuracy of $\pm 6\text{cm}$ (0.2~6m)
- Central wavelength of 905nm, Class 1 Eye-safe
- Powered by 3.3V.
- Communication with UART TTL 3.3V levels.
- Low weight: 1.35g.
- ODR of 250Hz.
- Fixed frame, transmitted at 115200bps 8N1
- Easy to understand frame, the Distance is a 16 bit unsigned number with a resolution of 1cm/LSbit

```
struct{
    uint16_t header;
    uint16_t distance;
    uint16_t strength;
    uint16_t temp;
    uint8_t checksum;
}LiDAR;
```

Byte0-1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
0x59 59	Dist_L	Dist_H	Strength_L	Strength_H	Temp_L	Temp_H	Checksum
Data code explanation							
Byte0	0x59, frame header, same for each frame						
Byte1	0x59, frame header, same for each frame						
Byte2	Dist_L distance value low 8 bits						
Byte3	Dist_H distance value high 8 bits						
Byte4	Strength_L low 8 bits						
Byte5	Strength_H high 8 bits						
Byte6	Temp low 8 bits						
Byte7	Temp high 8 bits						
Byte8	Checksum is the lower 8 bits of the cumulative sum of number of first 8 bytes						

```
HAL_UART_Receive(&huart1, &LiDAR,
    sizeof(LiDAR),1000);
```

Note: To estimate when to release the egg, we measure the distance to the floor by using trigonometry with the output of 2 LiDARs of previously known position inside the CanSat.



Descent Control Design

Ignacio Ferrando Bravo
Clara Müller
Nazareno German Pierri

Deployment mechanism

for all stages:

Fishing line attachment being burnt

Parts:

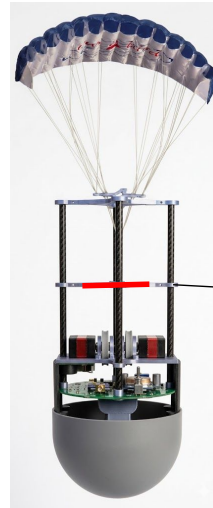
- Parachute
- Paraglider
- Fishing line



Container fitted configuration

(Apogee- 80% apogee height)

- Swivel link to avoid entanglement
- Wood disc to absorb impact

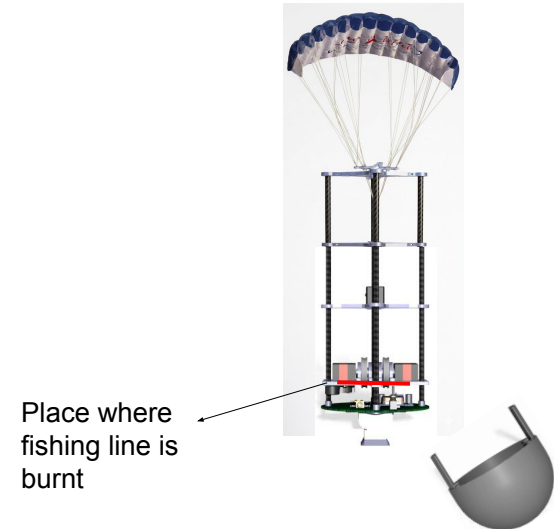


Place where fishing line is burnt

Deployed configuration

(80% apogee height -2m)

- Active control with a servo controlled winch system
- Both speed and steering are controlled by pulling the lines



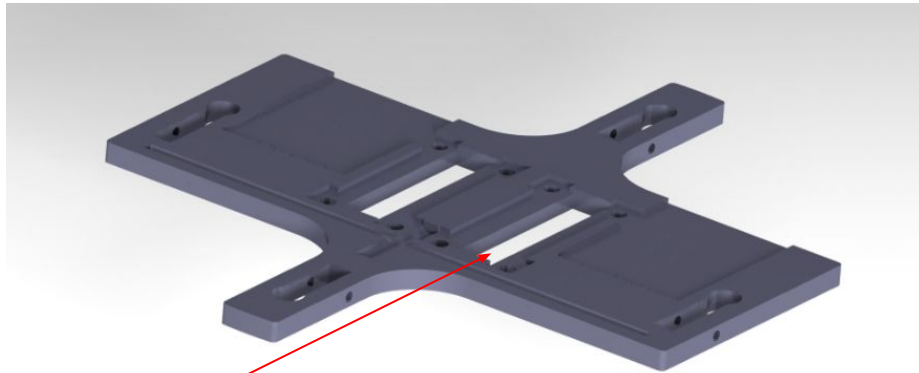
Place where fishing line is burnt

Post nose cone (egg container) deployment configuration

(2m-ground)

- Before the nose cone deploys, the cansat will brake as much as possible
- Nose cone and egg instrument absorb the shock from the impact

Change	Rationale
Winch system floor has been modified to facilitate assembly	Higher reliability of on-off assemblies, more suitable for servo and shaft positioning
Pulleys have been enlarged due to a change in the servo motor after weight reduction, which now only allows 270° rotations	Although they occupy more space, they still meet the required amount of line to be pulled



Slot for bigger pulley

blind slots have been made to secure positioning and repeatable assembly

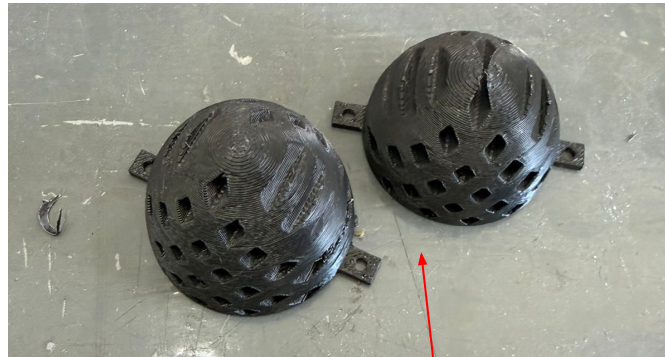
Descent Control Changes since PDR (2/2)

Prototype testing

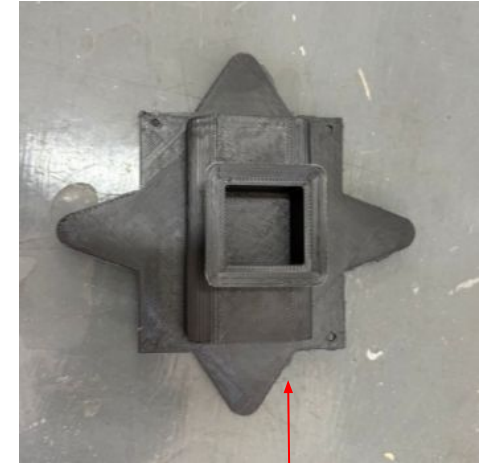
- First parts have been 3D printed, and will be tested along with the para-glider on the following weeks



Upper floor



Egg Container

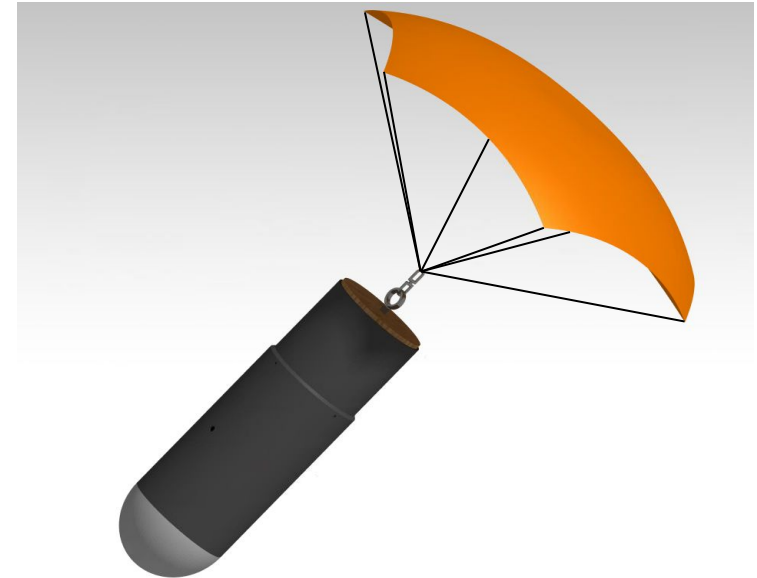


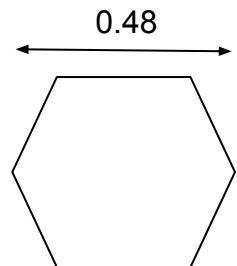
Batteries floor

Guide floor

Servos floor

Decisions	Rationale
Hexagonal shape	<ul style="list-style-type: none"> - Reduces oscillation during freefall - Lightweight & compact - Easy to manufacture
Diameter of 0.48 m	To comply with the required descent rate, according to calculations in the corresponding section.
Bright orange colour	Easily recognizable in long distances
Use of a swivel link	To avoid entanglement
Fishing line	To attach the parachute to the container
Passive nadir stabilisation	Enough to guarantee a stable descent



$$d = \sqrt{\frac{2mg}{\rho C_d 0.6495 v^2}}$$


Decisions	Rationale
Ram-air airfoil	Complies with the competition requirements It ensures an airfoil shape in while descending
1m wingspan and 0.3m chord 15 degree angle of attack	Enough area, lift and drag for maneuverability Complies with fall speed and acceptable horizontal speed Enough length for good maneuverability
Blue colour	Easily recognizable on vegetation





Para-Glider Descent Control Summary (2/5)



- Matlab simulation was implemented to calculate the dimensions of the para-glider
 - Common lift and drag coefficients were placed
 - Final velocity was set
 - Once dimensions were properly calculated and checked, an RC Para-glider (without the control device) was bought considering the dimensions proportionate by the simulation results



Para-Glider Descent Control Summary (3/5)



C:\Users\Usuario\OneDrive\Documents\CanSat\CalculoInverso.m

```
1 clc; clear; close all
2 %% 1. Input Parameters (Requirements and Aerodynamics)
3 m = 1; % Total mass [kg]
4 g = 9.81; % Gravity [m/s^2]
5 rho = 1.225; % Air density at sea level [kg/m^3]
6 V_target = 5; % Desired vertical landing velocity [m/s]
7 %% Typical coefficients for a real paraglider
8 Cd = 1.4; % Drag coefficient (typical 0.3 - 0.6)
9 CL = 1.2; % Lift coefficient (typical 1.0 - 1.5)
10 AR = 5.5; % Aspect Ratio (Span^2 / Area) - Typical 5 to 7
11 %% 2. Required Area Calculation
12 % At equilibrium (Terminal Velocity): Weight = Lift + Drag
13 % m*g = 0.5 * rho * (CL + Cd) * A * V^2
14 % Solving for A:
15 A_target = (2 * m * g) / (rho * (CL + Cd) * V_target^2);
16 %% 3. Geometric Dimensions Calculation
17 % Assuming an elliptical or stylized rectangular shape:
18 % A = b * c_avg where b is wingspan and c_avg is average chord
19 % We also know that AR = b^2 / A -> b = sqrt(AR * A)
20 b_calc = sqrt(AR * A_target); % Wingspan [m]
21 c_avg = A_target / b_calc; % Average chord [m]
22 c_max = (4 * A_target) / (pi * b_calc); % Maximum chord (if it were elliptical)
23 %% 4. Descent Simulation (Verification)
24 h0 = 500; % Initial height [m]
25 V0 = 15; % Initial free-fall velocity [m/s]
26 t_inf = 3.0; % Inflation/deployment time [s]
27 dt = 0.01;
28 t = 0:dt:100;
29 V = zeros(size(t));
30 h = zeros(size(t));
31 V(1) = V0;
32 h(1) = h0;
33 for i = 1:length(t)-1
34 % Progressive area inflation
35 if t(i) <= t_inf
36 A_inst = A_target * (t(i)/t_inf)^2;
37 else
38 A_inst = A_target;
39 end
40
```

C:\Users\Usuario\OneDrive\Documents\CanSat\CalculoInverso.m

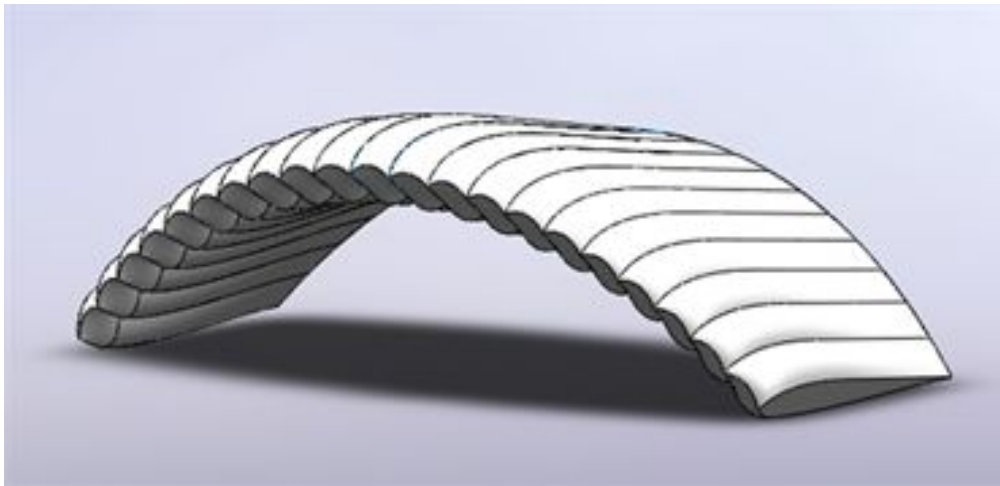
```
36 A_inst = A_target * (t(i)/t_inf)^2;
37 else
38 A_inst = A_target;
39 end
40
41 %% Forces
42 Drag = 0.5 * rho * Cd * A_inst * V(i)^2;
43 Lift = 0.5 * rho * CL * A_inst * V(i)^2;
44
45 a = g - (Drag + Lift)/m;
46
47 V(i+1) = max(V(i) + a*dt, 0);
48 h(i+1) = h(i) - V(i)*dt;
49
50 if h(i+1) <= 0, break; end
51 end
52 %% Trim vectors at impact
53 t = t(1:i+1); V = V(1:i+1); h = h(1:i+1);
54 %% 5. Display Results
55 fprintf('--- RESULTING DESIGN ---\n')
56 fprintf('Required Area: %2f m^2\n', A_target)
57 fprintf('Wingspan (b): %2f m\n', b_calc)
58 fprintf('Average Chord: %2f m\n', c_avg)
59 fprintf('Max Chord (est.): %2f m\n', c_max)
60 fprintf('-----\n')
61 fprintf('Final velocity reached: %2f m/s\n', V(end))
62 %% 6. Plots
63 figure('Name', 'Design Analysis')
64 subplot(2,1,1)
65 plot(t, V, 'r', 'LineWidth', 2); grid on;
66 ylabel('Velocity (m/s)'); title('Velocity Evolution (Braking)');
67 subplot(2,1,2)
68 plot(t, h, 'b', 'LineWidth', 2); grid on;
69 ylabel('Height (m)'); xlabel('Time (s)');
```

Command Window

```
--- RESULTING DESIGN ---
Required Area: 0.25 m^2
Wingspan (b): 1.16 m
Average Chord: 0.21 m
Max Chord (est.): 0.27 m
-----
Final velocity reached: 5.00 m/s
```

- **Para-glider characteristics**

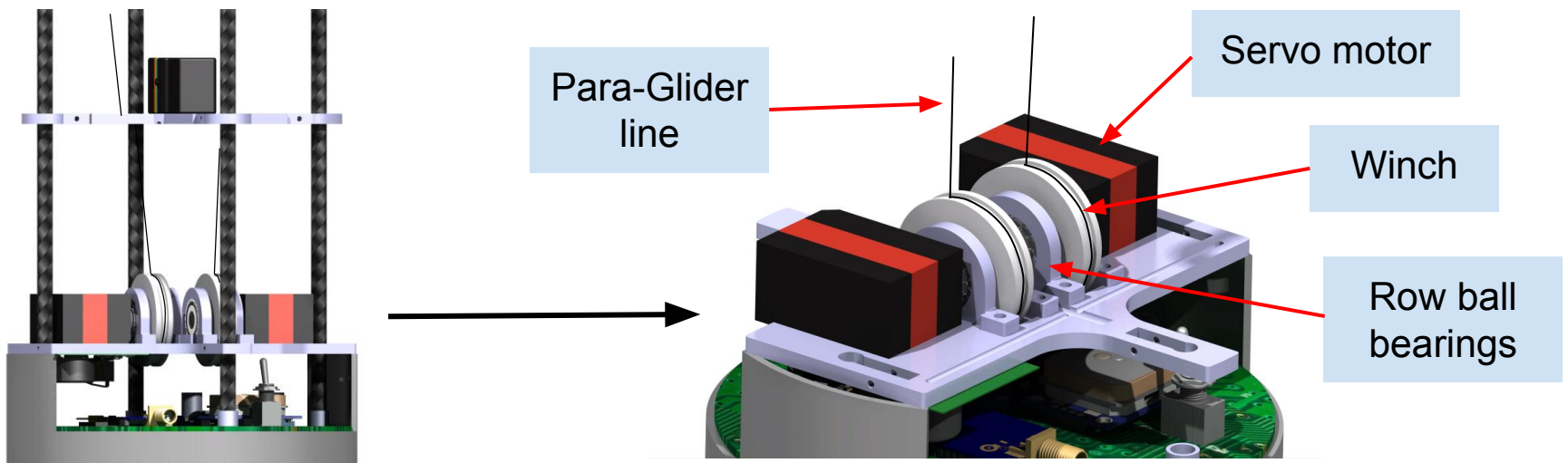
- Blue colour
- Ram-air airfoil
- 0.3 meters of chord, with a wingspan of 1 meter
- As soon as glider is deployed, air enters airfoil and gets inflated, turning into an actuating airfoil.
- Open cells gives high C_d , balancing forces to produce the necessary lift to maintain flight procedure.



Steering

Servo motors allow winch to roll up the line within itself to pull on one line or the other making the shape of the paraglider lean to that side.

This allows a linear control on the steering of the paraglider.





Para-Glider Descent Speed Control Design (1/3)



- **Speed control**

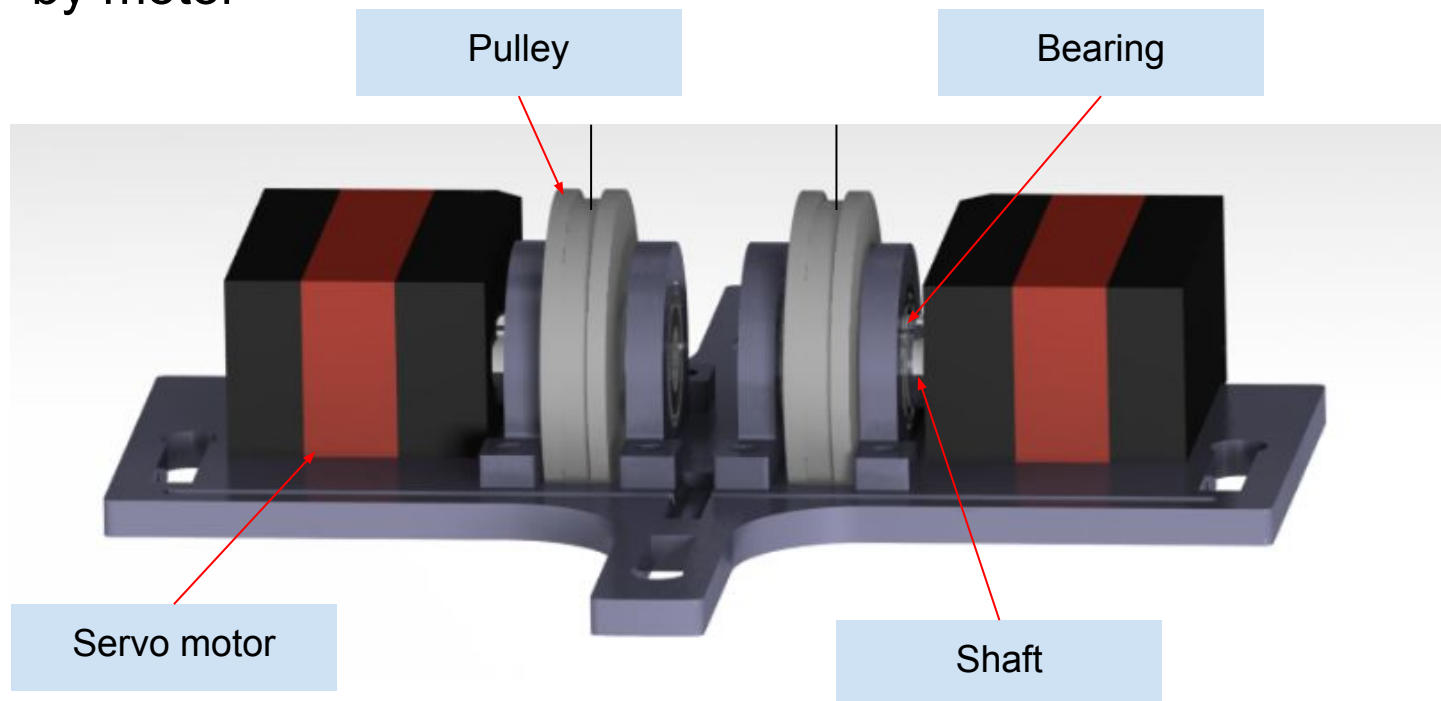
- Servo controlled winch system
- Software will detect variations in target descent speed, and will control servo to pull both lines at the same time
 - more resistance is created and speed is decreased
- Servos are connected to winch system, that pulls line when turning or braking is needed

- **Stability control**

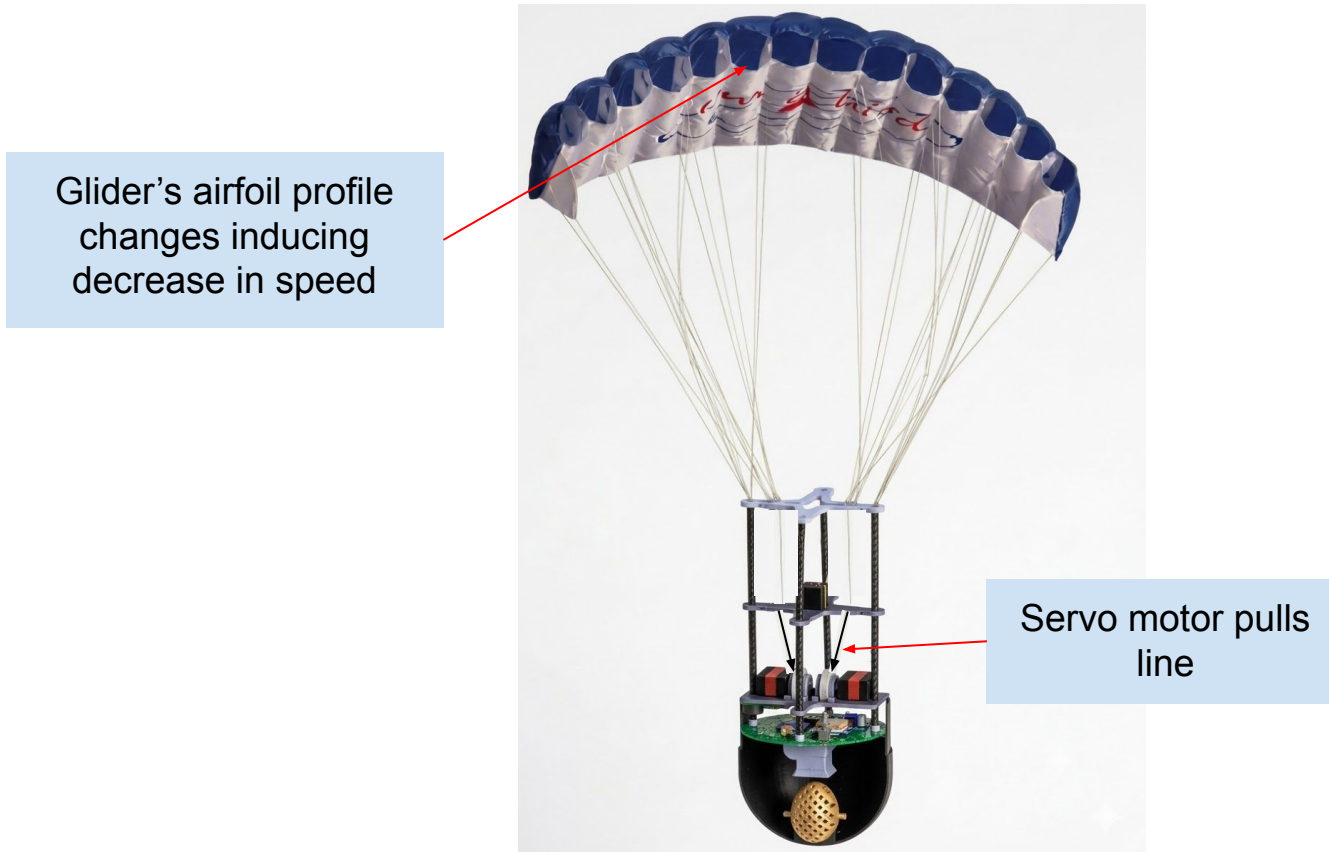
- A low center of mass provides vertical axis stabilization, damping destabilization created by the turning procedures
 - passive stabilization ensures reliable performance and better understanding of the flight behaviour

- **Winch system**

- Two independent servo motors are placed symmetrically, connected to shafts which have pulleys fitted on to them
- Glider line is attached to the shaft, pulling when this one is rotated by motor



- **Deployed para-glider configuration**
 - descent speed control

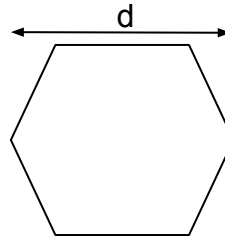


Assumptions

- Steady state descent
- $g = 9,81 \text{ m/s}^2$
- No wind
- Drag = Weight at terminal velocity
- Peak altitude = 700 m

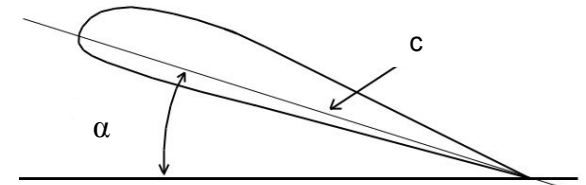
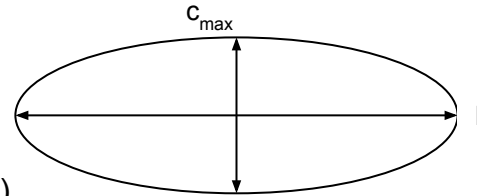
Container parachute

- $m_1 = 1 \text{ kg}$
- $\rho_1 = 1.15 \text{ kg/m}^3$ (at 700m)
- $A_1 = 3\sqrt{3}/8 d^2 = 0,6495 d^2$
- $Cd_1 = 0.8$ (should be experimentally verified)



Payload paraglider

- $m_2 = 0.70 \text{ kg}$
- $\rho_2 = 1.225 \text{ kg/m}^3$
- $A_{Planar} = \frac{\pi}{4} b c_{max}$ (Area of paraglider seen from below)
- $A_{Ef} = A_{Planar} \cos(\alpha)$ (Effective area after taking into account α)
- $Cd_2 = 1.5$ (should be experimentally verified)



Variables
m : Mass
g : Acceleration of the Earth
ρ : Density of the Air
v : Terminal Velocity
Cd : Drag Coefficient
C_L = Lift Coefficient
A : Area
b = para-glider wingspan
c = para-glider chord
d = length of the diagonal of the hexagon
α = angle of attack



Descent Rate Estimates (2/5)



Equations

Container parachute

$$F_{\text{gravity}} = F_{\text{drag}} + F_{\text{lift}} \quad mg = \frac{1}{2} \rho v^2 C_d A + 0$$

$$v = \sqrt{\frac{2mg}{\rho C_d 0.6495 d^2}}$$

$$d = \sqrt{\frac{2mg}{\rho C_d 0.6495 v^2}}$$

Payload paraglider

$$F_{\text{gravity}} = F_{\text{drag}} + F_{\text{lift}}$$

$$mg = \frac{1}{2} \rho C_d A v^2 + \frac{1}{2} \rho C_L A v^2$$

$$C_L = \frac{2mg}{\rho A v_{\text{target}}^2} - C_d$$

Variables

m : Mass

g : Acceleration of the Earth

ρ : Density of the Air

v : Terminal Velocity

C_d : Drag Coefficient

A : Area

b = para-glider wingspan

c = para-glider chord

d = length of the diagonal of the hexagon

α = angle of attack

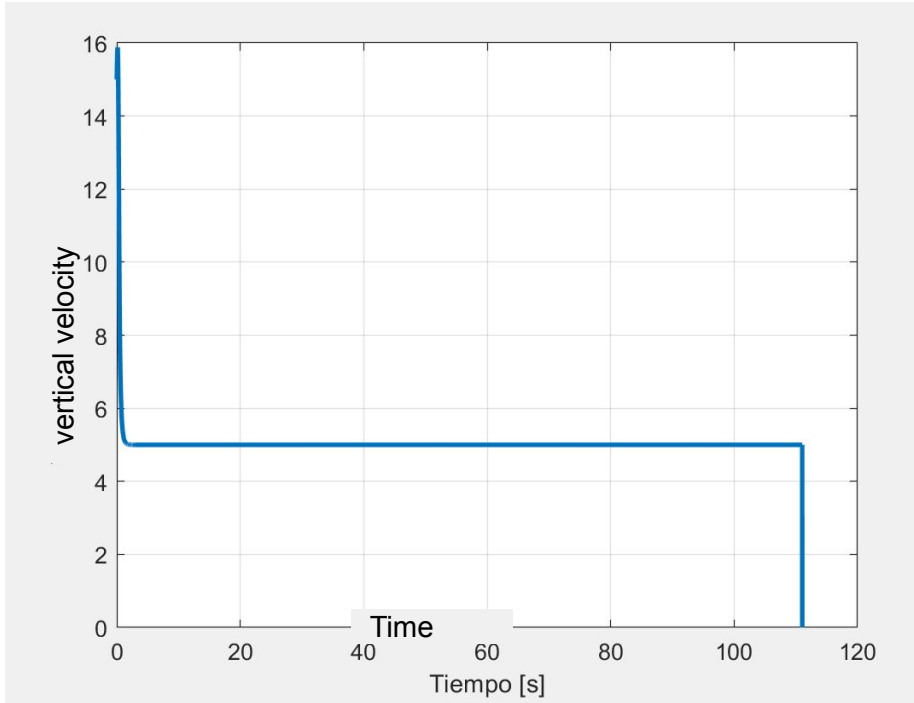


Descent Rate Estimates (3/5)

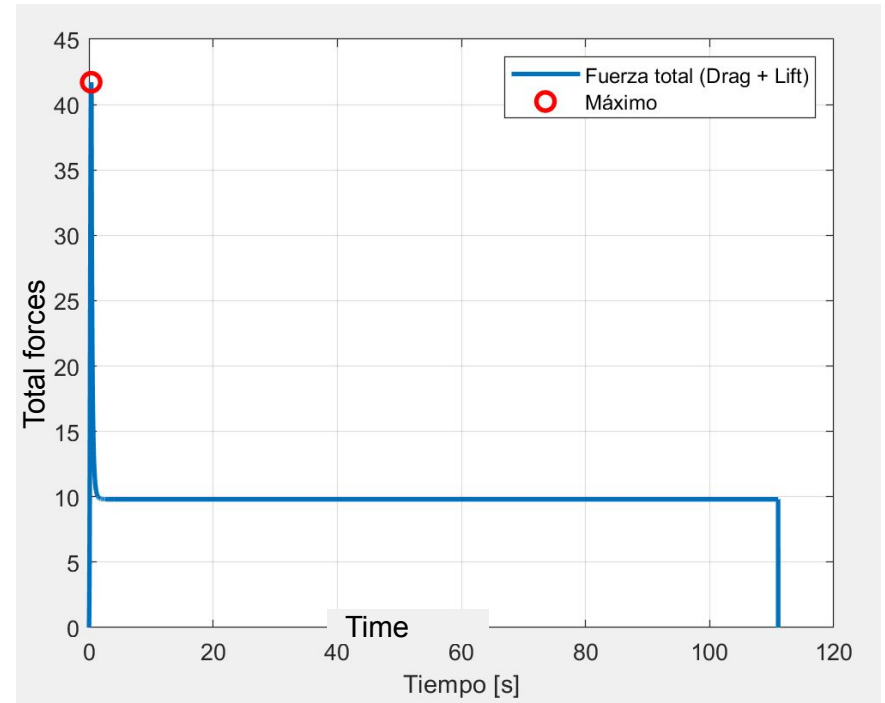


Parachute	Para-glider
<p>The descent rate should be 15 m/s \pm 3 m/s Dimensioning for 12 m/s to have a margin: d = 0.4775 m</p> <p>We choose d = 0,47 m for ease of assembly</p> <p>v = 12.19163 m/s</p>	<p>A simulation was performed including gravity, aerodynamic drag and lift, and a parachute inflation time of 0.4 s. The paraglider geometry was adjusted to ensure the descent velocity converges to the target value after inflation.</p> <p>b = 1.0 m c_{max} = 0.3 m $\alpha = 15^\circ$</p> <p>The lift coefficient was adjusted to meet the target descent velocity:</p> <p>C_L = 1.31</p> <p>These values provide sufficient aerodynamic area to reach the target descent velocity while keeping the system compact and easy to assemble.</p> <p>Final descent velocity:</p> <p>v = 4.6 m/s</p>

The forces and velocity variations were evaluated on a series of iterations of 0.1s to see the different points of interest during the descent.
This also provides a continuous analysis of the variables.



Vertical velocity throughout the descent



Total forces throughout the descent

Paraglider pulleys dimensioning

$$d_p = \frac{2 \cdot \Delta L}{\varphi}$$

For an approximation value the following expression is used:

$$\Delta L \approx \frac{b}{2} \tan(\theta) \longrightarrow \Delta L \approx \frac{b}{2} \theta$$

Taking $\theta = 9^\circ$ as a starting value $\longrightarrow \theta = 0.15708$ rad

$$\Delta L = 78.54 \text{ mm}$$

$$d_p = 33.33 \text{ mm}$$

Variables
ΔL : line pulled for an effective turn
d_p : pulley diameter
b : para-glider wingspan
θ : desired turning angle (rad)
φ : servo maximum turning angle (rad)

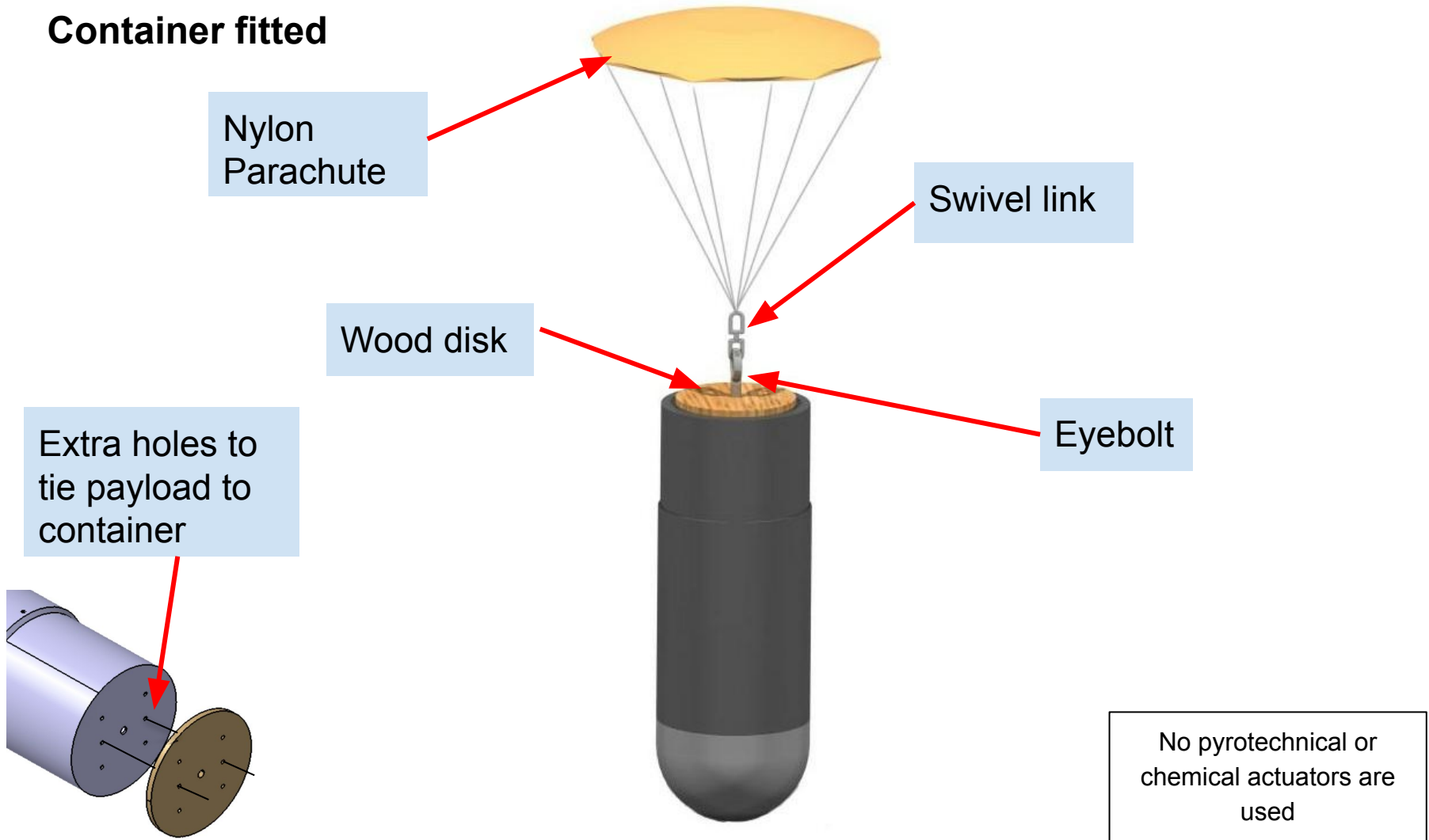
It is important to note that these values are approximations and that they shall be adjusted accordingly after testing.



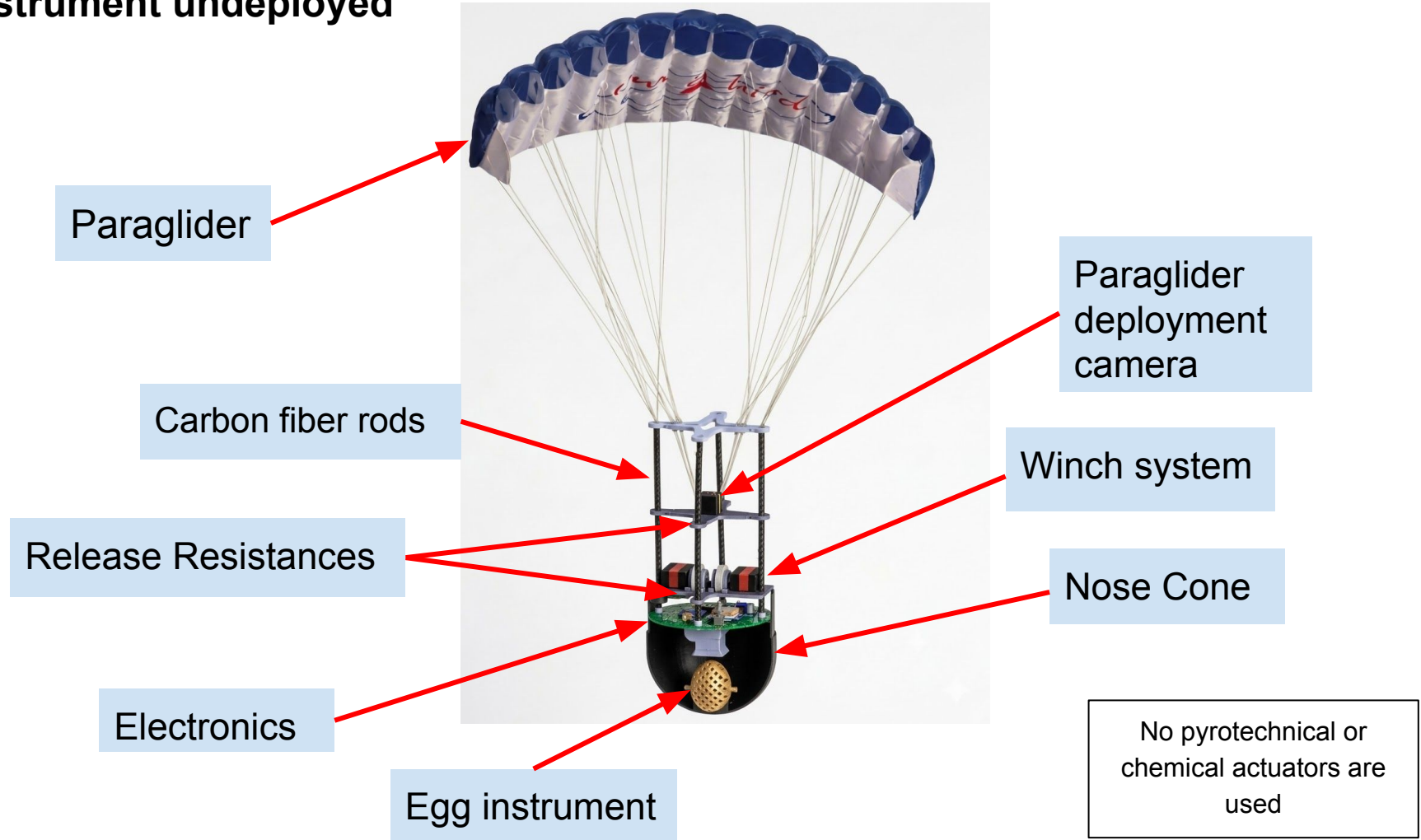
Mechanical Subsystem Design

Federico Agustín Pilotto
Ignacio Ferrando Bravo
Nazareno German Pierri
Clara Müller
Nicanor Otamendi
Nicolás Eyaralar

Container fitted



Instrument undeployed





Mechanical Subsystem Overview (3/3)



Materials

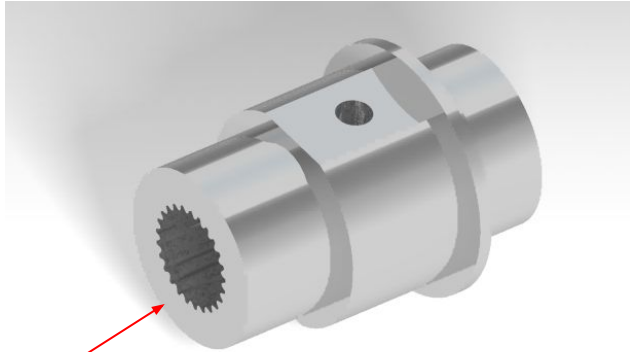
Part	Material
Container, Floors, Nosecone, camera support, battery support, rod positioners and bearing supports	ABS
Eyebolt support disk	Plywood
Structural rods	Carbon fiber
Paraglider	210T plaid Cloth
Parachute	Nylon
Bolts and nuts, eye bolt, swivel link, bearings	Steel
Winches and shafts	Aluminium



Mechanical Subsystem Changes Since PDR (1/2)

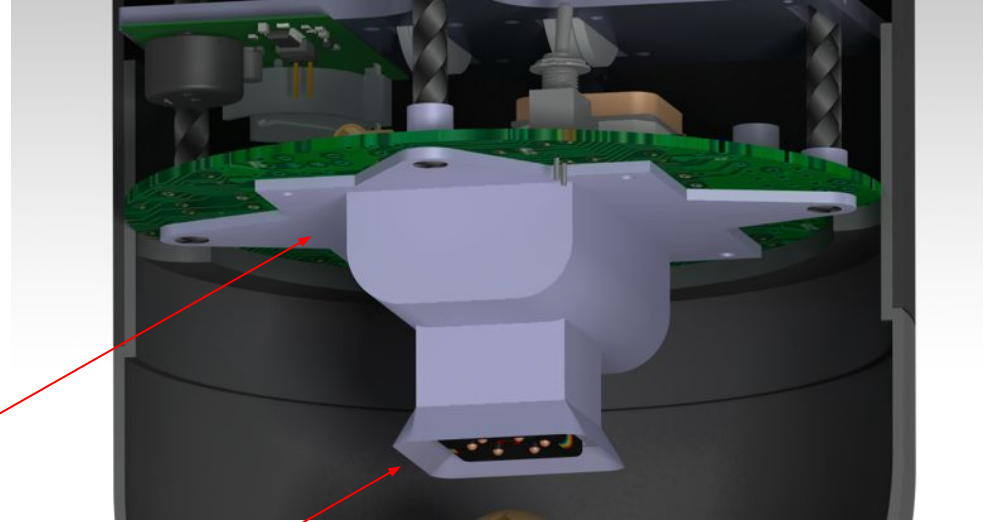


Change	Rationale
Hardware floor has been eliminated, adapting the PCB to act as a replacement	Lighter weight, and easier assembly procedure
Descent pointing camera support has been amplified	To make it more robust upon impact
Camera support has been attached to the batteries support	Avoid complex assembly, reduce weight, and increase rigidity
Batteries platform is extended to position rods and fix them	Secure positioning while fixing floor to the rods, while saving weight
Spline has been added to and end of the shaft to couple with servo motor	Ensure correct transmission of torque, and facilitate assembly
The servo motor selection was changed to a lighter and smaller one	Although current one only allows 270° rotations, a weight reduction was necessary and the required torque is still met
Upper floor's new design is thinner and has a two inclined planes to place the two LiDARs	Better view for LiDAR to reference the ground and paraglider deployment camera, and lighter weight

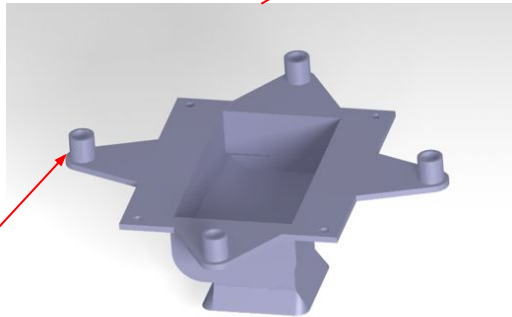


spline

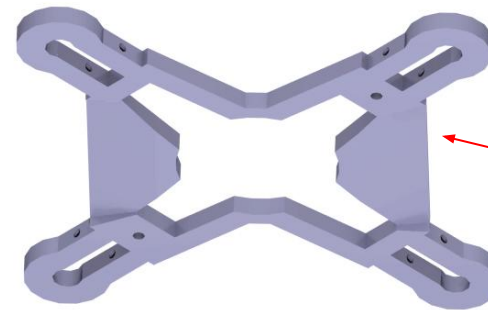
Winch shaft



Camera Support



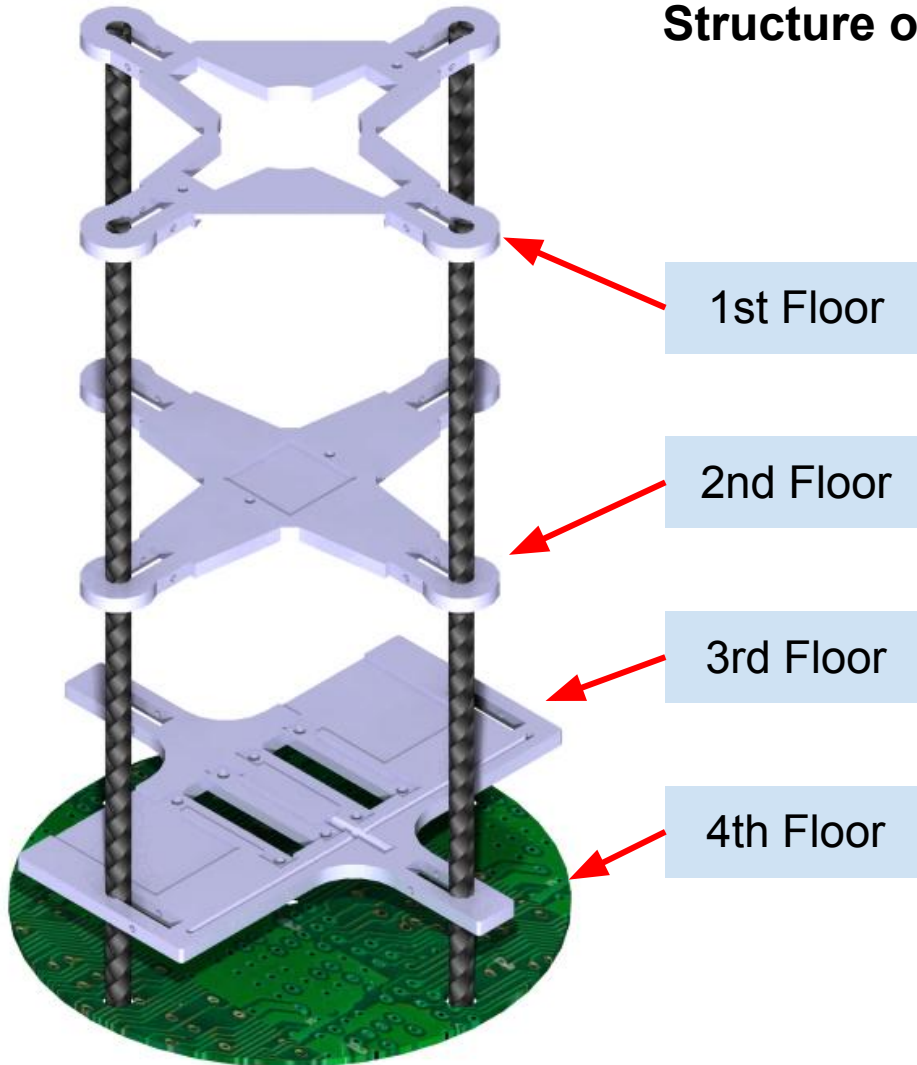
Rod fixer and positioner



inclined
planes

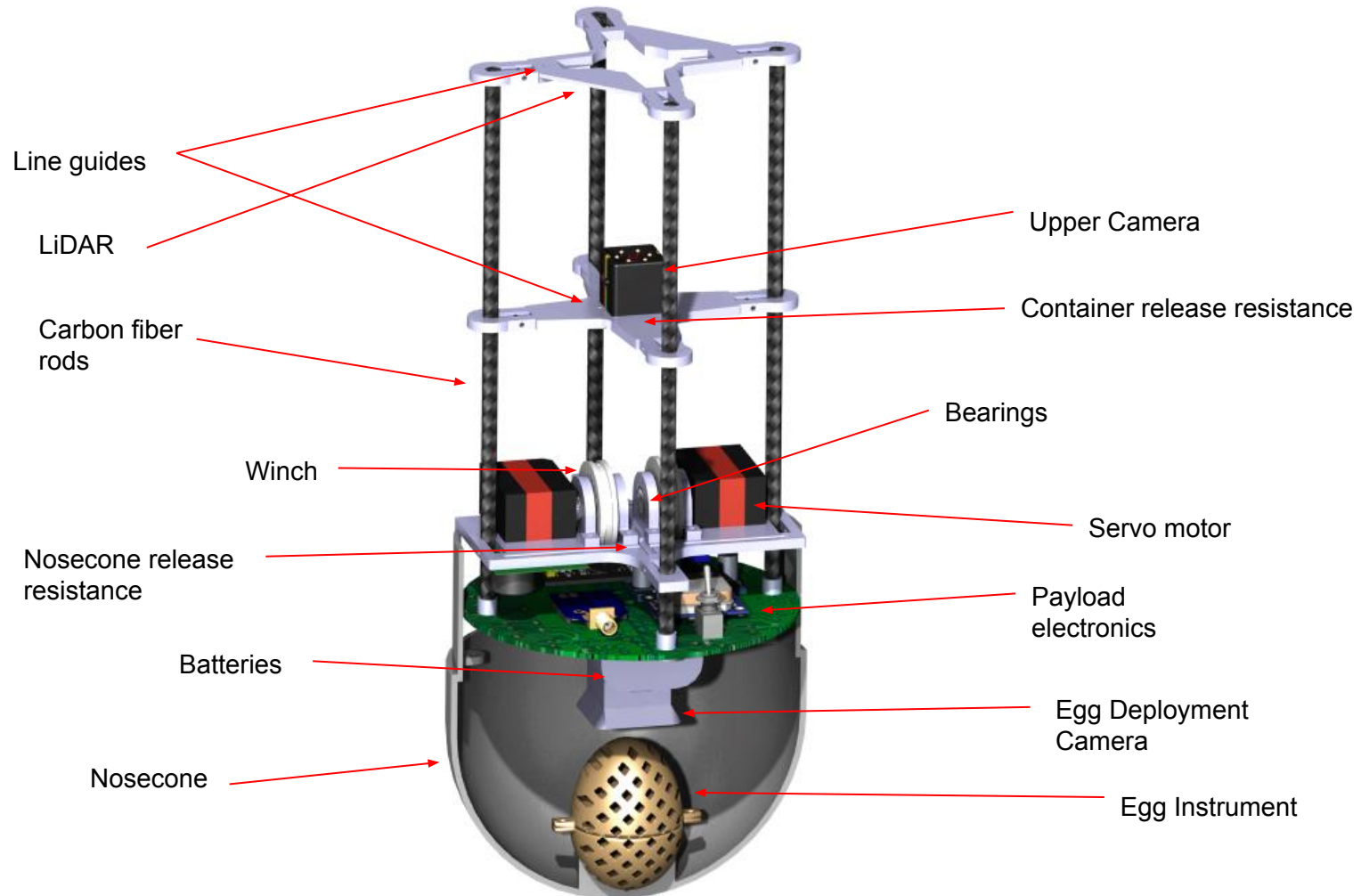
Upper Floor

Structure of payload

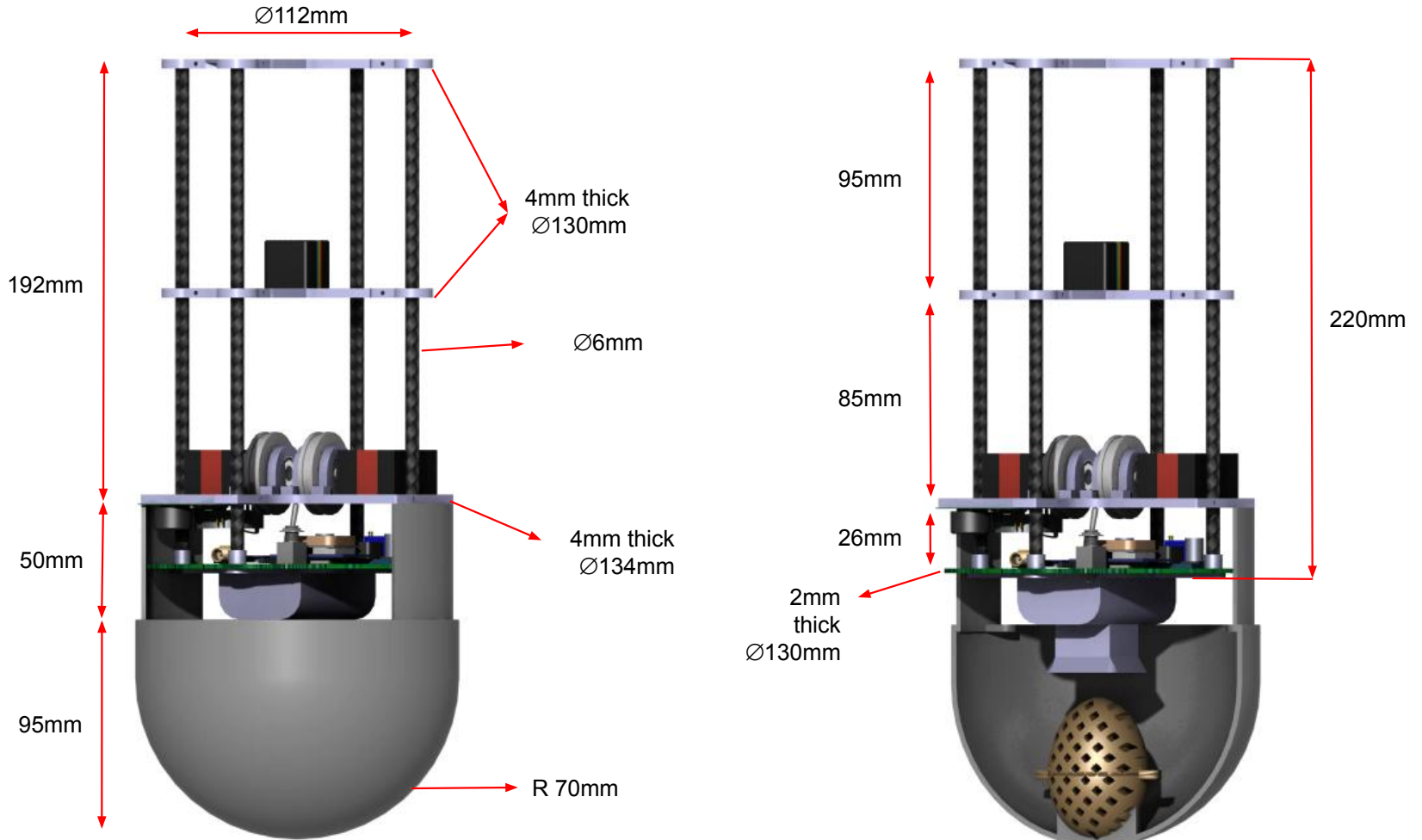


Floors	Components
1st Floor	Paraglider, LiDAR
2nd Floor	Upper Camera and container release resistance
3rd Floor	Winch control system, nosecone release resistance and beacon.
4th Floor	Electronic components, batteries, egg deployment camera and kill switch

Components Layout



Payload dimensions





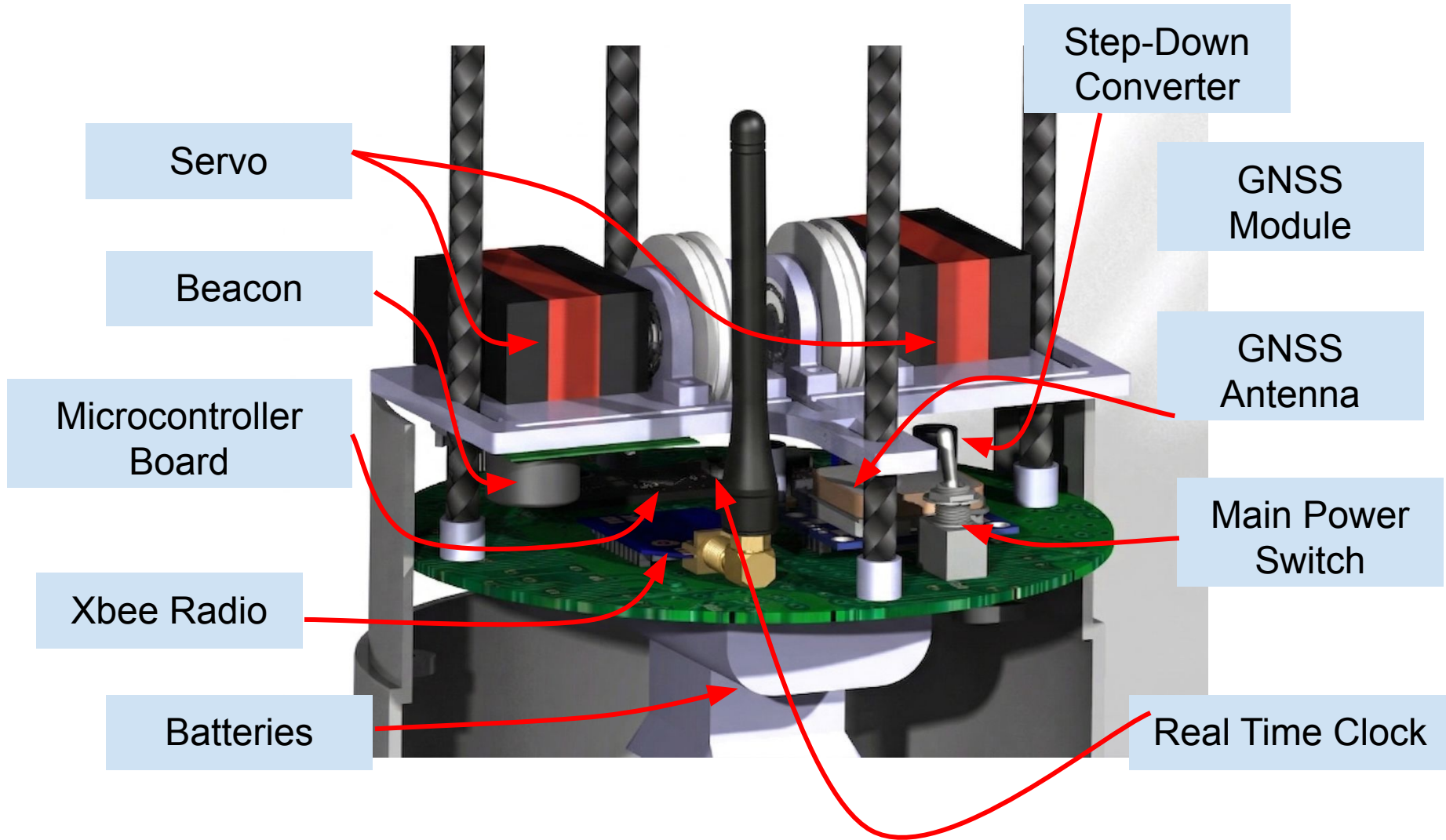
Cansat Mechanical Layout of Components (4/5)

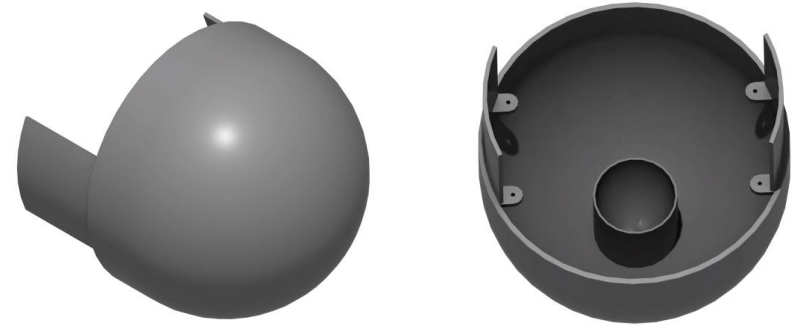
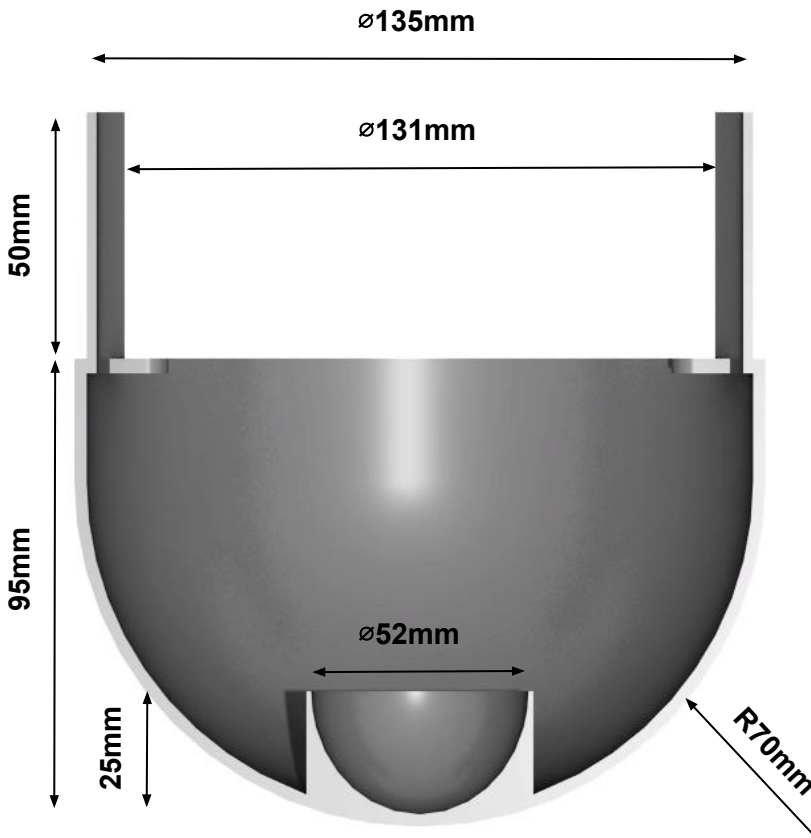


Structural materials

Part	Material
Structural rods	Carbon fiber
Floors	ABS
PCB	FR4

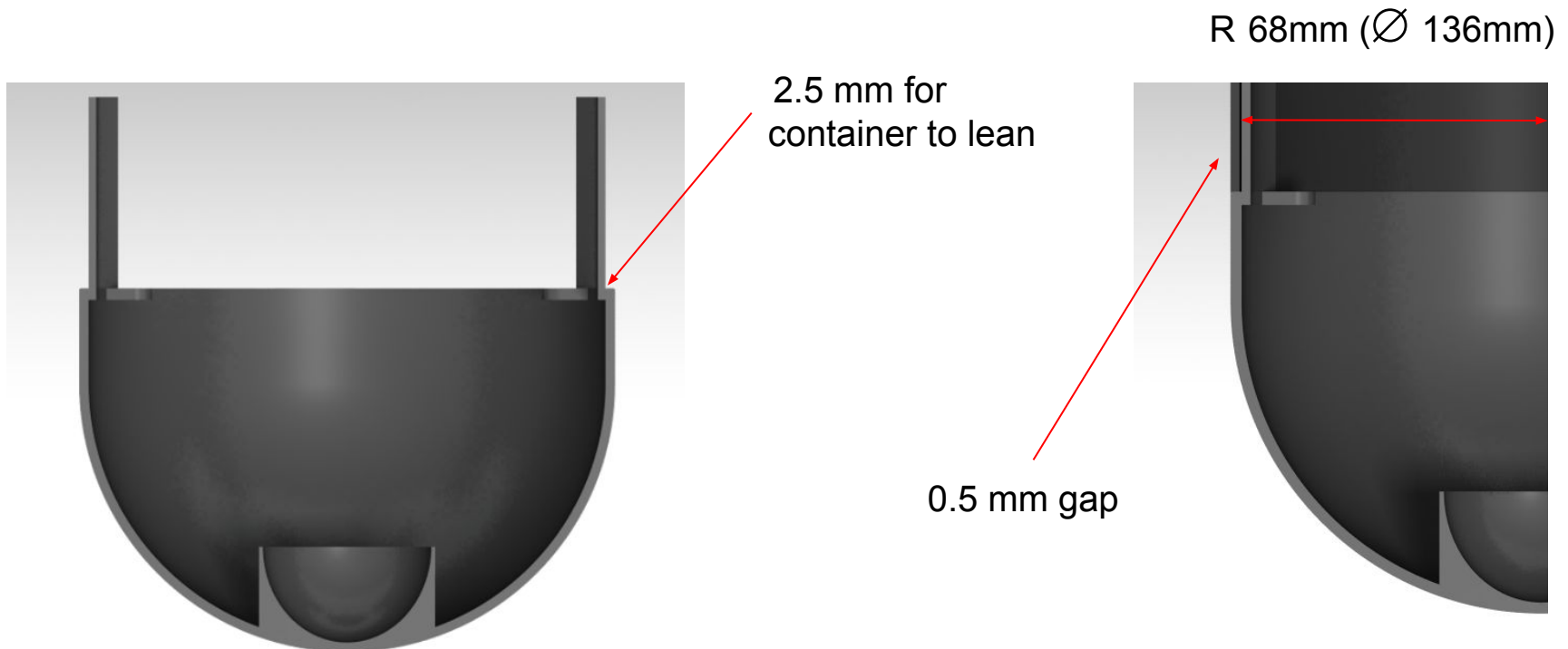
Cansat Mechanical Layout of Components (5/5)



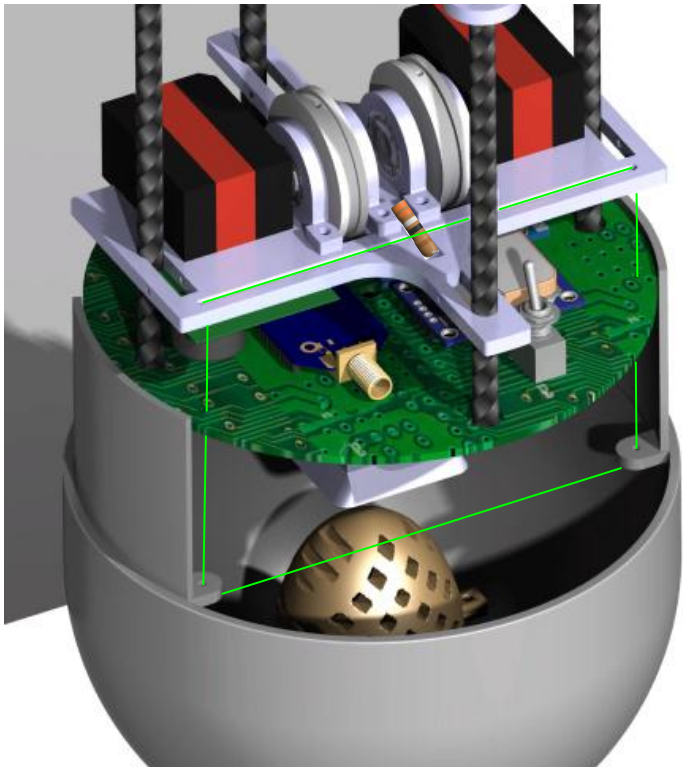


Nose Cone material	ABS
Manufacturing	3D printing
All around thickness	2mm
Fishing line guides thickness	3mm
Drag Coefficient	0.224

- Nose Cone shoulder design and dimensions
 - Nose Cone shoulder has a diameter of 135 mm, while the container has a diameter of 136mm



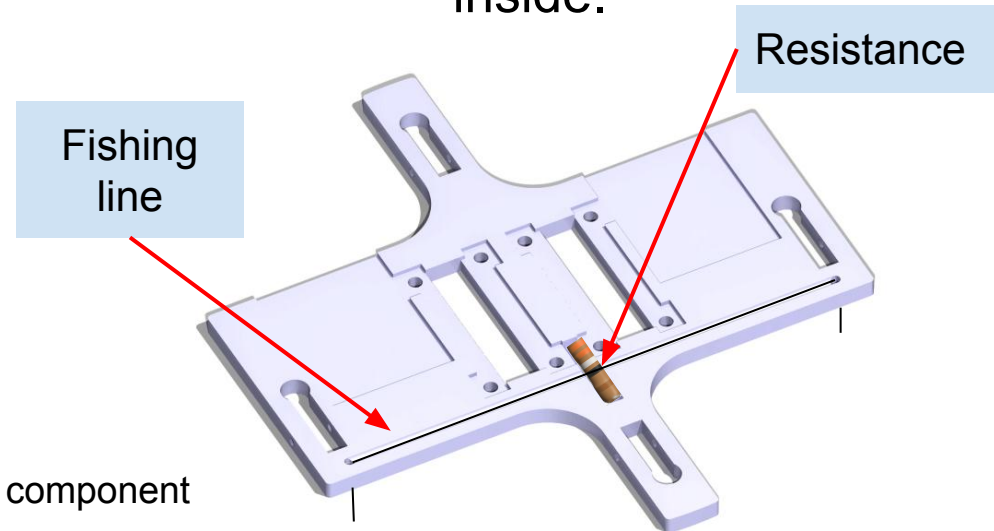
Fishing line nose cone attachment

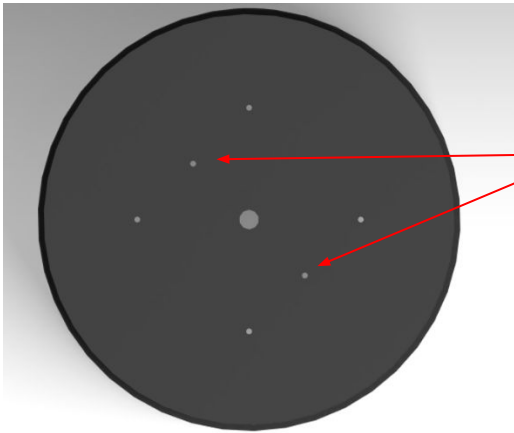


Different color used for the fishing line component for better understanding of placement

The design consists on having the fishing line be the only component attaching the nose cone to the payload

Nose cone works as a container for the egg together with the protection held inside.

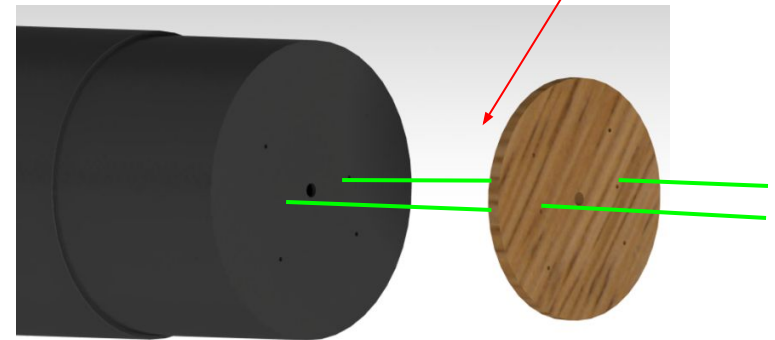




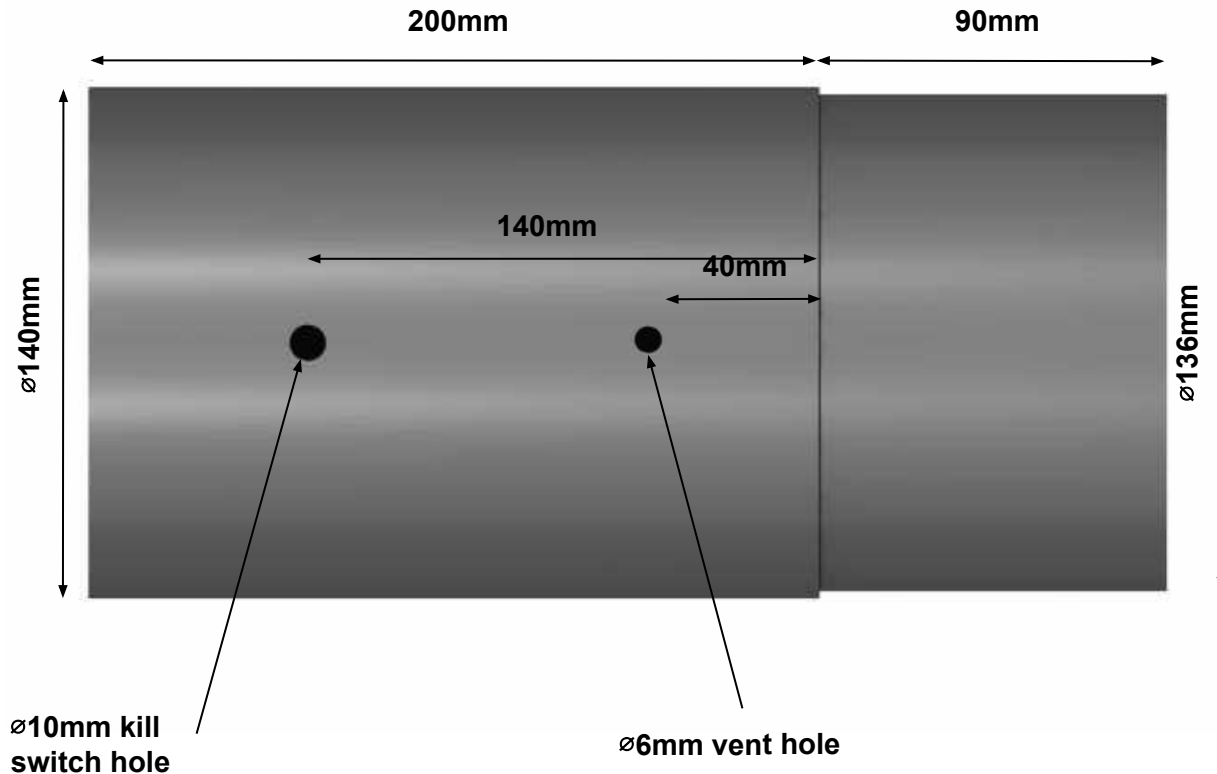
Container and wood disk have 2 extra holes to pass a fishing line through them and tie payload to the container

When CanSat reaches 80% of peak altitude, a resistance burns the fishing line letting the cansat separate from the container (Full mechanism in Payload Release)

Fishing lines are shown in green to contrast colours



Container Dimensions



Wall thickness is 2mm through the whole container

Dimensions will be carefully measured using highly precise tools to ensure a proper fit in the launch vehicle



Payload Pre-Deployment Configuration (1/3)



- **Payload Attachment to Container**

- fishing line runs through part of the payload, attaching the container to the payload
- At the middle part of the payload, the line is placed on a resistance below the upper camera floor
 - when 20% of the height has been descended, a current runs through the resistance, cutting the line, and detaching both parts

• Payload Attachment to Container

Different colours of the same components are shown to provide a better understanding of the mechanism

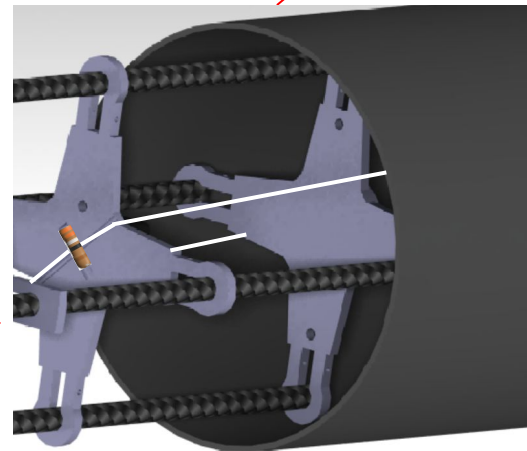
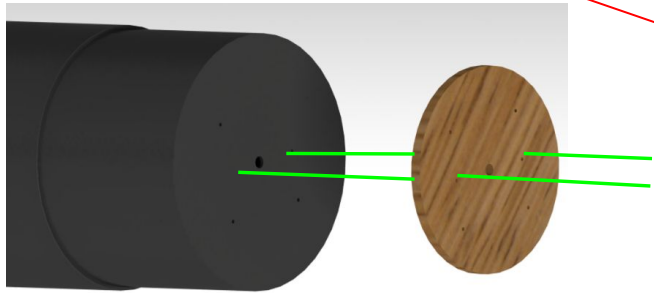
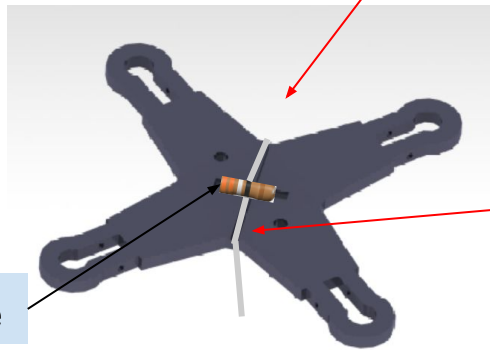


Image shows only the lower part of the container

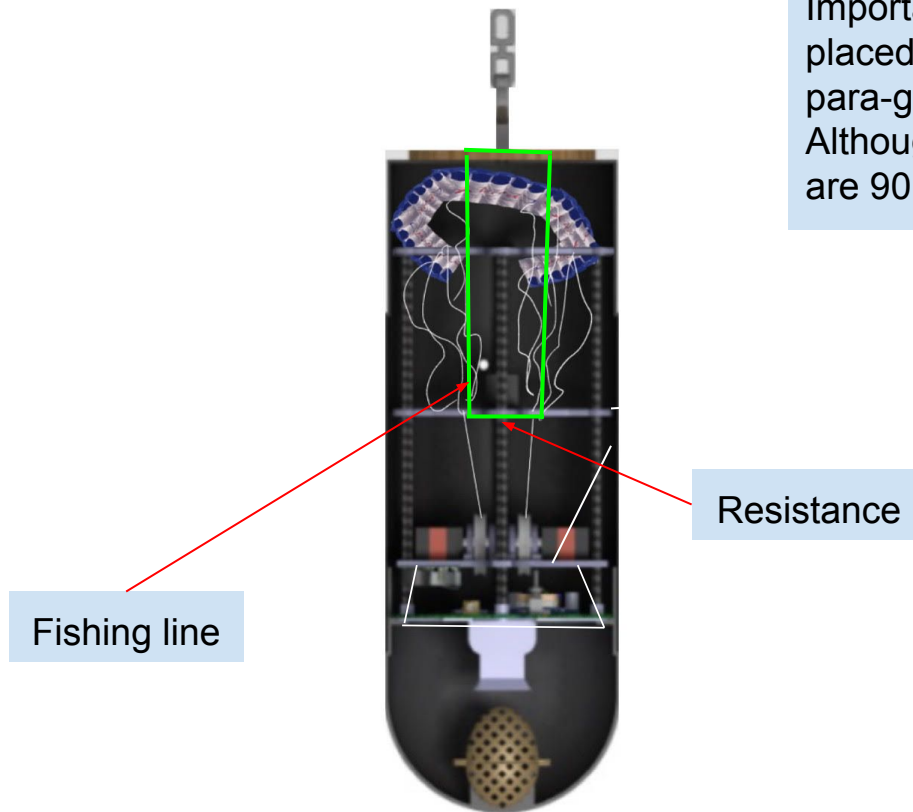
Image shows how the fishing line gets from the container top to the release resistance



Fishing line

Resistance

- **Payload Attachment to Container**



Important: Fishing line is carefully placed to avoid entanglement with para-glider line upon deployment. Although difficult to see, fishing lines are 90° rotated to glider lines

Fishing line attachment

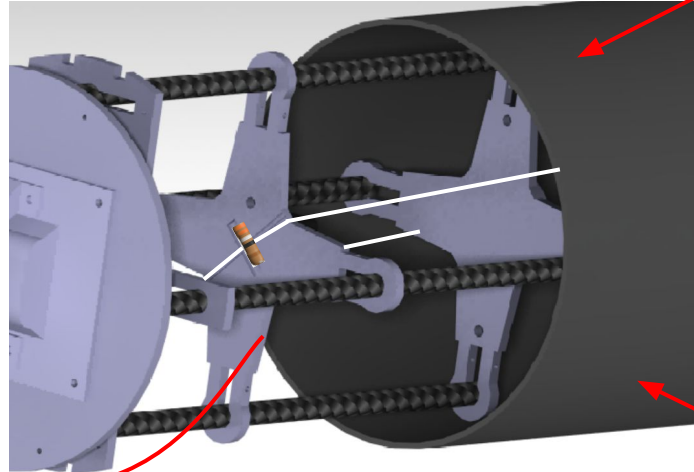
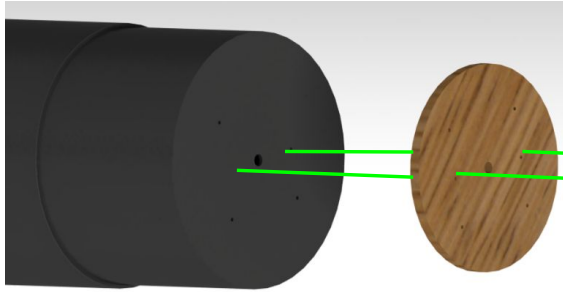
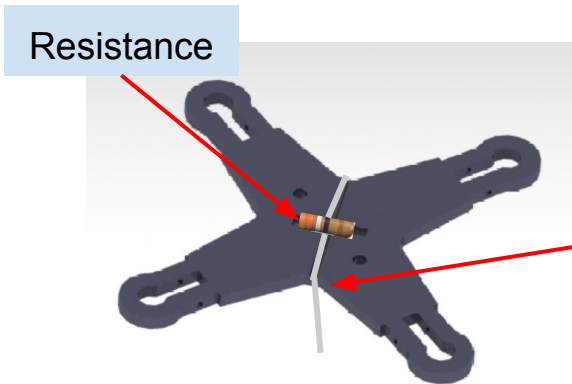


Image shows only the lower part of the container

Image shows how the fishing line gets from the container top to the release resistance



Resistance

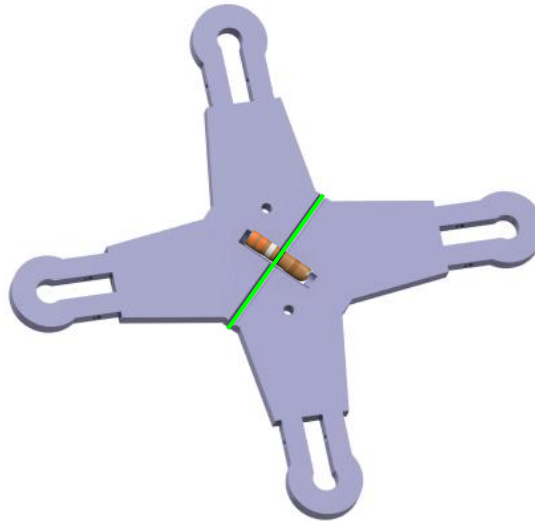
Fishing line

The design consists on having the fishing line be the only component attaching the payload to the container

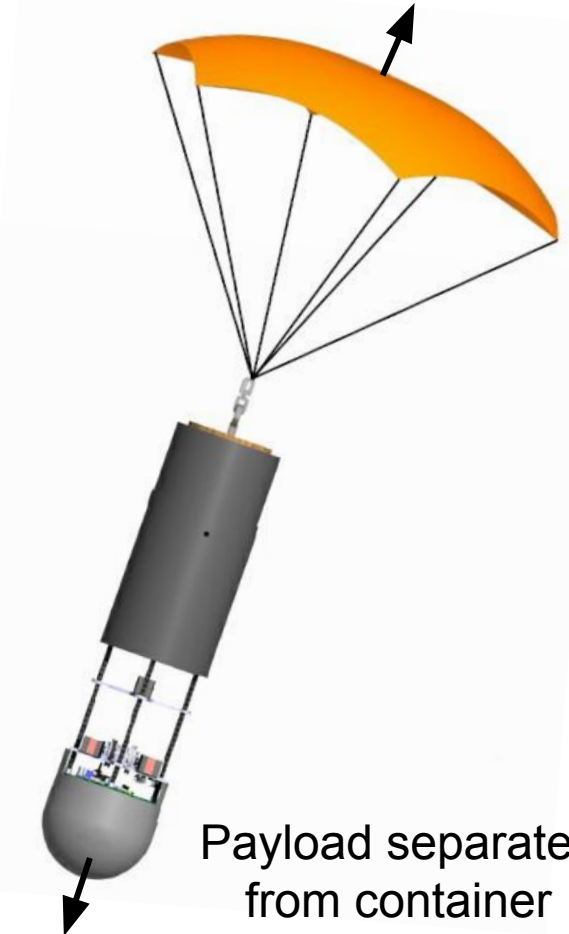
Sequence of operation for release



Payload and container are held together by a fishing line

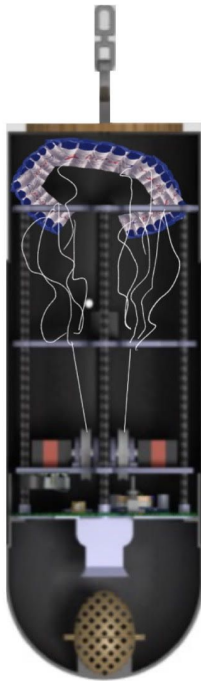


At 80% peak altitude the resistance heats up and the fishing line is burned



Payload separates from container

There's no change in payload structure after deployment.



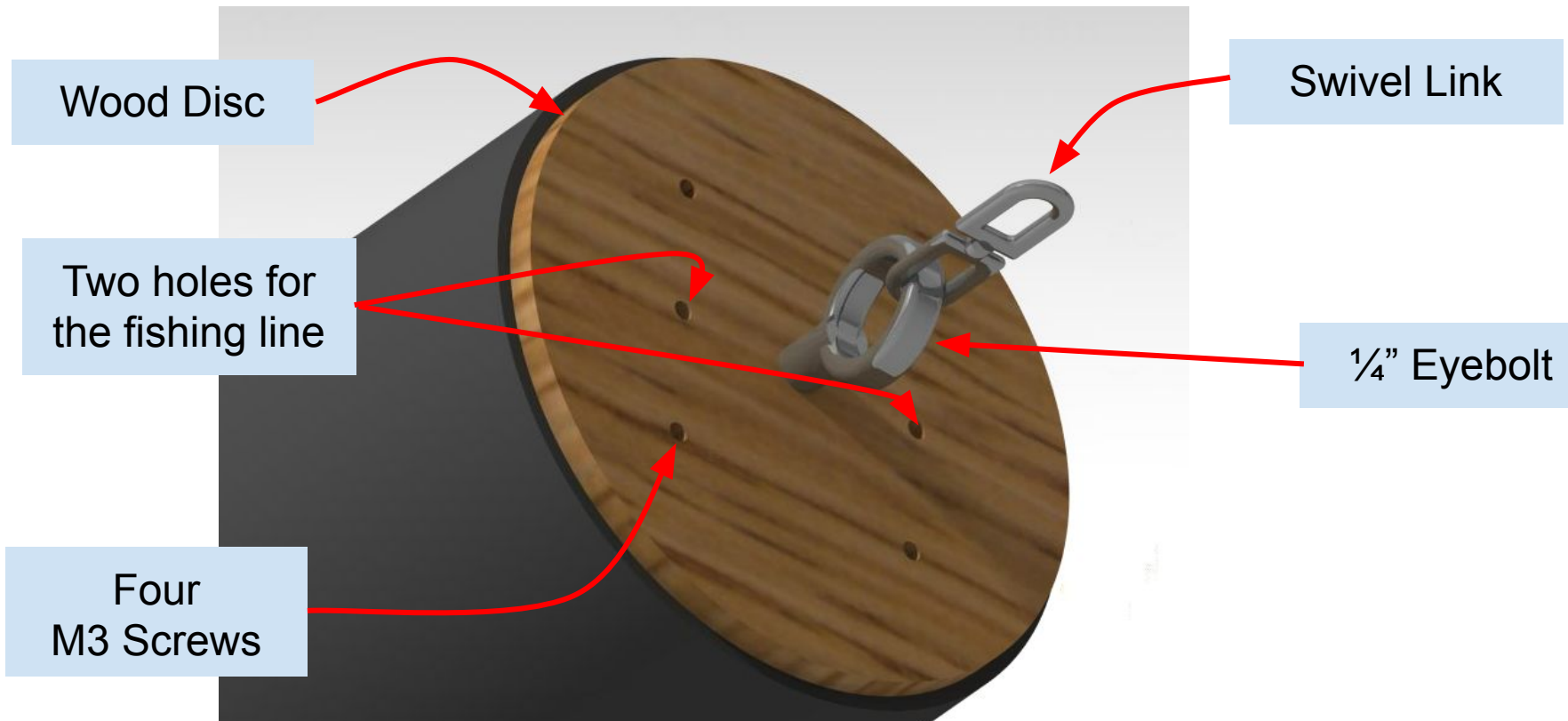
Stowed configuration



Deployed configuration

Parachute Attachment to Container

The parachute is attached to the Cansat through the eyebolt. A swivel link is also used to avoid its entanglement when the Cansat rotates. Four M3 screws are used to attach the wood disc to the container. This disc has two additional holes to pass the fishing line through.



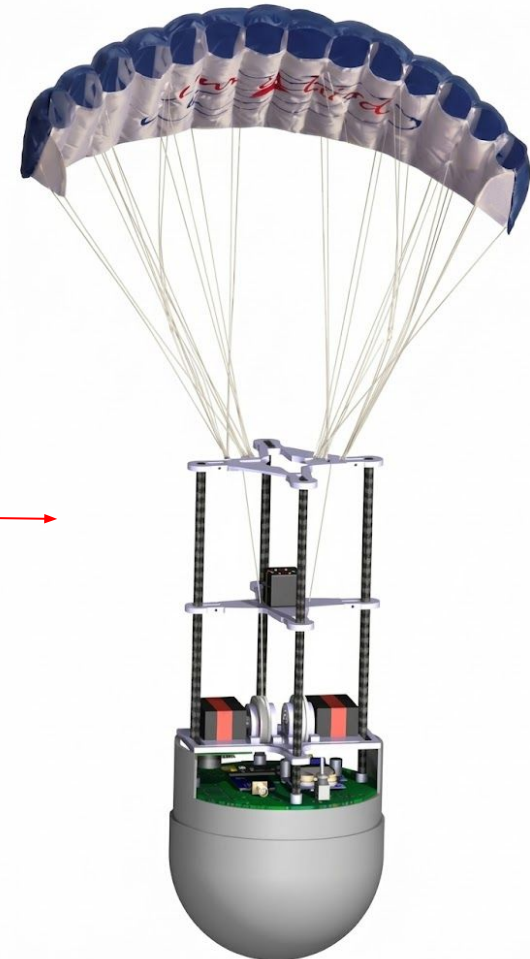


Mechanism relies on the shock wave of entering air to deploy automatically the glider



Transient

This passive mechanism ensures avoiding any type of entanglement

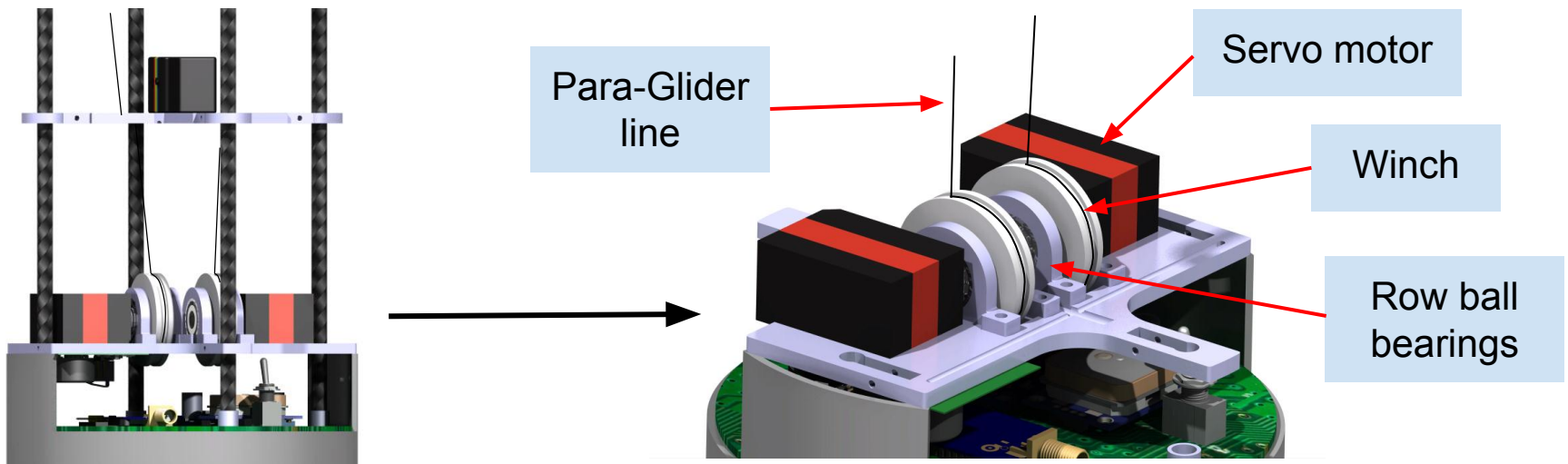


Servo motors allow winch to roll up the line within itself to pull on one line or the other making the shape of the paraglider lean to that side.

This allows a linear control on the steering of the paraglider.

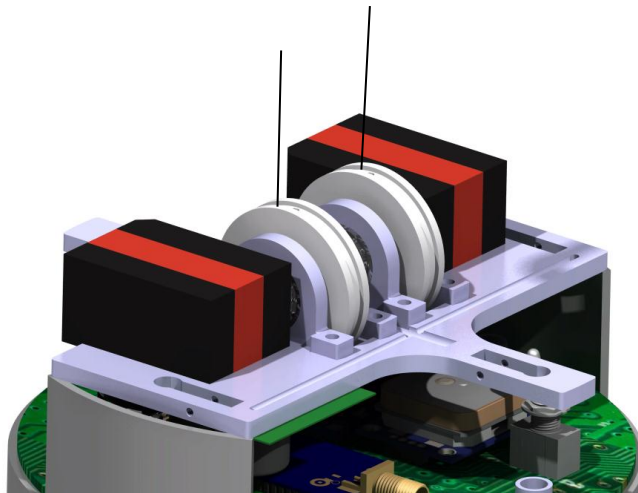
For speed control the winch system pulls symmetrically on both lines, increasing the angle of attack of the glider and therefore reducing the descent speed.

270° servo motors are used and pulleys are dimensioned accordingly to provide enough line pull.

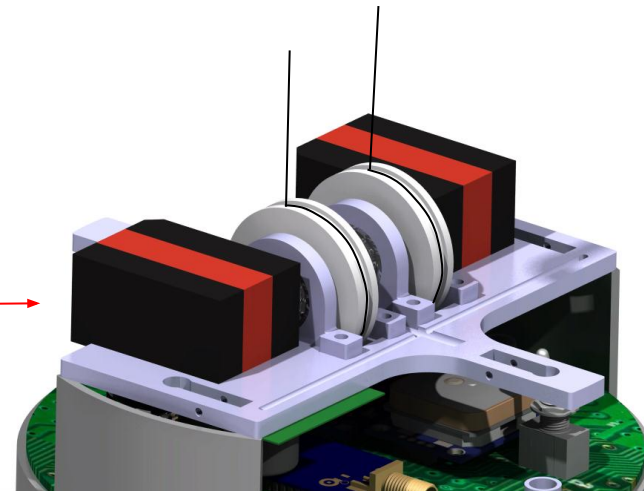


The servo is placed on its fully extended position upon payload deployment from container. This is meant to avoid any type of solicitation on the servo by the glider's expansion shock. Once it is fully deployed, the servo retracts the line to control the steering and the descent speed.

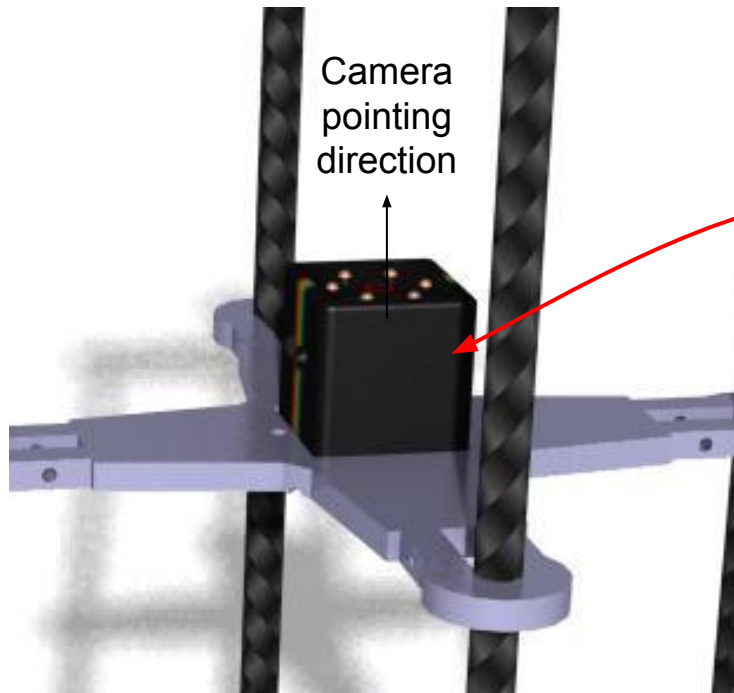
Servo fully extended



Servo fully retracted



Release Camera Pointing



Centered camera allows a central view of the paraglider during descent
The top floor is hollow in the center to allow the camera to have a better view of the paraglider and a panoramic view of the sky

For mounting the camera is glued to the floor

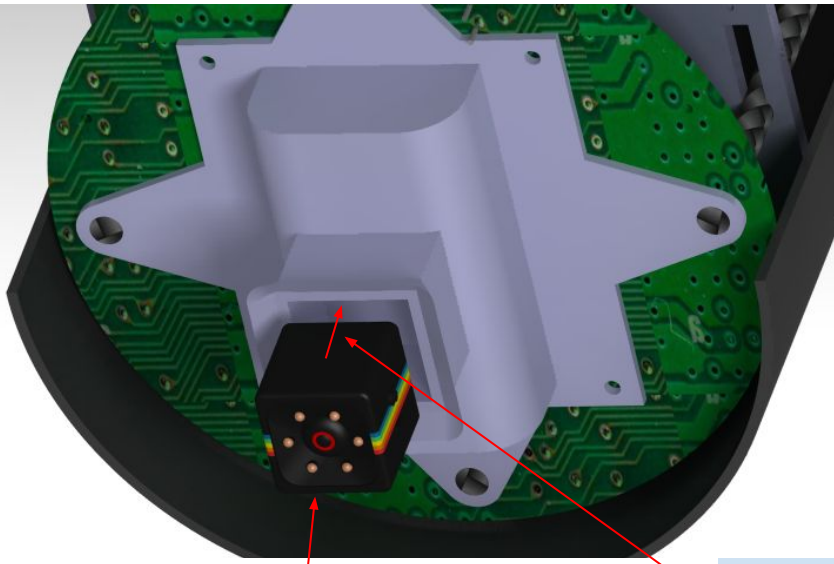


Ground Camera Pointing (1/2)



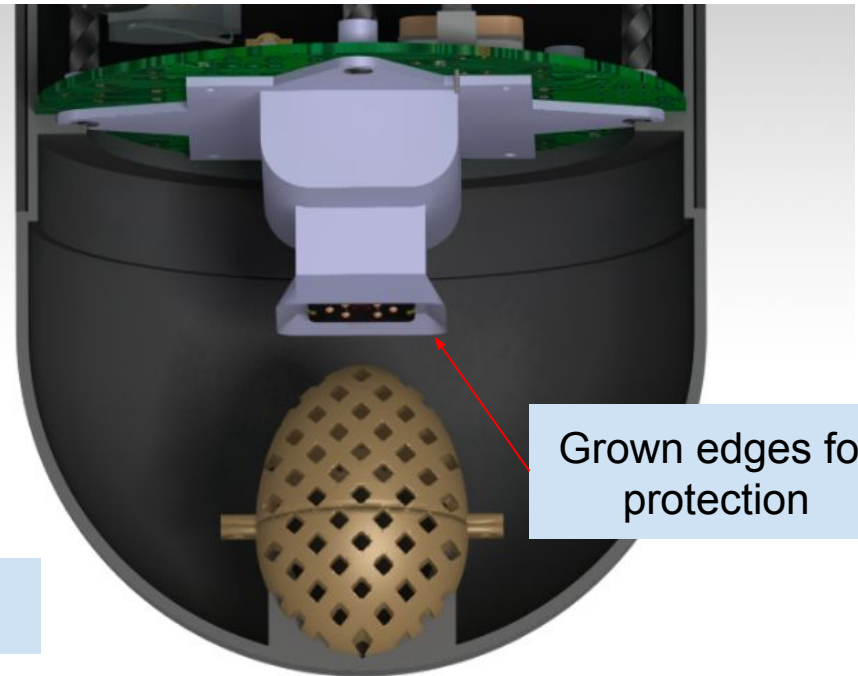
- **Ground Camera**

- Quelima SQ11 is fitted on a camera container, and secured using glue.
- Camera is centered on the CanSat vertical axis, which gives a full view of the ground upon nosecone deployment
 - before deployment, camera will record the top of the egg container, but will be mostly dark
 - upon deployment at 2 meters from the ground, camera will record separation and impact with the floor
 - Edges of the container have been extended to protect the camera upon impact
 - **they do not affect camera's field of view**



Quelima SQ11
Camera

Fitting



Grown edges for
protection

Egg container



The egg container is made in 3 parts:

Nosecone (ABS)

Egg instrument (TPU)

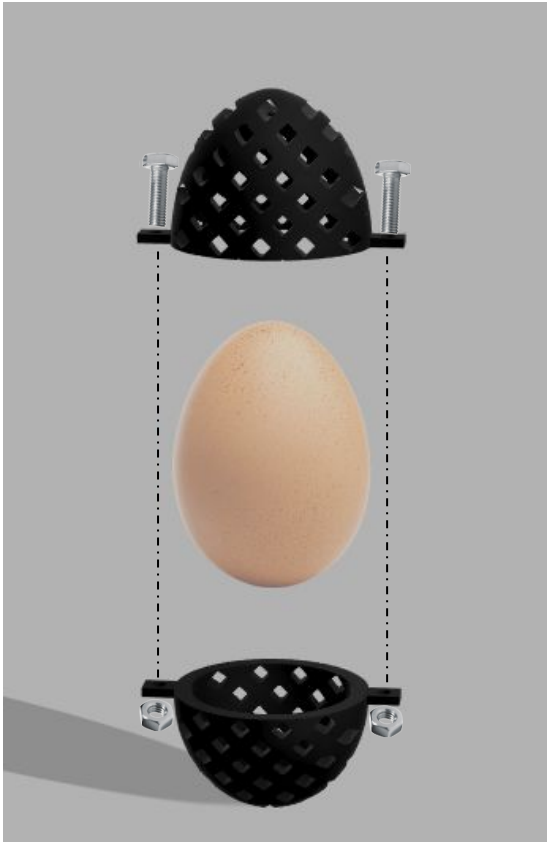
Memory foam

Protection method:

The nose cone acts as the impact surface, distributing the force over the egg instrument, which the flexibility and geometry of its lattice structure dissipates the energy along it and the memory foam ensures a snug fit while also dampening the shock

Parts		Method of attachment
Nose cone	Bottom egg instrument part	polyurethane-based glue
Bottom egg instrument part	Memory foam	polyurethane-based glue
Bottom egg instrument part	Top egg instrument part	M3 nuts and bolts
Top egg instrument part	Memory foam	polyurethane-based glue

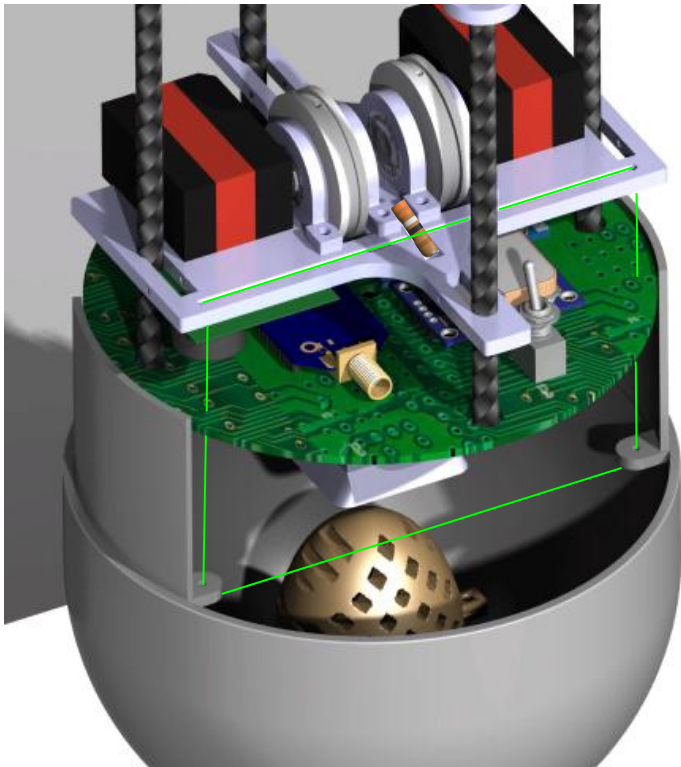
Egg container



Mounting method:

The egg is put in between both parts that are not glued and once it fits inside, both parts are tightened with 2 M3 bolts and 2 M3 nuts

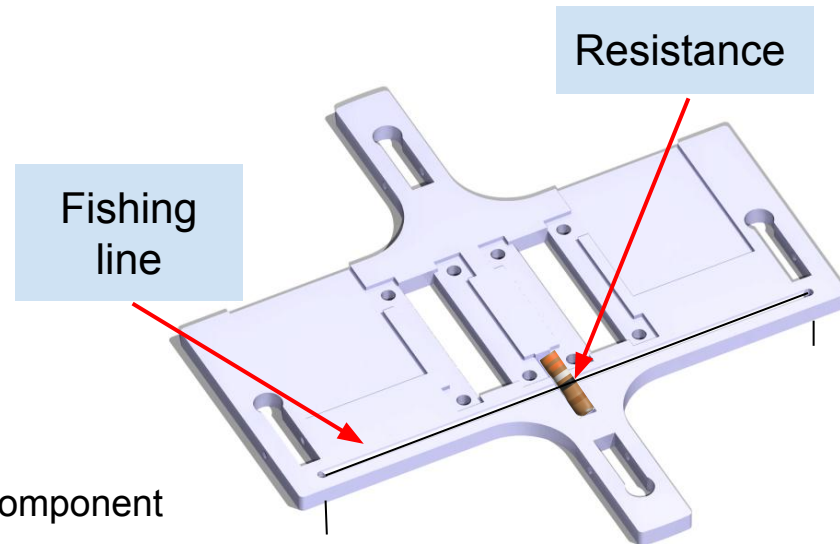
Fishing line attachment



Different color used for the fishing line component for better understanding of placement

The design consists on having the fishing line be the only component attaching the nose cone to the payload

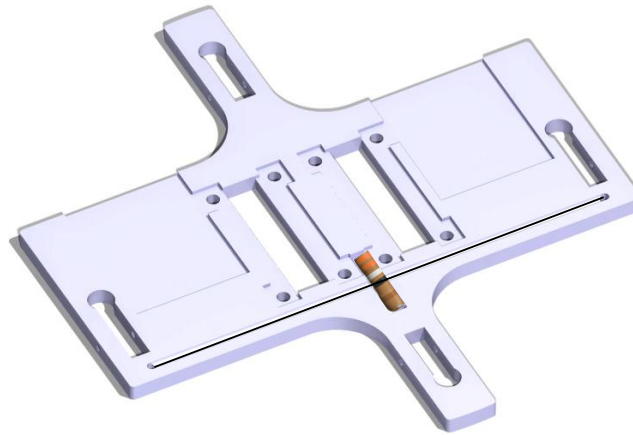
Nose cone works as a container for the egg together with the protection held inside.



Sequence of operation for release



Payload and nose cone are held together by a fishing line



2m above the ground the resistance heats up and the fishing line is burned



Nose cone (with the egg) separates from payload



Electronics Structural Integrity (1/5)



Mounting Methods

Method	Description
Screws and Standoffs	<ul style="list-style-type: none">• Some components and breakout boards are through-hole modules with screw holes.• Secures components in a robust manner facilitating airflow and heat dissipation.
High Performance Hot melt silicone	<ul style="list-style-type: none">• Thermoplastic material with a melting point around 100 °C• High-G vibration resistant• Can be easily applied using a hot glue gun
High Performance Adhesives (Epoxy)	<ul style="list-style-type: none">• Adheres components permanently to the payload framework.• Mass efficient: lightweight compared to metallic mounting parts.• Does not require pre drilled holes or any specific geometry.
Surface Mount Technology (SMT)	<ul style="list-style-type: none">• Facilitates the integration of lightweight components and modules with castellated holes by soldering them directly to the main PCB.• Minimizes the overall footprint and vertical profile by eliminating the need for bulky headers or connectors.



Electronics Structural Integrity (2/5)



Electronic component enclosures

Name	Description
Nose Cone walls	<ul style="list-style-type: none">• Electronics are enclosed with a 3D printed sleeve (ABS material).
Nylon wire burning resistor housing	<ul style="list-style-type: none">• The burning resistor is placed on its own 3D printed structure to prevent other components from burning or receiving any damage from the heat.

Securing Electrical Connections

Method	Description
Soldering electrical connections	<ul style="list-style-type: none"> ● Solder is applied to all connections or cables that require a permanent and resistant mechanical attachment improving durability and signal quality. ● Applies only to those components that do not need to be periodically serviced or removed.
<i>Micro-Lock</i> Connectors	<ul style="list-style-type: none"> ● <i>Micro-Lock</i> connectors are high-performance reduced size connectors used in automotive industry. ● Electrical connections (power, digital, sensor, etc) will use <i>Micro-Lock</i> connectors. ● Provides a strong connection lock and a reliable metal contact that ensures signal integrity. AEC-Q100 certified

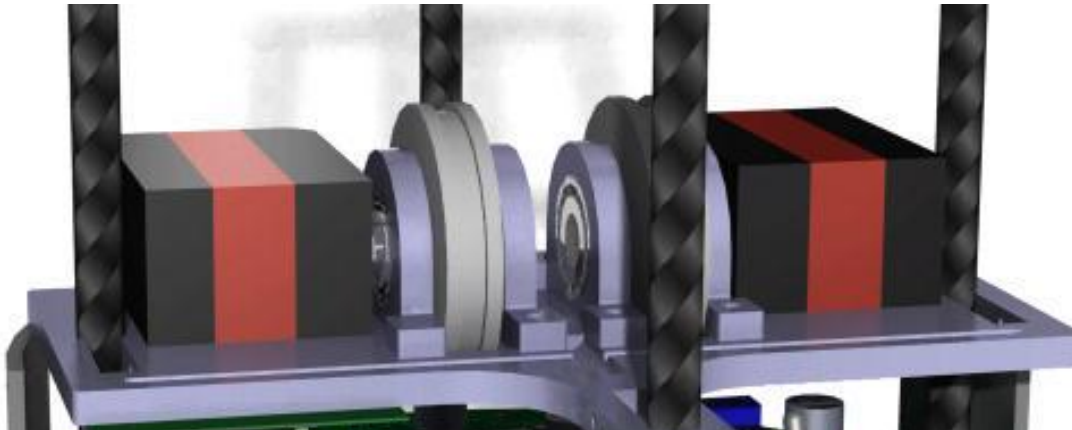
Micro-Lock Connectors

molex



Descent Control Attachments

Method	Description
Recessive Adhesive Mounting	<ul style="list-style-type: none"> • Utilizes high-performance adhesive within custom-fit mounting pockets to ensure the servos are permanently fixed. • Distributes mechanical stress across the bond surface, enhancing resistance to high-G deployment shocks. • Allows the structure to absorb part of the forces exerted by the paraglider.





Electronics Structural Integrity (5/5)

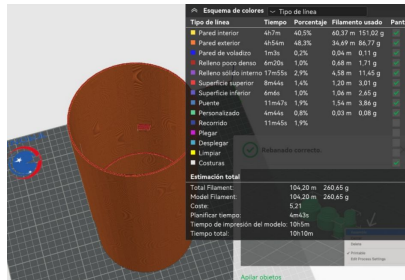


Acceleration and shock force requirements and testing

- Critical structural parts were tested for 15g acceleration and 30g shock with FEA
- Non critical parts were simplified and checked with hand calculations
- No real world tests have been conducted yet
- CanSat shock survivability will be tested with a 30g drop test

Sources of Uncertainties:

- CAD Estimate
 - Pieces like the eyebolt, bolts and swivel link, as they are standardized, they have fixed dimensions. Density added to the CAD software provides an accurate approximation of the real value.
- Slicer
 - ABS material pieces have their weight measured by the slicer software. The program used was BambuStudio. The uncertainty was measured by scaling the parts taking into account the 3D printer's dimensional accuracy.





Mass Budget (2/6)



Sources of Uncertainties:

- Estimates
 - Parachute weight estimation was done using the material's density and the geometry given. Uncertainties rely on small variations in dimensions, given the manufacturing process related to it.
 - Para-glider weight estimation was performed searching for real RC gliders in the internet, and making approximations based on our dimensions compared to them. Uncertainties rely on difference in model assimilation, and attachment points.
 - Electronic modules weight's uncertainty comes from the manufacturer's datasheet.



Mass Budget (3/6)



- **Mass of each structural element (1/2):**

Component	Material	Infill	Corrected mass [g]	Uncertainty[g]	Source
Nosecone	ABS	20%	95.6	±2	Slicing Estimate
Container	ABS	20%	250	±2	Slicing Estimate
Upper floor	ABS	10%	7.31	±0,3	Slicing Estimate
Guide floor	ABS	20%	9	±0,3	Slicing Estimate
Winch floor	ABS	20%	14.49	±0,3	Slicing Estimate
Bearing supports (4x)	ABS	20%	5.28	±0,2	Slicing Estimate
Winch (x2)	ABS	20%	3.2	±0,1	Slicing Estimate
Batteries floor	ABS	20%	20.42	±0,1	Slicing Estimate
Egg capsule	TPU	20%	15	±0,2	Slicing Estimate

- **Mass of each structural element (2/2):**

Component	Material	Mass [g]	Uncertainty[g]	Source
Parachute	Nylon	13	±2	Estimate
Paraglider	210T plaid cloth	109	±10	Measured
Eyebolt	steel	20	±2	CAD Estimate
Swivel link	steel	5	±1	CAD Estimate
Wooden disc	wood	19	±3	CAD Estimate
Bolts and Nuts	steel	23	±1	Datasheet
Fishing line	Nylon	5	±0,5	Estimate
Shaft (2x)	aluminium	12	±2	CAD Estimate
Bearing (4x)	steel	5	±0,5	CAD Estimate
Rod (4x)	carbon fiber	38	±3	CAD Estimate
Egg	Egg	59	±5	Mission guide
Total Structure Mass = 728.4± 26.5 [g]				

- Mass of each component of Cansat:

Component	Mass [g]	Uncertainty [g]	Source
MCU: STM32F4 (blackpill)	6,90	±0,1	Datasheet
GPS: Ublox Neo-6M + Antenna	18,20	±0,1	Datasheet
Cameras: Quelimá SQ11 (x2)	23,00	±0,1	Measured
Communication: XBee module + Antenna	15,10	±0,1	Measured
Servos (x2)	88,0	±0,2	Measured
TFS20-L (x2)	3,8	±0,2	Measured
RTC Battery	1,8	-	Datasheet
PCB + Cables + Connectors	25,00	±2,00	Estimated
Payload Battery + Holder	50,00	±2,00	Datasheet + Estimated
Step-down converter	15,2	0.1	Measured
Beacon Board	8,00	±1,00	Estimated
Beacon Battery	1,8	-	Datasheet
Buzzer	7,80	-	Datasheet
Total Hardware Mass = 264.6 ± 5.9 [g]			

- **Total mass of all components and structural elements:**

Total Mass Budget	
System	Mass[g]
Structure/Mechanic	728.4 ± 26.5
Hardware/Electronic	264.6 ± 5.9
Total Mass = 993 ± 32.4 g	

This approach provides a reliable and consistent basis for the mass data of each component, whether it's from datasheets, direct measurements, or estimates based on prior experience.

$$\text{Margin} = 1000\text{g} - 993\text{g} = +7\text{g}$$

Methods for correction:

- **3D Printer Parts Infill:** We will adjust the **infill** configuration of our 3D printed parts to get closer to the desired total mass (for increasing or decreasing mass)
- **Solder Wire:** Soldering wire (Tin-Lead Alloy) will be used to **fine tune** the total mass within the 1000±10g range, adding more material to specific sections of the PCB board designed for this
- **Removing material:** Extreme measure of mass reducing, only if needed at launch site, would be removing material on several parts of the payload (only on the ones that this is allowed)

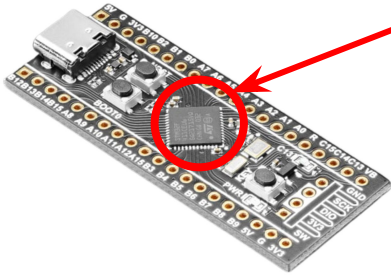


Communication and Data Handling (CDH) Subsystem Design

Jaime Nazar Anchorena
Emanuel Albornoz
Matteo Ginhson

STM32F411 "BlackPill" Development Board

Microcontroller Board with integrated Real Time Clock



STM32F411 Real Time Clock Hardware Module

ANT-900MR Flex ¼ Wave RPSMA Payload Antennash

Estimated Range > 10000 m (at Line Of Sight)



Xbee Pro S3B Radio



NETID/PANID: **1081**

XBees will not be set to Broadcast mode.

Telemetry rate: **1Hz**

SanDisk Ultra

Permanent memory storage for data recovery





CDH Changes Since PDR



Changes:

- **RTC module replaced by built in STM32F411 RTC Clock Module and the 32.768kHz external crystal in the Blackpill.**



Blackpill's RTC input clock:

The module was changed in order to make use of one of the features of the STM32F411, which includes an RTC Clock Module for timekeeping. It is paired with an external 32.768kHz standard crystal in the Blackpill as the input for the module. The module can be powered via the F411's V_{BAT} pin with a standard CR2302 Coin Cell (accessible as a pin in the Blackpill too), so its power is independent from the rest of the MCU. It is basically a standalone RTC.

This change also reduces the amount of modules we are using and slightly reduces the satellite

5.1 Power supplies

There are two main power supply schemes:

- $V_{DD} = 1.7$ to 3.6 V: external power supply for I/Os with the internal regulator disabled, provided externally through VDD pins. Requires the use of an external power supply supervisor connected to the VDD and PDR_ON pins.
- $V_{DD} = 1.8$ to 3.6 V: external power supply for I/Os and the internal regulator (when enabled), provided externally through VDD pins.

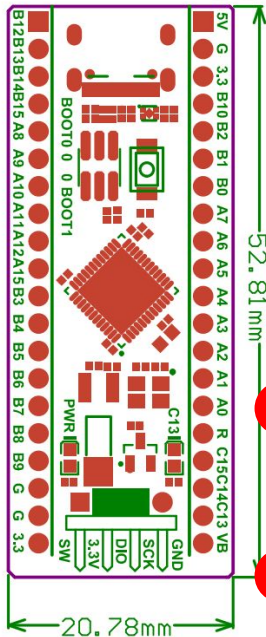
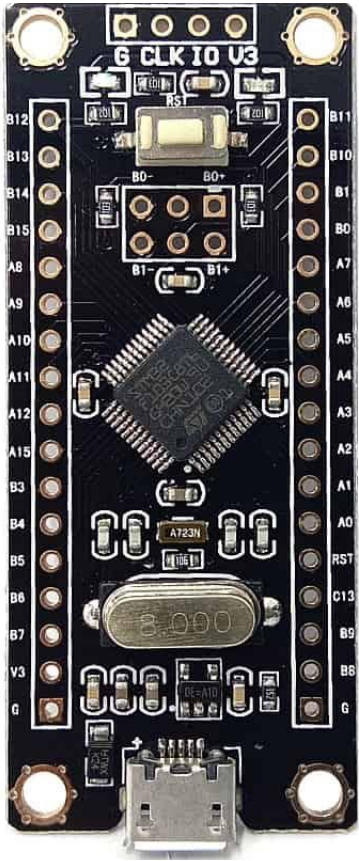
The real-time clock (RTC) and the RTC backup registers can be powered from the V_{BAT} voltage when the main V_{DD} supply is powered off.

Notes:

1. The above image is an extract from the F411's User Manual, detailing the Power Options for the MCU.

ARM STM32F411RET6 microcontroller

STM32F411 Blackpill development board



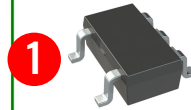
- Arm® Cortex®-M4 32-bit processor with FPU
- Processor speed: 100 MHz
- 512 kB Flash and 128 kB RAM memory
- ~150ms boot time (measured bare metal)
- Supply current: ~10mA at 3.3V
- Data bus: Multi-AHB bus matrix

Board Weight: 6g

Memory requirements for flight software code: 512 kB Flash

Additional features

Versatile Development: Seamless compatibility with both STM32 HAL/CMSIS and the Arduino ecosystem.



1

AP2112K-3.3
3.3V Step-Down Converter
Ultra-small footprint



2

Full Low-Level Control: Supported by STM32 HAL / CMSIS for direct hardware access and maximum efficiency.



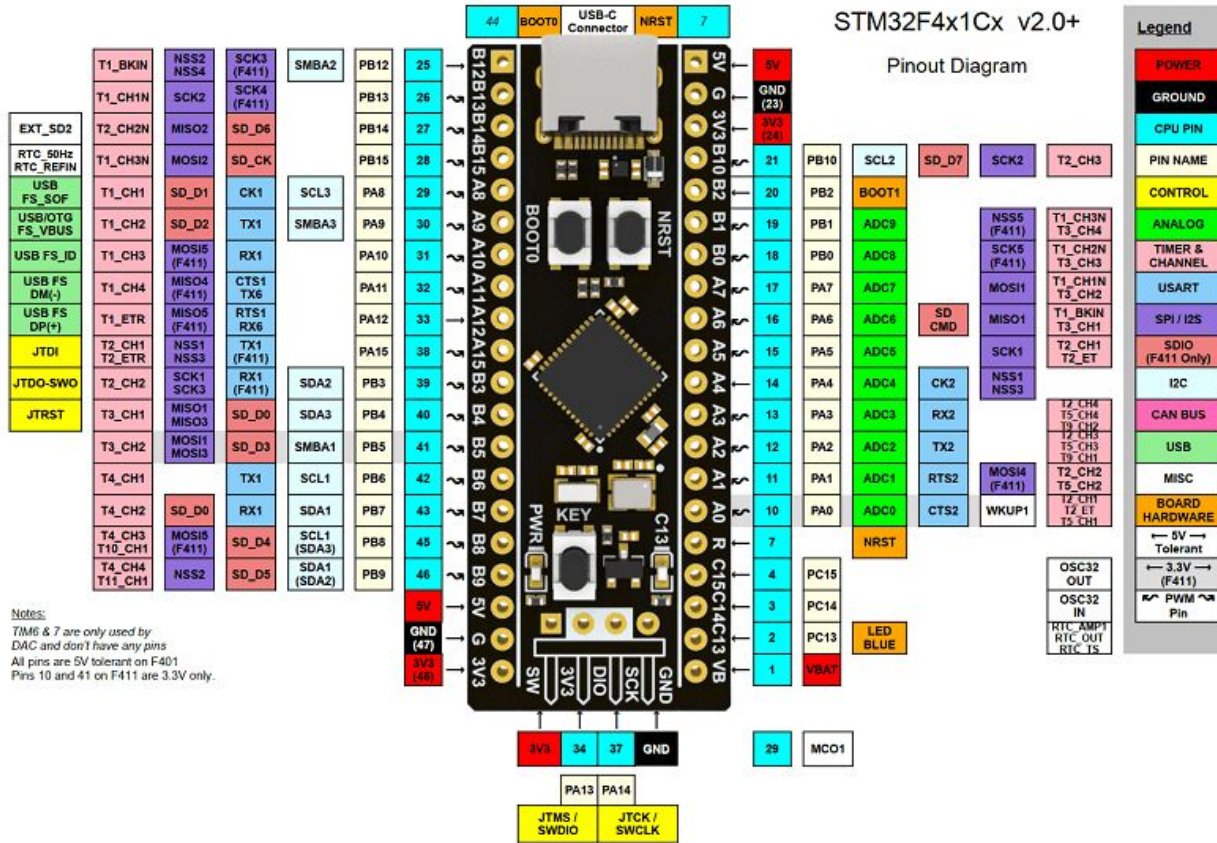
3

Rapid Prototyping: Full support for Arduino IDE (STM32duino) for easy access to thousands of open-source libraries.



RTC
The STM32F411 includes an integrated RTC for efficient timekeeping

Payload Processor Data Interfaces



I/O Pins	ADC Pins	~PWM Pins	UART ¹	SPI	I2C
32	10	11	3	5	3

Payload Processor Memory Selection



(1) Program Memory

512 kB Flash + 128 kB RAM
Included in the microcontroller

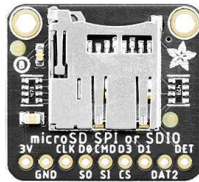


(2) Camera Memory

64 GB memory included
(*independent*)

For **maintaining** program state data and **configuration states** after power outages or processor resets during launch and mission.

(3) Permanent Memory Storage



SanDisk

MicroSDHC™ UHS-I Card

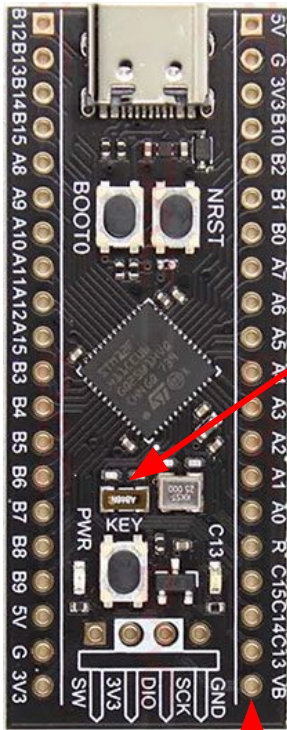
32 GB microSDHC™ UHS-I
Memory

[datasheet](#)

- **SPI clock speed:** Up to 50 MHz
- **Stand-by current:** ~200 μ A to 2 mA
- **Supply voltage:** 2.7V to 3.6V
- **Operating temperature:** -25 °C to 85 °C
- **Bus Speed:** UHS-I (Class 10)
- **Application Performance:** A1 (Optimized for 1500 Read IOPS / 500 Write IOPS)
- **Speed Class:** U1 (Minimum 10 MB/s sustained write speed)
- **Max Transfer Speed:** Up to 120 MB/s

STM32F411's RTC Module

Accurate built in Real Time Clock.



32.768kHz
Crystal
Oscillator

Access to
 V_{BAT} pin

- Supply **Voltage**: From 1.8V to 3.6V
- Average Supply **Current**: Up to 8.6 μA
- Battery **leakage current**: Up to 100 nA
- Active **battery current**: Up to 1 μA
- The module is **reset tolerant**
- No extra space needed in the PCB.
- **Accuracy** $\pm 10\text{-}50$ ppm
- Subsecond accuracy and Date timekeeping.

Table 31. Typical and maximum current consumptions in V_{BAT} mode

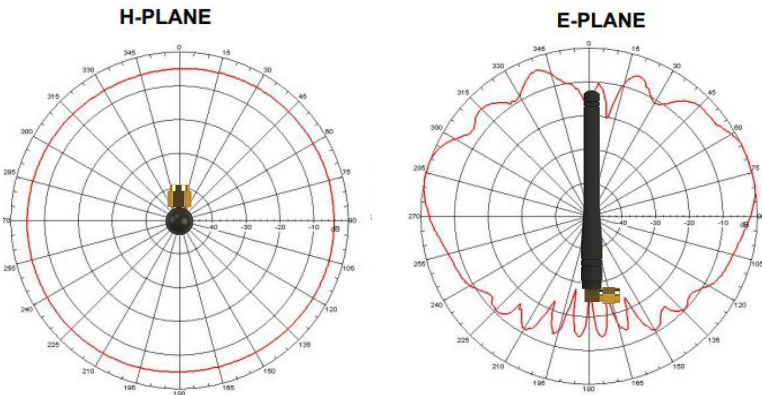
Symbol	Parameter	Conditions ⁽¹⁾	Typ			Max ⁽²⁾			Unit
			$T_A = 25^\circ\text{C}$			$T_A = 85^\circ\text{C}$	$T_A = 105^\circ\text{C}$	$T_A = 125^\circ\text{C}$	
			$V_{BAT} = 1.7\text{ V}$	$V_{BAT} = 2.4\text{ V}$	$V_{BAT} = 3.3\text{ V}$	$V_{BAT} = 3.6\text{ V}$			
I_{DD_VBAT}	Backup domain supply current	Low-speed oscillator (LSE in low-drive mode) and RTC ON	0.7	0.8	1.0	3	5	6.8	μA
		Low-speed oscillator (LSE in high-drive mode) and RTC ON	1.5	1.6	1.9	3.8	5.8	8.6	
		RTC and LSE OFF	0.1	0.1	0.1	2	4	5.8	

ANT-900MR Flex 1/4 Wave RPSMA

Wireless External Antenna for 900 MHz Applications



Antenna Radiation Pattern



- 2.15dBi **Gain**
- >10000m estimated **range** (LoS)
- 15g **weight** (measured)
- 105×18×11 mm **sized**
- **Nominal impedance:** 50 Ω .
- **Frequency range:** 868-915 MHz
- **VSWR:** ≤ 1.5 .
- **Operating temperature:** -40°C to 85°C

Radio used: XBee PRO S3B 915MHz

- **NETID/PANID** will be set to: **1081**, using XCTU software
- XBee will **not** be set to Broadcast mode.
- This XBee will be used to send payload **telemetry** at a **rate** of **1 Hz** to the ground station.
- Large range XBee provides larger distance coverage, thus, mitigating possible sources of error provided by unexpected rocket displacement



Used configuration:

- Radio **frequency**: 915 MHz
- Transmit **power**: 24 dBm (250mW)
- Receiver **sensitivity**: -101dB
- Range: >6500 m (dipole antennas)

Mission Phase Management

- **Operational Rate**: Constant 1 Hz telemetry transmission throughout all mission phases.
- **Standby (LAUNCH_PAD)**: 1 Hz heartbeat; sensors calibrated to zero altitude via ground station command.
- **Flight (ASCENT/DESCENT)**: 1 Hz full telemetry triggered by acceleration and altitude drop.
- **Separation (PAYLOAD_RELEASE)**: Triggered at 80% peak altitude to deploy paraglider.
- **Recovery (LANDED)**: Maintains 1 Hz transmission until recovery to ensure location tracking.
- **Transmission Control**: Non-broadcast mode; ACKs disabled to ensure real-time data flow.



Payload Telemetry Format (1/4)



Data Format	Example	Description
TEAM_ID	1081	Assigned team identification
MISSION_TIME	01:22:10	UTC time in format hh:mm:ss
PACKET_COUNT	50	Total count of transmitted packets
MODE	F	'F' for flight mode and 'S' for simulation mode
STATE	ASCENT	Operating state of the software
ALTITUDE	500.3	Altitude in units of meters relative to ground level. Based on pressure readings.
TEMPERATURE	25.7	Temperature in Celsius
PRESSURE	101.2	Air pressure measured in kPa



Payload Telemetry Format (2/4)



Data Format	Example	Description
VOLTAGE	8.3	Voltage of the payload battery
CURRENT	2.48	Payload battery current in Amperes
GYRO_R, GYRO_P, GYRO_Y	18, 21, 20	Gyroscope readings in degrees per second for the roll, pitch, and yaw axes
ACCEL_R, ACCEL_P, ACCEL_Y	30, 35, 33	Accelerometer readings for the roll, pitch and yaw axes
GPS_TIME	13:14:02	Time from GPS receiver in UTC
GPS_ALTITUDE	200.8	Altitude readings from the GPS in meters



Payload Telemetry Format (3/4)



Data Format	Example	Description
GPS_LATITUDE , GPS_LONGITUDE	3.8793 , 18.3672	Coordinate readings from the GPS in degrees
GPS_SATS	5	Number of GPS satellites being tracked by the receiver
CMD_ECHO	CXON	Text of the last command received and processed by the Cansat.
MOTOR_L , MOTOR_R	23 , 31	Para-glider control motors position readings in degrees



Payload Telemetry Format (4/4)



- **The Cansat telemetry packets will be transmitted at a rate of 1Hz with the following format*:**

TEAM_ID, MISSION_TIME, PACKET_COUNT, MODE, STATE, ALTITUDE, TEMPERATURE, PRESSURE, VOLTAGE, CURRENT, GYRO_R, GYRO_P, GYRO_Y, ACCEL_R, ACCEL_P, ACCEL_Y, GPS_TIME, GPS_ALTITUDE, GPS_LATITUDE, GPS_LONGITUDE, GPS_SATS, CMD_ECHO, **MOTOR_L, MOTOR_R**

- **Example:** 1081, 01:22:10, 50, F, ASCENT, 500.3, 25.7, 101.2, 8.3, 2.4, 1.2, 18, 21, 20, 30, 35, 33, 13:14:02, 200.8, 3.8793, 18.3672, 5, CXON, **23, 31**

*Data in bold indicates it isn't part of the required telemetry



Payload Command Formats



Command	Format	Command Description	Example	Example Description
CX	CMD , <TEAM_ID> , CX , <ON_OFF>	Payload telemetry On/Off command	CMD , 1081 , CX , ON	Activates payload telemetry transmission
ST	CMD , <TEAM_ID> , ST , <UTC_TIME> GPS	Set time	CMD , 1081 , ST , 13 : 35 : 59	Sets the mission time to 13:35:59
SIM	CMD , <TEAM_ID> , SIM , <MODE>	Simulation Mode Control Command	CMD , 1081 , SIM , ENABLE	Enables simulation mode
SIMP	CMD , <TEAM_ID> , SIMP , <MODE>	Simulated Pressure Data	CMD , 1081 , SIMP , 101325	Provides a simulated pressure reading of 101325 Pascals
CAL	CMD , <TEAM_ID> , CAL	Calibrate Altitude to Zero	CMD , 1081 , CAL	Sets altitude to 0
MEC	CMD , <TEAM_ID> , MEC , <DEVICE> , <ON_OFF>	Activate a specific mechanism. 0 for autopilot, 1 for egg drop and 2 for probe release.	CMD , 1081 , MEC , 1 , ON	Turn mechanism 1 on
CAL_PRY	CMD , <TEAM_ID> , CAL_PRY	Calibrate Pitch, Roll and Yaw angles	CMD , 1081 , CAL_PRY	Set Pitch, Roll and Yaw angles to 0



Electrical Power Subsystem Design

Nicanor Otamendi
Juan Sambucetti

Payload Batteries

2x Vapcell INR14500



Beacon/RTC Battery (one cell each)

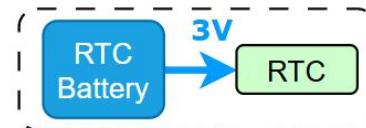
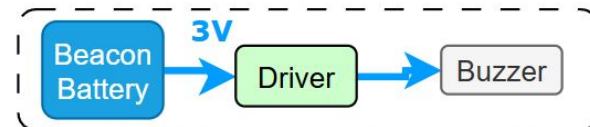
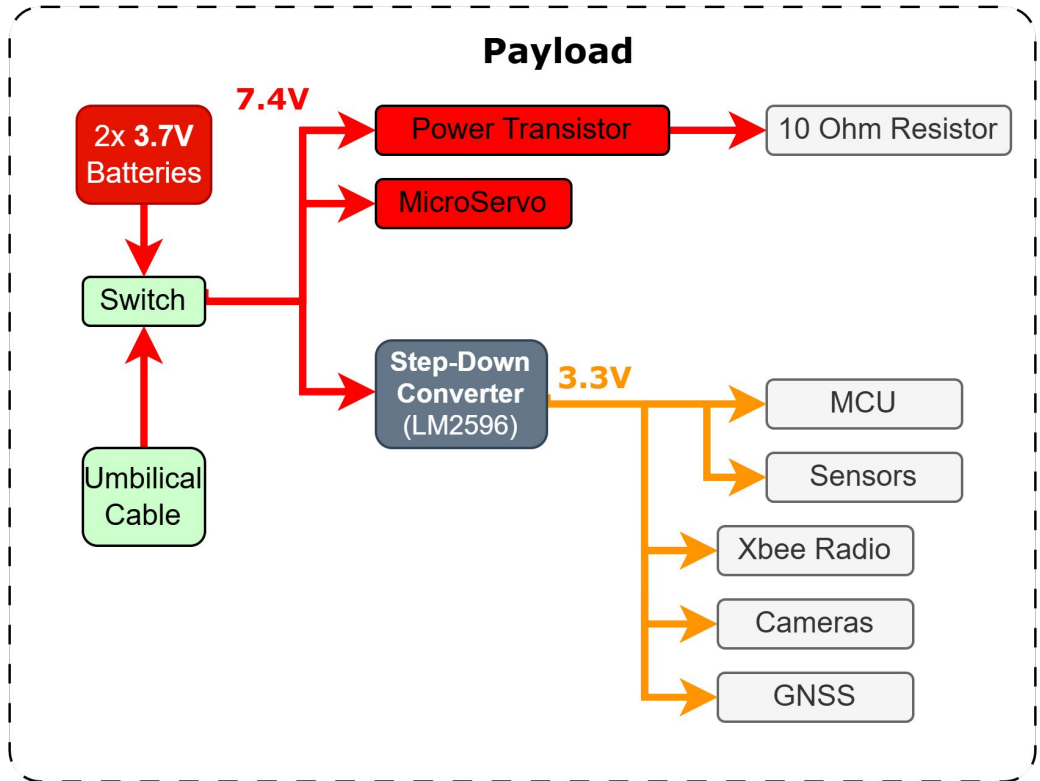
CR2032 (225mAh)



Step-down 3.3 V Converter LM2596



a 10 Ohm Resistor and a Power Transistor are used to burn the fishing line





EPS Changes Since PDR



Changes:

- Main battery: 2x Vapcell H10 to 2x Vapcell K10
- Beacon battery: 2x2477 to 1x2032



EPS Changes Since PDR



Main battery:

The battery was changed due to the lack of availability of the selected model.

Therefore another model of the same manufacturer with the desired characteristics was selected.

The greatest point against using these cells is the lower maximum constant discharge current. However the technical specifications of this new model in addition to the 2 series configuration complies satisfactorily with the design current and voltage needs.



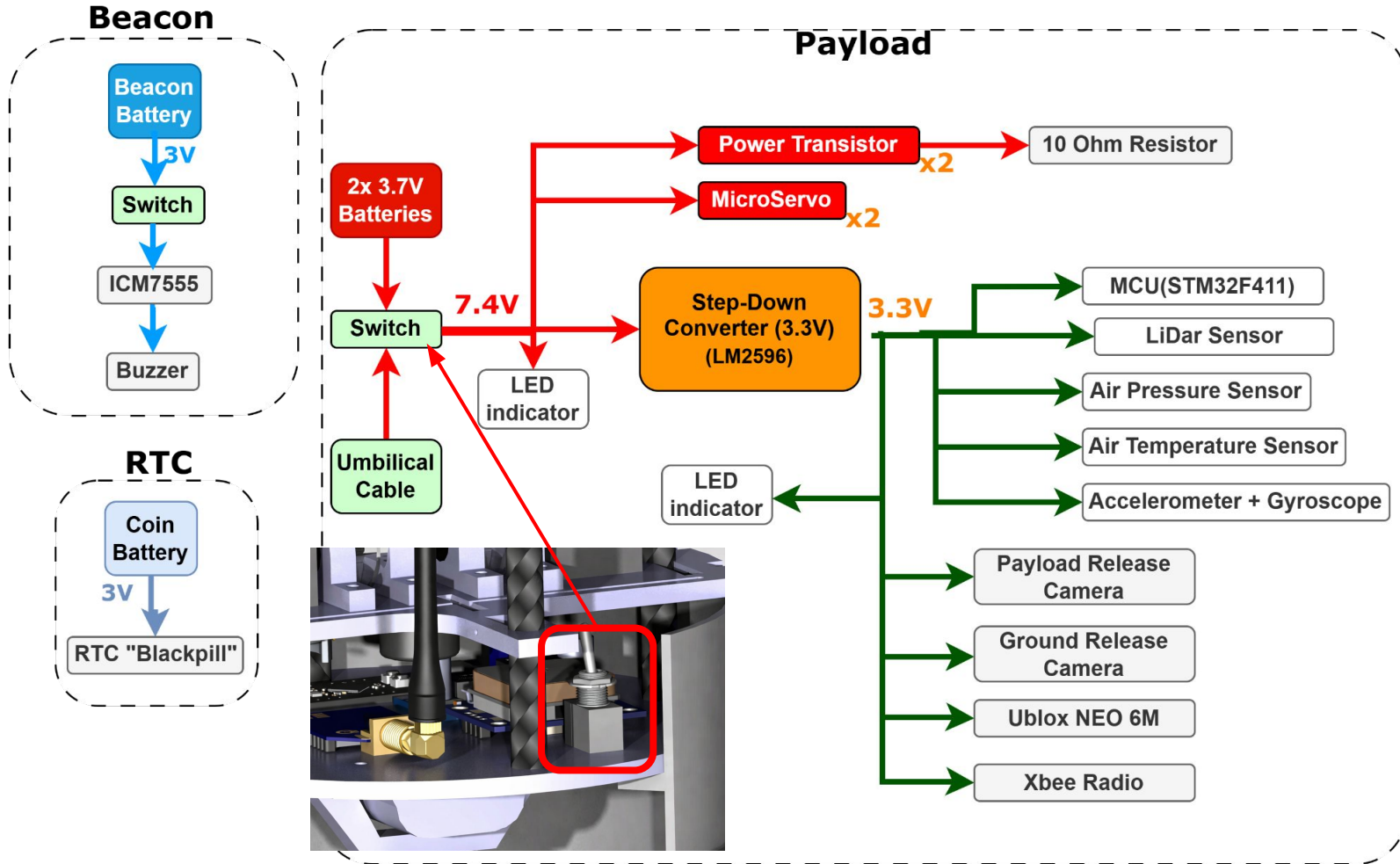
EPS Changes Since PDR



Beacon battery:

One of the main concerns with the current design stage of the CanSat is weight. The beacon was redesigned to utilize a single 2032 cell instead of dual 2477 cells, to reduce weight. Functionality remained the same.

The previous design used a 2S configuration exclusively for the voltage increase. A redesign of the beacon board allowed for running on 3V, while also reducing power draw. With a new power budget calculation it was determined that a single 2032 cell could supply enough energy for the whole mission, greatly reducing weight.



Note: The switch is externally accessible through a hole.

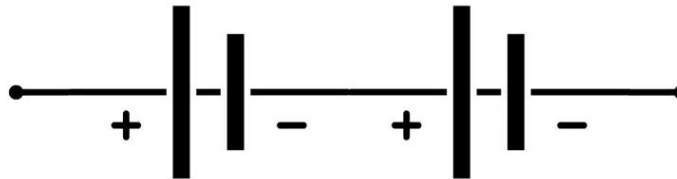
Note: LED's are power indicators and are visible through the same hole as the switch.

Vapcell INR14500 (2S configuration)

- **Cell voltage:** 3.7V(Nominal) to 4.2V(Fully charged)
- **Weight:** 24 g
- **Density energy:** 0.154 Wh/g
- **Nominal current:** 1000mA
- **Nominal capacity:** 1000 mAh
- **Max. discharge current:** 8A (continuous)
- **Dimensions:** 14 mm (diameter) x 50 mm



IN 2S configuration:



- **Total Energy:** 7.4 Wh
- **Nominal Voltage:** 3.7 V



Payload Power Budget (1/2)



Type	Component	Qty.	Duty Cycle [min]	Duty Cycle [%]	Peak Current [mA]	Voltage [v]	Energy [Wh]	Source
Sensor	LPS22HB	1	120	100.00%	0.012	3.3	0,00010	Datasheet
Sensor	HS3003	1	120	100.00%	0.0244	3.3	0,00020	Datasheet
Sensor	Resistor Divider + ADC Shunt	1	120	100.00%	0.02	3.3	0,00017	Estimated
GPS	Ublox Neo-6M	1	120	100.00%	40	3.3	0,33000	Datasheet
Sensor	BNO055	1	120	100.00%	12.3	3.3	0,10148	Datasheet
Sensor	TFS20-L	2	5	4.17%	130	3.3	0,00012	Datasheet
Clock	Integrated Blackpill's RTC	1	120	100.00%	0.015	3.3	0,08257	Estimated
Camera	Quelima SQ11	2	5	4.17%	120	3.3	0,31350	Datasheet
MCU	STM32F411	1	120	100.00%	38	3.3	1,94400	Datasheet
Motor	SERVOS	2	3	2.50%	2500	7.2	0,14775	Datasheet
Radio	XBee Transmitting	1	10	8.33%	215	3.3	0,01632	Datasheet
Radio	XBee Idle	1	110	91.67%	2	3.3	0,08938	Datasheet
Heating Resistor	10 Ohm Resistor 1/4W	2	0.042	0.03%	740	7.4	0,00657	Estimated
TOTAL					6947.37		3,03214	

Note: the power consumption was calculated **considering 80% efficiency** of the DC/DC buck converter.

Note: Stall current was assumed to estimate the servo's consumption.

Note: Total current provided by the battery will always be lower than estimated.



Payload Power Budget (2/2)



Power Source: Payload Battery	Energy [Wh]
Total Energy Consumption	3.03
Battery Energy (100% discharge depth)	7.4
Energy Margin	4.07

Power Source: Beacon Battery	Energy[Wh]
Total Energy Consumption	0.1518
Battery Energy (100% discharge depth)	0.675
Energy Margin	0.5232

Power Source: RTC Battery	Energy[Wh]
Total Energy Consumption (RTC)	0.0012
Battery Energy (100% discharge depth)	0.675
Energy Margin	0.6738

Discharge Depth	Operating Time [h]
100%	4.88
60%	2.93

Discharge Depth	Operating Time [h]
100%	8.89
60%	5.34

Discharge Depth	Operating Time [h]
100%	1125
60%	675



Flight Software (FSW) Design

Jaime Nazar Anchorena



FSW Overview(1/3)



- **State Overview**

STARTUP
Retrieve stored data from memory. If a processor reset took place, skip to the state found in memory.

LAUNCH PAD
Wait for CXON command. When received, take measurements, send telemetry, calibrate altitude, start radio transmission, set UTC time, receive commands from ground, activate GPS and wait for ascent.

ASCENT
Send telemetry, determine flight state based on altitude and receive commands from the ground.

APOGEE
Send telemetry, save maximum altitude, set para-glider and ground cameras to record and receive commands from the ground.

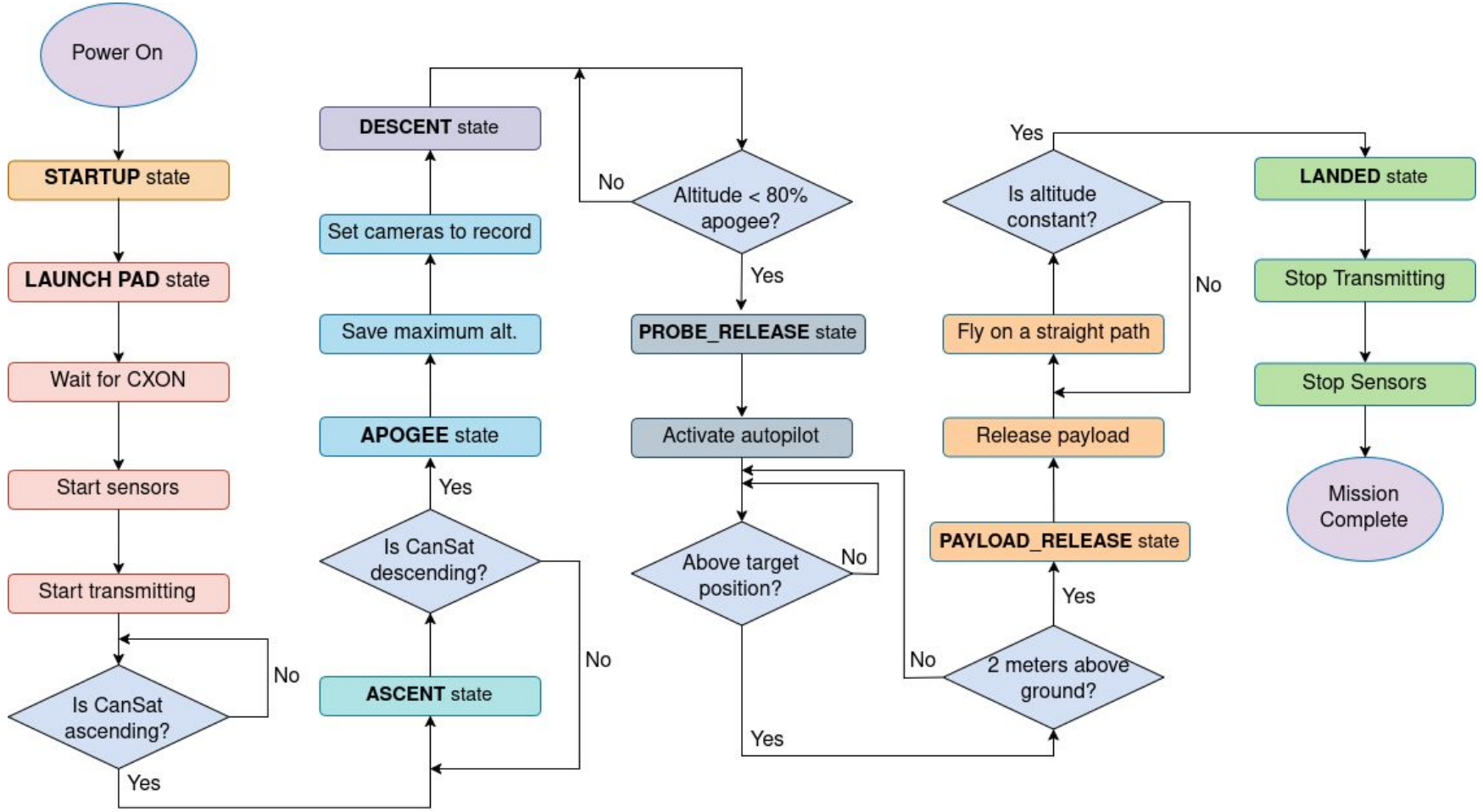
DESCENT
Take measurements and send telemetry, determine flight state based on altitude, receive commands from the ground, wait to reach 80% altitude.

PROBE_RELEASE
Release probe, take measurements and send telemetry, determine flight state based on altitude, receive commands from the ground, activate the autopilot, wait to be 2 meters above the target location.

PAYLOAD_RELEASE
Release payload, take measurements and send telemetry, determine flight state based on altitude, receive commands from the ground, continue flight on a straight path.

LANDED
Stop camera recording and deactivate payload telemetry.

• Basic FSW Architecture





FSW Overview(3/3)



- **FSW Tasks**

- Transmit sensor measurements once per second to the Ground Station
- Send, receive and process packets via XBEE radios
- Keep track of mission state (based on altitude data) in case the processor resets
- Steer CanSat towards the required position
- Control deployment mechanisms
- Keep track of mission time through processor resets
- Operate in simulated flight mode

- Programming language: **C**

- Development environments: **STM32CubeIDE**



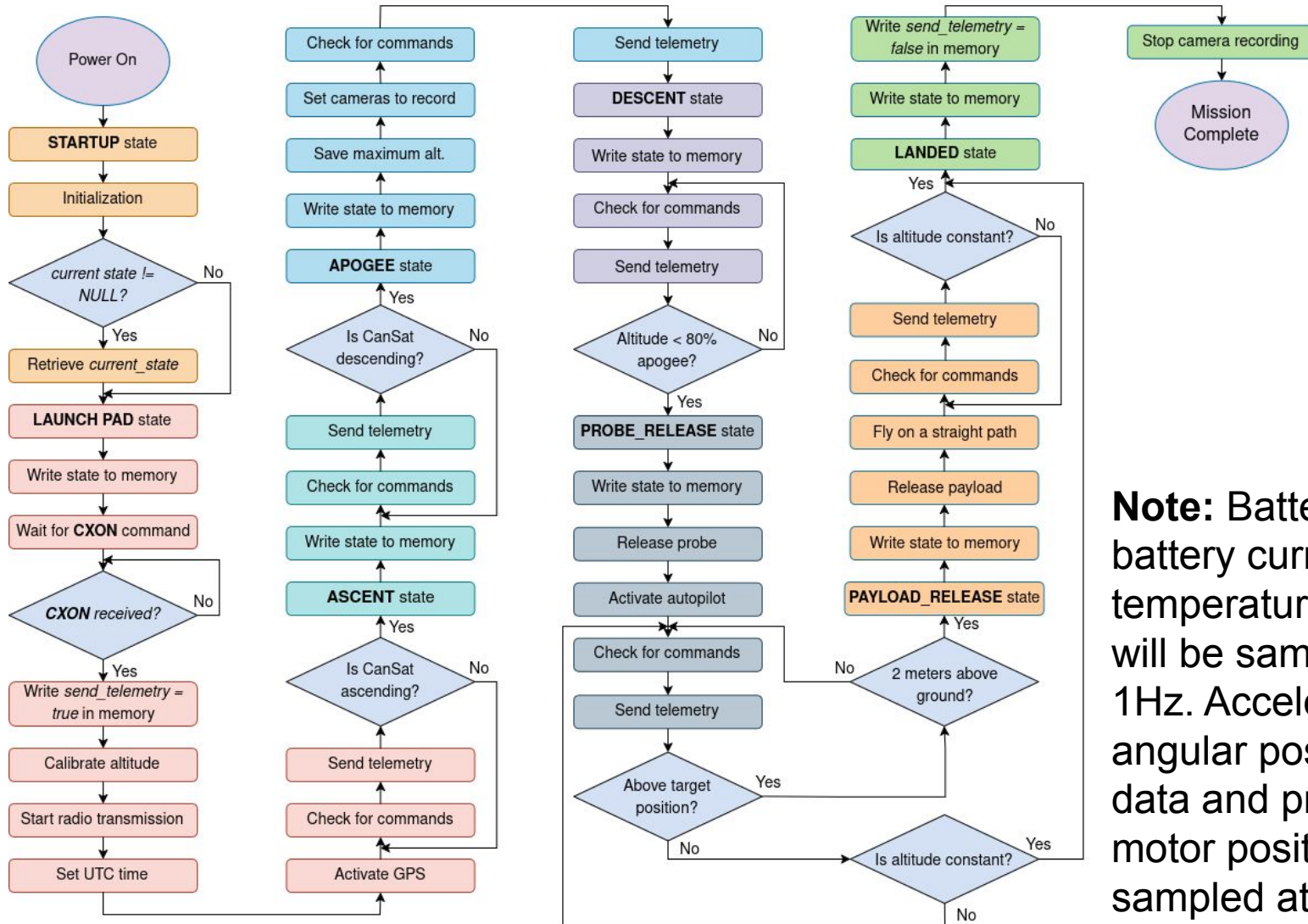
FSW Changes Since PDR



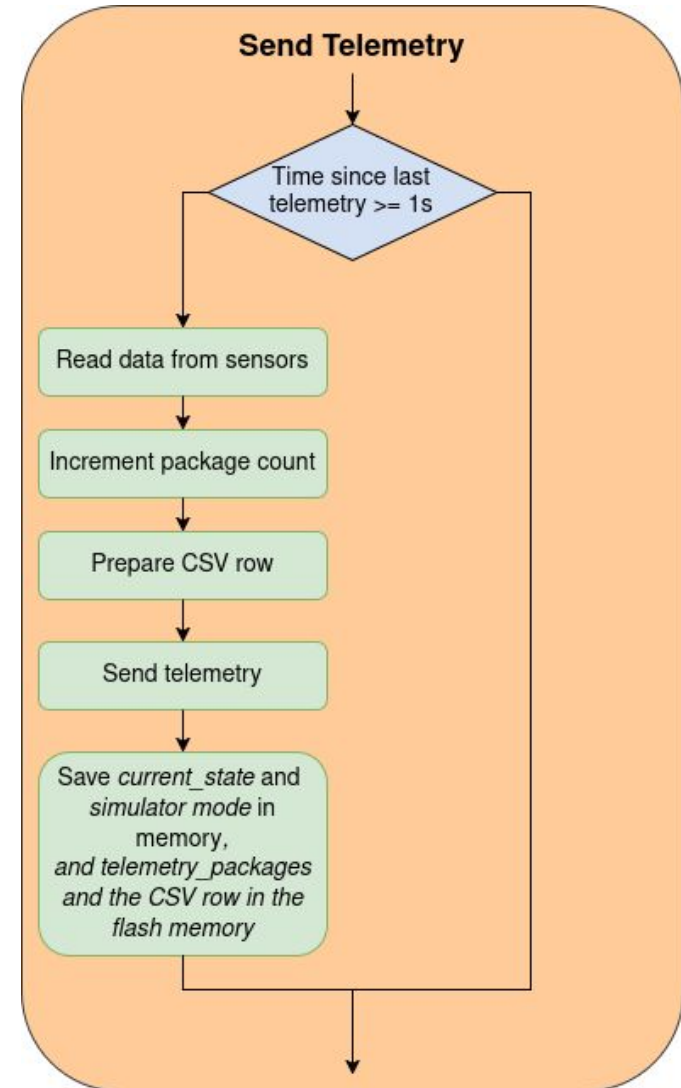
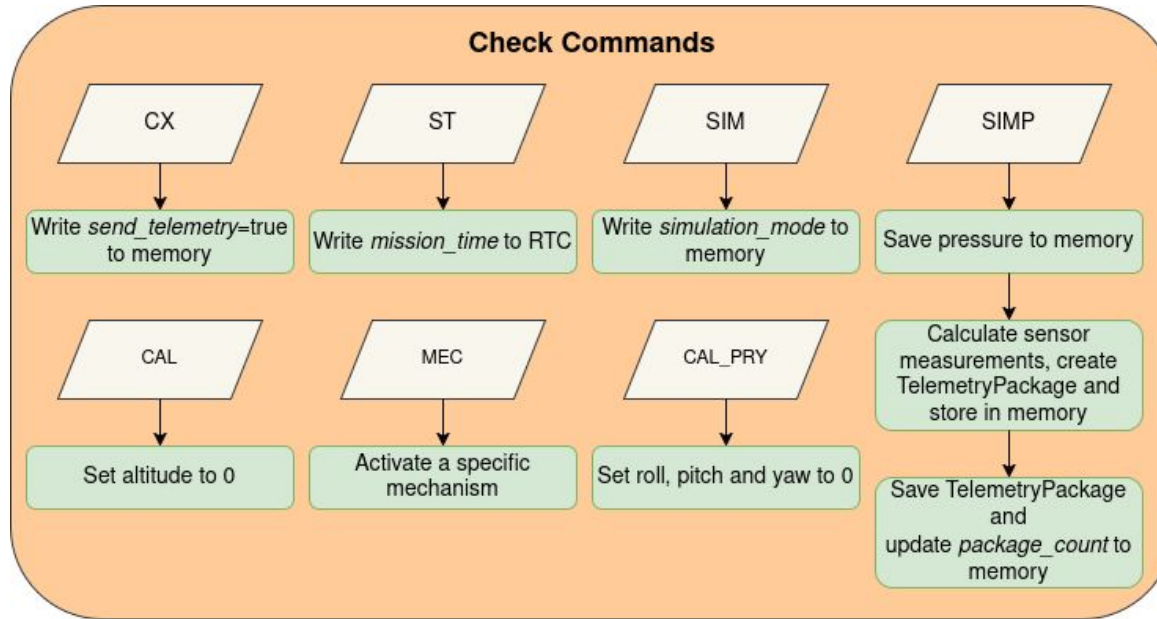
No changes have been made to the Flight Software design since the PDR.



Payload CanSat FSW State Diagram(1/2)



Note: Battery voltage, battery current, temperature and time will be sampled at 1Hz. Acceleration, angular position, GPS data and pressure, motor position will be sampled at 100Hz.



In the event of a power loss, the processor would reset. We will store the current state, *send_telemetry*(boolean), *simulation_mode*(boolean), the telemetry packages in the system memory, and the zero altitude calibration reference, to be retrieved on startup.

We also store in memory the content of each *TelemetryPackage* in case it needs to be sent again.



Simulation Mode Software(1/2)



- **Simulation Mode**

The Ground Station reads simulated barometric pressure values once per second from a .csv provided by the competition and transmits them via commands to the Cansat. Then, the values are used for calculations of altitude and flight software logic instead of the actual pressure sensor readings.

- **Commands**

- **SIM (Simulation Mode Control):** Sets the current operation mode:
 - **ENABLE:** Enable the simulation mode.
 - **ACTIVATE:** Activates the simulation mode.
 - **DISABLE:** Disables and deactivates the simulation mode.
- **SIMP (Simulated Pressure Data):** Sends simulated barometric pressure values.



Simulation Mode Software(2/2)



- **Simulated sensor data**

- Flight software activates the simulation mode after receiving SIM ENABLE and SIM ACTIVATE commands
- Once activated, the flight software monitors the radio link for barometric pressure sensor commands (SIMP) sent from the Ground Station
- Received values are used as if they were actual barometric pressure readings in the calculation of altitude, determination software state, and when to release the CanSat.
- Values other than the pressure and altitude (calculated from the pressure values) will be actual sensor readings (e.g., actual battery, temperature, and GPS).



Software Development Plan (1/6)



- **Prototyping and prototyping environments**
 - All sensors will be tested individually as development progresses.
 - Breadboards and homemade PCB's will be used to create prototype circuits to test software modules. Data obtained will be monitored and evaluated.
- **Test methodology**
 - Pre-existing libraries will be used for unit testing of individual components, as well as integrated tests.

- **Naming conventions**

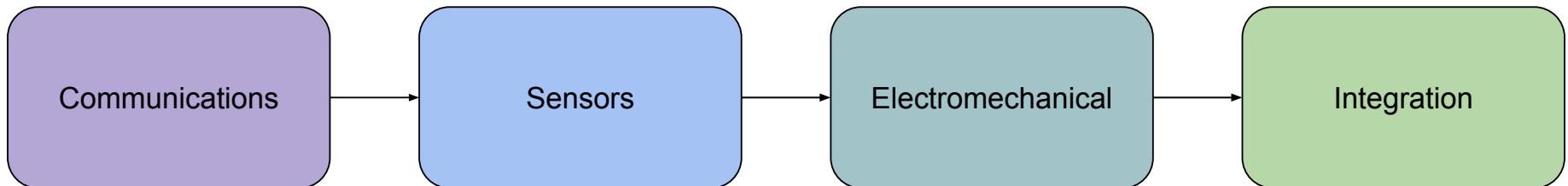
- Snake case for naming files, functions and variables
- Pascal case for naming data structures

- **Constraints**

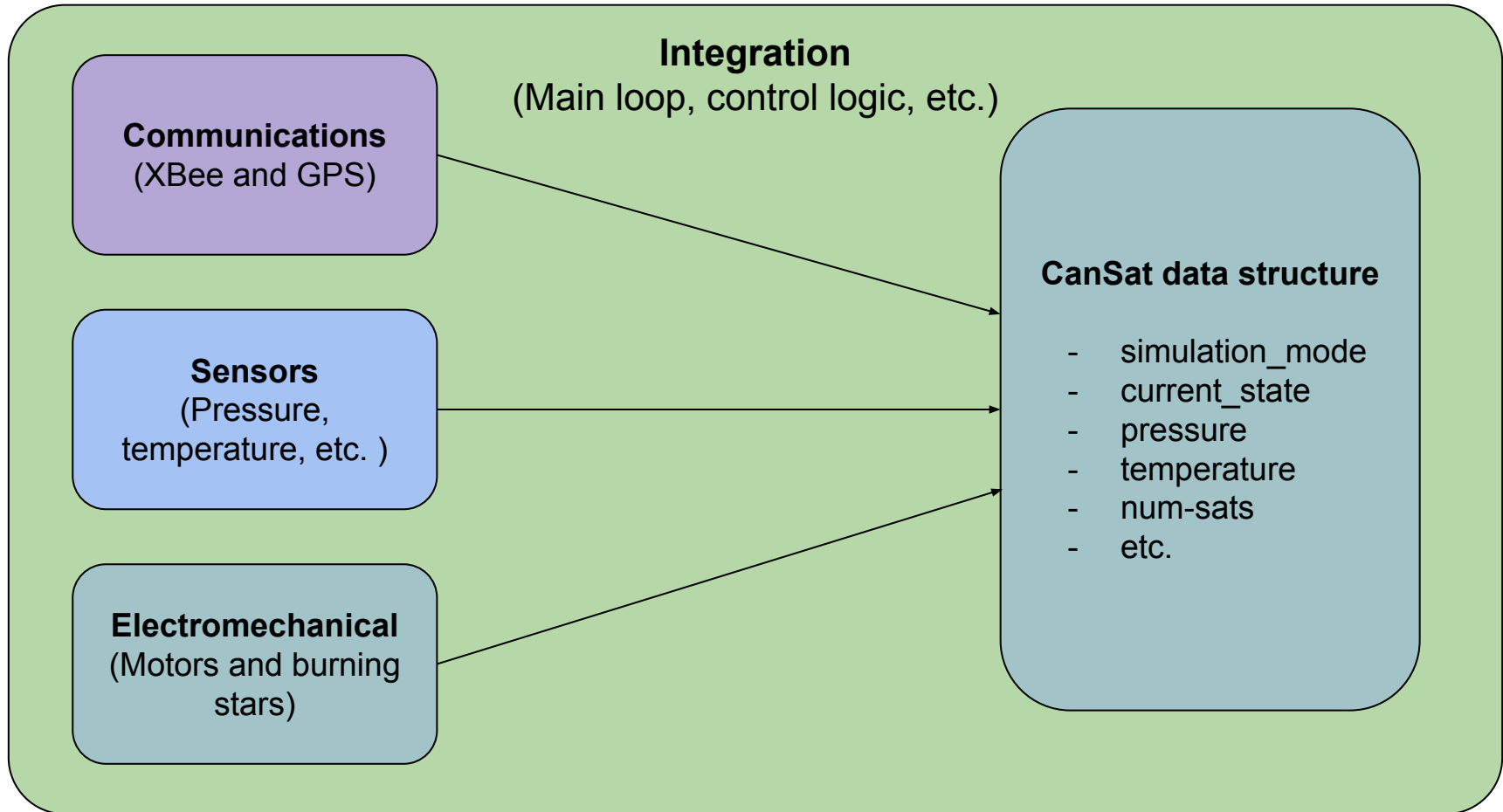
- 512KB of flash memory available for instructions
- Limited to imperative programming
- STM32 not as widely supported compared to Arduino

- **Software subsystem development sequence**

The software will be developed in different modules, to be able to test each module individually and to prioritize reusability.



- **Module structure**





Software Development Plan (4/6)



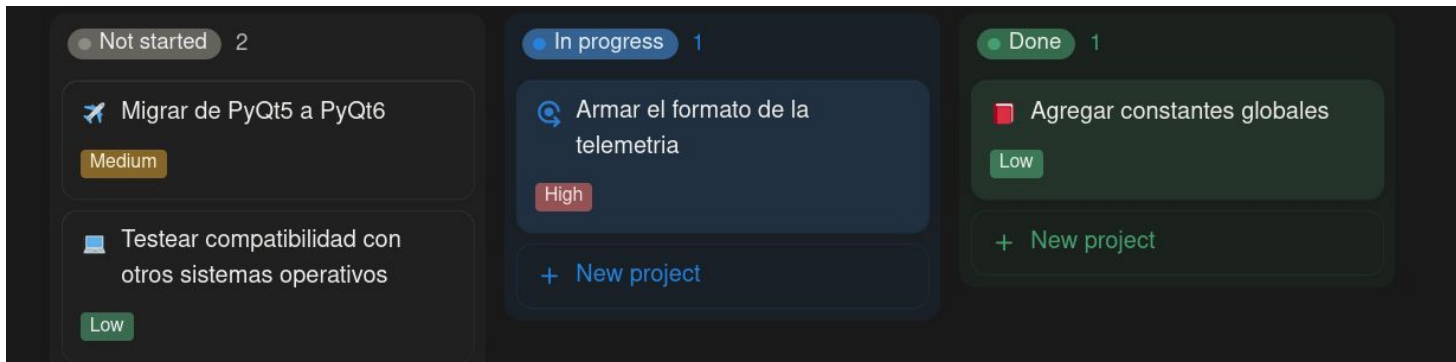
- **Development and testing team**
 - Matteo Ginhson
 - Jaime Nazar Anchorena
 - Nicanor Otamendi
 - Emanuel Agustín Albornoz
 - Juan Manuel Sambucetti
- **Plans to reduce the risk of late software development**
 - Agile methodologies to develop and test software as soon as possible
 - Weekly meetings to track progress and possible problems
 - Use of Github and Notion to organize and set tasks

- **Github**

- We will use Github to be able to collaborate and track changes
- Code can be easily revised and reverted in case of errors.

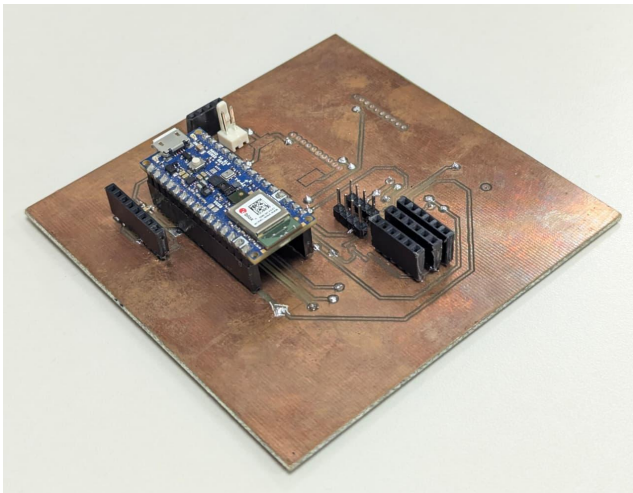
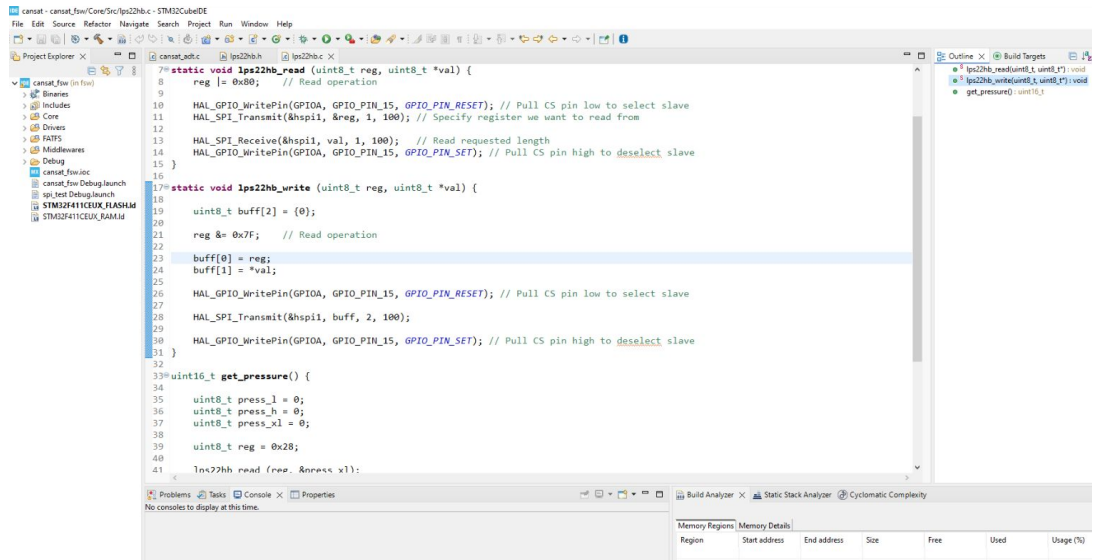
- **Notion**

- Similar to Jira and Trello, allows collaborators to set and organize tasks, as well as track progress
- We'll use Kanban Boards to visualize the progress



- **Progress since PDR**

- Individual sensor drivers have been implemented and tested individually in protoboards.
- Individual sensors tested simultaneously in a prototype of the main PCB with an Arduino microcontroller.
- Currently working on the Electromechanical module.

```

17=static void i2s22hb_read(uint8_t reg, uint8_t *val) {
18     reg |= 0x80; // Read operation
19
20     HAL_GPIO_WritePin(GPIOA, GPIO_PIN_15, GPIO_PIN_RESET); // Pull CS pin low to select slave
21     HAL_SPI_Transmit(&hspi1, &reg, 1, 100); // Specify register we want to read from
22
23     HAL_SPI_Receive(&hspi1, val, 1, 100); // Read requested length
24     HAL_GPIO_WritePin(GPIOA, GPIO_PIN_15, GPIO_PIN_SET); // Pull CS pin high to deselect slave
25 }
26
27=static void i2s22hb_write(uint8_t reg, uint8_t *val) {
28     uint8_t buff[2] = {0};
29     reg &= 0x7F; // Read operation
30     buff[0] = reg;
31     buff[1] = *val;
32
33     HAL_GPIO_WritePin(GPIOA, GPIO_PIN_15, GPIO_PIN_RESET); // Pull CS pin low to select slave
34     HAL_SPI_Transmit(&hspi1, buff, 2, 100);
35     HAL_GPIO_WritePin(GPIOA, GPIO_PIN_15, GPIO_PIN_SET); // Pull CS pin high to deselect slave
36 }
37
38=uint16_t get_pressure() {
39     uint8_t press_l = 0;
40     uint8_t press_h = 0;
41     uint8_t press_xl = 0;
42     uint8_t reg = 0x28;
43     In<2>hb read (reg, Annex x1);
44 }

```

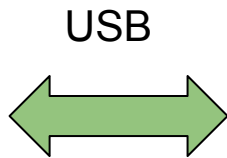


Ground Control System (GCS) Design

Jaime Nazar Anchorena

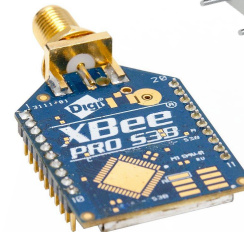


Laptop with **GCS**

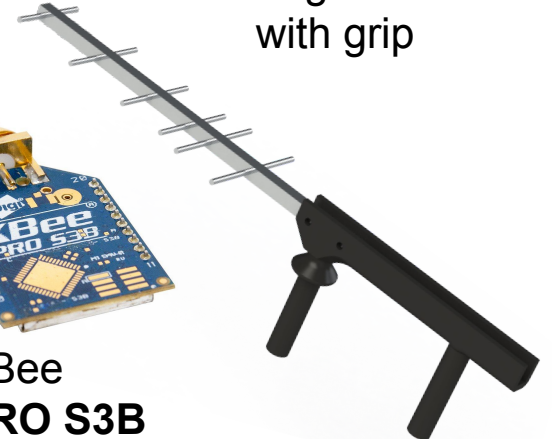


XBee USB Adapter
FT232RL

Through-Hole
Mount



XBee
PRO S3B



Hand-held
Yagi Antenna
with grip



GCS Changes Since PDR



- Plots sections moved to the upper-right corner of the UI.

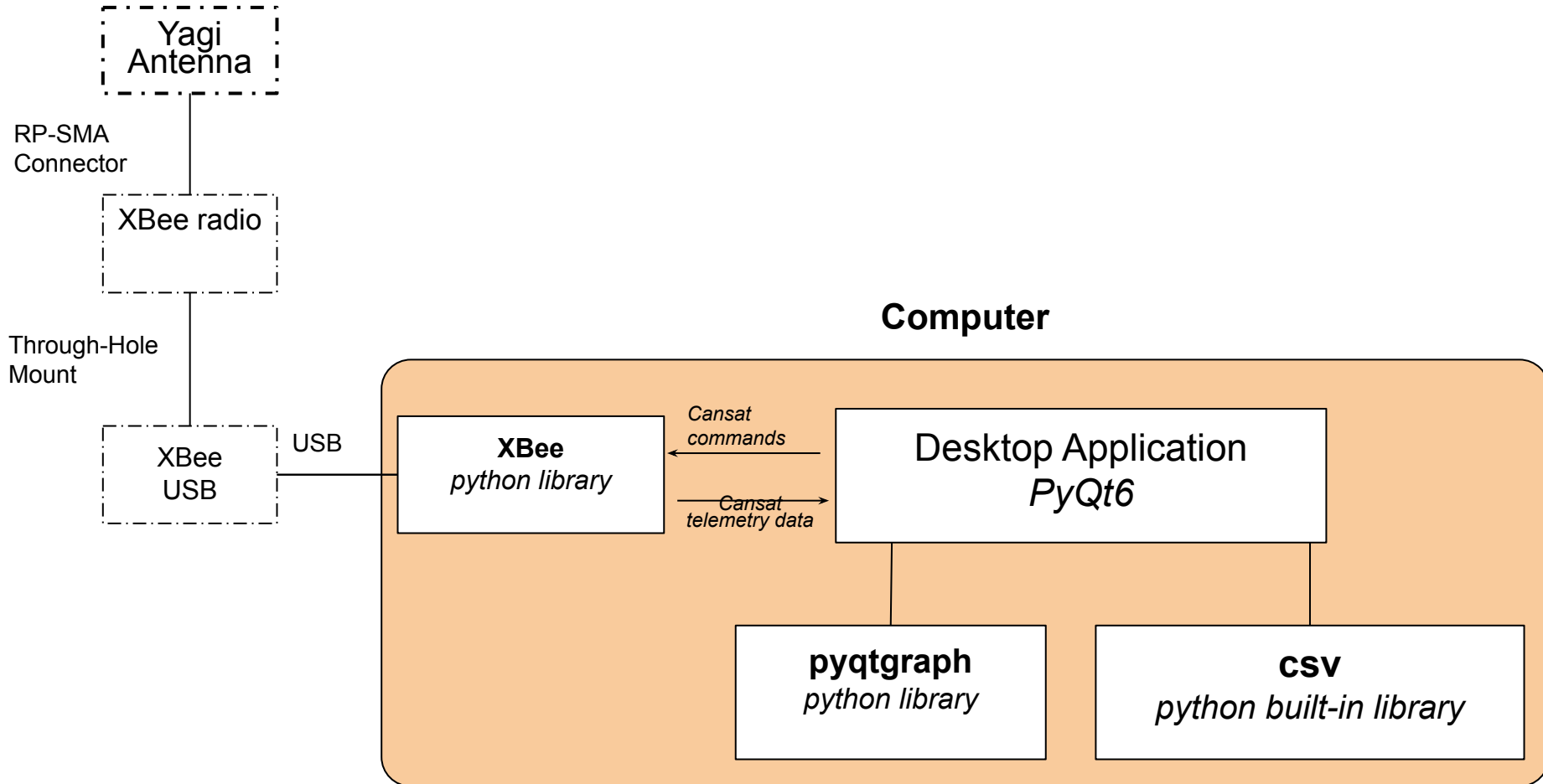


Before(prototype)



After

• Ground Station Diagram





GCS Design (2/2)



- **Specifications**

- **Battery life**

- The GCS will run on a laptop with an average battery life of 6 hours

- **Overheating mitigation**

- The laptop will be kept in the shade, using a sunshade if necessary

- **Auto update mitigation**

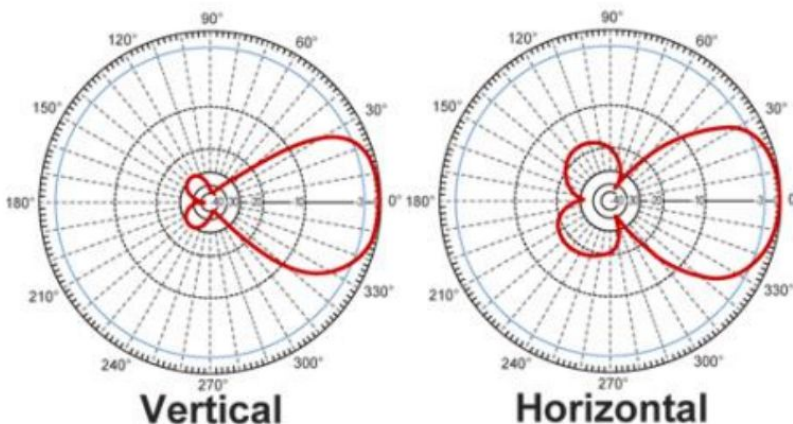
- If running Windows, Windows Updates will be disabled on the laptop

A09-Y11NF

880 MHz to 960 MHz, Heavy-Duty Yagi Antenna, 11dBi, RP-SMA Connector



Typical Radiation Pattern

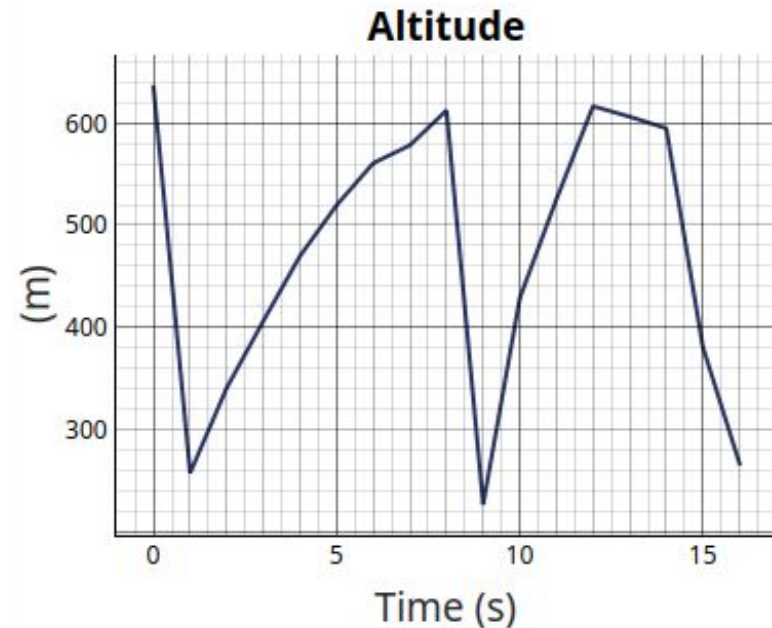


Gain:	11 dBi
Horizontal Beam Width:	54 Degrees
Vertical Beam Width:	48 Degrees
Maximum Input Power:	100 Watts
Impedance:	50 Ω
Range:	890 - 960 MHz
Polarization:	Linear
Radiation Pattern:	Directional
Typical VSWR:	1.3:1
Maximum VSWR:	1.5:1
Dimensions (L x W):	635 x 150 mm
Weight:	837 g
Range (LoS):	> 46000 m

- **Telemetry display screen shots**

- Telemetry will be displayed in **real-time** in the Ground Station using the ***pyqtgraph*** library
- Telemetry will be recorded in a **.csv** file using the csv library from Python.

Graph display example





GCS Software (2/7)



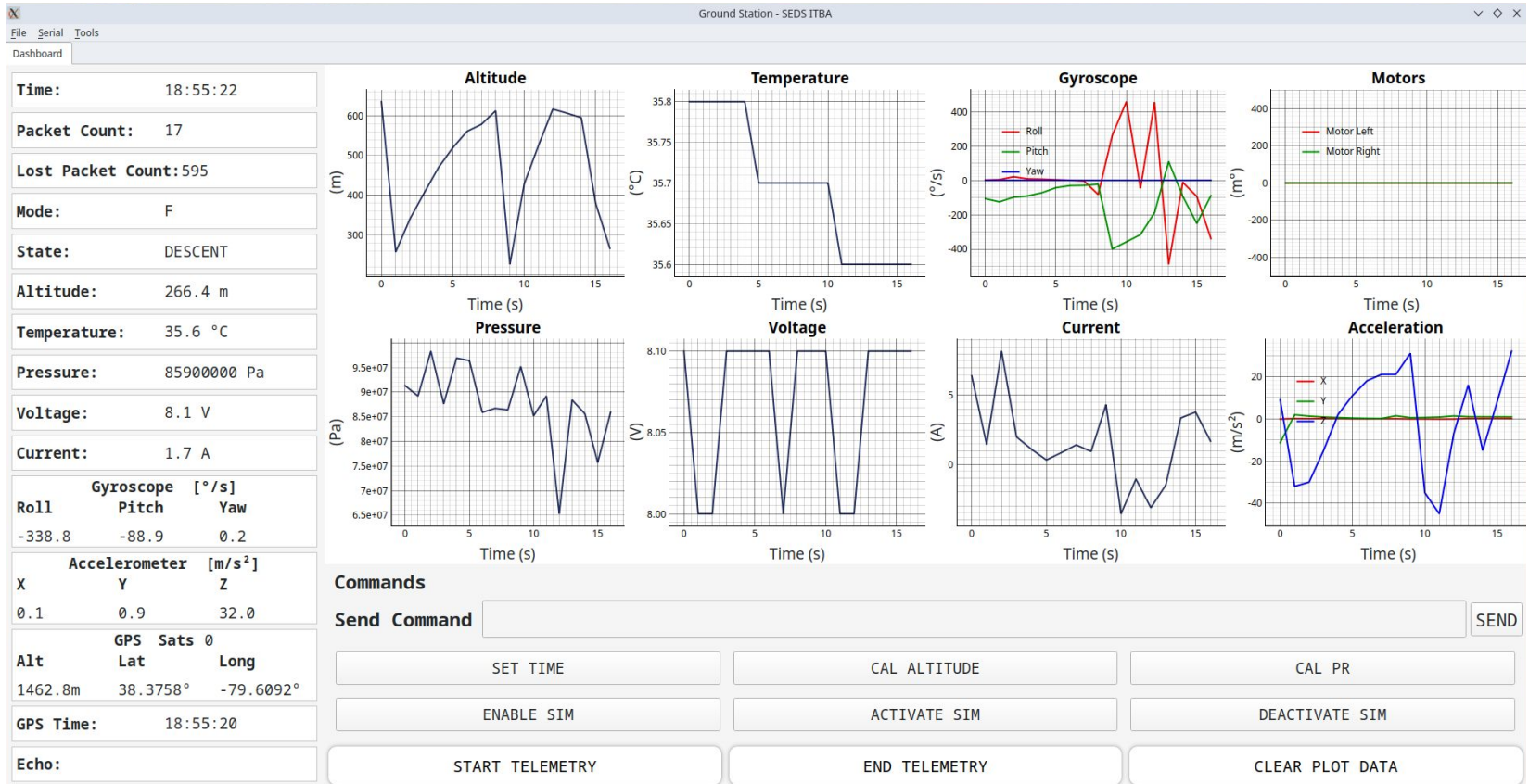
- **Commercial off the shelf (COTS) software packages used**
 - **Python3 Desktop Application**
 - Allows for efficient, cross-platform development, and it takes advantage of the team's familiarity with the language.
 - **Python libraries used**
 - **PyQt6**
 - **pyqtgraph**: high performance real-time plots
 - **CSV**: built-in module for file reading and writing
 - **XBee**: Python library for communication with the antenna



GCS Software (3/7)

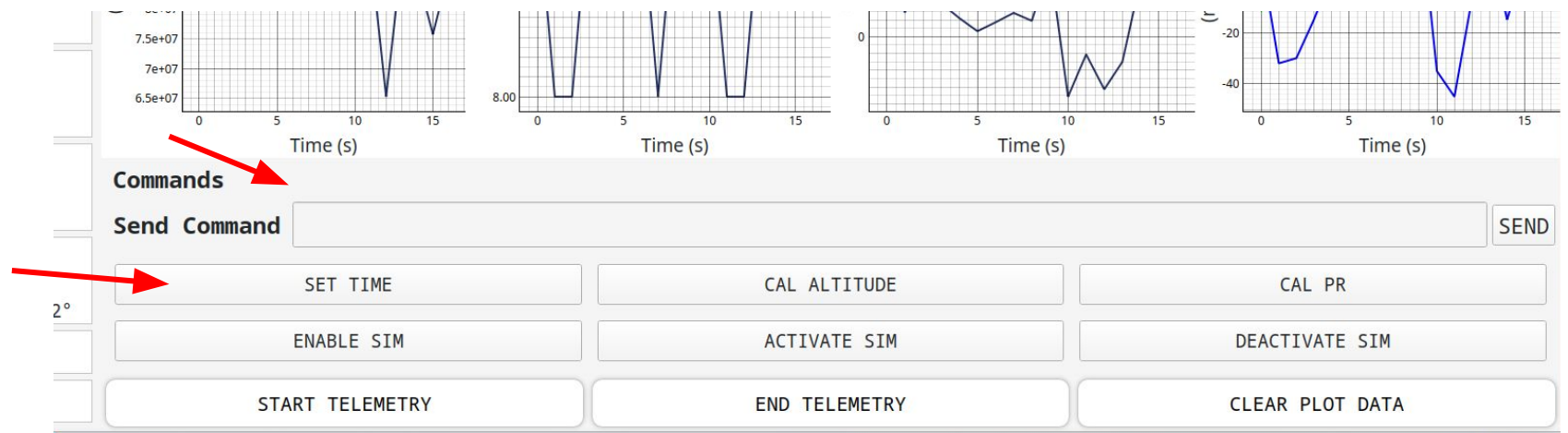


Real-time plotting software design(beta version)



- **Command software and interface**

Buttons for frequently used commands and command prompt
Positioned in the top-right corner





GCS Software (5/7)



- **Simulation mode description**

The user can command the software to send **ACTIVATE**, **ENABLE** and **DISABLE** commands to the container to set the simulation state.

When the commands **SIM ENABLE** and **SIM ACTIVATE** are sent, the ground station will read the provided csv file and send them once per second(at 1 Hz) to the Cansat.

The python built-in library `csv` will be used to read the csv file.

- **Telemetry data recording and media presentation to judges for inspection**

The module `csv` in Python allows us to write content to a CSV file on the system.

```
1  import csv
2
3  header = ['TEAM_ID', 'MISSION_TIME', ..., 'CMD_ECHO']
4  csv_file_path = 'Flight_1234.csv'
5  with open(csv_file_path, 'w', newline='') as csv_file: # Creates new CSV file
6      writer = csv.writer(csv_file)
7
8  telemetry = ['2099', '00:01:30', ..., "CXON"]
9  with open(csv_file_path, 'w', newline='') as csv_file:
10     writer = csv.writer(csv_file)
11     writer.writerow(telemetry) # Saves telemetry data to the csv file
12
13  print(f'Telemetry data saved to {csv_file_path}')
```

The file can be transferred to an USB drive if necessary or used to create more user friendly formats such as graphs.



GCS Software (7/7)



- **Progress since PDR**

- Developed the beta version of the Ground Control Station
- Tested the UI with mock data
- Now working to integrate the Communications and test the data link



CanSat Integration and Test

Juan Sambucetti



CanSat Integration and Test Overview (1/2)



Subsystem	Test Description
Sensor	<ul style="list-style-type: none">• Individual test of each sensor (Hardware & Software)• Integrated sensor subsystem test
CDH	<ul style="list-style-type: none">• Individual test of each component (Hardware & Software)• Integrated CDH subsystem test
Mechanical	<ul style="list-style-type: none">• Structural integrity test• Mass budget test
EPS	<ul style="list-style-type: none">• Measurement of real energy consumption• Measurement of batteries real capacity• Integrated EP subsystem test
Radio Communications	<ul style="list-style-type: none">• Individual test of each receiver/emitter (Hardware & Software)• Range test (Antenna + XBee)
FSW	<ul style="list-style-type: none">• Ensure data saving• Verification of subsystems• Verification of all software states• Testing of simulation mode
Descent Control	<ul style="list-style-type: none">• Opening forces on the glider's line attachment• Integrated Descent Control subsystem test• Rotation stability test



CanSat Integration and Test Overview (2/2)



Test Plane	Test Description
Integrated Level Functional Test Plans	<ul style="list-style-type: none">• Descent test• Communications test• Mechanisms test• Deployment test
Environmental Test Plans	<ul style="list-style-type: none">• Drop test• Thermal test• Vibration test• Fit check• Vacuum test
Simulation Test Plans	<ul style="list-style-type: none">• Simulation mode sensors test• Simulation mode communications test• Simulation mode software test



Subsystem Level Testing Plan (1/4)



SENSORS	Description
AIR PRESSURE	The sensor is tested to ensure that the barometric pressure readings are correctly converted into altitude values and that the accuracy meets the mission requirements.
AIR TEMPERATURE	Thermal readings are validated by comparing them against a reference thermometer to ensure the sensor provides accurate ambient temperature data.
GPS	Testing involves verifying the transmission of NMEA sentences to the ground station and ensuring the parsing logic correctly extracts coordinates and time.
VOLTAGE AND CURRENT	The module's power data is cross-referenced with a digital voltmeter to ensure precise monitoring of the CanSat's electrical consumption and battery health.
ROTATION	The rotation rate data is verified by rotating the CanSat on its axes and checking the telemetry in the simulation image to ensure precise orientation tracking.
ACCELERATION	Acceleration data is tested along the X, Y, and Z axes using a ground station simulation to verify that the sensor correctly detects changes in velocity and impact.
CAMERA	Both cameras are tested for video quality and field of view



Subsystem Level Testing Plan (2/4)



CDH	Description
MCU	Testing verifies that the microcontroller unit successfully processes raw sensor data and executes the transmission protocol to the ground station.
XBEE	The wireless link between XBEE modules is validated through range and signal strength tests to ensure stable communication at maximum mission distance.
CAMERA	Testing confirms that both camera modules record video data to the SD card simultaneously without frame loss or file corruption.
SD CARD	High-speed logging is checked to ensure that all telemetry packets sent to the ground station are also backed up locally on the SD card.
RTC MODULE	The accuracy of the Real-Time Clock is validated to ensure precise timestamping of all sensor data and system events during the flight.

EPS	Description
Power Consumption	Current values are measured at different mission stages to verify that the power profile remains within expected limits
Endurance (2-hour task)	A continuous operation test is performed for 2 hours to ensure the system remains stable and functional throughout the entire mission duration.
Fault Protection	Short-circuit fault testing is conducted to verify that the protection circuits correctly isolate failures without damaging the main bus.
Voltage Monitoring	Voltage dividers are measured with a multimeter to calibrate the scaling factors and ensure precise telemetry readings.
Switching & Beacons	The functionality of the main power switches and the audio beacon is verified, ensuring the recovery system activates correctly upon command.
Battery Redundancy	Separate battery connections and voltage levels for the audio beacon are checked to ensure independent power supply for recovery.
Motor & Thrust Power	Motors are tested during start-up and landing phases to verify that the batteries provide sufficient current without voltage drops or power interruptions.



Subsystem Level Testing Plan (3/4)



Radio Communication	Description
RF Range & Environment	XBee communication is tested across various distances and environmental conditions to ensure link stability.
Data Integrity & Loss	Tests verify minimal data loss during telemetry transmission, ensuring frequency and data format comply with mission specifications.
Antenna Performance	Transmission power and antenna orientation are tested in open terrains to optimize the link between the payload and the ground station.
GCS Interface	The ground station interface is tested for correct packet reception, real-time display, and the execution of uplink commands.

FSW (Flight Software)	Description
Data Accuracy	Flight software accuracy is validated by comparing sensor readings against known environmental reference values.
Transmission Logic	The FSW is checked to ensure that the data transmission order strictly follows the sequence defined in the mission guide.
Recovery Algorithms	In the event of a microprocessor reset, data recovery and state restoration algorithms are tested to ensure mission continuity.
Flight Dynamics	The flight algorithm is tested through drop tests from specific heights to verify the separation mechanism and para-glider activation.
Command Execution	Uplink commands from the ground station are tested to ensure they correctly trigger safety or recovery mechanisms during mishaps.
System Integration	The software's ability to activate all mechanisms (both individually and simultaneously) is validated under simulated flight conditions.



Subsystem Level Testing Plan (4/4)



Test Plan	Test Description
Mechanical	<ul style="list-style-type: none">• Mass Budget Test• Each part will be weighted individually and then with all the components assembled (with glue and other fixing elements)• Cansat Structural integrity, verify if the subsystems resist the forces required• Several drone tests will be performed to confirm functioning of subsystems and if forces are the ones calculated. Structural integrity will be evaluated after each drop• Each iteration will be accompanied by data analysis• Verify the release resistance mechanism reliability• As mentioned before, drone tests will be performed to assess functioning of deployment subsystem• Verify all subsystem functions separately: Parachute deployment, Payload release, egg instrument release.• Again, drone tests will test each separate mechanism



Integrated Level Functional Test Plan (1/4)



Descent

- A container and payload equivalent will be dropped from a drone to verify descent rate with the parachute and then will do the same with the para-glider.

Mechanisms

- Critical parts will be tested both in the laboratory using real scale forces, and also on the field doing drop tests. To **ensure they survive the required force limits**.
- Expected theoretical values will be compared to real experimental ones enabling us to change elements in case of unsuccessful results.



Integrated Level Functional Test Plan (2/4)



Deployment

- Payload **release trigger** will be tested using simulation mode to ensure its correct release from the container at 450m.
- Para-glider deployment trigger will be tested using simulation mode with the cansat stationary to ensure it activates at 450m, after the payload is released.
- Para-glider deployment will be tested using simulation mode in conjunction with a descent test.
- Fishing line's resistance will be tested to **ensure parachute keeps attached** to the container during deployment.
- Prototype will be dropped from progressively higher altitudes to test the payload release mechanism and the para-glider deployment mechanism, to ensure the triggering of both mechanisms works correctly



Integrated Level Functional Test Plan (3/4)



Communication Test Plan

Communications

- Communication range will be tested using a testing mode on the FSW Communication Module.
- Signal blocking will be tested using different materials to cover the radios.
- Different orientations and moving conditions of the payload will be tested to ensure a robust communication in any kind of situation or context scenario.

Ground Station Software

- Storing the received sensor data in a CSV file and real time data plotting will be tested using an Xbee connected to the computer.
- To find bugs, each button will be pressed multiple times.



Integrated Level Functional Test Plan (4/4)



Communication Test Plan

Telemetry

- Telemetry format will be checked to comply with the format requirements
- Time between packets will be checked
- Data will be checked.

Antennas

- Communication range will be tested using a testing mode on the FSW Communication Module.
- Radios will be placed at least 2 km away in an open field.
- Antennas will be set in the horizontal axis, pointing at the same direction
- Handling of lost radio messages (and automatic resending) will be tested using a testing mode on the FSW Communication Module.
- Signal blocking will be tested using different materials to cover the radios.



Environmental Test Plan (1/3)



Test Plan	Test Description
Drop Test	<ul style="list-style-type: none">• 61 cm non-stretching cord is attached to a fixed point in the ceiling and to the parachute• CanSat is raised to the ceiling and released• A mattress is placed under the CanSat in case of a structural damage on the joints.
Thermal Test	<ul style="list-style-type: none">• An electric oven (thermal chamber) with the CanSat inside will be heated up to around 60 degrees Celsius for 2 hours to test if temperature affects the proper working of the CanSat with ongoing communications.
Vibration Test	<ul style="list-style-type: none">• A orbital sander provided by the university is used to simulate vibration on the CanSat for 5s five times.• The purpose of this vibration is to check that all components and structural joints stay fixed and working.• Telemetry and proper working of the sensors are to be controlled during the test.



Environmental Test Plan (2/3)



Test Plan	Test Description
Fit Check	<ul style="list-style-type: none">• The CanSat is inserted in the open section of the payload to make sure all components fit inside the way they are supposed to.
Vacuum Test	<ul style="list-style-type: none">• The CanSat is placed in a closed box with a hole prepared to insert the hose of a vacuum cleaner to remove the air.• Once a vacuum starts forming the pressure sensor is used to measure the simulated altitude.• When peak altitude is reached the hose will be removed and the air will be let back in slowly.



Environmental Test Plan (3/3)



Dimensions Verification:

To ensure the CanSat meets mission requirements, precise measurements will be conducted using calibrated tools. A digital caliper will be used to verify critical dimensions such as the outer casing, payload compartment, and clearance between components. A micrometer will check the thickness of structural parts and small tolerances to ensure proper assembly. A high precision ruler will confirm overall height and width, ensuring the CanSat fits within the required envelope.

To validate accuracy, physical measurements will be cross-checked against the CAD model, and a fit test will be performed in a mock launch container to ensure there are no obstructions. The verification is considered successful if all dimensions remain within tolerances and the system integrates seamlessly.



Test Procedures Descriptions (1/6)



#	Test Name	Description	Requirements	Pass / Fail Criteria	Status	Category
1	Drop Test	CanSat attached at 3m height, raised 61cm and dropped. Mattress placed under in case of structural damage on joints.	S9, S17, M3	Payload and container expected to have lowest damage	Not Tested Yet	Structural
2	Mass Requirement Test	Verify mass is 1000g ± 10g weighing on a scale.	S1	Weight within margin	Not Tested Yet	Structural
3	Simulated Mission Test	Payload release and para-glider deployment tested in simulation mode. Mechanism activations verified at 80% of peak altitude.	C5, C6, SN7	All mechanisms deploy correctly at 80% altitude	Not Tested Yet	Mission
4	Descent Rate Test	Equivalent CanSat dropped from drone to verify descent velocity with parachute and para-glider system.	C4, C7	Velocity, descent rates and rotation within margin	Not Tested Yet	Mission
5	Thermal Endurance Test	Electric oven heats CanSat to ~60°C for 2 hours. Test if temperature affects proper working and communications.	S17, M3, E6	All systems and comms function properly for entire 2hr test	Not Tested Yet	Environmental



Test Procedures Descriptions (2/6)



#	Test Name	Description	Requirements	Pass / Fail Criteria	Status	Category
6	Vibration Test	Orbital sander simulates vibration on the CanSat.	S8, S17, M3	All systems work correctly, structural integrity not compromised	Not Tested Yet	Environmental
7	Vacuum Chamber Test	CanSat placed in vacuum chamber, deployment mechanism tested.	C5, C6, S17, M3	All deployment should work	Not Tested Yet	Environmental
8	Measurements Test	Container placed inside correctly sized tube. Payload placed inside container. Dimensions checked.	C3, S3, S4, S7, S10-S14, S18	Container fits tube, payload fits container, dimensions meet requirements	Passed	Structural
9	Cameras Recording Test	Ground pointing camera direction and AG camera field of view checked.	C9, C11	Ground camera $45 \pm 3^\circ$ from nadir. AG camera records payload release and operation clearly	Not Tested Yet	Sensors
10	Flash Memory Fail Recovery Test	Store data to Flash Memory and recover after processor reset and power loss scenarios.	F1, F2, G4	Data and program status persist correctly	Not Tested Yet	Software



Test Procedures Descriptions (3/6)



#	Test Name	Description	Requirements	Pass / Fail Criteria	Status	Category
11	Telemetry Module Test	FSW Communication Module used with XBee connected to Arduino Nano 33 BLE Sense Rev2.	X1, X4	Arduino sends and receives packages	Passed	Comms
12	Simulation Mode Test	GCS Software sends commands to enable simulation, reads values from CSV and sends them via CDH running FSW.	G11, G12, G17, F4, F5, F6	FSW reacts to pressure values, sends telemetry, activates mechanisms at right moment	Not Tested Yet	Software
13	Simulation Data Test	CSV file read using Python csv library running on PyQt6 app.	G12, F4	File read and transmitted with correct data	Passed	Software
14	Telemetry Test	CSV file written using Python csv library running on PyQt6 app.	G2	Software sends, receives, and parses packets correctly	Passed	Comms
15	Battery Life Test	GCS Software Communication Module used running on PyQt6 app.	E6	Battery lasts at least 2 hours with all components connected	Passed	Electrical



Test Procedures Descriptions (4/6)



#	Test Name	Description	Requirements	Pass / Fail Criteria	Status	Category
16	Landing and Retrieval Test	Simulate landing state, check telemetry state. Audio beacon range tested in open field.	C13	FSW stops transmitting. Audio beacon audible from 20m	Not Tested Yet	Mission
17	Battery Test	Connect batteries via 0.1Ω resistor at 10Hz. Run 2 hours, check remaining capacity.	E3	Current ≤8A peak, ≤2.75A for >10s. Battery ≥60% remaining. Switch accessible	Not Tested Yet	Electrical
18	XBee Long Distance Test	CanSat and GCS in open field 2km apart. CXON command sent, data checked in GCS.	C9, G16, F1, X2, X4	No missed packets. Time between packets 1s ±50ms. NETID set correctly	Not Tested Yet	Comms
19	Sensor Test	All sensors (altitude, temp, battery, position, acceleration, rotation, magnetic field) tested via telemetry.	X5, SN1-SN6, SN11	Sensor data meets precision and format criteria. Telemetry format and frequency meet requirements	Not Tested Yet	Sensors
20	HW & SW Design Compliance	Requirements reviewed using checklist (no experimental test needed).	E, X3, G1, G3, G6-G9, G14, F3, F7	All hardware and software design requirements met	Not Tested Yet	Review



Test Procedures Descriptions (5/6)



Phase	Period	Tests	Prerequisite
1 - Subsystem electronics	Mar 25 - Apr 15	PCB assembly #19 Sensor test #10 Flash memory recovery #9 Camera recording test	PCB manufactured
2 - Comms & EPS	Apr 16 - 30	#17 Battery test (2hr) #18 XBee long-distance (2km) #12 Simulation mode test #20 HW & SW design compliance	Pending components arrive: HS3003, INA181A2, Vapcell K10, Carbon fiber rods
3 - Mech + environmental	May 1 - 12	#2 Mass requirement #8 Fit check #1 Drop test (30G) #6 Vibration test (15G) #5 Thermal	Full mechanical integration complete
4 - Full system	May 12 - 20	#7 Vacuum chamber #3 Simulated mission #4 Descent rate (drone drops, iterative tests with drones. Analysis between drops will be made) #16 Landing + retrieval	All subsystems validated individually
5 - Final verification	May 23 - Jun 2	Full mission rehearsal Pre-ship verification	All tests passed ETD submitted (by may 22)



Test Procedures Descriptions (6/6)



NOTE

All Requirements that aren't mentioned in the previous slides, don't need an empirical test. They either don't correspond to our design or they were thought in the design and will be checked with a checklist.



Simulation Test (1/2)



Simulation Test Process:

To verify the correct functionality of the CanSat's simulation mode, the following test procedure will be carried out: First, the SIM ENABLE and SIM ACTIVATE commands will be sent to the CanSat to activate the simulation mode. Once the mode is activated, the Ground Station should begin transmitting simulated barometric pressure data by reading a .csv file and sending one SIMP command every second to the CanSat. This will be checked.

It will be verified that the CanSat correctly receives each SIMP command and processes the simulated pressure data as real sensor readings for altitude calculations and flight software state determination. It will also be verified that the CanSat Probe release mechanism is correctly triggered based on the altitude calculations derived from the simulated pressure data.

It will be confirmed that telemetry data such as battery, temperature, and GPS readings come from the actual sensors, with only the pressure readings being simulated.

The procedure will be repeated with various simulated scenarios to verify that the CanSat consistently and reliably responds to the simulated data. Any discrepancies or failures in the system's behavior will be identified, and adjustments will be made to the software or hardware as necessary to ensure proper operation under all test conditions.



Simulation Test (2/2)



Test Plan	Test Description
What parts of the CanSat get tested during simulation?	The simulation validates the performance of all software components and the communication link with the Ground Station. Furthermore, every onboard sensor is tested during this phase, with the specific exclusion of the LiDar.
How is the simulation implemented?	When simulation mode is active, the CanSat software behaves precisely as it does during normal operations. The only deviation is that physical barometer data is bypassed; instead, the system processes pressure values received directly from the ground via radio communication (FSW Simulation Mode set by the GCS).



Mission Operations & Analysis

Nicolás Eyaralar



Overview of Mission Sequence of Events (1/2)



Arrival to Launch Site

PHASE 1

Basic Configuration

Check In

Pre Launch Preparations

- Prepare Cansat for turn-in
- Final CanSat tests
- Teams present fully integrated CanSat at the check-in station.

- Prepare antennas and set up the ground station
- Verify CanSat is communicating with the ground station
- Power on CanSat and place it in the rocket
- Transport launch vehicle to the pad and await rail integration.

PHASE 2

Flight

Launch

Recovery and Post-Flight

- CanSats must be flight-ready, only power switch actuation is allowed
- The mission control officer executes launch procedures at the control table, overseen by the flight coordinator
- Ground station crew performs all required flight operations
- Once the flight is complete, the team recovery crew will wait until cleared to enter the field

- Following the launch of all CanSats, the recovery crew will proceed to retrieve the payload and verify the structural integrity of the Egg.
- Ground station crew clears the area and submits a thumb drive with data to the ground station judge
- The recovery crew will return to check-in for any final judgment requirements



Overview of Mission Sequence of Events (2/2)



Position	Tasks	Members
Mission Control Officer	<ul style="list-style-type: none">• Manages the Team Launch• Verifies that everything is ready with The Ground Station Crew• Executes the launch procedure with flight coordinator oversight	<ul style="list-style-type: none">• Nicolás Eyaralar
Ground Station Crew	<ul style="list-style-type: none">• Monitor the ground station for telemetry reception• Issue commands to the CanSat.• Performs all required flight operations	<ul style="list-style-type: none">• Matteo Ginhson• Emanuel Agustin Albornoz• Jaime Nazar Anchorena
Recovery Crew	<ul style="list-style-type: none">• Track and recover the CanSat• Interact with field judges• Make sure all field scores are filled in	<ul style="list-style-type: none">• Federico Agustín Pilotto• Ignacio Ferrando Bravo• Nicanor Otamendi
CanSat Crew	<ul style="list-style-type: none">• Prepare the CanSat and integrate it into the rocket• Verifying status before launching	<ul style="list-style-type: none">• Clara Müller• Nazareno German Pierri• Juan Manuel Sambucetti



Field Safety Rules Compliance



The Mission Operations Manual will be divided into the following sections:

- GCS Configuration and Command Reference
- CanSat Preparation
- CanSat Integration
- Launch Preparation
- Launch Procedure
- Removal Procedure

Development status: The Mission Operations Manual will be ready and assembled in a 3-ring binder by the end of May before beginning flight rehearsals.



CanSat Location and Recovery (1/6)



CanSat Recovery

- On a successful flight, the CanSat will arrive at the desired GPS location, so retrieving it will be quick.
- Cansat will have a loud **audio beacon**
- Cansat will have **contact** and **return information** printed on the exterior in case it cannot be found after landing.

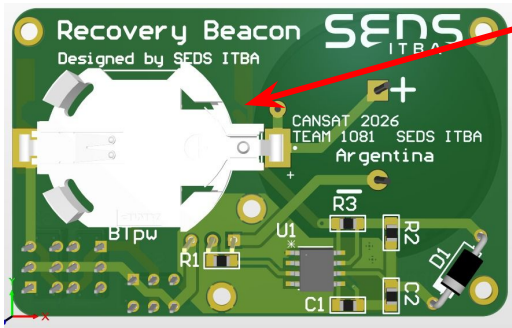
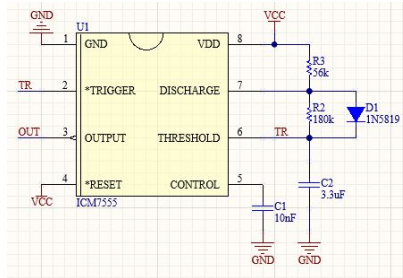
Beacon Overview

- Beeps for 250 ms every 1 second
- Multiple power switches to prevent the system from turning off during flight.
- Lasts up to 8 hours

Active Buzzer

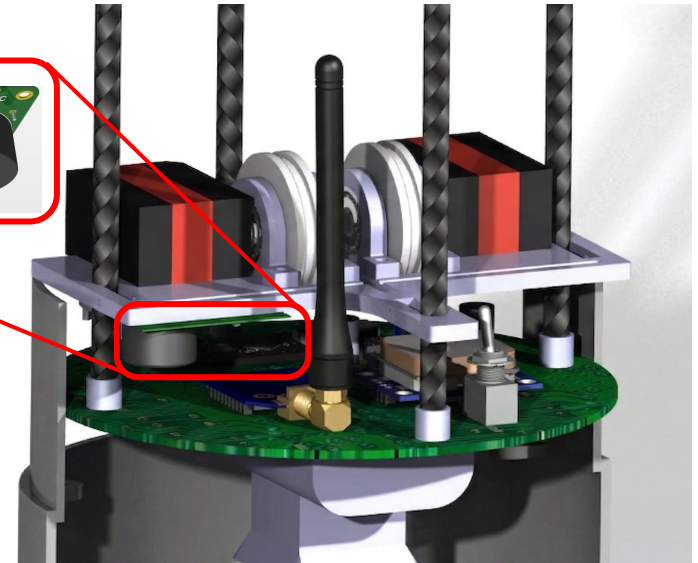
Power Switches

Location



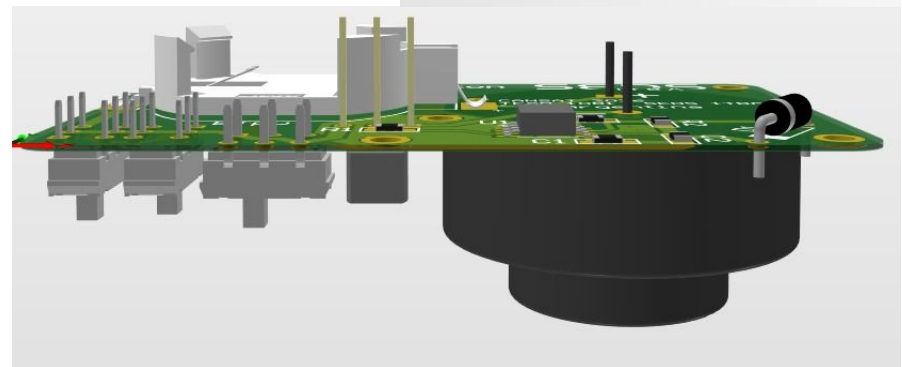
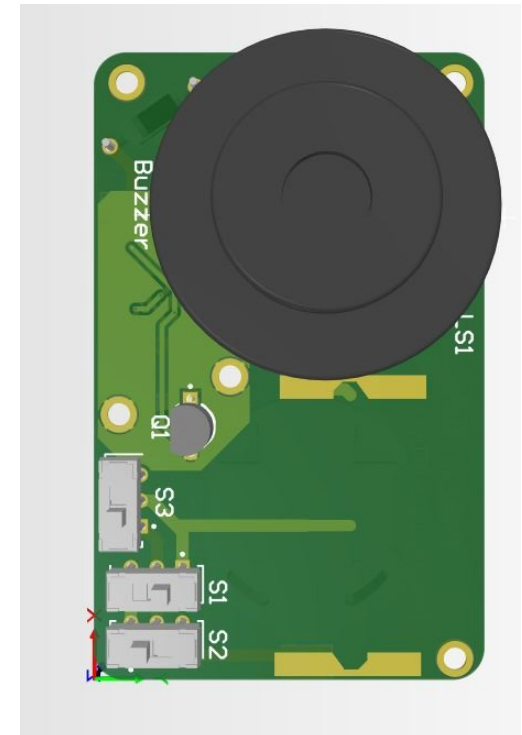
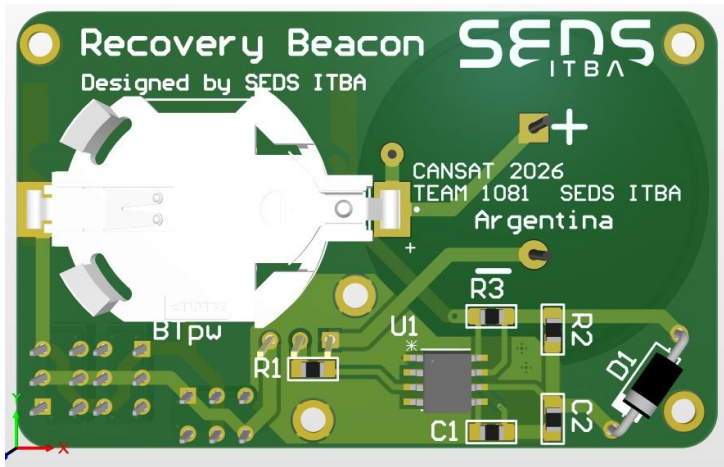
Independent battery

CR2032 (1Ah)



- **Introduction:**

The beacon is a fully **independent tracking circuit** for post-flight payload recovery. It operates on a dedicated Lithium Cell **power source** (CR2032) and emits **250 ms pulses every one second** using a **555 timer**, optimizing energy consumption. A **safety switch** prevents unintended turn-off due to high-g vibrations or crash at landing.



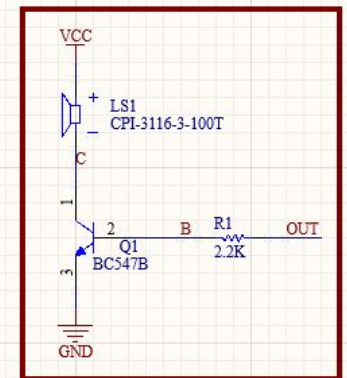
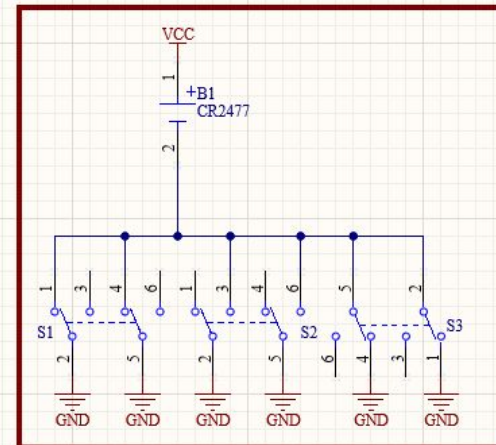
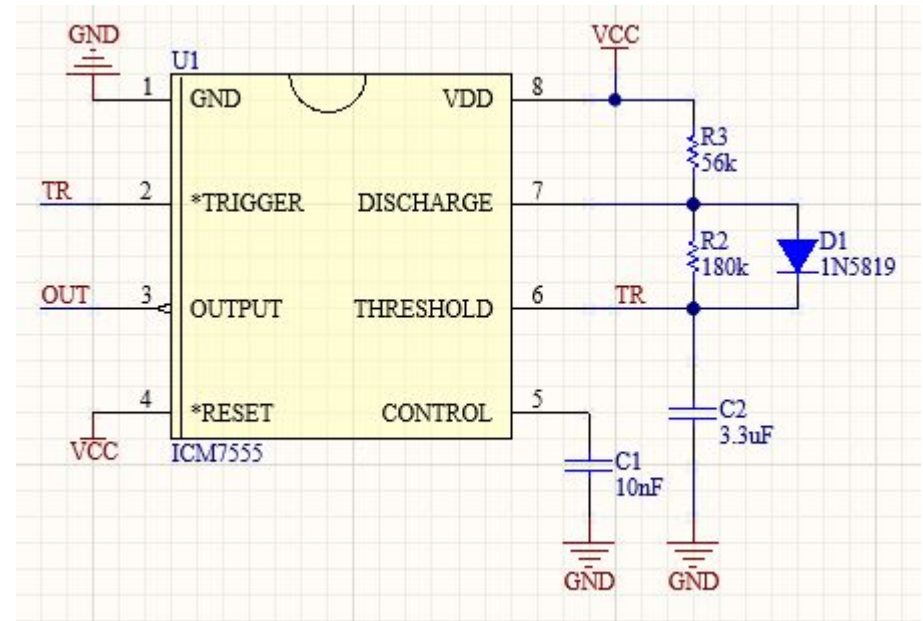
• Beacon LTSpice diagram:

• Benefits:

- Independent Power Source
- Energy Efficiency
- Minimized Interference
- Modular Design

• Operating Values:

- Beacon frequency: 1Hz
- Duty Cycle (Timer555): 25%
- Operating Voltage: 3.3V-5V
- Temperature Range: -40°C to 85°C
- Total Weight: $\sim 40\text{g}$
- Total Price: $\sim \$25$





CanSat Location and Recovery (5/6)



Component	Name	Characteristics
Timer 555	NE555DR	SMD version, low power, SOIC-8 / Operating voltage: 4.5V - 15V / Quiescent current: ~200 μ A (astable mode)
Capacitor 1	Multilayer Ceramic Capacitor	10 μ F
Capacitor 2		10nF
Resistor 1	Carbon Film Resistor	180k Ω
Resistor 2	Carbon Film Resistor	60k Ω
Buzzer	Murata PKM22EPP-20	Resonant frequency: 2.0 kHz / Operating voltage: 3 - 20V
Switch	SPDT	Slide Type
Battery	CR2032	Capacity: 225 mAh / Nominal voltage: 3V / Maximum current: 225A
Diode	Schottky	Maximum reverse voltage: 20V



CanSat Location and Recovery (6/6)



- **Power control**

Power Calculations

1. Timer 555 Power Consumption (Active):

$$P_{\text{Timer555}} = 0.3 \text{ mA} \times 3 \text{ V} = 0.9 \text{ mW}$$

2. Beacon Power Consumption (Active):

$$P_{\text{Beacon}} = 100 \text{ mA} \times 3 \text{ V} = 300 \text{ mW}$$

Total Average Power (Considering Beacon Duty Cycle at

$$P_{\text{Total}} = P_{\text{Timer 555}} + (P_{\text{Beacon}} \times \text{Duty Cycle})$$

$$P_{\text{Total}} = 0.9 \text{ mW} + (300 \text{ mW} \times 0.25) = 75.9 \text{ mW}$$

Conclusion:

- The **total power consumption is 75.9mW.**
- With **one 3V, 220 mAh battery** the estimated operation time is approximately **8.69 hours.**

Battery Operation Time

The total available energy from the batteries is:

$$E_{\text{Battery}} = 220 \text{ mAh} \times 3 \text{ V} = 660 \text{ mWh} = 0.66 \text{ Wh}$$

To calculate the estimated operation time:

$$T = \frac{E}{P} = \frac{0.66 \text{ Wh}}{0.0759 \text{ W}} \approx 8.69 \text{ h}$$



Mission Rehearsal Activities



Activities rehearsed as of March 27

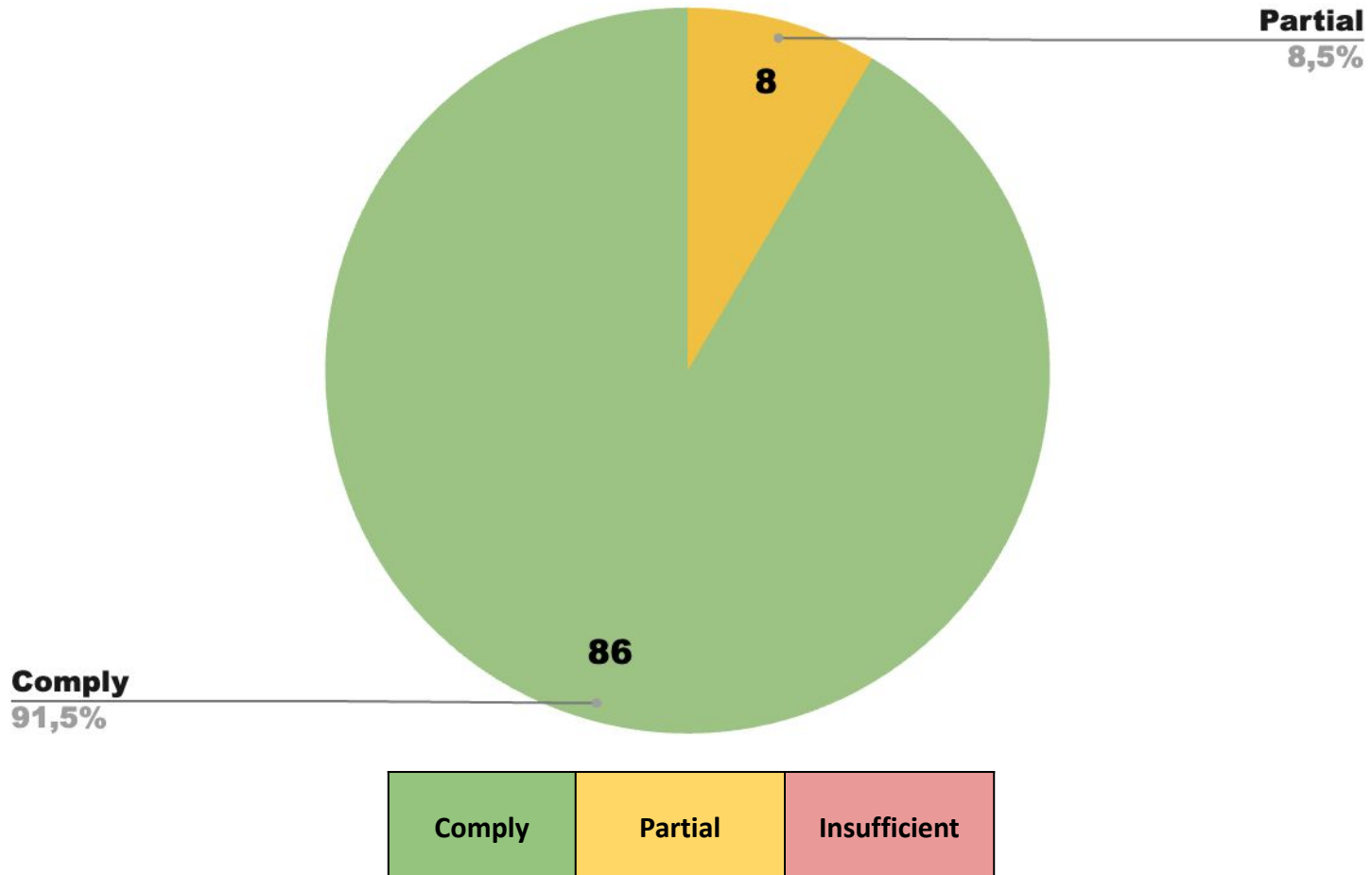
- **Ground system radio link check procedures:**
 - Two Xbees will be used for a short range transmission test, following the test procedures detailed in the previous sections
- **Testing sensors**
 - We have manufactured a PCB for testing all sensors. Not yet tested
- **Launch configuration preparations (e.g., final assembly and stowing appendages)**
 - We haven't tested the payload stowing mechanism nor the stowage configuration of the AG
 - Final assembly procedure defined; pending physical integration.
- **Loading the CanSat in the launch vehicle**
 - We have not done any loading rehearsal yet
- **Telemetry processing, archiving, and analysis**
 - CSV files were plotted correctly using the GCS.
 - No radio communication test was performed
- **Recovery**
 - We have yet to test the buzzer.
 - We have yet to test the GPS positioning.
- **Electrical Power Subsystem basic functionality:**
 - Correct battery and voltage converters behaviour were tested while **switching on and off** our basic PCB board for testing purposes



Requirements Compliance

Nicolás Eyaralar

Requirements Compliance of CDR





Requirements Compliance (1/10)



#	Code	Requirement	Status	Slide Ref.	Comments
1	C1	The Cansat payload shall function as a nose cone during the rocket ascent portion of the flight.	Comply	6 , 17 , 33	
2	C2	The Cansat container shall be mounted on top of the rocket with the shoulder section inserted into the airframe.	Comply	6 , 17 , 33	
3	C3	The Cansat payload and container shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	33	
4	C4	After deployment, the Cansat payload and container shall descend at 15 meters/second using a parachute that automatically deploys. Error is +/- 3 m/s.	Partial	45 , 46 , 47	Theoretically complies, further testing needed.
5	C5	At 80% flight peak altitude, the payload shall be released from the container.	Comply	33 ,	
6	C6	At 80% peak altitude, the payload shall deploy a para-glider descent control system.	Comply	33 , 37	
7	C7	The payload shall descend at 5 meters/second averaged over the entire descent within +/- 3 meters/sec with the para-glider descent control system.	Partial	45 , 46 , 47	Theoretically complies, further testing needed.
8	C8	The payload shall steer toward a target location.	Partial	33 , 41 , 74 , 75	Theoretically complies, further testing needed.
9	C9	The sensor telemetry shall be transmitted at a 1 Hz rate.	Comply	95 , 103	



Requirements Compliance (2/10)



#	Code	Requirement	Status	Slide Ref.	Comments
10	C10	The payload shall record video of the release of the payload from the container and the deployment of the para-glider descent control system.	Comply	76	
11	C11	A second video camera shall point at the ground.	Comply	78	
12	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.	Partial	31 , 33 , 35 , 63 , 79 , 80	Theoretically complies, further testing needed.
13	C13	The Cansat payload shall include an audible beacon that is turned on separately and is independent of the Cansat battery and electronics.	Comply	174 , 175 , 176	
14	C14	Cost of the Cansat shall be under \$1000. Ground support and analysis tools are not included in the cost of the Cansat. Equipment from previous years shall be included in this cost, based on current market value.	Comply	199	
15	S1	The Cansat and container mass shall be 1000 grams +/- 10 grams.	Comply	93	
16	S2	The nose cone shall be symmetrical along the thrust axis.	Comply	17 , 61 , 62	
17	S3	Nose cone radius shall be exactly 70 mm	Comply	17 , 61 , 62	
18	S4	Nose cone shoulder length shall be a minimum of 50 mm	Comply	17 , 61 , 62	



Requirements Compliance (3/10)



#	Code	Requirement	Status	Slide Ref.	Comments
19	S5	The nose cone shall be made as a single piece. Segments are not allowed.	Comply	61 , 62 , 63	
20	S6	The nose cone shall not have any openings allowing air flow to enter.	Comply	61 , 62 , 63	
21	S7	The nose cone height shall be a minimum of 76 mm.	Comply	17 , 61	
22	S8	Cansat structure must survive 15 Gs vibration	Partial	162	Theoretically complies, further testing needed.
23	S9	Cansat shall survive 30 G shock.	Partial	162	Theoretically complies, further testing needed.
24	S10	The container shoulder length shall be 90 to 120 mm.	Comply	64 , 65	
25	S11	The container shoulder diameter shall be 136 mm.	Comply	65	
26	S12	Above the shoulder, the container diameter shall be 140 mm	Comply	65	
27	S13	The container wall thickness shall be at least 2 mm when 3D printed and must not flex or be deformed when under stress.	Comply	14 , 17	
28	S14	The container length above the shoulder shall be 200 mm +/- 5%.	Comply	14 , 17 , 58	
29	S15	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	17	



Requirements Compliance (4/10)



#	Code	Requirement	Status	Slide Ref.	Comments
30	S16	The Cansat container can be used to restrain any deployable parts of the Cansat payload but shall allow the Cansat to slide out of the payload section freely.	Comply	16 , 17 , 33 , 40 , 44 , 52	
31	S17	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	83	
32	S18	The Cansat container shall meet all dimensions in section F.	Comply	51 , 53 , 65	
33	S19	The Cansat container materials shall meet all requirements in section F.	Comply	53	
34	S20	If the nose cone is to separate from the payload after payload deployment, the nose cone shall descend at no more than 5 meters/sec.	Comply	45 , 46 , 47	
35	S21	If the nose cone is to separate from the payload after payload deployment, the nose cone shall be secured to the payload until payload deployment with a pull force to survive at least 15 Gs acceleration.	Partial	45 , 46 , 47 , 149	Theoretically complies, further testing needed.
36	M1	No pyrotechnical or chemical actuators are allowed.	Comply	51 , 52 , 53	
37	M2	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting the vegetation on fire.	Comply	84	



Requirements Compliance (5/10)



#	Code	Requirement	Status	Slide Ref.	Comments
38	M3	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial	42 , 43 , 44 , 67 , 68 , 73 , 79 , 80	Theoretically complies, further testing needed.
39	M4	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	85	No connection will be made using connectors other than the ones shown in this slide
40	E1	Lithium polymer batteries are not allowed.	Comply	115	
41	E2	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Comply	115	
42	E3	An easily accessible power switch through the container is required.	Comply	114	
43	E4	The container shall have small access holes for power switches of no more than 10 mm.	Comply	114	
44	E5	Power indicator is required.	Comply	114	
45	E6	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	117 , 118 , 178	
46	E7	The audio beacon shall operate on a separate battery.	Comply	110 , 113	



Requirements Compliance (6/10)



#	Code	Requirement	Status	Slide Ref.	Comments
47	E8	The audio beacon shall have an easily accessible power switch through the container.	Comply	174	
48	X1	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	95 , 103	
49	X2	XBEE radios shall have their NETID/PANID set to their team number.	Comply	95 , 103	
50	X3	XBEE radios shall not use broadcast mode.	Comply	95	
51	X4	The Cansat shall transmit telemetry once per second.	Comply	95 , 103 , 107 , 122	
52	X5	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	104 , 105 , 106 , 107	
53	SN1	Cansat payload shall measure its altitude using air pressure.	Comply	19 , 21 , 104	
54	SN2	Cansat payload shall measure its internal temperature.	Comply	19 , 22	
55	SN3	Cansat payload shall measure its battery voltage.	Comply	19 , 24 , 25	
56	SN4	Cansat payload shall track its position using GPS.	Comply	19 , 23	



Requirements Compliance (7/10)



#	Code	Requirement	Status	Slide Ref.	Comments
57	SN5	Cansat payload shall measure its acceleration and rotation rates.	Comply	19 , 27 , 28	
58	SN6	Cansat payload shall video record the deployment of the para-glider at 80% peak altitude.	Comply	120 , 121 , 124	
59	SN7	Cansat payload shall video record the ground during descent.	Comply	30 , 77 , 78	
60	SN8	The ground pointing camera shall capture video of the instrument (egg) being released and reaching the ground.	Comply	30 , 77 , 78	
61	SN9	The video cameras shall record video in color and with a minimum resolution of 640x480.	Comply	29 , 30	
62	SN10	Cansat payload shall measure its battery current.	Comply	19 , 24 , 26	
63	G1	The ground station shall command the Cansat to calibrate the altitude to zero when the Cansat is on the launch pad prior to launch.	Comply	108 , 125 , 143	
64	G2	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	137 , 147	
65	G3	Telemetry shall include mission time with 1 second resolution.	Comply	104 , 124	
66	G4	Each team shall develop their own ground station.	Comply	142	



Requirements Compliance (8/10)



#	Code	Requirement	Status	Slide Ref.	Comments
67	G5	All telemetry shall be displayed in real time in text format during ascent and descent on the ground station.	Comply	142	
68	G6	All telemetry shall be displayed in the International System of Units (SI) and the units shall be indicated on the displays.	Comply	104 , 105 , 106 , 142	
69	G7	Teams shall plot altitude, battery voltage, battery current, accelerometer value and rotation rates in real time.	Comply	141 , 142	
70	G8	Teams shall display mission time, temperature, GPS position, received packet count, lost packet count, and flight software state in real time.	Comply	142	
71	G9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	135 , 138	
72	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.	Comply	135 , 138	
73	G11	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Comply	143 , 144	



Requirements Compliance (9/10)



#	Code	Requirement	Status	Slide Ref.	Comments
74	G12	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the Cansat.	Comply	144	
75	G13	The ground station shall use a table top or handheld antenna.	Comply	135 , 139	
76	G14	Because the ground station must be viewed in bright sunlight, the displays shall be designed with that in mind, including using larger fonts (14 point minimum), bold plot traces and axes, and a dark text on light background theme.	Comply	138 , 142	
77	G15	All data shall be shown simultaneously in the ground station GUI. Tabs are not allowed.	Comply	142	
78	G16	The ground system shall count the number of received packets. Note that this number is not equivalent to the transmitted packet counter, but it is the count of packets successfully received at the ground station for the duration of the flight.	Comply	142	
79	G17	The ground station shall be able to activate all mechanisms on command.	Comply	143	
80	F1	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	125	



Requirements Compliance (10/10)



#	Code	Requirement	Status	Slide Ref.	Comments
81	F2	The Cansat shall maintain mission time throughout the entire mission even in the event of a processor resets or momentary power loss.	Comply	125	
82	F3	The Cansat shall have its time set by ground command to within one second UTC time prior to launch.	Comply	125 , 143 , 108	
83	F4	The flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile file.	Comply	126	
84	F5	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Comply	127	
85	F6	The flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	126 , 127	
86	F7	The flight shall include commands to activate all mechanisms. These commands shall be documented in the mission manual.	Comply	108	
87	F8	Configuration states such as zero altitude calibration software state shall be maintained in the event of a processor reset during launch and mission.	Comply	125	



Management

Nicolás Eyaralar



Status of Procurements (1/3)



Component	Quantity	Status	Expected Arrival
LPS22HB	1	ARRIVED	
HS3003	1	PENDING	4/15/26
INA181A2 (For the current sensing)	1	PENDING	4/15/26
Resistors for the voltage divider	1	ARRIVED	
Ublox NEO-6M	1	ARRIVED	
BNO055	1	ARRIVED	
Quelima SQ11	2	ARRIVED	
TFS20-L	2	ARRIVED	
STM32F4	1	ARRIVED	



Status of Procurements (2/3)



Component	Quantity	Status	Expected Arrival
DS3231 mini	1	ARRIVED	
ANT-900MR Flex ¼ Wave RPSMA	1	ARRIVED	
XBee PRO S3B 915MHz	2	ARRIVED	
Vapcell INR14500	2	PENDING	4/14/26
A09-Y11NF	1	ARRIVED	
Wishiot TD-9512MG	2	ARRIVED	
PKM22EPP-40	1	ARRIVED	



Status of Procurements (3/3)



Component	Quantity	Status	Expected Arrival
Nylon Ripstop 900 cm ²	1	ARRIVED	
Carbon Fibre Rods (4x350mm)	4	PENDING	4/14/26
Braid fishing line	1	ARRIVED	
ABS 1 kg	1	ARRIVED	
Aluminum 0.1kg	1	ARRIVED	
Torsion Spring	4	ARRIVED	
Screws, washers and nuts	10	ARRIVED	
Bearings	2	ARRIVED	



CanSat Budget – Hardware (1/4)



Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual/Free
Electronics-Payload				
LPS22HB	Yes	1	3.28	Actual
HS3003	Yes	1	3.45	Actual
ADC (2 channels) + Voltage divider + Shunt Resistor	No	1	0.2	Estimated
Ublox NEO-6M	Yes	1	10.9	Actual
BNO055	No	1	12.34	Actual
Quelima SQ11	Yes	2	12	Actual
TFS20-L	No	2	24.16	Actual
STM32F4	No	1	12	Actual



CanSat Budget – Hardware (2/4)



Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual/Free
Electronics-Payload				
DS3231 mini	Yes	1	17.5	Actual
XBee PRO S3B 915MHz	Yes	2	58.08	Actual
Vapcell INR14500	No	2	3.6	Actual
A09-Y11NF	Yes	1	155	Actual
Wishiot TD-9512MG	No	2	14.3	Actual
PKM22EPP-40	Yes	1	0.87	Actual
RTC Battery CR2032	Yes	2	4.99	Actual

TOTAL (Electronics Payload) = 449.8 USD



CanSat Budget – Hardware (3/4)



Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual
Mechanics				
Nylon Ripstop	YES	900 cm ²	0.001 per cm ²	Estimated
Carbon Fiber Rods (4x350mm)	YES	4	59/1m	Actual (MercadoLibre)
Braid fishing line	NO	1	6.5 per 100m	Actual (MercadoLibre)
ABS	NO	1 kg	20/kg	Actual (MercadoLibre)
Aluminum	NO	0.1kg	2.59/kg	Actual
Torsion Spring	NO	4	4	Estimated
Screws, washers and nuts	NO	10	5	Estimated
Bearings	NO	2	5	Estimated
Eyebolt + Swivel link	YES	1	5	Estimated

TOTAL (Mechanics) = 191.26 USD



CanSat Budget – Hardware (4/4)



Subsystem	Cost (USD)
Electrical	449.8 USD
Mechanical	191.26 USD
TOTAL = 641.06 USD	



CanSat Budget – Other Costs (1/2)



Ground Station				
Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual
Yagi Antenna	YES	1	155	Actual
Yagi Antenna Mounting (Hand-held)	YES	1	25	Estimated
XBee USB Adapter FT232RL	YES	1	14.2	Actual
Laptop Computer	YES	1	500	Estimated
Umbrella	YES	1	9	Actual
TOTAL (Ground Station) = 703.2 USD				



CanSat Budget – Other Costs (2/2)

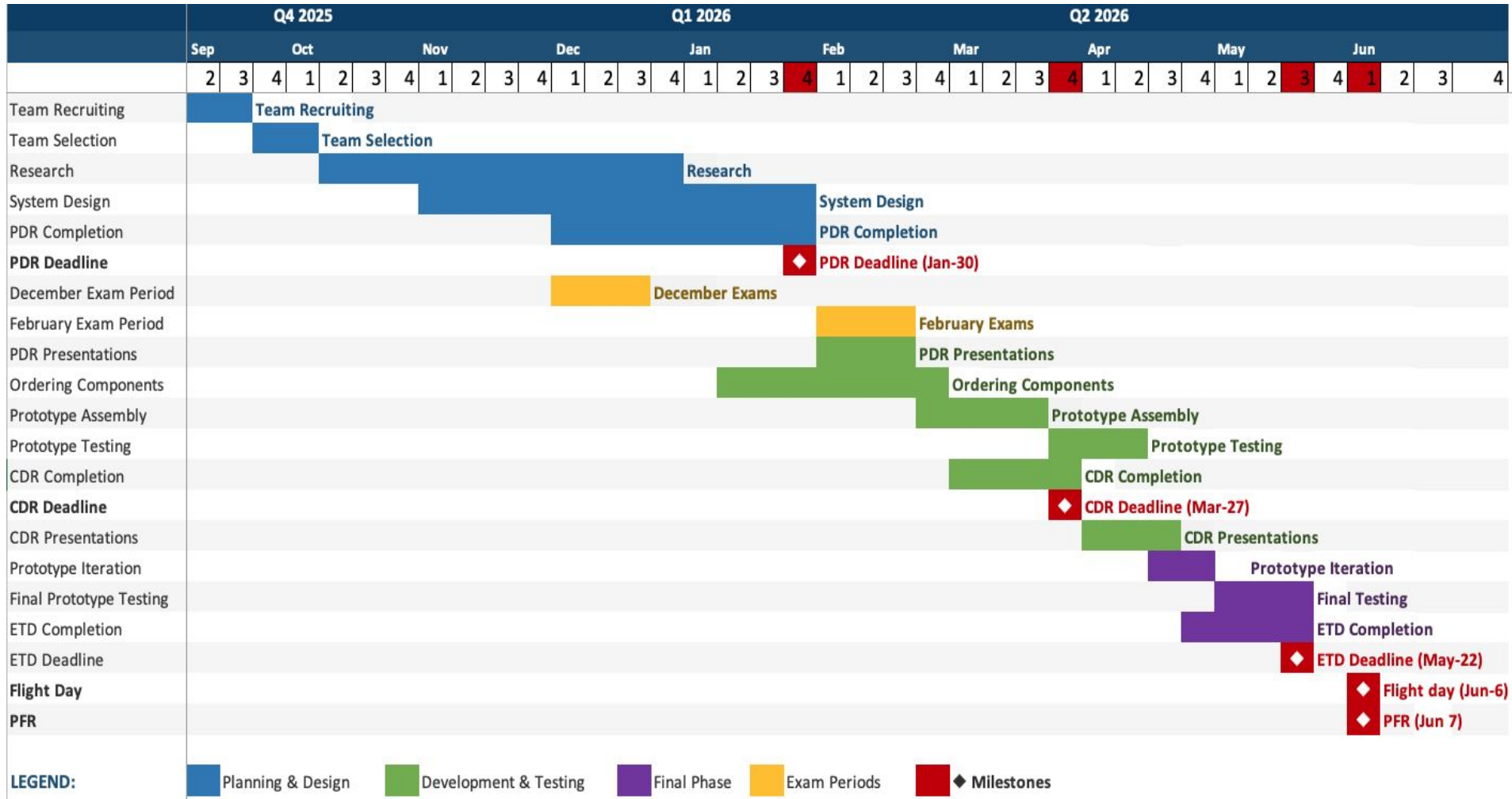


Travel Costs					
	Description	Quantity	Cost [USD]	Total Cost [USD]	Source
Airline	Round Trip	10	1350	13500	Estimated
Hotel		10 (4 Nights)	65 (per night, per person)	2600	Estimated
Food	15 meals	10 (5 Days)	45 (per day)	2250	Estimated
Transport	Rental Van + Gas	2	310	620	Estimated
PER PERSON = 1897 USD					
TOTAL = 18970 USD					

Competition Fee was paid by **Instituto Tecnológico de Buenos Aires**.
CanSat build cost financing is yet to be determined.
We are still in the process of looking for sponsors for the travel expenses.
**All costs are estimates and may vary depending on availability and exchange rates.*



Program Schedule Overview





Detailed Program Schedule (1/3)



LEGEND

TABLE COLORS:

	Table 1: Project Management & Logistics
	Table 2: Mechanical & Descent Subsystem
	Table 3: Electronics & Flight Software
	Table 4: Ground Station Subsystem
	Exam Periods

ASSIGNEE CODES:

TL	Team Leads (Mechanical, Electronics & PM)
MT	Mechanical Team
EF	Electronics & Firmware Team
SGS	Software & Ground Station Team
ALL	All Teams

TABLE 1: PROJECT MANAGEMENT & LOGISTICS

ID	Task Name	Assignee	Start Date	Finish Date	Duration
1.1	Team Recruiting	TL	15/09/2025	30/09/2025	16 days
1.2	Team Selection	TL	30/09/2025	10/10/2025	11 days
1.3	Research Phase	ALL	07/10/2025	30/12/2025	85 days
1.4	Summarize and Analyze Mission Guide	TL	16/10/2025	22/10/2025	7 days
1.5	Contact University and Sponsors for Funding	TL	17/10/2025	02/06/2026	229 days
1.6	System Design Phase	ALL	20/11/2025	20/01/2026	62 days
1.7	December Exam Period	ALL	03/12/2025	23/12/2025	21 days
1.8	Ordering Components	ALL	15/01/2026	24/02/2026	41 days
1.9	PDR Completion	ALL	15/01/2026	30/01/2026	16 days
1.10	PDR Deadline	ALL	30/01/2026	30/01/2026	MILESTONE
1.11	February Exam Period	ALL	02/02/2026	21/02/2026	20 days
1.12	PDR Presentations	ALL	02/02/2026	20/02/2026	19 days
1.13	CDR Completion	ALL	01/03/2026	27/03/2026	27 days
1.14	CDR Deadline	ALL	27/03/2026	27/03/2026	MILESTONE
1.15	CDR Presentations	ALL	06/04/2026	24/04/2026	19 days
1.16	ETD Completion	ALL	01/05/2026	22/05/2026	22 days
1.17	ETD Deadline	ALL	22/05/2026	22/05/2026	MILESTONE
1.18	Flight Day	ALL	06/06/2026	06/06/2026	MILESTONE
1.19	PFR	ALL	07/06/2026	07/06/2026	MILESTONE



Detailed Program Schedule (2/3)



TABLE 2: MECHANICAL & DESCENT SUBSYSTEM

ID	Task Name	Assignee	Start Date	Finish Date	Duration
2.1	Design and Analyze Different Mechanical Layout Prototypes	MT	22/12/2025	10/01/2026	20 days
2.2	Descent System Research and Selection	EF & MT	10/01/2026	20/01/2026	11 days
2.3	Define Mechanical Electronics Requirements	EF & MT	14/01/2026	27/01/2026	14 days
2.4	Integrate Descent Design with Electronic Components	EF & MT	18/01/2026	27/01/2026	10 days
2.5	ETD Planning and Completion	MT	20/01/2026	28/01/2026	9 days
2.6	Prototype Assembly	ALL	24/02/2026	21/03/2026	26 days
2.7	Prototype Testing	ALL	28/03/2026	15/04/2026	19 days
2.8	Prototype Iteration	ALL	15/04/2026	28/04/2026	14 days
2.9	Final Prototype Testing	ALL	05/05/2026	20/05/2026	16 days

TABLE 3: ELECTRONICS & FLIGHT SOFTWARE

ID	Task Name	Assignee	Start Date	Finish Date	Duration
3.1	Define Software Requirements for Payload, Container and GS	EF	30/11/2025	18/12/2025	19 days
3.2	Design Architecture for Container Software	EF & MT	19/12/2025	25/12/2025	7 days
3.3	Electronic System Research and Selection	EF	19/12/2025	07/01/2026	20 days
3.4	Create Container State Diagram	EF	03/01/2026	21/01/2026	19 days
3.5	Define Electronics Based on Research	EF	08/01/2026	14/01/2026	7 days
3.6	Integrate Design with Electronic Components	EF	17/01/2026	30/01/2026	14 days
3.7	Integrate Designs with Electronic Component Definitions	EF	15/01/2026	01/02/2026	18 days
3.8	Determine Software Development Process	EF	22/01/2026	27/01/2026	6 days
3.9	Develop and Test Flight Software	EF	28/01/2026	01/02/2026	5 days

TABLE 4: GROUND STATION SUBSYSTEM

ID	Task Name	Assignee	Start Date	Finish Date	Duration
4.1	Design Architecture for Ground Station Software	SGS	26/12/2025	05/01/2026	11 days
4.2	Research Antenna Technology	SGS	03/01/2026	20/01/2026	18 days
4.3	Design and Prototype GCS Software	SGS	15/01/2026	26/01/2026	12 days
4.4	Determine or Design Antenna	SGS	25/01/2026	02/02/2026	9 days



Detailed Program Schedule (3/3)



~70%

Overall project completion at CDR. Breakdown by subsystem below.

Subsystem	% Done	Remaining work
Sensors	80%	Final calibration on flight PCB
Descent Control	75%	Para-glider flight testing, steering algorithm tuning
Mechanical	80%	Full integration, mass fine tuning
CDH	80%	Flight PCB assembly, SD card logging validation
EPS	85%	Battery endurance test on flight hardware
FSW	55%	Electromechanical module, GPS nav algorithm, STM32 integration
GCS	80%	Radio link integration
I&T	25%	5/20 tests passed; 15 remaining across 5 phases (Apr–May)
Management	85%	Mission Operations Manual, shipping plan, travel logistics, FRR preparation



Shipping and Transportation



Taking into account airline restrictions, and that we are flying by plane from Buenos Aires, Argentina to Virginia, which is not a direct flight, and in where we will take transportation to Virginia Tech we have decided that:

Carry on Baggage	Checked Baggage
<ul style="list-style-type: none">● Computer● Batteries	<ul style="list-style-type: none">● Various tools (such as screwdriver, hammers, etc)● Extra 3d printed parts, if CanSat is broken during travel● CanSat padded with bubble wrap or foam



Conclusions (1/2)



Major Accomplishments

- The majority of electronic components and mechanical materials have been procured; most have already arrived
- Hardware budget finalized at \$641.06 USD, within the \$1000 competition limit
- Paraglider acquired (210T plaid cloth) and winch-based servo steering system designed and prototyped
- Good weight optimization since PDR

Major Unfinished Work

- Final PCB manufacturing and assembly with all flight components
- Para-glider steering algorithm tuning and autonomous GPS navigation implementation
- Testing of mechanisms due to missing pieces

Testing to complete

- Environmental tests
- Subsystem Level tests
- System Level Tests
- Full payload weight testing



Conclusions (2/2)



We are ready to move to the next phase!

The team has met successfully met most of the critical design requirements and is ready to proceed to the next stage of development as all major goals and milestones are complete. As we move into the next stage, we remain committed to resolving these final details and ensuring that all functionalities are thoroughly verified through our testing campaign before final implementation.