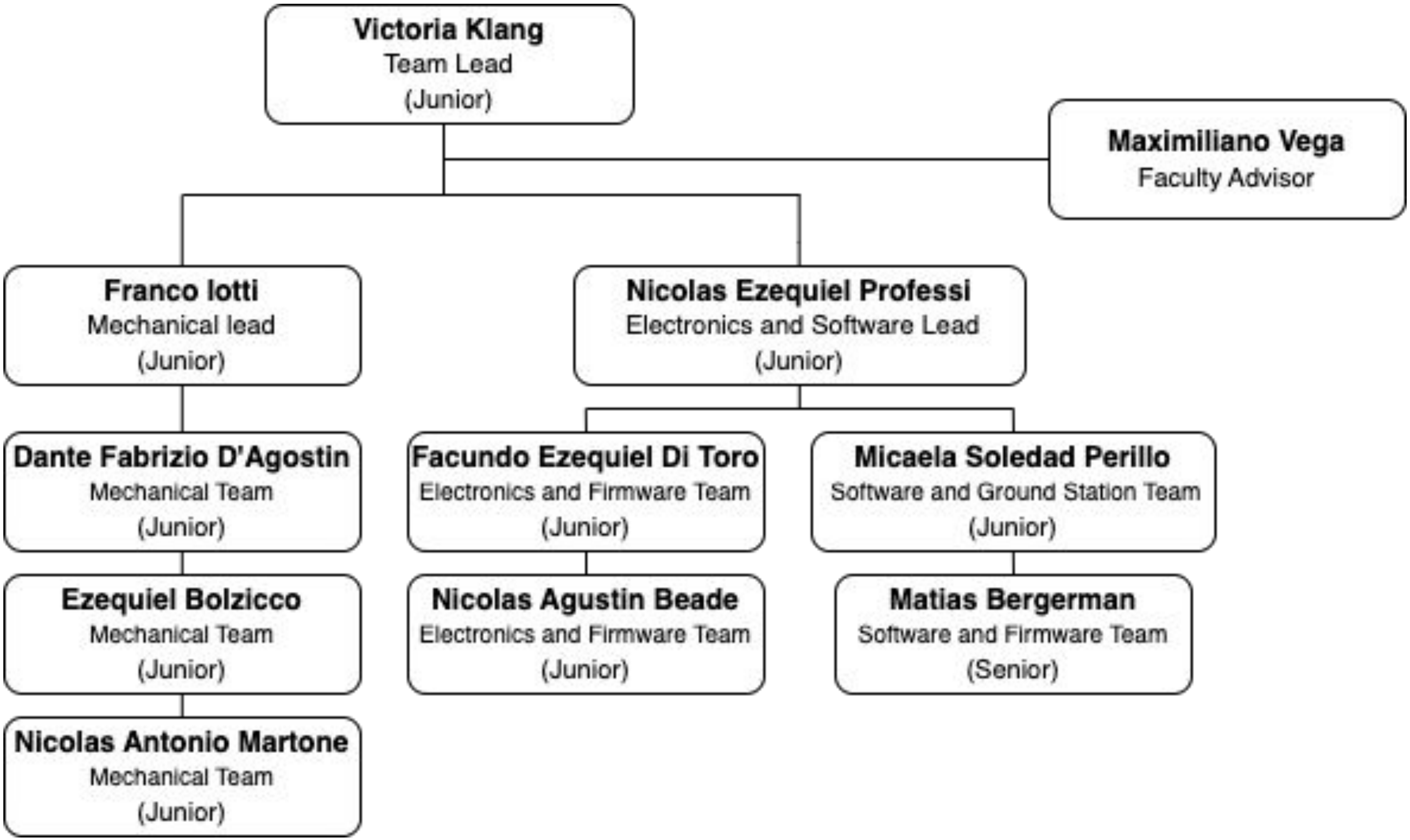
CanSat 2024
Critical Design Review (CDR)
Outline
Version 1.1

Team # 2099

SEDS ITBA

Presentation Outline

Team Organization



Acronyms (1/2)

Acronym	Explanation
MECH	Mechanical Subsystems
ES	Electrical Systems
FSW	Flight Software
m	Mass
g	Acceleration of the Earth
ρ	Density of the Air
v	Terminal Velocity
Cd	Drag Coefficient
A	Area
GCS	Ground Control System
HS	Aerobraking Heat Shield
MCU	Microcontroller Unit

Acronyms (2/2)

Acronym	Explanation
RTC	Real time clock
GPS	Global Positioning System
NiCr	Nichrome
Li-Ion	Lithium Ion
Ni-Mh	Nickel–metal hydride
LED	Light emitting diode

System Overview

Victoria Klang & Dante F. D'Agostin

Mission Summary

The mission embarks on a journey that focuses on two critical aspects: safeguarding the payload and effectively managing descent speed. The Cansat, initially simulating the role of the nose cone, is launched with the rocket to a maximum altitude of 725 meters. During this ascent, it assumes control of both the rocket's speed and the cargo's orientation, a task challenged by the potentially violent conditions.

Upon reaching the maximum altitude, the ejection charge fires, separating the Cansat from the main structure. At 725 meters, the Cansat opens a heat shield, aiming to reduce speed to 15m/s while maintaining stability and control. At 100 meters, a pivotal phase begins as the Cansat releases the heat shield and simultaneously, a parachute deploys to further slow the descent, aiming for a final speed of 5m/s. The ultimate mission goal is to achieve a successful landing with the egg intact, simulating the careful handling of a delicate cargo.

Bonus objective: The team has chosen to follow the bonus objective because we are confident that, drawing from our past CanSat experience, adding a static camera will not compromise the CanSat in terms of mass or complexity.

External objectives:

- Apply class concepts to real practice and gain more experience on the aerospacial 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 (1/3)

Sensor Subsystem Changes
New PCB layout to not interfere with antenna's radiation pattern

Descent Control Changes
Magnet and latching of the Heatshield bars
Elastic links between the CanSat and the parachute
Descent rates have been recalculated
Nichrome wire replaced with cable and resistance

Summary of Changes Since PDR (2/3)

Mechanical Subsystem Container Changes
Changed mounting to fiber rods from screws to glue
Change of design in Egg Containment
Place of batteries changed

Flight Software Changes
Merged two states into one
Changed development environment to PlatformIO

Ground Control Station Changes
Changed antenna

Summary of Changes Since PDR (3/3)

CHD Changes
Cansat to Ground Station XBEE radio module
Ground Station to Cansat XBEE radio module
Cansat to Ground Station XBEE antenna
Ground Station to Cansat XBEE antenna
Real time clock IC changed from DS1307 to DS3231
SD added

EPS Changes
Battery configuration changed from 1S to 2S
Power domain voltage regulators changed from LDO+StepUp to StepDown+StepDown
Power switches removed except for the NiCr wires, camera and buzzer
Flight state led removed

System Requirement Summary (1/3)

Requirement Number	Requirement	Subsystem
1	The Cansat mass shall be 900 grams +/- 10 grams without the egg being installed.	MECH
2	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	MECH, ELECTRICAL
3	The Cansat shall perform the function of the nose cone during rocket ascent.	MECH
4	All mechanisms shall be capable of maintaining their configuration or states under all forces.	MECH
5	The Cansat shall deploy a heat shield after deploying from the rocket.	MECH
6	At 100 meters, the Cansat shall deploy a parachute and release the heat shield.	MECH

System Requirement Summary (2/3)

Requirement Number	Requirement	Subsystem
7	"The Cansat shall protect a hens egg from damage during all portions of the flight.	MECH
8	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	MECH
9	At 100 meters, the Cansat shall have a descent rate of less than 5 m/s.	MECH
10	Cansat shall survive 30 G shock.	MECH
11	Cansat structure must survive 15 Gs vibration	MECH
12	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed	ELECTRICAL

System Requirement Summary (3/3)

Requirement Number	Requirement	Subsystem
13	Easily accessible power switch is required	ELECTRICAL
14	Power indicator is required for each voltage domain	ELECTRICAL
15	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	ELECTRICAL
16	The maximum current of the cansat cannot exceed the maximum discharge current of the battery.	ELECTRICAL
17	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."	BUDGET

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

Pre-Launch

1. Last CanSat check
2. CanSat placement
3. CanSat turned on
4. Start Cameras Recording
4. Calibration of Sensors
5. Start transmitting data

Launch

1. Rocket ignition and ascension
2. Maximum altitude reached (725m)
3. CanSat deployment

HS Deployment

1. HS deployment (at maximum altitude)

2, Fins deployment

Parachute Deployment

1. HS released (at 100 m)
2. Parachute deployment (at 100 m)

Cansat Landing

1. CanSat stop transmitting Data
2. Beacon is activated
3. Cansat is ready for recovery

Ground Station

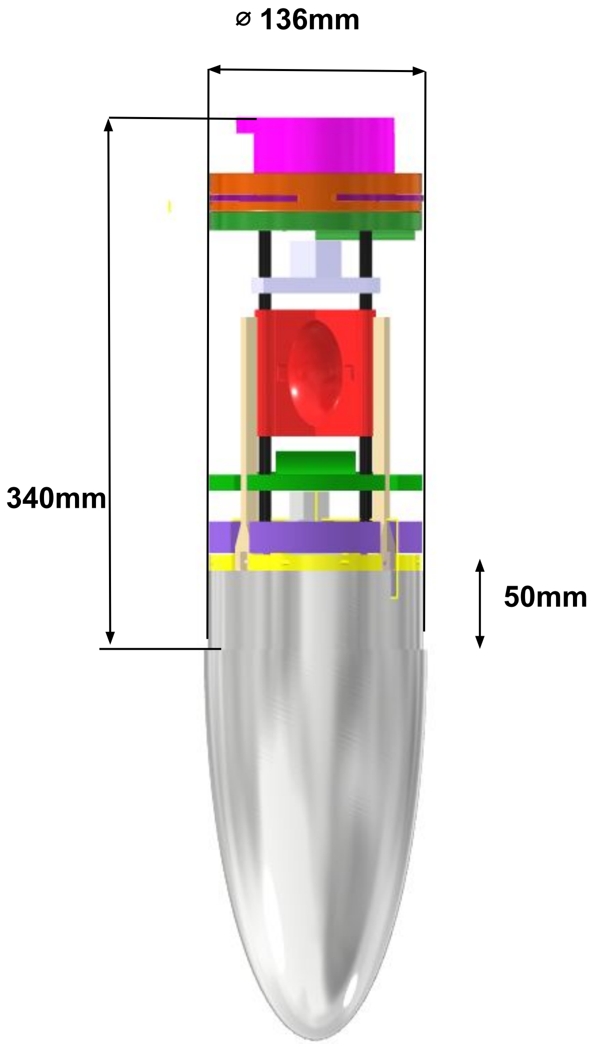
1. Team Briefing: get everyone into position for launch
2. Send UTC time to CanSat and command it to transmit telemetry

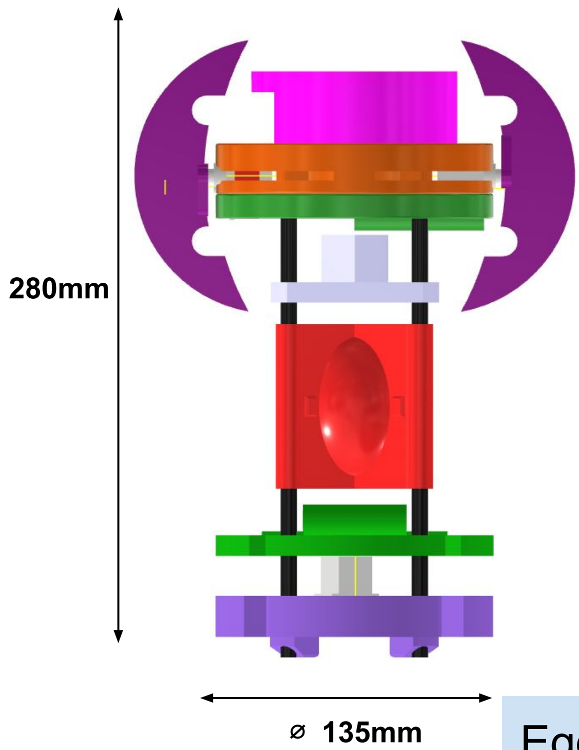
1. Receive and plot telemetry in real time
2. Generate csv files of all sensor data

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

Position	Tasks	Members
Mission Control Officer	• Manages the Team Launch • Verifies that everything is ready with The Ground Station Crew • Executes the launch procedure with flight coordinator oversight	• Victoria Klang
Ground Station Crew	• Monitor the ground station for telemetry reception • Issue commands to the CanSat. • Performs all required flight operations	• Micaela Perillo • Facundo Di Toro • Nicolas Beade • Matias Bergerman
Recovery Crew	• Track and recover the CanSat • Interact with field judges • Make sure all field scores are filled in	• Franco Iotti • Nicolas Professi
CanSat Crew	• Prepare the CanSat and integrate it into the rocket • Verifying status before launching	• Nicolas Antonio Martone • Ezequiel Bolzicco • Dante D’Agostin

CanSat Physical Layout (1/4)





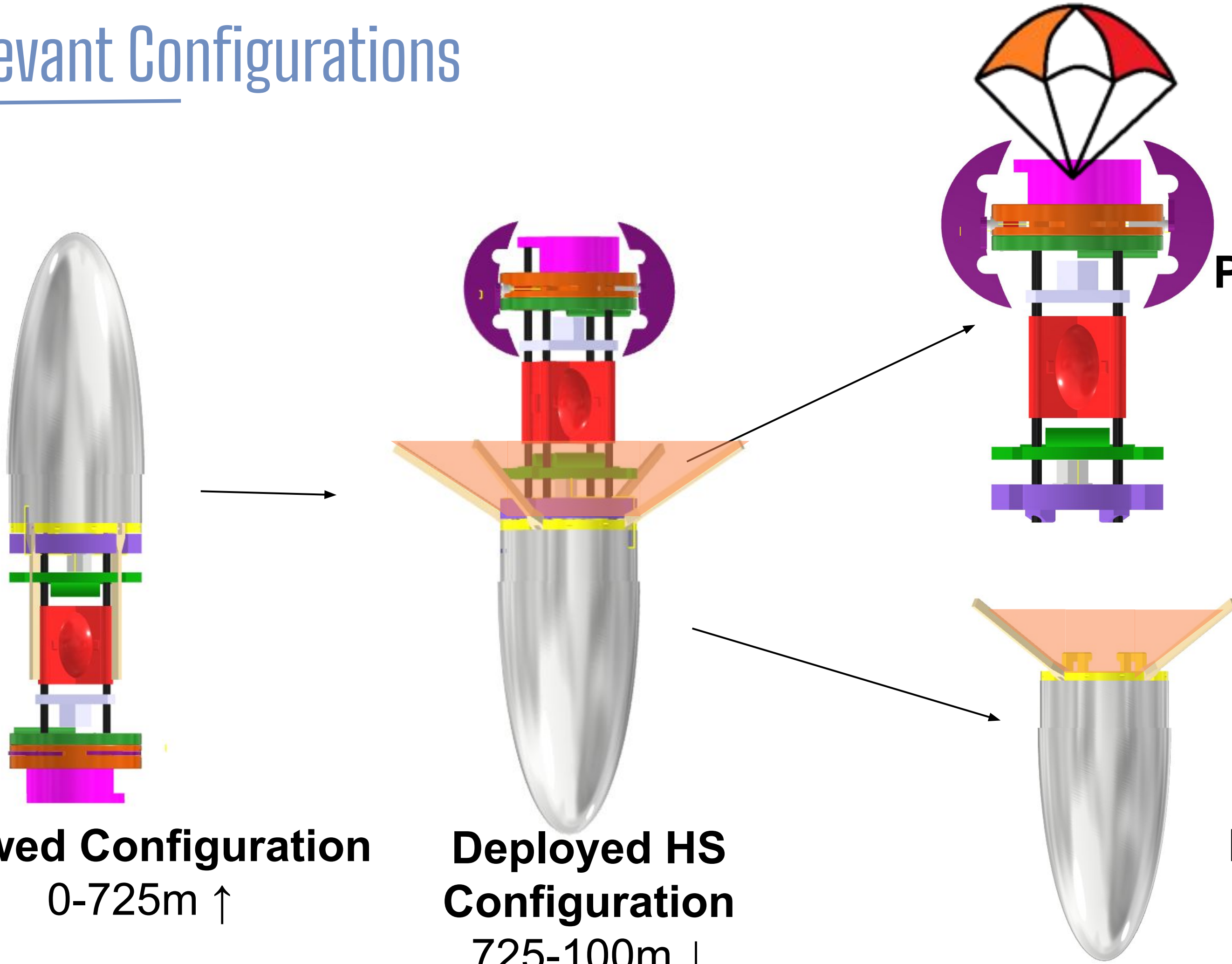
Burning fishing line-controlled systems will open the spring-loaded HS and parachute.

Rotation control and HS separation are to be commanded by Servo motors.

Egg will be encapsulated in a spring suspended container.

CanSat Physical Layout (2/4)

Relevant Configurations



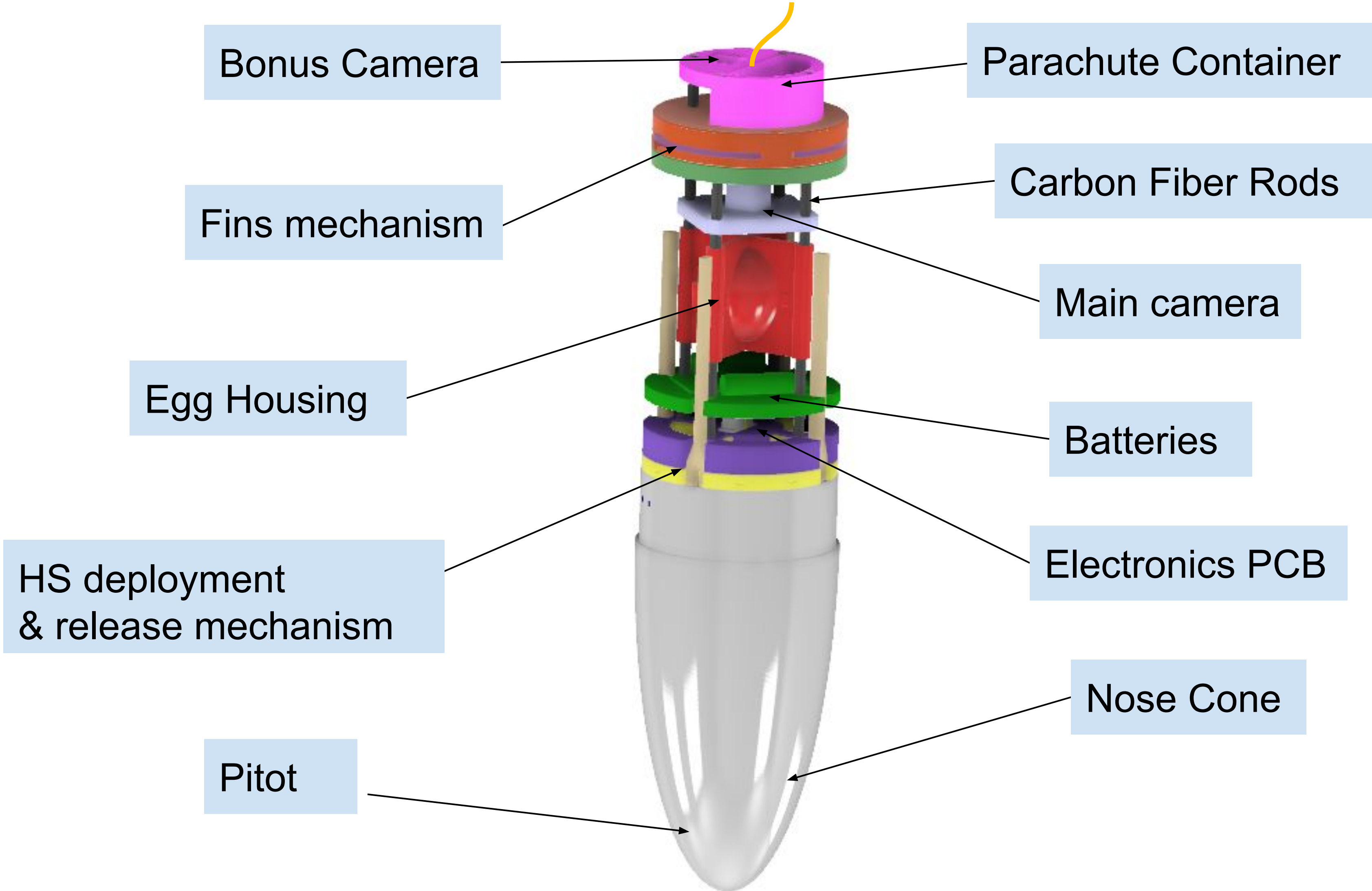
Parachute Deployed Configuration
100m - 0m ↓
at 3m/s

Stowed Configuration
0-725m ↑

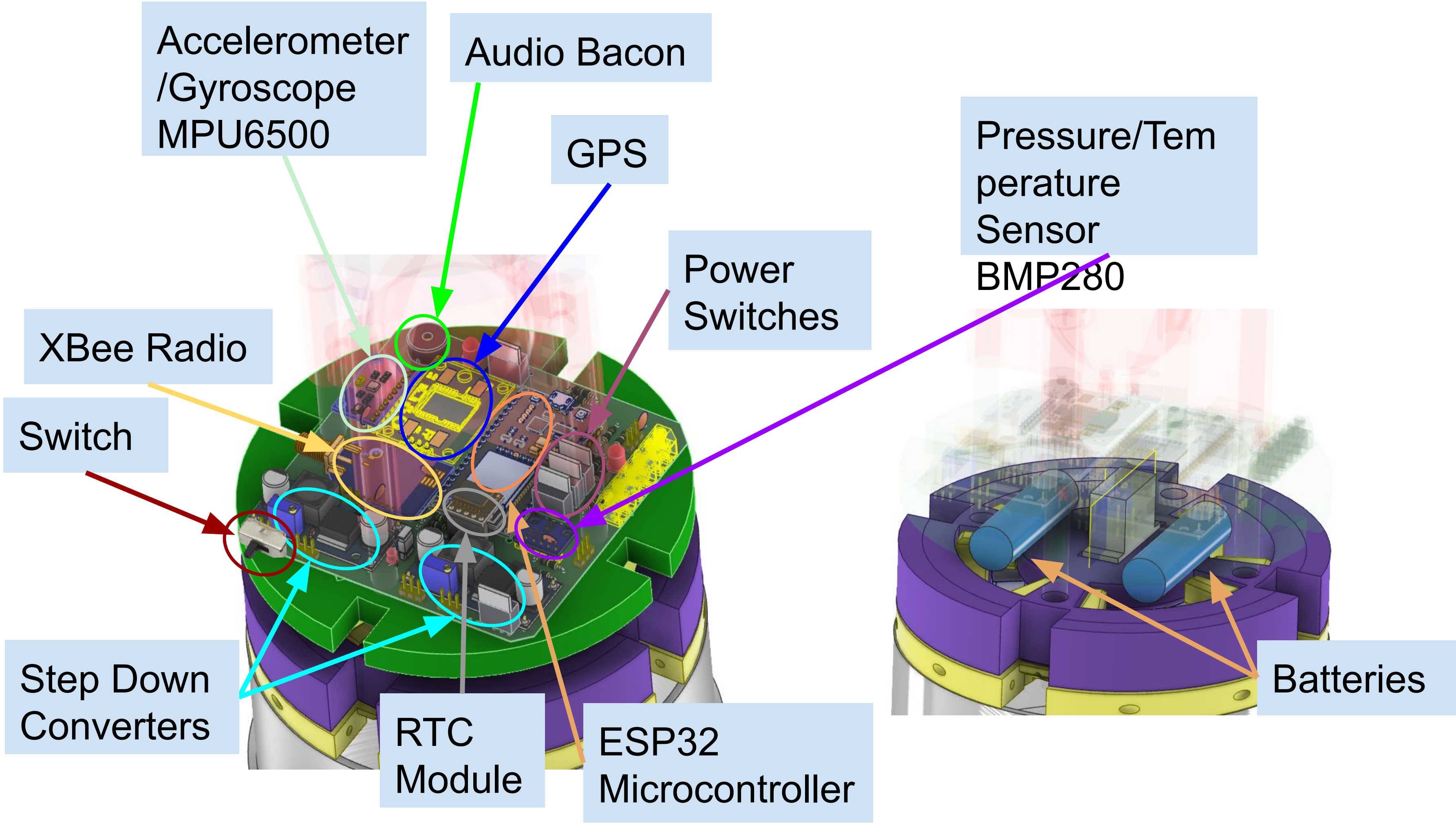
Deployed HS Configuration
725-100m ↓
at 15 m/s

Nosecone and HS detached
100m ↓

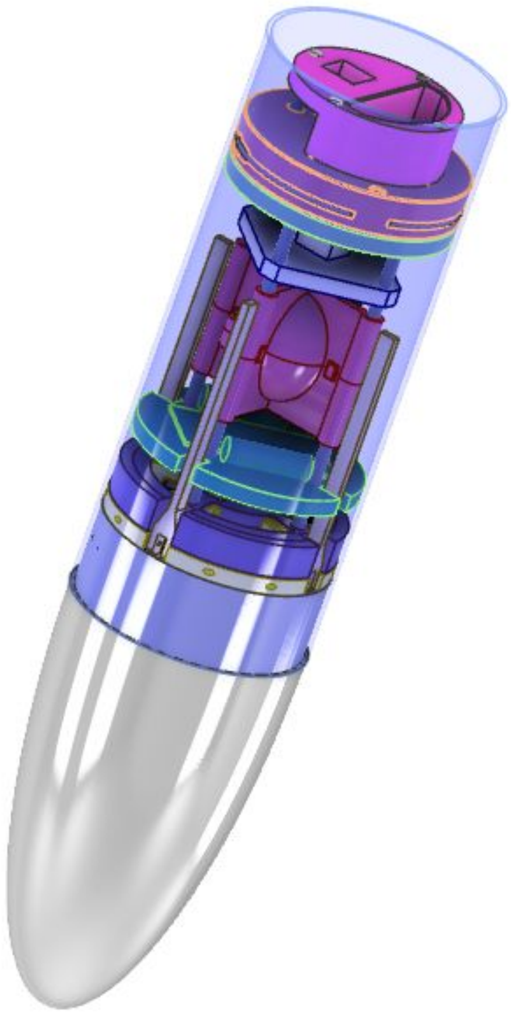
CanSat Physical Layout (3/4)

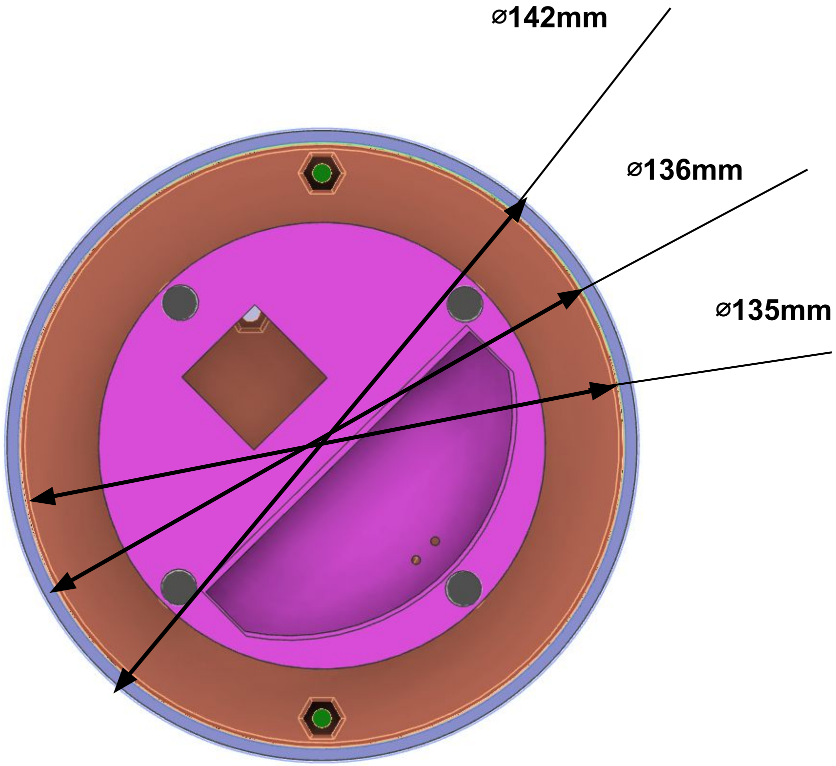


CanSat Physical Layout (4/4)



Launch Vehicle Compatibility (1/2)





Launch Vehicle Compatibility (2/2)

	Payload section dimensions (mm)	CanSat dimensions (mm)	Clearance (mm)
Diameter	136	135	1
Height	350	340	10

Sensor Subsystem Design

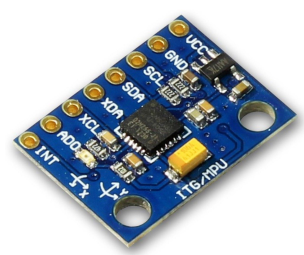
Facundo E. Di toro & Nicolás Beade

Sensor Subsystem Overview

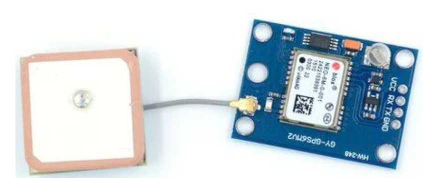
Payload		
BMP280	Pressure and Temperature sensor	Measure air pressure to determine altitude and air temperature.
MPU6500	Rotation rate and orientation sensor	Measure rotation rate and orientation as the Cansat descends.
MPXV7002 + Pitot tube	Airspeed sensor	Measures differential pressure in order to determine airspeed.
ADC Pin Raspberry Pi Pico	Battery voltage sensor	Measure battery voltage.
NEO-6M	GPS	Determine Cansat´s position.
SQ11	Video camera	Records flight footage pointing towards the south.

MPCV7002

BMP280



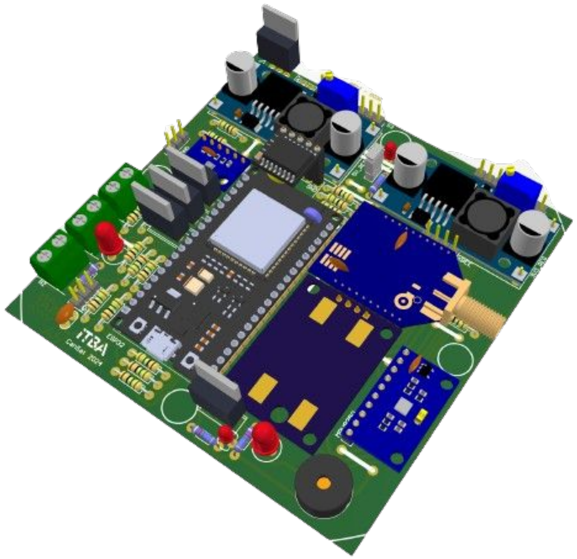
MPU6500

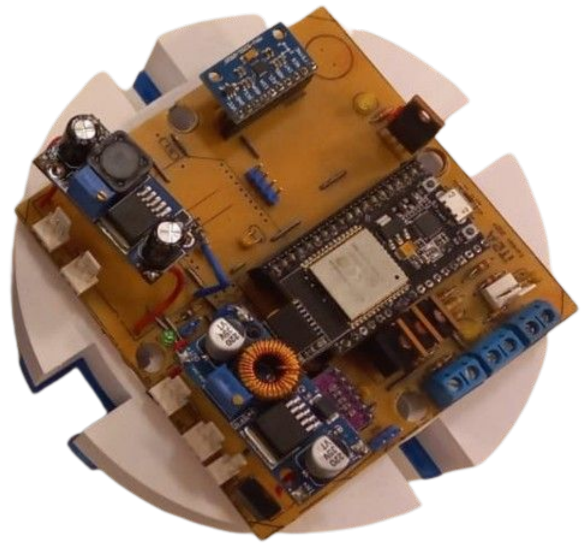


NEO-6M

SQ11

Sensor Changes Since PDR





First prototype

For testing all sensors

- All sensors are working properly and meet the requirements.
- No changes needed to be made in the selection of sensors.
- We were able to use the same I2C bus for 3 ICs, optimizing the pins' usage of the ESP.

Second prototype

Currently under design

Two stacked PCBs that will provide more space for placing components and reduce interference with the antenna's radiation.

Pitot Tube

We are evaluating the possibility of manufacturing our own pitot tube. This is due to the difficulty of obtaining the tube in Argentina.

Payload Air Pressure Sensor Summary

Name	Size [mm]	Mass [gr]	Operating current [µA]	Operating voltage [V]	Range [Pa]	Resolution [Pa]	Interface	Price ($)
BMP280	PKG: 13.5x10.5x2	1	2.8	1.7-3.6	300 - 1100h	0.18	I2C	9.05

Pros

- High resolution and wide range
- Low power consumption.
- Low PCB weight

Equation used to determine altitude

$$Altitude = 44330\,x\,(1 - (\frac{P}{P_0})^{\frac{1}{5.255}})$$

P : Atmospheric pressure measured by the sensor.
P_0: Atmospheric pressure at sea level.

- Average altitude accuracy results in ±1 meter
- Sensor will be connected to microcontroller using I2C interface.
- Library used: Adafruit BME280

Testing and data overview

```
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
```

Payload Air Temperature Sensor Summary

Name	Size [mm]	PCB Weight [gr]	Operating current [µA]	Operating voltage [V]	Temperature Range [°C]	Resolution [°C]	Interface
BMP280	PKG: 13.5x10.5x2	1	2.8	-40 - 85	1.7-3.6	0.1	I2C

Pros

- High resolution and wide range
- Low power consumption.
- Low PCB weight

Testing and data overview

```
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
Temperature = 24 *C
  Pressure = 101382 Pa
  Humidity = 65 ¬%
  Approx altitude = 56 m
```

- Sensor will be connected to microcontroller using I2C interface.
- Library used: Adafruit BME280 (no major equations needed)

Payload GPS Sensor Summary

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating voltage [V]	Navigation update rate [Hz]	Horizontal accuracy [m]	Interface	Price ($)
Ublox NEO-6M	16x12.2x2.4	12	67	2.7-3.6	2.5	2.5	UART	16.07

Pros

- Great horizontal accuracy (not used for vertical positioning).
- Optimal power consumption.
- Simple coding and communication protocol.

Testing and data overview

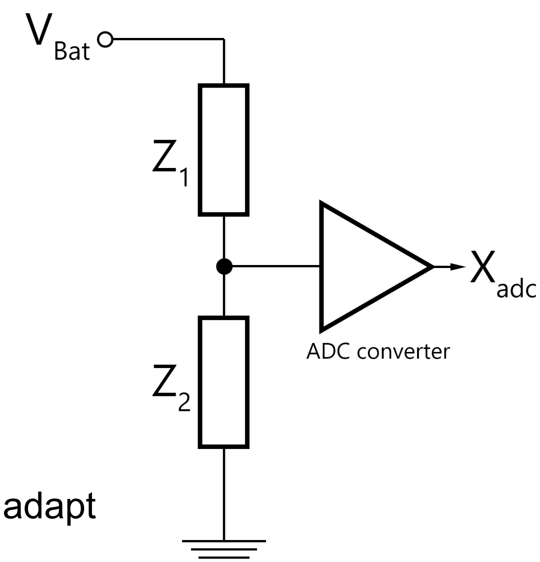
- Data will be obtained in NMEA Format
- Not tested due to lack of time

- Sensor will be connected to microcontroller using UART interface.

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [mV]	Interface	Price ($)
ADC Pin + Voltage divider	Negligible	Negligible	0.2	0-3.3	10	ADC	Negligible

Pros

- No additional cost, weight or space needed
- Simple method



Equation used to determine battery voltage

$$V_{Bat} = \frac{3.3V}{2^{12}} \cdot X_{adc} \cdot \frac{Z_1 + Z_2}{Z_2}$$

- Since ADC Max input voltage is 3.3v, we are using a voltage divider to adapt the battery voltage (8.4V fully charged)
- The average accuracy of the obtained battery voltage results in ±10 mV
- The format of the raw data collected from ADC is an integer from 0 to 4095 (X_{adc})

Speed Sensor Summary

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [bits]	Interface	Sensitivity
MPXV7002 + Pitot Tube	11x11x13	3	10	4.75 - 5V	12	ADC	1V/kPa

Pros

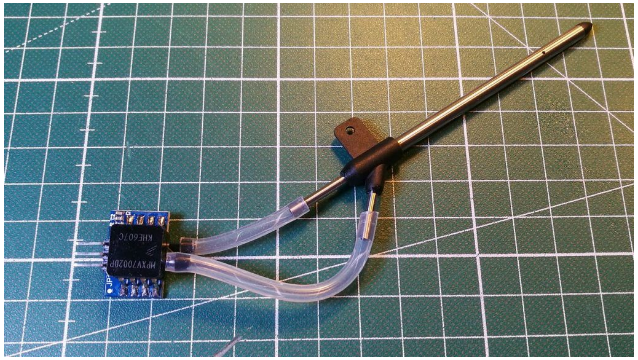
- Sends data through ADC pin to ESP

- It is cheaper, the only problem is the high consumption
- Easier to acquire in Argentina
- Works appropriately in temperatures the Cansat will find itself exposed to

Equation used to determine True Air Speed

$$IAS = \sqrt{\frac{2 \cdot P_{Dynamic}}{\rho_0}} \quad TAS = \frac{IAS}{1 + Altitude \cdot 0{,}00002}$$

IAS: Indicated Air Speed
ρ_0: Density of air in standard atmosphere 1.225kg/m^3
$P_{Dynamic}$: Dynamic pressure measured with pitot and MPXV7002
Altitude: Obtained making use of BMP280
TAS: True Air Speed

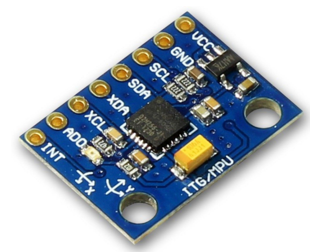


Not tested due to impossibility of obtaining the pitot tube in Argentina

Payload Tilt Sensor Summary

Name	Size [mm]	PCB Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [º/s]	Interface	Price ($)
MPU-6500	20x16x3	3.2	0.4	2.9 - 3.6	0.018	I2C	3.15

On-Module Sensors



- Gyroscope: full-scale ranges from ±250 to ±2000 °/s, ±3% accuracy, 16 bits
- Accelerometer: full-scale ranges from ±2 to ±16 g, ±3% accuracy, 16 bits
- Magnetometer: full-scale range of ±4800 μT, 0.6 μT/LSB accuracy, 14 bits

Testing and data overview

```
   X Acc:  -92
Y Acc: -916
Z Acc: 15276
X Tilt:  -3.44
Y Tilt: 0.29
Z Tilt: 0.29
   X Acc:  -212
Y Acc: -968
Z Acc: 15324
X Tilt:  -3.44
Y Tilt: 0.30
Z Tilt: 0.30
```

Pros

- Numerous possible ranges.
- Low power consumption.
- Software simplicity and reliability

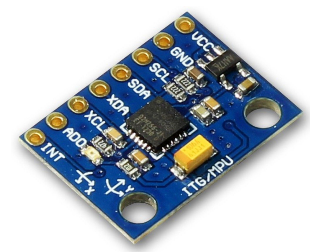
- In order to maximize the ESP's pins usage, this module will communicate through I2C.
- Libraries used: I2CDevLib (no major equations needed)

Payload Rotation Sensor Summary

Name	Size [mm]	PCB Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [bits]	Interface	Price ($)
MPU-6500	20x16x3	3.2	0.4	2.9 - 3.6	16	I2C	3.15

On-Module Sensors

- Gyroscope: full-scale ranges from ±250 to ±2000 °/s, ±3% accuracy, 16 bits
- Accelerometer: full-scale ranges from ±2 to ±16 g, ±3% accuracy, 16 bits
- Magnetometer: full-scale range of ±4800 μT, 0.6 μT/LSB accuracy, 14 bits



Testing and data overview

```
>>> %Run -c $EDITOR_CONTENT

  Running MPU test:
  Acceleration: (10.00297, 0.1508347, -1.058237)
  Gyroscope: (-0.005995409, 0.01891884, 0.0002664626)
  Magnetic: (47.33438, 45.69024, -17.34375)
```

Pros

- Numerous possible ranges.
- Low power consumption.
- Software simplicity and reliability
- It will also be used as tilt sensor

- In order to maximize the ESP’s pins usage, this module will communicate through I2C.
- Libraries used: I2CDevLib (no major equations needed)

Notes: Rotation sensor will be used to measure angle stability during aerobraking and rotation during descent

Camera Summary

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [px]	FPS	Viewing Angle	Included Memory [GB]	Price($)
SQ11	23x23x23	15	120	3.7	720	60	140	64	23

Pros

- High resolution (color) and viewing angle
- Optimal power consumption
- SD card connection already integrated
- Easy customization and control

Testing and data overview (pending)

- The format of the videos obtained is an mp4 file, with a 720p resolution, in color, and at 60fps.
- The video files will be saved in a 64GB Micro SD Card
- Camera will be controlled by pulses sent directly from the microcontroller, replacing the power button.
- Camera casing will not be heavily modified or removed.

Bonus Camera Summary

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating voltage [V]	Resolution [px]	FPS	Viewing Angle	Included Memory [GB]	Price($)
SQ11	23x23x23	15	120	3.7	720	60	140	64	23

Pros

- High resolution (color) and viewing angle
- Optimal power consumption
- SD card connection already integrated
- Easy customization and control

Testing and data overview (pending)

- The format of the videos obtained is an mp4 file, with a 720p resolution, in color, and at 60fps.
- The video files will be saved in a 64GB Micro SD Card
- Camera will be controlled by pulses sent directly from the microcontroller, replacing the power button.
- Camera casing will not be heavily modified or removed.

Notes: The standard and bonus cameras will be two separated cameras pointing accordingly to different places in order to fulfill their corresponding functionalities.

Descent Control Design

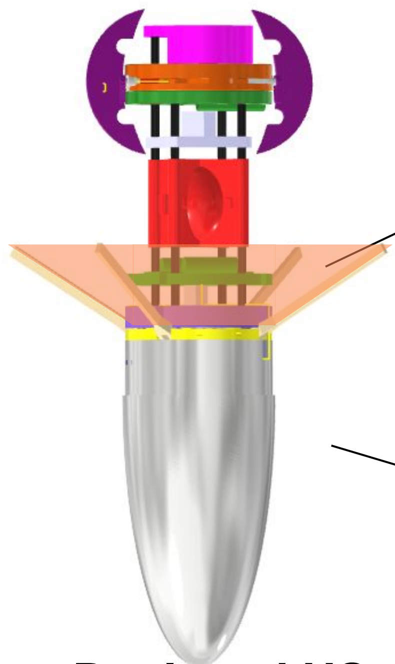
Dante F. D’Agostin & Franco Iotti

Descent Control Overview

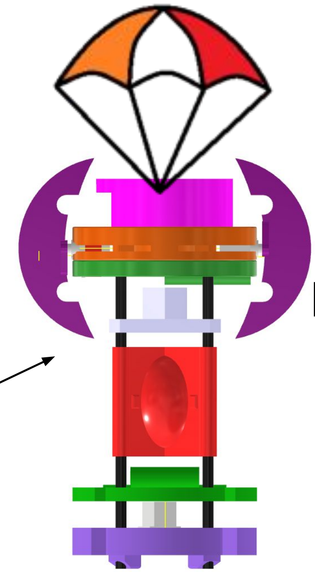
- Nose Cone is part of the Heat Shield
- Hexagonal Nylon Parachute

Parts:
- HS
- Fins
- Parachute

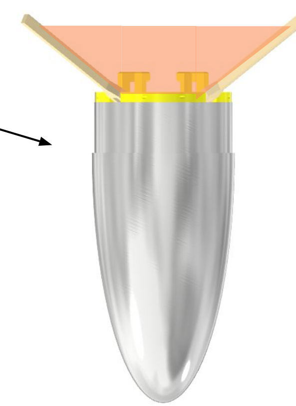
Stowed Configuration
0-725m ↑



Deployed HS Configuration
725-100m ↓
at 15 m/s



Parachute Deployed Configuration
100m - 0m ↓
at 3m/s



Nosecone and HS detached
100m ↓

Descent Control Changes Since PDR (1/2)

Change	Rationale
Magnet and latching of the Heatshield bars	To guarantee the angle and shape of the HS during descent.
Elastic links between the CanSat and the parachute	To dampen the shock of the parachute opening
Descent rates have been recalculated	To comply with the scoresheet
Nichrome wire replaced with cable and resistance	Because of its lower price and higher availability

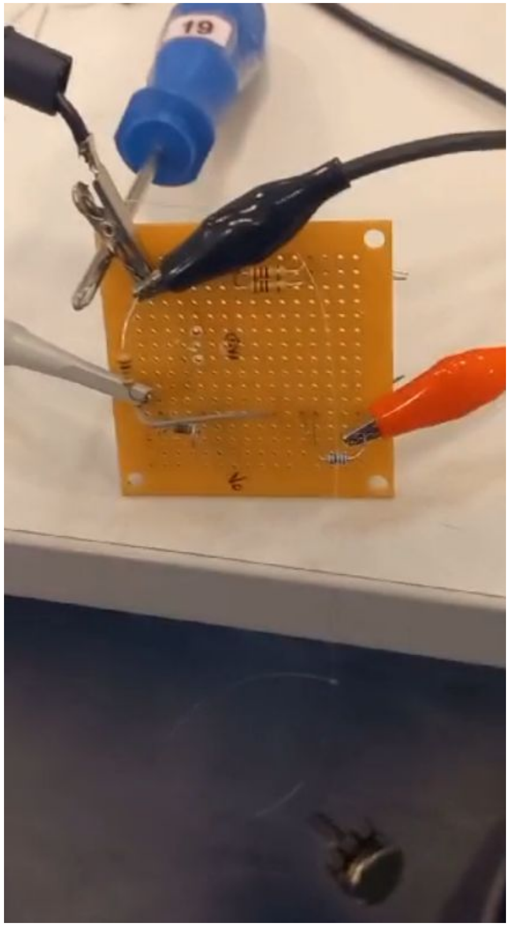
Prototype Testing

Prototype of the magnet latch mechanism let us measure the holding and closing force they have to know if it will be sufficient.

Descent Control Changes Since PDR (2/2)

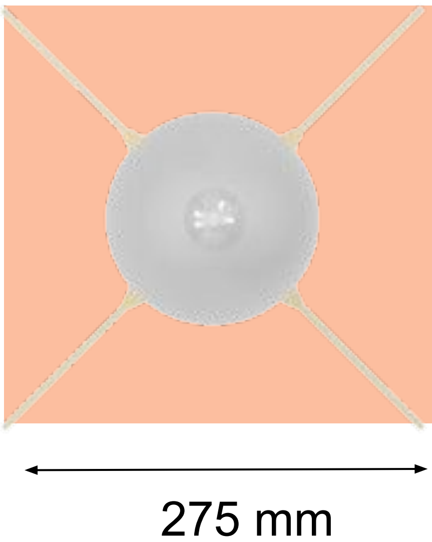
Prototype Testing

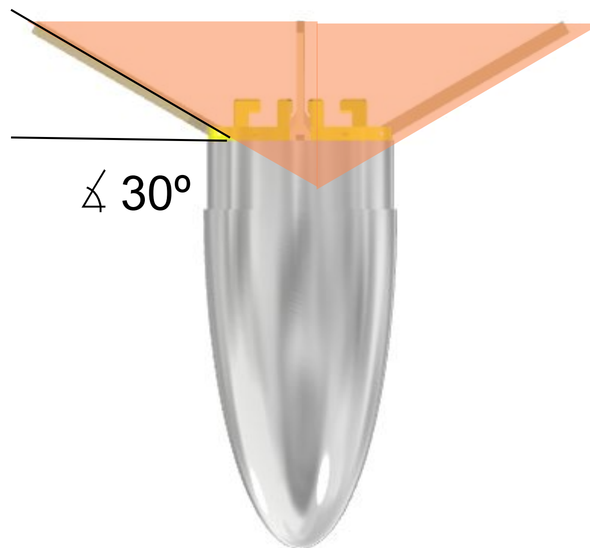
Prototypes of the Heat Shield and Parachute were tested to empirically obtain their Drag of Coefficient

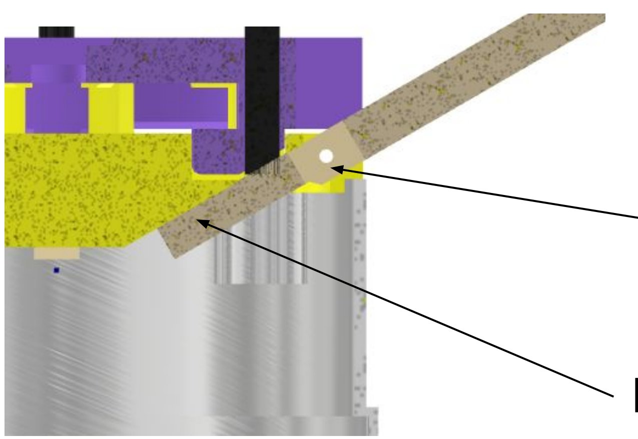


The fishing line is attached to a weight and entangled with a cable. The testing concludes that the fishing line was cut successfully with the resistance.

Payload Aerobraking Descent Control Hardware Summary







4-Arms Nylon String Attached

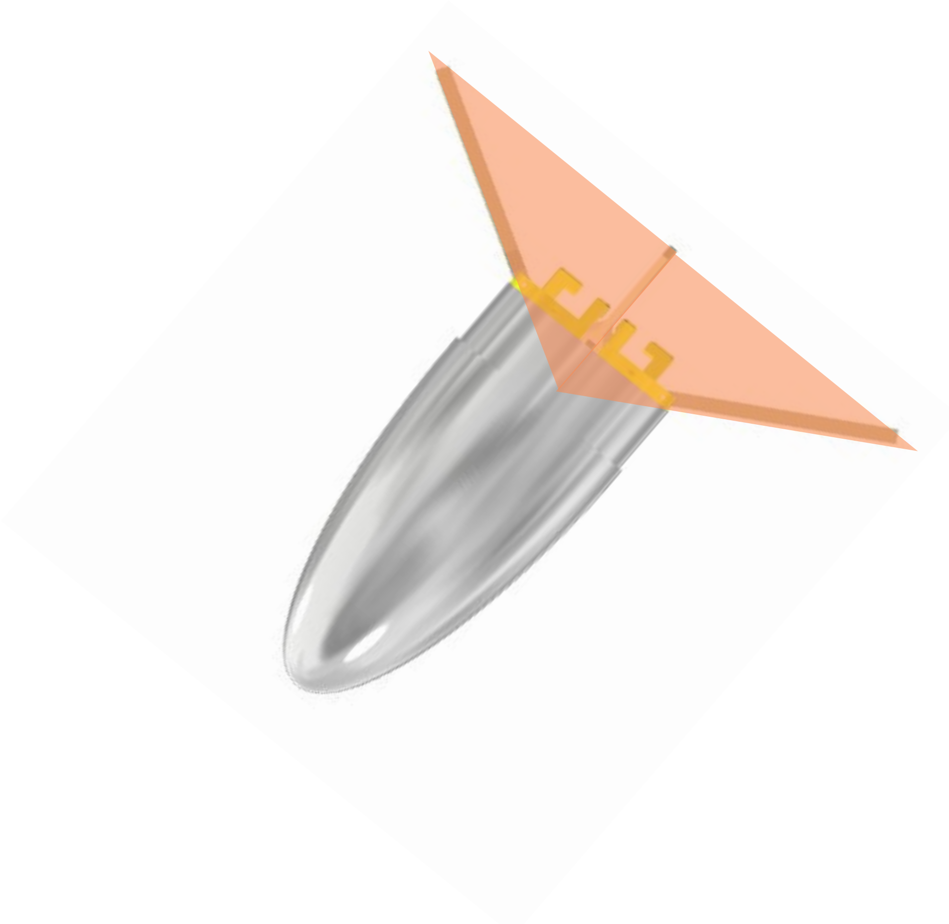
Ripstop Nylon Aerobraking Heat Shield

Orange HS

No Servos required, Springs and magnets deployment

Pyramid Shape

Payload Descent Stability Control Design



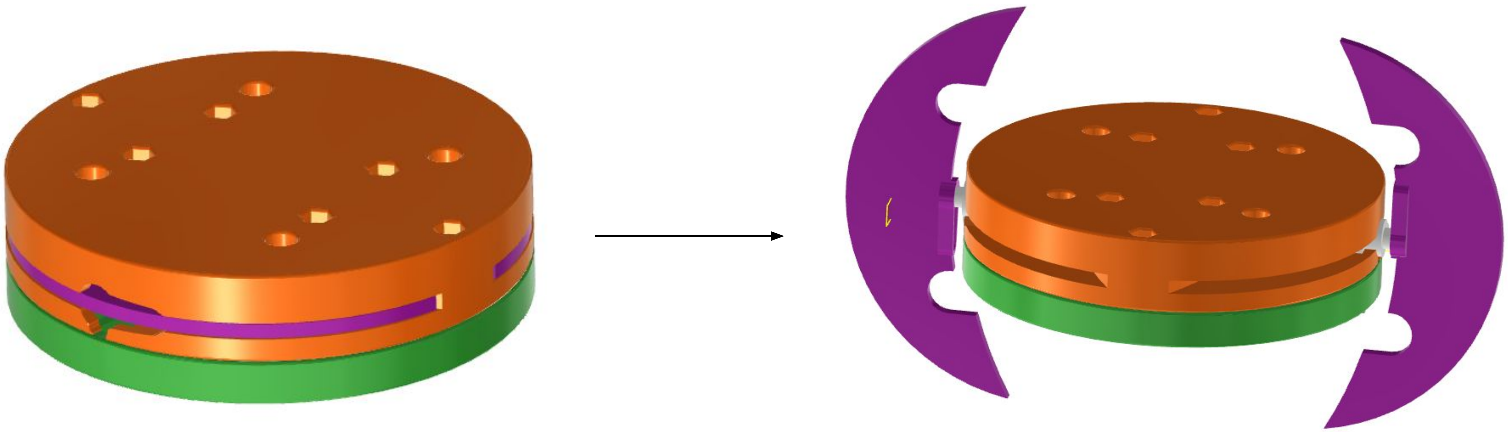
Passive Nadir Stabilization

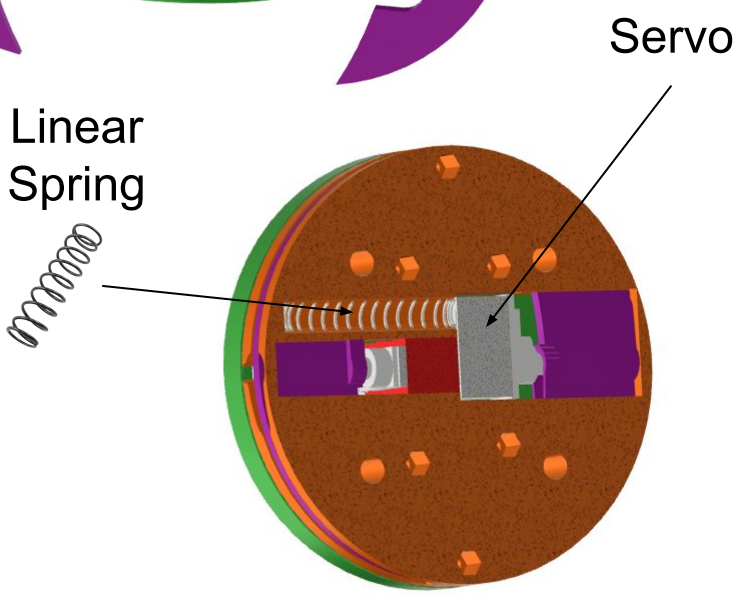
Mechanisms used are spring loaded HS.

Stability is controlled passively, the center of pressure sits higher than the center of mass

Center of pressure will be fixed, leaving us with no control over stabilization.

Payload Rotation Control Strategy

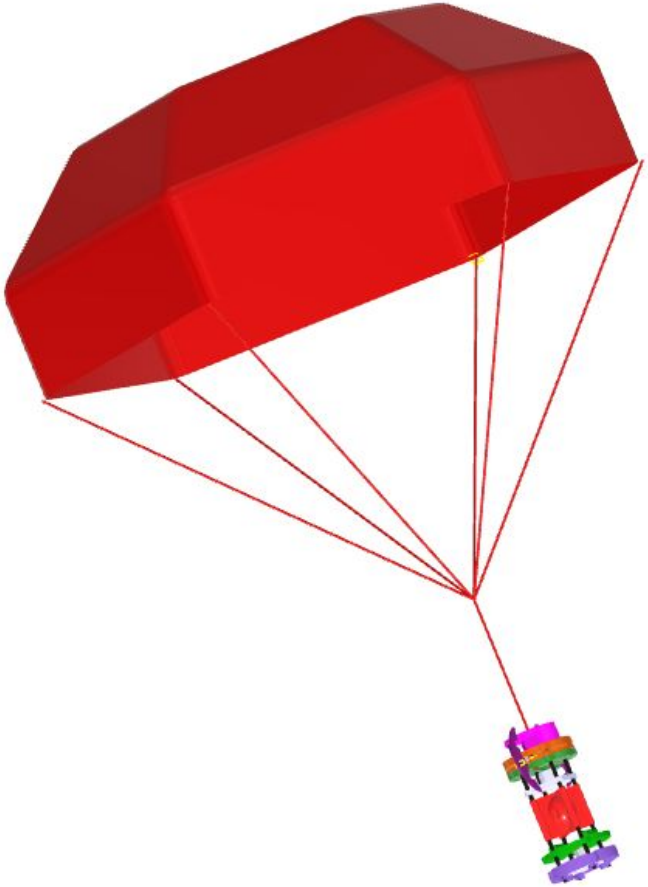




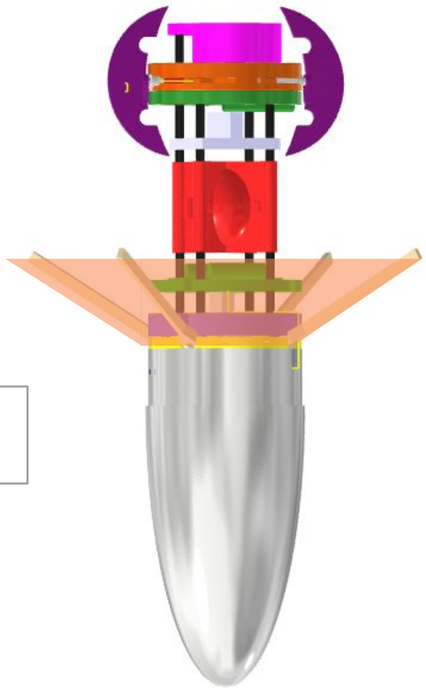
This design opens the fins at deployment of the Cansat burning with nichrome wire a fishing line that maintains them in place.
The fins can rotate separately and by tilting in opposite directions it can control the rotation of the Cansat during aerobraking. Also, this way the camera always points the same direction.

Payload Parachute Descent Control Hardware Summary (1/2)

Red Parachute

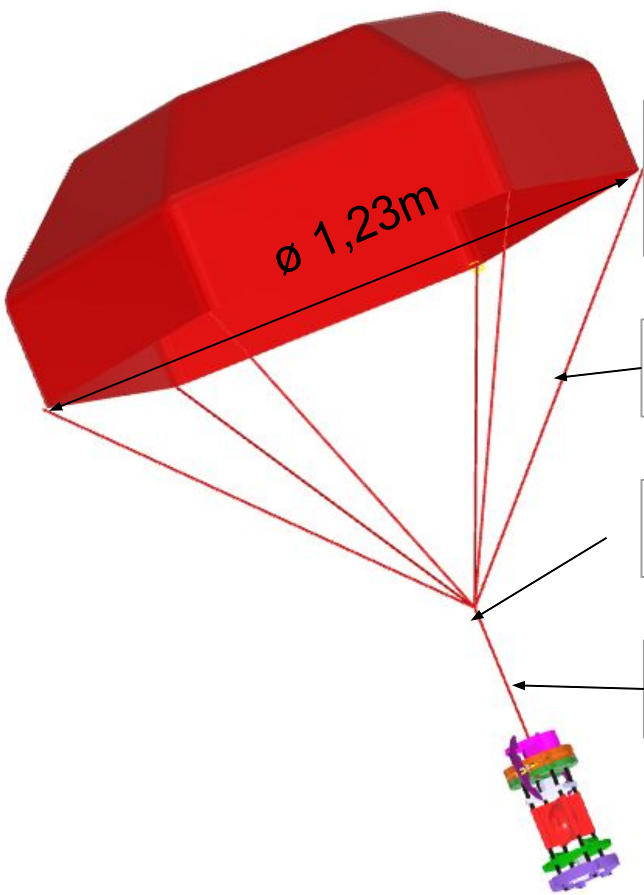


In summary, parachute descent control works by relying on in passive nadir stabilization using the hexagonal parachute to locate the center of pressure and the general CG of the cansat. And in active rotation stabilization, using fins cutting through the air to induce a torque in the roll axis of the cansat.



Orange Heat Shield

Payload Parachute Descent Control Hardware Summary (2/2)



Parachute	
Red Hexagonal Parachute	Passively Nadir Stabilisation
Fishing Line	→ attach Cansat to Parachute
Elastic Cord	→ absorb shock force at opening (needs testing)
Swivel Link	→ prevent entanglement if Parachute and Cansat rotate at different ratios

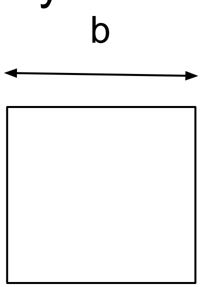
Descent Rate Estimates (1/4)

Assumptions

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

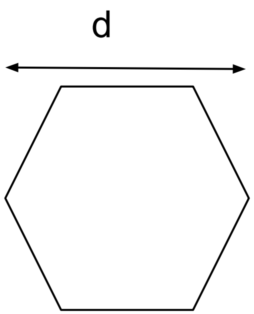
Heat Shield

- $m_1 = 0{,}9\ kg$
- $\rho_1 = 1{,}15\ kg/m^3$ (at 725 m)
- $A_1 = b^2$
- $Cd_1 = 0{,}9$ (from testings)



Parachute

- $m_2 = 0{,}7$ kg
- $\rho_2 = 1{,}2\ kg/m^3$ (at 100m)
- $A_2 = 3\sqrt{3}/8\ d^2 = 0{,}6495\ d^2$
- $Cd_2 = 1{,}3$ (from testings)



Variables
m : Mass
g : Acceleration of the Earth
ρ : Density of the Air
v : Terminal Velocity
Cd : Drag Coefficient
A : Area
d : length of the diagonal of the hexagon
b : length of the side of the square

Equations

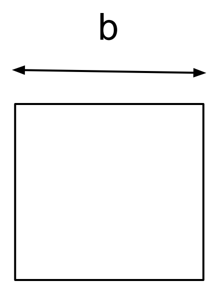
$$F_{gravity} = F_{drag}$$

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

Heat Shield

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

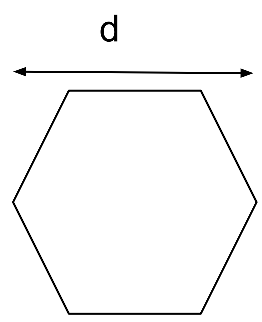
$$b = \sqrt{\frac{2mg}{\rho C_d v^2}}$$



Parachute

$$v = \sqrt{\frac{2mg}{\rho C_d 0{,}6495 d^2}}$$

$$d = \sqrt{\frac{2mg}{\rho C_d 0{,}6495 v^2}}$$



Variables
m : Mass
g : Acceleration of the Earth
ρ : Density of the Air
v : Terminal Velocity
Cd : Drag Coefficient
A : Area
d : length of the diagonal of the hexagon
b : length of the side of the square

Descent Rate Estimates (3/4)

Testing

We dropped both the HS and parachute from different heights and measured its needed time. We took into account the current weather for the calculation of the density of the air. With all these data and numerous attempts to have the most reliable results, we calculated the Drag coefficient of both mechanism

$Cd_{HS} = 0,9$

$Cd_{Parachute} = 1,3$

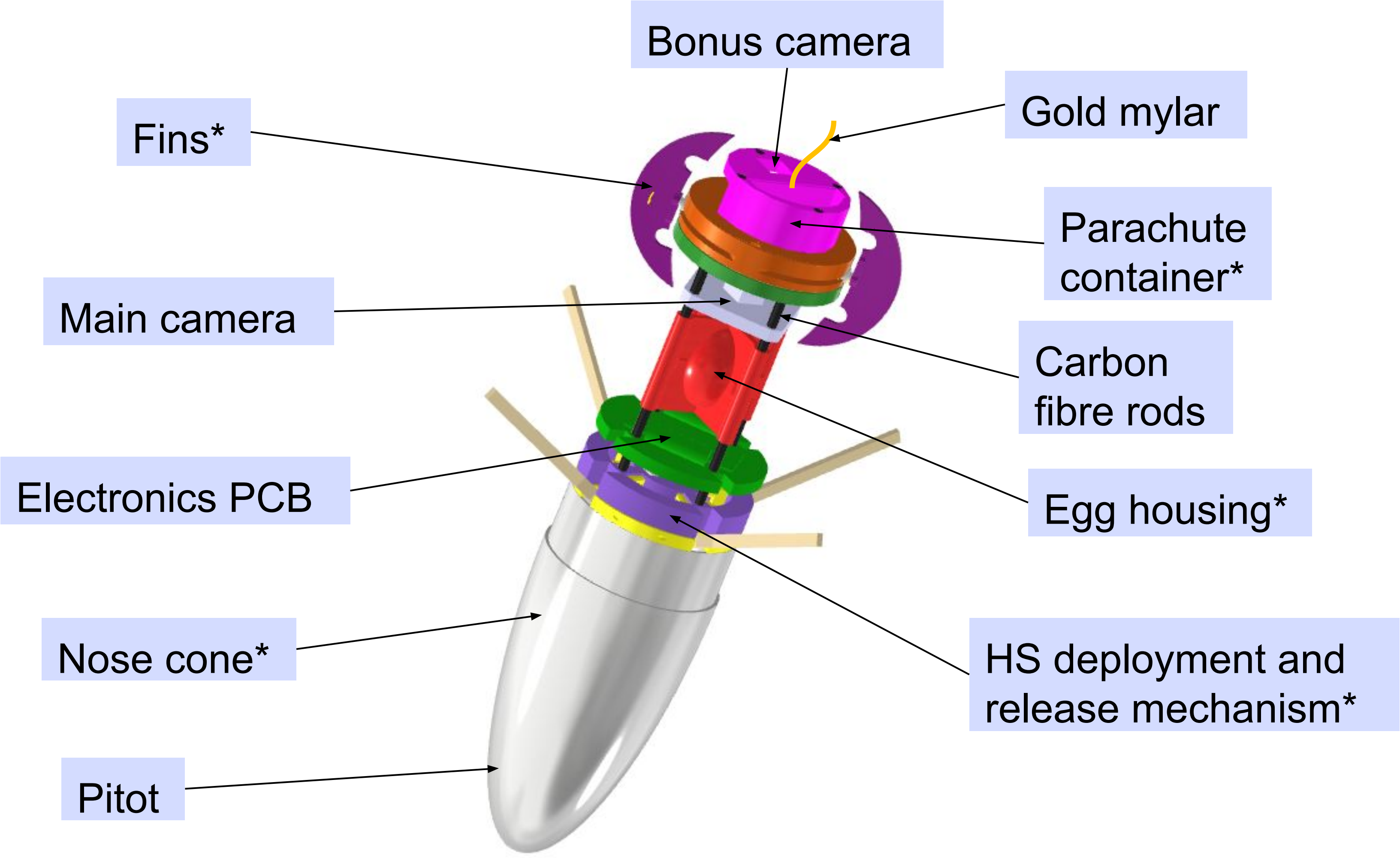
Descent Rate Estimates (4/4)

Heat Shield	Parachute
The descent rate should be 10-30 m/s We decide v = 15 m/s to have margin $b = 0{,}2753\ m$ We choose b = 0,275 m for ease of assembly v = 15,02 m/s	The descent rate should be les than 5 m/s We decide v = 3 m/s to have margin $d = 1{,}227\ m$ We choose d = 1,23 m for ease of assembly v = 2,993 m/s

Mechanical Subsystem Design

Nicolás Martone & Ezequiel Bolzicco

Mechanical Subsystem Overview

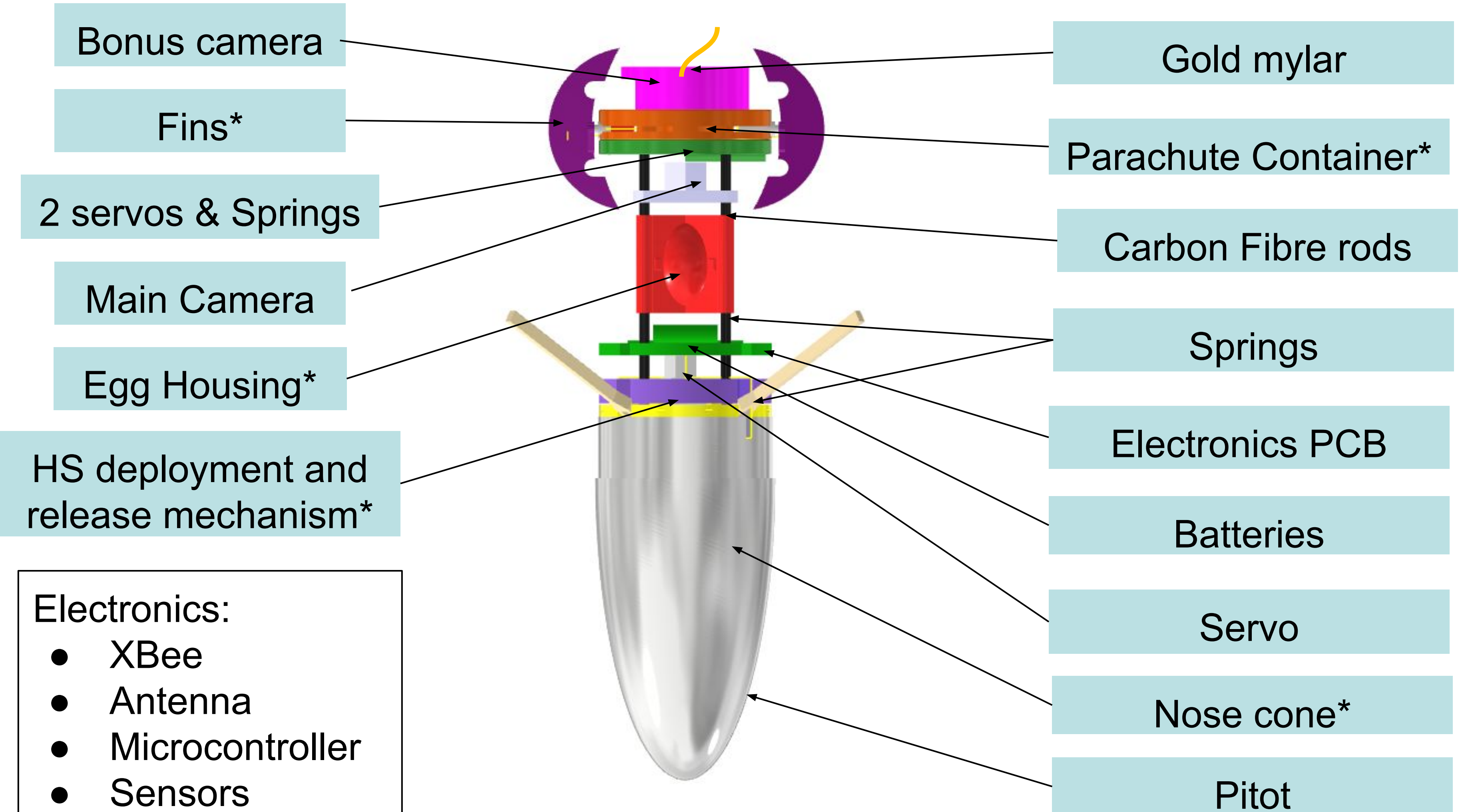


*ABS 3D-printed

Mechanical Subsystem Changes Since PDR

Change	Rationale
Changed mounting to fiber rods from screws to glue	To not compromise the structural integrity of the carbon fiber
Change of design in Egg Containment	Have another way of keeping it shut than the spring force and removal of unnecessary structure
Place of batteries changed	The new battery mount is sturdier and allows for easier access to the battery and faster battery swaps.

Payload Mechanical Layout of Components (1/4)

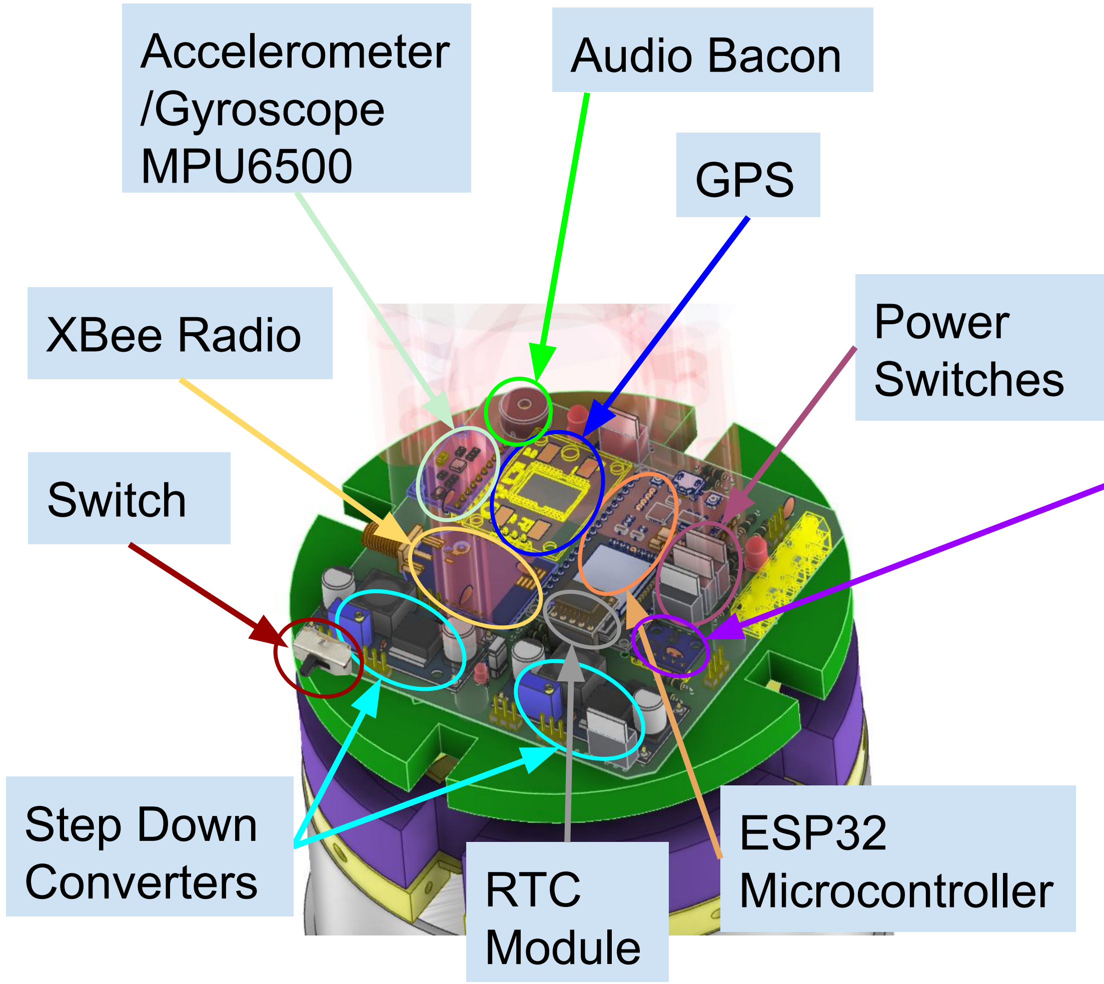


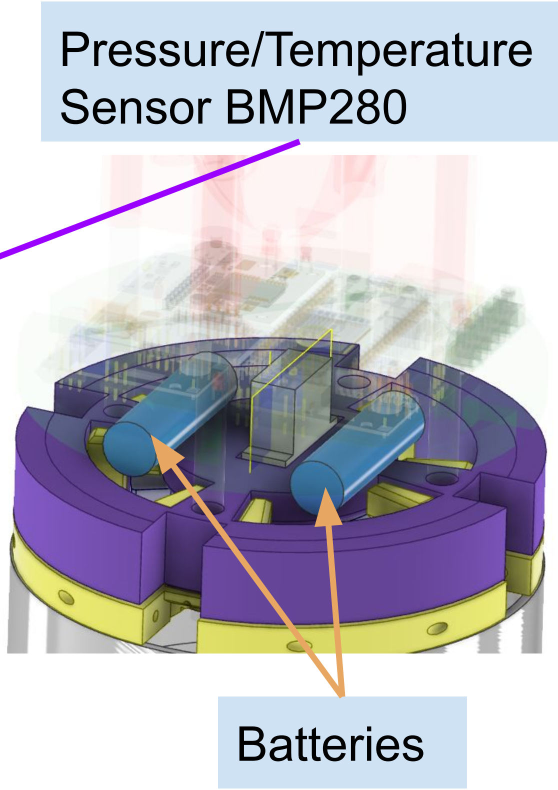
Electronics:

- XBee
- Antenna
- Microcontroller
- Sensors
- etc.

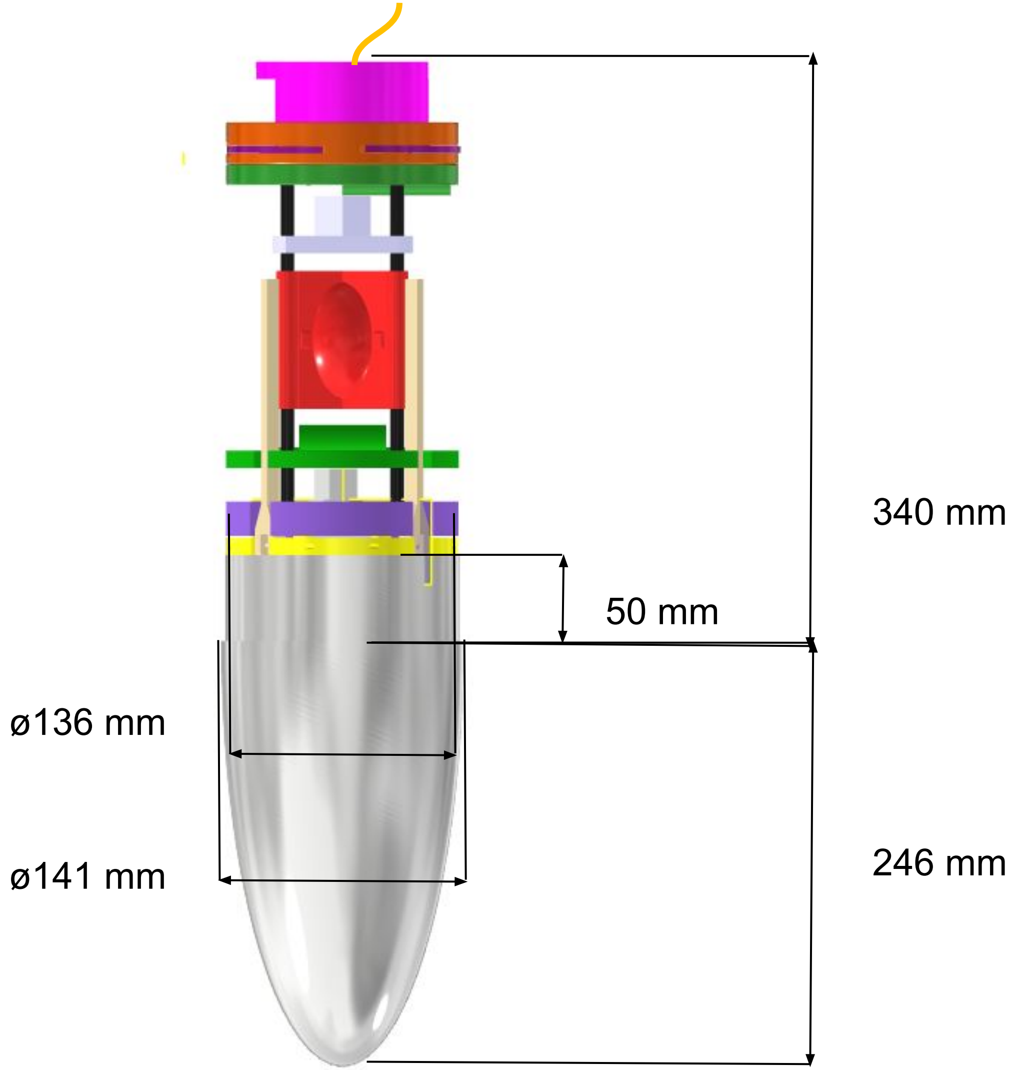
*ABS 3D-printed

Payload Mechanical Layout of Components (2/4)





Payload Mechanical Layout of Components (3/4)



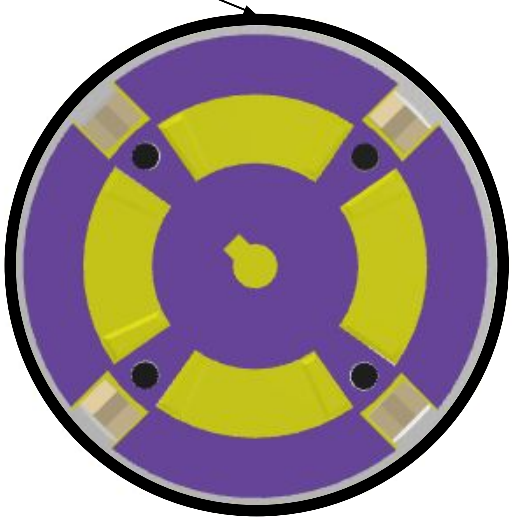
Material Selection

	Support Structure	Density	Tensile Strength	Flexural Stress	IZOD Impact, notched	Heat Deflection Temperature	Tg
ABS	Breakaway	1.05 g/cm^3	XZ:41 MPa	XZ:74 MPa	XZ: 205 J/m	82 °C	~=110 °C

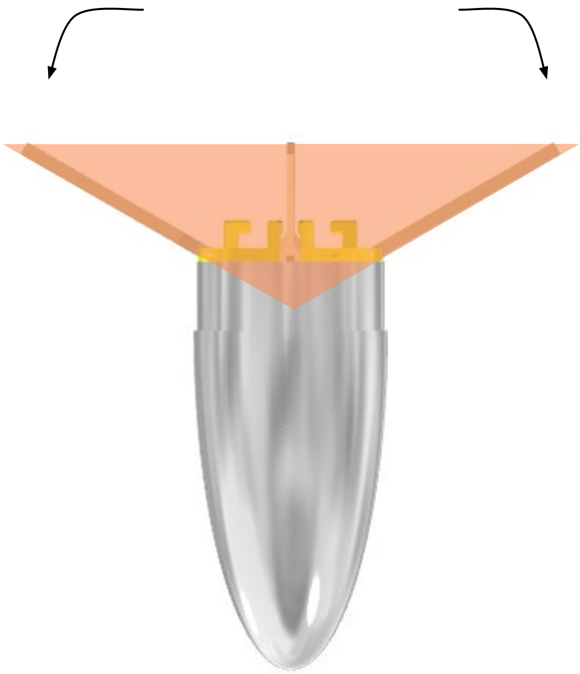
The heat shield is kept inside the cansat with a fishing line.

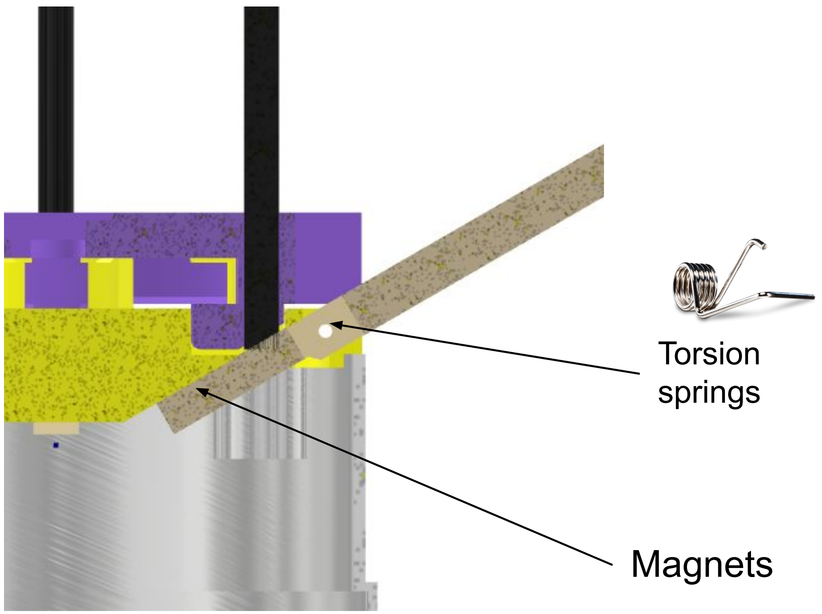
For deployment, the fishing line is burned with a resistance

Payload section



Payload Aerobraking Deployment Configuration (1/2)



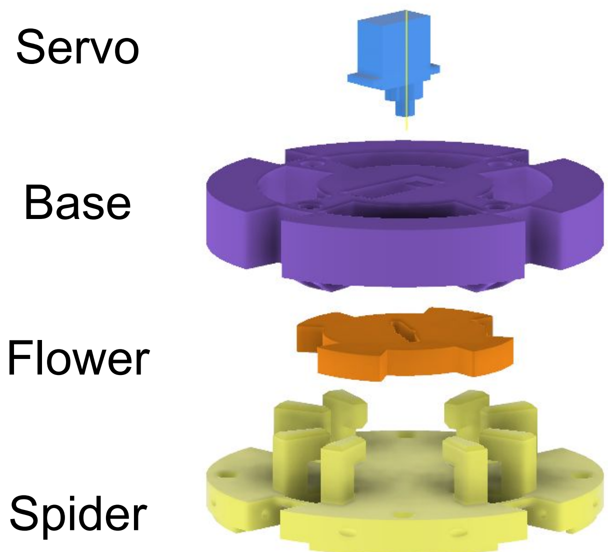


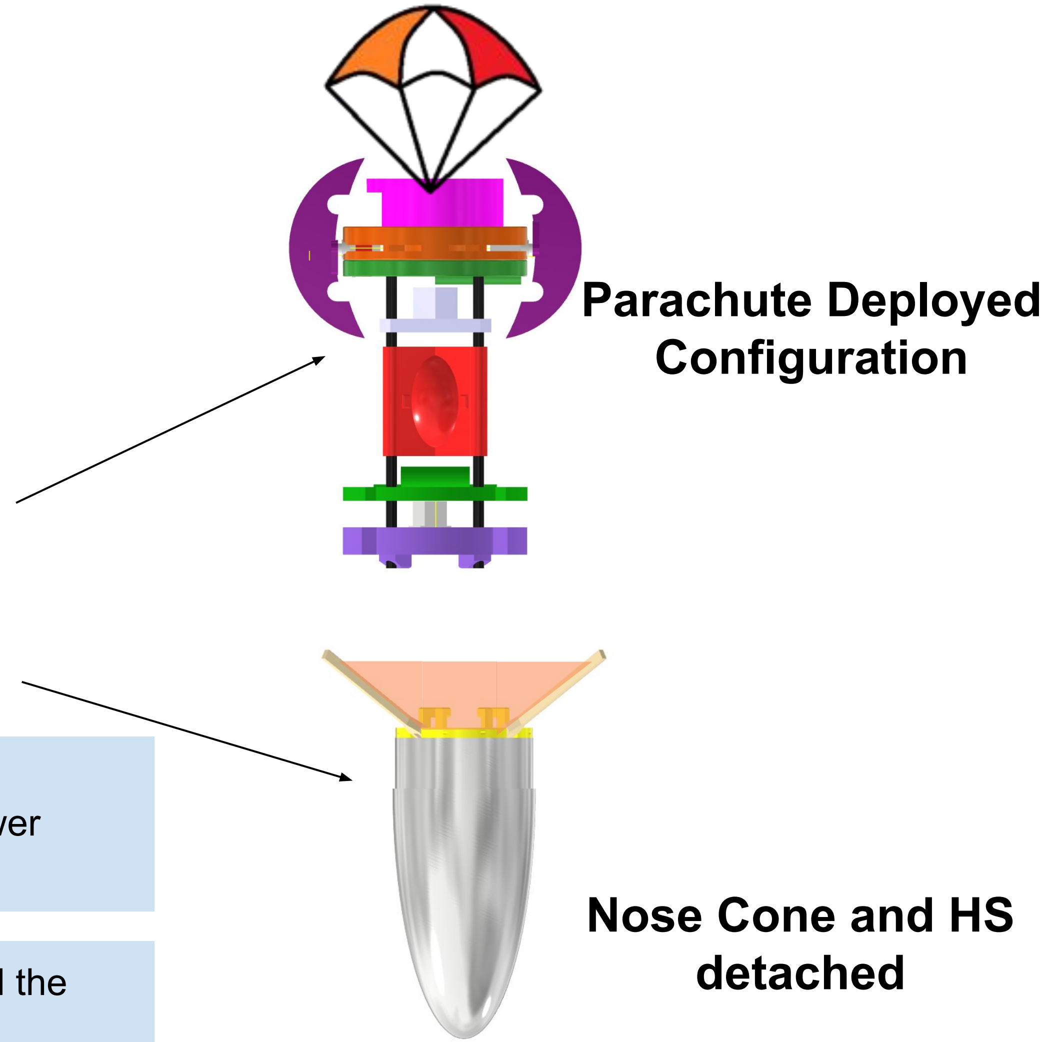
Each leg has a torsional spring at the pivot. Heat Shield auto deploys.

To keep the HS in deployed configuration, each leg has a locking mechanism.

With testing we confirmed the magnet can withstand a force of 8,5N, enough for its function

Payload Aerobraking Deployment Configuration (2/2)

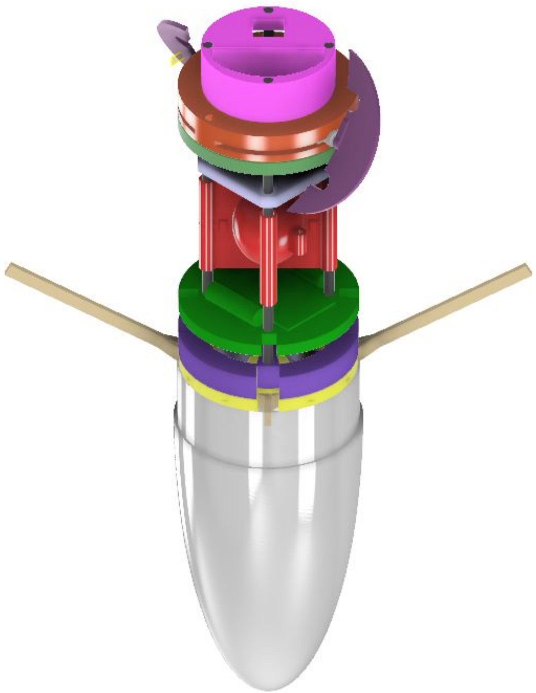




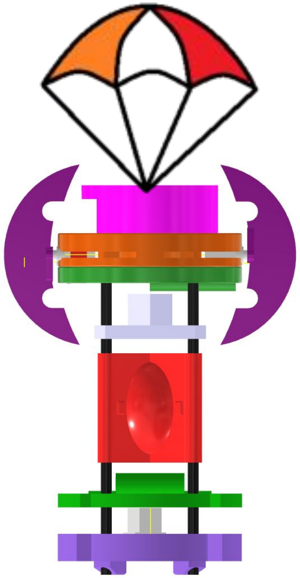
Spider is connected to the HS and Nose Cone.
Base is connected to the rest of the Cansat. Flower holds together both elements.

With the help of the Servo the Flower rotates and the Spider can be released from the Base.
The parachute opens

Camera Pointing Control



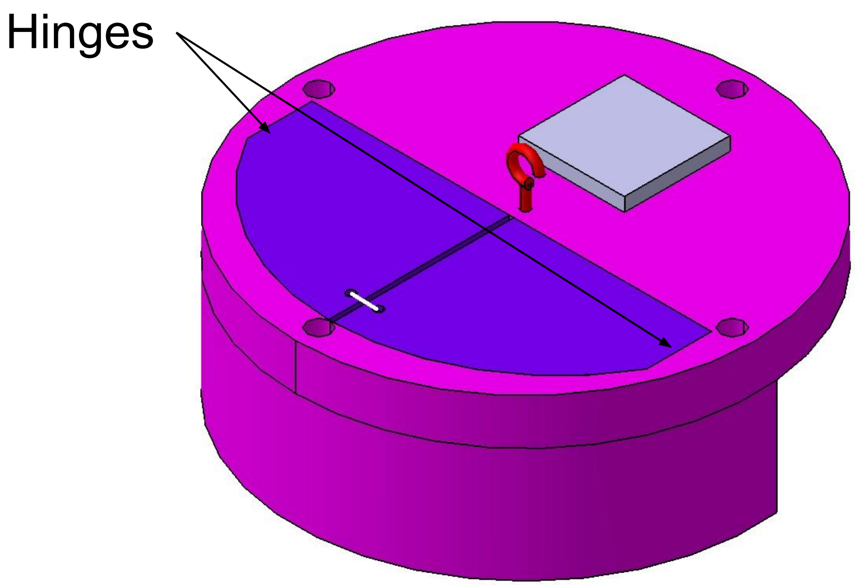
The fins can rotate separately and, by tilting in opposite directions, it can control the rotation of the Cansat during aerobraking.

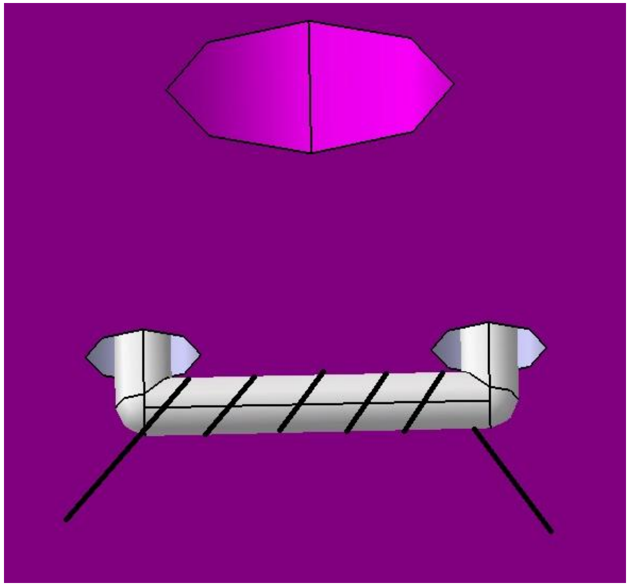


The center of mass is forward of the center of pressure to maintain Nadir direction

It would be optimal if the distance between center is, at least, 1 diameter of the CanSat.

Payload Parachute Deployment Configuration





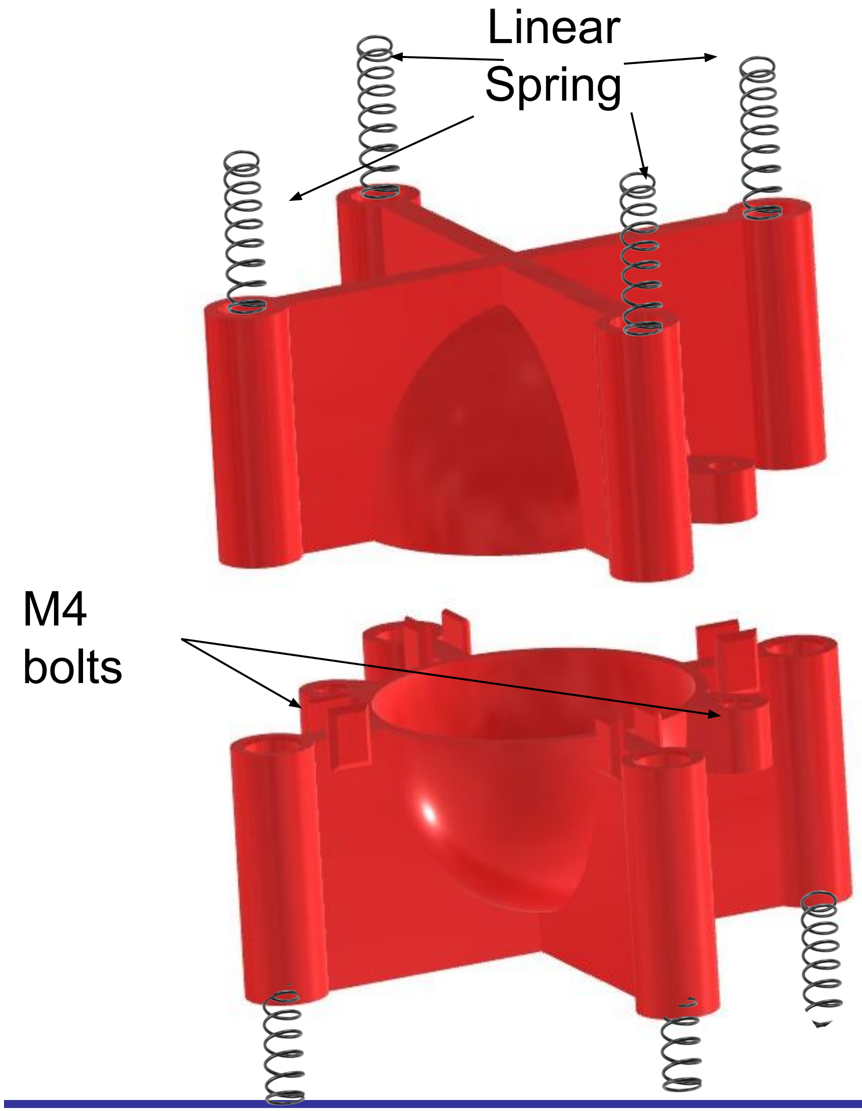
The parachute wires attach to an eye bolt. Parachute is folded inside the Parachute housing and is held by 2 doors and a fishing line.

For deployment, a resistance cuts the line and the doors pivot on hinges.

An elastic line is placed between the eye bolt and the parachute chords to absorb the initial shock.

Swivel link is added to prevent entanglement if Parachute and Cansat rotate at different ratios

Payload Egg Containment Configuration



The egg is inserted in a two-part capsule.

The capsule is lined with a sponge to absorb variations in the eggs shape.

The capsule is suspended by springs to absorb shocks.

Two M4 bolts are used to keep the capsule shut.

Structure Survivability (1/2)

Electronic Mounting	
Material	**Properties**
Hot melt silicone	• It has a melting point of roughly 100 degrees Celsius. • It's simple to use. • It's a thermoplastic glue that can be implemented using a hot glue gun.
Mounting slot	• A component of the payload's structure as components are fitted to the Payload framework.
High Performance Adhesive	• Components are firmly adhered to the payload framework. • Permanent. • Lightweight. • Surface-applicable.
Screws and Standoffs	• The majority of components are through-hole modules with screw holes. • Secures components in a robust manner. • Sizes can vary

- All electronic components that go on the PCB will be soldered to the PCB
- All electric connections will be secured with resin epoxy

Structure Survivability (2/2)

Payload Enclosure Method	
Payload's walls	• The payload's electronics are enclosed with a 3d printed sleeve

- 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
- Eyebolts for parachute attachment points have been chosen with a safety factor of at least 2

Mass Budget (1/5)

Electronics Mass Breakdown			
Component	**Mass[g]**	**Uncertainty[g]**	**Source (Estimate/Manufacturer/Datasheet)**
MCU: ESP32	10	±1	Manufacturer
Camera: Quelima SQ11 x 2	30	±2	Manufacturer
Battery: Samsung INR18650	46.5	±5	Datasheet
PCB + Resistors + Capacitors + Power Switches + tin	40	±5	Estimate
Sensor: BMP280 module	1	±0.2	Manufacturer
RTC module + battery	11	±1	Datasheet
GPS Ublox NEO-6M + Antenna	16	±1	Datasheet
XBEE S2C PRO + Radio Antenna	4.2	±0.3	Manufacturer
MPXV7002 + Pitot Tube	10	±5	Estimate

Mass Budget (2/5)

Electronics Mass Breakdown			
Component	**Mass[g]**	**Uncertainty[g]**	**Source**
Cables & Connectors	10	±2	Estimate
Mechanical Switch	1	±1	Estimate
Buzzer	1	±0.01	Datasheet
DC/DC Boost Converter Xl6009 Module	12	±1	Manufacturer
LDO	0.5	±0.5	Estimate
Servo Tower Pro Mg90 x3	40.2	±3	Manufacturer
Sensor MPU-6500	5	±0.3	Manufacturer
Resistance x3	1	±0.5	Estimate
PCB	20	±5	Estimate
TOTAL = 239.4 g ± 33.9			

Mass Budget (3/5)

Mechanics Mass Breakdown (1/2)			
Component	**Mass[g]**	**Uncertainty[g]**	**Source**
Carbon Fiber Rods x 4	32.4	±0.5	Measured
Fins x 2	13.5	±0.5	Measured
Fins floor	60.5	±0.5	Measured
Egg holder	65	±0.5	Measured
Nose cone	171.8	±10	Slicer estimate
Parachute Housing	60.9	±0.5	Measured
Parachute door	2,8	±0.5	Slicer estimate
Heat shield legs x 4	40.6	±0.5	Measured
Heat shield deployment mechanism (Spider)	44	±0.5	Measured
Heat shield deployment mechanism (Base)	45.7	±0.5	Measured

Mass Budget (4/5)

Mechanics Mass Breakdown (2/2)			
Component	**Mass[g]**	**Uncertainty[g]**	**Source**
Heat shield deployment mechanism (Flower)	18.5	±0.5	Measured
Nylon	17	±0.5	Measured
Parachute	56.3	±10	Estimate
Torsion Spring x 4	2	±0.5	Measured
Linear Spring x 10	20	±3	Estimate
Elastic Cord	2	±0.5	Estimate
Swivel Link	2	±0.5	Estimate
TOTAL = 656.7g ± 29			

Mass Budget (5/5)

Total Budget	
System	**Mass[g]**
Electronics	239.4 ± 33.9
Mechanics	656.7 ± 29
Total	896.1 ± 62.9

Our calculated mass falls in the tolerance range.

The margin of error in the mass calculation due to uncertainties in each component and the added mass of assembly materials (Glues, wires length, screws, etc) can fall outside the requirement. If it is the case, we explain methods to mitigate it.

Methods to increase mass

- Raise infill of parts that go under big forces
- Add weight near the nose cone to add stability

Methods to decrease mass

- Decrease infill
- Optimize design for minimal usage of material

Communication and Data Handling (CDH) Subsystem Design

Matias Bergerman

CDH Overview

Cansat		
ESP32	Microcontroller + memory	Contains and runs whole code. Receives data from all sensors, process it and controls the movement of the fins for rotation stabilization.
XBee S2C + SMA Monopole Antenna	RF Module + Antenna	Sends telemetry to the Ground Station at a rate of 1 Hz.
DS3231	RTC	Keeps time accurate throughout the whole mission even if CanSat is turned off or suffers a power loss.
SD card	SD	Stores the all the telemetry data sent as backup.

CDH Changes Since PDR (1/2)

Change	Rationale
Cansat to Ground Station XBEE radio module	We changed XBee XBP24CAWIT to XBEE XBP9B-DMST-002. The reason of this change is that XBEE XBP9B-DMST-002 is available locally, it also has better range (3.2 Km vs 15.5 Km).
Ground Station to Cansat XBEE radio module	We changed XBee XBP24CAWIT to XBEE XBP9B-DMST-002. The reason of this change is that XBEE XBP9B-DMST-002 is available locally, it also has better range (3.2 Km vs 15.5 Km).
Cansat to Ground Station XBEE antenna	Since the new Xbee module uses the 900Mhz band and has an SMA connector, the antenna was changed from a wire whip to a 900Mhz SMA monopole antenna.
Ground Station to Cansat XBEE antenna	Since the new Xbee module uses the 900Mhz band and has an SMA connector, the antenna was changed from a wire whip to a 900Mhz SMA monopole antenna.

CDH Changes Since PDR (2/2)

Change	Rationale
Real time clock IC changed from DS1307 to DS3231	Already available in our labs. DS3231 is compensated from temperature.
SD card was added	The SD card has better accessibility and is independent from the MCU in case it fails. The write cycles rating and storage capacity are also much greater. There is physical space and available data pins to support this addition on the PCB. Low weight and cheap.

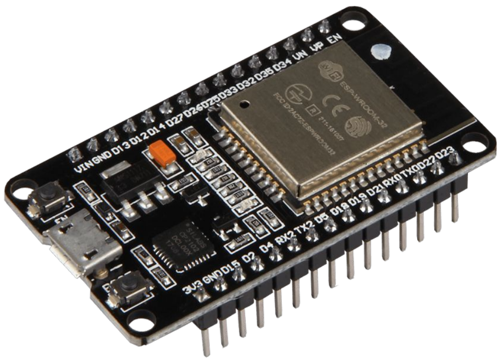
Payload Processor & Memory Selection (1/3)

Name	Outline Size [mm]	Weight [gr]	Flash Memory [KB]	SRAM [KB]	Boot Time	Clock Speed [MHz]	Micro controller	Interfaces	Price($)
NodeMCU ESP32	48x26	9.3	4000	520	250 ms	80	Xtensa® **32-bit** LX6	SPI: 4 I2C: 2 UART: 3	11.5

Pros

Boot Time: 250ms (Measured with current version of firmware)

- **Processor Speed:** 80Mhz
- **Data bus width**: 32 bits
- **Cheap**
- **Arduino toolchain compatible**



Payload Processor & Memory Selection (2/3)

Name	Outline Size [mm]	Weight [gr]	Flash Memory [KB]	SRAM [KB]	Boot Time	Clock Speed [MHz]	Micro controller	Interfaces	Price($)
NodeMCU ESP32	48x26	9.3	4000	520	250 ms	80	Xtensa® 32-bit LX6	SPI: 4 I2C: 2 UART: 3	11.5

Pros of using ESP's flash memory

- Does not require additional space, cost, weight and significant power usage.

Cons

- Partition formatting needed
- Low write cycles admitted
- Harder to retrieve

Type	Usage (estimated)
Cansat code	150 KB
Mission telemetry	170 KB
Total	320 KB

Pros of using SD card

- Cheap
- Easy to retrieve
- Can backup more data because of its memory

- Memory is intended to store telemetry data from launch to landing in case of important telemetry loss.

Payload Processor & Memory Selection (3/3)

- **Data Interfaces:**

Interfaces	Usage
I2C	BMP280, DS3231, MPU6500 (same bus)
UART	GPS NEO 6-M, XBEE Module
SPI	Sd card
Digital pin (OUT)	SQ11 Control, Nichrome wire, Buzzer, Servo motors (PWM)
Analog pin (IN)	Battery measurement, Pitot measurement

Payload Real-Time Clock

Name	Size [mm]	Weight [gr]	Operating current [mA]	Operating Voltage [V]	Temperature Range [°C]	Accuracy [ppm (@ 60° C)]	Interface	Price ($)
DS3231	22x35x2.5	8.00	0.65	2.3 - 5.5	0 - 70	±3.5	I2C	5

Reasons

- Previous experience with successful results.
- Team is familiarized with its libraries
- High accuracy and optimal power consumption.
- Temperature sensibility corrected.
- Integrated crystal oscillator.
- CR2032 battery keeps real time for long periods of time.

Name	Range [m]	Radiation Pattern	Dimensions [mm]	Gain [dBi]	Weight [gr]	Polarization	Connector type	Price ($)
HP-915-JW-3800N	10000 Estimated	(2)	80x13x13	2	10	Linear	RPSMA	6.67

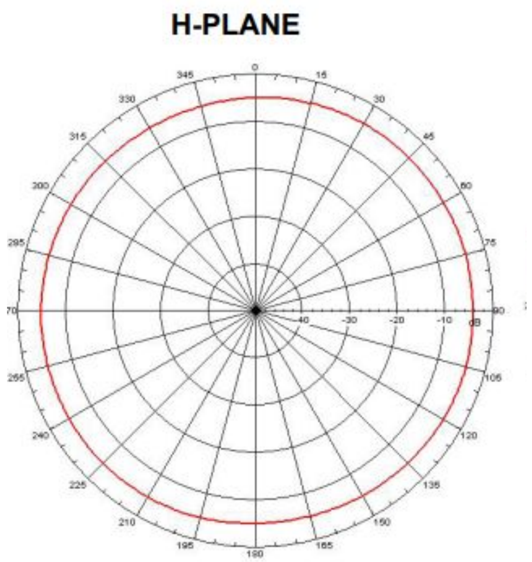
Antenna used for Payload to Ground Station link.

Pros

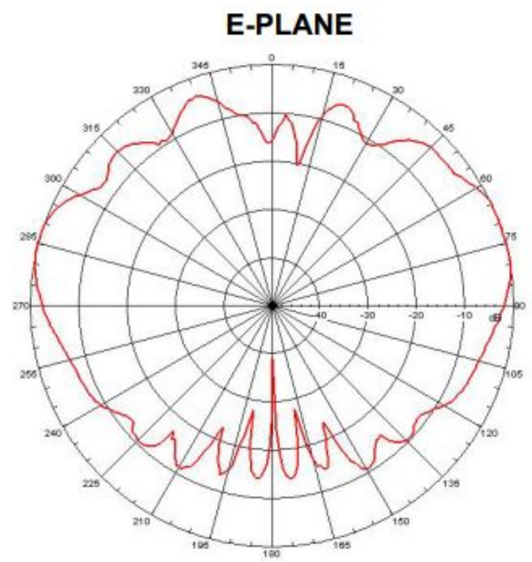
- Antenna is more robust and uniform omnidirectional pattern.
- Small enough to fit inside.
- Connector type allows to aim the antenna correctly.

Notes

- Antenna tests have started and are still ongoing.
- Antenna will be placed along the horizontal axis of the payload.



(1)



(2)

- Low antenna gain allows the antenna pattern to be omnidirectional.
- The patterns shown here can be interpreted as the 2D projection of the whole radiation pattern across all panes.

Payload Radio Configuration

Name	Frequency [GHz]	Antenna Connector	Transmit current [mA]	Receive current [mA]	Operating Voltage [V]	Range [m]	Sensitivity [dBm]	RF Data Rate [Kbps]
XBee XBP9B-DMST-002.	0.9	RPSMA	215	39	2.7-3.6	15500	-101	200

- **NETID/PANID will be set to: <u>2099</u>, using XCTU software**
- XBees will **<u>not</u>** be set to broadcast mode.
- This XBee will be used to send payload telemetry at a rate of 1Hz to the ground station.

- **The transmission control for the payload will follow the next steps:**
  - **StandBy:** Payload On, not transmitting telemetry, waiting for CX command.
  - **Pre- Launch/Launch:** Payload On, transmitting telemetry.
  - **Release of the Cansat:** Cansat starts polling sensors. cameras set to record and transmitting telemetry to GS with a frequency of 1Hz.
  - **Landing:** The Cansat shall stop polling payload telemetry and stop all transmissions when it lands.

Payload Telemetry Format (1/4)

Data Format	Example	Description
TEAM_ID	2099	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
AIR_SPEED	2	Air speed in meters per second
HS_DEPLOYED	C	‘C’ for deployed heat shield, ‘N’ otherwise

Payload Telemetry Format (2/4)

Data Format	Example	Description
PC_DEPLOYED	P	‘P’ for deployed parachute, ‘N’ otherwise
TEMPERATURE	29.4	Measured temperature in degrees Celsius
VOLTAGE	7.8	Voltage of the Cansat battery
PRESSURE	101.2	Measured air pressure in kPa
GPS_TIME	13:14:02	Time from GPS receiver in UTC
GPS_ALTITUDE	200.8	Altitude readings from the GPS in meters
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

Payload Telemetry Format (3/4)

Data Format	Example	Description
TILT_X, TILT_Y	75.01, 3.12	X and Y Cansat angles
ROT_Z	13.4	Rotation rate in degrees per second
CMD_ECHO	CXON	Last command received and processed
GYRO_P, GYRO_Y	18, 21	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
POINTING_ERROR	0	Yaw pointing error in degrees
WIRE_FIN, WIRE_HS, WIRE_PC	1, 1, 1	State of fins, heat shield and parachute wires. 1 for burnt wire, 0 otherwise

Payload Telemetry Format (4/4)

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

  TEAM_ID, MISSION_TIME, PACKET_COUNT, MODE, STATE, ALTITUDE, AIR_SPEED, HS_DEPLOYED, PC_DEPLOYED, TEMPERATURE, VOLTAGE, PRESSURE, GPS_TIME, GPS_ALTITUDE, GPS_LATITUDE, GPS_LONGITUDE, GPS_SATS, TILT_X, TILT_Y, ROT_Z, CMD_ECHO,, GYRO_P, GYRO_Y, ACCEL_R, ACCEL_P, ACCEL_Y, POINTING_ERROR, WIRE_FIN, WIRE_HS, WIRE_PC

- **Each telemetry field is delimited by a comma, and each packet is concluded by a single return character. Fields following the double comma in the telemetry format constitute optional data.**

- **Example:**

  1000,01:22:10,50,S,ASCENT,500.3,10,P,C,29.3,4.31,100.3,15:25:09,300.4,10.0543,20.1078,20,18.03,21.56,30.5,CXON,,18,21,30,35,33,0,1,1,1

- **The presented format matches the competition requirements**

Payload Command Formats

Command	Format	Command Description	Example	Example Description
CX	CMD,<TEAM_ID>,CX,<ON_OFF>	Payload telemetry On/Off command	CMD,1000,CX,ON	Activates payload telemetry transmission
ST	CMD,<TEAM_ID>,ST,<UTC_TIME>|GPS	Set time	CMD,1000,ST,13:35:59	Sets the mission time to 13:35:59
SIM	CMD,<TEAM_ID>,SIM,<MODE>	Simulation Mode Control Command	CMD,2099,SIM,ENABLE	Enables simulation mode
SIMP	CMD,<TEAM_ID>,SIMP,<MODE>	Simulated Pressure Data	CMD,2099,SIMP,101325	Provides a simulated pressure reading of 101325 Pascals
CAL	CMD,<TEAM_ID>,CAL	Calibrate Altitude to Zero	CMD,2099,CAL	Sets altitude to 0
CAL_PITCHROLL	CMD,<TEAM_ID>,CAL_PITCHROLL	Calibrate Pitch, Yaw and Roll to Zero	CMD,2099,CAL_PITCHROLL	Sets Pitch, Yaw and Roll to Zero
BCN	CMD,<TEAM_ID>,BCN,<ON_OFF>	Audio bacon On/Off command	CMD,2099,BCN,OFF	Deactivates the audio bacon

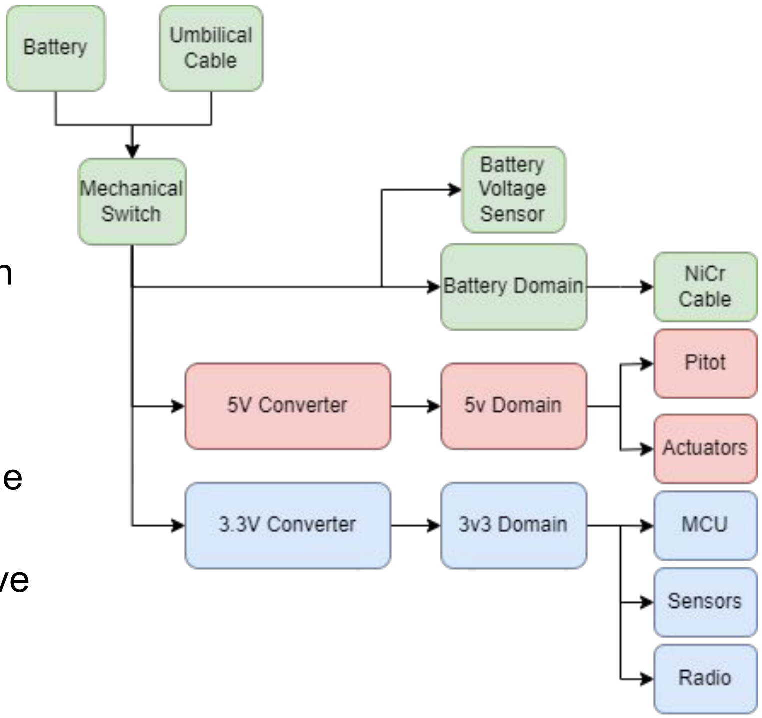
- **The presented format matches the competition requirements**

Electrical Power Subsystem Design

Nicolas E. Professi

EPS Overview

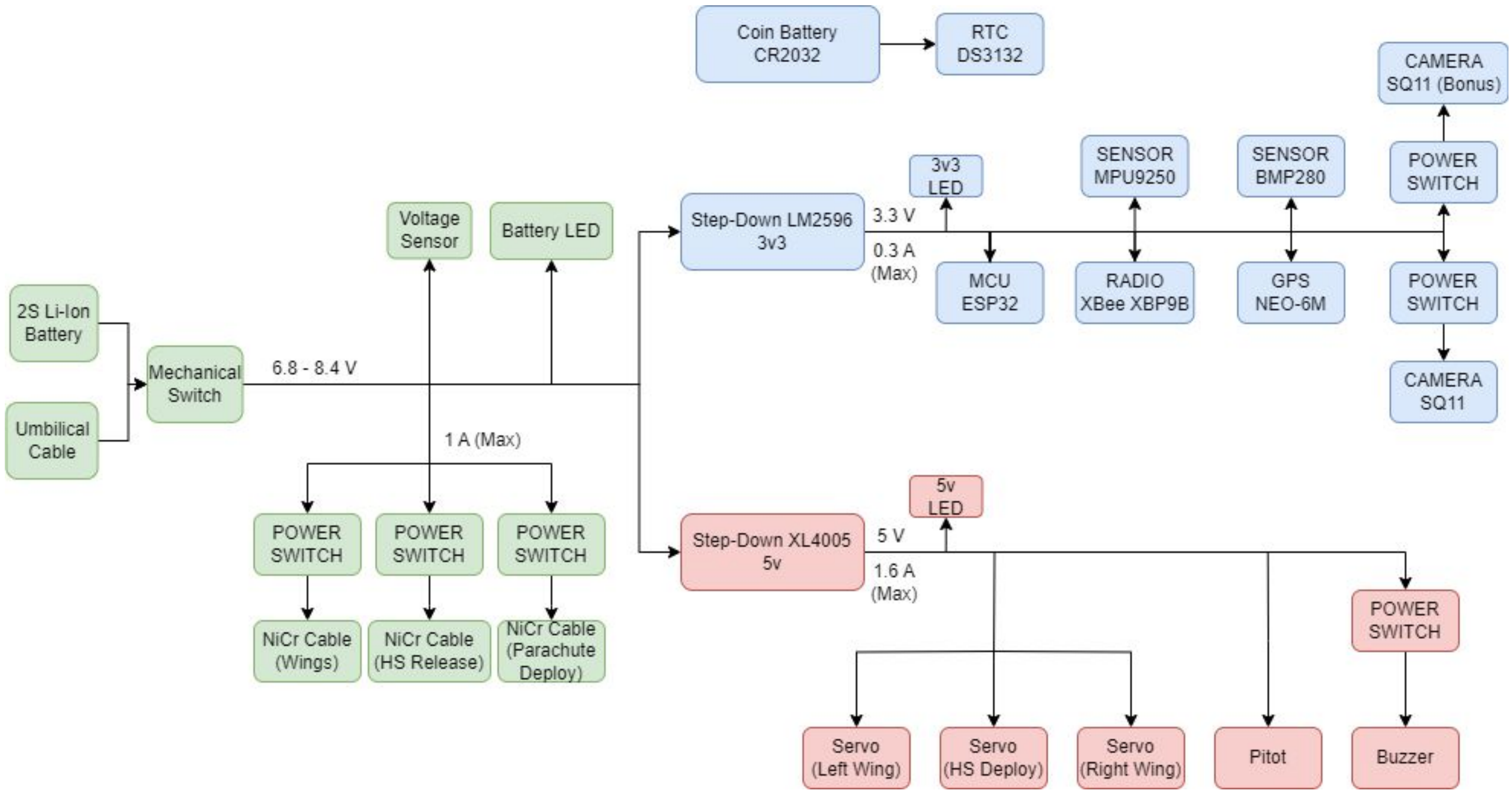
- **Battery**: Used as power source for components.
- **Umbilical Cable:** Power source for testing.
- **Mechanical Switch**: To turn on and off the system.
- **Battery Voltage Sensor:** To gather battery voltage.
- **NiCr Cable**: Used to deploy spring mechanism inside the cansat.
- **5V Converter**: Decreases battery voltage using a step-down converter to 5v for the actuators.
- **3.3V Converter**: Decreases battery voltage using a step-down converter for the microcontroller, the sensors and the radio module.
- **Sensors**: Used for information gathering throughout flight.
- **Radio**: To provide communication between the CanSat and the Ground Station.
- **Actuators**: Used for movement control (servos), and to retrieve module after landing with a sound alarm.
- **Pitot:** Pitot tube sensor for air speed.
- **Power Switches:** To turn on and off high power components during flight.
- **LED:** Visual indication of correct voltage in every domain.
- **RTC:** Real time clock, uses a coin battery.



EPS Changes Since PDR

Change	Rationale
Battery configuration changed from 1S to 2S	The fings servo motors were changed from TowerPro MG90 to Airtronics 94102 (wich drain twice the current). Also we changed the radio module and the new one drains 215 mA (transmitting), 39 mA (receiving), a lot more than the old one 120 mA (transmitting), 31 mA (receiving). Altough this new power budget complies with the energy budget, exceed the maximum battery current. For that reason, and for better energy margin, we decided to change the battery configuration using two batteries in series.
Power domain voltage regulators changed from LDO+StepUp to StepDown+StepDown	With the new battery configuration, the battery voltage is always above 6.8V. Using step-downs converters for the 5v and 3.3v power domain is a cheap and a power efficient solution.
Power switches removed except for the NiCr wires, camera and buzzer	Power switches were put in first place to avoid some idle current and to save energy. With the new battery configuration, we decided that power switches don´t save a lot of battery and they can fail. NiCr wires and buzzer preserve the power switch because they need to be activated only in certain moments.
Flight state led removed	Fight state led was very useful for debugging, but we needed to remove it to save GPIO pins.

Payload Electrical Block Diagram



Payload Power Source

- **Power Source: 2x Samsung 18650 Lithium Ion Battery**

Name	Technology	Weight [gr]	Voltage [V]	Capacity [mAh]	Energy Density [Wh/gr]	Nominal Current [mA]	Rechargable	Price ($)
Samsung INR18650	Lithium ion	46.5	3.7	2550	0.203	2750	Yes	10

Battery Configuration : Two batteries cells in series will be used.

Voltages: Battery voltage will be between 6.4V and 8.4V

Current: Maximum continuous nominal current is 2.75 A. For not continuous discharge, current can be 8.25A. For CanSat, we estimate 1 A during descent and 2.4A in the worst case (during NiCr cable burn out).

Power domains regulator: Since the battery nominal output voltage is higer than 6.4V. Step down modules will be used to generate 3.3V and 5V

Connection: The battery pack will be electrically connected to the cansat with JST connectors. Between the batteries, nickel strips and spot welding will be used.

Voltage Range: Full Charge = 8.4±0.05V Cut Off = 3.2V

Payload Power Budget (1/2)

Type	Component	Quantity	Voltage [v]	Current [mA]	Duty Cycle [s]	Duty Cycle [%]	Energy [Wh]	Source
MCU	ESP32	1	3,3	68	7200	100,00%	0,503	Datasheet
Sensor	BMP280	1	3,3	1,12	7200	100,00%	0,008	Datasheet
Sensor	ADC Pin + Voltage divider	1	3,3	0,2	7200	100,00%	0,001	Estimated
Sensor	MPU-6500	1	3,3	0,4	7200	100,00%	0,003	Datasheet
Sensor	MPXV7002 + Pitot Tube	1	5	10	7200	100,00%	0,111	Datasheet
Camera	Quelima SQ11	2	3,3	90	80	1,11%	0,015	Measured
GPS	Ublox NEO-6M	1	3,3	67	7200	100,00%	0,496	Datasheet
Actuator (Wings)	Airtronics 94102 servo	2	5	600	80	1,11%	0,148	Measured
Actuator (HS)	Airtronics 94102 servo	1	5	600	3	0,04%	0,003	Measured
Actuator (HS+Wings)	Airtronics 94102 servo (IDLE)	3	5	3	80	1,11%	0,001	Measured
Actuator	NiCr Wire	3	3,7	2000	2	0,03%	0,012	Estimated
Actuator	Buzzer CMT-8540S	1	5	150	1800	25,00%	0,417	Datasheet
Radio	XBEE XBP9B-DMST-002 Trasmiting	1	3,3	215	80	1,11%	0,018	Datasheet
Radio	XBEE XBP9B-DMST-002 Idle	1	3,3	39	7140	99,17%	0,286	Datasheet
Total							2,023	

Note:

- 5V and 3.3V component`s power consumption was calculated considering the 90% efficiency of the DC/DC buck converter.

Payload Power Budget (2/2)

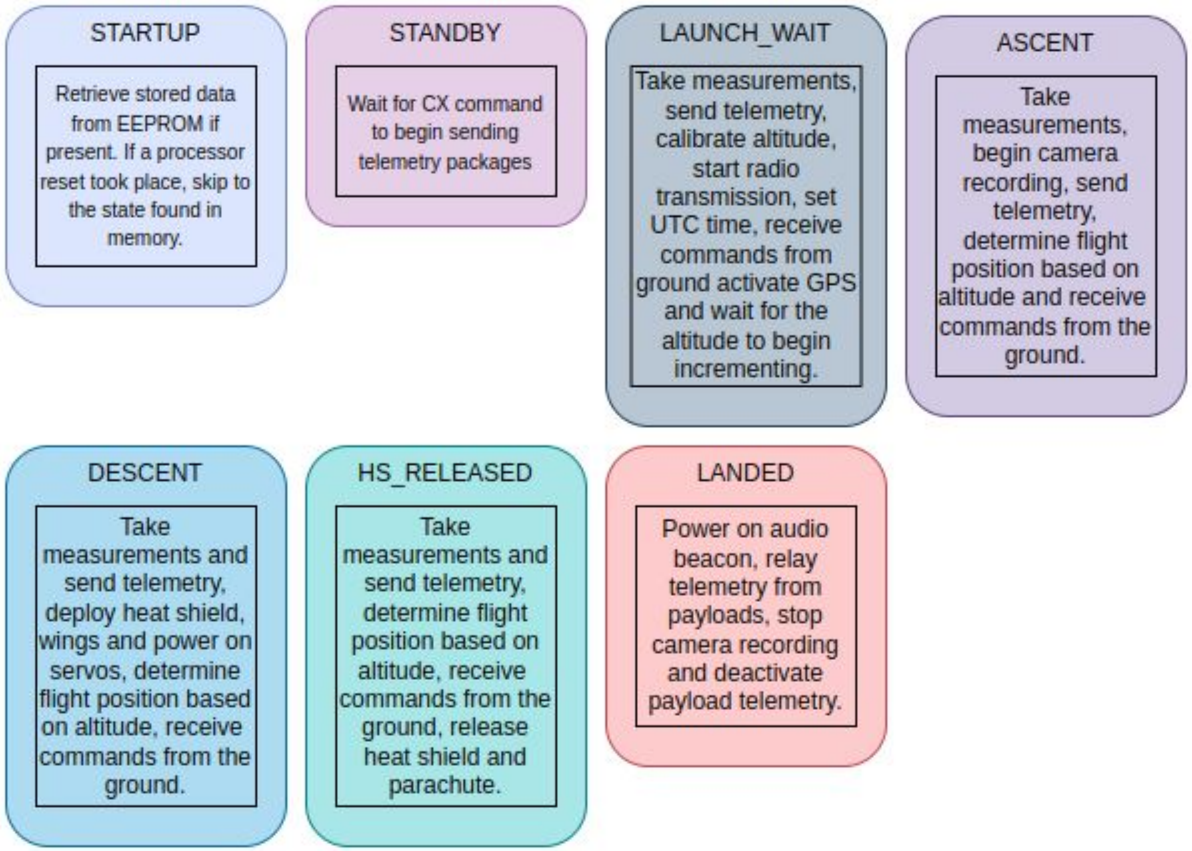
Power Source: Payload Battery	Energy [Wh]
Total Energy Consumption	2,13
Battery Energy (100% discharge depth)	18,5
Energy Margin	16,37
Operating Time (60% discharge depth)	10 Hour
Power Source: RTC Battery	**Energy**
Total Energy Consumption (RTC)	0,2 mWh
Battery Energy (100% discharge depth)	0,675 Wh
Operating Time (100% discharge depth)	20 Months

Flight Software (FSW) Design

Micaela Perillo

FSW Overview (1/2)

- **State Overview**



FSW Overview (2/2)

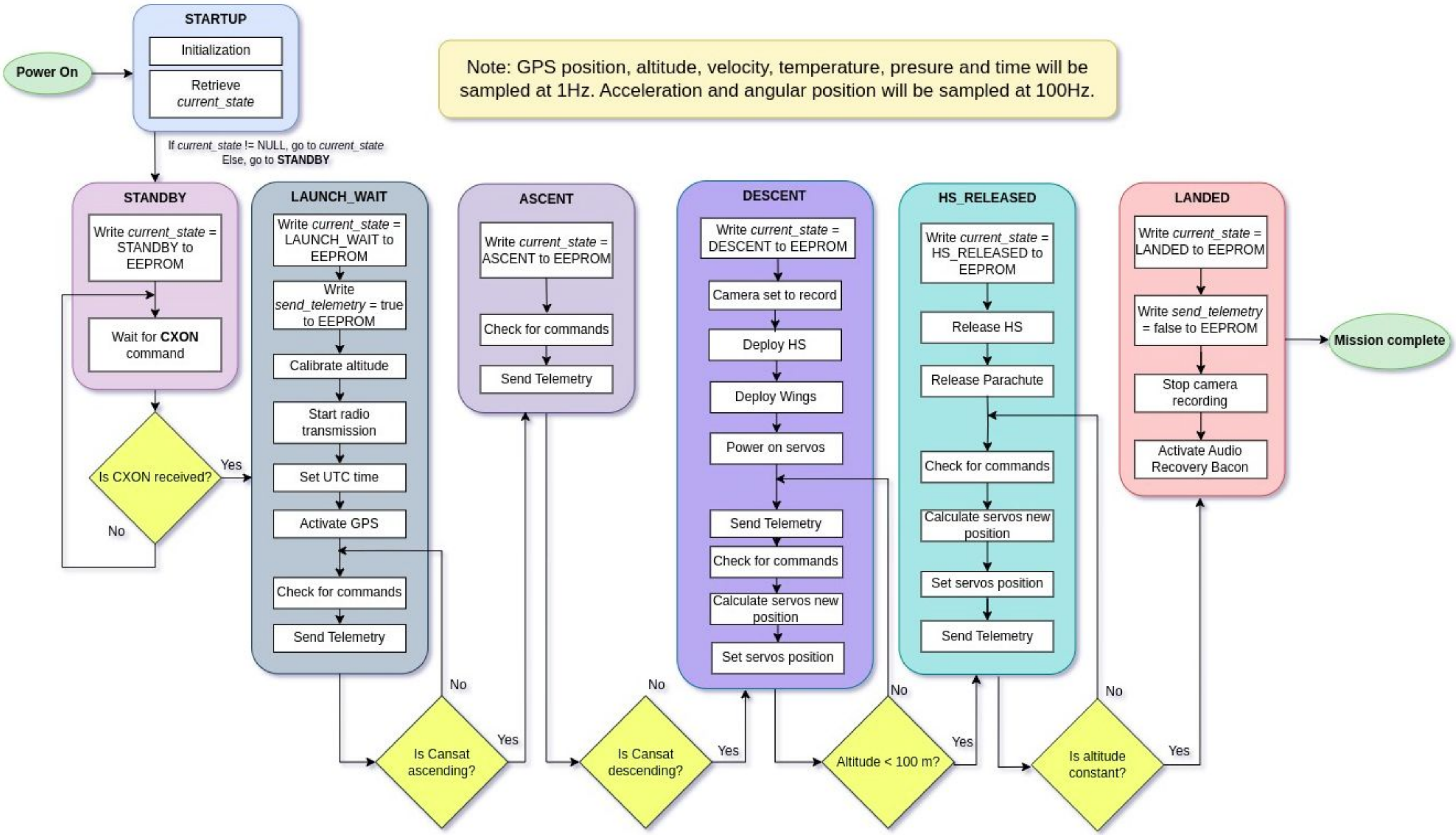
- **FSW Tasks**
  - Transmit sensor measurements once per second to the Ground Station
  - Send, receive and process commands via XBEE radios
  - Keep track of mission state (based on altitude data) in case the processor resets
  - Control deployment mechanisms
  - Power up Audio Beacon for recovery after landing
  - Keep track of mission time through processor resets
  - Operate in simulated flight mode

- Programming language: **C++**
- Development environment: **VSCode, with PlatformIO**

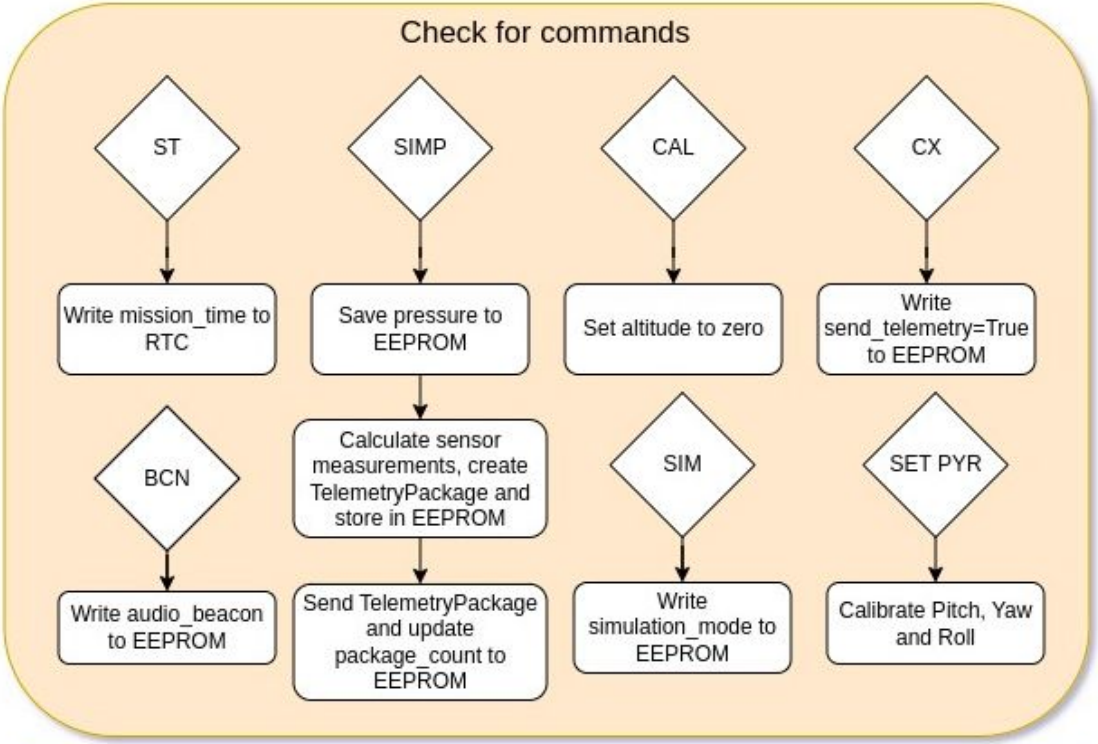
FSW Changes Since PDR

- We changed the setup of the Development Environment. Instead of using only VSCode we are now using **VSCode + PlatformIO**
- We decided to merge the states **LAUNCH_WAIT** and **PREDEPLOY** into **LAUNCH_WAIT**

Payload CanSat FSW State Diagram (1/3)

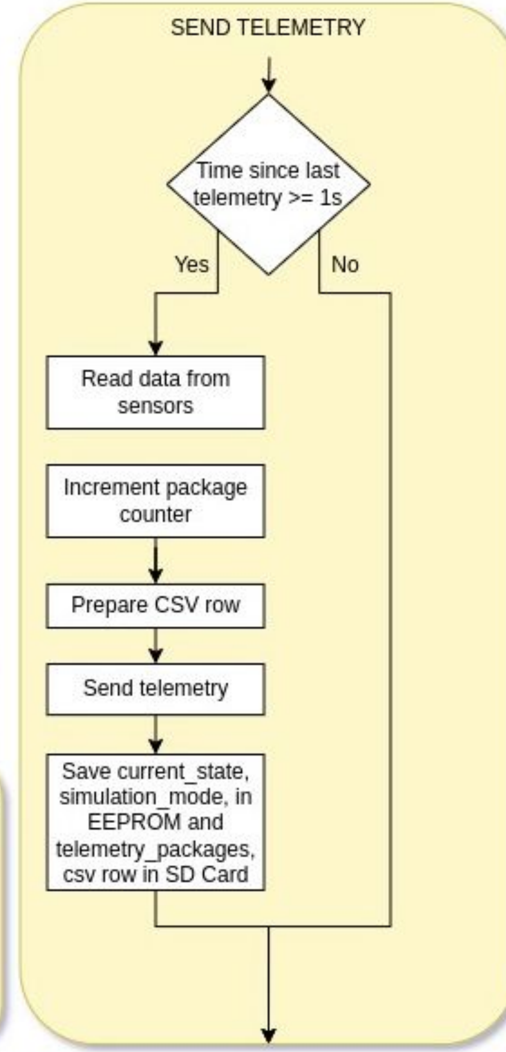


Payload CanSat FSW State Diagram (2/3)



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

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



Payload CanSat FSW State Diagram (3/3)

- **FSW recovery to correct state after processor reset during flight**

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

We will also store in SD card the content of each **Telemetry Package** in case it needs to be sent again

Simulation Mode Software (1/2)

- **Simulation Mode**

The Ground Station reads simulated barometric pressure values 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).

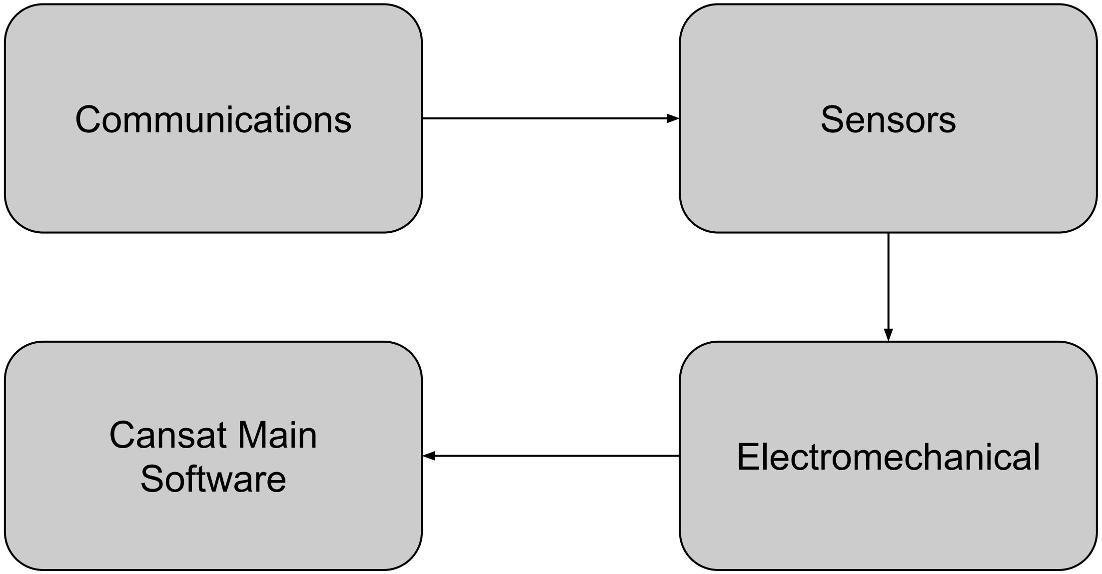
Software Development Plan (1/4)

- **Prototyping and prototyping environments**
  - All sensors are tested individually as development progresses.
  - Breadboards are used to create a prototype circuit. Data obtained is monitored and evaluated.

- **Test methodology**
  - Pre-existing libraries are used for unit testing of individual components, as well as integrated tests.

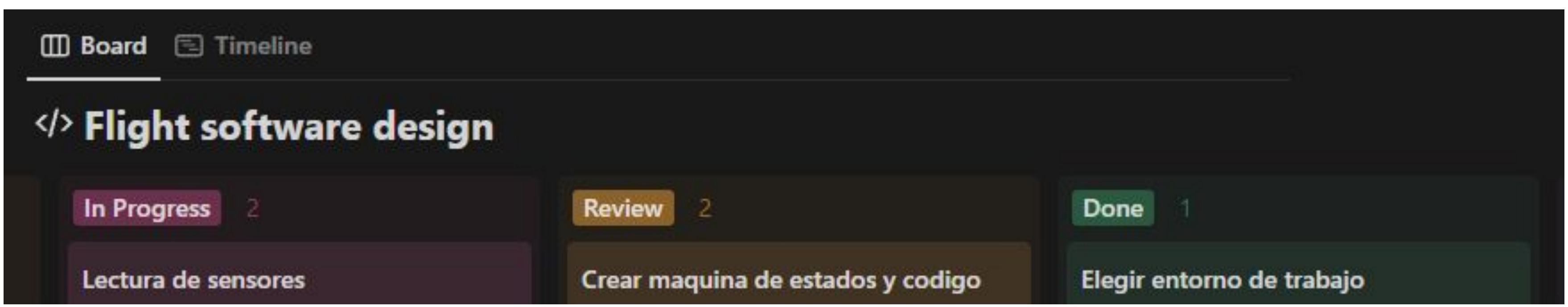
- **Software subsystem development sequence**

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



Software Development Plan (3/4)

- **Development team**
  - Nicolas Professi
  - Micaela Perillo
  - Matias Bergerman
- **Plans to reduce the risk of late software development**
  - Agile methodologies to develop and test software
  - Weekly meetings to track progress and possible problems
  - Use of Github and Notion to organize, collaborate and set tasks

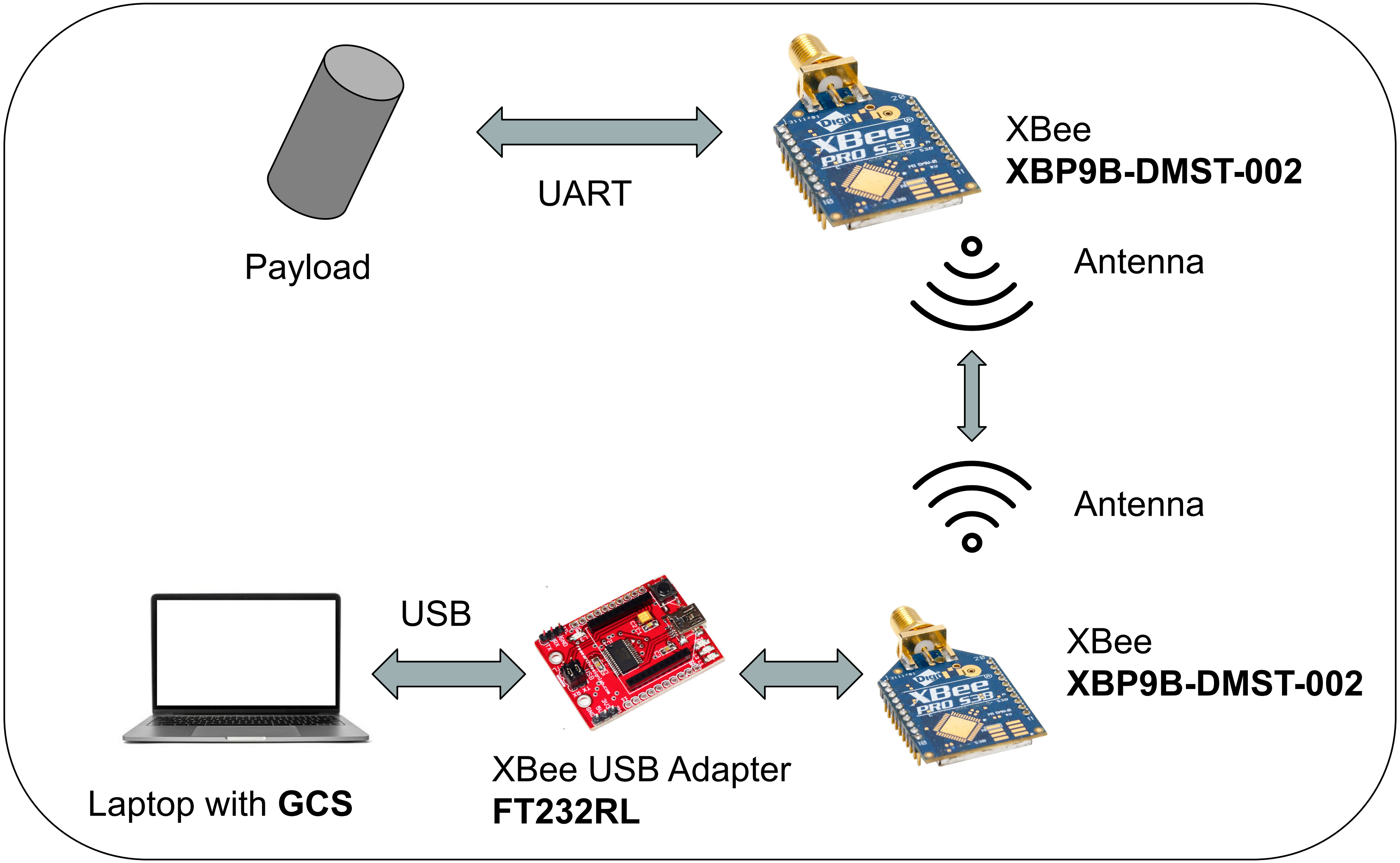


Software Development Plan (4/4)

- **Progress since PDR**
  - Tested sensors individually
  - Developed and tested Sensors module
  - Developed Cansat Main Software
  - Currently working on the Electromechanical and Communications module

Ground Control System (GCS) Design

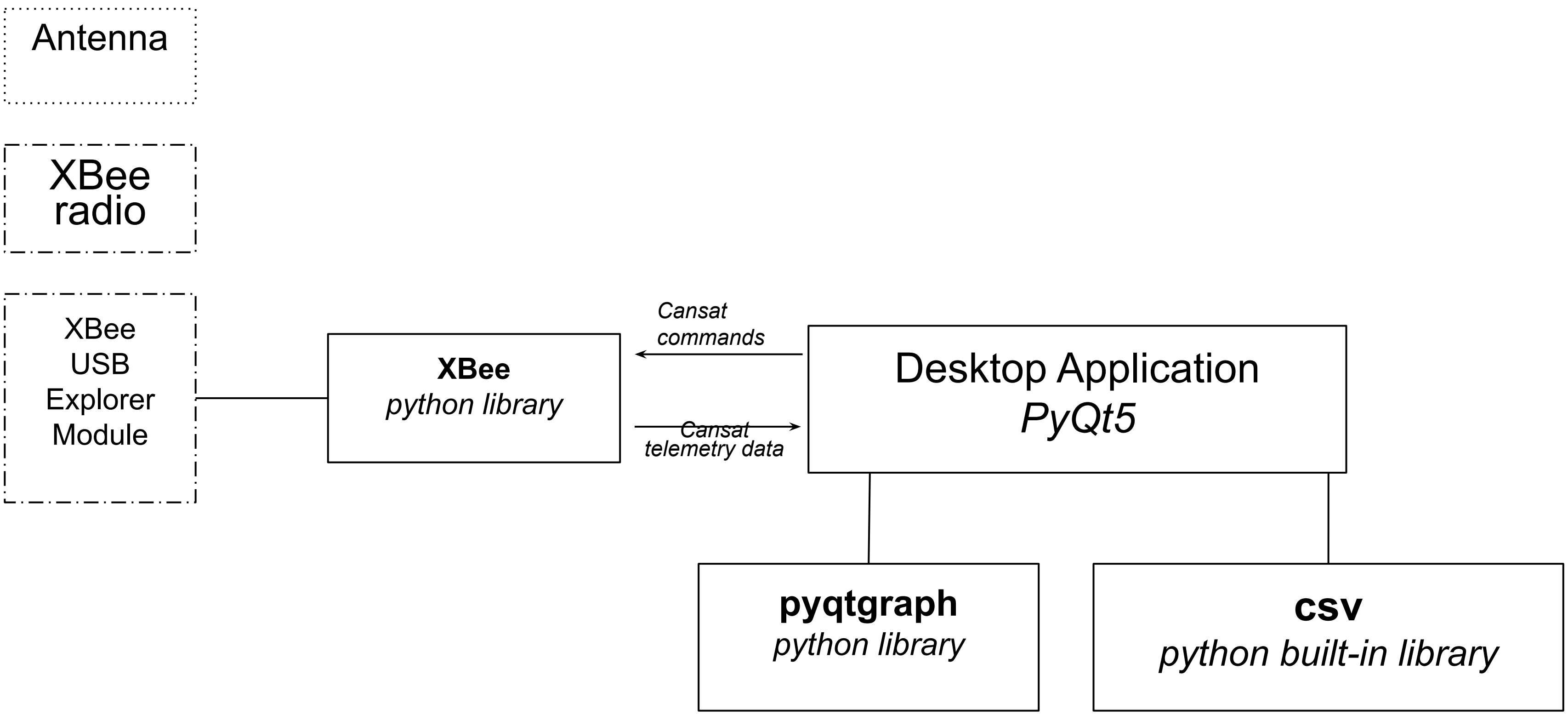
Micaela Perillo


Payload
UART
XBee
XBP9B-DMST-002
Antenna
Antenna
USB
XBee
XBP9B-DMST-002
Laptop with GCS
XBee USB Adapter
FT232RL

GCS Changes Since PDR

- Changed GCS radio module from Xbee XBP24CASIT-001 to Xbee XBP9B-DMST-002
- Antenna mounting mesign changed from handheld to table-top mounting
- Chosen antenna changed from Tp-link Tl-ANT2408CL to HP-915JW-3800N

- **Ground station diagram**



GCS Design (2/2)

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 to prevent overheating.
- The air vents will be cleaned and diagnostic software will be used to make sure laptop's fans are running properly previous to mission.

Auto update mitigation

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

Name	Range [m]	Radiation Pattern	Dimensions [mm]	Gain [dBi]	Weight [gr]	Polarization	Connector type	Price ($)
HP-915-JW-3800N	10000 Estimated	(2)	80x13x13	2	10	Linear	RPSMA	6.67

Antenna used for Ground Station to Cansat link

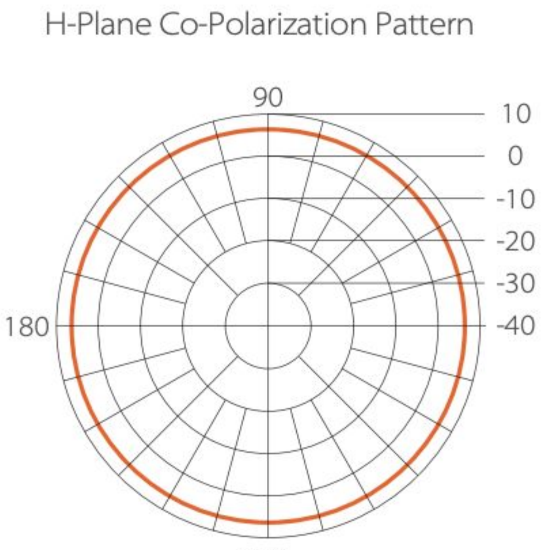
Pros:

- Portable, will be easy to carry when travelling.
- Connector type allows us to aim the antenna correctly.
- Easily replaceable in case of any damage or malfunctions.

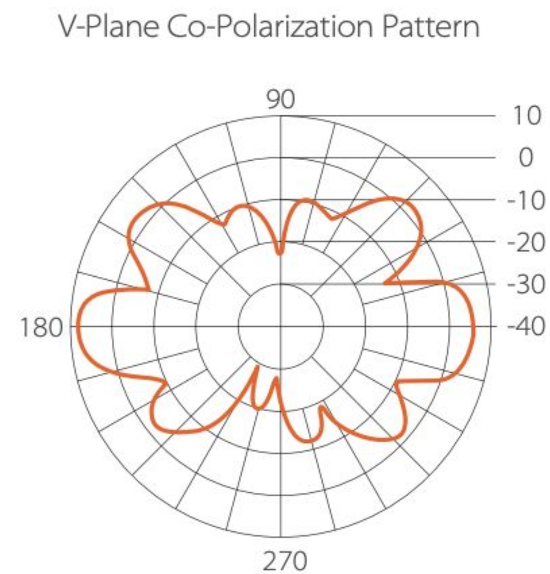
Mounting:

- Antenna will have to be aimed in the horizontal axis.
- The connector type and size of the radio device (XBee + Antenna) do not require the antenna to be hand held.
- The antenna will be placed on a table connected to the XBee and aimed towards the horizon.

GCS Antenna (2/3)



(1)



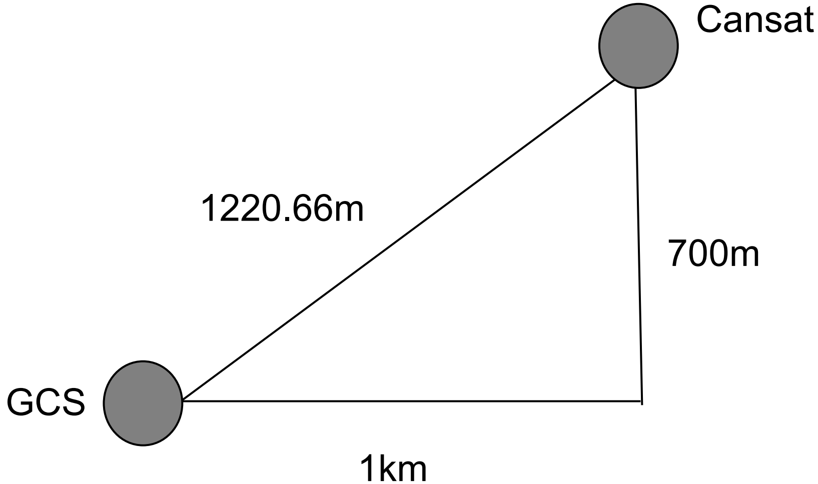
(2)

- Long antenna allows for extended range if radio supports it
- The patterns shown here can be interpreted as the 2D projection of the whole radiation pattern across all panes.
- Tp-link TI-ANT2408CL radiation pattern is omnidirectional.

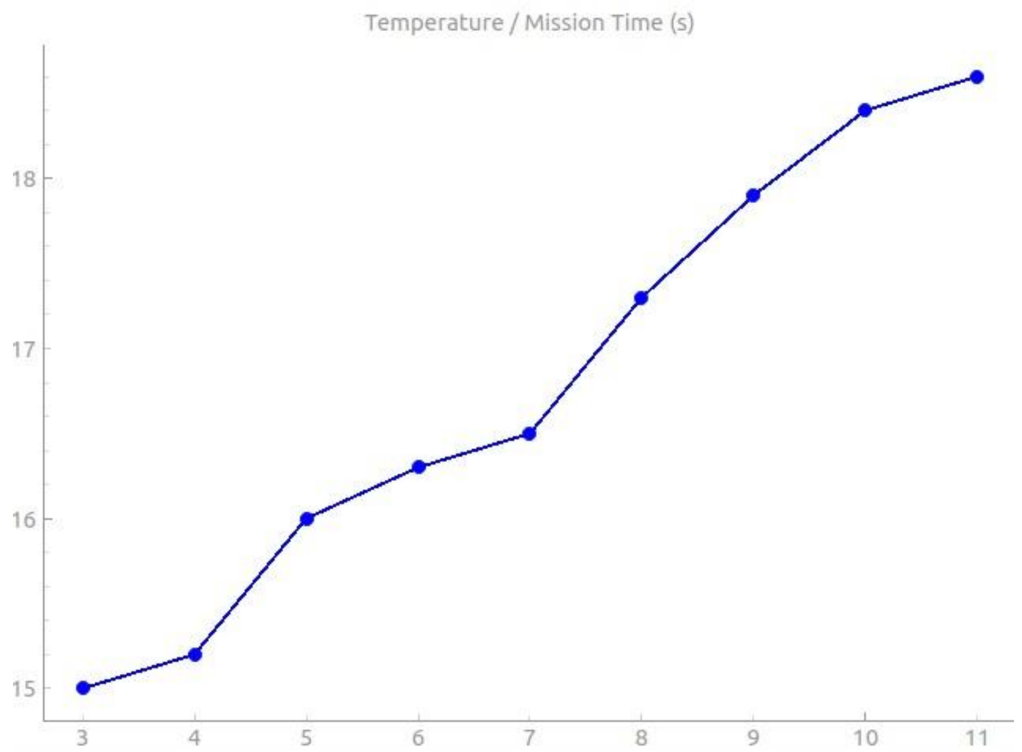
Distance link prediction

- Allows for directional adjustment
- Accessible and widely available.
- Familiarity

Assuming that the CanSat has a maximum horizontal displacement of 1km at the highest point of its trajectory the distance between the CGS to the Cansat results in a total of 1220.66 m. Thus, the selected antenna meets the distance requirements.



- **Telemetry display screen shots**
  - Telemetry will be plotted using PyQTGraph
  - The graph will expands as more data is received

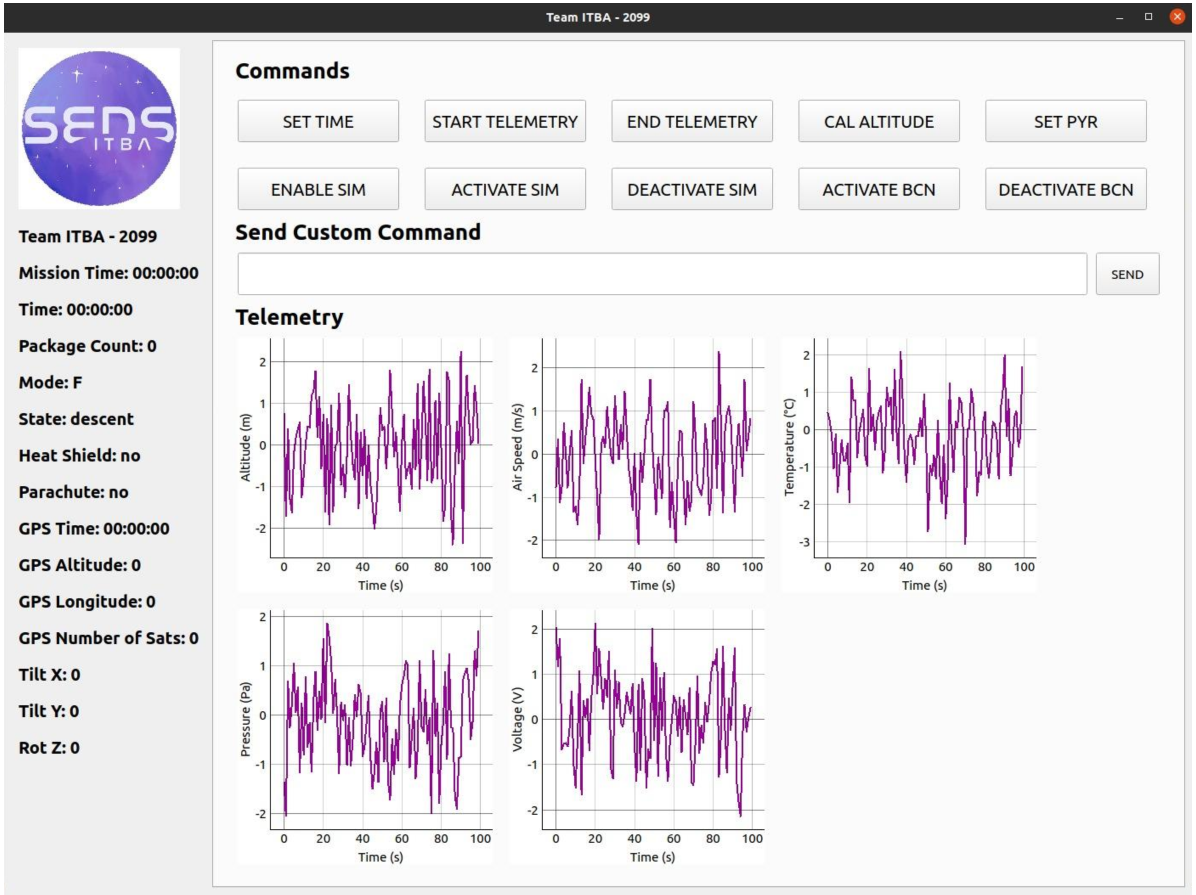


- **Commercial off the shelf (COTS) software packages used**

- **Python3 Desktop Application**
  - Allows for efficient, cross-platform development, and it takes advantage of the team's familiarity with the language.
- **Python libraries used**
  - PyQt5
  - CSV: built-in module for file reading and writing
  - XBee: Python library for communication with the antenna

GCS Software (3/7)

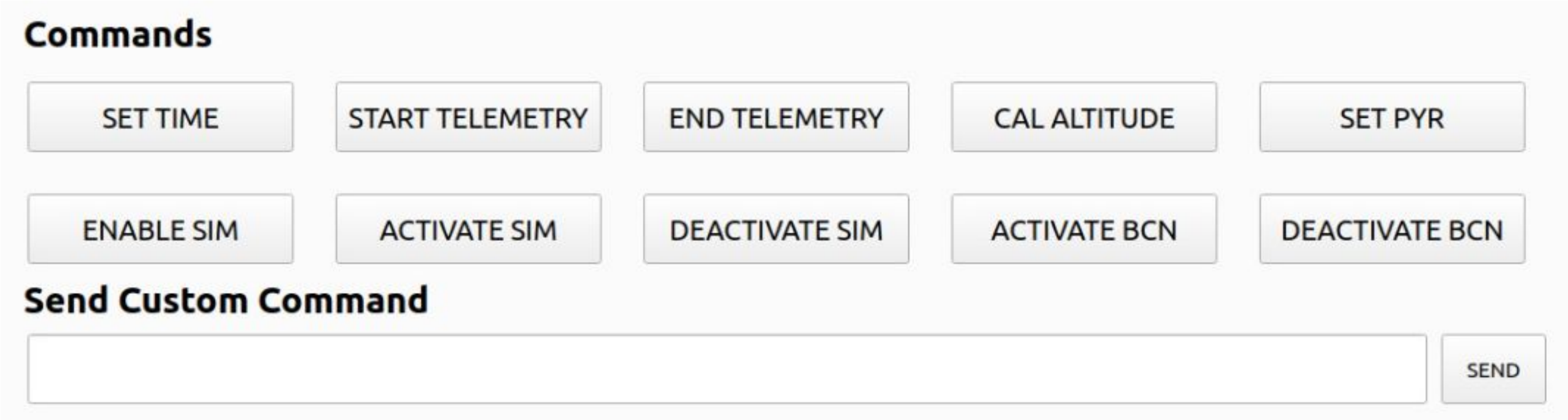
- **Real-time plotting and command software**



This is our GCS, developed in PyQt5

- **Commanding**

The operator can send commands to the Cansat by using the buttons or the command line in the UI



- **Simulation mode**
  - The user can command the software to send **ACTIVATE, ENABLE** and **DISABLE** commands to the Cansat to set the simulation state using the buttons of the GCS.
  - 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 to the Cansat with the **SIMP** command.
  - The python built-in library *csv* will be used to read the csv file.

GCS Software (6/7)

- **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

```python
import csv

header = ['TEAM_ID', 'MISSION_TIME', ..., 'CMD_ECHO']
csv_file_path = 'Flight_2099.csv'
with open(csv_file_path, 'w', newline='') as csv_file: # Creates new CSV file
    writer = csv.writer(csv_file)

telemetry = ['2099', '00:01:30', ..., "CXON"]
with open(csv_file_path, 'w', newline='') as csv_file:
    writer = csv.writer(csv_file)
    writer.writerow(telemetry) # Saves telemetry data to the csv file

print(f'Telemetry data saved to {csv_file_path}')
```

- The files can be transferred to an USB/uploaded if necessary

GCS Software (7/7)

- **Progress since PDR**
  - Fully implemented the User Interface
  - Tested the UI with mock data
  - Now working to integrate the Communications

CanSat Integration and Test

Nicolás Beade

Subsystem level test plans

Sensor
- Individual test of each sensor (Hardware & Software)
- Integrated sensor subsystem test

CDH
- Individual test of each component (Hardware & Software)
- Integrated CDH subsystem test
- Cansat reset test

Mechanical
- Structural integrity test
- Mass budget test

EPS
- Measurement of real energy consumption
- Measurement of batteries real capacity
- Integrated EP subsystem test

Radio Communications
- Individual test of each receiver/emitter (Hardware & Software)
- Range test (Antenna + XBee)

FSW
- Ensure data saving
- Verification of subsystems
- Verification of all software states
- Testing of simulation mode

Descent Control
- Opening forces of the HS and wings test
- Integrated Descent Control subsystem test
- Rotation stability test

CanSat Integration and Test Overview (2/2)

Integrated Level Functional Test Plans

- Descent test
- Communications test
- Mechanisms test
- Deployment test

Environmental Test Plans

- Drop test
- Thermal test
- Vibration test
- Fit check
- Vacuum test

Simulation Test Plans

- Simulation mode sensors test
- Simulation mode communications test
- Simulation mode software test

Subsystem Level Testing Plan (1/2)

Sensors

- Testing environments will we developed in order to simulate real scenarios and check each sensor functionality
- All sensor will be connected to an ESP32 development board via a connection PCB to check connections and simultaneous functionality
- Readings will be checked with standards for further calibration

CDH

- ESP32 - XBee communication will we tested individually for every XBee module used, in order to check connections and adapter module functionality
- Altitude will be simulated, in the middle of the test cansat will be power off for a second and then powered on again

Mechanical

- Mass Budget Test
- Cansat Structural integrity, verify the Subsystems resist the forces required
- Verify the spring-resistance mechanism reliability
- Verify all subsystem functions separately: Movement of the wings, Egg Containment function, HS deployment, HS release & Parachute deployment,

Descent control

- The electric part of the descent control subsystem will be tested before integration with the Cansat
- The opening forces of the HS and wings to overcome air resistance will be verified.
- The capability of the payload to stabilize itself and the camera will be tested by inducing external rotation.

Subsystem Level Testing Plan (2/2)

EPS
- The real energy consumption of the Cansat will be measured with a multimeter in different controlled environments
- Batteries' real capacity will be tested in different controlled environments with a battery capacity indicator
- The system will be tested when already integrated in the Cansat by checking Cansat's battery life
- Max current drain will be tested in a simulated flight
- Max temperature of component´s package will be measure

Radio Communications
- XBee will we connected to ESP32. The other XBee will be connected to a PC using an usb Xbee adapter. Telemetry will be send to ensure correct functionality.
- Cansat-GS communication will be tested in an open field in a 2 Km range

FSW
- Ensure saving data in case of processor reset
- Verification of subsystems such as release mechanisms and communications
- Verification of all software states
- Testing of simulation mode

Integrated Level Functional Test Plan (1/2)

Payload Release:

Descent

- An equivalent container will be dropped from a drone to verify descent velocity with the HS and then with the parachute separately.

Mechanisms

- Simultaneous communication and servo / wire with Resistance activation will be tested to ensure sufficient power.
- Opening of all mechanism will be checked

Deployment

- HS & parachute & Fins deployment will be tested using simulation mode with the Cansat stationary.
- HS & parachute & Fins deployment will be tested using simulation mode in conjunction with a descent test.

Integrated Level Functional Test Plan (2/2)

Communications test plan:

Ground station software

- CSV and real time data will be tested using an Xbee connected to the computer.
- To find bugs, each button will be pressed multiple times.

Telemetry

- Telemetry format will be checked
- 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 2km 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 (1/2)

Drop Test:
- 61 cm 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:
- 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.

Vibration Test:
- A orbital sander provided by the university is used to simulate vibration on the CanSat for 5s four 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.

Vacuum Test:
- The CanSat is placed in the university's vacuum chamber.
- Once a vacuum starts forming, the pressure sensor is used to measure the simulated altitude.
- When pak altitude is reached the hose will be removed and the air will be let back in slowly.

Fit Check:
- The CanSat is inserted in the open section of the payload (it will be made of a correctly sized tube) to make sure all components fit inside the way they are supposed to.

Simulation Test:
- Cansat will be mounted and connected. GCS sends these commands:
CMD,2099,SIM,ENABLE   CMD,2099,SIMP,101325 CMD,2099,SIM,ACTIVATE
Cansat telemetry will be check and after two hours, the command:
CMD,2099,SIM,DISABLE will be sent.

Test Procedures Descriptions (1/6)

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
1	Drop Test: The CanSat is attached at 3m height, raised 61cm and dropped. A mattress is placed under the CanSat in case of structural damage on the joints.	S7 S11 M3 M8	The CanSat and the parachute are expected to have the lowest damage.	Not yet tested
2	Verify that the mass is 900 g ± 10 g weighing it on a scale.	S1	The weight should be within margin	Not yet tested
3	HS, Fins and parachute deployment will be tested using simulation mode with a stationary container	C3 C5 M5	All subsystems must deploy correctly	Not yet tested
4	A container equivalent will be dropped from a drone to verify descent velocity with only the HS and then only the parachute. Both will have the fins and pitot tube	C10 C11 M6 M7 SN1 SN7	The velocity and rotation should be within margin	Not yet tested

Test Procedures Descriptions (2/6)

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
5	An electric oven (thermal chamber) with the CanSat inside will be heated up to around 60 degrees Celsius to test if temperature affects the proper working of the CanSat	M3	All systems should work correctly and structural integrity not be compromised	Not yet tested
6	A orbital sander provided by the university is used to simulate vibration on the CanSat	S6 S11 M3 M8	All systems should work correctly and structural integrity not be compromised	Not yet tested
7	The CanSat will be placed in a vacuum chamber	C3 C5 M3 M5 M7	All deployment should work	Not yet tested
8	The CanSat will be placed inside a correctly sized tube to make sure all components fit inside the way they are supposed to	S3 S4 S5 S9	The CanSat should pass fit through the tube without difficulties	✓

Test Procedures Descriptions (3/6)

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
9	The payload will be attached by a thread on a moving car with velocity 15m/s in order to test stabilization and camera orientation control.	SN1 SN7	The camera should face to a specific direction within +/. 20 degrees for the duration of the test. Velocity Sensors should measure correct speed	Not yet tested
10	Storing data to the EEPROM and recovering it in case of a processor reset	F1 F2	Data should persist correctly	Not yet tested
11	The FSW Communication Module is used in conjunction with an XBee connected to the ESP32	X1	The ESP32 must send and receive packages	Not yet tested

Test Procedures Descriptions (4/6)

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
12	The GCS Software sends commands to enable simulation, reads simulation values from a CSV file and sends them to an ESP32 running the FSW.	G11 G12	The FSW should react to the pressure values, sending adequate telemetry and activating the servo mechanisms at the right moment	Not yet tested
13	A CSV file is read using the csv Python library running on an PyQt5 app	G12 F4	The file should be read and transmitted with the correct data	✓
14	A CSV file is written using the csv Python library running on an PyQt5 app	G2	The software should be able to send and receive packets and parse their content.	✓
15	The GCS Software Communication Module is used running an PyQt5 app	G10	The battery chosen should be able to last at least 2 hours working with all components connected	✓

Test Procedures Descriptions (5/6)

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
16	Simulating landing state, we will check cansat telemetry state and the activation of the audio beacon. The audio bacon range will be tested in an open field	C5, C6	The FSW should stop transmitting data. Cansat audio bacon must be audible from 20 meters	Not yet tested
17	Cansat power on test: We will connect the batteries to the cansat using a 0.1ohm ressitor in series to retrieve current drain at 10Hz.Then,we will turn it on using the mechanical switch. After two hours, we will disconnect the battery and check the remain capacity.	E3,E4,E5,ES1,ES2	Current cannot exceed 8A in any moment, and cannot exceed 2.75A for more than 10 seconds. Battery remain capacity must be 60% at least. Switch should be easily accessible.	Not yet tested
18	Xbee transmittion test: Cansat and Ground Station will be set in an open field 2km away. XCON command is sent. Then we will check the data received in the GCS	X2, X4,X5, G2, G3	GCS should not miss any packet. Telemetry time between packets must be 1s +- 50ms. We will check NETID seted to the team number and the telemetry format.	Not yet tested

Test Proc	Test Description	Rqmts	Pass Fail Criteria	
19	Pitot tube test: In a non windy day, pitot tube connected to an ESP32 will be set in the window of a car. We will retrieve data at 10 Hz writing down the car velocity.	SN1	Pitot shall measure the velocity with a precision of 10%	Not yet tested
20	Sensors test: All sensors will be conected to a ESP32. Temperature sensor will be tested with a termomether and a hair dryer. Altitude sensor will be tested going up a floor and writing down the altitude difference. For the gyroscope sensor, we will test each axis witha protractor. For the voltage sensor, we will be check its data with a multimeter.	SN2,SN3,SN4,SN5,SN6	After selling time temperature sensor shall measure the same temperature as the termomether with a precision of 2 °C. Altitude sensor shall measure 2.7 meters of diference between floors +-0.5m. For the other sensors, 5% of precision is accepted.	Not yet tested
21	Calibration test: Command CAL_PITCHROLL is sent while cansat sats on a flat table. Then CAL command sis sent.	X2, X4,X5	GCS should recive altitude, pith,roll and yaw =0	Not yet tested

Test Procedures Descriptions (6/6)

Note
- All Requirements that aren't mentioned in the previous slices, don't need a test. They either don't correspond to our design (M10) or they were thought in the design (S2)

Simulation Test Plan

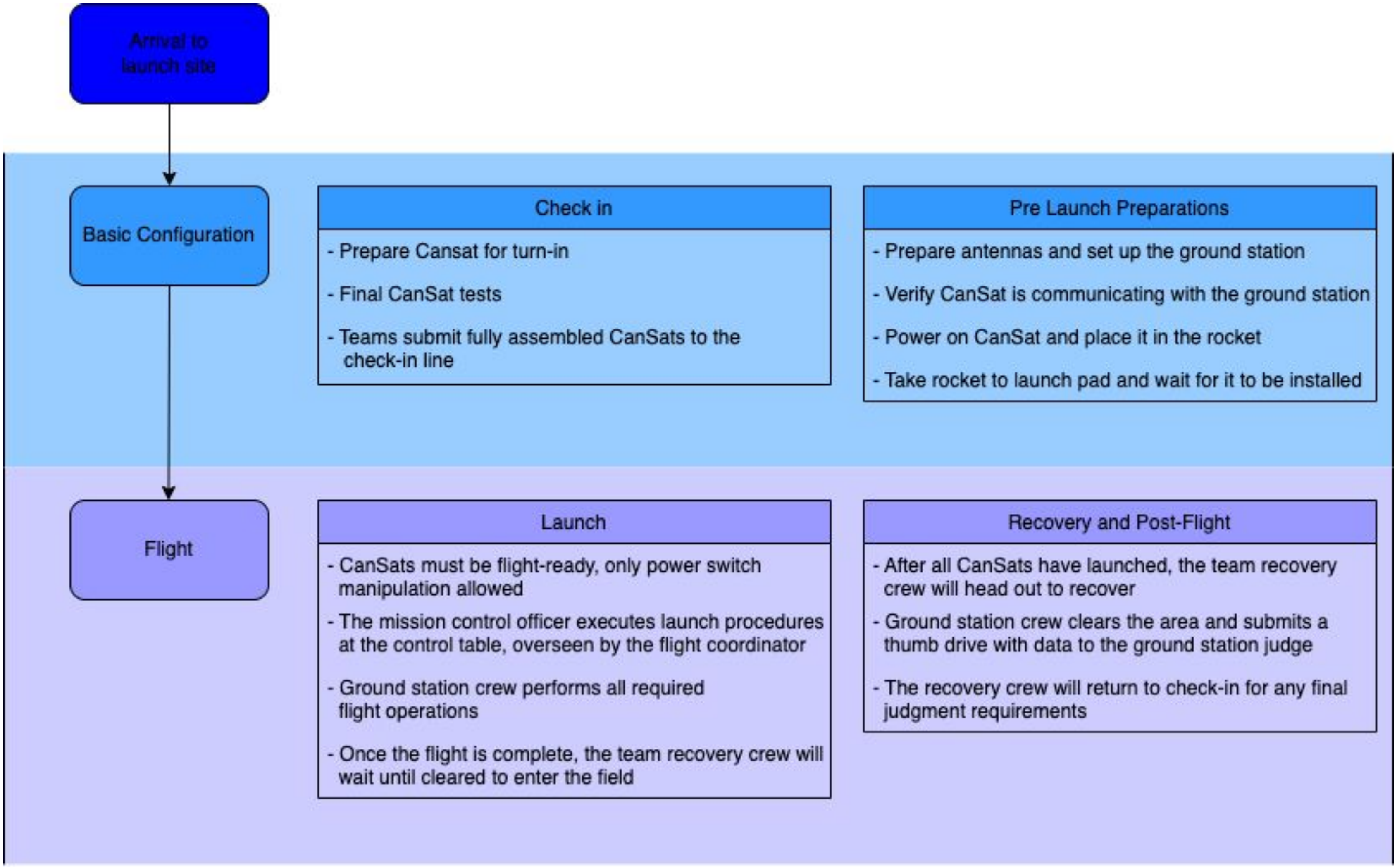
What parts of the CanSat get tested during simulation?
- During the simulation, every sensor except for the barometer is tested, the communication between ground and Cansat are also tested, and the behaviour of all software components is tested as well.

How is the simulation implemented?
- Once in simulation mode, the Cansat software will act exactly as in normal mode, except that the readings from the barometer will not be taken and, instead, the air pressure values will be processed once they are received as communication from the ground.

Mission Operations & Analysis

Victoria Klang

Overview of Mission Sequence of Events (1/2)



Overview of Mission Sequence of Events (2/2)

Position	Tasks	Members
Mission Control Officer	• Manages the Team Launch • Verifies that everything is ready with The Ground Station Crew • Executes the launch procedure with flight coordinator oversight	• Victoria Klang
Ground Station Crew	• Monitor the ground station for telemetry reception • Issue commands to the CanSat. • Performs all required flight operations	• Micaela Perillo • Facundo Di Toro • Nicolas Beade • Matias Bergerman
Recovery Crew	• Track and recover the CanSat • Interact with field judges • Make sure all field scores are filled in	• Franco Iotti • Nicolas Professi
CanSat Crew	• Prepare the CanSat and integrate it into the rocket • Verifying status before launching	• Nicolas Antonio Martone • Ezequiel Bolzicco • Dante D’Agostin

Field Safety Rules Compliance

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

- GCS Configuration
- CanSat Preparation
- CanSat Integration
- Launch Preparation
- Launch Procedure
- Removal Procedure

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

CanSat Recovery

- GPS location will be used to assist CanSat recovery
- Cansat will be colored bright pink for easy identification
- Payload will be colored bright orange for easy identification
- Cansat will have a loud audio beacon
- Cansat will have contact and return information printed on the exterior

Activities rehearsed as of march 29

- **Ground system radio link check procedures:**
  - Two Xbees were used for a short range transmission test
- **Testing sensors**
  - We have manufactured a PCB for testing all sensors.
- **Launch configuration preparations (e.g., final assembly and stowing appendages)**
  - We have tested the stowage configuration of the HS
  - Final assembly is yet to be done
- **Loading the CanSat in the launch vehicle**
  - We have not done any loading rehearsal yet
- **Telemetry processing, archiving, and analysis**
  - Data was received and saved to CSV using the GCS, verifying its integrity.
  - CSV files were plotted correctly using the GCS.
- **Recovery**
  - We have tested the buzzer.
  - We have yet to test the GPS positioning.
- **Descent**
  - We rehearsed the parachute for the desired descent rate.

Requirements Compliance

Dante F. D'Agostin

Requirements Compliance Overview

The design complies with most requirements according to the 2024 CanSat Mission Guide. The majority of the present design meets the standards, as those requirements that do not are still to be empirically tested.

A table showing the requirement states is shown on the slides below with each requirement taken from the Competition Guide is labelled according to 3 categories:

Comply	**Partial**	**Insufficient**

Requirements Compliance (1/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
1	The Cansat mass shall be 900 grams +/- 10 grams without the egg being installed.	Comply	Mass Budget	
2	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	Structure Survivability	
3	The Cansat shall perform the function of the nose cone during rocket ascent.	Comply	Mechanical Subsystem Overview	
4	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial		Test required
5	The Cansat shall deploy a heat shield after deploying from the rocket.	Comply	Payload Aerobraking Deployment	
6	At 100 meters, the Cansat shall deploy a parachute and release the heat shield.	Comply	Payload Parachute Descent Control Hardware Summary Payload Aerobraking Deployment	

Requirements Compliance (2/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
7	The Cansat shall carry a provided large hens egg with a mass range of 51 to 65 grams	Comply	Payload Egg Containment	
8	During descent with the heat shield deployed, the descent rate shall be between 10 to 30 m/s.	Comply	Descent Rate Estimate	
9	At 100 meters, the Cansat shall have a descent rate of less than 5 m/s.	Comply	Descent Rate Estimate	
10	Cansat shall survive 30 G shock.	Partial		Test required
11	Cansat structure must survive 15 Gs vibration	Partial		Test required
12	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	Payload Power Source	

Requirements Compliance (3/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
13	Easily accessible power switch is required	Comply	Cansat Physical Layout	
14	Power indicator is required for each voltage domain	Comply	Payload Electrical Block Diagram	
15	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	Payload Power Budget	
16	XBEE radios shall not use broadcast mode.	Comply	Payload Radio Configuration	
17	XBEE radios shall have their NETID/PANID set to their team number.	Comply	Payload Radio Configuration	
18	The Cansat shall transmit telemetry once per second.	Comply	Payload FSW State Diagram	

Requirements Compliance (4/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comment
19	The Cansat telemetry shall include altitude, air pressure, temperature, battery voltage, Cansat tilt angles, air speed, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Comply	Payload Telemetry Format	
20	The Cansat shall function as a nose cone during the rocket ascent portion of the flight	Comply	Mechanical Subsystem Overview	
21	The Cansat shall be deployed from the rocket when the rocket motor ejection charge fires.	Comply	Payload Aerobraking Pre Deployment	
22	After deployment from the rocket, the Cansat shall deploy its heat shield/aerobraking mechanism.	Comply	Payload Aerobraking Deployment	
23	A silver or gold mylar streamer of 50 mm width and 1.5 meters length shall be connected to the Cansat and released at deployment.	Comply	Mechanical Subsystem Overview	
24	Upon landing, the Cansat shall stop transmitting data.	Comply	Payload FSW State Diagram	

Requirements Compliance (5/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
25	Upon landing, the Cansat shall activate an audio beacon.	Comply	Payload FSW State Diagram	
26	0 altitude reference shall be at the launch pad.	Comply	GCS Software	
27	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	CanSat Budget – Hardware	
28	Nose cone shall be symmetrical along the thrust axis.	Comply	Physical Layout	
29	Nose cone radius shall be exactly 71 mm	Comply	Launch Vehicle Compatibility	
30	Nose cone shoulder radius shall be exactly 68 mm	Comply	Launch Vehicle Compatibility	

Requirements Compliance (6/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
31	Nose cone shoulder length shall be a minimum of 50 mm	Comply	Physical Layout	
32	The rocket airframe can be used to restrain any deployable parts of the Cansat but shall allow the Cansat to slide out of the payload section freely.	Comply	Launch Vehicle Compatibility	
33	The rocket airframe can be used as part of the Cansat operations.	Comply	Payload Aerobraking Pre Deployment	We do not use it
34	No pyrotechnical or chemical actuators are allowed.	Comply	EPS Overview	
35	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.	Partial		Ubication of nichrome wires not defined yet
36	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	Payload Power	

Requirements Compliance (7/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
37	The heat shield shall be used as an aerobrake and limit the descent rate to 10 to 30 m/s.	Comply	Descent rate estimate	
38	At 100 meters, the Cansat shall release a parachute to reduce the descent rate to less than 5 m/s.	Comply	Descent rate estimate	
39	The Cansat shall protect a hens egg from damage during all portions of the flight.	Comply	Payload Egg Containment	
40	If the nose cone is to be considered as part of the heat shield, the documentation shall identify the configuration.	Comply	Descent Control Overview	
41	After the Cansat has separated from the rocket and if the nose cone portion of the Cansat is to be separated from the rest of the Cansat, the nose cone portion shall descend at less than 10 meters/second using any type of descent control device.	Comply	Payload Aerobraking Release	
42	Lithium polymer batteries are not allowed.	Comply	Payload Power Source	

Requirements Compliance (8/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
43	The maximum current of the cansat cannot exceed the maximum discharge current of the battery.	Partial		Test required
44	The total energy required shall be less than 60% of the energy in the battery.	Partial		Test required
45	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	Payload Radio Configuration	
46	Cansat shall measure its speed with a pitot tube during ascent and descent.	Partial		Position is to be defined
47	Cansat shall measure its altitude using air pressure.	Comply	Payload Air Pressure Sensor Summary	
48	Cansat shall measure its internal temperature.	Comply	Payload Air Temperature Sensor Summary	

Requirements Compliance (9/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
49	Cansat shall measure its angle stability with the aerobraking mechanism deployed.	Comply	Rotation Sensor Summary	
50	Cansat shall measure its rotation rate during descent.	Comply	Rotation Sensor Summary	
51	Cansat shall measure its battery voltage.	Comply	Payload Voltage Sensor Summary	
52	The Cansat shall include a video camera pointing horizontally.	Comply	Mechanical Subsystem Overview	
53	The video camera shall record the flight of the Cansat from launch to landing.	Comply	Payload FSW State Diagram	
54	The video camera shall record video in color and with a minimum resolution of 640x480.	Comply	Camer Summary	

Requirements Compliance (10/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
55	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	GCS Software	
56	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	GCS Software	
57	Telemetry shall include mission time with 1 second or better resolution.	Comply	Payload FSW State Diagram	
58	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	Comply	Payload FSW State Diagram	
59	Each team shall develop their own ground station.	Comply	GCS Design	
60	All telemetry shall be displayed in real time during descent on the ground station.	Comply	GCS Software	

Requirements Compliance (11/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comm ents
61	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) and the units shall be indicated on the displays.	Comply	GCS Software	
62	Teams shall plot each telemetry data field in real time during flight.	Comply	GCS Software	
63	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and an antenna.	Comply	GCS Overview	
64	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	GCS Overview	
65	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	GCS Software	

Requirements Compliance (12/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
66	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	GCS Software	
67	The ground station shall use a table top or handheld antenna.	Comply	GCS Design	
68	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	GCS Design	
69	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	GCS Design	
70	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	GCS Design	

Requirements Compliance (13/13)

#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments
71	The Cansat shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	Comply	Payload FSW State Diagram	
72	The Cansat shall have its time set to within one second UTC time prior to launch.	Comply	Payload FSW State Diagram	
73	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 csv file.	Comply	Simulation Mode Software	
74	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	Simulation Mode Software	
75	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Comply	Simulation Mode Software	

Management

Victoria Klang

Status of Procurements (1/3)

Component	Quantity	Status	Expected Arrival
BMP280	3	Arrived (2), Pending (1)	05/17/2024
MPU6500	2	Arrived	-
XBEE S2C + Radio Antenna	1	Arrived	-
XBEE S2C PRO + Radio Antenna	2	Arrived	-
XBEE Adapter Module	4	Arrived	-
Voltage Regulator (3-5v)	9	Arrived (4), Pending (5)	05/17/2024
CR123A Battery	2	Arrived	-
Switch	1	Arrived	-
ESP32	1	Arrived	-
SQ11 Camera	3	Arrived (2), Pending (1)	05/17/2024

Status of Procurements (2/3)

Component	Quantity	Status	Expected Arrival
GPS Sensor Ublox NEO-6M + Antenna	3	Arrived (2), Pending (1)	05/17/2024
RTC (w/ Battery)	2	Arrived	-
Samsung 18650 Battery	1	Arrived	-
Sound Beacon: Buzzer	2	Arrived	-
MPXV7002 + Pitot Tube	4	Arrived	-
PCB & SMT Electronics	9	Arrived (4), Pending (5)	05/17/2024
Servo Tower Pro Mg90	2	Arrived	-
LED	1	Arrived	-
Cables + Conectors	1	Arrived	-

Status of Procurements (3/3)

Component	Quantity	Status	Expected Arrival
Nylon Ripstop 4000 cm^2	1	Arrived	-
Nylon Ripstop 9800 cm^2	1	Arrived	-
Carbon Fibre Rods	2	Arrived (1), Pending (1)	15/04/2024
Braid fishing line	2	Arrived(2)	-
PLA	4	Arrived (4)	-
ABS	4	Arrived (4)	-
Torsion Spring	4	Arrived(4)	-
Linear Spring	10	Pending (10)	17/04/2024
M4 Bolts	10	Pending (10)	05/04/2024

All pending components has been required to our main sponsor (ITBA), and since they will send us all in one shipping, the expected arrival date is the same for everyone.

CanSat Budget – Hardware (1/4)

Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual/ Free
Electronics				
BMP280	NO	1	4.9	Actual (MercadoLibre)
MPU6500	NO	1	7	Actual (MercadoLibre)
XBEE XBP9B + Radio Antenna	YES	2	150	Actual (Electrocomponentes.com)
XBEE Adapter Module	YES	1	9	Actual (MercadoLibre)
Step Down Lm2596	NO	1	2.2	Actual (MercadoLibre)
Step Down Xl4005	NO	1	3	Actual (MercadoLibre)
Switch	NO	1	1	Actual (MercadoLibre)
ESP32	NO	1	10	Actual (MercadoLibre)
SQ11 Camera	NO	2	18	Actual (MercadoLibre)

CanSat Budget – Hardware (2/4)

Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual/ Free
Electronics				
GPS Sensor Ublox NEO-6M + Antenna	YES	1	12	Actual (MercadoLibre)
RTC DS3231 (w/ Battery)	YES	1	6	Actual (MercadoLibre)
Samsung 18650 Battery	NO	2	11.18	Actual (MercadoLibre)
Sound Beacon: Buzzer	NO	1	4.54	Actual (MercadoLibre)
MPXV7002 + Pitot Tube	NO	1	45	Estimated (Ebay)
PCB & SMT Electronics	NO	1	20	Estimated
Servo Airtronics 94102	NO	2	12	Actual (MercadoLibre)
Servo Tower Pro Mg90	NO	1	4	Actual (MercadoLibre)
LED	NO	2	0.1	Actual (MercadoLibre)
Cables + Conectors	NO	1	2	Actual (MercadoLibre)
TOTAL = 513.2 USD				

CanSat Budget – Hardware(3/4)

Component/Hardware	Reuse?	Quantity	Cost per Unit (USD)	Estimated/Actual
Mechanics				
Nylon Ripstop 4000 cm^2	NO	1	6,4	Actual (MercadoLibre)
Nylon Ripstop 9800 cm^2	YES	1	0.001 per cm^2	Estimated
Carbon Fibre Rods	NO	2m	33/1m	Actual (MercadoLibre)
Braid fishing line	YES	50m	5 per 100m	Actual (MercadoLibre)
ABS	NO	1 kg	21/kg	Actual (MercadoLibre)
Torsion Spring	NO	4	1,65	Actual (Shop)
Linear Spring	NO	10	1,6	Estimated
M4 screws	NO	10	0.1	Actual (MercadoLibre)
TOTAL= 129,3 USD				

CanSat Budget – Hardware(4/4)

Subsystem	Cost (USD)
Electrical	513.2
Mechanical	129,3
TOTAL = 642.5	

CanSat Budget – Other Costs (1/3)

Travel (per person)		
	Price (USD)	Price (ARS)
Airline	1100	-
Visa	160	-
Hotel	250	-
Food	50	-
Other travel fees	50	-
TOTAL= 1610 USD per person		
TOTAL=16100 USD		

CanSat Budget – Other Costs (2/3)

Ground Control Station		
	Price (USD)	Price (ARS)
Computers	1000	-
Others	70	-
TOTAL = 1070 USD		

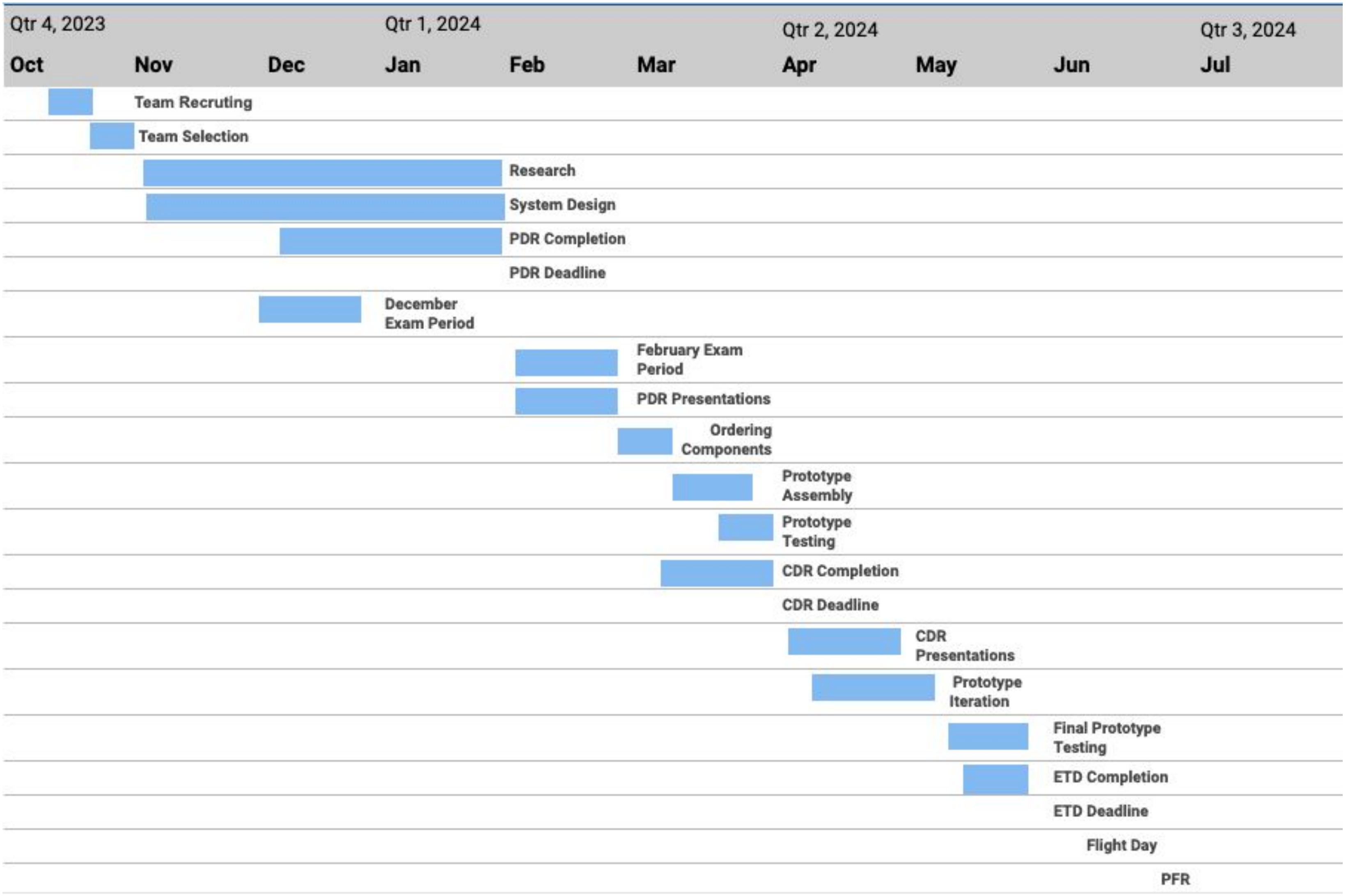
We will use a team member’s computer, so its cost is an estimate.

CanSat Budget – Other Costs (3/3)

Overall Mission Cost		
	Price (USD)	Price (ARS)
Hardware	571	-
Ground Station	1070	-
Team Travel	16100	-
Contingencies	100	-
TOTAL = 17841 USD		

- Competition inscription was paid by ***Instituto Tecnologico de Buenos Aires***.
- CanSat build cost is being financed partially by ***Instituto Tecnologico de Buenos Aires***.
- We are still in the process of looking for sponsors for the travel expenses.
- This cost is an estimate, and may fluctuate because of the considerations mentioned before.

Program Schedule Overview



Detailed Program Schedule (1/3)

1	Competition Overview				
1.1	Team Recruting	All	15/10/23	21/10/23	6
1.2	Team Selection	All	21/10/23	31/10/23	10
1.3	Research	All	01/11/23	19/11/23	18
1.4	System Design	All	20/11/23	14/01/24	54
1.5	PDR Completion	All	15/01/24	02/02/24	17
1.6	PDR Deadline	All	02/02/24	02/02/24	0
1.7	December Exam Period	All	05/12/23	23/12/23	18
1.8	February Exam Period	All	06/02/24	24/02/24	18
1.9	PDR Presentations	All	05/02/24	23/02/24	18
1.10	Ordering Components	All	05/02/24	24/02/24	19
1.11	Prototype Assembly	All	20/02/24	02/03/24	12
1.12	Prototype Testing	All	03/03/24	17/03/24	14
1.13	CDR Completion	All	07/03/24	29/03/24	22
1.14	CDR Deadline	All	29/03/24	29/03/24	0
1.15	CDR Presentations	All	08/04/24	26/04/24	18
1.16	Prototype Assembly	All	26/04/24	04/05/24	8
1.17	Prototype Iteration	All	05/05/24	12/05/24	7
1.18	Final Prototype Testing	All	13/05/24	18/05/24	5
1.19	ETD Completion	All	07/05/24	24/05/24	17
1.20	ETD Deadline	All	24/05/24	24/05/24	0
1.21	Flight day	All	08/06/24	08/06/24	0
1.22	PFR	All	09/06/24	09/06/24	0

Detailed Program Schedule (2/3)

2	**Management**				
2.1	Recruit Interested Team Members	Team Lead	15/10/23	21/10/23	6
2.2	Summarize and Analyze Mission Guide	Team Lead	16/10/23	22/10/23	6
2.3	Contact University and Sponsors for Funding	Team Lead	17/10/23	01/06/24	224
3	**Flight Software**				
3.1	Define Software Requirements for Playload, Container and Ground Station	Software and Firmware Team	30/11/23	18/12/23	18
3.2	Design Architecture for Container Software	Software and Firmware Team	19/12/23	25/12/23	6
3.4	Design Architecture for Ground Station Software	Software and Firmware Team	26/12/23	02/01/24	6
3.5	Integrate Design with Electronic Components	Software and Firmware Team	03/01/24	21/01/24	18
3.6	Create Container State Diagram	Software and Firmware Team	22/01/24	27/01/24	5
3.7	Determine Software Development Process	Software and Firmware Team	28/01/24	01/02/24	3
3.8	Develop and Test Software	Software and Firmware Team	03/02/24	01/06/24	118
4	**Container and Playload Design**				
4.1	Design and Analyze different Mechanical Layout Prototypes	Mechanical Team	19/12/23	06/01/24	17
4.2	EDT Planning and Completition	Mechanical Team	07/01/24	21/01/24	14
4.3	Define Electronics to be used based on Research	Mechanical Team	22/01/24	01/02/24	9
5	**Descent Control Design**				
5.1	System Research and Selection	Electronics and Firmware Team	03/01/24	21/01/24	18
5.2	Integrate Design with Electronic Components Definitions	Electronics and Firmware Team	22/01/24	01/02/24	9

Detailed Program Schedule (3/3)

6	**Electronic Systems**				
6.1	System Research and Selection	Electronics and Firmware Team	19/12/23	07/01/24	18
6.2	Define Electronics to be used based on Research	Electronics and Firmware Team	08/01/24	14/01/24	6
6.3	Integrate Designs with Electronic Component Definitions	Electronics and Firmware Team	15/01/24	01/02/24	16
7	**Ground Station**				
7.1	Research Antena Technology	Software and Ground Station Team	03/01/24	21/01/24	18
7.2	Design and Prototype GCS Software	Software and Ground Station Team	22/01/24	26/01/24	4
7.3	Determine or Design Antena	Software and Ground Station Team	27/01/24	01/02/24	4

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
• Computer • Batteries	• 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 (1/3)

Major accomplishments
- We have ordered and received most electronic components and mechanical materials needed.   - The sensors proposed in the PDR function as expected, and we did not need to do any major changes.   - We have tested multiple payload prototypes for component fitting and we reached a working payload design.   - We have tested the and it works as expected.   - Software was developed in a modular achieving more efficient code.   - Most software components have been tested with the hardware and work as expected.

Conclusions (2/3)

Major unfinished work
- Waiting sponsor to travel - Waiting sponsor´s components (900mhz xbee module, batteries)

Testing to complete
- Test all the subsystem level test that are left - Test all System level - Environmental Test
Flight software status
- GCS completed, now moving on to connecting it to the Cansat via the Communications module - Modules were tested individually, now we have to connect them and test them as a whole

Conclusions (3/3)

We are ready to move to the CDR phase!

All in all, the team has met most critical design requirements and is ready to proceed to the next stage of development as all major goals and milestones are complete. Team SEDS-ITBA is made up of students from multiple areas in engineering, who are ready to confront the challenge of designing and building a space-type system. Having analysed the requirements of the mission, carried out a rigorous study of different ways we can meet them and defined optimal solutions to all encountered problems, we are ready to advance to the next stage!