EPFL SPACECRAFT TEAM

Project El Tonio

Preliminary Design Review

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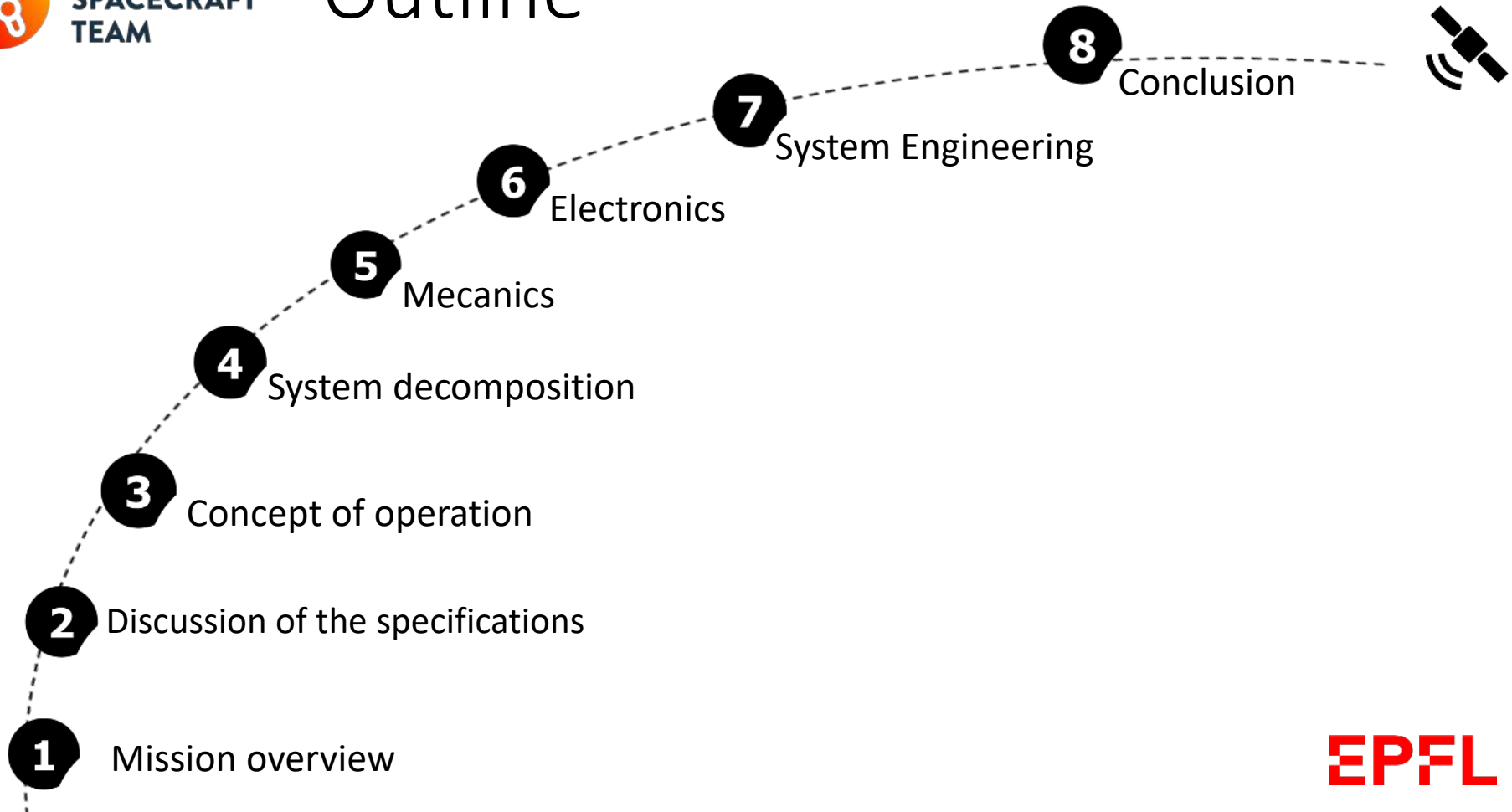
Outline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1
Mission overview

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Mission overview

The Cansat projet has different objectives:

Elaboration of an idea

Study of designs and respecting certain features

Working as a team

Learn to work with a budget

Working under time-constraints

Practical experience

It is a great opportunity to learn all the way up until the launch !

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Specifications

Interpretation and definition

General specifications

- EPFL spacecraft team's requirements

Personal specifications

- Implement a paraglider and a guidance system
- We shall film the flight of the Cansat
- Measure of multiple environmental parameters
- Battery monitoring
- Be user friendly HMI
- Easy accessbility
- Professional looking

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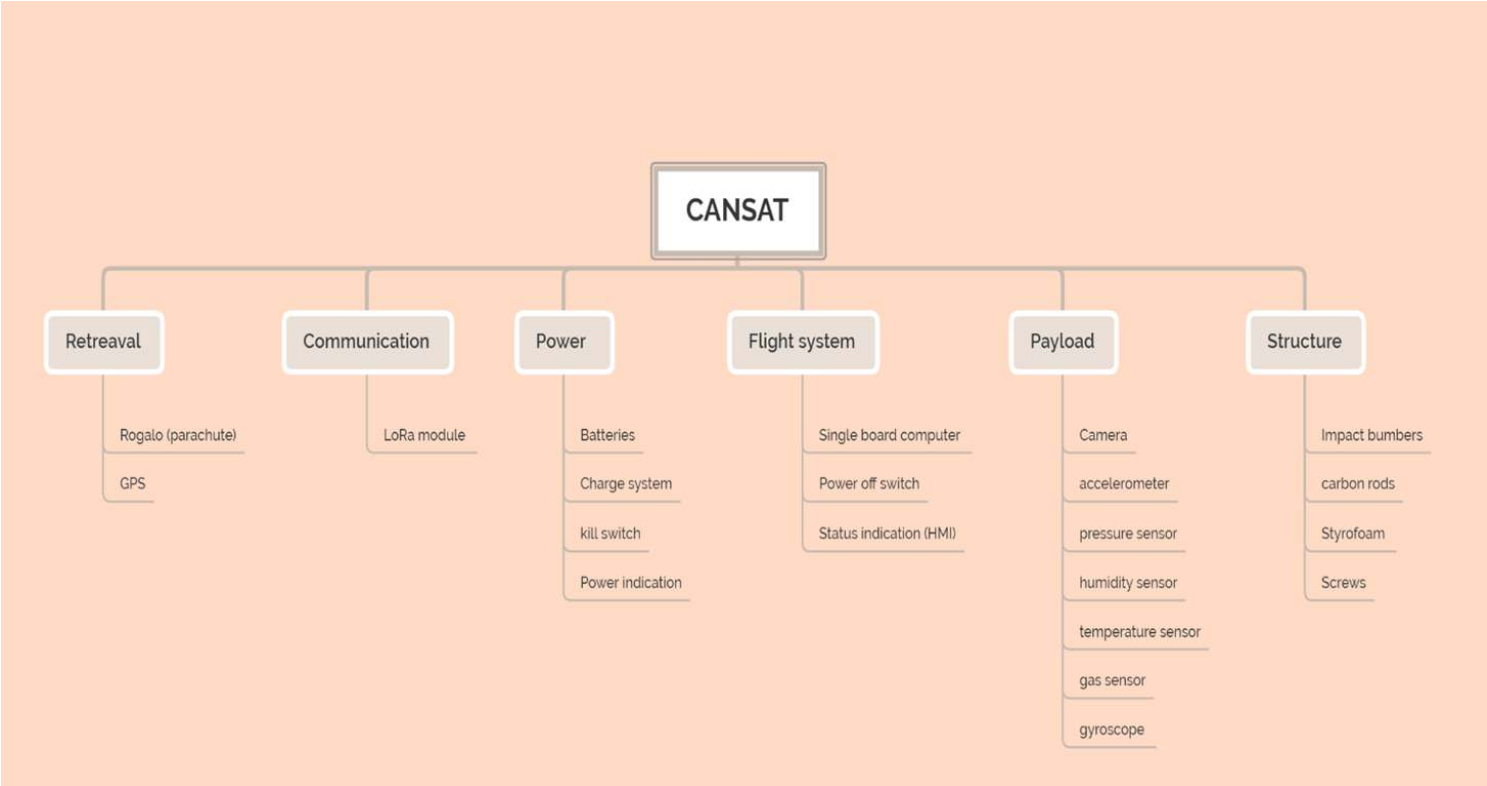
Sub-systems decomposition



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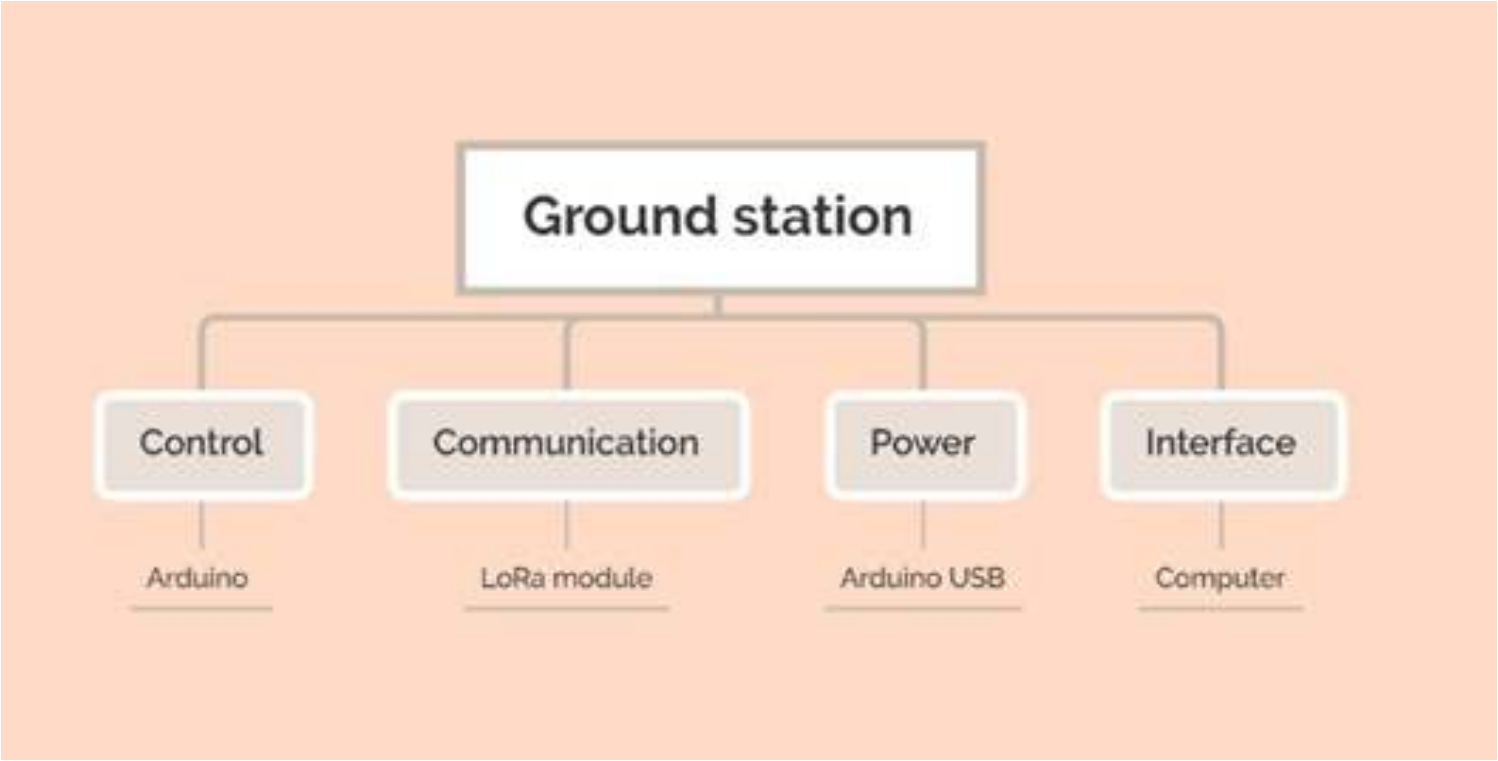
Sub-systems decomposition



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Concept of operation

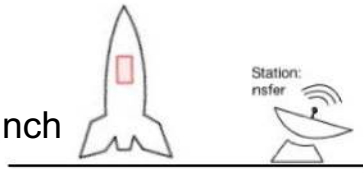
Mission overview

Step 4 : CanSat separation and stabilisation

Step 3 : Rocket separation

Step 5 : gliding in circle environmental measures

Step 2 : Rocket ascent



Step 1 : launch

Step 6 : Landing and retrieval

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Mecanics

Parachute

First idea :

- Build a paraglider and fly back to launch pad

Adaptation : Rogallo parachute

- Easy to build
- Horizontal speed component
- Takes less space
- Safe opening

A big thanks to Yoan Cangemi for providing us with the plans of the rogallo parachute

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Mecanics

Structure

Idea 1

Batteries and PCB on opposite side
- Easy connection
- Poor stability

Idea 2

PCB and OBC on opposite sides, batteries in the middle
- Better stability during flight

4 principal rods and 2 horizontal plates

- Poor shocks resistance
- Lots of screws

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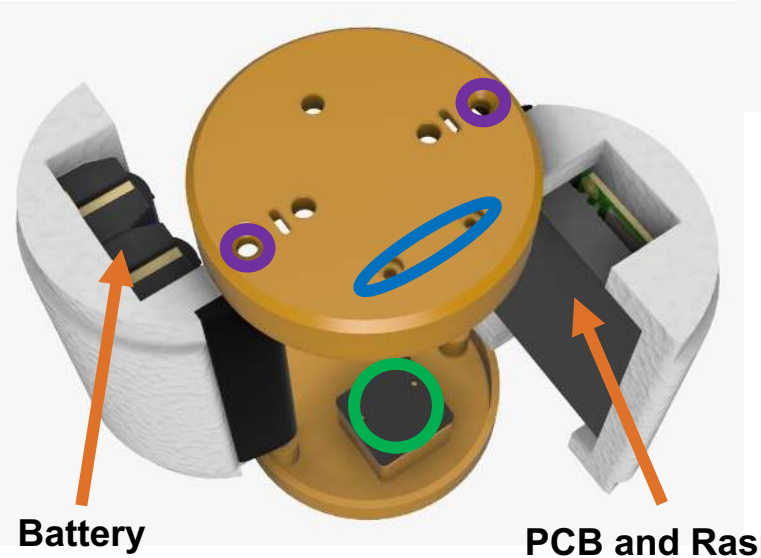
Mecanics

Structure

Final idea

External bumpers
keep the cansat closed and act as a skeleton

Butterfly-like opening
Easy and quick access to components and batteries



GPS, **camera** and **parachute** directly attached to the bumpers

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Many thanks to Stéphane Clerc & Marc Philippe Wettstein from SKIL who pointed us to the right direction

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Mecanics

Structure

Weight

Components	Weight [g]
Raspberry zero	9
PCB	20
GPS	10
Caméra	10
Batteries	48
Battery holder	30
Polystyrene structure	10
Bumper + rods	40
Parachute	40
Miscellaneous	20
Total	**333 [g]**

Materials

- Carbon rods
  → Strong and light
- TPU for the bumpers
  → Flexible and easy to manuf.
- Polystyrene (exp., extr. or EPP)
  → Light, cheap, absorbs shocks
  Original

Construction & manufact.

- Machining
- 3D printing
  → Flex and PLA
- Screws and glue for the rest

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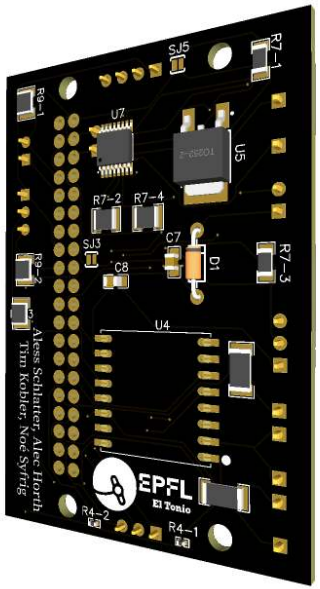
Electronics

Telemetry



General criteria of choice

- Temperature range : -10°C to 50°C
- Arduino and python library
- Quality
- Price and availability

We took our inspiration from Adafruit Sparkfun to choose our sensors and build our own PCB

A big thanks to Taras Pavil and Michael Linder that have helped us to improve our PCB

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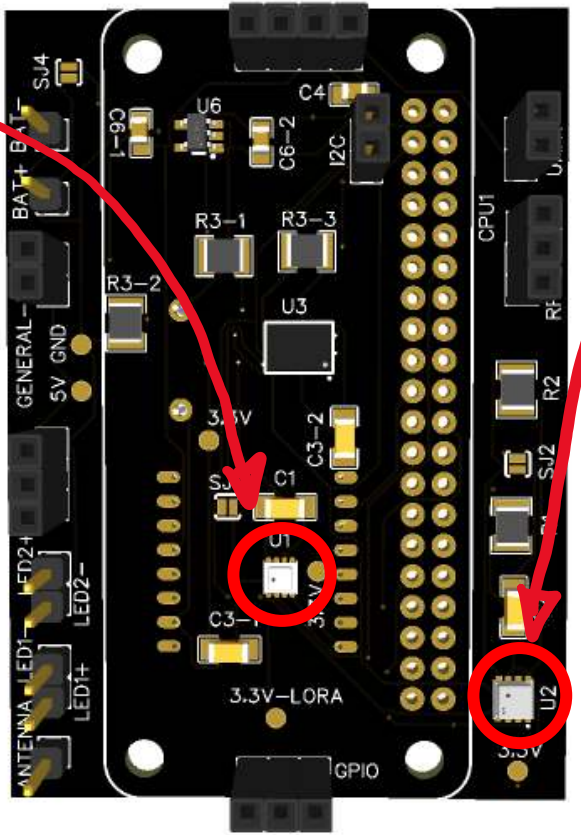
Electronics

PCB

BME280 (temp2)

Humidity (+-3%)
Pressure (+-1hPa)
Temperature (+-1°C)

I2C comm.
3,3V alim.



BME688 (temp1)

Humidity (+-3%)
Pressure (+-1hPa)
Temperature(+-1°C)
VOC gaz

I2C comm.
3,3V alim.

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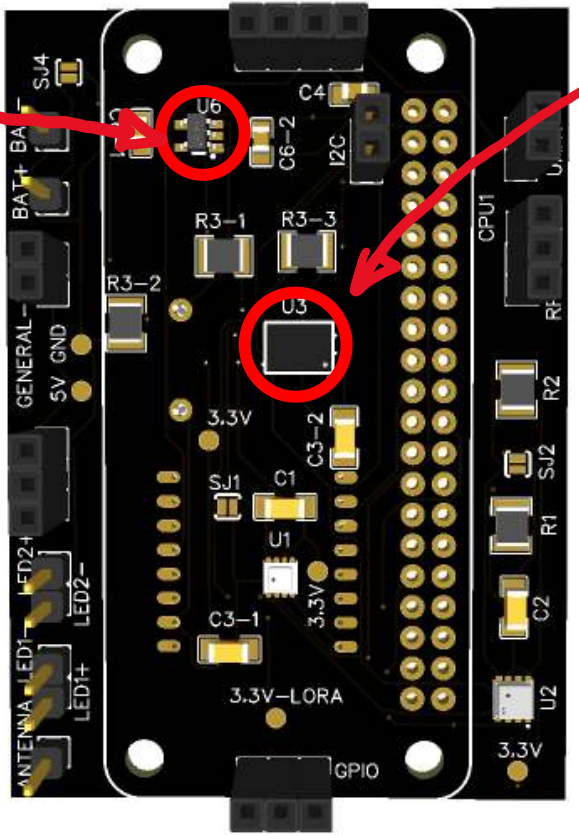
Electronics

PCB

3,3V high Amper

Alows to **propperly power** the **communication** module and the **GPS**.

Convert 5V to 3,3V with a higher amper capacity



BNO055 (accelo)

Accelerometer
Gyroscope
Magnetometer

I2C comm.
3,3V alim.

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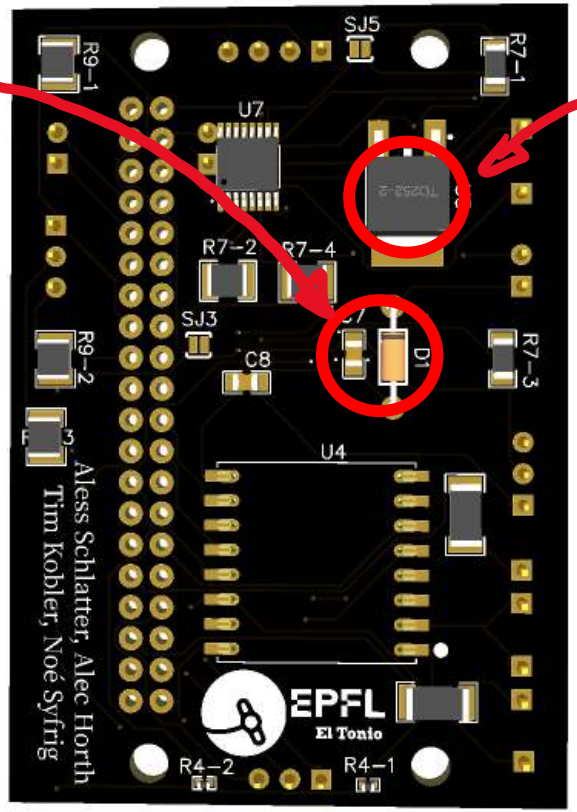
Electronics

PCB

Raspi protection

Zener Diode
1u capacitor



6,6 V to 5V converter

Alows to take take down the 6,6V bettery to stable 5V to power the Raspi trough the GPIOs

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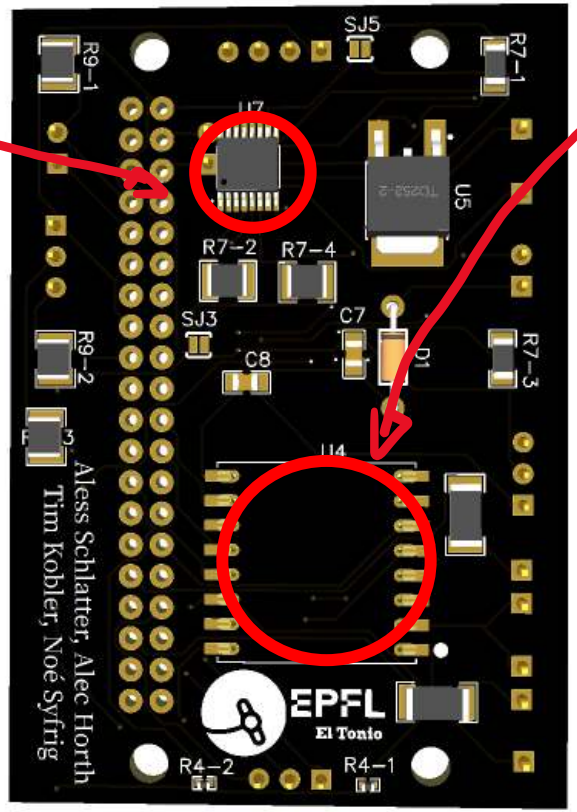
Electronics

PCB

INA260

Voltage mesure and current mesure of the battery



LoRa comm. module

868 MHz
Data rate : 300kbps
Power output : 20dBm
Sensitivity : -148dBm

SPI comm.
3,3V

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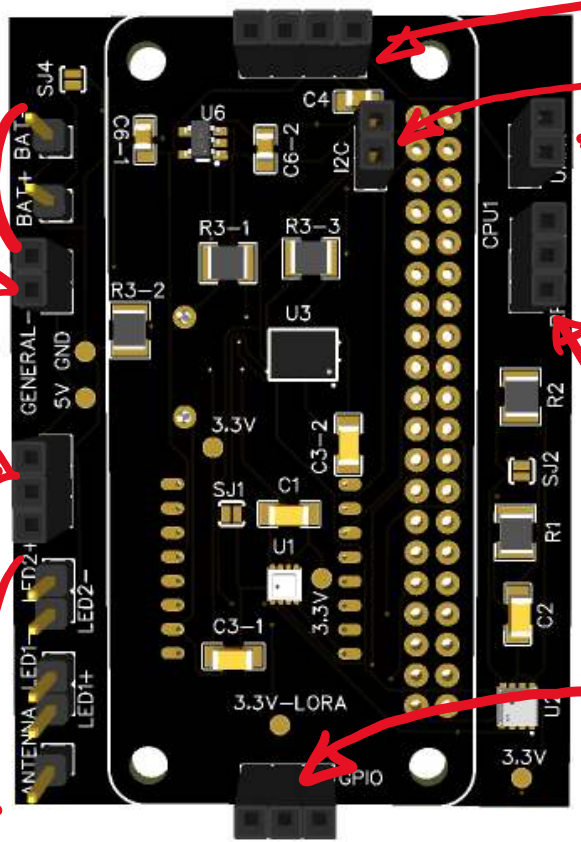
Electronics

PCB



Battery

General Killer switch

Power out

LED indicator 1 and 2

GPS

I2C

UART

Raspi killer

GPIO

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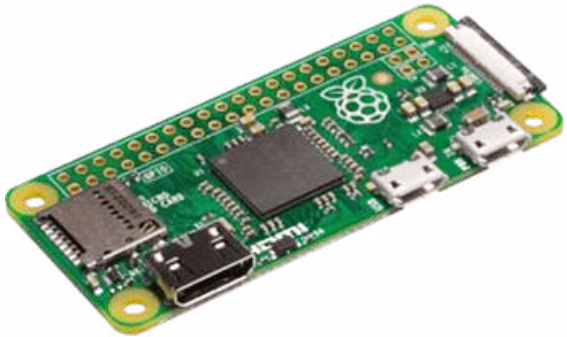
Electronics

Microcontroller

Raspberry pi zero



Main reasons for our choice:

- Supports a relatively good quality camera
- Integrated Sd-Card

Short description

- 1GHz single-core CPU
- 512MB RAM
- Mini HDMI port
- Micro USB OTG port
- Micro USB power
- HAT-compatible 40-pin header
- Composite video and reset headers
- CSI camera connector (v1.3 only)

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Electronics

Power supply

Rechargeable Battery type	Lead	Alkaline	Nickel			Lithium			
Criteria	**Lead-acid**	**RAM**	**Ni-Fe**	**Ni-Cd**	**Ni-Mh**	**Li-Ti**	**Li-Fe**	**Li-Co**	**Li-Mn**
Masse energy density [Wh/kg]	35,00	80,00	21,00	30,00	100,00	110,00	160,00	195,00	150,00
Volumic energy density [Wh/dm^3]	67,50	160,00	125,00	100,00	400,00	177,00	333,00	560,00	420,00
Voltage per cell [V]	2,10	1,57	1,20	1,20	1,20	2,30	3,20	3,70	3,90
Cutoff voltage [V]	1,75	0,90	0,75	0,90	0,90	1,80	2,00	2,50	2,50
Market disponibility	---	+++	--	+++	+	-	++	+++	+
Heat résistance [°C]	-40 to 49	-18 to 55	-40 to 40	-60 to 65	-30 to 75	-20 to 60	-20 to 60	-20 to 60	-20 to 60
Vibration & impact résistance	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maintenance	+++	--	-	-	-	+	+	+	+
Safety	--	+++	++	+	+++	-	++	--	-
Price/cell (approximation)	++	+++	-	++	+++	---	+	+	+
Durability [life cycle]	1500	2000 - 3000	700-1000	700-1000	700-1000	3000 - 5000	3000 - 5000	3000 - 5000	3000 - 5000

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Electronics

Power supply

Lead	Alkaline		Nickel			Lithium			Weight coeficient [%]
Lead-acid	RAM	Ni-Fe	Ni-Cd	Ni-Mh	Li-Ti	Li-Fe	Li-Co	Li-Mn	
0,03	0,09	0,03	0,06	0,09	0,09	0,12	0,15	0,12	**15,00**
0,01	0,02	0,02	0,02	0,08	0,02	0,06	0,10	0,08	**10,00**
0,02	0,01	0,01	0,01	0,01	0,03	0,04	0,04	0,04	**5,00**
0,03	0,04	0,04	0,04	0,04	0,04	0,03	0,03	0,03	**5,00**
0,00	0,20	0,04	0,20	0,12	0,08	0,16	0,16	0,12	**20,00**
0,02	0,02	0,03	0,05	0,05	0,04	0,04	0,03	0,04	**5,00**
0,03	0,05	0,05	0,05	0,05	0,05	0,05	0,03	0,05	**5,00**
0,10	0,02	0,04	0,04	0,04	0,06	0,06	0,06	0,06	**10,00**
0,03	0,15	0,12	0,09	0,15	0,06	0,12	0,08	0,06	**15,00**
0,04	0,05	0,02	0,04	0,05	0,00	0,03	0,03	0,03	**5,00**
0,01	0,02	0,04	0,04	0,04	0,05	0,05	0,03	0,05	**5**
0,31	**0,67**	**0,44**	**0,64**	**0,72**	**0,52**	**0,76**	**0,72**	**0,68**	

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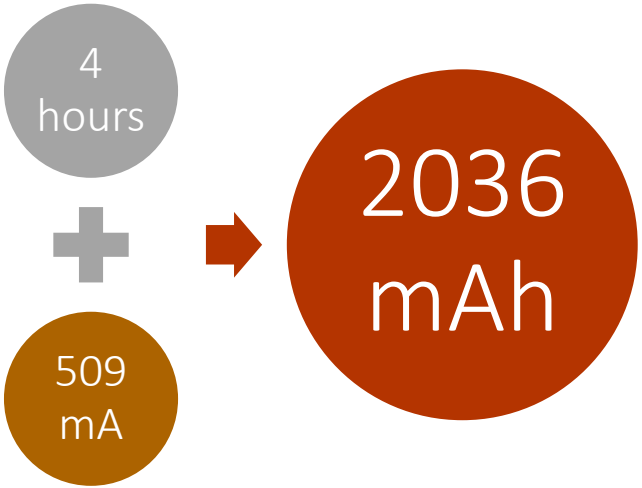
Power supply - Consumption

Component	Power consumption
Raspberry pi zero	100 mA à 370 mA
RFM96W (LoRa)	30 à 100 mA
BME688 (Pression)	1 à 4 mA
BME280 (Pression)	0.4 mA
GPS	29 à 34 mA
BNO055	80 µA
LIS331	370 µA
INA260	310 µA
Maximum total	509 mA



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Power supply batteries Ansmann

- 2 x 3,6 V Output
- 3600 mAh Capacity
- IEC 18650 – Aluminium casing
- Rechargeable by micro-USB 5V
- Short-circuit protection

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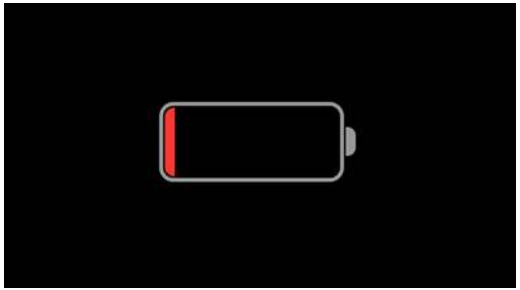
Power supply features

Voltage regulation	Power off	Power monitoring	Batteries housing
• L7805 • 0..35V -->5V • 0.5A	• Kill off switch • Raspi shutdown switch	• Tension and current monitoring • Coulomb counter	• IEC 18650 • Easily replaceable



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Electronics

Ground station

General Concept

- Lora module identical to the one on the CanSat
- Controlled by an Arduino
- Communication with the computer through an USB cable and to the serial monitor.
- Non-directional antenna for the reception

Note: We won't create a PCB for this, a simple "Perfboard" should suffice

If we have the opportunity to find an "all in one" usb-dongle, we will preferably use this

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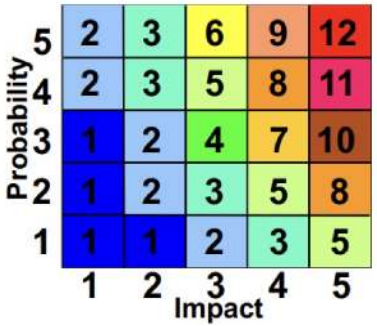
System engineering

Risk analysis



Level	Technical Criteria	Eventual Solution
9	Parachute deployment	Rogallo parachute
6	Retrieval of the CanSat	GPS, Bright colours for the CanSat
4	Environmental sensors damaged during launch	BME redundancy (two different types)
5	Structure integrity	Flexible and light material
7	Battery catching fire	Battery monitoring, Li-ion (aluminium casing)
6	Telecom range too short	High range LoRa comm. Module, and Sd-card for later recovery of the data and post-processing
3	Ground receiver application crashes	Backup text file with the received data, quick restart functionality
5	on board storage gets corrupted/ damaged on landing	telecom monitoring and storage on computer
7	battery does not last 4h	Enable low power modes (GPS, …), transmit only essential data
2	Sensor disconnects	ensure connections are robust, ensure software can recover from unresponsible io, redundancy of sensors

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System engineering

Budget estimation

Category	Estimated price
Structure	30 CHF
Parachute	10 CHF
PCB manufacturing	20 CHF
PCB components	80 CHF
Other electronics	40 CHF
Testing	20 CHF
Shipping	50 CHF
TOTAL	**250 CHF**

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System engineering

General

Requirement compliance

- **Structure requirements:**
  - 75x110 mm so it leaves 40 mm for the parachute
  - Main structure in polystyrene so it's pretty light (~330g)
  - Flexible bumpers and structure to protect from shocks
- **Feature requirements:**
  - Batteries and electronics easily accessible thanks to butterfly opening
  - 2 switches to control power supply
  - A customized PCB with multiple environmental sensors
  - A LoRa module and a GPS allows recovery and communication
  - Primary mission: Camera & PCB design
  - Secondary missions: pressure, temperature, telecommunication, position in space
  - Rogallo parachute for recovery (4m/s fall rate)
- **Logistic requirements :**
  - Budget: 250.-
  - No operation is irreversible so multiple launches are possible

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System engineering

Requirement compliance

Our requirements

- We didn’t succeed to implement a paraglider
- We implemented a camera
- Our customized PCB has multiple sensors for environmental parameters and power regulation
- We implemented switches and LEDs to have a user friendly HMI
- Our structure with butterfly opening and polystyrene casing allow an easy accessibility

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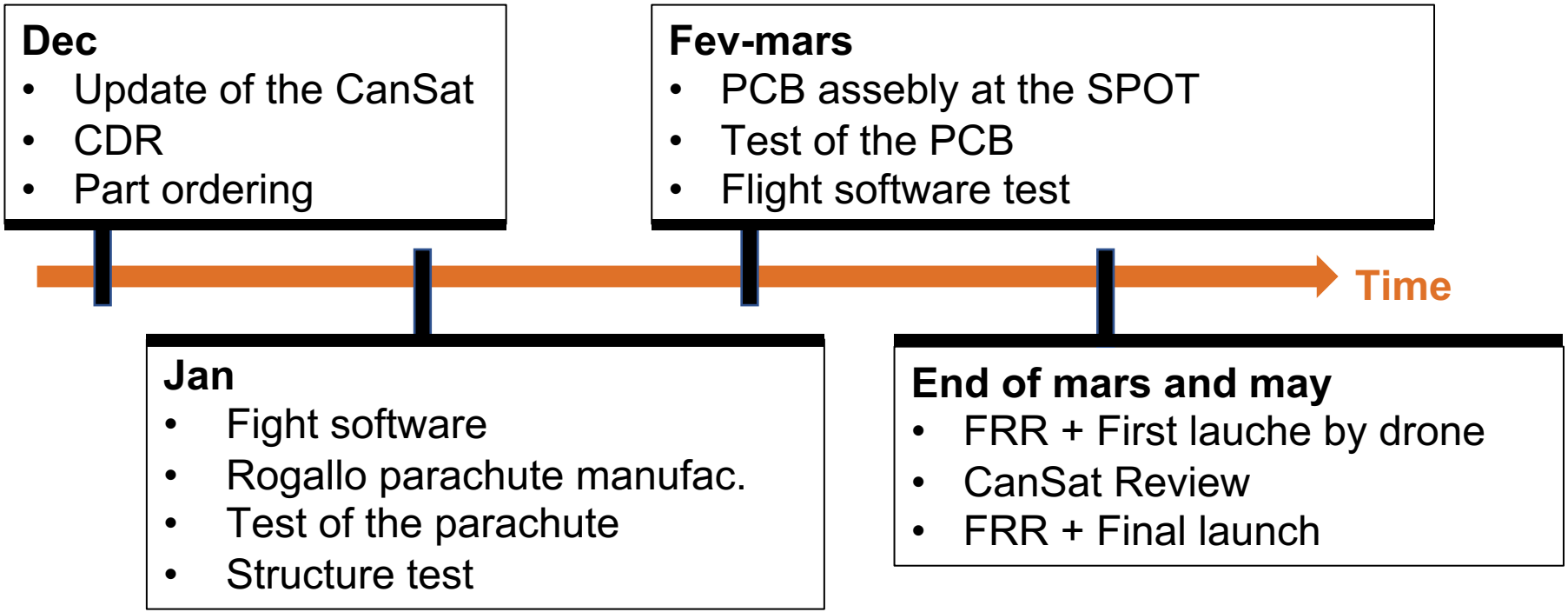
System engineering

Shedule



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System engineering

Testing plan

- GPS test (accuracy)
- Communication test (distance and orientation, data rate)
- Sensors test (temperature, pression, acceleration, giro)
- Longevity test of the power system
- Parachute test and steering calibration
- Material and structure test (rupture, solidity, etc...)
- Camera and OBC test

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Conclusion

- We succeded to respect most of our requirements (Only the paraglider wasn't implemented)
- On our PCB we have extra pins for future extra sensors and unexpected changes
- We learned how to combine EPFL related work and the organisation of our spare time as a group
- Looking forward for the next step!

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If you have any questions, we are happy to answer them!

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