LES PROJETS CANSAT

Flower Power CanSat Project Article:

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Introduction:

Flower Power CanSat Project is an associative project of ESO-ESTACA students. There are 4 students currently taking parts inside the project, all of us working on some different units of the Cansat (like software, electronic component, mechanical component…). This CanSat project is the only one this year in the association and it has new purposes in front of the previous years ESO's CanSat. The CanSat is composed of two parts: the probe/experiment (Seed) and the container (ERA), each of them has been made with 3D printing material and this is one of the goals of the project. In fact, the two aims of the project are to test a mechanical fuse printing in 3D and to determine static pressure and temperature of the environment.

I. CanSat Team

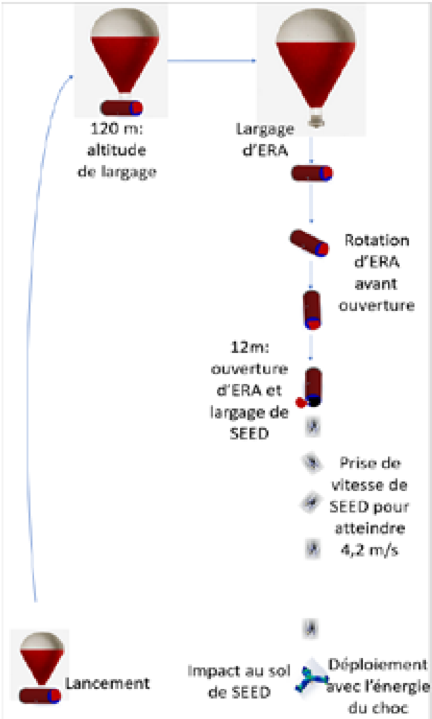
The team is composed of 4 students of the ESTACA. Two are in their penultimate years and the two others are in years 2 out of 5 years. All the members have skills in software like CATIA V5 and Abaqus, in mechanical design and conception and in electronic. The team's project has used 3D printers, computers, electronical and mechanical materials (like soldering iron, drill press…) to do the CanSat.

II. CanSat missions

The mandatory mission of the CanSat is to test a mechanical fuse. The mechanical fuse is printing in 3D with PLA and must keep the experiment close until the impact of the probe with the ground. At the impact the fuse will break and the probe will be able to deploy itself in a good way. To size the fuse, tests on Abaqus and designs on CATIA V5 have been conduct. Moreover, several concepts have been printing and test in order to choose the best for the experiment.

The secondary goal of the project is to evaluate the temperature and the static pressure inside the probe during the flight phase and after the impact. That's why there is a telemetry module and some sensors inside the probe. The sensors will evaluate the temperature and the pressure and will transmit it to the telemetry module, that will broadcast it to a computer.

The schema below shows how the flight and the experiment will unfold.

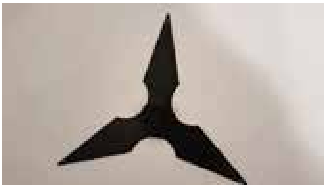


III. <u>CanSat design</u>

The CanSat is in two parts: the probe (Seed) and the container (ERA). The whole CanSat has a weight of 250g and is a hollow cylinder with a trap on its front side. Also, there is a parachute attach to the CanSat container in order to have a safe product.

Mechanical part

Inside the cylinder, that is also the container, there is the probe. The probe has a structure in FLEX, a kind of plastic that can be used for 3D printing. Inside the probe there is the telemetry and the sensors for temperature and pressure. Furthermore, the probe is close with the mechanical fuse, which is at the top of the probe.



Electronic part:

The telemetry used two 2pcs Wemos Lora 433 Mhz modules and has a range of 1km. It built with two like-Arduino cards (one in the probe and one on the ground). The cards in the probe is power by a 2S battery. The container also has an electronic part, that allow for the opening of the cylinder's door when the container is at 11m meter before the ground. This electronic is composed of a 2S battery, an Arduino Uno and a servomotor.

IV. Discussion and conclusion

All the members of the project are proud of the job that has been done. The CanSat is ready for its flight and the tests are conclusive. We don't think it can be improved because we had solved all the issues that we encounter during the conception.

The missions will be a success if the flight is going well and if the two experiments are passed. The telemetric data will be record on a computer and the fuse will be analyzed after the end of the two experiments.

V. Acknowledgement

Sponsors: ESO and ESTACA

Development of a Cansat "Allpa Llamk'ay" prototype Focus on the Measurement of Environmental Parameters in Agricultural Crops

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Summary- The significant influence that climatic factors on the development of pests and plant diseases of great concern in the community of agricultural producers worldwide, being necessary to control the impact on crops, knowing that microclimates is developing the cultivation process, for which we have accurate measurements of parameters such as temperature, air pressure, relative humidity, incident radiation and also toxic gases in the atmosphere near crops.

This project implements the Cansat Allpa Llamk'ay prototype with the aim of collecting data by UV radiation sensors, solar radiation, pressure, relative humidity and other; for later sent to a receiving station using telemetry modules. With the information received the study of environmental parameters (fluid temperature, relative humidity, radiation, etc.) that influence the formation of factors that may be risk certain crops, for which the allowable ranges will be established and will be performed risk ranges must be detected by the weather station.

The receiving station, using a mathematical modeling of the data, displays a graphical interface which will provide diagnoses any problems that arise.

In Incidence of climatological factors in the evolution of pests and plant diseases [1] the importance of warning stations shown in this case Cansat [2] type, which advise farmers control measures ideal against crop pests. Economic and ecological value of the same is evident as the proper use of the stations farmers decrease losses in crops and more treatments will not give the necessary thus saving money is achieved while avoiding environmental pollution due to unnecessary treatments.

The Cansat Allpa Llamk'ay participant C'space 2019, will be released approximately 200 meters high, falling with controlled rate of 4 m / s thanks to the parachute which is equipped to meet at 1 meter height above the floor, the Cansat, detach the upper capsule including the parachute and crew as established competition from that point the prototype ends up landing in free fall, to finally stabilize ground vertically deploying the system 8 fins designed for this order and to provide power by photovoltaic solar modules installed on each wing; Once the Cansat Allpa Llamk'ay is on the ground will proceed to culminate other established missions.

***Keywords*- Cansat, Agriculture, Micro weathers, Sensors, Telemetry.**

I. INTRODUCTION

The prototype Cansat Allpa Llamk'ay is developed by the Aerospace Team Peru, part of Smart Machines Laboratory CTIC UNI - Lima Peru, with reference to the standards set by the organization C'space 2019, therefore it meets every one of the goals set by competition and similarly focuses on an application in the Peruvian reality to support the development of small-scale agriculture.

For this edition the team has considered making various improvements in the quality of development of the missions of the contest.

As for sensors, we use three commercial sensors: MQ-7, BME / BMP ML 280 and 8511; in the case of direct sunlight we develop a solar cell calibrated using two flexible solar modules.

The design of the structure was made following cansat guidelines aircraft design and fabricated using 3D printers, carbon fiber laminate and conventional mechanical manufacturing.

Furthermore the data transmission between the prototype and the receiving station was implemented with telemetry modules Lora SX1276 (SEMTECH), one in the transmitter and another at the receiver; Likewise a graphical interface to display the data reading was performed on a computer.

And finally power is supplied to the circuits by a Li-Po battery 1000 mAh 8.4 V and which in turn is backed by a charging system for a solar cell array 6 3V and 25 mA each.

II. DESCRIPTION OF MISSIONS

A. *During the fall and landing*

The cansat Allpa Llamk'ay, will be roughly 200 meters, falling controlled by parachute 4 m / s speed; to meet at 1 meter height above the floor, the Cansat, it will release the upper capsule including the parachute and crew; This action will be controlled with a servomotor and a deployment mechanism. Once on the ground, 8 fins will emerge, which ensure that the CanSat is in the correct position for the following missions, said fins which are equipped with flexible solar cells which provide it with energy to prototype and in turn use them as sensors.

During the fall of pressure measurements made at different heights and are sent to the information receiving unit.

B. *After landing*

After landing the CanSat will have three main missions:

- Measurement of direct solar radiation using the photoelectric effect occurring in the solar cells located in the fins; for this mission circuit and calibrated using a cell current generated in the cells that provides a mathematical analysis we radiation in w / m2 PERFORM.
- Ambient temperature measurement, for measuring the BME module 280 was installed, the information that gives us the module is in ° C and is performed using the I2C protocol.
- Measuring relative humidity, BME 280 module, which by programming codes the values obtained in a range of 0 to 100% is also used.

III. DETAIL DESIGN AND CONSTRUCTION

CanSat development is divided into 4 areas of work to get better results:

- Electronics and sensors.
- Telemetry and communications.
- Use of Energy.
- Mechanical and Manufacturing.

A. *Electronics and Sensors*

The prototype cansat Allpa Llamk'ay has a system composed of the following sensors:

- MQ - 7: Sensor Carbon Monoxide Gas.
- BME / BMP 280: atmospheric pressure sensor, Relative humidity, temperature and altitude.
- ML 8511: Sensor UV Light.
- Solar cell calibration.

For proper operation and data transmission, sensors are connected to the microcontroller ATmega280 to manage and transmit the information census.

BME280 / BMP280: I2C protocol by this sensor will measure the absolute pressure, ambient temperature and relative humidity.
The height is an additional parameter to be determined by code and serve to angularly displace the axis of a servomotor actuate the separation of the upper cansat (capsule) of the lower body during its fall.

NOTE: The code for obtaining pressure at different heights, the temperature and the relative humidity is in Annex 1.

MQ-7: It will measure the concentration of carbon monoxide in the atmosphere.
This information is vital because the carbon monoxide produced enormous effects on human health. According to research, the human body undergoes severe reactions in the presence of this gas when the levels are above the 30 to 50 ppm (parts per million).

Concentración de CO en el aire		Tiempo de inhalación y efectos
30 ppm	0,003 %	Valor límite umbral (concentración máx. que se puede respirar durante un periodo de 8 horas)
200 ppm	0,02 %	Dolor de cabeza leve en 2 ó 3 horas
400 ppm	0,04 %	Dolor de cabeza en el área de la frente en 1 ó 2 horas, que se extiende a todo el área de la cabeza
800 ppm	0,08 %	Mareo, náuseas y temblores en las piernas en 45 minutos. Pérdida de consciencia en 2 horas
1600 ppm	0,16 %	Cefalea, náuseas y mareos en 20 minutos. **Muerte** en 2 horas
3200 ppm	0,32 %	Cefalea, náuseas y mareos en 5 ó 10 minutos, **muerte** en 30 minutos
6400 ppm	0,64 %	Cefalea y mareos en 1 ó 2 minutos. **Muerte** en 10 ó 15 minutos
12800 ppm	1,28 %	**Muerte** en 1 ó 3 minutos

Table concentration levels of CO in air and its effects.

Based on this, the MQ-7 sensor used in our circuitry is accompanied by an RGB LED.
Depending on the color of luminescence handles this warning if the CO concentration is low and safe for human life.

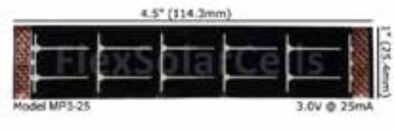
NOTE: The code for obtaining the CO concentration in ppm is in Annex 1.

ML 8511: It will measure the UV index and like the MQ-7 work together with one RGB LED as a warning if the area is safe or hazardous to the user.
The World Health Organization together with the World Meteorological Organization, the United Nations Environment Program and the International Commission for Protection against Non-Ionizing Radiation released a standard measurement system UV index, which is shown below .

Color	Riesgo	Índice UV
Verde	Bajo	<2
Amarillo	Moderado	3-5
Naranja	Alto	6-7
Rojo	Muy Alto	8-10
Morado	Extremadamente alto	> 11

UV index and human health risk.

CELDA Calibrated The solar cell calibrated will determine the solar radiation in W / m2 incident daily in the place where the Cansat make his landing, this has been one of the bonus missions that our team has implemented since it is very important to know the resource that they have certain territories in the aspect of power generation and for this it is necessary to know the solar radiation. For this we use a circuit where two flexible solar cells 3 V and 25 mA in parallel and these in see are connected to a calibrated resistance Shunt was implemented.



flexible solar cell used

Through resistance shunt we can measure the incident radiation in the cells since this is proportional to the short circuit current at the time of measurement, this in turn is proportional to the potential difference in the Shunt, thus measuring the difference potential in the Shunt we can establish the radiation incident on the solar cell, according to the following equation:

$$G_{med} = \frac{I_{med}}{I_{STC}} G_{STC} + a(Tc_{med} + Tc_{STC})$$

Where we have radiation incident upon the surface of the solar modules depends Imed, I_STC and G_STC; the second member of the equation helps correct measurement of radiation temperature effects, which is not within the scope of this mission.

We solve the above equation and replace values and obtain:

$$G_{med} = \frac{1000 * V_{shunt}}{V_{shunt\ STC}}$$

Vshunt: Voltage measured directly on the shunt resistor at the time of testing.
Vshunt STC: Stress that represent the shunt resistor under normal conditions, in mV.

By an analog Pin in ATmega 280 data Vshunt is taken, the data is sent to the receiver module by sending protocol data will detail in the following chapters, once the computer by programming codes spectrum is obtained radiation and the data expressed in numbers.

*B. **Telemetry and Communications***

Send census data and correct reception is a vital pillar in the operation of Cansat Allpa LlamK'ay since then these data will be processed for their respective objectives, therefore the information received must be the same as that which was sent to achieve this a telemetry system detailed below is implemented.

Lora is a technology whose spread spectrum modulation allow us to have greater range compared to other (5km open field), is also made for a low power consumption, has a high noise immunity and a transfer rate of 256 Bytes, these are enough features for data to be sent are correctly received

Implementation:

For the development of this area use the telemetry module Lora SX1276 (SEMTECH) this was done for two basic implementations module - Arduino Nano, in which one of them will be located in the Cansat issuer and the other the receiver.
Arduino connections between the module and the telemetry module are as follows:

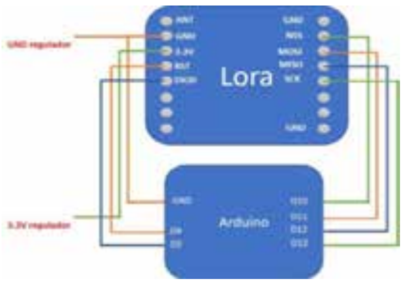


Diagram Lora connections between the module and the Arduino Nano

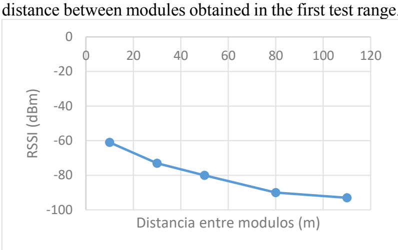
Telemetry details:

These are the parameters used in most tests

PARAMETERS	VALUE
Frequency	433.0 MHz (ISM band)
Potency of transmission	*2. 3 dBm*
Bandwidth	125 KHz
Coding rate	4/5
Spreading factor	128chips / symbol

Tests:

In the test range is important to know the RSSI signal, this parameter indicates the intensity of the signal which is received.
The following chart shows how the RSSI varies with the distance between modules obtained in the first test range.



RSSI variation graph according separation modules

In the results you can see that the RSSI values are greater than -139dBm for values less than that, according to the manufacturer, the data cannot be received.

Observation

information coding loses its helical antenna when the transmitter was in contact with the fingers of it manipulated

C. **Use of Energy:**

Our prototype Cansat has a Li-Po battery 2 cells at 4.2 V each connected in series, and with a total storage of 1,000 mAh.

According to the characteristics of electronic design Cansat this battery ensures 20 min of autonomy with all sensors and actuators working, estimated sufficient to perform all the missions.

Likewise, the prototype has 6 flexible solar cell 3V and 25mA c / u, arranged fins cansat, these cells will supply electricity to the batteries through the photoelectric effect; the battery charge was performed properly implementing a circuit including a BMS (Battery Management System) to balance loaded in the cells of the battery and to protect it against overload or excessive discharge.

*D. **Mechanical & Manufacturing***

The mechanical design of prototype cansat 2019 is divided into 3 main parts: structure, panel system and parachute; design all the systems was performed taking into account parameters significant as the total weight of the prototype, the type of conditions in which perform their functions, the average temperature, the rate at which the prototype descend from its fall and the maximum efforts that will be subjected, so that an assembly time meets all specifications the system requires.

Cansat Allpa Llamk'ay - C Space 2019

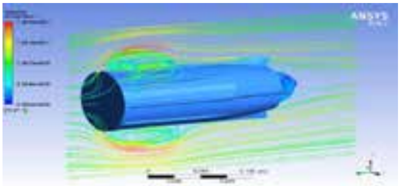
Working algorithm:

Structure: a model which has three distinguishable and easily assembled (base, body and head) is worked parts. HIPS (high impact polystyrene) material he is chosen and manufactured using 3D printing and supports panels used laminated with carbon fiber.

main parts of the prototype Cansat Allpa Llamk'ay

Fuselage: In airframe design NACA 0025 profile (symmetrical profile) was considered for the Kammtail, which allow a laminar flow at the outlet of longitudinal wind.

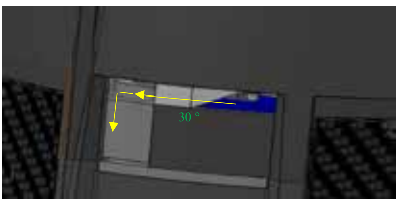
The model has four fins on the top which will help stability to side winds and contribute to the proper location of the center of pressure.
analysis with longitudinal flow of 8 m / s transverse 2m / s were performed to simulate winds which will be subjected cansat in its fall.



System Deployment: The base contains the set of torsion springs which condition the opening mechanism 8 fins for deployment of the panels and ensure that the cansat remain upright for performing missions.

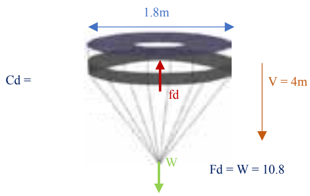
Scheme moments about the fulcrum

Detachment system: Mechanism driven by a servo motor to dislodge the top (astronaut capsule establishing missions C'space) of the bottom (spacecraft).



Operating system release

Parachute:



Disk Analysis Parachute Band Gap

IV. DISCUSSION AND RESULTS

During the first tests of operation of the prototype were problems with electronic boards, many of these relating to the voltage required for operation of the different components just as the MQ-7 and ML8511 sensors did not collect the respective data for which had been implemented, this because of a coding error in programming, in the case of transmission of data during the first tests detected the presence of noise in the signals sent; however, after following a protocol testing and troubleshooting of each area, conducting further tests we determined that failures had been resolved.

Completed the testing process data transmission was correctly all sensors; we are currently working on improving the graphical interface of data presentation, in order to present them in an appropriate and understandable way, but with the advances described the project we can conclude that meets the main objectives and the prototype Cansat Allpa Llamk 'ay is operating according to established design and is ready to be tested under the conditions of C'space 2019.

Educational Project in Aerospace Engineering

Autonomous Rover Back CanSat "Chaski"

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ABSTRACT

Researches in Aerospace Technology are mostly being carried out in Peru at the National Commission of Aerospace Research and Development, CONIDA. Universities such as National University of Engineering, also contribute in this field by promoting the participation of students in research groups such as TEAM CANSAT PERU and UNISEC PERU.

This paper presents an educational project in Aerospace Engineering whose purpose was the design and results of the development of a CanSat prototype, "Chaski", a satellite that can easily fit inside a can of soda, whose purposes are the collection of data, perform controlled returns and in some cases complete a default mission.

Categories and Subject Descriptors

K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI); H.5 [**Information interfaces and presentation**]: Group and Organization Interfaces

General Terms

Aerospace engineering

Keywords

Educating, CanSat, Aerospace Engineering

1. INTRODUCTION

The Chaski project was developed in the Smart Machines Laboratory. It consists of the design and construction of a Rover-Back CanSat with the ability to navigate autonomously. The CanSat will be released from an altitude of almost 300 meters above ground level. Immediately, the parachute will be activated to reduce its descent speed so the structure of the CanSat can reach the ground without getting damaged.

During the descent of the CanSat to the ground, a barometric sensor module will be ejected with its own parachute in commemorating the 50th anniversary of the arrival of man on the moon. Throughout its trajectory the CanSat Chaski will be sending data to the station by radio frequency, such as its position, speed and other atmospheric parameters. These data will be used in a simulator to know the trajectory and the data transmission.

Once the CanSat impacts the ground the separation mechanism is activated releasing it from the parachute to be start the navigation until it reaches a point of global positioning system (GPS). Likewise, if it finds an obstacle in its path, the Control of Terrain. It. Image processing is used to achieve the closest approach to the point of arrival, since the GPS modules have a margin of error of approximately 10 to 15 meters. A camera was incorporated to allow orientation through image detection. In the point of arrival, a striking color object will be placed so that when the camera detects said color, they only go in that direction, reaching the final point as close as possible. After the recovery, a mosaic of images will be made combining several images in an arbitrary way to form a large, in addition to the analysis of all the recorded data.

The innovations that are used for the development of the present project, lies in the use of composite materials for the manufacture of the chassis, for the Chaski glass fiber has been used since it considerably reduces the net weight of the prototype. As well as the design of navigation and image processing algorithms.

2. CANSAT TEAM

Founded in 2014 the AEROSPACE PERU club of the National University of Engineering, was created with the purpose of promoting collaboration among students from different Academic Schools to work together in an educational based project on Aerospace Engineering that allows the acquisition of new knowledge and the development of autonomous robotic systems such as the CanSat.

Currently, the team consists of seven members that have designed the Cansat called Chasky. One of the advantages of having a different group of students is to be able to see and analyze problems and propose solutions from more than one point of view. The team is composed by students from the Schools of Mechatronical Engineering, Physical Engineering, Systems Engineering and Computer Science, who have the necessary skills to perfom to their best capacity in the area they were working in the developing of the CanSat, either with the knowledge to define and implement the mechanical structure of the satellite, as well as the design of an algorithm to optimize its autonomy.

The skills and knowledge of each of the team members added to the equipment at our disposal in the facilities of the Smart Machines Laboratory[1], such as a computer center with software tools and harware needed for the development of the CanSat, is how we achieved the realization of this educational-based project.

3. CANSAT MISSIONS

3.1 Mandatory Mission

DEPLOYMENT AND DESCENT OF THE CANSAT

The mission is to ensure the deployment of the parachute so the CanSat can descend at an average speed of $4m/s$. The speed range should not be greater than $2m/s$ to be able to ensure that the landing does not generate physical damage to the satellite, which would make it impossible to fulfill the secondary missions. For this purpose, a parachute was designed to meet the conditions of the descent speed using the CanSat weight as a parameter.

The mechanical development proposes a robust design for the missions. The wheel consists of an ergonomic design of 6 teeth that will open when the objtect is ejected, it will also have 3 shock absorber rings. The payload (batteries, motors, circuits, sensors, etc.) is placed inside a structure that was built in a 3D printer using ABS as a material.

3.2 Secondary Mission

CONTROL AND NAVIGATION

The objective is the development of the autonomous navigation algorithm. To obtain an estimate of the location of the CanSat, sensors such as wheel encoders, gyroscopes, accelerometers and compasses are used along with external sensors such as GPS.

In order to optimize the precision of the location of the CanSat we combine the use of sensor with the Kalman Filter extended algorithm.

For the control subsystem an algorithm will be based on a PID control on the error of the reference point of the trajectory and the current state of the CanSat. The general purpose of reaching the goal or following a trajectory and the use of the localization and control algorithms explained above.

Furthermore, through the digital processing of each frame captured by the camera, the position of the object referring to the center of the frame is obtained, this allows us to determine the direction towards which the CanSat must turn. A Color Detection Algorithm will helps us guide the CanSat to the point of arrival with a much better proximity that using only a GPS sensor.

IMAGE MOSAICING BASED ON SIFT FEATURE DETECTOR

Image mosaicing is gaining a lot of interests in the research community for both its scientific significance and potential derivatives in real world applications. Therefore, the objective is to use a method based on Scale Invariant Feature Transform (SIFT) to generate a mosaic image of the digital data obtained after the mission is completed, we would like to create mosaic images of two in two original images the CanSat has obtained.

Figure 1: CanSat Rover Structure

3.3 Bonus Mission

In commemoration of the 50th anniversary of the arrival of man to the moon, the bonus mission is to eject a small astronaut or tripulant of the CanSat. It will have its own small parachute to break its fall. The tripulant will be placed inside the capsule. It will shoot out by the expansion of the spring. The parachute of the tripulant will be the same model as the CanSat, but a smaller scale.

4. CANSAT DESIGN

The desing of the CanSat was divided in five subsystems: Mechanics, Telemtry, Electronic and Sensors, Control and Navigation and Image Processing.

4.1 Mechanical

The mechanical subsystem of the CanSat was addressed in four subparts: structure, wheels, parachute and separation mechanism.

4.1.1 *Structure*

The structure was designed to optimize the spaces for the layout of each electronic component and taking into account the rough terrains to which the CanSat will be subjected. The structure has a foldable and rigid form that allows resistance to damage during its free fall. Figure 1 shows the internal structure of the CanSat where the electronics components, motors and wheels are assembled. The design of the structure has been printed in a 3D printer using Acrylonitrile Butadiene Styrene (ABS) a terpolymer that is stronger than pure polystyrene. ABS was choosen because of its most important mechanical properties, its impact resistance and thoughness. To corroborate the rigidity of the structure a simulation by finite elements was carried out.

The software gives us greater ease in the use of tools to design, this propitious Solidworks SIMULATION which gives us 5 types of studies: frequency studies, buckling, thermal, fatigue and fall. The latter is the one we will use to see how our designs behave when faced with falls, as it automatically calculates the impact and gravity loads.

The finite element analysis with SOLIDWORKS Simulation allows to know the exact geometry during the meshing process, and it is integrated with the 3D CAD software of SOLIDWORKS. For the precision between the meshing and the geometry of the product. Figure 2 shows the stress test, to know the characteristics of the material, in Figure 3 it

Figure 2: Numeric Simulation of Stress

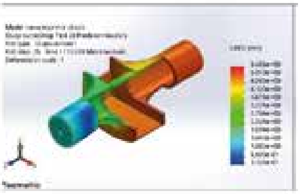

Figure 3: Numeric Simulation of Desplacent

presents the displacement test and in Figure 4 we show the deformation test.

4.1.2 Wheels

The wheels design plays an important role so that the CanSat can continues its trajectory without major complications in rough terrains. The wheels are made of fiberglass, Figure 5. They have a deployable design that will "open" once it is realesed from the capsule and the parachute. It consists of five "teeth" that in the beginning will be covering all the electronic components as a "shelf" protecting them during the fall and the impact to the ground.
The wheel rim will have three shock absorber rings attached to the coupling, . These will act as a shock absorber system capable of resisting the impact of the fall without letting the maternial break or crack. These shock-absorber rings have the ability to increase or shrink depending of the direction of the force related to it.
The flexibilty of the wheel rim has a better resistance since it is made of fiberglass.

Figure 4: Numeric Simulation of Strain

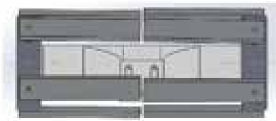

Figure 5: Profile view of the design of the wheels made of fiber glass

Figure 6: Three shock absorber rings inside the wheel

Figure 7: Final Model of the Cansat Rover

Ve	4 m/s
ρ	1.225 kg/m^3
Wt	9.81 N
Cd	0.75

Table 1: Default values for the calculation of the parachute surface.

4.1.3 *Parachute*

The parachute design is based on the final weight so that its descent speed is lower than in free fall to reduce damage to the structure at the moment it impacts the ground. The descent speed depends on the drag generated by the parachute to counteract the force of gravity. We show two equations that will allow us to perform the calculations, based on the area of its surface.

$$F = \frac{1}{2}\rho CdAV^2 \quad (1)$$

Where F is the drag force. ρ, density of air. Cd, drag coefficient. A cross-sectional area of the object. And V, speed.

$$Ve = \sqrt{\frac{2Wt}{SCd\rho}} \quad (2)$$

Where Ve is vertical descent speed, Wt, total weight of the object and the parachute, S, surface of the parachute, Cd, coefficient of drag and ρ, density of the air.

For the design of our parachute the approximate fall speed of the cansat was taken as reference, any other factor that may influence the drag coefficient is disregarded because our design is limited to a payload of one kilogram.

From equation 2, we clear the value of the surface, we have:

$$S = \frac{2Wt}{\rho CdVe^2} \quad (3)$$

Replacing values of the attached Table 1, $S = 1.33m^2$. For the design of the parachute, the "Semi-Spherical Plane" model has been chosen because it has a higher coefficient of aerodynamic drag, as well as less oscillation at the time of fall, so this model is adapted to the weight of the Rover, the design is shown in the Figure 8 and the design made in the software "Autocad" is shown in the Figure 9.

From the results obtained, we will make a design with a diameter of $1.33m^2$. according to what was obtained as calculation in equation 3, by using a 2D design software, an approximate $1.4m$ diameter is estimated.

The design shows an internal hole of 10 cm in diameter that allows you to make a more vertical fall, for its assembly will be composed of 8 pieces, which forms a non-Euclidean triangle since the sum of its internal angles is greater than 180 degrees. Figure 9 shows the design made.

The area of each triangular portion is approximately $0.153m^2$, which when adding the eight parts gives 1.224m2, of the calculations we have $1.33m^2$, which represents a margin of error of 7.9%.

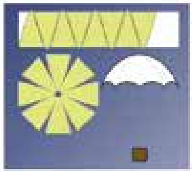

Figure 8: Model of the parachute

Figure 9: Design of the parachute made in Autocad

In figure 10, we can see the test of our parachute with a load of 1 kg thrown 20 meters above the ground.

4.1.4 *Separation Mechanism*

In the separation mechanism, nichrome wires were used to hold the capsule that englobes the CanSat which is at the same time tied to the parachute. When the CanSat reaches the ground, a mechanism previously programmed in the Raspberry Pi will grant 5V to the ends of the nichrome wires causing it to burn. By doing this the CanSat will be released from the parachute and the capsule to continue its trajectory to the arrival point.

4.2 Telemetry

For the telemetry subsystem we propose the use of transceiver devices with LoRa technology with the version SX1278. This version presents improvements at the architecture level with respect to the SX1272.

The main improvement is the incorporation of multiplexers and demultiplexers for the management of low and high frecuencies (137MHz - 525 MHz). For our work we selected

Figure 10: Parachute Test using a load of 1 Kilogram

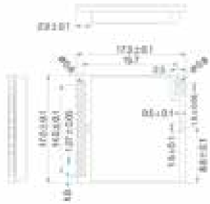

Figure 11: Dimensions of LoRa

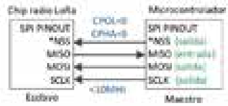

Figure 12: Conection of LoRa and Raspberry

Components	Features
Wheel	Length: 20mm Diameter: 78mm Thickness: 2mm Material: Aluminum
Wheel Teeth	Length: 100mm Width: 20mm Material: Fiberglass
Chassis	Min. Diameter: 30mm Max. Diameter: 80mm Length: 160mm
Coupling	Diameter: 50mm Width: 16.6mm Material: Aluminum

Table 2: Default values for the calculation of the parachute surface

433 MHz because it is the frecuency allowed by European standards. The main considerations for the choice of the LoRa device: weight of 3 g which is very important to reduce the weight of the CanSat Rover and dimensions are 17.3X17.0 mm Fig. 11.

This device communicates through the SPI communication protocol. which facilitates communication with the raspberry pi zero w. since the other communication ports will be occupied by the sensors and the GPS.

The proposed connection scheme between the radio transceiver LoRa and the microcontroller of the embedded system is presented in Fig. 12

Computer equipment: a computer with Linux Ubuntu 18 Operating System was used, on which the IDE versions of Arduino and Eclipse were installed for the programming and debugging of the source code incorporated in the embedded systems. Next we show the proposed scheme in Fig. 13

The way these two devices communicate are configured to perform a point-to-point communication, with a data rate of 30Kbps, enough to send data from the sensors.

Figure 13: communication scheme

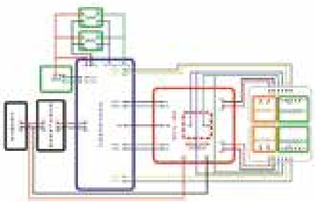

Figure 14: Desing of main circuit.

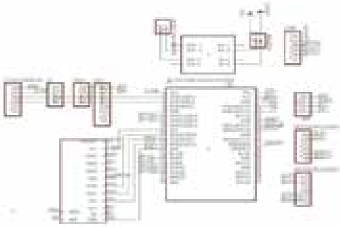

Figure 15: Scheme of the electronic board.

4.3 Electronics and sensors

The electronic components were selected according to the mission of this, taking into consideration mainly:

- Automatic release of the rover's shell when making contact with the earth's surface.
- Atmospheric sensing of pressure , temperature and humidity by environmental sensor (Environmental Combo Breakout - CCS811/BME280) and radiation sensor (UV Light Sensor Breakout - VEML6075).
- For autonomous navigation we use motors for the locomotion of the differential type rover. Also for the sensing of positioning and control. the main sensors are accelerometer (MPU 6050), GPS (NEO M8) and magnetometer (QMC 5883) respectively; and as the main processing center we implemented the Raspberry pi zero W.
- For telemetry the LORA SX1278 is used to send data and preserve the environmental data recorded by the sensors.
- For image processing we use a camera directly connected to the raspberry.

In the following image the design of the main circuit of the rover is presented.14

The following image shows the scheme of the electronic board in which uv and environmental radiation sensors are included. 15

4.4 Navigation and Control

For the development of the autonomous navigation algorithm a differential model robot is considered according to the presented design of the rover.

To obtain an estimate of the location of the robot, sensors are used, in our particular case internal sensors such as wheel encoders, gyroscopes, accelerometers, and compass will be used to estimate the position and orientation of the robot and external sensors such as GPS that will correct the accumulated long-term error of navigation.

To obtain a better precision in the estimation of the location of the robot, the multiple measurements of the sensors will be merged using the extended kalman filter algorithm.

The control algorithm of the robot will be based on a PID control on the error of the reference point or trajectory and the current state of the robot, which will act physically through the manipulation of the angular velocities of the wheels (motors).

The general system structure is shown in Fig. 16, the general algorithm for the autonomous navigation is shown in Fig. 17 and the electronic diagram is shown in Fig. 18.

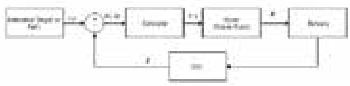

Figure 16: General system structure

4.4.1 *Extended Kalman Filter*

To fuse both internal and external positioning sensors the extended kalman filter was used. The kalman filter allow us to get an optimal state estimate of the system even with noise measurements. Due to the non linearity of the kinematic model of the system the EKF is used instead of the KF.

The extended kalman filter is described by the next equations:

$$x_k = f(x_{k-1}, u_{k-1}) + w_{k-1} \tag{4}$$

$$y_k = h(x_k) + v_k \tag{5}$$

Where f represents the non linear system and h represents the measurement model. Both the dynamic system noise w_k and the measurement noise v_k are zero mean gaussian with associated covariance

$$w_k \sim \mathcal{N}(0, Q_k) \, .$$

$$v_k \sim \mathcal{N}(0, R_k) \, .$$

The filter works by a two steps loop. First predict the mean and co-variance of the updated state estimate at some time step k based on the previous state and any inputs we give to the system.

Prediction

$$\bar{x}_k = f(\bar{x}_{k-1}, u_{k-1}) + w_{k-1} \tag{6}$$

$$\bar{P}_k = F_{k-1}\bar{P}_{k-1}F_{k-1}^T + Q_{k-1} \tag{7}$$

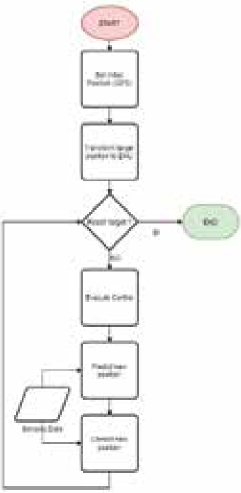

Figure 17: Flowchart of the autonomous navigation algorithm

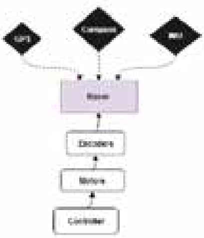

Figure 18: System electronic diagram

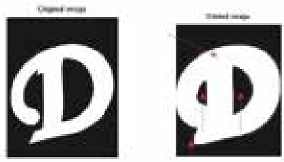

Figure 19: Dilatation of a Image

The filter then uses a measurement model to predict what measurements should arrive based on the state estimate and compares these predictions with the measurements that actually arrive from our sensors. The Kalman gain tells us how to weight all of these pieces of information, so that we can optimally combine them into a corrected estimate, that is, a new state and an updated co-variance.

$$OptimalGain$$

$$K_k = \bar{P}_k H_k^T (H_k \bar{P}_k H^T + R_k)^{-1} \tag{8}$$

$$CorrectionUpdate$$

$$\hat{x}_k = \bar{x}_k + K_k(y_k - h(\bar{x}_k)) \tag{9}$$

$$\hat{P}_k = (I - K_k H_k)\bar{P}_k \tag{10}$$

4.5 Image Processing

Image processing is a method to perform some operations on an image, in order to extract some useful information from it. The useful information that the CanSat will need is the positioning of a certain object in the image in order to update its trajectory.

4.5.1 Morphological Operations

The objective of using morphological operations [4] is to remove the imperfections in the structure of image.

4.5.1.1 Dilatation.

The dilation operation makes an object to grow by size. The extent to which it grows depends on the nature and shape of the structuring element. The dilation of an image A (set) by structuring element B is defined as

$$A \bigoplus B = \{z | (\hat{B})_z \cap A \neq \} \tag{11}$$

If set B is reflected about its origin and shifted by z, then the dilation of A by B is the set of all displacements z such that B' and A have at least one common element. Dilation adds pixels to the boundary elements, as seen on Figure 21. The dilation process enlarges the number of pixels with value one (foreground) and shrinks the number of pixels with value zero (background).

4.5.1.2 Erosion.

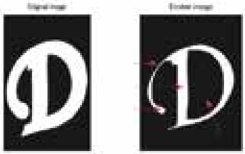

Figure 20: Erosion of a Image

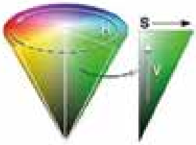

Figure 21: Color in the HSV spectrum

The erosion operation is complement of the dilation operation. The erosion of an image A by structuring element B is defined as

$$A \ominus B = \{z|(B)_z \subseteq A\} \quad (12)$$

The erosion operation removes those structures which are lesser in size than that of the structuring element. So it can be used to remove the noisy connection between two objects. The erosion operation is analogous to sharpening high pass filter that are used in linear filtering of an image, Figure 20.

4.5.2 *HSV Color Model*

We chose to use the HSV color model, because this model is more similar to the way in which the human eye perceives colors.
The HSV color model is a description of the color in terms of three components: Hue, Saturation and Value (Hue, Saturation and Value). This model describes in a circular way the frequency of each color in the visible spectrum in the H component, with the component S representing the purity of the color while V means the proximity of the pixel to black and white.
This model, therefore, allows us to separate the information from the color of the luminosity, being particularly useful when processing images taken outdoors, typically under sunlight.

4.5.3 *Color Detection Algorithm*

By digitally processing each frame with the morphological operations in OpenCV3.4[3], the position of the object is obtained in reference to the center of the image in pixels, this allows us to determine where the CanSat should turn to get as close as possible to the object . This update is done in each frame that is processed until the CanSat is as close as possible to the point of arrival. Aproximately, 1 to 2 meters of difference.
In Figure 22, the green line represents the center of the image. The oranges lines represent the interval in where the

Figure 22: CanSat Orientation

CanSat is orientated, so its direction does not need to be adjusted, the width of the interval is one tenth of the width of the image. In this example the object is in the left side of the image. We use this information to adjust the direction of the CanSat by accelerating the left wheel so it can rotate to the left and place the object exactly in the center of the frame. Analogously, when the object is on the right.
The information sent is a number proportional to the distance of the object $currentPosition$ from the center of the image $setPoint$.

$$setPoint = \frac{imageWidth}{2} \quad (13)$$

$$error = currentPosition - setPoint \quad (14)$$

Basically, we want to establish a speed difference between the wheels proportional to the $error$ in Eq.14. Once we have this value, we can express how much the speed of a wheel (left or right) needs to be adjusted to correct the direction of the CanSat.

$$speedRate = \frac{error}{setPoint} \quad (15)$$

This information is send to the Navigation and Control subsystem so they can update the speed of the wheels and the CanSat can continues is trajectory.

4.5.4 *Mosaicing Image*

SIFT algorithm [2] is alow-level feature detection algorithm which detects distinctivefeatures (also called "keypoints") from images. The SIFT descriptor is invariant to translations, rotations and scaling transformationsin the image domain and robust to moderate perspective transfor-mations and illumination variations. SIFTâĂŹs operation is based on five steps:
Initially, a scale space is constructed byconvolving an image repeatedly using a Gaussian ïňĄlter with chang-ing scales and grouping the outputs into octaves as[5]:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \quad (16)$$

where $*$ is the convolution operator, $G(x, y, \sigma)$ is a Gaussian filter with variable scale σ, and $I(x, y)$ is the input image. After the scale space construction is complete, difference-of-Gaussian (DoG) images are computed from adjacent Gaussian-blurred images in each octave as

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma) \quad (17)$$

Following that, candidate keypoints are identified as local extrema of DoG images across the scales.In the next step,

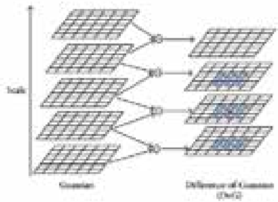

Figure 23: DoG: difference-of-Gaussian

Figure 24: First Image as Reference

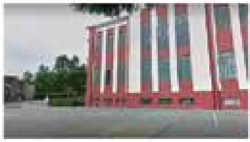

Figure 25: Second Image to be projected

Figure 26: Final Results

low contrast keypoints and edge response points along the edges are discarded using accurate keypoint localization. The keypoints are then assigned one or more orientations based on local image gradient directions as

$$\theta(x,y) = \tan^{-1}\frac{(L(x,y+1) - L(x,y-1))}{(L(x+1,y) - L(x-1,y))} \quad (18)$$

En equation 18, θ, represents the gradient direction for $L(x,y,\sigma$. In order to ïňAnd the initialmatching keypoints from two images, nearest neighbor of a key-point in the ïňArst image is identiïňAed from a database of keypointsfor the second image.

Finally,images are warped using the transformation parameters and stitched to generate the mosaic image. SIFT based image mosaicing algorithms are particularly suitable for stitching high resolution images under variety of changes (rotation, scale, afïňAne, etc.), however, at the cost of high processing time. Therefore, this processing can not be performed in the raspberry pi. We used MatLab to process the images to find a mosaic of two images. Preliminaries results are shown in the Figure 26

5. DISCUSSION AND CONCLUSSION

The Chaski project involves a wide and varied range of knowledge in navigation control algorithms, image processing algorithms, mechanical design, communication and logistics to achieve the missions, where each of the members shows all the knowledge acquired and consolidated to date in their respective subsystems for the development of CanSat. During the developement of the CanSat we have to deal with certain complications when integrating the functionalities generated by each area of work and make the CanSat work as an integrated system. Thanks to the high level of programming skills and electronic knowledge of the developer team, they were successfully integrated.

6. ADDITIONAL AUTHORS

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Copernicus CanSat: the atmospheric probe

Pennanech, Santos, Scheffelmeier, Thalgott, Vaucamps, Velin Cassim, Wolfarth

Abstract: The Copernicus CanSat is a project of seven students at ECAM whose purpose is to scan the atmosphere and take pictures of its surroundings. It will be presented during the annual French CanSat competition, a contest that allows dozens of students from all over the country to present their project.

I) Introduction

The CanSat project consists in realizing a satellite in a small volume, similar to that of a soda can, but without the constraints of space. The Copernic CanSat is an atmospheric probe, whose purpose is, in line with the European satellite Copernicus that shares its name, to scan and observe the earth and its weather. It features both a camera and atmospheric sensors.

II) CanSat team

1) Presentation

We are a group of seven third year students at ECAM Strasbourg-Europe. We all are passionate about space and therefore, chose as our "free project" (the main project of third years at ECAM) the CanSat project. Our long-term goal would be to path the way for future ECAM students who will wish to realise space related projects (CanSat, rocket, balloon...).

Figure 1:Team Copernic

2) Team organisation

After having surveyed the skills of every team member, we divided the team in two sub teams: mechanical team and electronics and programming team.

Team member	Skills	Function
PENNANECH Aurélien	Team management, mechanical design, CAD	Team manager Mechanics sub team
SANTOS Vignon Gisèle	Team management, programming, electronics	Assistant manager Communications Electronics and programming sub team
SCHEFFELMEIER Nicolas	Mechanical design, CAD	Mechanics sub team
THALGOTT Line	Electronical wiring and soldering	Electronics and programming sub team
VAUCAMPS Tom	CAD	Mechanics sub team
VELIN CASSIM Clarisse	Programming, general knowledge on Raspberry PI	Electronics and programming sub team
WOLFARTH Léa	Programming, electronics	Electronics and programming sub team

Table 1: Team organisation

The following step was to make a general planning of the project, which we kept up to date as we progressed. We also had regular meetings with our referent teacher to check with our progress and discuss the issues we were facing.

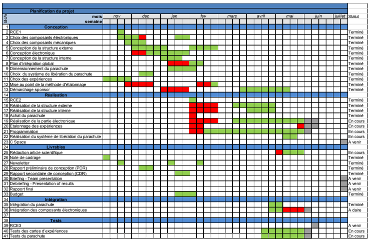


Figure 2: Project's general planning

III) CanSat missions

1) Mandatory mission

The mandatory mission of the CanSat competition consists in a mechanical deployment. We decided that we would open a door, on which a camera will be attached, to film and take pictures of the surrounding area during the descent of the CanSat.

2) Secondary mission

As we wanted to realise an atmospheric probe, the secondary mission we chose is the recording of data such as the temperature, the atmospheric pressure and the humidity.

IV) CanSat design

1) Electronic structure

Our CanSat is controlled by a raspberry PI model A+. A raspberry sense HAT collects the atmospheric data that will be stored on a microSD card in a CSV file while a servo driver will control a servo motor in order to open the CanSat's door.

Figure 3: Raspberry cards with the camera

Figure 4: The servo motor and its driver and batteries

A switch will be placed between the CanSat's structure and the parachute, when the latter is deployed, it will trigger both the opening of the door and the recording of the data.

Figure 5: CanSat's switch

2) Mechanical structure

Our CanSat is composed of two main elements: an external cylindrical structure and an internal structure. The external structure possesses a door for the deployment as well as a lid. The internal structure is made of three threaded rods and three discs separating the different levels.

The CanSat was designed using CAD software SolidWorks. It was then 3D printed, with the exception of the aluminium threaded rods.

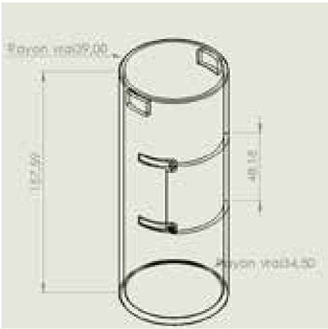


Figure 6: CanSat's main structure's dimensions

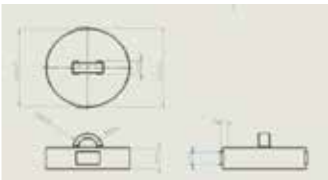


Figure 7: CanSat's lid's dimensions

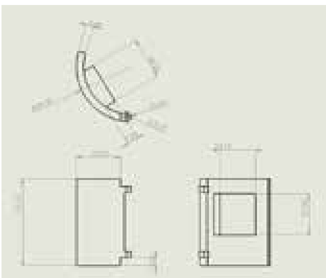


Figure 8: CanSat's door's dimensions

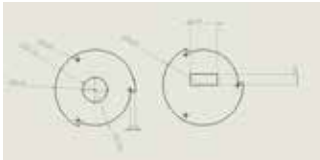


Figure 9: Internal disc's dimensions

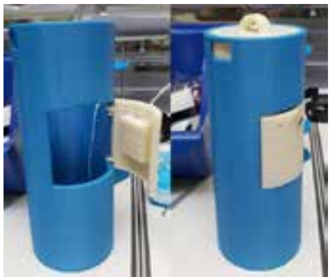


Figure 10: CanSat's main structure

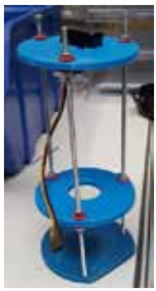


Figure 11: Internal structure

V) Discussion and conclusion

The CanSat project is the first technical project that we have had the occasion to work on. It is a great opportunity for us to familiarize with project management, but also with embedded electronics and mechanical design. Due to our lack of experience in the matter among other things, we encountered many difficulties during the project such as lack of time, organizational missteps or difficulty to obtain the necessary components. However, we were able to overcome most of these obstacles and pursue the project, we are now finalising our CanSat.

Acknowledgement

We would like to thank the following individuals for their contributions:

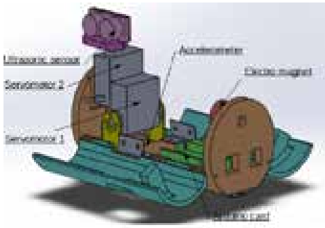
- Mr. Grégoire CHABROL who allowed us to participate in the CanSat competition and assisted us in every aspects of the project
- Mr. JAMSHIDPOUR, Mr. KAZEMI and Mr. TURKO for their help with electronics
- Mr. AZOTI for his assistance with the 3D printing
- Pr. Shichichi NAKASUKA of the University of Tokyo for his advice
- Pr. Taiwo TEJUMOLA of International Space University for his advice and his support
- Every teacher and staff member at ECAM Strasbourg-Europe
- The team of Planète Sciences and the CNES who gave us this great opportunity

Cansat scientific article – Template and Method

Satlxm, discover the environnement before a landing

BERTRAND Maxime DARCOT Paul LIMAT Mathis

I) Introduction



Our project is to develop a satellite module which can achieve a mission to pick up some data that we can use after. Moreover, this project contributes for our Personnal Project during this year which represents 25 % of our Engineering Sciences mark for the baccalauréat.

Our module must land, be stable, and take data about the environnement around the satellite to make a representation and to know the positions of obstacles. The components are not expensive and our module is very little so it could be use for instance to prepare a landing of a robots on a planet.

Our Cansat can answer to the question : « Is this place favorable for a landing ? ». To answer, we will use our module to make a representation of the surroundings of the module.

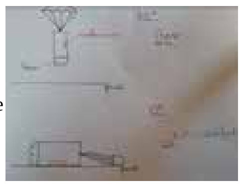
II) Cansat Team

Our club, Spatialxm, was founded last year. It's the first project of our club with Planètes Sciences but there one in our high school which developp some projects in relation whith the space and aérospatial. Currently, there are 4 members in our team for the Personnal project in Engineering Sciences : BERTRAND Maxime, DARCOT Paul and LIMAT Mathis. Our teacher, M. Laloy helps us in this project. In the future, this club could have some other members if some others students of Xavier Marmier, our school, participate to an other contest of Planètes Sciences.

Maxime knew how use Solidworks and he had the possibilities to use some equipments at home so he takes care of mecanics, Mathis prefered the programmation and Paul take care of everything in relation whith electronical components.

III) Cansat Missions

III.1 Mandatory Mission : The landing



The first mission of our module is the landing and the deployment of the components to prepare the second mission. For this mission, we have chosen some many components as a parachute and foam at the extremity to cushion the fall. We use an accelerometrer to know when the satellite will be stabilized (the programm deduce the inclinaison of our module) . The programm launch the deployement for θ<10° to prevent the inclinaison of ground and the possible mistakes of the sensor. The calibration shows a mistake of approximately 4° maximum.

Calibration:

Real angle (in °)	0°	10°	20°	30°	50°	70°	90°
Mesured angle (in °)	0,3°	9°	20,5°	28,8°	48,8°	66,8°	88°

When the angle is enough low, we deactivate an electro magnet which kept the walls closed. One hings on each walls deploys it. To conclude, a servomotor rotates 90° to deploy the ultrasonic sensor.

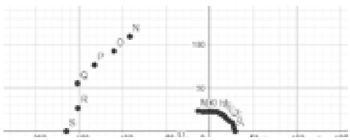
III.2 Secondary Mission

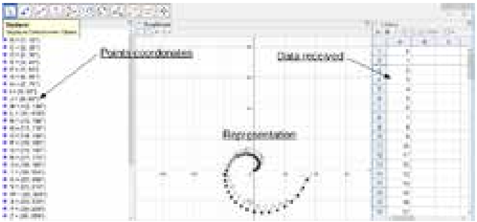
The Secondary mission of our Cansat will be to collect data about the position of the differents obstacles using a ultrasonic sensor. This sensor deliver a ultrasonic impulsion and calculate the length between the sensor and the first obstacle with the time between the impulsion and the reception and the sound speed. We have chosen a HC-SR04 sensor, very less expensive, an easy programmation and a good precision for this price.

Calibration:

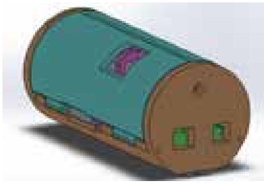
Real distance (in cm)	5 cm	15 cm	20 cm	25 cm	30 cm	100 cm	180 cm	200 cm	250 cm	300 cm
Mesured distance(in cm)	4,9 cm	15,6 cm	19,9 cm	25,2 cm	30,1 cm	101 cm	176 cm	197 cm	246 cm	296 cm

To recolte data around the module, we use an other servomotor where is fixed the ultrasonic sensor. This servomotor turns 10° each time that the sensor collecte data about a position and it does this action 36 times. So we can have the position of everythink around the landing place (the length maximal that the sensor can found is 4 meters). After each data collect, a Radio module send the data to a receptor in link with an other arduino (we use also an arduino card in our Cansat) which write this data on the serial-port. With the Geogebra software, we can make a representation of the environnement of our module. You can found our best test of representation bellow.





IV) Cansat design



Our Cansat has a weight of 600 g, a height of 21 cm with the foam and a diameter of 7,8 cm.

To build the structure, we have using the 3D printer of our Engineering Sciences classroom.

For the programmation, we use Arduino because our teacher use often this software so he was able to help us. So we use one Arduino card on our module to control the components and one other to receive the data (with the receiver) shared by the transmitter. Datas are transmited with a radio module 433 MHz and we use four batteries of 1,5V for our alimentation.

This logigramme represents the most important lines of our programm (I send it also in attachments).

V) Discussion and conclusion

In conclusion, we can say that our results are what we expected. The precision is not very high but it’s our fisrt project so we have make this module with our abilities and we have chosen a mission that we were able to achieve.

To improve our module we can use some other components whith more precision. Moreover, we can add a system to move our Cansat according to the data collected to discover bigger place around the landing place but it seemed too hard for us.

We hope that there will have no issues for the launch. The most important probleme that there could have is that a electric wire disconnected but we will try to reduce this risk but without, our module should work.

We just want to thank our high school for the purchase of our components and our teachers for their help during our project.

Sorbonne Sky Explorer:
CanSat scientific article – Template and Method

Marion Pillas
Come Delfino
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Florian Cavernes
Taki Soualhi

We decided to build a satellite whose size is as large as that of a can (0,33cl) The satellite launch is planned for 2019, so we are actively getting to work. Its mandatory mission is deployment. During the descent, the satellite would unfold to wings as well as a mini parachute.

We also choose a second mission: atmospheric data collection such as temperature, pressure or radiation.
If we get enough money and time, we would like to add to the device a camera for an observation mission. Our choice will be on the telemetry" kiwi" because of its simple implementation. Moreover, we will provide with an esthetic touch, creating a personal and original design.

The challenge will be both to optimize the inner space thanks to a very compact device containing a maximum of electronic sensors, and to minimize the budget. That is the one of the main competition criteria.

All the questions we asked each other among the team resolve around those two purposes.
The team is member of Top Aero, a recent Association created in 2018 by Alexandre Pecheux, the current president who is studying in master 2, Aerodynamics and Aeroacoustics, at Sorbonne
University.

The main purpose of this Association consists of supporting student initiatives relating to aerospace sector at Sorbonne University.
Students can participate to different projects and competitions such as CanSat and Fusex to stir up their scientific curiosity.
The organization is based on a presidential office and about 30 members who each participate to a specific project or contest.
The club managing CanSat and Fusex competitions is called "Sorbonne Space Programm" whose managers are Luc Bruchet and Alesia Herasinenka.

DEPLOYMENT

One of the most important performance will be to manage to stabilize the satellite and to navigate automatically in order to reach the precise foreseen landing area.

For that purpose, the satellite will be equipped with a GPS to locate at any moment its position, a magnetometer to control its direction an accelerometer to monitor its stability and speed.

Besides, the satellite will have to deploy a parachute in order to slow down during the descent.

If we have enough time, we are ready to deploy a small wheeled rover out of the satellite as soon as it touches the ground without any damage. it will travel a short distance while mapping its environment thanks to a radar/lidar.

The two main points, within this step, are first to be able to monitor the satellite direction and secondly to well-size the parachute (surface, height opening, etc...) in order to insure that it will slow down the system correctly.

FREE EXPERIENCE

Regarding to free experience, the parameters we choose to measure are the evolution of radiation, pressure and temperature during the descent. Data collected will be transmitted to a PC on the ground to be analyzed in the form of usable graphs.

Moreover, we will be able to store data into the rover that will be deployed at the end of the mission.

In order to succeed in this experience, we will have to minimize both the size of the different sensors, the transmittor for the communication and the microprocessor linking all the devices of the system. At last, the sensors position will also be and important point to manage during the design phase.

EXTERNAL STRUCTURE

The two support of our satellite are one in Plexiglas and one in PBC, they will support the external structure made in ABS plastic. The rods are in aluminum. In the first phase (before
deployment), the satellite's rods have an exotic shape: the rods will be hold by electromagnets. After the deployment, thank to gravity, because the entire weight is concentered in a specific part of the rod, we "turn off" the electromagnet, that's why the rod can drop. The rods are sloping to make the deployment easier. In the middle of the structure will be place the raspberry.

PARACHUTE

$$S = \frac{2.g.M}{R.C_x.V_d^2}$$

With a speed of 8m/s and a mass of 1kg, we found a surface of 47cmx47cm.

INTERNAL STRUCTURE

Tools

We chose the Raspberry Pi, which is a small computer the size of a credit card. It was designed by a non-profit educational foundation to bring a new perspective to the world of computing, it was on 1981.
Specially we used Raspberry Pi Zero. It is based on the specifications of the A/B model with a processor running at 1 GHz instead of 700 MHz, but it is smaller and has minimal connectivity.

Use of the system

The potential applications of this tool are endless. A little tour of the internet leaves no doubt about the possibilities. When you leave the box, it allows you to use it in office automation with Free Office, Internet access with a web browser, learning programming with Scratch, Python and Minecraft Pi or Ruby and Sonic Pi. Further on there is the whole universe of free and open source utilities under GNU/Linux.
In November 2015, the Raspberry Pi Foundation added the Raspberry Pi Zero to its family of single card computers. The features of this special version are generally very similar to those of the Pi-1 model model A+, but the zero edition is half as small as the version published a year earlier, which suits us given its use in the CanSat project.
The minicomputer has a 1 gigahertz processor, a weight of 9 grams and an ARMv6 architecture.
This tool is compatible and the various sensors that will be connected to it as part of this project.

Programming

The choice of programming language will be python, some language rich in libraries given the strong community on the net.

CONCLUSION

The tests on electronical devices have been made and it’s working. The external structure have been created. We just have to put the pieces together and test the deployment.

SCIENTIFIC ARTICLE

Simulación y Análisis del clima para el cultivo de semillas andinas mediante una capsula no tripulada Wanka

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1. INTRODUCCIÓN:

Los frutos del Ande peruano son variados y según la literatura, poseen altos valores nutritivos en proteínas, calorías y vitaminas [1], [2]. Estos pueden ser parte de misiones espaciales por su gran capacidad de adaptación a los climas fríos y de alto nivel de radiación. El concepto de sembrío inteligente depende de varios parámetros que nos permitan determinar si el terreno y ambiente colindante es idóneo por ello proyecto posee dos etapas, el primero por la parte Francesa, data del desarrollo de una góndola inteligente que permitirá realizar el sensado de índices de CO2, Ozono Radiación UV y agentes atmosféricos como la temperatura, presión atmosférica y humedad relativa a tiempo real a una altura máxima de 28 km de altura impulsado por un globo estratosférico de Helio (Fig Nº1,2), esto permitirá luchar contra la polución y radiación excesiva en lugares exactos de las ciudades industriales o terrenos accidentados partiendo de un análisis integral de toda la columna de recorrido del globo.

Figura 1. Lanzamiento del primer globo estratosférico del laboratorio Smart Machines-Proyecto Q'inti

Por la parte peruana, se construirá una capsula que poseerá semillas de origen andino, como la Kiwicha, Maca, y Quinua a la vez tendrá un sistema embebido que permitirá analizare ambiente con los sensores anteriormente mencionados y podrá decidir si el que cultivo de las semillas mencionadas podrán ser liberadas en tierra. Estas semillas serán sembradas por la capsula mediante un mecanismo que será accionado de acuerdo a los parámetros estudiados, simulando así un sembrío en otros planetas mediante una capsula en tierra. (Fig Nº3). Con ello se busca incentivar la cultura andina, promoviendo el sembrío de las plantas autóctonas de la región en futuras misiones espaciales que desarrolle la Agencia Espacial europea (ESA). El presente proyecto fue aprobado para competir en la campaña de lanzamiento CSPACE 2019 (Organizado por la Agencia Espacial Francesa) como proyecto innovador (Fig Nº5).

Figura 2. Proyectos concursantes en la campaña de lanzamiento C'space 2019

2.- EQUIPO WANKA PROJECT

El equipo peruano de Club Aerospace Peruvian Team, fue fundado el 2010 y consta de 20 miembros el clubo, consiste en la búsqueda constante de la vanguardia tecnológica en la ingeniería aeroespacial, promoviendo la industria y la innovación de esta ingeniería en nuestra región. Al mismo tiempo, ser un equipo reconocido internacionalmente por la participación constante en competiciones aeroespaciales con una gran apertura y suma de elementos de ingeniería que son muy útiles para la comunidad científica en su búsqueda por descubrir los secretos del universo.

El proyecto se estructura en un equipo binacional, entre Francia y Perú, consta de dos etapas; el desarrollo de una góndola estratosférica propulsada por un globo de helio en Francia y una carga útil desarrollada en Perú, esta carga útil es desarrollada con fines de promover la producción y siembra de semillas andinas para misiones espaciales. El equipo está conformado por estudiantes de pregrado de ingeniería mecánica, eléctrica y robótica y un ingeniero eléctrico como asesor del proyecto. La imaginación y técnicas del equipo junto con el compromiso del desarrollo tecnológico de la región andina llevaron al equipo a promover la cultura andina en la campaña de lanzamiento C'space 2019 en Francia

Figura 3. Team Proyecto Wanka

1. MISIONES

La principal misión mandatorial es la expansión de la capsula expulsada del globo estratosférico Francés (Fig Nº4) a una altura de tres kilómetros de altura, para ello se cuenta con un secuenciador para aproximar la altura de caída con ayuda de un sistema de encapsulamiento con hilo de nylon y un actuador con cable de resistencia omhinca de hilo Nicrom en una placa asegurada con la capsula. Fig Nº4

Figura 4. Caída de la capsula, liberada a una altura aproximada de 3 km

La segunda misión será analizar parámetros ambientales para el sembrío de semillas de los andes peruanos, se necesita saber parámetros como la temperatura, radiación UV, humedad relativa y Presión para ser introducidos en un análisis mediante un interfaz gráfico de sondeo que nos permitan descargar las semillas, la misión consta en la llegada a tierra sin daños y la liberación inmediata de las semillas. Todos los datos del despegue y aterrizaje estarán siendo almacenados internamente en la capsula, luego para ser recopilados en el recojo de la capsula.

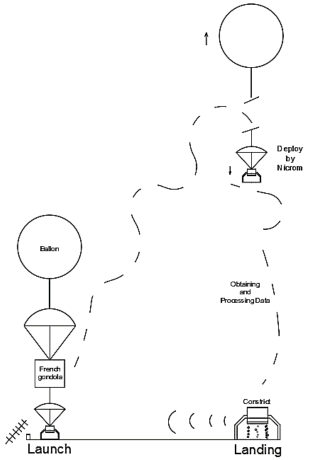

Figura 5. Misión Proyecto Wanka CSpace 2019 [10]

DISEÑO

Según la regulación de la agencia espacial francesa, el peso de la capsula sin paracaídas oscila un valor máximo de medio kilogramo 500 gr, y las dimensiones son estrictas en cuestión de tamaño con un mínimo de 150 mm de altura y 10 mm de diámetro base.

Debido a las proporciones, el prototipo consta de sensores básicos y la estructura construida por varios materiales compuestos como; poliuretano, plástico ABS, Fibra de carbono de refuerzo y pernos.

La metodología de diseño data de establecer funcionalidad en el prototipo creando una interface compatible de acuerdo al propósito del proyecto. También ver el objetivo de impacto visual que poseerá el equipo, todo el esquema general de diseño se ve en la siguiente figura:

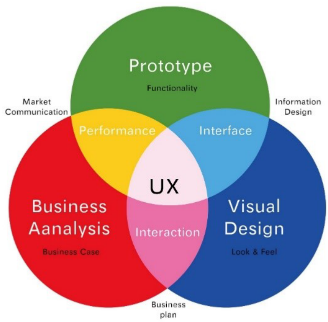

Figura 6. Diagrama de Ven del diseño del *prototipo*

MECÁNICA:

El diseño se basa en una capsula Dragon de volumen rígido [3], para poder cumplir con la norma y limitación del peso, su utilizaron materiales compuestos, como el poliuretano, fibra de carbono en los soportes de las patas, impresión 3D para la protección de las placas y para almacenar los tres tipos de semillas, el sistema innova en la parte del accionamiento del servomotor con solo 180 grados de giro para seleccionar el tipo de semilla que se desea sembrar.

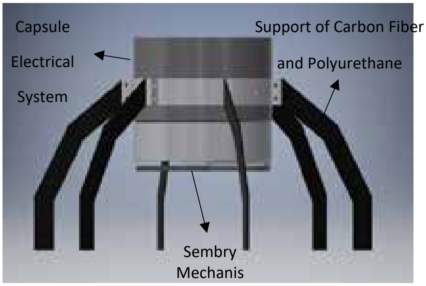

Figura7. *Diagrama sistema mecánico de la capsula*

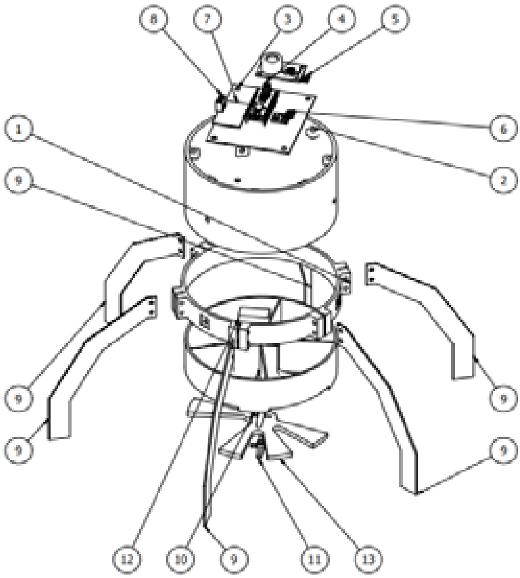

Figura 8. *Vista de Explosión del Prototipo*

ELEMENTO	CTDAD	Nº DE PIEZA
1	1	Aro Soporte
2	1	Caja de Componentes
3	1	Placa de componentes
4	1	Arduino Nano
5	1	Sensor de Temperatura mq
6	1	Sensor de Presión
7	1	Base Nicrom
8	1	Nicrom sujetador
9	6	Patas Soporte
10	1	Secciones
11	1	Conector Motor
12	1	Servomotor HTX900
13	1	Aperturador

Tabla 1. *Elementos del prototipo*

SISTEMA ELECTRÓNICO:

El sistema principalmente consiste en un sistema embebido en base de la placa Arduino Nano y sensores integrados, además este mismo opera los módulos de telemetría para la ubicación por GPS, finalmente este sistema también opera el servomotor de seccionamiento de las semillas.

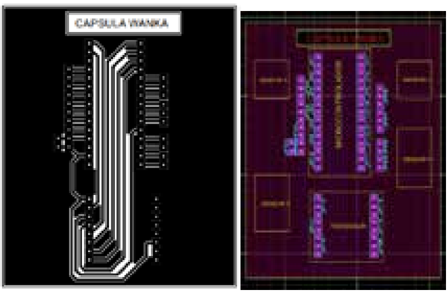

Figura 9. *PBC del sistema embebido de la capsula*

SENSORES:

- **ML8511**

El ML8511 es un sensor UV, que es adecuado para adquirir intensidad UV en interiores o exteriores. El ML8511 es equipado con un amplificador interno, que convierte la corriente fotoeléctrica a voltaje dependiendo de la intensidad UV. Esta característica única ofrece una interfaz fácil para circuitos externos como ADC. En el modo de apagado, típico La corriente de reserva es de 0.1uA, lo que permite una mayor duración de la batería.

- **BMP180**

BMP180 es una placa de circuito impreso, que incluye un sensor de presión barométrica/atmosférica absoluta, de alta precisión (la presión atmosférica es la fuerza por unidad de superficie que ejerce el aire sobre la superficie terrestre), tiene un rango de medida de entre 300 y 1100 hPa (Hecto Pascal) y un margen de error de 0.03 hPa, además dispone de sensor de un sensor de temperatura y por medio de software permite calcular la altitud con respecto al mar.

El sensor de presión está basado en tecnología piezo-resistiva de alta eficiencia, linealidad y larga duración, tiene un rango de alimentación de entre 1,8 voltios y 3,6 voltios dc (corriente continua), por lo que, si lo vamos a usar con un microcontrolador que funcione a 5 voltios, necesitaremos adaptadores de nivel en los pines SDA (línea de datos) y SCL (línea de reloj) del bus I2C. El módulo central dispone de una fuente de 3.3 voltios integrada, puede ser alimentado a 5 voltios en el pin marcado como Vcc, pero también puede ser alimentado con 3.3 voltios en el pin marcado como 3.3 voltios.

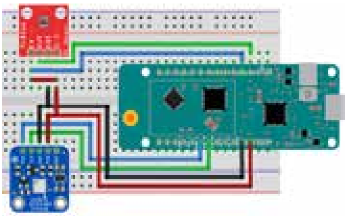

Figura 10. *Circuito eléctrico entre el sensor DHT22 y el Arduino Nano*

- **DHT22**

Los sensores DHT11 y DHT22 son sensores digitales de Temperatura y Humedad, fáciles de implementar con cualquier microcontrolador. Utiliza un sensor capacitivo de humedad y un termistor para medir el aire circundante y solo un pin para la lectura de los datos. Tal vez la desventaja de estos es la velocidad de las lecturas y el tiempo que hay que esperar para tomar nuevas lecturas (nueva lectura después de 2 segundos), pero esto no es tan importante puesto que la Temperatura y Humedad son variables que no cambian muy rápido en el tiempo.

El rango de medición de temperatura es de -40°C a 80 °C con precisión de ±0.5 °C y rango de humedad de 0 a 100% RH con precisión de 2% RH, el tiempo entre lecturas debe ser de 2 segundos.

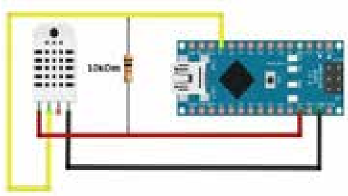

Figura 11. *Circuito eléctrico entre el sensor DHT22 y el Arduino Nano*

INTERFAZ GRAFICA

Diagrama de bloques en LabView:

Figura 12. *Diagrama de bloques entre los sensores BMP180 – ML8511 en LabView*

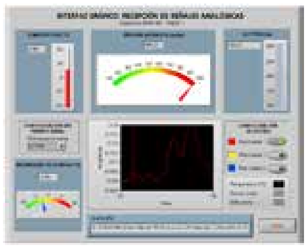

Figura 12. *Interfaz gráfico con los sensores BMP180 – ML8511 en LabView*

Sensor	Nombre	Rango de Medición	Rango de Temperaturas	Voltaje	Conexiones
Presión	BMP180	300 – 1100 hPa	-40 a 85 °C	3,3 V	GND => GND VIN => 5V SCL => A5 SDA => A4
Luz UV	ML8511	0 – 15 mW/cm2	-30 a 85 °C	3,3 V	GND => GND VIN => 3.3V OUT => A0 EN => A1
Arduino Nano			-40 a 85 °C	6 – 12 V	

Tabla 2. Datos de los sensores y microcontrolador

TELEMETRIA

Los módulos Lora son una tecnología por IOT utilizando un tipo de modulación especial para obtener alcances de 15km con una potencia de solamente 10 mW.
Con una antena clásica en la recepción y 10 mW (18 dBm) en emisión, la potencia en la recepción es de -104 dBm. Con la sensibilidad teórica de -141 dBm, no hay problema. Pero, con nuestras pruebas en Lima, parece que debajo de -100 dBm, el módulo Lora no recibe nada.
Dos soluciones son posibles. La primera es de utilizar más potencia en emisión. Es posible, pero este aumenta la masa de baterías necesaria. La mejora solución es de utilizar una antena de alta ganancia en la recepción.
El tipo de antena lo más clásico por estudiantes es una antena Yagi. Este tipo de antena tiene tres tipos de elementos diferentes.

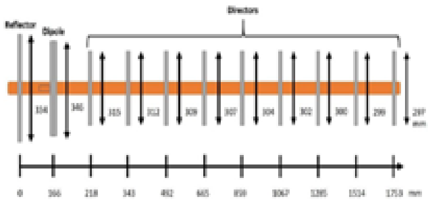

Figura 13. Partes de una antena Yagui (Referencial)

Los directores, son palos de metal sin conexiones con el dipolo, que guían las ondas electromagnéticas hasta el dipolo. El reflector es otro palo de metal sin conexión con el dipolo, para asegurar que la antena recibe ondas viniendo de solamente una dirección. Y por fin, el dipolo, un palo de aluminio cortado en dos, conectado al módulo LoRa.
Las dimensiones de la antena utilizada son las siguientes. El soporte (naranja en el dibujo) es de madera, pero puede ser de cualquier material que no conduce la electricidad.

El dipolo es cortado en dos, y conectado de esta manera a un cable coaxial de 50 ohms compatible con el LoRa (RA-02).

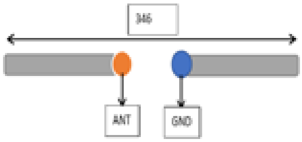

Figura 14. Conexiones internas de la antena Yagui

La ganancia teórica de la antena es de 12,3 dBi, pero la ganancia real debe ser un poquito menor, a causa de las perdidas con el cable coaxial.

Las conexiones del módulo LoRa con el Arduino son las siguientes:

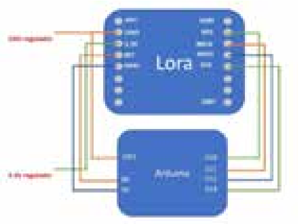

Figura 15. Diagrama de conexiones del sistema embebido de Telemetria

Construcción de una antena Yagi, a fin de realizar la transmisión de la información se ha visto necesario el diseño y construcción de una antena, y dadas las facilidades para poder construir una antena de este tipo, además de sus características tanto de ganancia como de direccionalidad, se decidió usar este tipo de antena, la cual ya se encuentra terminada.

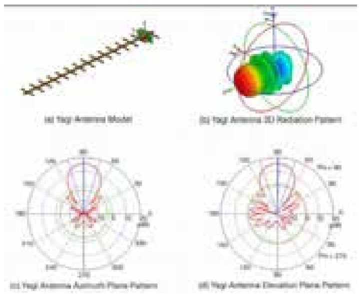

Figura 16. Diagrama de radiación de una antena tipo Yagui [10]

Para poder realizar la antena se han tenido que realizar ciertos cálculos, los cuales nos indican tanto la longitud que debe poseer cada varilla, como la distancia de separación que debe haber entre las mismas, siendo realizados los cálculos de la siguiente manera.

Para la frecuencia de 433 MHz:

$$L = (5 * 10.4) + 17.3 + 10 = 79.3\ cm$$

Separación entre elementos:
Entre reflector y dipolo: $7500/f$
Entre dipolo y director: $4500/f$
Entre directores: $4500/f$

Element	Length (K/MHz = cm)
Reflector	150/433 = 34.6 cm
Dipolo	142.4/433 = 32.8 cm
Director 1	135/433 = 31.1 cm
Director 2	133/433 = 30.7 cm
Director 3	130/433 = 30.0 cm
Director 4	129/433 = 29.7 cm
Director 5	126/433 = 29.0 cm

Table 3. Tabla de valores de directores de antena

Tubo de soporte de elementos:
Además, se usó un ajuste de gama

Reflector-Dipolo	17.3 cm
º	10.4 cm
Director 1 – Director 2	10.4 cm
Director 2 – Director 3	10.4 cm
Director 3 – Director 4	10.4 cm
Director 4 – Director 5	10.4 cm

Table 4. Tabla de valores de longitud inicial de antena

"Gama Match" a fin de poder regular la frecuencia en cierto rango, e incluso modificar la ganancia de la manera que se desee.
Gracias a estas medidas se desarrolló la construcción de la antena:

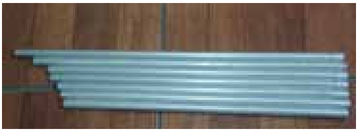

Figura 17. Barras cortadas a las dimensiones calculadas

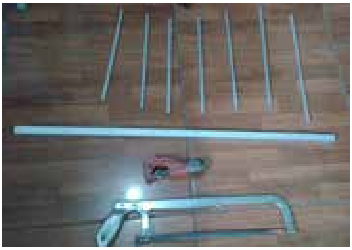

Figura 18. Todos los elementos junto con el soporte

Figura 19. Antena Yagi para 433 MHz

MISIÓN DE SEMBRIO:

Los valores nutritivos de los cultivos andinos son muy positivos para la alimentación de los seres humanos y animales en todas las edades de crecimiento [8]. Según los estudios desarrollados por el ministerio de agricultura y producción del gobierno peruano se obtiene las siguientes tablas de valor nutricional por cada 100 gr de cultivo tratado:

Componentes / *Components*	Por 100 g / Per 100 g
Proteínas *Protein*	12,9 g
Calcio *Calcium*	247 g
Fósforo *Phosphorus*	500 mg
Hierro *Iron*	3,4 mg
Ceniza *Ash*	2,5 g
Grasa *Fat*	7,2 g
Fibra *Fiber*	6,7 g
Carbohidratos *Carbohydrates*	65,1 g
Humedad *Humidity*	12,3 %
Valor energético *Energy Value*	358 Kcal
Tiamina *Thiamine*	0,14 mg
Riboflavina *Riboflavin*	0,32 mg
Niacina *Niacin*	1,0 mg
Vitamina C *Vitamin C*	3,0 mg

Figura 20. Valor nutricional de la Quinua. (Fuente: PromPeru)

El mecanismo para la siembra consta de un servomotor de 1kgr de torque que abrirá una compuerta que liberará la semilla de acuerdo al ángulo establecido de giro.

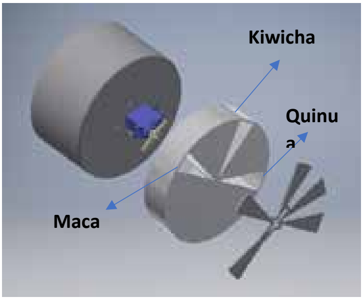

Figura 21. Almacén de semillas y mecanismo de liberación mediante

La selección de la semilla será de acuerdo al terreno donde cayese la capsula, esto debido a un estudio satelital previo según el earthobservatory.nasa al medir cuidadosamente las longitudes de onda y la intensidad de la luz visible e infrarroja cercana reflejada por la superficie de la tierra en el espacio, los científicos utilizan un algoritmo llamado "Índice de vegetación" para cuantificar las concentraciones de vegetación de hojas verdes en todo el mundo. [7]

Mediante un algoritmo en Matlab se extrae un área de posible caída de la capsula, de ahí se trata con sensores satelitales mediante librerías y se tiene un área posible donde los cultivos prosperaran de acuerdo los parámetros ambientales de esa zona geográfica (FIGURAS)

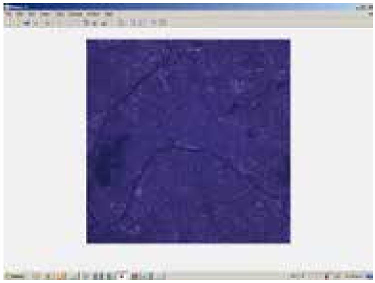

Figura 22. Zona de estudio por satélite

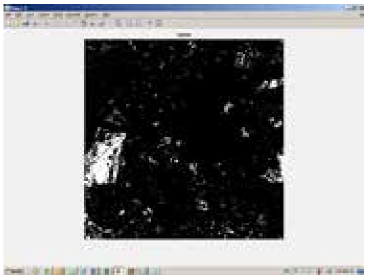

Figura 23. Zona tratada mediante NDV1 (índice de vegetación) para

CONLCLUSIONES Y DISCUSION

Durante los primeros ensayos de la capsula la parte mecánica sufrió leves daños en los soportes inferiores, por ello se tuvo que realizar simulaciones de impacto por el método de elementos finitos y se concluyó que se tendría que cambiar los soportes por materiales compuestos, en este caso la fibra de carbono fue escogida para reforzar la parte interna de las patas. Por las normas de que se nos plantean en Planet Sciences, se recubrirán la patillas con poliuretano para reducir riesgos de accidentes en el lanzamiento. Fig 27.

Figura 24. Análisis de caida de la capsula, Deformaciones Equivalentes

Las pruebas de los sensores fueron correctas, el error que se presenta es por toma de temperatura, y varia de acuerda a la calidad del sensor esto se puede mejorar cambiando de componente, mediante el interfaz gráfico se puede ver como varían los parámetros de acuerdo a los lanzamientos y el desempeño del sistema embebido.

Figura 25. Pruebas de sensor de temperatura

Se realizaron pruebas de diferentes puntos, desde el interior de la universidad a una distancia aproximada de 1.1 km (Figuras 1 y 2) y desde dos distritos costeros de la ciudad de Lima; desde el distrito de Chorrillos a sur de la ciudad y el distrito del Callao, desde la península de la punta tomando una distancia aproximada de 17.8 kilómetros (Figura 3 y 4),

Figura 26. Primera prueba dentro de la Universidad, con éxito en la toma de datos del GPS

Figura 27. Primera prueba: Antena Yaggi en posición para recepción de datos.

Figura 29. Segunda prueba: Antena Yaggi en posición para recepción de datos.

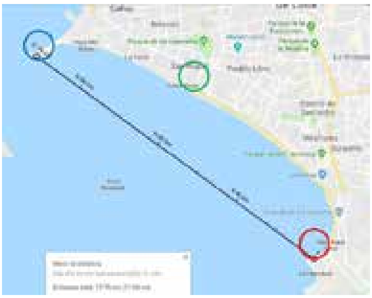

Figura 28. Segunda prueba dentro desde dos distritos de la ciudad, con éxito en la toma de datos del GPS.

La transmisión de datos fue exitosa, los parámetros de emisión en las pruebas fueron de presión, temperatura y coordenadas GPS (Figura). El ruido o interferencia fue mínimo y se espera tener éxito en los envíos de datos, pero esto depende del nivel de interferencia que se tenga.

Figura 30. Datos en transmitidos por el sistema embebido, Monitor serial Arduino.

Para la obtención de datos para el sembrío, es complejo instalar un sistema de análisis por imágenes in-situ en la capsula por motivos de peso, por ello es mejor estudiar datos obtenidos por los satélites de internet, y realizar una interpolación días previos al lanzamiento. Es sistema en caída debe liberar una, dos o a la vez los 3 tipos de semillas dependiendo del ambiente si es fiable para que prospere de acuerdo al estudio previo NDV1.

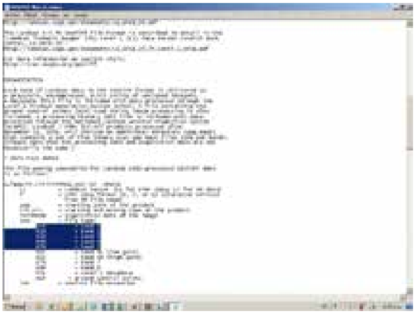

Figura 31. Código de análisis NDV1 utilizado en el proyecto

PROYECTOS A FUTURO

Planeamos lanzar mediante un globo estratosférico hecho en CTIC-UNI una misma carga y simular la misión en la ciudad de Huancayo, Perú con él un plus que hemos estado trabajando, como es el control de caída mediante control no lineal mediante un parafoil (Era nuestra propuesta para el concurso C'space pero no entra en las reglas). Realizar las misiones y sacar datos tanto de la estratosfera como en la capsula de sembrío.

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Figura 32. Logo del proyecto, Capsula y Sonda Estratosferica.

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