# DESIGN AND DEVELOPMENT OF A CANSAT PROTOTYPE FOR THE COLLECTION OF ATMOSPHERIC PARAMETERS


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***Abstract*-The aerospace technology is a very important sector in the world in the reality of each country. Important research is being worked and developed in different part of the world. In this context, Peru is not indifferent to this reality, the national commission of Aerospace Research and Development, CONIDA, has been making progress, which are reflected in rockets capable of studying the median atmosphere, control and image processing of Peru-Sat 1.**

**University institutions such as the National University of Engineering also promote the development of these technologies through UNISEC-PERU and TEAM CANSAT-PERU in addition to the support of international institutions such as UNISEC-GLOBAL and PLANÈTE SCIENCES; we have used the CANSAT methodology for this purpose. Which consists of the design and validation of a miniaturized "satellite" in the volume of a soda can, usually has the mission of collecting data, performing controlled returns or in some cases fulfilling a predetermined mission profile.**

**This paper will present the design and results of the construction of a CANSAT prototype which performs atmospheric data collection and transmission, gps location, kinematic parameters and the storage of images on a sd card; Which will be captured on the descent. In addition to deploying a system of photovoltaic recharge and ejection mechanism of a miniature astronaut.**



**Keywords-Mosaicing, Sensor, Cansat, aeroespacial,fotovoltaico**


# I. INTRODUCTION

Aerospace science is interdisciplinary and includes concepts of different specialties in this scope, allowing a wide field of research. Nowadays, in a CanSat mission, not only atmospheric data (pressure, humidity, temperature, etc.) are taken, but also can include the taking of images for later processing, these images can give us useful information about the landing terrain, the type of Soil, predominance of green areas and others.

The structure of this paper consists of the definition of objectives, the definition and design of each subsystem, the integration of subsystems into what is the preliminary design. And the results and conclusions obtained from the final design.

In the phase that contemplates the conceptual definition defines the mission of our CanSat and the subsystems such as the Mechanics, Electronics, the control and processing of images.

The design continues with the selection of electronic components and embedded systems, calculation of the energy requirement, modeling of the control system, mechanical design of the support structure and mechanical drive systems, as well as the aerodynamics of the blanket and parachute. Post processing of the images obtained.

The following section shows the integration of the CanSat by adjusting some design parameters to allow the joint work of the subsystems. Finally, a summary of the results.

# II. OBJECTIVES

## II.1 General Objectives

Design and development of a system of atmospheric data collection and imaging for later processing based on CanSat technology

## III.2 Specific Objectives

1. Obtain a mechanical structure that is rigid enough for launch conditions.
2. Design and manufacture electronic boards and the power system to allow the taking of atmospheric data in free fall.
3. Get a panoramic relief image from photos taken by the vehicle on the descent.
4. Design and manufacture a solar cell deployable mechanism to improve the autonomy of electric charge to the system.

# III. DESIGN

The design of the Can-sat was worked by subsystems:

1. Mechanics
2. Sensing electronics.
3. Control
4. Acquisition and postprocessing of images.

The development of subsystems is detailed below

## III.1 Mechanical

The mechanical part of the Can-sat comprises the support structure, parachute ejection mechanism, solar cell deployment system and the parachute. Each of them were designed optimized to the conditions of the mission of the Can-Sat

A. the support structure

The structure allows the correct arrangement of electronic devices. Manufacturing was achieved with a 3D printer, made of ABS plastic.

In addition to the distribution, the structure safeguards the integrity of the internal components, so that in the design a rigidity analysis was performed using the finite element method to the most critical conditions of work, to ensure that it can land at 5m / s.

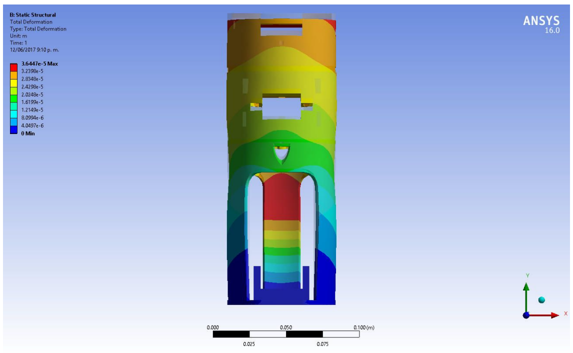


*Figure 1. Fem simulation of the structure (Deformation results)*

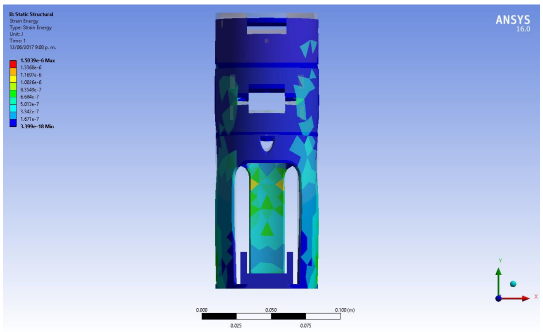


*Figure 2. Fem simulation of the structure. Deformation energy results*

B. Ejector mechanism

Mechanism driven by 8 springs and initialized by the burning of a cable of nichrome. This results in the expulsion of the parachutist

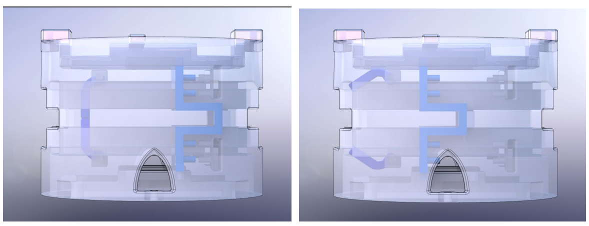

*Figure 3 Starting position and end of the parachute ejection mechanism*

C. Solar cell deployment system

The system allows the release of an extendible support that allows to orient solar cells to be able to collect energy for the electronic systems.

The system is driven by torsional springs and released by heating a nichrome wire.

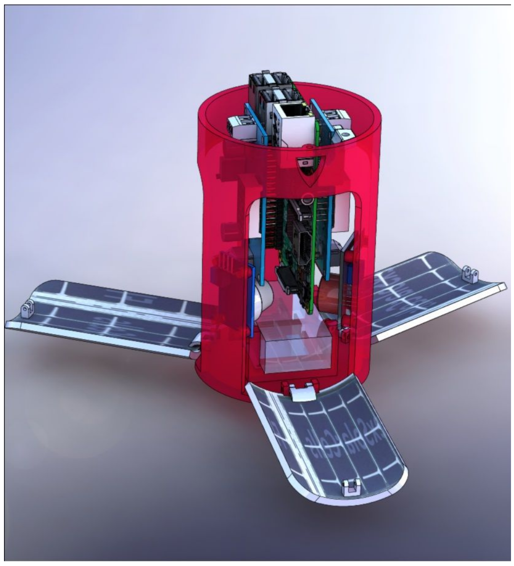

*Figure 4. Photovoltaic energy collector system deployed.*

Additionally, the displacer system provides a greater drag force compared to cansat without unfolding the cells. The CFD analyst said that the drag force is increased by 260%.

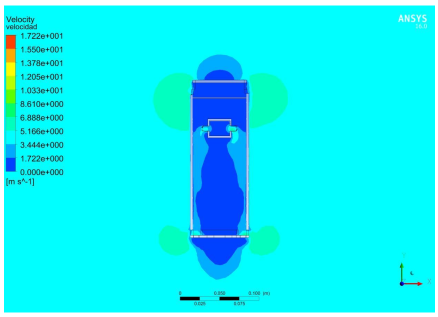


*Figure 5. Cansat CFD simulation without deploying the photovoltaic system*

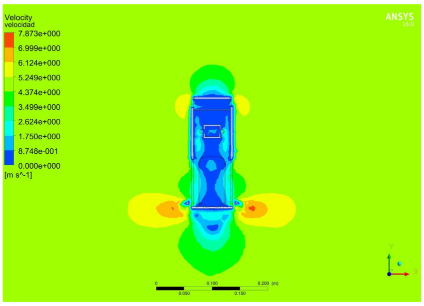

*Figure 6. Cansat CFD simulation deployed the photovoltaic system*

## II.2 Electronics

Considering the requirements in the telemetry mission and the planetary probe mission the CanSat hardware was implemented in such a way to select the appropriate components.

The main part of the CanSat is a microcontroller which is the power supply of the sensors and the RF module; the electronic components will be integrated into an electronic board which is fed from a source at a voltage set at 5v.

The list of components found in the following table

| Components | Function |
|---|---|
| Arduino FIO 3V3 | Flight Computer |
| BME-280 | Atmospheric pressure, temperature and humidity |
| MQ-7 | Carbon monoxide |
| MQ-135 | Nitrogen oxides |
| GY-521MPU6050 | accelerometer |
| EM-506 | Latitude and longitude |
| Xbee-Pro | RF transmitter |
| Micro- SD | Storage of data |

*Table 1. Hardware CanSat and functions.*

The electronic architecture will be appreciated in the following figure, both the hierarchy and the connection of the different devices.

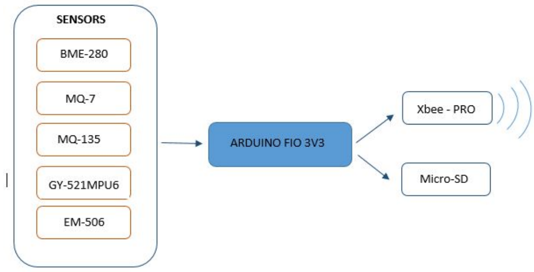


*Figure 7. Block diagram of the electronic architecture*

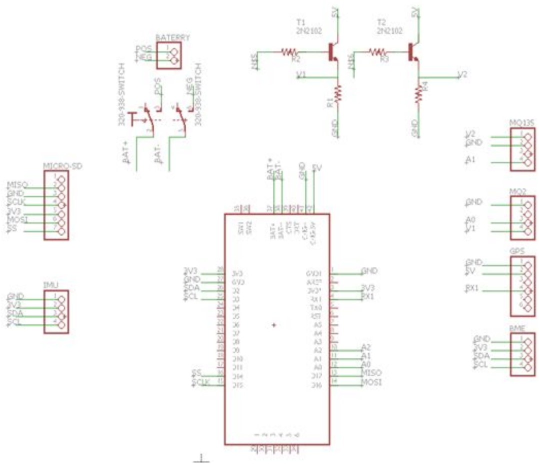

*Figure 8. Can-sat schematic board of (Eagle 7.5.0 software)*

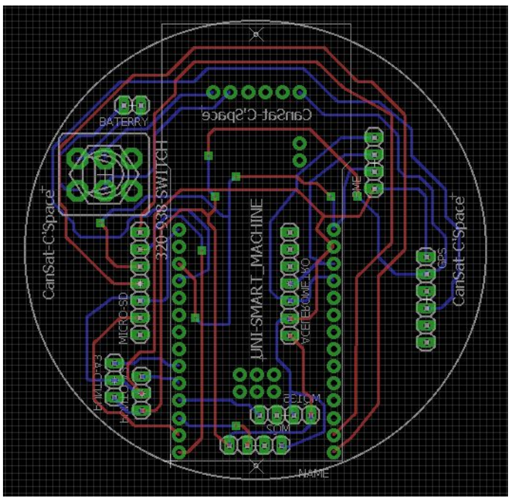


*Figure 9. Can-sat electronic board (Eagle 7.5.0 software)*

The following table has been designed considering the current consumption of the circuit

| Description | Voltage avg (V) | Current (A) | Energy consumption (Wh) | Current consumption (Ah) |
|---|---|---|---|---|
| Arduino FIO 3V3 | 3.7 | 0.04 | 0.148 | 0.04 |
| BME-280 | 3.3 | 0.0000036 | 0.00001224 | 0.0000036 |
| MQ-7 | 5 | 0.07 | 0.035 | 0.07 |
| MQ-135 | 5 | 0.07 | 0.035 | 0.07 |
| GY-521MPU6050 | 3.3 | 0.0046 | 0.01518 | 0.0046 |
| EM-506 | 5 | 0.05 | 0.25 | 0.05 |
| Xbee-Pro | 3.3 | 0.12 | 0.01518 | 0.0046 |
| Micro- SD | 3.3 | 0.045 | 0.1485 | 0.045 |

*table 2. consumption of energy and current in the board.*

The power distribution are shown below.

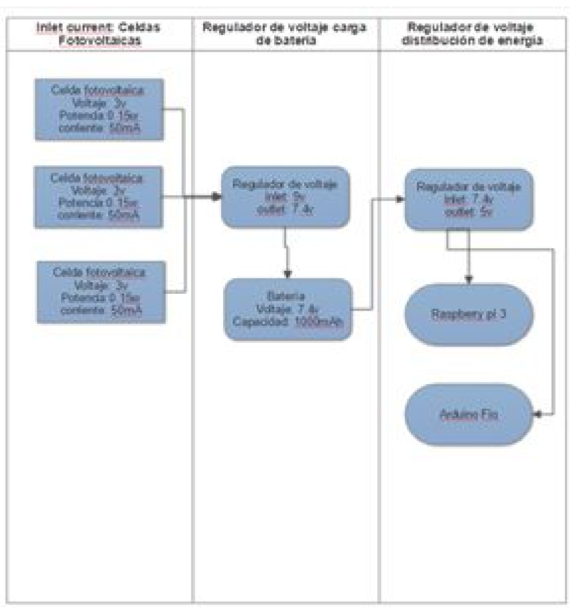


*Figure 10. Diagram system power.*

## II.3 Control

The control system allows the correct functioning of the actuators, sensors and the acquisition of images.

Initializing all the systems, and activating, according to the condition of reading of the accelerometer, the mechanical systems of deployment and ejection, through the cable of nicron.

The following diagram shows the flowchart of the logic control system.

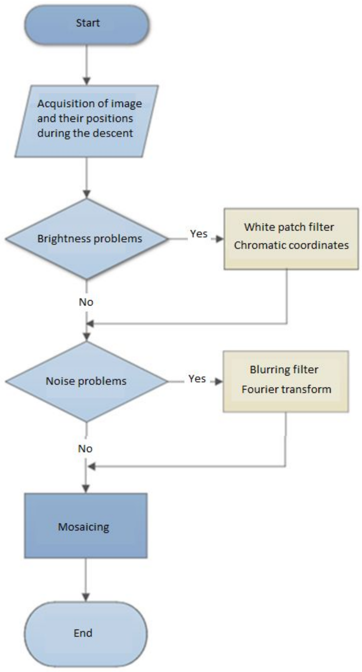


*Figure 11. Flow chart of the control system*

## II.4 Image acquisition and post-processing

A. The image acquisition.

The image acquisition process is implemented with the raspberry pi 3 plate and its camera module V2.


*Figure 12. Raspberry Pi Camera Module V2*

The raspberry pi has an algorithm that gives a time interval (t) for sequencing shooting. The time interval will depend on the height at which it is released and the estimated descent rate.

```
import os
import time

FRAMES = 1000
TIMEBETWEEN = 6

frameCount = 0
while frameCount < FRAMES:
    imageNumber = str(frameCount).zfill(7)
    os.system("raspistill -o image%s.jpg"%(imageNumber))
    frameCount += 1
    time.sleep(TIMEBETWEEN - 6) #Takes roughly 6 seconds to take a picture
```

*Figure 13. Script imaging algorithm.*

B. Post-processing of images

In the post-processing it is sought to obtain a single general image of the launch area from the images obtained during the landing.

For them is that a series of filters is made in order to correct the errors present in the image capture, so that you can get to integrate all the images through a process called "Mosaicing".

The filters are detailed below:

## B.1. Chromaticity coordinates

This transformation minimized the negative effect of light intensity change

## B.2. White Patch

White patch algorithm is an algorithm of color constancy.

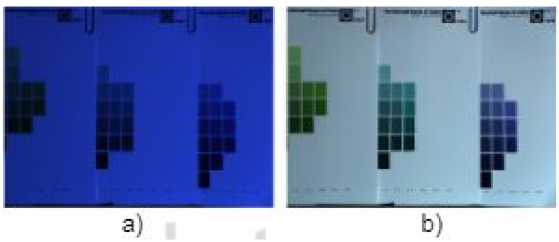


*figura 14. a)original image b)Processed image with white patch algorithm.*

## B.3. Blurring

The blurring filter is a low-pass filter is used to remove noise.

*figure 15. application example fourier transform*

## B.4 Transformada de Fourier

Frequency filters process an image working on the frequency domain.

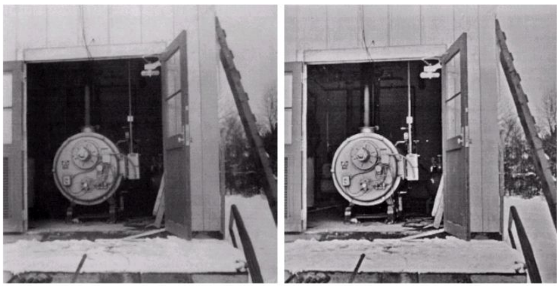

*figure 16. Application example of Fourier transform*

## B.5. Mosaicing or Stitching

It is the process of combining several images to produce a segmented panorama or high-resolution image.

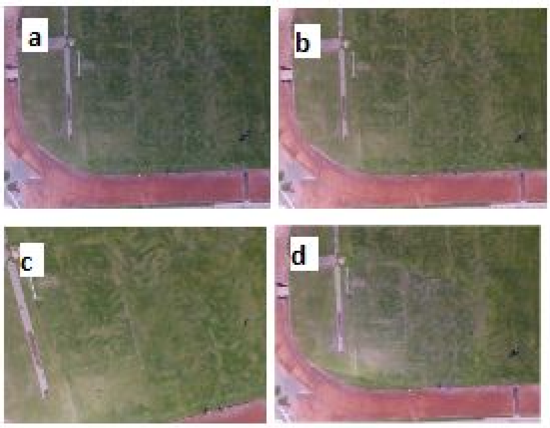


*Figure 17 a, b y c. Images taken at 20 m. high in the stadium of the National Engineering*

*University. d.mosaicing of images a, b and c without filters.*

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