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CENTRE NATIONAL
D'ÉTUDES SPATIALES

Dossier de présentation

Competition CANSAT FRANCE 2017

CanSat France

17 - 19 JUILLET
Camp militaire de Ger du 1er RHP
(Régiment de Hussards Parachutistes)

TARBES
MINISTÈRE DE LA DÉFENSE ET DES ANCIENS COMBATTANTS
Planète Sciences
une aventure pour les jeunes

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Compétition CANSAT France 2017

La compétition CanSat France se déroule du 17 au 19 juillet sur le camp militaire de Ger du 1er Régiment de hussards parachutistes (RHP).

6 équipes en compétition
8 CanSat à larguer

La compétition CanSat France a lieu dans le cadre du C'Space, rendez-vous annuel des étudiants avec l'espace, organisé par le CNES avec l'association Planète Sciences. Durant cette manifestation, les projets spatiaux des étudiants seront mis en œuvre sur le site pyrénéen du 1er RHP, à partir d'un ballon captif. Le défi CanSat consiste à fabriquer un satellite de la taille d'une canette de soda et à lui faire réaliser des expériences scientifiques et techniques spécifiques.

Lâché à 150 m depuis un ballon, le CanSat devra réaliser une mission obligatoire : le déploiement et au moins une mission libre. Cette année, une mission bonus apparaît : objectif parachutage d'une figurine de spationaute.

Un jury d'experts du spatial évaluera les projets et récompensera la meilleure équipe selon des critères prédéfinis. Un prix spécial sera décerné par le CNES au meilleur projet.

~~La compétition CanSat a pour ambition d'offrir aux étudiants un contact direct avec un véritable projet technique comprenant toutes les phases : conception de la mission et du véhicule, rapports intermédiaire et final, certification, campagne de lancement, analyse des résultats...~~

L'idée de la compétition CanSat a vu le jour aux États Unis, en 1998, lors d'un meeting à Hawaï. Cette compétition destinée aux étudiants a eu un fort succès dès son lancement. Depuis, l'événement a dépassé les frontières américaines pour conquérir le Japon, l'Argentine, puis l'Europe et notamment l'Espagne, les Pays-Bas et la France depuis 2009 à l'occasion du C'Space.

Le mot CanSat est la contraction de canette et satellite. Lors de la création d'un CanSat, il s'agit donc d'intégrer tous les éléments essentiels d'un satellite dans une canette de soda. Le volume de ces sondes spatiales doit se situer entre 33 cl et 1 litre.

Les CanSat sont des dispositifs autonomes, capables de réaliser des missions définies. Toutes les fonctions de base d'un satellite (alimentation, communications, géolocalisation…) y sont contenues.

Cet outil représente une plate-forme d'apprentissage exceptionnelle pour tous les jeunes intéressés par la conception et la fabrication de sondes spatiales ou de satellites.

Qu'est-ce qu'un CANSAT ?

Les CanSat sont largués à 150 m d'altitude, depuis un ballon captif et peuvent effectuer plusieurs types de missions :

- Les aspects technologiques vont permettre de déployer des appendices, de communiquer avec une station au sol, de faire de la navigation GPS ou de réaliser un atterrissage en douceur sur une cible prédéfinie.
- Les aspects scientifiques vont permettre de mesurer des paramètres liés à l'environnement de la sonde. Par exemple, le CanSat pourra transmettre au sol des informations générées par des capteurs, telles que des données atmosphériques et de l'imagerie.
- La mission libre est proposée par l'équipe, en plus de la mission scientifique obligatoire et de la mission bonus facultative.

Dans la compétition française, il existe 2 catégories :

- L'International Class, concernant tous les CanSat de 33 centilitres et de 350 grammes.
- L'Open Class, concernant tous les CanSat de plus de 33 centilitres allant jusqu'à 1 litre et ne dépassant pas 1 kilogramme.

Le projet CanSat se déroule en 2 phases :

- La phase de conception et réalisation,
- La phase de présentation, mise en œuvre et conclusion.

Lors de la compétition et devant un jury de professionnels et industriels du spatial, les clubs devront :

- Exposer leur projet au jury.
- Mettre en œuvre l'atterrisseur sur le terrain.
- Présenter leurs résultats de vol et le bilan de leur projet en faisant une analyse aussi bien scientifique qu'organisationnelle.

Une compétition riche d'expériences

Les missions de la compétition 2017

Mission obligatoire

- **Le déploiement :** lors de sa descente ou de son atterrissage, le CanSat devra effectuer un déploiement hors du volume du Cansat qui doit répondre à un but clairement établi (similitude avec une sonde, intérêt du déploiement, originalité du concept). Les CanSat de l'édition 2017 devront être originaux et pertinents si les équipes souhaitent remporter cette édition devant un jury de professionnels du domaine.

Exemples de missions libres

1- **Le sondage atmosphérique :** lors de sa descente, le CanSat devra prendre et transmettre par télémesure, une mesure de température et d'altitude au moins toutes les 5 secondes. La vitesse moyenne de descente sera estimée grâce à l'altitude de départ (connue de l'organisation) et du temps total de descente. Elle sera comparée à la moyenne des vitesses de descente transmises.

2- **La détermination de la position du CanSat sans GPS :** les planètes autres que la Terre ne disposent pas de satellite GPS. Si une sonde doit se poser, il faudra qu'elle connaisse sa position pour orienter son antenne. La mission consiste à déterminer la position du CanSat au maximum 5 minutes après l'impact. Il sera demandé sa latitude et sa longitude en WGS84 – système de référence de positions au voisinage de la Terre. La localisation exacte sera alors mesurée par l'organisation.

3- **La terraformation :** technique essentiellement théorique et source d'inspiration de la science-fiction. Elle consiste à faire évoluer l'environnement d'une planète pour le rendre compatible avec les besoins humains. Pour cette mission, il est demandé au CanSat, après atterrissage, de percer un petit trou dans le sol et d'y déposer une graine de céréale.

Mission bonus 2017

- **Objectif parachutage :** cette mission est facultative et permet à une équipe d'obtenir un bonus pour le largage d'un spationaute depuis le CanSat. Il s'agit de procéder au parachutage d'une figurine de spationaute munie d'un parachute durant le vol du CanSat.

Programme

CanSat 2017	9 h - 13 h		14 h - 18 h
Dimanche 16/07	Accueil des participants		
Lundi 17/07	Installation moyens sol		Tests en vol
Mardi 18/07	Présentation des projets devant le jury		Démonstration en vol
Mercredi 19/07	Retours d'expériences des vols devant le jury	• Délibération du jury (11 h 30 - 12 h 30) • Remise des prix (12 h 30 - 13 h)	Bilan des projets (18 h)

Le Jury 2017

Comme chaque année, un jury d'expert est présent pour départager les CanSat en compétition. Composé de trois professionnels du secteur spatial, il évalue les projets en fonction de critères spécifiques et récompense la meilleure équipe.

Lors de la compétition, les clubs devront :

- Exposer leur projet au jury
- Mettre en œuvre le CanSat à bord d'un ballon captif
- Présenter leurs résultats de vol et le bilan de leur projet en analysant les aspects scientifiques et de gestion du projet.

Les 8 projets CanSat

Club	Projet	Ville ou pays	Missions libres	Responsable
CanSat-Perú Team	Cansat-rover Comeback	Pérou	Navigation autonome, photographies, collecte de données atmosphériques	Williams SOLIS QUISPE
CanSat-Perú Team	CanSat-UNI-Perú	Pérou	Détection atmosphérique, cellules solaires	Williams SOLIS QUISPE
Estaca Space Odyssey	Can-Diver	Saint-Quentin-en-Yvelines	Navigation autonome	Charles MERINO
Estaca Space Odyssey	Swarog	Saint-Quentin-en-Yvelines	Mesures environnementales, transmission de données en autonomie	Hadrien BILLIAU
Louis Lumière	VMSat	Marly le Roi	Mesures de pression, de température, de composition de l'air en altitude	Vipulan PUVANESWARAN
OCTAVE	Cansat-UEVE	Evry	Déploiement d'un trépied pour un atterrissage vertical, mesures atmosphériques (Pression, CO^2, température, altitude, humidité)	Aurélien DURUISSEAUX
UGC-17	Hinadori CanSat	Japon	Mesures environnementales, transmission de données au sol	HINADORI
UGC-17	土竜	Japon	Mesures d'accélération, de vitesse, de pression, du magnétisme et utilisation d'un GPS	MOGURA

Compétition 2017

C'Space 2017, Camp de Ger

SCIENTIFIC DESCRIPTION

CanSat projects

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

Williams Solis
Departamento de Ingeniería Mecánica
Universidad Nacional de Ingeniería
Lima, Perú
williams.solis.q@uni.pe

Luis Alvarado
Departamento de Ingeniería Mecánica
Universidad Nacional de Ingeniería
Lima, Perú
luis.alvarado@uni.pe

Jhoseling Melgarejo
Departamento de Ingeniería Física
Universidad Nacional de Ingeniería
Lima, Perú
jmelgarejo@uni.pe

Richard Santiago
Departamento de Ingeniería Mecánica
Universidad Nacional de Ingeniería
Lima, Perú
rsantiagos@uni.pe

José Espinoza
Departamento de Ingeniería Electrónica
Universidad Nacional de Ingeniería
Lima, Perú
jespinozar@uni.pe

***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.

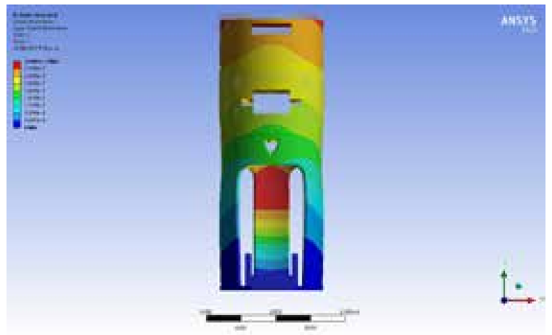

Figure 1. Fem simulation of the structure (Deformation results)

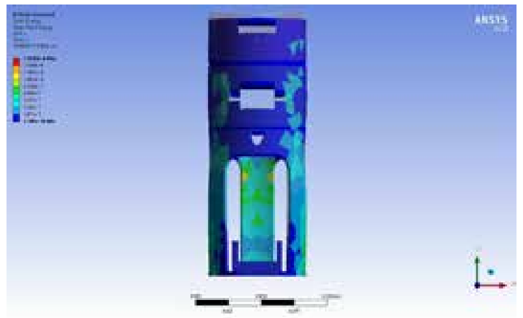

Figure 2. Fem simulation of the structure. Deformation energy results

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

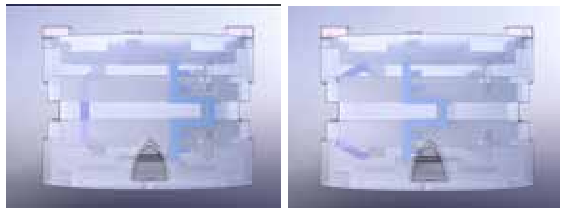

Figure 3 Starting position and end of the parachute ejection mechanism

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.

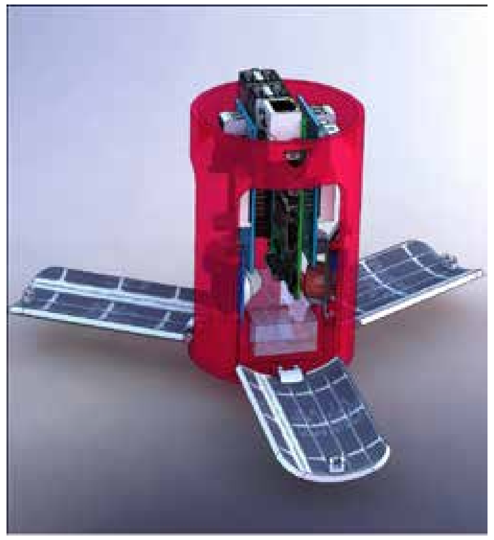

Figure 4. Photovoltaic energy collector system deployed.

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%.

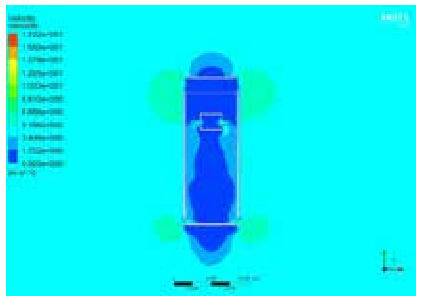

Figure 5. Cansat CFD simulation without deploying the photovoltaic system

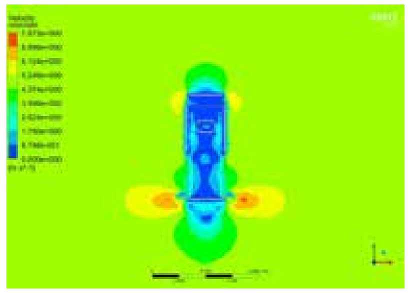

Figure 6. Cansat CFD simulation deployed the photovoltaic system

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.

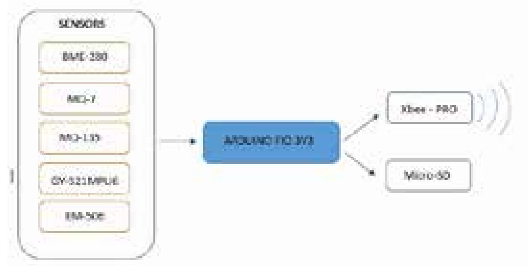

Figure 7. Block diagram of the electronic architecture

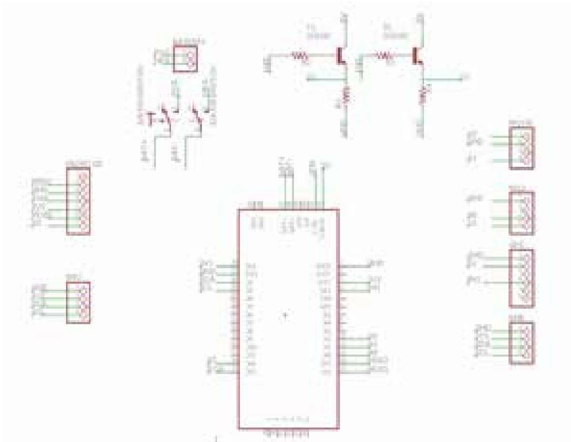

Figure 8. Can-sat schematic board of (Eagle 7.5.0 software)

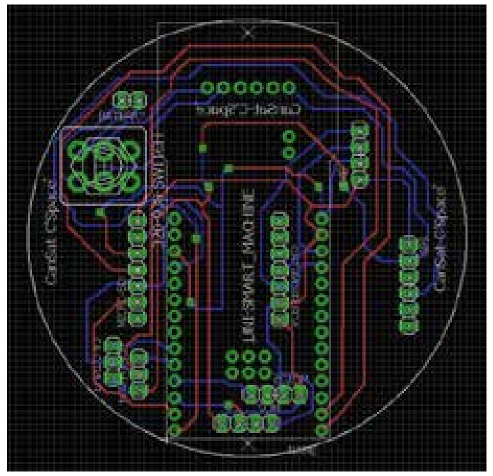

Figure 9. Can-sat electronic board (Eagle 7.5.0 software)

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.

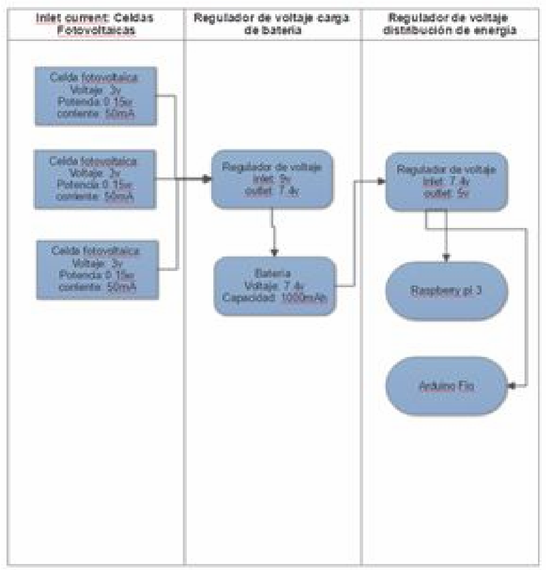

Figure 10. Diagram system power.

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 rt of the logic control system.

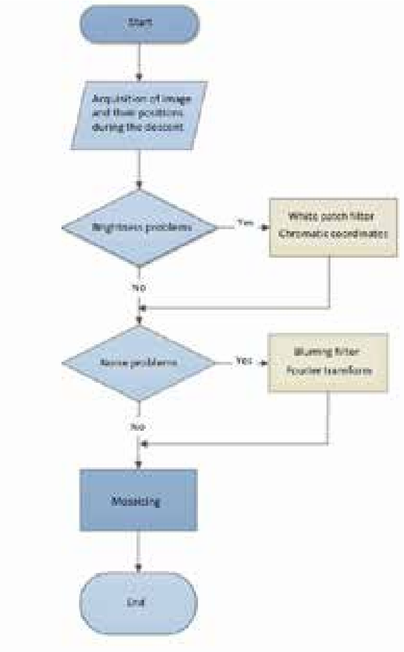

Figure 11. Flow chart of the control system

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.

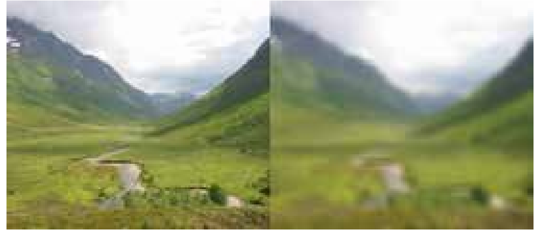

figure 15. application example fourier transform

B.4 Transformada de Fourier

Frequency filters process an image working on the frequency domain.

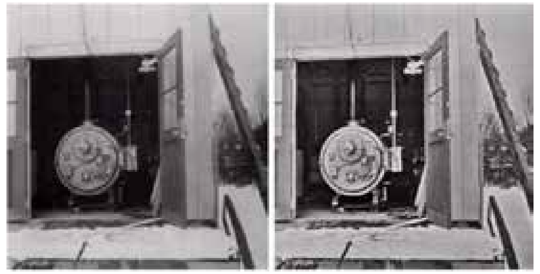

figure 16. Application example of Fourier transform

B.5. Mosaicing or Stitching

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

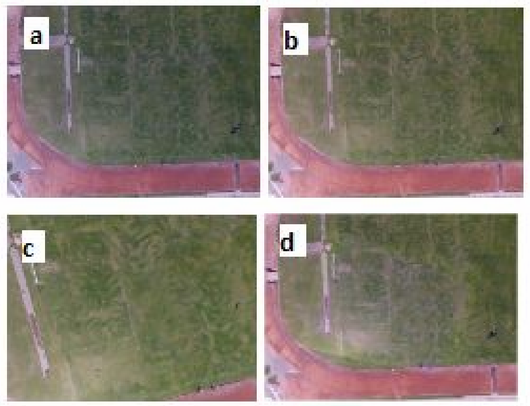

Figure 17 a, b y c. Images taken at 20 m. high in the stadium of the National Engineering

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

Acknowledgment

Each member of the laboratory "Smart-Machines".
The director of the Center of Information and Communication Technologies (CTIC-UNI) Alonso tenorio Trigoso for the support .

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DISEÑO Y DESARROLLO DE UN PROTOTIPO DE ROVER, USANDO LA METODOLOGÍA CANSAT EN PERÚ

Juan Huaroto
Departamento de Ingeniería Mecánica
Universidad Nacional de Ingeniería
Lima, Perú
tutohuarotosevilla@gmail.com

Adriana Ticona
Departamento de Ingeniería Electrónica
Universidad Nacional de Ingeniería
Lima, Perú
aticonag@uni.pe

Rider Paredes
Departamento de Ingeniería Mecatrónica
Universidad Nacional de Ingeniería
Lima, Perú
rider.paredes@uni.pe

Bruno Chumbes
Departamento de Ingeniería Mecánica Eléctrica
Universidad Nacional de Ingeniería
Lima, Perú
cristian.bruno7@gmail.com

***Resumen*—Actualmente en el Perú la ingeniería aeroespacial se viene desarrollando con la agencia aeroespacial de Perú (CONIDA) y con diversas organizaciones, en su mayoría universidades como la Universidad Nacional de Ingeniería, la Universidad Nacional de Piura y la Universidad San Cristóbal de Huamanga, las cuales promueven a nivel académico la investigación en este tema por medio de la organización *University Space Engineering Consortium* (UNISEC). UNISEC-PERÚ promueve la metodología CANSAT, la cual consiste en diseñar un satélite de dimensiones como el de una lata de soda (CANSAT), para fines educativos. Generalmente, un CANSAT puede ser del tipo telemetría y del tipo Rover. El primero tiene como misión principal, realizar un sensado de datos y comunicarlos con una estación en tierra, mientras que el segundo posee como misión principal la navegación autónoma, en tierra; en ambos casos están conformados básicamente por 3 subsistemas: mecánica, electrónica y control. En este artículo abordaremos el diseño y los resultados de la construcción de un prototipo de Rover el cual realiza sensado de parámetros en tierra, tales como temperatura, presión y humedad.**

Palabras clave-aeroespacial, diseño, satélite, sensado, autónoma, Rover.

I. INTRODUCCIÓN

Un CANSAT posee básicamente 3 subsistemas, los cuales permiten tener una estabilidad en mecánica, energía, electrónica y sistema de control. El diseño del Rover se ha realizado desde diversos puntos de vista considerando parámetros ambientales como terrestres [1][2].

Este artículo se divide en 2 partes principales, abordando en principio el diseño y abstracción del sistema como un conjunto y finalmente se presenta os resultados del ensamblaje final del prototipo propuesto.

Dentro de la etapa de diseño se ha desarrollado el diseño mecánico, considerando la estructura, ruedas, paracaídas y carcasa del Rover, lo cual garantiza un correcto funcionamiento del robot, tanto en aire como en tierra. En el sistema electrónico se abordó la elección de componentes electrónicos, con su respectivo balance energético y de consumo de corriente, para elegir correctamente las baterías utilizadas y la autonomía de funcionamiento. Finalmente se describe el sistema de control el cual tiene por función principal realizar la codificación de los algoritmos de navegación autónoma, como el de afinar las señales captadas provenientes del sensado que realiza el Rover en tierra.

En la sección de resultados se muestra las imágenes del diseño final, así como del ensamblaje del prototipo.

II. DISEÑO

El diseño del Rover, se dividió en tres módulos: Mecánica, Electrónica y Control. La descripción de cada módulo se detalla a continuación.

A. Mecánica

La mecánica del Rover se abordó en 3 sub partes: estructura, ruedas, cáscara de estructura y Paracaídas. La estructura se diseñó optimizando los espacios para la disposición de los componentes electrónicos y teniendo en cuenta el tipo de terreno al cual estará sometido el robot. La estructura tiene una forma rígida que permite la resistencia del robot al momento de la caída con el paracaídas. El case sobre el cual el paracaídas se diseñó para envolver a la estructura del Rover y ser el elemento al cual este atado el paracaídas. Finalmente, las ruedas juegan un papel importante al momento de ser diseñadas y ensambladas para que el Rover pueda seguir su marcha, sin atascarse, cuando este se encuentre sobre el terreno lleno de pasto.

A continuación, se explica cada una de las sub partes.

1) Estructura: En la figura 1, se muestra la estructura del rover, donde se puede observar los espacios donde se ensamblarán los componentes electrónicos, la placa electrónica, motores y ruedas.

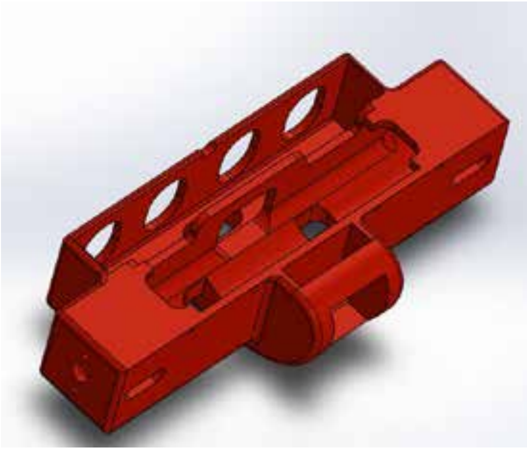

Figure 1. Estructura ensamblada del Rover.

El diseño de la estructura se ha realizado por una impresora 3D y se ha utilizado ABS de material. Para corroborar la rigidez de la estructura, se ha realizado una simulación por elementos finitos [3], tal como se muestra en la figura 2.

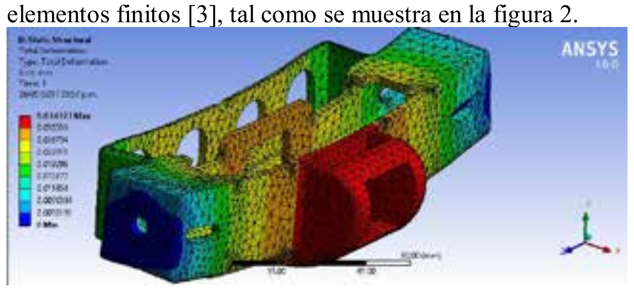

Figure 2. Simulación numérica de la estructura.

2) Ruedas: Debido a las condiciones del terreno, se ha considerado unas ruedas que puedan expandirse al momento de que el Rover entre en contacto con la tierra, para ello se ha diseñado tres tipos de ruedas:

a) Con cocada, sin expansores: En este diseño se consideró la cocada como medio para que el Rover en movimiento no pueda atascarse con el pasto. Dependiendo de las condiciones del terreno físico se propone utilizar este tipo de rueda (ver figura 3).

Figure 3. Ruedas con cocada y sin expansores.

b) Con cocada y expansores 1: En este diseño se propone usar como elemento de expansión unos resortes lineales los cuales irán acoplados a el cubo de la rueda y tambien a las partes que irán en contacto con el terreno (ver figura 4).

Figure 4. Ruedas con cocada y expansores 1.

c) Con cocada y expansores 2: En este diseño se propone usar como elemento de expansión unos resortes de torsión los cuales irán acoplados a el cubo de la rueda y tambien a las partes que irán en contacto con el terreno (ver figura 5).

Figure 5. Ruedas con cocada y expansores 2.

3) Cáscara de la estructura: La finalidad principal de la cáscara, es encapsular a la estructura del Rover permitiendo que las ruedas estén presionadas, en el caso que usen expansores. La cáscara será atada por hilo de nylon, el cual será quemado por un cable de nicrom, dejando libre al Rover, para que empieze a navegar. Por otro lado, la cáscara será el elemento que este atado al paracaidas y estará en primer contacto con la superficie del terreno. La figura 6 muestra la disposición de la cáscara con la estructura del Rover.

Figure 6. Cáscara de la estructura.

4) Paracaidas: En el diseño del paracaidas se ha tenido en cuenta el tipo de paracaidas "Vortex Ring" [4]. Este diseño se ha elegido porque posee mayor coeficiente de arrastre aerodinámico, asi como menor oscilación al momento de la caida. Esto nos permite optimizar la cantidad de tela que se utilizará para la fabricación del paracaidas.

Para calcular el paracaidas, se han hecho uso de las siguientes ecuaciones.

$$Fd = \frac{1}{2}\rho v^2\, Cd\, S \qquad (1)$$

$$W = mg = Fd \qquad (2)$$

Con las ecuaciones mostradas anteriormente, se puede calcular el área que requiere el paracaídas, para su posterior diseño. Para las condiciones dadas de la misión, se está considerando la densidad de la zona, así como una velocidad de descenso comprendida entre 6 – 7 m/s. Dado que el coeficiente de arrastre es un parámetro sumamente importante en el diseño de un paracaídas, se ha elegido un diseño convencional de paracaídas con el mayor coeficiente de arrastre y la menor oscilación posible al momento de la caída [4].

El diseño elegido es el de "Vortex ring" tal como se muestra en vista de perfil en la siguiente figura.

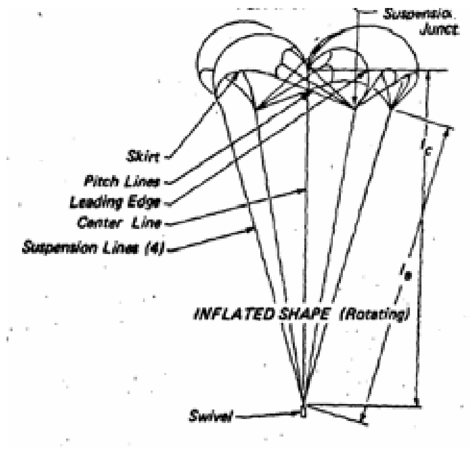

Figure 7. Paracaidas Vortex Ring.

B. Electrónica

Los componentes electrónicos del Rover, fueron seleccionados según la misión de este, considerándose principalmente:

- Liberación automática de la cáscara del Rover al momento de hacer contacto con la superficie terrestre
- Sensado atmosférico y en tierra de: presión, temperatura y humedad.
- Navegación autónoma en tierra.

Todos los componentes en el ROVER, motores, sensores, actuadores, etc. Tienen que ser suministrados con energía eléctrica. El núcleo del ROVER se basa en la tarjeta electrónica, diseñada para la distribución de energía y el procesamiento informático. La tarjeta está diseñada para usar una batería de LiPo de 7.4v. Dos motores son usados para la locomoción del ROVER tipo diferencial. La mayoría de los componentes están conectados y se fusionaran a 2 unidades centrales de procesamiento (Teensy 3.2) ubicados en la placa electrónica. Los principales sensores son acelerómetro, IMU y GPS usados con fines de ubicación, navegación y manipulación del ROVER; de la misma manera estará considerado un lugar dentro de la tarjeta electrónica para el xbee pro usado para la comunicación del ROVER. En la figura 1 se muestra la distribución de los sensores, y controladores en la placa electrónica (figura x).

Figure 8. Placa electrónica del rover, usando el software Eagle 8.0

Además, se ha considerado el consumo de corriente del circuito, se ha diseñado el siguiente cuadro.

TABLE I. CONSUMO DE ENERGÍA Y CORRIENTE DE LA PLACA.

Description	Voltage avg (V)	Current (A)	Energy consumption (Wh)	Current consumption (Ah)
BME 280	3.4	0.0000036	0.00001224	0.0000036
EM - 506	5	0.05	0.25	0.05
IMU LSM9DS1	3.3	0.0046	15.18	4.6
XBEE PRO	3.3	0.12	0.01518	0.0046
DRIVER JRK 21V3	7.4	3A	22.2	3
MOTOR 1	6	2.4A	14.4	2.4

MOTOR 2	6	2.4A	14.4	2.4
TEENSY 3.2	3.3	0.18	0.594	0.18
TEENSY 3.2	3.3	0.18	0.594	0.18

Como se puede visualizar en la table anterior, se tiene un consume de corriente de 12.81 Ah, por lo que, si deseamos que el circuito funcione para una autonomía de seis minutos, se requiere dos baterías de 1000 mAh.

C. Control

Para que el rover realice una navegación autónoma lo primero que se necesita es conocer su posición en cualquier instante de tiempo. Es por esto que usaremos un módulo GPS (EM-506), el cual nos dará la posición en latitud y longitud de nuestro móvil, luego se transformaran estos valores de coordenadas geodésicas a UTM lo que nos permite tener su posición en un plano XY.

Para poder determinar la trayectoria que está siguiendo nos valdremos un sensor inercial (IMU) y de motores con encoders, estos conjuntos de sensores nos darán la posición, orientación y trayectoria que sigue el Rover.

Dada la carga computacional que amerita toda esta toma y procesamiento de datos, se optó por elegir un controlador de tipo ARM de 180Mhz (Teensy 3.6). El diagrama electrónico en el cual se indica las conexiones esta detallado en la figura y.

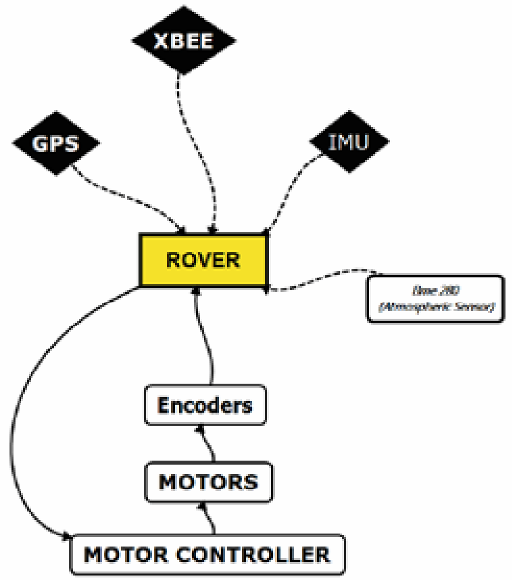

Figure 9. Diagrama del sistema electrónico, de transferencia de datos y de posicionamiento.

La transferencia de datos se hará por medio de un Xbee Pro, mientras que el GPS nos dará la ubicación del móvil en cada instante de tiempo. Finalmente, el sensor IMU sensará una medición indirecta de si el móvil se ha atorado durante la navegación

Se reconoce que todo sensor tiene un error en medición, por lo que para afinar las mediciones registradas se propone la implementación de un filtro. El cual mejore la precisión de estos sensores, dado que es un sistema no lineal, se vio en la necesidad de implementar el EFK el cual se basa en las siguientes ecuaciones [5][6].

$$x_t = g(u_t, x_{t-1}) + \varepsilon_t \qquad (3)$$

$$z_t = h(x_t + \delta) \qquad (4)$$

Donde g y h son ecuaciones no lineales.

EFK depende de los siguientes parámetros (u_{t-1}, u_t, z_t)

Por lo que el algoritmo del EFK vendría caracterizado por las siguientes ecuaciones [7][8].

$$\bar{u}_t = g(u_t, u_{t-1}) \qquad (5)$$

$$\bar{\Sigma}_t = G_t \Sigma_{t-1} G_t^T + R_t \qquad (6)$$

$$K_t = \bar{\Sigma}_t H_t^T (H_t \bar{\Sigma}_t H_t^T + Q_t)^{-1} \qquad (7)$$

$$\mu_t = \bar{\mu}_t + K_t(z_t - h(\bar{\mu}_t)) \qquad (8)$$

$$\Sigma_t = (I - K_t H_t)\bar{\Sigma}_t \qquad (9)$$

Lo que hace el filtro es estimar un estado posterior en base a un estado anterior. El primer paso es predecir el estado futuro mediante el modelo dinámico del sistema, luego se corrige con el modelo de observación, de modo que la covarianza del estimador de error se minimiza. Esto se hace en cada instante de tiempo, ya que es un filtro de tipo recursivo[5][6].

A continuación, se muestra un diagrama que permite visualizar el algoritmo del EFK.

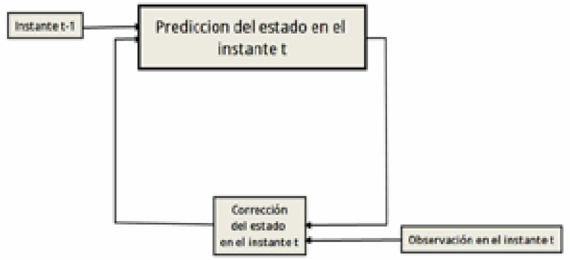

Figure 10. Diagrama de algoritmo EFK.

En nuestro caso usamos este filtro como un estimador de estado [7][8] y este se determinará mediante el diagrama mostrado en la siguiente figura.

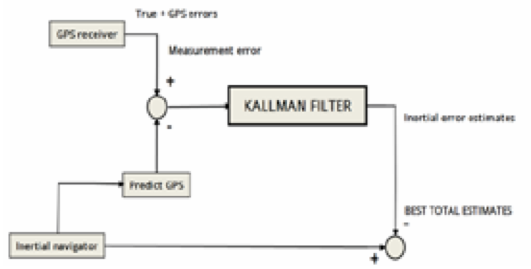

Figure 11. Diagrama de filtro de Kallman.

Finalmente se muestra en la siguiente figura el diagrama de flujo del sistema de control de navegación autónoma del sistema.

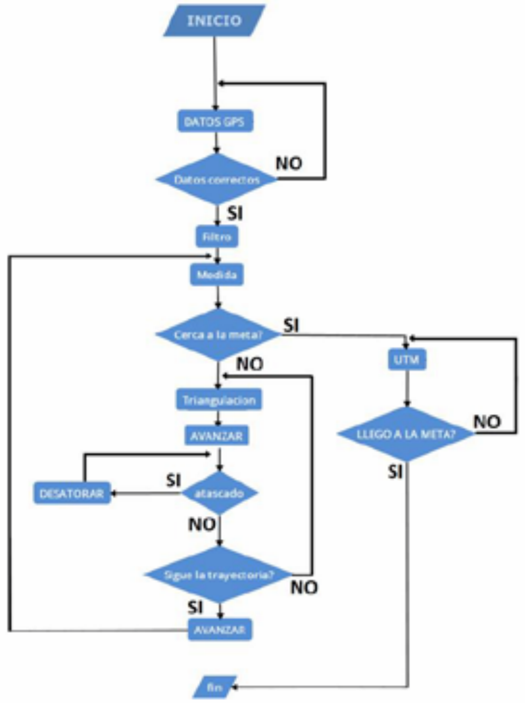

Figure 12. Diagrama de flujo del sistema de control de navegación autónoma.

III. Agradecimientos

A cada uno de los miembros del laboratorio "Smart Machines" del CTIC- UNI, destacando a Aldo Guardia que realizó gran parte del algoritmo de navegación y de filtrado de señales provenientes de la recolección de datos por medio de los sensores, así como a Cristian Gómez que se encargó del diseño y construcción de la carcasa del Rover.

IV. Resultados

Luego de definir cada componente adecuado para el diseño mecánico, electrónico y de control, se procedió a ensamblar cada subsistema, obteniéndose el diseño del prototipo final, el cual puede observarse en la siguiente figura.

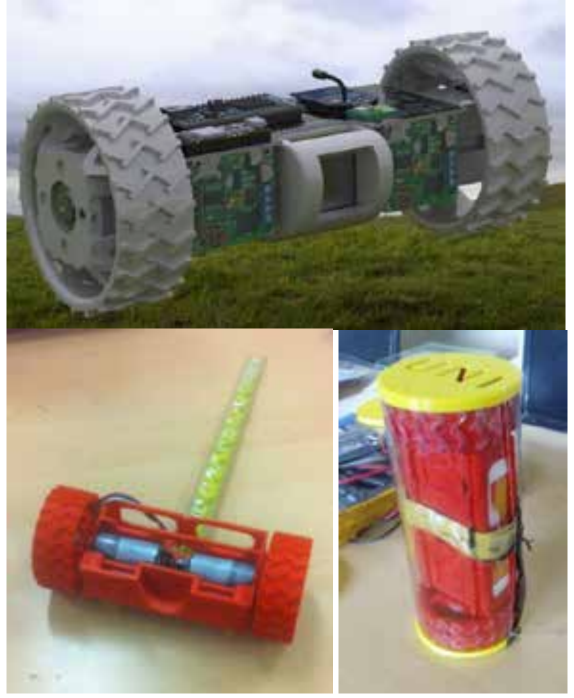

Figure 13. Diseño y ensamblaje del prototipo final.

V. Agradecimientos

A cada uno de los miembros del laboratorio "Smart Machines" del CTIC- UNI, destacando a Aldo Guardia que realizó gran parte del algoritmo de navegación y de filtrado de señales, provenientes de la recolección de datos por medio de los sensores, así como a Cristian Gómez que se encargó de diseñar y construir la carcasa del Rover.

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Swarog, the explorer of the unknown worlds

BILLIAU Hadrien, CLAQUIN Thomas, GALIDIE Julien, GUERSON Dimitri, PERTEL Victor

Abstract – We have one mandatory mission: deploying on the ground, after landing a part of the CanSat, and a free mission. We designed the CanSat to deploy an upper part containing some of the sensors to get a more accurate measurement of the external temperature, pressure, and humidity.
Our free mission is the measurement of atmospheric characteristics (pressure, temperature, humidity) and other characteristics such as the composition of the surrounding light (with a RGB decomposition), and the motion of the CanSat during its fall.

I. Introduction

This article focuses on the Swarog project (pronounced "Svarog"), designed to participate to the CanSat 2017 challenge (Open Class) which takes place in Tarbes, France from July 15th to July 22nd. It will also be launched from a rocket, as it was originally its payload.
The Swarog project is designed to explore Earth like planets. Therefore, we decided to create a CanSat that could fit in a rocket, fall and start to measure during the fall to collect data about the planet environment.

II. Context of development

A. A student project

This project was made inside the ESO – ESTACA Space Odyssey – association, a student association from the ESTACA, engineering school in Saint-Quentin en Yvelines, France. It was initiated as a school project first and was carried on and made real as an associative project.
We decided to participate to the CanSat challenge because the conditions and obligations were close to the ones we had with the FUSEX.

B. A tiny challenge

Once the project started, it has been thought to fit as a payload for a FUSEX. Therefore, the external dimensions of the CanSat have been shortened to 6,5 cm for the diameter and 20 cm height. This was a challenging part of the project as the components and some parts originally designed had to be redesigned.

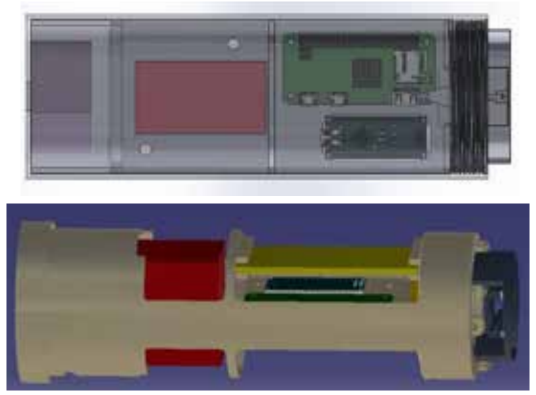
III. Definition of the missions

A. Mandatory mission

This year the challenge's mandatory mission is to realize a deployment mechanism which expends itself out of the CanSat volume. We decided to deploy some sensors in order to first protect them during the fall and the landing, and second to get more accurate measures.
To achieve this, we decided to make an upper container. It was made to fit at the top of the structure, and it is pushed by a servomotor, a simple and tiny enough solution to activate the deployment. Further details will be provided in the next section.

B. Free mission

The free mission makes echo to the search of exoplanets and habitable planet. As we are searching habitable planets outside our solar system and exploring other solar systems to find out extraterrestrial life, the key to probe planets is still to gather data about them. A tiny CanSat is small and light enough to be delivered far away, and cheap enough to let students make simple missions as a training repeatedly.

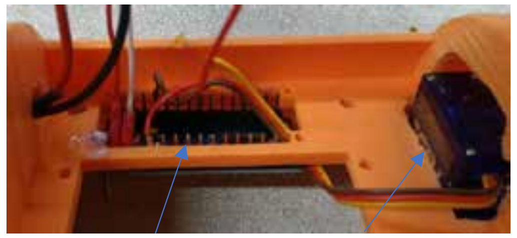


Early concepts of the Swarog project.

IV. Technical solutions

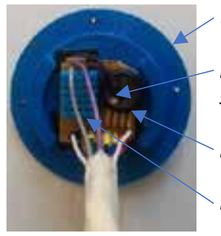
A. Mandatory mission

To realize the mandatory mission, we used a servomotor, controlled by an Arduino Nano. This part is autonomous, as it is easier to secure both the measuring part and the electromechanical part this way. A blinking LED is used to indicate that the CanSat initiated its deployment mission. A jack connector is the way we control the CanSat is no longer in the launching pod or the FUSEX, and the blinker is here for visual inspection purpose.
The servomotor will push outside the upper compartment which contains a humidity sensor, a temperature sensor, and a pressure sensor at the end of a timer, initiated by unplugging the jack connector.

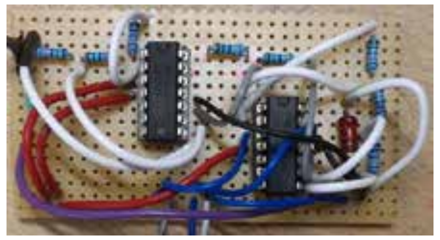


B. Free mission

To measure and record the characteristics of an Earth like planet, we use some analogical sensors and some numerical ones.
First, the upper compartment contains a DHT11 humidity sensor, a P0K1.232.6W.B.007 temperature sensor, and a MPX2202A absolute pressure sensor.



An amplification card is connected to the outputs of the sensors, so the measures can be sent to the core of the CanSat.



Finished amplification card – some wires are not connected yet.

Those measures are read by an analog to digital converter (ADC), and the converted signal is processed and recorded on a micro SD card. The Raspberry Pi Zero v.1.3 is the nano-computer which processes the signal to regroup all the measures on a CSV file and records it on the embedded micro SD card. This card contains the OS of the Raspberry Pi Zero, Raspbian (a modified and light version of Debian Operating System).

Core system – the ADC is on the left of the Enviro pHat additional card, and the Raspberry Pi Zero is under it.

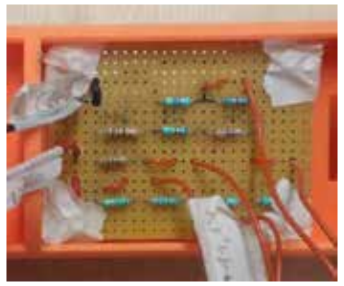
In addition, we use an Enviro pHat which concentrate a motion sensor, a light sensor (or RGB colors sensor), an absolute pressure sensor, a temperature sensor and an ADC. The measures of the temperature are slightly above the test values, which is due to the heat generated by both cards.

The software was coded with Node-RED. This allowed us to use visual scripting, a quicker way to code via diagrams and programable boxes. It was faster to code and to debug this way.

On the lower part of the 3D printed structure, we embedded a camera which will film the ground during the fall of the CanSat. This kind of camera plugs itself on the camera port of the Raspberry Pi Zero (a compatible one is needed).

These cards and sensors are powered by 2 batteries in parallel, 11.1V, 0.5 A (5000 mAh) each. 2 diodes prevent one to charge the other. A LED indicates that the power is on, and a sliding switch allows to turn it on or off. A power card steps down the input voltage to every used voltage using resistances.


The 2 diodes are linked to the positives outputs and the negatives outputs are directly linked.

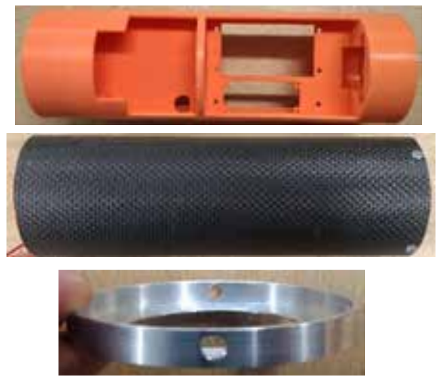


Final design of the power card.

V. Architecture

A. Mechanical architecture

The mechanical structure consists in a 3D printed structure, an aluminum ring and a carbon fibers tube.
The 3D printed structure is the bone of the project: it contains the batteries, the Arduino Nano, the Raspberry Pi Zero, the camera, the Enviro pHat and the servomotor.
The tube is the skin of the project, protecting everything it contains. It is linked to the metallic ring with screws and nuts. A second nut is used to fix 4 cords to the parachute, the 4 others are glued to the carbon tube and reinforced with tape.
The upper container is also 3D printed and the sensor card is glued to it. It is maintained to the structure thanks to nylon reinforced wires.



The 3D printed structure, the carbon tube and the ring.

B. Electrical architecture

Everything is powered by the 2 batteries. 2 diodes prevent dysfunctions and the power card redistributes power at the right voltages and amperages to the components. The Arduino powers and controls the servomotor and the blinking LED.
The amplification card is powered, as the sensors and the Raspberry Pi Zero by the power card. The camera, using the flexible cable, is powered via the Raspberry Pi Zero.

C. Work organization

Another kind of architecture, but without this one, none of this would exist!

BILLIAU Hadrien – Project leader

CLAQUIN Thomas & **GUERSON Dimitri** – Mechanic team

GALIDIE Julien & **PERTEL Victor** – Electronic team

VI. Conclusion

The CanSat is still in progress, because the integration is nearly finished. The different elements are working fine, but the final test will be done when the project will be assembled. This project was a fantastic opportunity to design and build a full functional project starting from zero.
This working prototype will be another concept to explore remotely other worlds, and we hope it will be a source of inspiration for other students or projects makers.

VII. Acknowledgement

We would like to thank for their help and their participation:

Mr. Pierre-Emmanuel Mangin and **FabLab ESTACA** for the 3D printing technology and the advices
Mr. Claude Caruel for the supervision of the school project part
ESO association for the advices, materials and the tools
Mr. Clément Bordeaux for all the help with his coding skills
Mr. Marcel Billiau for all the help for the assembly
Mr. Marcel Tran-Phu-Tri for all the help and the advices
Mr. Marin Sangouard for the help at the beginning of the project

CANDIVER

CanDiver is a French cansat from ESTACA SPACE ODYSSEY. It consists in performing a come-back test before being set on an experimental rocket if successful. Although it is part of the CANSAT 2017 challenge, the device will also take place in a rocket as payload for the FUSEX challenge. In the spirit of recovering first stages, we want to pilot the cansat thanks to a parafoil and land it on a specific location. A GPS and a barometer will feed an Arduino Nano with data which will command two servomotors to control the parafoil. An inertial navigation unit should take care of the whole attitude of the cansat. Also, the structure is 3D-printed. The device will be first dropped from a quadcopter for tests before the campaign.

I. INTRODUCTION

CanDiver is a project developed at ESTACA to demonstrate the first stage's recovery problematic and the mechanism should be set on an experimental rocket in the next few years. Its purpose is to land somewhere we will define at the drop zone with a pilotable RC-parafoil.

Characteristics:
Flat wingspan: 236cm
Ratio: 5.1
Flat surface: 1,1m2
Bridle: Spliced Aramid 50daN / DFL
Tissue: Nylon Ultra-light 20D 32gr
Cells: 23
Space between risers: 10 to 16cm

RC-Parafoil used

The cansat uses several sensors with an Arduino nano to complete its mission.

- GPS Adafruit Ultimate for its position
- Barometer Bmp180 for its altitude
- Inertial Navigation Unit Mpu6050 for its attitude

Flight data are collected on a SD card to be analysed after the landing. They will help to determine if the cansat follow the track we set thanks to waypoints. Landing legs will also be deployed.

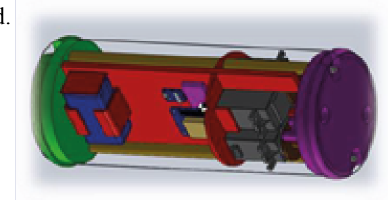
II. CONTEXT OF DEVELLOPEMENT

The project team is composed of 5 members from the 2nd year to the 4th year of ESTACA in aerospace engineering. We are part of ESTACA SPACE ODYSSEY which participate in the campaign of the C'Space for years now and launching several small and experimental rockets. This association takes places with the courses in class and work is done in our free time. We have earned money from two sponsors to finance this project.

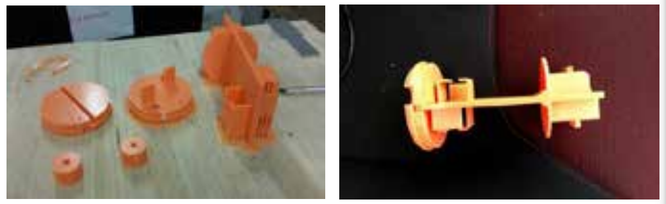
III. CANSAT ARCHITECTURE

A. Mechanical parts and structure

The cansat was designed with Solidworks and then 3D-printed.



3D model with Solidworks



CanDiver's structure

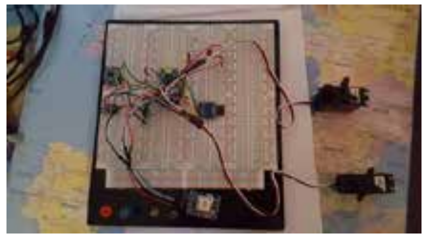
The main issue was the characteristics which must fit the challenge's requirements. We began with an Arduino Uno too large, it could not fit with the servomotors inside. So, we changed for a Nano, lighter. Then, we had to figure out how to place the servos to use the commands properly. We chose to redirect them while they enter in the cansat from two holes placed on its forward's perpendicular axis.

We shall have to fix how to deploy the parachute. We have now the program for the assurance of its well deployment after the fall but not the mechanical part. We must think about how to pack it properly within the balloon's basket to guarantee the deployment. We will approximately use the same method as used in skydiving but with few adjustments because it is a parafoil.

Finally, the device is 200mm long, 80mm large and weight 1kg. These are the greatest dimensions allowed.

B. Electrical architecture

The electrical design is based on drones. Basically, CanDiver uses its GPS to know where he is; a barometer to determine its altitude and an inertial navigation unit to determine its attitude while it is controlling the servos. During the flight, data will be stored into the SD card to be further analysed to determine how successful the mission is.



CanDiver's electrical architecture on a breadboard

IV. DEFINITION OF THE MISSION

The cansat will target waypoints determined before the flight, on the ground. They will be selected depending on the wind, the drop zone and the precision of the sensors. The GPS has from 5 to 10m of precision like all civilian positioning systems and the barometer is 1m precise. So, we will choose a dozen of waypoints every 15m on the horizontal plan and every 5m high also due to the altitude of the drop. All of the waypoints should be stored directly on the Arduino Nano. The trajectory will be as straight as possible because we do not take wind in consideration for the drop from the balloon. The altitude is too low. From the rocket, we shall use wind to wait between to waypoints which will more separated.

The inertial navigation unit will provide information about the attitude. It will directly pilot the servomotors by commanding them how long they have to stay in there position. When the cansat need to turn, a servo pull its command for a time and the Mpu controls how long. So, we need to filter the noise if we want to prevent the cansat from changing the servos' position during all the flight. We use a filter of Karman, learnt during courses, to adjust the noise and guarantee a safe travel.

V. CONCLUSION

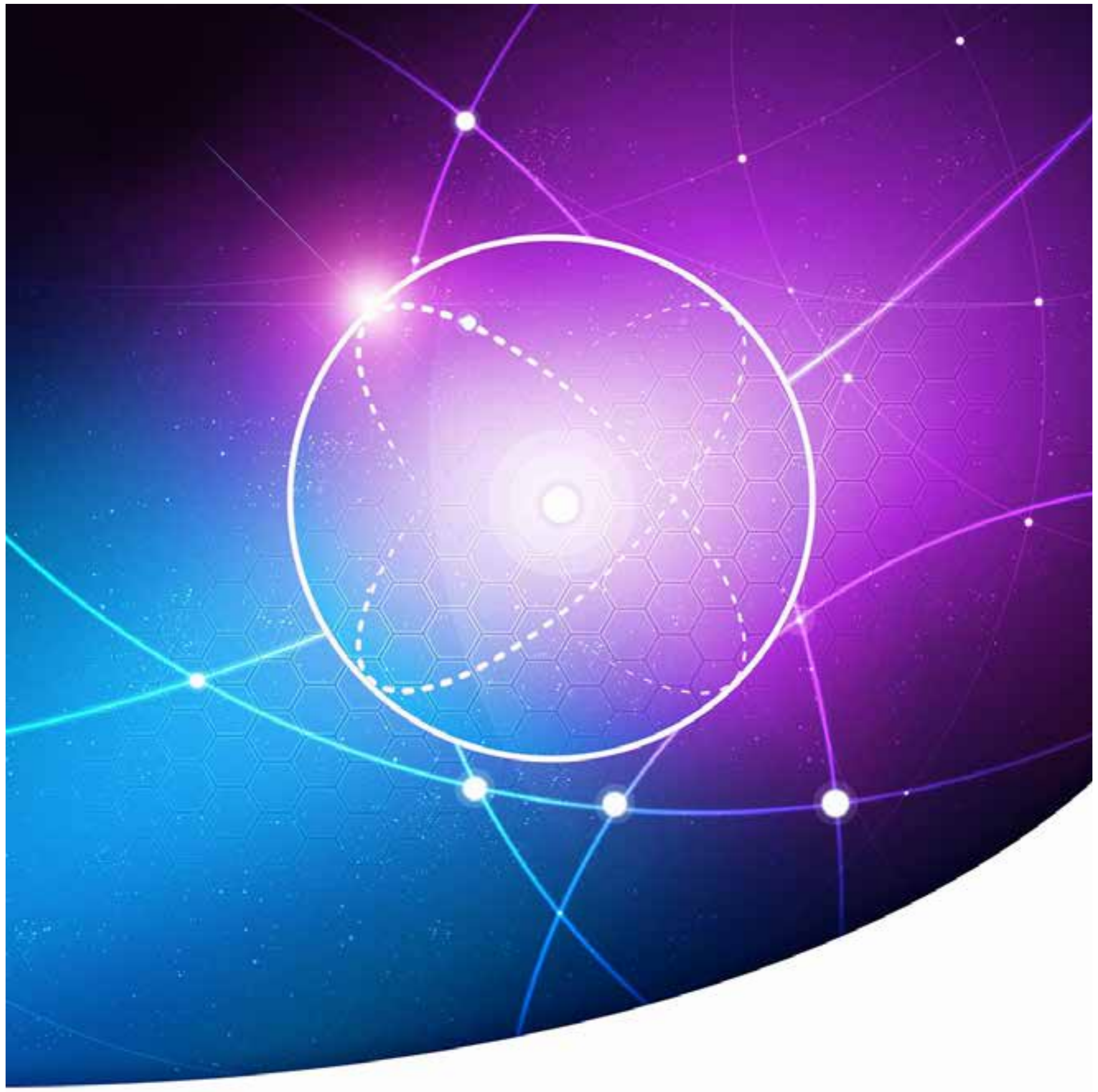
We are now working on the main program and will perform tests to control the parafoil properly and detect all errors which may occur. CanDiver will be dropped from a quadcopter in a field owned by a member of the project.

It is a wonderful project which twist electrical and mechanical knowledge, math and physics. It aim to participate in the actual problematic of recovering first stages. Also, it permits to work on ours courses about the navigation of rockets.

Acknowledgement

We want to thank ESO, AREVA and ACYDEL for their support on this project.

We also want to thank Planète Sciences and CNES for giving the chance to many students to take part in this wonderful adventure.



VMSAT

- Deployment of a hatch to release a seed and an astronaut
- Measurement of air quality as a function of altitude

Presented by some members of the Scientific Club of the School Louis Lumière

Our club (Louis Lumière) usually do mini-rockets and fusex. But this year, we wanted a change to what we usually do. So we chose to do a CanSat, this is the first time for our club. Our group is composed by: ALLAIRE Hugo, PUVANESWARAN Vipulan, SERENO Matthieu and LLORCA Victor. All people are in grade 8, without Hugo who is in grade 10. You can see a photo of us just below.

Left to right: Victor, Vipulan, Matthieu and Hugo

I. INTRODUCTION

A. Overview

We chose to do a CanSat to learn to cope with different constraints (we have limited space and we have a mandatory mission). We also wanted to test how to do a nanosatellite. We do this project inside our scientific club, and each one thinks about the project in his home and propose ideas.

B. Budget

The budget of the project is about 100 euros, we managed to get partial sponsors who offered us discounts on some products. The sponsors are kubii, gotronic and lextronic. All the group thanks them.

II. MISSIONS

A. Deployment mission

For our first year, we didn't want to do something complicated and we wanted to do something realistic. So we decided to deploy a hatch. The hatch will release a seed and the astronaut. We will explain that a bit later.

In our main experience electronic circuit which we can name timer, we use a jack. When the jack plug will be removed all circuits will start working. For the one that we use for main experience, when the jack will be removed, there'll be a little waiting time of 2 seconds and then the hatch will be

An Arduino Nano

deployed thanks to a motor. We do that thanks to an Arduino Nano that we use for all missions.

The seed which we'll use will have a biodegradable parachute essentially composed of leaves. We will do tests of resistances of the parachute to be sure that it does not tear during our flight.

B. Free mission

For the altitude, we use a BMP180 which is a barometric pressure, temperature, and an altitude sensor. It's sold by Adafruit. It's a 5V sensor. For the air quality, we use a Click board module with a MQ-135 sensor. It reacts to ammonia (NH3), nitrogen oxide (NOx), benzene, smoke, CO2 and other harmful gases. We will use the meteorological information given by the organization to know if that will impact measures.

The BMP180

The Click board module

All those sensors are programmed thanks to the Arduino and they also use the jack to start their measures. They give us the data at the same time because we want to do a graphic with air quality as a function of altitude and if we don't have the data at the same time, we can't do that.

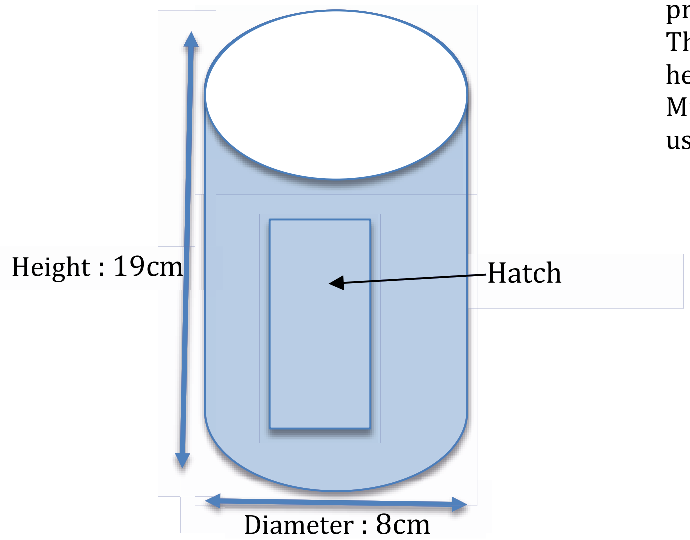
The astronaut
(Image provided by Planètes Sciences)

C. Bonus mission

We chose to do the bonus mission because we are really fans of Thomas Pesquet. We eject that thanks to the same hatch than for the seed. We have a little square parachute for the astronaut with 10cm a side. The astronaut's weight is about 1 gram.

III. CANSAT ARCHITECTURE

Schema showing the exterior architecture of the CanSat.



The volume of our CanSat is about $955cm^3$.
Our CanSat have a parachute. We'll do resistance test in the grass (as a test flight). The tube we use has an outside diameter of 80mm and an inside diameter of 74mm, it is made of PVC. Our CanSat is not covered in the top and in the bottom.

IV. CONCLUSION

The main objective of the project VMSAT is discover how to make a CanSat. Now, we have finished all the circuits, we have to do the mechanical part. We have already started to prepare for the competition of July. For the CanSat drop altitude, we will choose the highest possible to have the maximum data as possible. It's a good experience for all the group to do this competition and we are really happy to do this competition with engineer schools and other special schools (compared to that, we're only in the middle school and Hugo in the high school).

V. ACKNOWLEDGEMENT

First, we want to thank Planètes Sciences and CNES to give us a chance to do this project even though we're in middle school. Then, we would like to thank our club for helping us in many things. Finally, we thank Military camp of Ger of 1st RHP to welcome us during C'Space.

CanSat91

BIGOR Mickael, DJAE Arsène, EL MAAROUFI Rédouane, PERES Benjamin

Abstract– The CanSat UEVE is a University of Evry Paris-Saclay project whose objective is to develop a mini-satellite. The word "CanSat" is the fusion of two words: "Can" and "Satellite". The aim is to develop a mini-satellite with the dimensions of a 33cl can. The CanSat must not exceded a volume of 1 liter, a diameter of 80 millimeters with a length of 200 millimeters and the maximum weight allowed is 1 kg.

The CanSat will be dropped from a captive balloon 80 meters high, when it falls, we will have to control the vertical drop speed with a parachute. The speed of fall have to be controled between 2 and 15 meters per second. During the fall, it has to do several missions like a real nanosatellite. A mandatory mission will be the deployment of a tripod landing gear to ensure a vertical landing of our CanSat. A free mission will be the measurement of atmosphere characteristics (Pressure, CO_2 capture, temperature, altitude and humidity). And a bonus mission will be the ejection of a paratrooper during the fall.

I. INTRODUCTION

This article will present our project by which we will participate in the C'space competition in tarbes on July 21st 2017. It will explain the selected missions. We designed our CanSat in 3 parts, the first part devoted to the ejection of a paratrooper, the second part for the electronics and the last part for the mechanical part with the deployment of the tripod of the landing gear.

II. Context of development

A. Project Team

The CanSat UEVE project team is composed by four students from Master 1 Engineering of Complex Systems at the University of Evry. The team work in partnership with the University space association Octave which has taken part to the Cansat and Fusex 2017 competitions.

This project have occupied a important place in our academic year beacause it was necessary to carry out the CanSat project in order to obtain the master 1 degree. The project has been financed by the University of Evry and supervises by the teacher G. Porcher.

The Scientific's skills of the team members are various and the project led us to improve our abilites in differents skills areas. In order to carry out this project we have attached great importance to the project schedulling and we set up a collaborative work which has proved to be efficient. Each member of the group performed a specific task. Benjamin has managed the project, Arsène has worked to develop and to size the parachute. Rédouane has worked on the design of the differents mechanicals parts and the computer aided design with Solidworks. Benjamin and Mickael have worked on the choice of electronics components, the development of the telemetering chain and C++ programing.

B. Work organization

Our project started with a complete analysis through a bibliographic research of the differents CanSat which competed the last two years. And then with the comprehension of the requirements specification of the competition 2017. After this first step, we understood the workload to be realized, and how we have to planned our work. In the end of the month of January, we chose the missions that we will set up for the competiton.

With the aim to carry out the work, we shared the tasks and responsibilities. The main tasks were bibliographic research, the differents calculations, design and development, the choice of electronics components and program writing. Each member was working on the part to which he was assigned and then make a report to see the progress of the work and therefore of the whole project

During this academic year, there were approximately 100 heurs which was dedicaded for this projetc by the University but it was not sufficient. So we have planned overtime to cover the entire workload. The substantial task was the computer-aided design with the conception of the tripod landing gear.

C. Budget

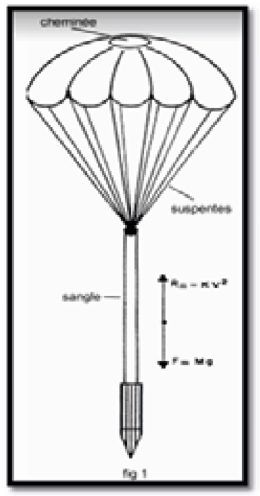
Our project is financed by the University of Evry, with a budget allowed 500 euros. Travel, accommodation and other expenses during C'Space competiton are also funded by the University of Evry. For the time being, we estimate the cost of the project at 450 euros but without taking into account various resources that we can not estimate such as meetings and trainings with Planète Sciences.

III. DEFINITION OF THE MISSIONS

As agreed in the regulation we realize the three types of proposed missions, in the first place we are going to realize a vertical landing, for the free missions we chose to make atmospheric measures as well as the temperature, the atmospheric pressure the rate of hygrometry and the rate of particles of CO2 in the air. We will also perform the bonus mission which consists of the ejection of the parachutist

IV. CANSAT ARCHITECTURE

- Dimensioning of the parachute



In order to make the choice of the parachute, we've calculated the speed of the fall according to the surface of the parachute.

The CanSat attached to the parachute is subjected to gravity (P-weight) while the air exerts a force on the parachute (-R).

These forces are expressed:

Weight: P= Mg

Figure 1-The

The resistance of the air: **R= -Kv²**

-**M**: Mass of cansat and parachute

-**G**: acceleration of gravity (9.80m/s²)

- **V**: speed of descent

- **K**: aerodynamic coefficient

The acceleration of gravity tend to increase the speed of the CanSat, this increasing the resistance of the air. This situation quickly leads to a state of equilibrium where the speed of descent becomes practically constant (Fig 1) It is called falling speed limit: V²=Mg/K Besides, K=RoSCx/2.

So : V²=2MG/RSCx

Ro: Density of air

Cx: aerodynamic coefficient of the parachute

S: Surface of the parachute

This speed is not constant since **R** and **g** vary with altitude. For a calculation:
R=Rs+Rh/2

Rs: Density of air on the ground

Rh: Density of the air at the culmination altitude

After we've calculated with M= 0.8 Kg; G=9.81 m/s²; Cx=1 and Ro=1.3, we've got a table that shows the variation of the speed as a function of the surface of the parachute.

We chose a parachute of 2m² for the speed at the time of the impact with the ground to be 2 m/s (minimum speed). Moreover, for her stability throughout the fall, the parachute will be composed of the chimney (hole) to avoid overpressure. Indeed, the air steps into the parachute and tends to escape (overpressure) by the sides of the parachute and make it tilt. Whereas with a chimney, air can flow from the top of the parachute.

- Paratrooper part

The ejection of a paratrooper is our bonus mission, we have modeled an ejection system using an electromagnet, a spring and an ejector. The ejector is guided by rails, a magnetized part is fixed to the rear of the ejector to ensure the magnetization with the electromagnet. Between these two components, there is a spring, when the power supply is switched off, the magnetization is no longer assured then the spring will suddenly expand and push the ejector, the paratrooper will be expelled outside the CanSat, a hatch opens before the power cut of the electromagnet so that the paratrooper can leave the CanSat.

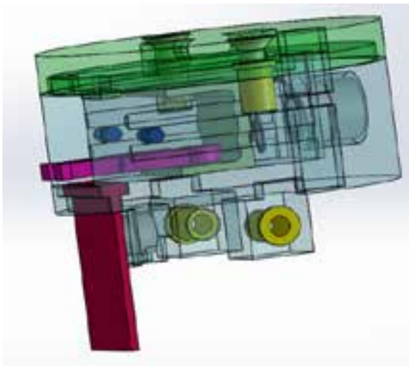


Figure 2-Paratrooper ejection system

- Electronic part

As mentioned before, we all do the bibliographic research and it help us to see how to make a cansat. We can see an general architechture of all the Cansat, a micro-Processor, a micro-sd card, and sensors to accomplish the mission. First of all I made an inventory of last year's Cansat program, then I classified them in several categories: dimensions, weight, consumption, etc. because we a have a constraint of minutes, size, weight that cannot exceed 1kg, Voltage, Current and price that should have a maximum of 500€.

Afterwards the growth of an electronic component like a position radar (mtk3339) and a pollution sensor(mq135). I had to do a feasibility study with a great deal of the respect of constraints (Period, budget, bill of specification).
After the choice of the component, I had to resize them as needed to have the best performance. Resize the battery, the electromagnet engine, and conditioning the acquisition chain because output Sensors signal are very weak (Mv). To resolve that a gain I must do a gain out of the sensors to increase their power and amplitude. Generally, the gain is calculated according to the ratio of output / input signal. This conditioning will allow a better measuring range.

Not too long ago, we make an order for the electronical part, until I receive the package I do the electrical diagram which would be validated shortly by a professor. And after the electronic and the informatic and mechanic part would be assembled we will be in the realization stage. So, we developed integration test between electronical, program, mechanic parts.

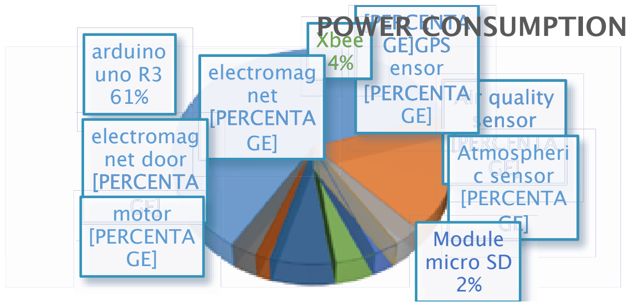


Figure 3- Power

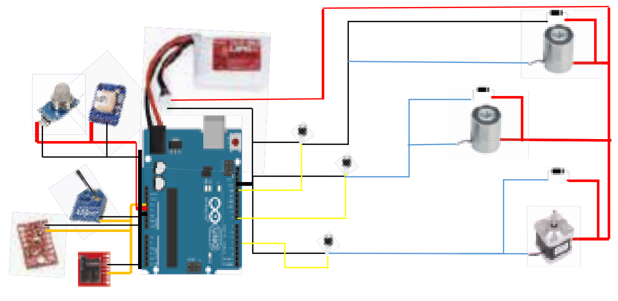


Figure 4- Electric schema

- Mechanical part

Although the CanSat is equipped with a parachute, it will always have a vertical drop rate that will transform into kinetic energy in contact with the ground, this energy will have to be dissipated to avoid the rebound of CanSat and does not miss its landing. We calculated the strength that our CanSat will generate during the fall. Then we chose shock absorbers that can absorb this force to avoid the rebound for the good landing of our CanSat. These shock absorbers will be included in the landing gear. The landing gear will be fixed through shock absorbers on a ring itself associated with a screw of a stepping motor. The rotation of the screw will cause the system to be deployed out of the envelope.

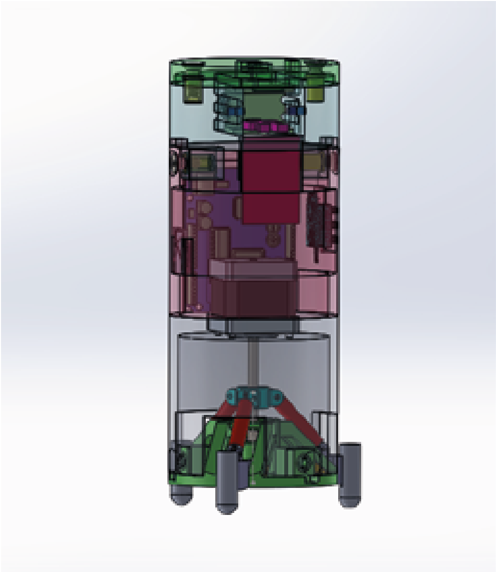


Figure 3-The CanSat91

- Program design

First, at the opening of the jumper circuit, a voltage variation is detected on the wire and initializes a sequence called "Drop". The Drop sequence operates the electromagnet of the trapdoor twice, one second each time; one second after the sequence is initialized. Then, one second latter, the magnetic linear actuator is turn on in order to eject the parachutist figurine. Finally, one second later, the first servo-motor turn from an initial position of 0° to 20° and open the three bottom side door. This sequence is timed with the Arduino function millis(), that return the number of milliseconds since the Arduino began running. A reference point of the time is taken at the moment CanSat91 is dropped, and each delays are calculated from this reference. Another sequence is initialized when the jumper opens and is dedicated to the measurement and record of the atmospheric data. This sequence operates all along the fall, until the Cansat reach the ground.

Finally, few seconds after the Arduino no longer detect variation of the altitude, the "Digging" sequences are initialized. This sequence operates the turn on of the digging motor and Which is going to deploy the landing gear. After that, the Arduino won't do anything else.

I. CONCLUSION

The CanSat will soon be printed and assembled and only the tripod landing gear will improve further because we focus on this part to maximize the success of the vertical landing of our CanSat. We conducted several tests of electrical components with the Arduino board.

Finally, the beneficial aspect of this project was the opportunity to discover project management with planning, collaboration and partnership work, but also to have the possibility to develop this project since the beginning of the end and To cope with technical and temporal constraints.

ACKNOWLEDGMENT

We would like to thank the following people for their support:

- Mr DAVESNES of IBISC laboratory for the 3d printing
- Mr PORCHER for its assistance and framing throughout the project
- Mme VASILJEVIC, Mr NEHAOUA, Mr DIDIER professors at the University of Evry
- Mr KOSSA, Mr LAVASTROU, Mr KANOUTE & Mr BIYORO of Octave association
- To the members of Planète Sciences

We also want to thank CNES for giving the opportunity to many students to take part in this competition.

HINADORI

UCG-17 CanSat Project

Emi Sugiyama, Nobuto Honda

Abstract- Uchu Club Gifu(UCG) make model rockets every year as part of manufacturing education. We are participating in the French competition (C'Space) because we can't launch a rocket to high altitude with Japanese law. In 2017, we decided to make 2 CanSats as a new challenge. To explain the team "Hinadori" mission:

-Mandatory Mission: to conduct air quality survey (temperature, humidity, dust, CO_2, etc.), detect features and stepwise to distinguish air quality.

-Free Mission: telemetry by XBee.

1. INTRODUCTION

CanSat refers to a small simulated satellite with a can size for the purpose of space technology education. The rockets and atellites is required large sums of money, failure is not allowed. Therefore, CanSat, which can carry out experiments cheaply and casually, is conducted in a wide range from high school students to members of the social workers. In this report, we describe the research background, mission, mechanical parts, electrical architecture and program of CanSat.

2. CONTEXT OF DEVELOPMENT

A. UCG

UCG is composed of Gifu University students. The director is Professor Sasaki Minoru. In 2005 we started activities from the water rocket competition in France and in 2006 we are making model rockets to launch to higher altitudes. In 2017 it was decided to participate for the first time in the CanSat competition. The UCG project is divided into a rocket team and two CanSat teams, and the team Hinadori is composed of 8 members (Sasaki lab members: Sugiyama, Honda, Koide, Hayashi, Morita, Ito; Yamada lab members: Ishiyama, Tachibana).

Fig. 1 Logo mark

B. Work plan

We will make CanSat for the first time, but taking advantage of the technology of rocket making which was done every year, it is divided into three major parts of mechanical parts, electrical architecture and program, and we will do the work.

In March and April, all the team members decided the mission, and from May, the aircraft group starts creating, the program and the circuit group select the sensors and create, respectively. We aim for completion by combining each in June.

3. DEFINITION OF THE MISSIONS

A. Mandatory mission

The main mission of our team is air quality survey. Generally speaking, Japanese people say "Air is delicious" when going to places where nature abounds like forests and waterfalls. Also, in 2016, when Astronaut Takuya Ohnishi returned from the International Space Station, he commented that "The air on the earth is delicious." What does "air is delicious" mean? Therefore, we collect some sample data such as the delicious air we think (waterfall, plateau etc.) and not delicious air (toilet, car exhaust gas etc.), and we will prepare delicious air standards in advance from the data by themselves. On the event day, we will compare the data taken with the standard, and measure the quality of air.

B. Free mission

Free mission is the success of telemetry. XBee is used for telemetry. We have never used XBee and are in search. If the data is successfully transmitted to the ground, the mission will be successful.

4. CANSAT ARCHITECTURE

A. Mechanical parts and structure

The body is produced using 3D printers. The body has a cylinder shape with a height of 180 mm. Weight including electronic parts is 450 g. There is a gap of 2 mm in the inner cylinder and the outer cylinder, which is designed to measure the quality of air by taking in outside air. The parachute is designed to fall at a falling speed of 2.2 m / s to increase measurement time.

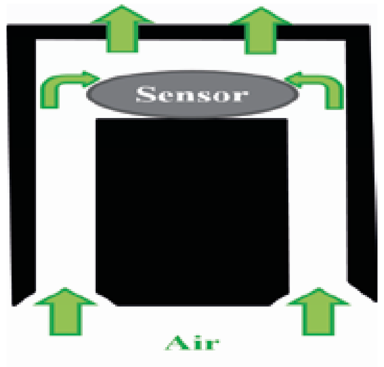


Fig. 2 Mechanical architecture

B. Electrical architecture

We use Arduino Uno for microcontroller. In the air quality survey of the main mission, we use 5 sensors.

1) Air quality sensor module [MQ135-4P]
MQ135 could analyze the ratio of CO2.This sensor is very cheap and output is an analog signal easy to process.

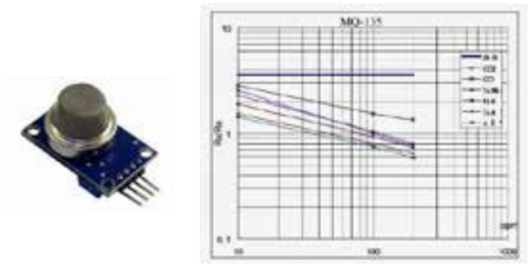


Fig. 3 MQ135 and sensibility characteristics

2) Grove-Multicannel Gas Sensor
Grove – Multichannel Gas sensor is a environment detecting sensor with a built in MiCS-6814 which can detect many unhealthful gases, and it can help you to monitor the concentration which more than one gas (CO, NO2, C2H5OH, H2, NH3, CH4, C3H8, C4H10). The interface of it is I2C.

Fig.4 Multichannel Gas Sensor

3) Optical Dust Sensor [GP2Y1010A0F]
It is an optical sensor that detects the amount of reflected light from dirt in the air with an infrared light emitting diode and a phototransistor, and it can detect tobacco smoke, house dust, etc.

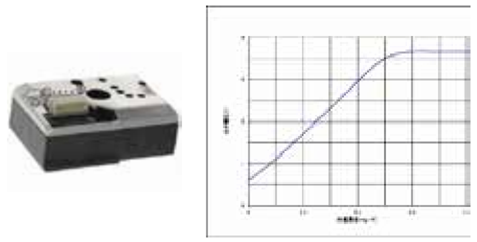


Fig.5 Optical Dust Sensor and sensibility characteristics

4) Temperature-Humidity-Pressure sensor module [BME280-7P]
It is equipped with a Bosch's BME 280 and is a sensor module that can simultaneously measure three environmental information of temperature, humidity, and atmospheric pressure. The communication interface with Arduino is I2C.

Fig.6 Temperature-Humidity-Pressure sensor module

5) GY-80[BMP085]
GY-80 is a compact module that includes a gyroscope, accelerometer, digital compass, and a barometric pressure, temperature sensor.

Fig.7 GY-80

5. CONCLUSION

Origin of mechanical parts, electrical diagrams, and programs are built. From now on, we will create and electrical circuits and parachutes and conduct experiments. Also, increase the number of samples and clarify the standard of air quality.

6. ACKNOWLEDGMENT

We would like to thank Professor Sasaki, Associate Professor Matsushita, Associate Professor Mori, Associate Professor Nitta for guidance in this project. We also thank all of Sasaki Laboratory and Yamada Laboratory who received much knowledge and suggestions through discussion.

"土竜(MOGURA)", belong to UCG-17

Kazuki Yokoyama, Ryutaro Miyabe, Tatsuya Uda, Hideaki Tochigi, Shunta Ito,
Yuina Watanabe, Souichiro Yamauchi, Tomoki Ueno

Abstract–The UCG (Uchu Club Gifu) project has been making small rockets every year. This year, as part of the project, CanSat production is divided into two groups.

The CanSat project have two main missions. First mission is Analysis of ground hardness using acceleration, angular velocity and pressure. Second mission is Move to destination using GPS and geomagnetism.

I. INTRODUCTION

The CanSat project is carried out in UCG-17 project. There are two CanSat projects in the UCG project, and the CanSat is called "土竜(MOGURA)". The"土竜" means mole. It is come from our mission analyzing of the ground.

The "土竜" missions is save the data of sensor (acceleration, angular velocity, GPS, geomagnetism, pressure), Analysis of ground hardness using acceleration, angular velocity and pressure and Move to destination using GPS and geomagnetism.

II. CONTEXT OF DEVELOPMENT

A. Project Team

The CanSat is developed as one of UCG projects. The UCG project is carried out mainly by students of Sasaki laboratory at Gifu University, which we are making small rockets every year to experience manufacturing.

The number of "土竜"s member is 8 people. The composition of the team is Yokoyama of the leader, Miyabe, Ito and Watanabe of the structure group, Uda, Tochigi, Yamauchi and Ueno of the control team. The structure team designs the whole image and parts using CAD and then manufactures CanSat with parts using 3D printers and processed aluminum. The control team has designed a circuit using Eagle, creates a program for saving sensor data and moving it to a destination, and creates a system for data processing.

B. Work Plan

The UCG-17 project is being implemented from April for the C'Space, and the project team as a whole gathers ideas, then divides into groups and decides the mission and then plans.

First, we decided the idea to analyze the ground and move to the destination, and we discussed all the data and mechanisms needed to realize it.

Next, divided into each team, the structure team designed the main body and each part with CAD according to the regulation, the control team selected the selection of the sensor for necessary data from the sampling frequency, the size and the range.

After that, the structure team creates the body mechanism by using a 3D printer and processes the aluminum, and assembles them. The control team is divided into a person who creates a program for storing and processing data and a person who creates a program which moves to the destination. When each program is combines, it coalesces and checks the operation and then designs the circuit.

C. Component Parts

The main body mainly manufactures aluminum and uses 3D printers for fine parts like mechanism for investigating the ground.

The sensor uses acceleration, angular velocity and pressure to investigate the ground and uses GPS and geomagnetism to move to the destination. Therefore, CanSat uses GY-80(acceleration, angular velocity, geomagnetism), pressure sensor and GPS. Also, use micro SD to store those data

We use two servo motors to rotate the tire for movement and a small geared motor for disconnecting the parachute.

Two microcomputers are used on the move and data processing side. Therefore, we selected a small Arduino Pro Mini microcomputer from Arduino which even beginners can easily use.

Table1. Component Parts and Price

Parts	Number	Price
Body	-	
Mechanism	-	10€
Sensor	3	81€
Motor	3	49€
Micro SD	1	12€
Microcomputer	2	24€
Parachute	1	20€
TOTAL		

III. DEFINITION OF MISSION

In this chapter, we explain the "Ground Investigation Mission" and the "Movement to destination Mission" which our group carries out.

A. Ground Investigation Mission

Investigating the ground leads to the safety and resource exploration of the place, and it serves as a guide for development and living development there. So, our group is carried out a mission to analyze the hardness of the ground at that point by measuring the changes in acceleration, angular velocity and pressure due to the force bouncing off CanSat by striking the ground. Also, compare the GPS data with data of multiple points obtained by acquiring these data while moving.

B. Movement to Destination Mission

In searching for a new star, there is a possibility that the place where small satellites can be recovered is limited, so it is necessary to move to a specific position. So, our group will carry out as a mission to move to the destination using GPS and geomagnetism after falling with the parachute. Destination is set on the day of launch and aims at a location within 5 m radius from the destination from GPS error.

IV. CANSAT ARCHITECTURE

A. Machine Body

This CanSat was designed to be a rover type to move, and the tire was made to be three wheels so that the hammering mechanism always faces downward. The third tire was shrunk when it was stored in a carrier and made to stretch when released from the carrier. Also, each tire is made of aluminum and is wrapped around with rubber to make it easy to move.

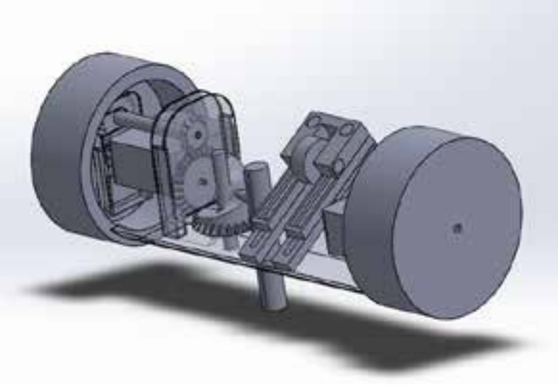


Fig. 1. Model of body

B. Striking Mechanism

In the mechanism for the Ground Investigation Mission, the striking part rises upward, so that the spring on the mechanism is contracted and the ground is hit by releasing the force. Using one motor that rotates the tire, its rotation is transmitted by gears and converted into up and down motion of the striking part. Since the distance traveled by one revolution of the motor is about 0.25m from the size of the tire, we designed to make a single strike per 4 revolutions of the motor using the gear ratio.

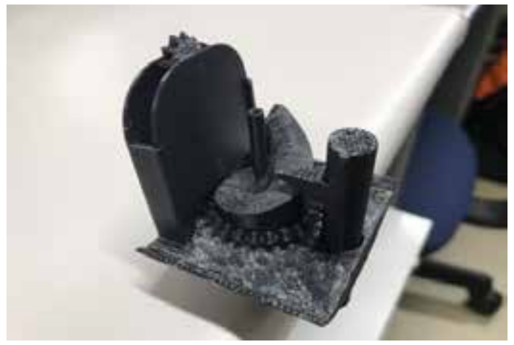


Fig. 2. Striking mechanism (prototype)

C. Parachute

Since the size of the parachute varies depending on the weight, it is thought that the determination of the size will be delayed, and decided to make his own rather than an order. The falling speed was designed to fall at 7 m/s considering the failure of CanSat due to the shock of the fall and the time to perform the mission after the fall.

If the weight of CanSat will be 1 kg, the area of the parachute will be 0.3 m^2, and we will adjust it according to the weight from now on.

D. Program

The sensor side acquires GY-80 data as I2C communication, GPS as serial communication, pressure as change in voltage, and saves these raw data in SD by SPI communication. In addition, GPS and geomagnetism data necessary for movement of CanSat are transmitted to Arduino for driving by using serial communication.

Based on the data sent from the sensor side, the driving side obtains its own position and the direction of the destination, and rotates the servomotor accordingly. After that, when you arrive at your destination, light the LED and quit the program.

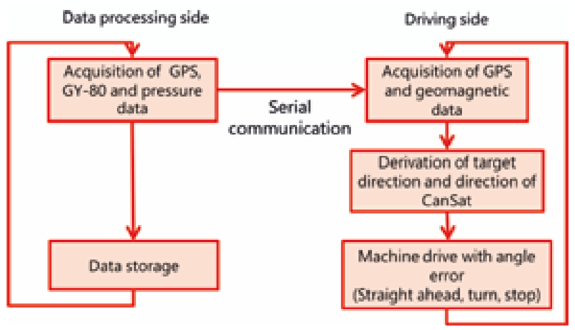


Fig. 3.Program flow

V. CONCLUSION

Currently, the Structure group manufactures and assembles each part, responds to the problems caused by that, and the control team has been working on the program of each microcomputer, so we are working on unifying two microcomputers.

In the future, we will combine the results of both teams and perform test and acquire sample of data change. We will verify the results and make better ones.

ACKNOWLEDGMENT

We would like to thank Prof. Sasaki, Mr. Mouri and Mr. Matsushita for pointing out various advice and problems.

We would like to thank Factory people who gave me advice on how to process and use machining place.

We would like to thank Everyone of CNES who gave me a place of experience like C'Space

NOTES

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CENTRE NATIONAL
D'ÉTUDES SPATIALES

VOS CONTACTS

CNES

Claire Edery-Guirado
Responsable CanSat CNES
claire.edery-guirado@cnes.fr

Planète Sciences

Bourenane Khermane
Responsable CanSat Planète Sciences
bourenane.khermane@planete-sciences.org

En savoir plus sur la compétition 2017

http://www.planete-sciences.org/espace/Activites/CanSat/

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