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INNOVATION & INSPIRATION

25 - 27 JUILLET
Camp militaire de Ger du 1er RHP
(Régiment de Hussards Parachutistes)

Compétition CanSat France 2016

DOSSIER DE PRÉSENTATION

CanSat France

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Compétition CANSAT France 2016

La compétition CanSat France se déroule du 25 au 27 juillet sur le camp militaire de Ger du 1er Régiment de hussards parachutistes (RHP).

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.

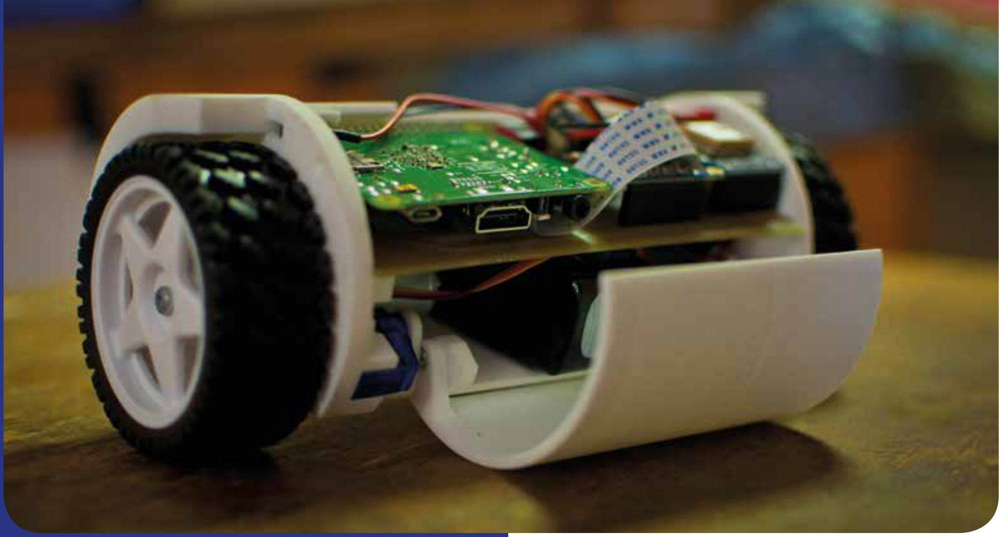
La compétition accueille cet été huit équipes dont une du Pérou

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, il devra réaliser une mission obligatoire : le déploiement et au moins une mission libre. Cette année, une mission bonus apparaît : Objectif parachutage.

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.



Qu'est-ce qu'un CANSAT ?

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 plateforme d'apprentissage exceptionnelle pour tous les jeunes intéressés par la conception et la fabrication de sondes spatiales ou de satellites.

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, communiquer avec une station au sol, faire de la navigation GPS ou 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.

La compétition 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

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.

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

Les missions de la compétition 2016

Les missions sont réalisées durant la phase de descente et peuvent se poursuivre après l'atterrissage (tels les atterrisseurs Curiosity et Philae). L'équipe doit réaliser une mission obligatoire et une ou plusieurs missions libres.

Mission obligatoire 2016

- **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 2016 devront être originaux et pertinents si les équipes souhaitent remporter cette édition devant un jury de professionnels du domaine.

Exemples de missions libres

- **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.

- **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 ses latitude et longitude en WGS84 – système de référence de positions au voisinage de la Terre. La localisation exacte sera alors mesurée par l'organisation.

- **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 2016

- **Objectif parachutage :** cette mission est facultative et permet à une équipe d'obtenir un bonus pour le largage d'un parachutiste du camp de Ger depuis le CanSat sur la Planète Rouge. Il s'agit de procéder au parachutage d'une figurine de parachutiste et de son parachute, fournie par l'organisation, durant le vol du CanSat.

Programme

CanSat 2016	9 h - 13 h		14 h - 18 h
Dimanche 24/07	Accueil des participants		
Lundi 25/07	Installation moyens sol		Tests en vol
Mardi 26/07	Présentation des projets devant le jury		Démonstration en vol
Mercredi 27/07	Présentation 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)	

Moments clefs de la compétition accessible à tous les participants du C'Space

- **Démonstration en vol :** Mardi 26/07, 14 h - 17 h
- **Remise des prix :** Mercredi 27/07, 12 h 30 - 13 h
- **Bilan de tous les CanSat France 2016 :** Mercredi 27/07, 18 h

Le Jury 2016

Le jury qui évaluera et récompensera les projets CanSat sera composé des membres suivants :

CNES :
Claire Edery-Guirado
(Chef du service Education Jeunesse)
Jean-Michel Tourraille
(Chef du service Opérations ballons et Responsable du site ballon d'Aire-sur-l'Adour)

Airbus Defence & Space :
Jacques Béhar
(Ingénieur retraité, Consultant en systèmes balistiques et spatiaux)
Thierry Duhamel
(Head of Space Research & Development France)

Les 8 projets CanSat

Club	Projet	Ville ou pays	Missions libres	Responsable
Aero Ipsa	Horizon	Ivry-sur-Seine	Mission come-back, altimètre, caméra et données atmosphériques	Quy DIEP
CanSat Peru Team	CanSat Rover	Pérou	Test de la conception électronique et du contrôle central de gestion d'informations des systèmes de navigation, d'orientation et d'exploration du CanSat	Juan Carlos HUAMANI ASTO
Ecole de l'air	Starcan	Salon-de-Provence	Pression atmosphérique, température, altitude, hygrométrie et gaz	Kévin HILL
N6K'nSAT	Clans	Toulouse	Pression, température, luminosité, accéléromètre	Stella DENNI
Kamino	Cloning Gaïa	Evry	Mesure de température et de pression, capteur de pression	Djamel BERTAL
Octave	Celesta II	Evry	Mesure de trajectoire pendant la descente, déplacement au sol et prise d'images	Dembo KANOUTE
Phelma	Phœnix	Grenoble	Prise de données, repositionnement horizontal et sortie de la caméra	Patrice PETITCLAIR
UTSpaCe	JawaCan	Compiègne	Étude environnementale, prise de vues aériennes et panorama	Christophe MAESTLÉ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De l'espace pour la Terre

Compétition 2016

C'Space 2016, Camp de Ger

SCIENTIFIC DESCRIPTION

CanSat projects

HORIZON: the small cartography rover

Benjamin Corbelet, Quy DIEP, Claire Graff, Cyril Langlais, Safa Riahi

Project Horizon is part of the CanSat contest. It's an exploration rover which first mission is to take a panoramic picture of the landing place. Others missions of project Horizon are the repositioning of the CanSat and data recording.

I. Introduction

Horizon is a small cartography rover. It has been created to be a part of the CanSat contest. The final purpose of this project is to recreate a 3D cartography representation of a location with multiple pictures took by Horizon. However, this year we aim to only take clear panorama pictures. It consists of a camera, an inertial measurement unit and two wheels. The camera will take the panorama. The inertial measurement unit is a captor which manages the position of the rover and the wheels will allow the rover to reposition itself when necessary.

II. Context of development

A. Club

Fig. 1 Picture of the Horizon team

The association AeroIPSA has been created in 1992 by students who were passionate by the Aerospace field. Nowadays, the associationsg counts 50 members, it's rising year after year. We propose to teach students, futures engineers how to create a project, work in team and work with companies. It's the first time we're part of the CanSat contest. In effect, we use to be part of C'Space organised by CNES and Planet' science since 1996 which aim to design experimental shuttles and little shuttles. We want to expand our actions area in order to give new sources of inspirations to our members and future members. We'd like to thank our school IPSA which finance most of our projects funding included this contest. Thanks to this contest, we wish to expand our sponsors list. The group who represents the charity this year is composed by 5 students (see Fig.1): Benjamin CORBELET, Quy DIEP, Claire GRAFF, Cyril LANGLAIS and Safa RIAHI. Group composed with to electronics/computer programmer Safa and Benjamin; three mechanics Claire, Cyril and Quy. This group is call CAN IPS'AT.

B. Work plan

After we decided to sign up to the contest. We knew we had to make up a schedule to achieve our project in one school year.

Tab. 1 PROJECT SCHEDULE

PROJECT SCHEDULE	
January	Define our project, its methods and its limits
February	Computer assisted design, sequencer and inertial central
March	Computer assisted design
April	Assembly
May	Assembly line
June	Test

The design brief imposes us to pick up characteristics of an installed instrument in a flying sensor or being design sensor. It was a common choice to choose a rover as a flying sensor. Moreover, we just had one requirement: we wanted a camera. Throughout well-known rovers, Opportunity attracted us. It's a mythic rover which was the third rover to be send on Mars and still being working 12 years after its landing. The next step was to identify the different tasks to be shared. Benjamin worked on the image capture and the sequencer. Safa worked on the inertial central and the system which will save the recording on the SD card. The mechanics such as Claire and Cyril had to realise pieces and integrate them on Horizon. Finally, Quy had to work on the computer assisted design to give a general and clear view of the project (see Fig.2).

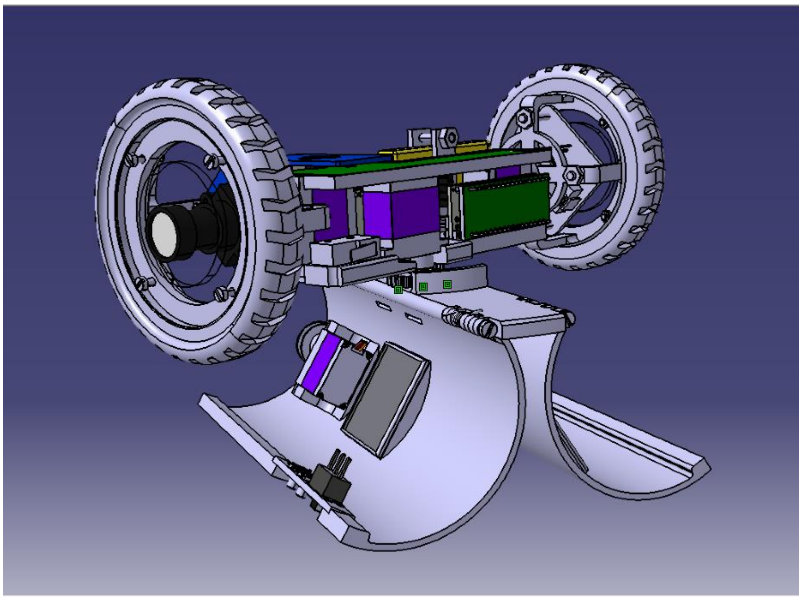

Fig. 2 MODELLING ASSISTED BY COMPUTER OF THE PROJECT

III. DEFINITION OF THE MISSIONS

A. Scientific mission

This year, we wanted to realise a panorama of a landing emplacement location by deploying a rotating camera. The experience elapse after the landing phase of Horizon. However, the conception made us wonder how we will detect the landing of Horizon and what will happen if there's high weed.

Fortunately, we find a solution for both problems. If the weels were to be too high, we created a system which would raise Horizon after the landing using two hulls. Nevertheless, these two hulls could only be opened if Horizon is on the right position. Thus, the rover needs to detect its position and rectify it if necessary. When it is in the right position the two hulls will open themselves and by being open it will raise Horizon. Once raised, the structure is able to rotate on itself to take panorama of the landing emplacement.

About the landing, we did several airdrops trials (see Fig.3) to detect the landing time from the third floor of our school building. It results as de landing time of our rover is 3 seconds for approximately 10 meters. This scale will able us to set the timer.

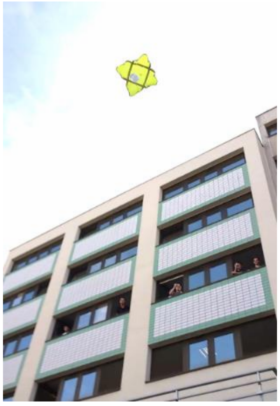

Fig. 3 Crash test

B. *Free Mission*

In addition to the scientific mission, we will realise two other free missions: repositioning of Horizon and data recording on the SD card. This second experience consists on properly repositioning Horizon once it's on the ground. For this purpose, the rover has two wheels directed by some servomotors to direct in function of inertial central's data. This year, the rover won't move. The wheels will only be use to reposition the rover.

The last experience will be the recording of the servomotor data and the position of rover from the exit of the balloon. In other words, the position of the rover according to the three axis, the rotation of the servomotors and the images captured during the descent and the experience.

IV. CanSat Architecture

A. *Electrical architecture*

The CanSat is composed of three electronical cards (see Fig.4): a sequencer, a card managing the camera and a card managing the inertial measurement unit and the SD card. More precisely, the sequencer controls the timer and the several servomotors which allow the structure to turn on itself and the wheels. The camera card retrieve data from the sequencer at the start of the recording, send data to the sequencer which direct the servomotors. Finally, all data have been retrieve and save in the SD card.

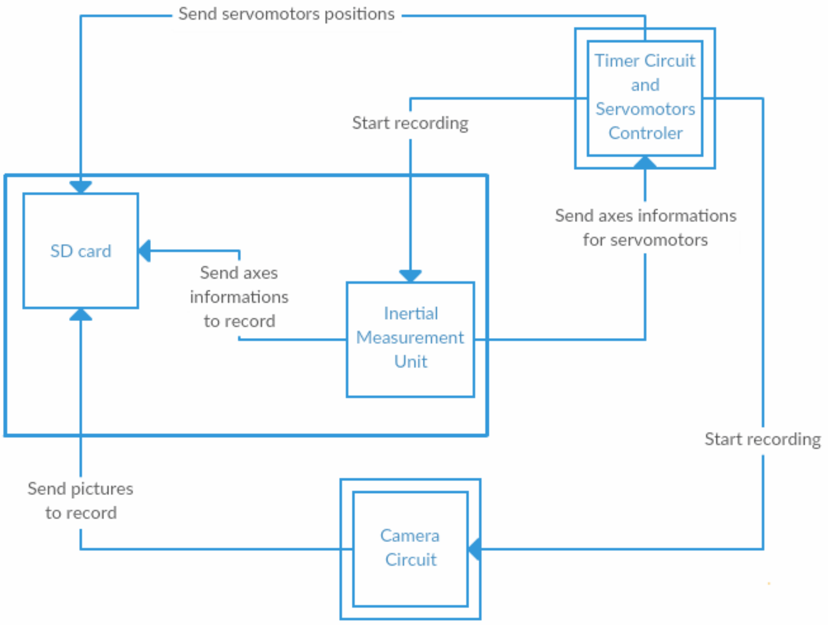

Fig. 4 Electrical architecture

B. *Mechanical parts*

The mechanical part has been divided in four parts (see Fig.5): mobile, fixe, the half hulls and the wheels. The mobile part turns around a fixed point. The camera will be able to take pictures. Then the fixe part is a support for the mobile part and grounded. The wheels allow the structure to reposition itself before the opening of the two half hulls and replace the camera straight. The two half-hulls cover the CanSat during the flight and open from about 150° to raise the structure.

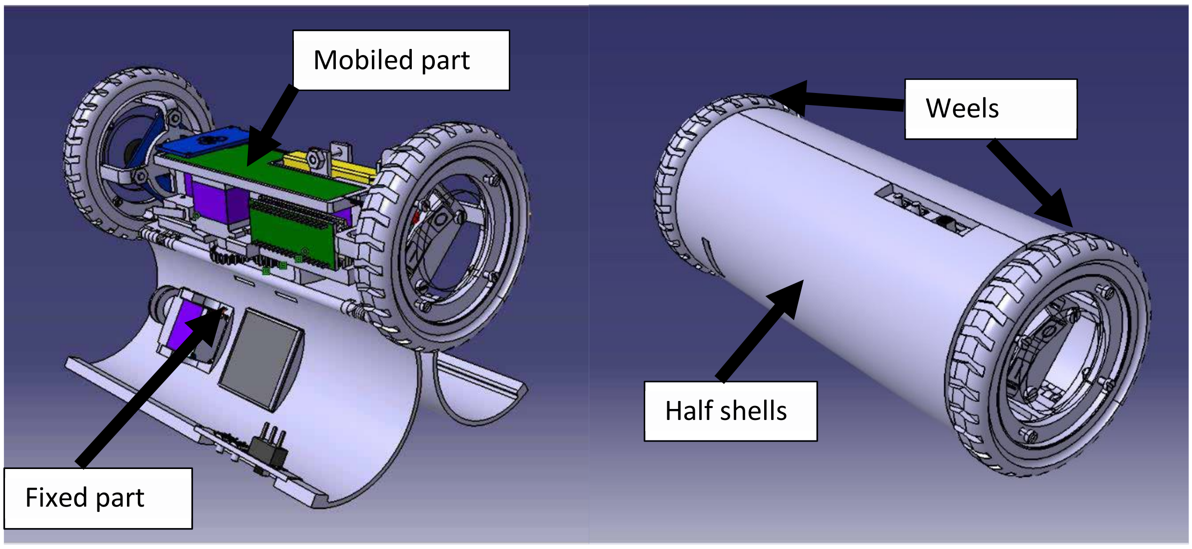

Fig. 5 MODELLING ASSISTED BY COMPUTER OF THE PROJECT IN TWO DIFFERENT POSITIONS

C. *Chronology*

The CanSat will be launched from a balloon under a parachute. We'll use a jack socket as a switch which when it's unplug will start the timer. From there, the descent by parachute starts and take images from the descent. At the landing, it will analyse its position. Then reposition the rover. Once the camera is straight, it start rotate and take panorama. At the same time, it records all data. End of mission, retrieve of data.

D. *Telemetry*

With lack of place, it's impossible to put a telemetry system and a data recording on SD card because the system is more reliable and well known by the members of our group. However, the rover will have a telemetry system in the following prototype.

V. HELPFUL HINTS

A. *Figures and tables*

E. *Abbrevations and Acronyms*

IPSA : Institut Polytechnique des Sciences Avancées
CNES : Centre National d'Etude Spatial
IMU : Inertial Measurement Unit

VI. Conclusion

Nowadays, Horizon is in the test and debugging phase. We still have modifications and adjustment to do. The project will be ready for the D-day of the competition. If we succeed this step, we will validate several experiences for our next rover.

Acknowledgment

We'd like to thank our school IPSA for providing us with funding and materials which help us to realise our projects. We'd like to thanks Cyril ARNODO who followed us during our journey. He helped us a lot and provide us with many advices and answered our questions. Sasha RUBILLON supervised us during the contest and more important we'd like to thank Planète Sciences who organised this contest.

IMPLEMENTATION OF A CANSAT FOR COLLECTING ATMOSPHERIC DATA

Andree Salazar, Juan Huamani, Luis Hilasaca, Rider Paredes, Williams Solis

Abstract — A Come-back CanSat or CanSat Rover is an autonomous robot capable of positioning itself by means of a GPS or an inertial navigation system and move to a target location. This system is launched by an amateur rocket and after reaching a certain height is released, after that and using a paraglider must control its trajectory and heading towards its goal. Once at ground level should be released the paraglider and scroll to a predetermined point.

Keywords — **CanSat Rover, natural fall, aerospace systems, atmospheric data.**

I. INTRODUCTION

Aerospace science is interdisciplinary and includes concepts from different specialties in its scope, allowing a wide field of research; further research in aerospace systems is very useful for the development of nations, as in the case of artificial satellites, which since its creation have caused major positive impacts on the daily lives of people and generators and producing countries these technologies.

II. OBJECTIVES

General Objetive

The objective of this project is the development of the system of atmospheric data collection; in addition to the autonomous vehicle that will transport the system.

Specific Objetive

1. Perform the design and implementation of a mechanical structure that is able to withstand the impact of the fall.
2. Get a sufficiently accurate mathematical model to design control algorithms to simulate the dynamics of the mobile.
3. Design the navigation system and central control
4. Design electronic boards and the feed system to enable decision atmospheric data in free fall.
5. Validate sensors measures for future acquisitive purposes you may have.

III. PROJECT DEVELOPMENT

The project was divided into three modules to better cover the development in each of their fields, these being:

1. Armour and mechanical structure
2. Central Control and navigation.
3. Electronic design and communications.

1. Armour and mechanical structure

It is responsible for the design and implementation of the mechanical structure; this should be adequate to the challenges offered by the project. In the case of armor should take into account the strength of the material, and weight, plus the design must consider restrictions CanSat standard.

1.1 Design of mechanical structure

The design of mechanical or EMEC structure was made taking account management and location of the sensors and plates, besides the implementation of a worker will avoid imbalance CanSats Rover. The designs are made in the 'SolidWorks' software, as shown in Figure 1.

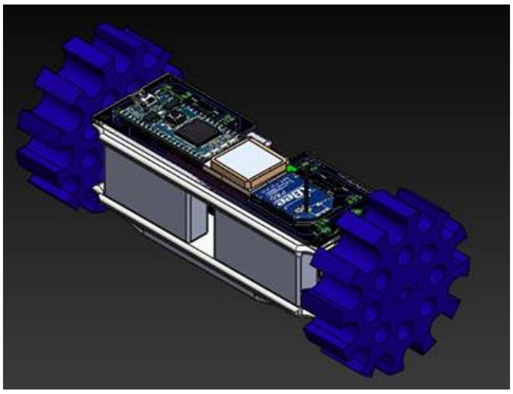

Figure 1. Mechanical design structure CanSat Rover.

2. Central control and navigation

It is the module responsible for ensuring that the measures from navigation sensors to influence the path of the CanSat Rover, as well as decisions wean the system.

It should be noted that the CanSat Rover can move in both air and ground, this means that different modeling is performed, the first to work the Earth system.

2.1 Earth System Modeling

It should be performed kinematic and dynamic analysis of CanSat Rover; in order to obtain a mathematical model that fits reality and allow more exercise optimal control algorithm
To check the kinematic and dynamic model is used Rover SimMechanics the toolbox Simulink. designed in the Simulink SolidWork to be imported.
Figure 2 shows the modeling of Rover in SimMechanics.

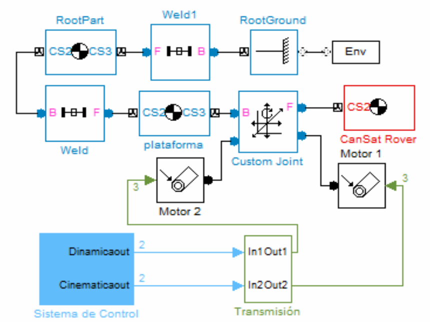

FIGURE 2. DIAGRAM MODELING WITH SIMMECHANICS SIMULINK, CANSAT ROVER.

For modeling system in Figure 2, taken into account the direct and inverse dynamics as well as the direct and inverse kinematics. That is the data collected by the encoders are processed in direct dynamics and then in the closed loop system is fed with the outputs of inverse dynamics, but should take into account the error that generates this type of control.

All kinematics and dynamics of CanSat Rover is modeled for system control, while its ground track depends on the sensor information guidance and recognition.

Modeling of Motors

Geared motors with encoder was used to perform closed loop control taking into account the output speed of the motors. Electrical equations are:

$$V_{IN} = V_o + iR_a$$

$$V_o = K_e \frac{d\theta_m}{dt}$$

And its mechanical equation is:

$$K_m = J\frac{d^2\theta_m}{dt^2} + B\frac{d\theta_m}{dt} + T_C$$

Where:

V_{IN}: Input voltage to the motors.

I: Motor current.

θ_m: Rotor position.

K_m: Constant motor speed.

R_a: Electric motor parameter.

J: Moment of inertia.

B: Coefficient of viscosity.

Tc: Load torque.

2.2 Control and Navigation System Inland

The autonomy of the system relates to its *'capacity'* choosing the magnitudes of the speeds of the motors, so that it can move according to their current states such as orientation and proximity to an obstacle.

Due to the characteristics of the system, chose the design of a fuzzy controller for this libraries *'Fuzzy Logic Toolbox'* MatLab are used.

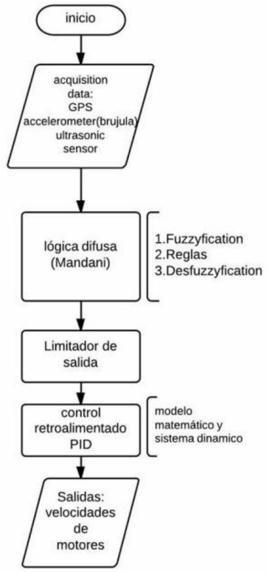

FIGURE 3. FLOWCHART OF CONTROL AND NAVIGATION SYSTEM INLAND

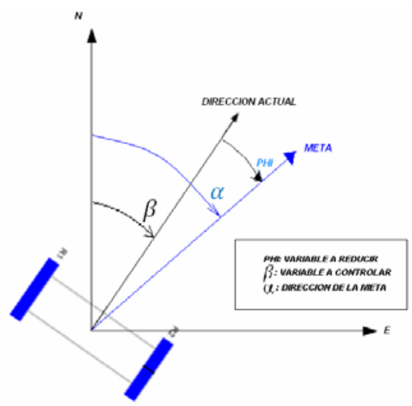

FIGURE 4. NAVIGATION PARAMETERS.

3. ELECTRONIC DESIGN AND COMMUNICATIONS

This module is responsible for wireless communications between EMEC and ARMEC, in addition to the acquisition and storage of data, and thermal control and system power.

The electronic interface board has a power and thermal control, data acquisition board and communication board. The characteristics of sensors and devices are shown in Table 1.

TABLE 1

CHARACTERISTICS OF SENSORS AND DEVICES CANSAT ROVER

	CÓDIGO	CANTIDAD
Módulo GPS	GT723F	1
Sensor de presión	SCP1000 D11	1
Acelerómetro	AE – KXM52	1
Memoria EEPROM	ATML U835	1
Brújula digital	HMC6352	1
S. Ultrasónico	HFK – TS601	2
Motor	AX 070121	2

Figure 5 shows the distribution of all elements of Rover.

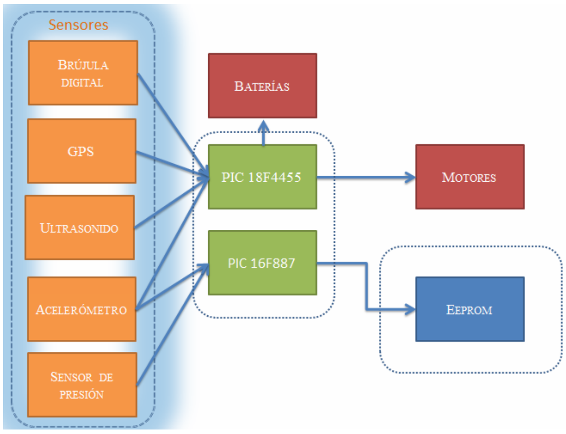

FIGURE 5. ELEMENTS IN THE ROVER.

Figure 6 shows electronics board design

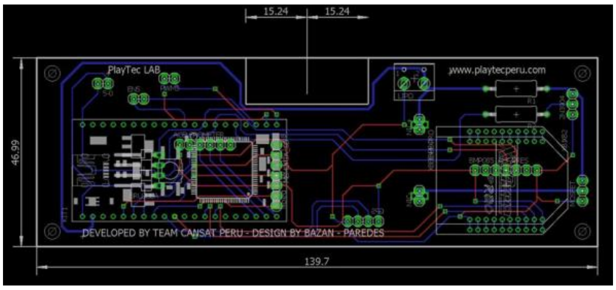

FIGURE 6. ELECTRONICS BOARD.

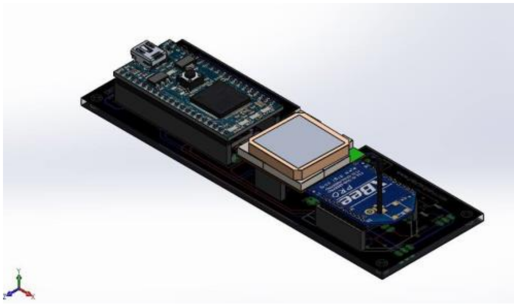

FIGURE 7. DISTRIBUTION OF ELECTRONIC DEVICES

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CANSAT PERU TEAM

CLANS: A Step forwards towards renewable energy

Stella Denni, Noé Aurelle, Alison Ponche, Louis Germain

***Abstract*- In this paper the N6K'n'Sat will present its CLANS, which is a continuation of the work that has been done in the previous years. This year again, the two main purposes of the N6K'n'Sat are to launch a CanSat from both Planète Science's balloon and from a fusex, a 1/25 replica of the Soyuz which is being built by a team composed of Russian students from Samara State Aerospace University. In order to achieve that, the association will improve the atmospheric probing and the roll- and pitch stabilization to land with precision. In addition to that, the N6K'n'Sat has focused on the obligatory mission of deployment which consists in deploying solar panels and to light a little LED.**

I. INTRODUCTION

The CLANS team is composed of four second year students from the French engineering school ISAE-SUPAERO (ENSICA), located in Toulouse. The school has been participating to the national CanSat France competition, the C'Space, organised by Planète-sciences in collaboration with the CNES since 2009.

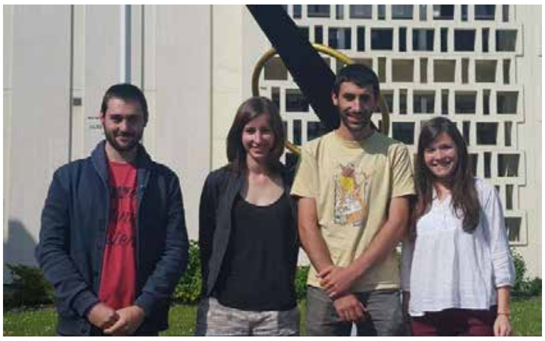


Figure 1 - The CLANS team

The previous teams of N6K'n'Sat have started working on the building of a CanSat which weighs 1 kg and is dropped from a balloon and a CanSat of 33cL which is launched from Russian Fusex, a replica of Soyuz. They have developed several guidance and steering programs and atmospheric data measurement system.

At first, we've started studying the previous CanSats, how they were made and how they worked, so that we can determine their weaknesses and improve them to reach our goals.

Finally, we have to develop the deploying of solar panels in order to lighten a little LED light.

Therefore we can summarize our work from the year in three main missions:

- Integration in the Fusex-rocket
- Precision landing
- Deployment of solar panels and lightening of a LED

II. CONTEXT AND DEVELOPMENT

A. Association

The association N6K'n'Sat, former Budstar, was founded in 2012 (under French law 1901), to promote and improve the work and research on the CanSat, since more and more students participated in the project and won many prices at the competition since 2009.

The association is subsidized by the ISAE-SUPAERO school thanks to the Initiative and Research Funds and by the ISAE Supaero Foundation. It is also aided by ISAE-SUPAERO research laboratories and teachers.

This year our team is composed of four students, two of whom working on the more technical part and the other two dealing with the management, the communication, the scheduling and the organization of the project. Since it is the first year there are so few students, the CLANS-team has got to rely on the work that has been done in the past few years because the amount of work is too much for only four students. Therefore, we kept the main structure of last year and concentrated on the deployment of solar panels and the improvement of the guidance algorithm in order to land with precision.

Alison Ponche and Louis Germain are in charge of the technical part of the project and Noé Aurelle and Stella Denni are managing it. But as there is a strong team spirit, the team parts are helping and supporting each other.

B. Work plan

We started scheduling and organising our project in November 2015. In January, the first step was to contact the Russian team working on the Fusex to organize the meeting at their University SSAU, so that both teams could work together on the integration of our CanSat in their rocket.

At early 2016, we determined the tasks that had to be done, the provisional budget and estimated how long it would take us to order the different electronical pieces and to build a 3D structure of the CanSat. The members in charge of the technical part started studying the necessary electronic pieces and improving the steering and guidance code.

Around April 2016, we had determined what we needed, designed the structure and ordered the different missing pieces. At the end of April we built the structure of the CanSat, ordered the electronics, which left us the end of May and June to put the whole together and to do the tests.

TABLE 1 represents the estimated budget of the whole project, from the components to the stay in Russia for the integration of our CanSat in their rocket, as payload.

TABLE 1: Estimated budget

Category	Product	Quantity	Unit price	Total price
Analogic	Li-Po	12	11	132
	Circuit	3	15	45
	Jack	1	10	10
	Cable	3	10	30
Structure	Sail 1L	1	35	35
	Sail 33cL	2	20	40
	Connections	3	20	60
Deployment	Solar panels	4	20	80
	Servomotor	4	13	52
	Latch	3	10	30
	Spring	8	1	8
Russia	Flight	2	600	1200
	Housing	2	150	300
	Visa	2	120	240
Total €				3,957

III. DEFINITION OF THE MISSION

A. Scientific mission

❖ *Atmospheric probing*

The scientific mission consists of 4 atmospheric probes of luminosity, hygrometry, pressure and temperature. We use three different sensors whose characteristics are:

- Luminosity: from 0.1 to 40,000 Lux and can be configured for different time and gain ranges.

- Temperature: accuracy ±1°C (3°C maximum).

- Pressure: accuracy 0.03hPa from 500 to 1100 hPa, that is to say 0.3m altitude resolution.

All data measured by these sensors will be saved on a micro SD card after being sent in real time on the autonomous ground station, in order to be sure to obtain the values at the end of the flight.

B. Free missions

1) Guidance and accurate landing

This mission consists in controlling the trajectory of the CanSat. For this mission, the embedded electronics remains very important. Indeed, we can obtain the altitude from the pressure data, the acceleration from the accelerometer and the position from the GPS module. All this information is gathered in the electronic card (an Arduino card) and the trajectory is calculated thanks to our algorithm, which compares every two seconds the real trajectory and the ideal trajectory. Then, this card send an instruction to the servomotors in order to control the sail and thus fly and land with precision in a radius of 75 meters around the launch point of the CanSat. The servomotors allow an asymmetrical deformation of the sail, which permits to turn. As we are limited in vertical speed by the CanSat's challenge for security reasons (15 m/s), we have to control the acceleration and speed data and engage a braking action if necessary. In this case, the sail is deformed symmetrically. As we have some constraints in terms of frequencies and interferences with the other teams, a clock will be used to stop the CanSat's electronics at the landing.

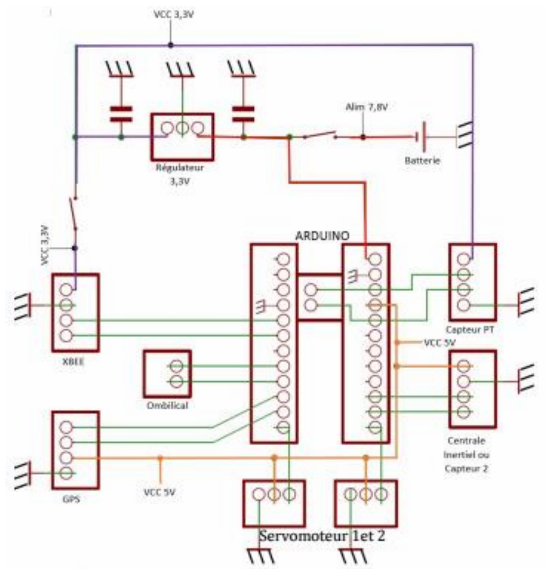


Figure 2 - Electronic system of the CanSat

2) Deployment of solar panels

During the flight, after the CanSat's parachute opens, the luminosity sensor captures the luminosity. If the light is sufficient, mechanical actuators release a latch so that the solar panels can deploy in order to lighten a little LED to prove that the panels are really working. The solar panels we have chosen are able to deliver 4 volts and 50 mA with a good sunning, which is normally sufficient to power a LED.

Figure 3 - Solar panel "stick" by Lextronic

C. Launch from Soyuz rocket

Our CanSat will be integrated in the Fusex made by Russian students and will be launched from the rocket during its flight, a few seconds after the rocket's parachute opens.

Figure 4 - CanSat prototype and its location in the Soyuz [1]

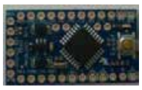
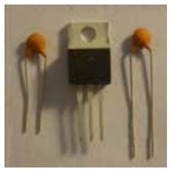
IV. CANSAT ARCHITECTURE

A. Electronical architecture

❖ *Components*

TABLE 2 (see below) is a list of the electronic components chosen with their characteristics, their purpose and a joint illustrative image [2]. All the components are compatible with the Arduino programming, which is closed to the C/C++ language. Therefore, the sensors are easy to use thanks to the API documentations, which are provided by Arduino.

TABLE 2. COMPONENTS

Function	Components	Image
Micro-controller	Arduino Pro Mini Atmega328, 5V, 16MHz Board	
Pressure measurement	BMP180Baro Breakout Board	
Light measurement	TSL2561 Breakout Board	
Temperature and humidity measurement	HIH613 Breakout Board	
Wing control	2 servomotors 9g A0090	
GPS	GPS OEM "EM-506"	
Data transmission	Xbee ProS2B and antenna	
Data saving	Breakout Board for µSD Card and µSD Card	
Roll and pitch measurement	MinIMU-9 V2 (L3GD20 and LSM303DLHC)	
Camera	FlyCamOne EcoV2	
Camera control	2 Servomotors 9g	
Image saving	µSD Card	
Components power supply	2 Batteries Gens aco 7,3V 800mAh	
Camera power supply	Battery Lipo 1000 3,7V 1000mAh	
3,3V regulation	LM1086 1.5A 3,3V Low Dropout Positive Regulators, 0,1µF capacitor, 0,33µF capacitor	

2) Power supply

In order to create a printed circuit board, we had to determine the power supply of each component, so that it was easier to put the different electronical pieces together into the CanSat.

The TABLE 3 lists the power supply of each element.

TABLE 3:. POWER SUPPLY

Component	3,3V	5V
LSM303DLHC	x	
µSD Breakout	x	
GPS		x
servomotors 9g		x
Xbee	x	
TSL2560	x	
BMP180Baro	x	
HIH6130	x	

B. *Mechanical parts*

Our CanSat is composed of a plastic skeleton designed on Catia, which role is to support the weight of the components. It was thought and designed to optimize the space of the electronics and to make sure that every component fits in.

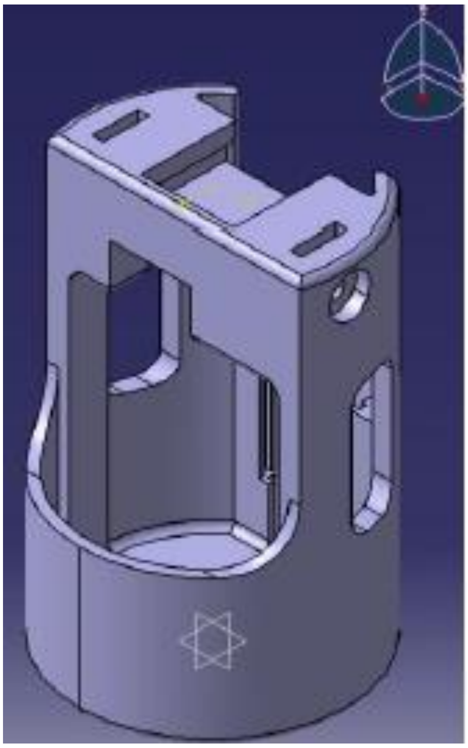


Figure 5 - Structure designed on Catia

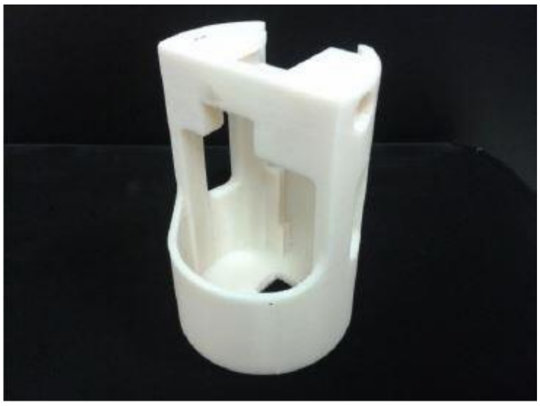


Figure 6 - 3D structure after being printed

C. *Telemetry*

1) *Antenna*

In order to transmit the measured data of the Soyuz rocket launch we use an Antenna made by N6K'n'Sat. As the data must be transmitted to the ground, we need an antenna with a signal range of 800m. The antenna is made of an exciting patch, a substrate and a probe linked to the Xbee. Its purpose is to maximise the received power ($P_{received}$) by maximising the emission gain ($G_{emission}$), since the emission power is limited to 10 dBm.

The Friis equation gives us the power received:

$$P_{received} = \frac{\lambda^2}{(4\pi R)^2} \times P_{emitted} \times G_{emission} \times G_{reception}$$

The communication channel of the Xbee and the substract properties determine the dimensions of the patch.
Figure 7 shows the composition of the antenna.

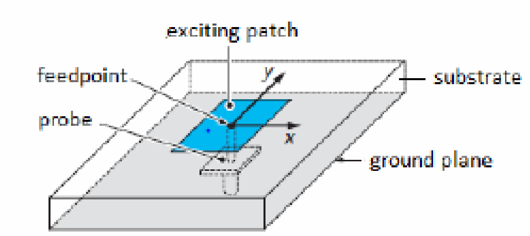


Figure 7 - Composition of the antenna

2) XBEE communication

XBEE is a communication module which enables the communication from a CanSat to the ground station. There are two parts, the first one, the mbed, works like a USB stick on the computer and receives the data measured by the second one, the XBEE pro module, in the CanSat. They have to be paired before using and work wireless. [3]

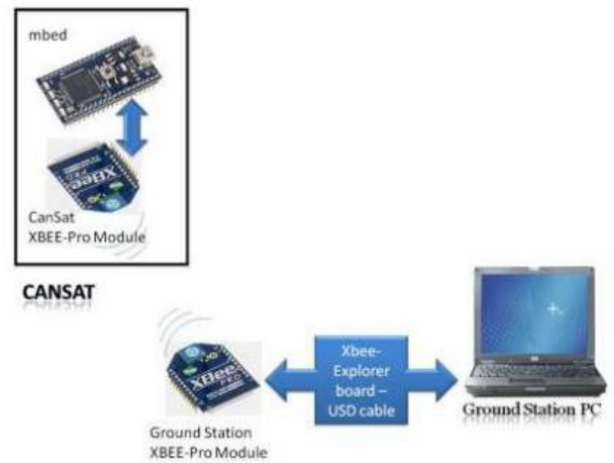


Figure 8 - Illustration of XBEE communication [4]

In order to pair the two modules and to make them recognize each other, so that they could exchange data, we had to install and to use the XCTU software, which is a special software made by XBEE manufacturer.

D. Guidance algorithm

To make the CanSat follow a precise trajectory and landing on a particular point, the algorithm in the Arduino card has been improved. It compares the current trajectory with the ideal path to follow in order to adapt the trajectory. Just before the launch, the coordinates of the target, which is the landing point and the launch spot, are written in the algorithm. After the launch, the loops in the codes of the sensors, the GPS module, the transmission to the ground station and the servomotors begin. Every two seconds, the ideal trajectory is calculated by the Arduino card and is sent to the servomotors. Once the distance between the ground target and the CanSat is lower than 5 meters, the guidance is interrupted and the CanSat enters in a spiral dive so that it can go down directly.

Figure 9 - Arduino software Interface

V. CONCLUSION

This year we focused on the mission which consists in the deployment of solar panels, as renewable energy is a real issue in the research. Therefore we used the general structure and organisation of the CanSat that had been used last year, corrected some weaknesses in control algorithms and added solar panels, which are supposed to lighten a little LED.
For now, we are assembling electronics and structure in order to conduct several tests on June to be ready for this year's C'Space session.

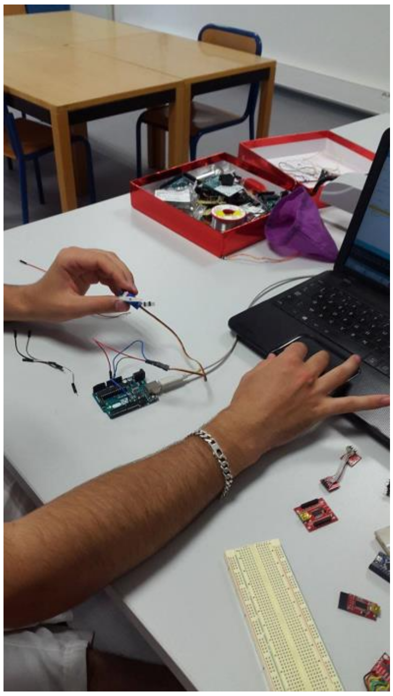


Figure 10 - Tests on the arduino card

ACKNOWLEDGMENT

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

- Joël Bordeneuve-Guibé and Christine Espinosa, professors at ISAE, for their support during the project;
- The former teams of N6K'n'Sat for their help;
- Daniel Gagneux, ISAE foreman, and his colleagues who gratuitously printed the structure and helped us to build the structure
- The Planète Sciences and CNES teams
- The ISAE-SUPAERO-Foundation which financially supported the project

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[1] Report of the CanSat team 2013

[2] http://www.arduino.cc/

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[4] http://www.rast.org.tr/UTEB/doc/egitim/doc-2.pdf

STARCAN

Second Lieutenant Thomas Pacorel

Abstract-The CanSat STARCAN is a École de l'Air (French Air Force Academy) project. Although it is part of the CANSAT 2016 challenge, the device will also take place in a rocket as payload for the FUSEX challenge. The payload's missions are to collect data as GPS coordinates, pressure and acceleration, and to transmit them to the ground. To achieve this, a 3D printer was useful to comply with the small required dimensions. Printed circuit boards designed within the academy have provided the project with great flexibility. The final device was tested and declared functional, able to send its data and also to register them for further analysis.

I. Introduction

THE project StarCan is carried out in the French Air Force Academy, which is already involved in the development of experimental rockets since four years. The goal of such a project is to extend the skills of students as they will need a large panel of them to fulfill the mission. The device developed is following strict specifications, ruling size, shape and weigh for instance.

The missions selected for StarCan are :

- deployment of an antenna,
- acquisition of GPS coordinate,
- acquisition of pressure and acceleration data.

The device is also transmitting data right after the drop and these data are collected and analyzed on the ground. Particularly, GPS coordinates can be used to facilitate recuperation of the device after landing.

Fig. 1.Starcan

II. Context of Development

A. Club

The CanSat is developed by a student as its final study project. Within the department of technology and sciences of information, the student can carry out the project by himself while getting the material support, not to mention some help too. This is the first year that the department is involved in the CanSat challenge. Nevertheless, it takes part to the FUSEX challenge since 2012 and is also involved in numerous other robotics and telecommunication projects.

Projects benefit from the material present in the department and can ask for additional resources if the spending is justified. Using common resources is convenient as it decreases spending and it also makes everybody work on similar material. That is why projects are often tightly knitted as are FUSEX and CANSAT projects.

B. Work Plan

This project is carried out on a three months period at the end of the third year of school. The project has been divided in three main parts: programming, electronics and finally structure.

There was at first a part of research to define the missions and the material which will be used. Then there was a part of testing and programming to validate the chosen components which had to match requirements for each mission.

At the end of the first month, the electrical design was over and electronic boards were ready to be created. Once the boards were achieved, they have been tested and often modified to better fulfill the specifications. It was also at this moment that the telecommunication system was designed and tested.

Finally the structure was then designed to fit the electronic boards. Everything was dimensioned to minimize the space taken by the device, less space meaning less weight. As the weight impacts on parachute size, the structure design was a critical part of the development.

All needed materials were provided by the department, from sensors to development tools as the 3D printer.

III. Definition Of The Mission

A. Mandatory mission

The mission proposed this year was the "deployment". To fulfill this mission, it has been chosen to deploy an antenna. This antenna was built from a coaxial cable. A servomotor is keeping the antenna inside the CanSat until the drop of the device. Once the drop is detected thanks to a photoresistor, the servomotor releases the antenna out of Starcan.

B. Free missions

The free missions chosen are the data acquisition delivered by different sensors. These data are registered on a memory card and transmitted to the ground station in charge of data analysis.

The first free mission is the acquisition of the device GPS coordinates. This is primordial to help to the CanSat recovery, especially after the drop from the Fusex at around 1500 meters high.

The second mission is the acquisition of the CanSat internal absolute pressure with a barometer.

Finally, acceleration on the three axis is measured in order to detect important flight's event (launch, drop, landing…).

IV. CANSAT ARCHITECTURE

A. *Electrical architecture*

The electronics inside the device is divided in three boards. Doing so is safer in case of issues on one of the boards and facilitates repairing operation. Thus, there is one board dedicated to the power supply, one to the radio module, and one to the sensors.

The power board integrates two switches, each one with a control LED. There is also one voltage regulator as the radio module needs to be supplied with 3,3V while the Arduino Uno module can adapt itself.

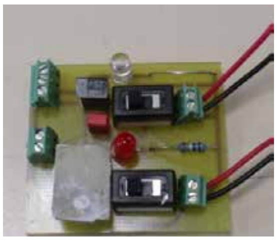

Fig. 2.Power supply board

The second board is the sensors' board. It gathers an inertial measurement unit Altimu10, one photoresistor, one GPS EM-406 and one microSD socket to register data. These components were selected because of their small size and their reliability as they had been already used in other projects. It is also via this board that the Arduino is supplied and that the servomotor and the radio board are connected.

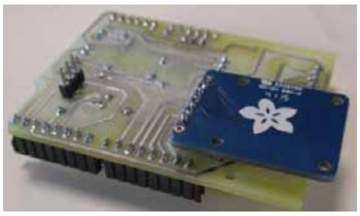

Fig. 3.Sensors'board

Finally there is the radio board on which is soldered the radio module and its antenna.

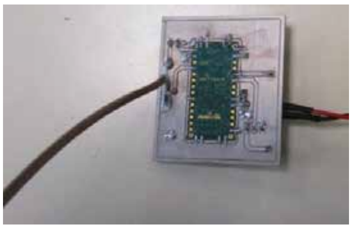

Fig. 4.Radio board

The radio board is plugged on the sensors' board which is itself plugged onto the Arduino UNO.

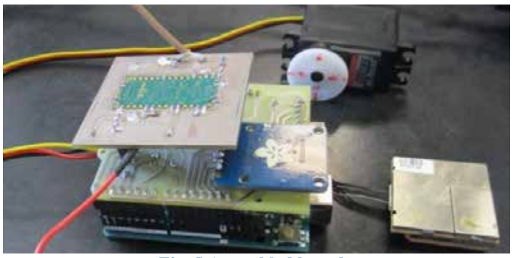

Fig. 5.Assembled boards

B. *Mechanical parts and structure*

The mechanical part consists in a servomotor which is holding the antenna. The servomotor is controlled by an Arduino plateform. The drop is detected thanks to a change in light intensity. When the light intensity crosses a precise threshold, then the servomotor releases the antenna.

The structure was created with a 3D printer. The CanSat is built on the basis of a 140 millimeters high cylinder. Inside, electronics fit perfectly and power switches can be triggered from the outside.

The total CanSat weight, including electronics, is 330 grams. The parachute was then designed to obtain a vertical speed of 4,5 meters per second. This speed was selected to let enough time to the CanSat to realize its missions.

Fig. 6 CAD model of the device

C. *Telemetry*

The telecommunication system is made from the NB868 module which is a transceiver. It uses a GFSK (*Gaussian frequency-shift keying*) to transmit data. The frequency is 869 MHz and a quarter-wave antenna is used. Thus, the antenna is an 8,6 cm coaxial cable and the range of the radio module is about 2 km in open area. Data transmission uses ASCII (American Standard Code for Information Interchange) code. Each data (GPS coordinate, pressure…) is separated by coma so that the software can correctly recognize them and fill columns of a LibreOffice spreadsheet.

V. CONCLUSION

The CanSat is now almost operational and only the parachute is still under construction. Tests have shown the device capability to successfully fulfill its missions. This project was a wonderful opportunity to discover project management. It was really interesting to have the opportunity of developing a functional device from the beginning to the end, and to be involved in every step of the conception. It has enabled to better understand the constraints that a project must face out.

It was finally a great experience to be involved in this challenge with other scientific clubs, aiming at the same goal. All we can expect now is good weather conditions for the C'Space week to provide the best chances of success to all competitors.

ACKNOWLEDGMENT

I would like to thanks every people that helped me on this project, especially Captain Hill for his management advices, Staff Sergeant Fugier and Warrant officer Deyrieux for their precious help.

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

KAMINO, Cloning GAÏA

A CanSat dedicated to Terraformation

Thomas Drocourt, Julien Jallu, Djamel Bertal

***Abstract*– The word "CanSat" come from the mix between two words: "Cans" and "Satellite".**

The word "cans" deals with the little size of the product we have to build. It has to be cylindrical with a height of 20 centimetres and a radius of 4 centimetres.

The word "satellite", because the "CanSat" will be drop from a balloon with a height of 100 meters approximately. During the fall, it has to do several missions like a real nanosatellite.

We have one compulsory mission: a deployment on the ground, after landing. That means, a part of the CanSat has to emerge of the cylinder.

A free mission: the measurement of atmosphere characteristics (pressure, temperature, altitude and humidity).

And a bonus mission: the ejection of a small piece during the fall.

About the deployment mission's we choose to make a hole in the earth to insert an organic substance. This common process is called « Terraforming ».

I. INTRODUCTION

THIS article focuses on our realisations called « KAMINO » which will participate at the C'Space 2016, a CanSat competition in Tarbes from July 18th to July 25th. Cansat is a kind of nanosatellite dropped from a balloon (Open class) or a rocket which have to do some missions during and after the fall according to the C'Space's rules.

This project is led by Octave association which using premises of Evry's University during all academic year.

The project's article will show the missions selected and how we have designed, produced and assembled parts to make the finished product.

II. CONTEXT OF DEVELOPMENT

A. Project team

The project team, named KAMINO, is composed of three students from Master 1 at the University of Evry. The team is part of the University space association Octave. Octave has taken part to the Cansat and Fusex competitions for several years even if it is the first time for the KAMINO members. Furthermore, the project result of a school work to qualify for the master 1 degree. The project has been financed by the University of Evry and supervises by a teacher: Mr G. Porcher.

Fig. 1. The team's logo

Fig. 2. KAMINO team's member

The Scientific's skills of the team members are various and the project led them to learn and improve their ability in different skill area. They have worked together in brainstorming, paper plan elaboration and project scheduling but have also specialization. Djamel is talented in computer aided design, Julien is talented in electronics and Thomas is talented in C++ programing.

B. Work plan

With the aim to succeed both objectives, Balloon and Fusex CanSat, our project needed some tools to be managed. To have the best productivity and result, a Gantt planning, task, cost price, purchase and communication management were developed. Also the combination of two organisations, University and Planète Science multiplied by two the milestones and deliverables with a total of 16. So with all these constraints through time, cost and quality, the management of project was vital.

Our project start with a complete analysis of the CanSat competition since 2011. This task called bibliographic research and was finished in December. After this first stage, the C'Space event, prior and next CanSat competition was totally understood. In January, we choose the missions who will characterise our satellite. At this time start the realisation, then with the interests and knowledge of each members, we shared the tasks and responsibilities.

The main tasks are bibliographic research, design and development, manufacture, program writing, assembly and testing procedures.

All members participated in the bibliographic research. The design and development started with preliminary scientific calculation and follow with computer-aided design. After validation, the manufacture started and using 3D printing technology. In simultaneous engineering, the programming began in order to understand and be ready to simulate in real the part printed and assembled.

With an estimation around a hundred hours was consecrated in our university planning but we had to work more with around

300 hours outside of the university. The substantial tasks were the computer-aided design and the programming.

C. Budget

Our project is funded by the University of Evry, with a budget of 500 euros and only for balloon version (CanSat France competition). The travel, accommodation and other cost during the C'Space are funded also by the University of Evry. At this time our satellite costs 400 € with 250 € for the buying's components and 150 € for ABS prototype material printed.

TABLE 1. COMPONENT'S PRICE EXTRACT

Mission	Parts	Qty	Price
System	Arduino UNO R3	1	25 €
System	Battery 12V	2	20 €
Terraforming	Parachute	1	40 €
Terraforming	Torsion spring	6	60 €
Terraforming	Servo-motor 5V	2	12 €
Terraforming	Motor 12V	1	5 €
Parachutist	Electromagnet lift 12V	1	40 €
Parachutist	Solenoid Actuator 12V	1	5 €
Atmospheric	Atmospheric sensor	1	18 €
Atmospheric	MicroSD Breakout	1	4 €

III. DEFINITION OF THE MISSIONS

A. Deployment Mission

This year the competition took a new dimension with a compulsory mission. The aim is to realise a mechanism deployment out of the CanSat volume. For that the inspiration of the real space probe was necessary to be the most realistic. The mission that we choose is called Terraforming. The objective is to drill the ground after landing and inject an organic substance in the hole. Thereby terraforming will consist in to transform the initial environment into habitable planet by a process of global environmental engineering through the organic substance.

This mission developed, consist of three phases:

1. Landing: Some landings gears like tripod will be deployed to increase ground's contact area.
2. Digging: a mechanism will drill the ground as per a deep, diameter size and speed.
3. Injecting: By using gravity, the organic substance will release and lead right in the hole.

B. Free Mission

This year, the atmospheric measuring wasn't a compulsory mission but the KAMINO team decided to run it. In this way, an atmospheric module purchase from Sparkfun supplier is set into the CanSat. The module's sensor is place in front of a little hole on the lateral side of the CanSat in order to be in direct contact with the outside air. Then, the sensor is able to measure pressure, temperature, humidity and altitude. To record these measured data, a SD module is also set in the CanSat with a micro SD card.

C. Bonus Mission

The bonus mission consists in the ejection of a figurine called "parachutist" during the fall of the CanSat. We did not choose to eject it on the bottom thanks to the gravity, because after the parachutist ejection, a collision with the parachute of the CanSat is highly probable.

Therefore, we have chosen to eject the parachute on the side with these processes:

Firstly, a trapdoor opens on the side to allow a necessary space for the throw out. This trapdoor is controlled by and electro magnet, when this magnet is supplied by electricity, the magnetic fields is zero and the trap door falls thanks to the gravity.

Secondly, a part push the figurine out thanks to a spring. This part is controlled a magnetic linear actuator using like a mechanical stop.

D. Descent chronology

The following figure presents the chronology the fall of KAMINO. Each steps are corresponding with a mission previously presented.

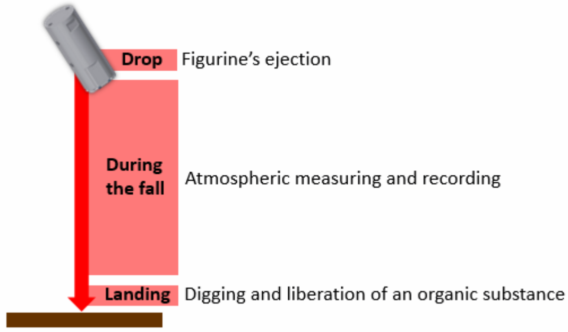

Fig. 3. KAMINO's descent chronology

IV. CANSAT ARCHITECTURE

A. Scientific calculation

i. Landing system

To achieve correctly the "terraforming" mission, the CanSat has to land vertically. Therefore, there were two critical things to determine:

- The diameter of the landing system.
- The strength of the spring to absorb the energy when the CanSat land.

Firstly, thanks to the CAD we are able to know the position of the centre of gravity. After that with a simple theorem of mechanics in 2 dimensions we can design the length of the landing door to be stable until a hill of 10°.

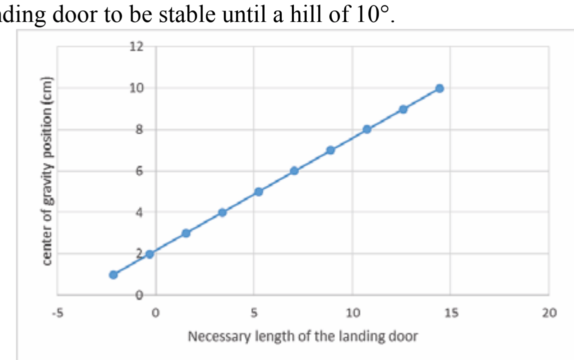

Fig. 4: Evolution of the necessary length of the landing door depending on the position of the centre of gravity.

Secondly, in add to allow a stability in vertical position the landing system have to absorb the energy when the CanSat land thanks to torsion spring. The weight of the CanSat is approximately 1 Kg and there is 3 landing gear:

$$F = \frac{1}{3}P = \frac{1}{3}mg = 3.3N$$

Each door has to supply a strength of 3.3N

$$C = F \times d$$

- C: Torque N.mm
- F: Strength N
- d: Length of the landing gear

ii. The drilling

For drilling we need to create two kind of movement at the same time: rotation and translation. We choose a gear rack to do this job because it's the best solution for our space requirement. However, there are several important constraints:

- Amplitude of translation=30mm
- Maximum amplitude of the pinion (servo-motor) =180°

The purpose is to find a pinion diameter which allow a translation of 30mm with a rotation under 180°.

Formula used:

$$Numbers\ of\ revolutions = \frac{Translation\ amplitude}{2\pi\ radius\ of\ the\ pinion}$$

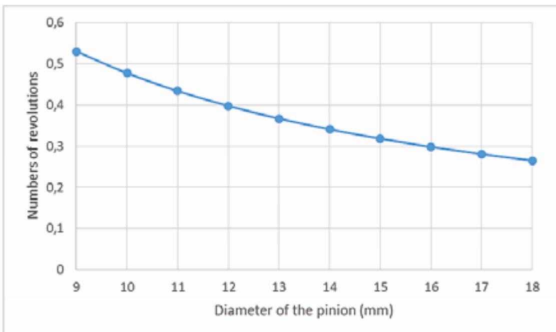

Fig. 5. This graph represents the numbers of revolutions depending on the diameter of the pinion.

iii. Battery

In order to accomplish the different missions, the "KAMINO CanSat" use many electronics components. It's very important to the consumption of the totality to design correctly the battery.

TABLE 2. ELECTRONICS COMPONENTS CONSUMPTION

	Tension in V	*Intensity in mA*	*Operating time in sec*	*Consumption in mAh*	*Consumption in %*
Electromagnet	12	215	1	0,059	0,16 %
Servo-motor (1)	5	200	1	0,055	0,14 %
Solenoid actuator	12	1000	1	0,277	0,72 %
Drill motor	6	500	3	0,416	1,08 %
Servo-motor (2)	5	200	3	0,166	0,43 %
Atmospheric sensor	3,3	0,0036	30	0,001	7,80 %
Arduino Uno	12	50	2700	37,5	97,46 %
Total			**2739**	**38,476**	**100 %**
Battery capacity in mA/h : 360					

B. Electrical architecture

In order to achieve the missions chosen, the CanSat include several electronic components monitored by an Arduino microprocessor. First of all, there are two servo-motor plugged to the Arduino. This kind of component is compatible with the microprocessor and can be directly connected into it. The servos have three wires for the power, the ground and the control.

On other hand, there are three components monitored with power circuits: an electromagnet, a magnetic linear actuator and a motor. They are connected to the Arduino with a transistor and a resistance. This specific arrangement is required for components that cannot be powered by the Arduino, which maximum delivery voltage is of 5 Volts. Thus, all three components are powered with a 12 volts battery and set-up with a fly back diode, in order to dissipate any magnetic induction. In addition, the Arduino is powered by the same 12 volts battery.

Finally, KAMINO is equipped with a jumper device. A Jumper is an electric circuit which will be open mechanically at the moment the CanSat will begin its fall. The figure below presents the electric diagram.

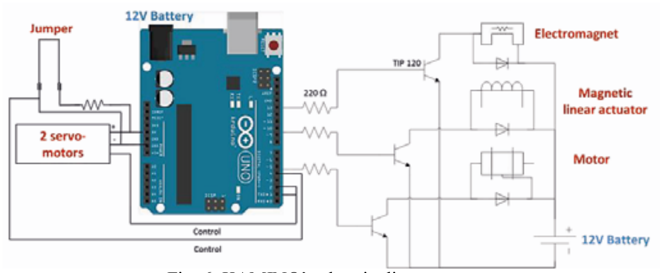

Fig. 6. KAMINO's electric diagram

It is important to notice that the atmospheric sensor and the SD module are also plugged into the Arduino.

In order to monitor rightfully the electrical components and achieve successfully the chosen mission, the Arduino is programmed as follows.

C. 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 KAMINO 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 is initialized. This sequence operates the turn on of the digging motor and two variation of the last servo-motor. The angle of rotation goes from an initial position of 70° to 110° with a step at 90°. This enables a progressive digging in the soil by lowering and lifting the drill. At the end, another variation from 70° to 130° is operated before lifting up to a final position at 50°, which will enable the opening of the seed trap and the fall of the seed. After that, the Arduino won't do anything else.

D. *Mechanical parts*

The whole mechanical structure of KAMINO was designed on two CAD software, Inventor from Autodesk and SolidWorks. The use of this both was due for the collaboration between two skill's member. This collaboration got shorten the design on computer by two.

To realise the objectives some missions needs some dynamics and mechanisms solutions.

For the Terraforming missions, three phases have own cinematic objective. The first consist in to land the CanSat in the digging position. For that a tripod is deployed with couple of torsion spring in which landing gear. This solution work with the potential energy stored as a result of spring's torsion. To hold the tripod back a system consist of three hook controlling in rotation by a servo-motor.

The second and the third phases are linked. The second phase consist in to drill the ground. A rack and pinion system is using to realise the feed rate combining with motor to produce the rotation who lead the digging tool.

The third phase use the translation generate by the rack-pinion technology to lift a trapdoor who release an organic substance by gravity.

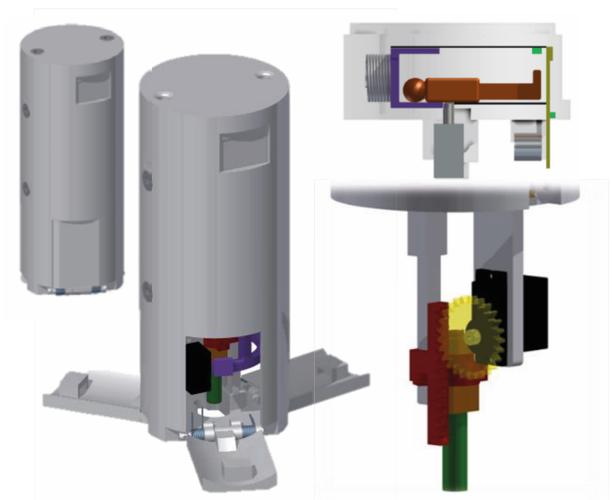

Fig. 7. KAMINO CAD view

V. Conclusion

The KAMINO project's status review on May 21st 2016 at Planète Science went well and shown good progress. The conception and printing of the different KAMINO parts are completed. Several tests with electrical components and the Arduino board have been done. But there are still several upcoming tasks to prepare for the competition in July. First, real condition tests will be performed to evaluate the landing attitude of KAMINO. Then, few adjustments might be operated but the Cansat will be cloth to its final state. However, several spare parts are going to be printed or purchase, in case of major problems during the competition. Finally, there is still the competition logistics to achieve in order to be in the best condition for the event.

Acknowledgment

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

- Our university tutor Mr. G. Porcher, for is support and advice,
- Mr. F. Davesne, of IBISC laboratory for is 3D printing assistance.
- Mr. B. Hugues, for is expertise sharing and program writing assistance.
- Mr. D. Biyoro and N. Kossa, of OCTAVE club for are welcome and support all project long.
- Mr. F. Dadié, of Planète Science for is support and advice.
- Mr. S. Magalhaes, for is invaluable helps, technical skills and advices in the workshop.

CELESTA II
UFRST EVRY
OCTAVE

Julien Ignaczak, Dembo Kanouté, Gautier Lavastrou, Ismael Sarsari

CELESTA II: a CanSat to explore surfaces and different properties of new planets.

TEAM OCTAVE

UFRST EVRY

2015 / 2016

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ABSTRACT

The CanSat CELESTA 2, designed and built by the team from Octave at the Science and Technology University of Evry, is a very complete droppable device, able to measure many physical quantities. Those measures will be stored on an SD Card and also be sent in real-time to the ground station. Moreover, Celesta 2 will be able to drop a figurine during his fall, to film the outside environment and finally to dig the ground with a shovel.

To have a better view of this project, we will briefly introduce you the different missions carried by CELESTA 2, then we will describe the context of its development, moreover we will focus more precisely on the aim and the architecture of this CanSat. Finally, we will conclude by studying the possible applications of CELESTA 2, the difficulties we faced and the things we learned.

I. INTRODUCTION

The missions of the CanSat CELESTA 2 are:

- Dropping a figurine with its parachute during the fall, thanks to an opening airlock. This application could be useful for real size satellites, which could release robots or independent devices to achieve their mission.

- Collecting physical data with sensors. Those data match with physical quantities: pressure, acceleration, temperature and altitude. Those measures are saved on an SD Card with a .cvs extension, readable by the software Excel. They will also be sent during the fall to the ground station thanks to an Xbee device.

- Digging the ground with a shovel after the landing. It can be used for example to collect ground samples to determine the properties and the nature of the explored aster, to see for example if it is able to welcome some kind of life.

- Filming the ground and the figurine's fall with an Arducam. The video is stored on an SD Card. This application may be important to have a real view of the behavior of the figurine during his drop, and to obtain video of the place where the CanSat lands.

The CELESTA 2 is an upgraded version of the CELESTA. This new project includes real-time data sending, figurine's drop and filming.

CELESTA II
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II. CONTEXT OF DEVELOPMENT

A. Club

The team is composed of four students studying different kinds of engineering at the university of Evry. The CanSat project takes place inside the offices of Octave, an aerospace technologic creation association for students of Evry, Robert Doisneau high school and Georges Brassens high school. Since many years, the university of Evry hosts an Aerospace Pole, providing interest for aerospace to students. Octave was created responding to the establishment of the PERSEUS Project (student space research European project), supported by Planète Sciences, STS and the CNES. Octave regroups many other projects:

EVE V1 (2009): The objectives were to achieve an experimental rocket motor solid with one or more onboard experiments. These objectives were fully satisfied with the qualification of the rocket, which took place by CNES engineers. The total mass of the rocket has been optimized to the maximum because it weighed less than 10 kg, without the motor. The onboard experiments have been validated in qualifying. According to the flight videos, altitude is reached around 1000m.

EVE V2 : This rocket has exactly the same structure as EVE V1, but the base engine has been modified, that was the cause of some integration problems on the engine firing. Concerning the electronic, it is to miniturize the cards, and turn them into digital. All the components are thus changed to have a more powerful equipment with codes in C language. Those modifications appeared to include an inertial unit.

DAVE (2011) : This project is a collaboration between Octave and the club DARE of the university of Delft (Netherlands). This approach is made to establish a close partnership with both universities but also for exchanges between students.
The mechanical part was made by Octave in Evry and the engine was provided by the club DARE, The shooting took place in April 2011 in Hollande.
Structure : transition to a support structure based on stringers carbons and aluminum ring.
Recovery system : development and integration of a transverse partition innovative.
Parachutes : development and integration of a dual parachute, the *drug* for a rapid descent and *main* for a soft landing.
The electronic part is not left with the integration of more powerful cards and the development of new media cards.
Embedded boards : IMU Octave, IMU ESIEE, SysNav, RDas.
DAVE was described by team NAVRO without major problem, even if a difference appear between the theoretical calculations and flight (we do not use the same tools).
Attention was at its peak when shooting was announced, the Dutch wanting to know what the French were able to do...

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The flight went very well, in triumph with the opening of the second floor of the parachute at 300m. The rocket was returned intact, the engine still hot in the tube.
We trained our system with this flight recovery (separation + parachutes) and certainly the beginning of a great collaboration between our two clubs.

B. Work Plan

1) Team organization

To achieve this project, the team decided to divide itself into two groups: mechanical conception and electronic conception.

The first group is constituted of Julien Ignaczak and Gautier Lavastrou. They had to design the different CanSat mechanical systems: make the shovel out of the CanSat, create a digging movement, and create an opening airlock for the figurine.

The second group is constituted of Dembo Kanouté and Ismael Sarsari. Their role was to write the code to receive information from sensors and send it in real time with an Xbee device. They also had to recover the video from the Arducam to an SD Card.

Of course, those groups had to communicate and work together all along the project, because all the systems put together needed to be slotted inside the CanSat, and also because some systems needed the attention of both groups, such as the oscillating movement of the shovel, controlled by an electronic card and a servomotor.

2) Time organization

First of all, the team focused on the missions CELESTA 2 had to achieve. Those missions where discussed and finally chosen during the month of December. After that, we needed to draw the general aspect of the CanSat including all the systems in it. At this point, the global design work was done, it ended on January.

Secondly, the team had to list the different needed component to start the conception. Julien and Gautier started to use CAO software for mechanical systems, as Dembo and Ismael were coding on their Arduino interfaces. This conception took about four months, and ended at the end of March.

Finally, we printed mechanical pieces in 3D and tested the electronic devices. Then we assembled the Celesta 2.

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III. MISSIONS

A) MAIN MISSIONS

Our CanSat has many principals mission to achieve during the competition. Those assignments are:

- The BMP035 sensor measures temperature, pressure and altitude.
- The ADXL335 sensor is a inertial measurement unit which gives us acceleration on three axes.
- The SD Card, to store the sensors' data.
- The shovel deployment to dig the ground just after the landing. Two servomotors working together to drive this shovel.

B) FREE MISSIONS

We have chosen three free missions:

- Telemetry:
  The plot of this mission is to send and to receive data from sensors to the ground station. An Xbee Pro S5 achieves this mission.

- Video:
  During and after its fall, Celesta 2 will be able to film the ground. The interest of this mission is to watch the parachutist's behavior and to have images of the ground we landed on.

- Drop a figurine:
  Just after the drop of the Celesta 2, its hatch will open to release the figurine with its parachute. The pressure sensor commands the drop. The interest of this mission is to be able to drop an object in order to achieve his own mission.

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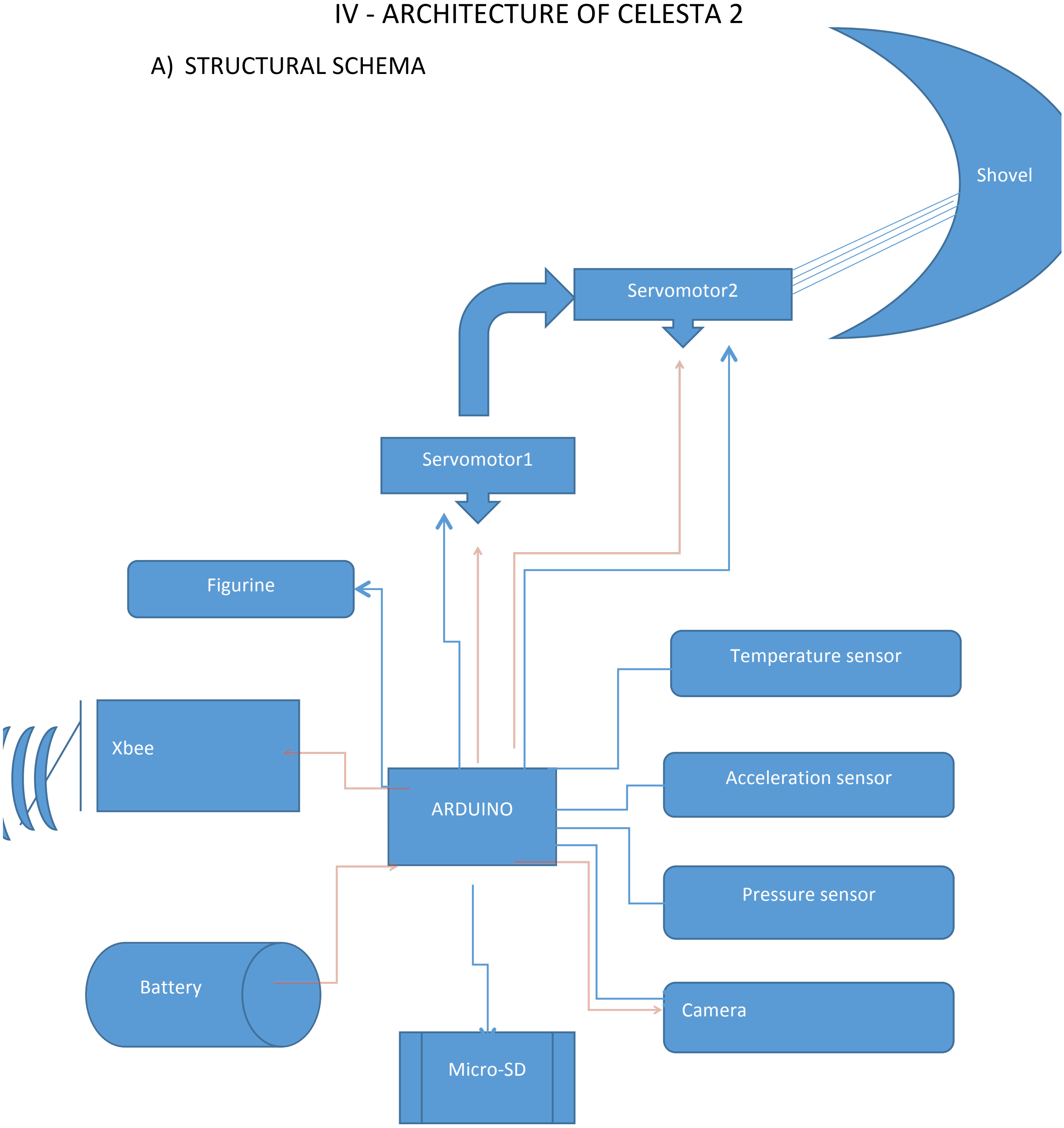
IV - ARCHITECTURE OF CELESTA 2

A) STRUCTURAL SCHEMA



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B) CAO

For the mechanical conception of our CanSat, we used the CAO software SolidWorks. We designed different pieces, such as:

The cap, the figurine's compartment, the main body, the shovel, the rack support ant the servomotor support.

After designing all those pieces, we made the assembly of the entire Celesta 2, by modeling the servomotors, the rack and pinion and the electronic cards.

C) TELEMETRY

The transmission reception and transmission is done through a Zig Bee web thanks to the Xbee devices pro S5.

We use two Xbee for Celesta 2 to communicate with the ground station, so we can collect the data. The signal has a emission power of 1mW at a frequency of 868MHz.

V-SOURCES

To achieve this project, we used those website:

https://www.sparkfun.com

https://www.arduino.cc

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VI-CONCLUSION

The CanSat Celesta 2 may be used to be dropped on a telluric planet and to measure its properties. Those measures could be used for example to check if the planet is able to welcome a robot or eventually humans. The Celesta 2 could also take ground samples, or plant seeds, for many applications.

During this project, we faced some difficulties. First of all, some people of the groupe went away during the conception. We also lost a very important CAO file, producing some late. Secondly, we had to pass our exams, so we didn't have so much time to progress the fabrication. Finally, we had some 3D impression issues, due to the unpredictable printer working.

Despite the issues we faced, we learned a lot of things. It was for us a good way to improve group work for a real project on a restricted time. We also learned to code in Arduino language, and improved our CAO level.

CELESTA II
UFRST EVRY
OCTAVE

Julien Ignaczak, Dembo Kanouté, Gautier Lavastrou, Ismael Sarsari

Octave

Cansat: Phoenix Mission

Gaëlle DUBUS, Pierre GUILLEMINOT, Baptiste KEROUANTON, Alex LEVACHER, Nathy PARTY

Abstract: A team of student of Phelma School has worked on a satellite-like system, compressed into the volume of a can which will be sent in the atmosphere in order to take and transmit pressure and GPS mesurements. Once on the ground, the cansat, as it is called, will use GPS datas and wheels in order to go back to the vertical of its landing point.

Introduction

The C'space is a competition organized by the CNES agency. It holds several distinct competitions, the one we are attending being the Cansat. The objective of the Cansat competition is to build a miniature satellite in a can that will be dropped from 150 meters high, to reproduce the mission of a probe arriving on another planet. It is a multidisciplinary project, that covers domains such as mechanics, electronics, telecommunication.

I. Context of development

A. The Club

It's not the first time that our engineering school PHELMA takes part in the Cansat competition. Taking part in this competition is proposed as a course in project management to first year students. Despite the fact that two groups were allowed to choose the Cansat as their project, our team, which has 5 members, is the only one that did so.

PHELMA was created in 2008 by uniting three former engineering schools which are ENSEEG, ENSPG and ENSERG. Electronics is one of the main courses of the school, thus giving us a solid fundation to work with for the competition.

We are financed by PHELMA with an amount of 80 euros but we have been allowed to use the material of previous groups that worked on the project.

B. Work plan

Our team is composed of 5 students from Grenoble INP- Phelma School, DUBUS Gaelle, LEVACHER Alex, GUILLEMINOT Pierre, KEROUANTON Baptiste and PARTY Nathy.

Fig.I.B.1 Picture of the team

In order to successfully complete the Cansat project, we had to share the different tasks and establish a precise schedule.

The project is divided into different parts: electronics, mechanics, telemetry or the development of the parachute as well. Initially, we shared the tasks according to the skills of each member of the group. Alex worked on the transmission of data, Baptiste and Gaelle were responsible for the development of the parachute, Pierre analysed the acquisition of GPS data and the control of the path of the Cansat and Nathy took care of the mechanical part. However, we worked as a team and helped each other, especially concerning the test of the parachute.

This project is included in our curriculum in Phelma, we had four hours per week to work on it. Therefore, we have spent six weeks on the development of the different solutions, seven more weeks on the realisation and the tests of the different parts of the system. Finally, we worked 4 weeks on the global conception of the can. It is approximately 70 hours of work a person, 350 hours in total.

II. Definition of the missions

A. Main mission and Solutions

For this project, our main goal is to simulate the landing of a satellite on a foreign planet. To do so, we had to plan the landing using a parachute, build a deployment structure and make a communication system between the can and a computer to fit in the contest rules.

To face this challenge, we decided to focus on the deployment of wheels which will be used by the can to move anywhere we want thanks to a GPS. The can will communicate data such as its position and the pressure using electronic devices.

B. Free mission

During the can's fall, we have to make measurements, in the same way a probe would do during an outer-space mission. We made two separate ones: a pressure and a GPS measurement. The former is straightforward but really meaningful due to its applications. Indeed, it is an important information to have when inspecting a planet, and it can be used to deduce an altitude or a fall speed using simple formulas.

The latter is central to our project. Indeed, it is thanks to the GPS coordinates that our cansat will be able to move towards it's destination after landing.

The second free mission we chose to work on is the driving system of the can so that it can return to its dropping point. To do so we needed to acquire geographical data thanks to a GPS. These are then processed through an Arduino program which enables to calculate the path the can has to make to return to the dropping. This program also allows the control of speed of the two driving wheels using the PWM signal and the inertia of the motor.

III. Cansat Architecture

A. Electrical Architecture

a) Motors

In order to move, the cansat uses two DC motors, these are powered by a battery delivering 7.5V charged before the launching. For the Cansat to turn, we need a difference of speed between the two wheels. Since the trajectory is calculated by the GPS, the motors must be controlled through the Arduino chip, however, given that chip can only deliver a fixed output voltage, the only way to properly control the motor is to send it a PWM and use the inertia of the motor in order to modulate its speed.

As the electrical circuit (fig.III.A.1) is showing, the motor is protected by a transistor whose purpose is to only let current flow when the arduino chip allows it and make a better use of power, a capacity (to suppress any stray current) and a diode in order to only let the current pass in one direction. There are two of these electrical installation in the Cansat, both are linked to the same battery and Arduino chip.

Finally, as it is not explicitly shown in the figure, the battery also supplies the arduino chip and indirectly all the components linked to It (Xbee, GPS, servo-motors…).

b) Servomotors

To realise our can we used four servomotors, two for the deployment of the two-wheel drive, one for the deployment of the stability wheel and another for the drop of the parachute.

Each servomotor is powered by a tension of 5 V supplied by the Arduino. Moreover, each one is controlled by a PWM supplied by different pins of the Arduino board like we can see on the Fig. III.A.2.

B. Mechanical Architecture

a) The parachute

To land on the planet we chose a cruciform parachute for the can. The surface of the parachute was calculated thanks to the equation (cf. eq.III.B.1) which describes the balance between the weight and the drag force. We targeted a speed of 7m/s, which means a surface of 0,66 square meters for a 1 kilogram can. The pictures (cf. fig.III.B.1 and fig.III.B.2) depict our parachute model and a photograph of the real one.

With many practical tests we noticed that the falling speed was not 7m/s but rather 5m/s. It can be explained by the can being lighter than it was supposed to be but there is no impact on our mission.

b) The parachute drop system

To allow an easier movement once the can has landed, we built a system to drop the parachute that uses a servomotor. All the ropes of the parachute are gathered to one small ring which can slip along a metal hook. Before the servomotor has turned, the ring is blocked by the metal hook, and once it has rotated enough, the ring is freed as our cansat starts moving. The picture (cf. fig.III.B.3) a close up view of the system.

c) Deployment

In order to realise the main mission, which consisted in the deployment of a driving wheel system outside of the can, we developed the following system (cf. fig.III.B.4 and fig.III.B.5).

According to the Figure III.B.1, this system is composed of a motor, a servomotor, a 3D printed wheel. We have chosen to knock the axe of the motor with the central axe of the can in order to make easier the deployment. So when the servomotor turns of 180 degrees, the entity composed of the wheel and the motor spread out as we can see on the second part of the figure III.B.5. To avoid the problem of the off-axis we have developed a system of gears inside the wheel as we can see on figure III.B.6.

To conclude, the servomotor enable to spin the group {motor, wheel} in order to deploy the system and then the motor enable to spin the wheel.

C. Telemetry

a) The pressure sensor

We have chosen to collect and transmit pressure reading during the fall. Indeed we already had a pressure sensor in our components and thus didn't have to buy it. The pressure sensor gives us two output voltage V+ and V-. The final output voltage Vout is the difference between them. This voltage being very low, we had to amplified it with an amplifier with a DC gain of 300 to make it usable by the Arduino card.

The pressure sensor we use is a MPX2200AP (K0724AL). This pressure sensor has a sensibility of 0.2 mV/kPa and is normally supply with a 10V voltage. Our battery only delivers 7,4 V voltage and we had to adapt our calcul as you can see in eq III. C. 1.
This calculation is made by the Arduino card and then are transmitted to the ground by the Xbee module.

b) GPS

Our team is using an industrial GPS: Adafruit Ultimate GPS Breakout, this device allows the Cansat to communicate with several satellites (at least 4 are required for it to properly work but during the tests, the number of satellites could go up to 7) and thus collect informations and update them every 0.1s. It is directly linked (cf. fig III.C.1) to the Arduino chip, sending informations to it.

While some datas are just sent via the Xbee, the GPS also collects them in order to calculate the path to take. To that purpose, the Arduino chip retrieves data such as longitude, latitude, altitude, speed and direction. Indeed, by using the first geographic coordinates as a reference, it can calculate a path thanks to the datas above (a precise code is given code. III.C.1).

Also, in order to function properly, the Adafruit GPS needs to be able to communicate properly with satellites, it is therefore mandatory to operate outside, if possible under a clear sky.

c) Xbee

In order to send data from our cansat to the group, we used a pair of Xbee modules. One is an Xbee S1, the other is an Xbee pro S1. The pair is able to communicate, allowing us to send data, from and to our cansat. It follows the requirements specifications, with a 2,4 MHz frequency range.

The wiring is as follows: The Xbee pro is attached to an Xbee Shield, which is directly wired to the arduino chip. The Xbee S1 is connected to a computer with the XCTU software, which allows to initialize and pilot the Xbee devices. We chose to link the pro device to the cansat as it has a far better range of a kilometer, which guarantees our computer to be in range, regardless of the setup during the lauch.

Using the loop in the Arduino code, the function (given in code.III.C.2) allows the Xbee linked to the chip to send information concerning the following parameters: pressure, GPS coordinates and fall speed. Those will be received in the XCTU console, which can later be saved for further analysis.

IV. Appendix

A. Figures and Tables

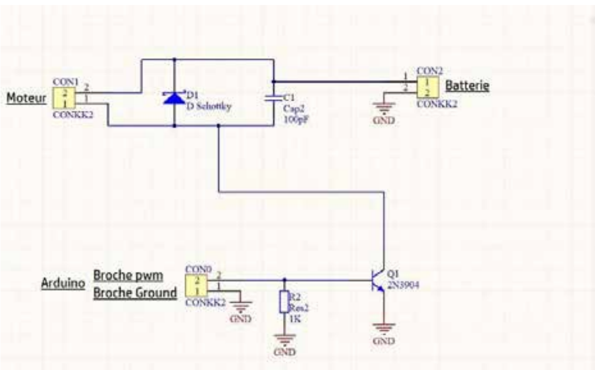

Fig. III.A.1 : Electrical Motor Diagram (Arduino)

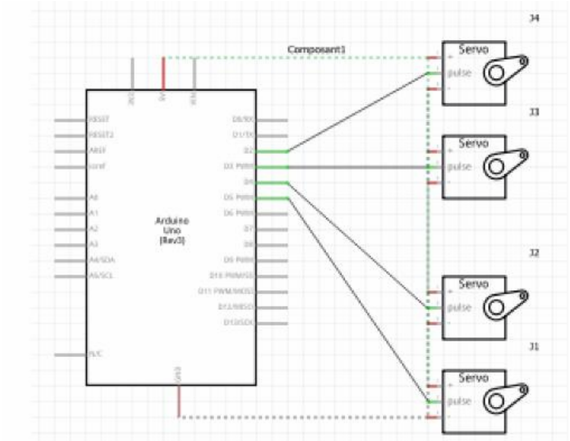

Fig.III.A.2 Electrical diagram of servomotor assembly

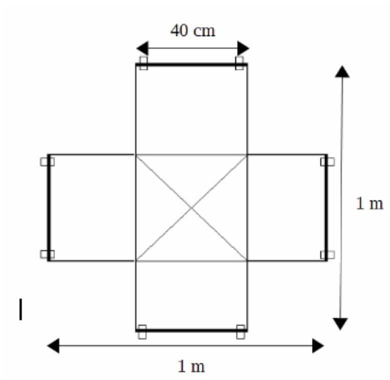

Fig.III.B.1 : Drawing of the Parachute

Fig.III.B.2 : Picture of the parachute

Fig.III.B.3 : Picture of the parachute drop system

Fig.III.B.6 Picture of the 3D printer wheel

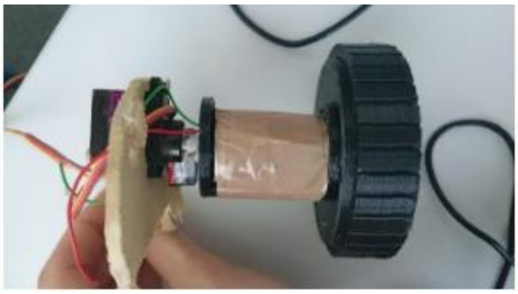

Fig. III.B.4 Picture of the deployment

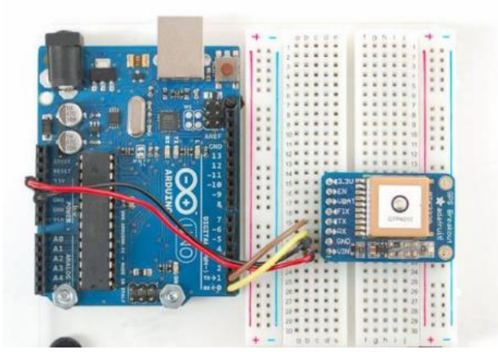

Fig. III.C.1: Picture of the likage between the Xbee and Arduino

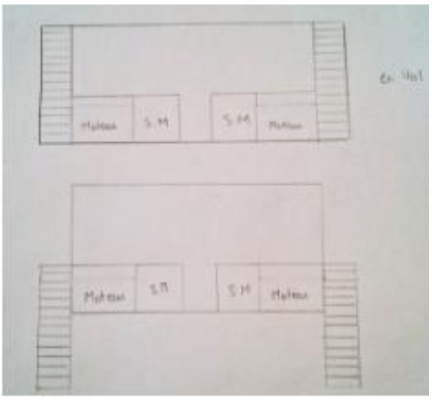

Fig. III.B.5 Diagram of the deployment

B. References

Websites :
https://cdn-learn.adafruit.com
https://www.arduino.cc
http://www.bde.enseeiht.fr/clubs/robot/node/34
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C. Abbreviations and Acronyms

CNES : Centre National d'Etudes Spatiales
PHELMA : Ecole nationale superieure de PHysique, ELectronique et MAtériaux
ENSEEG : École Nationale Supérieure d'Electrochimie et d'Electrométallurgie de Grenoble
ENSPG : Ecole Nationale Supérieure de Physique de Grenoble

ENSERG : École Nationale Supérieure d'Electronique et de Radioélectricité de Grenoble

D. Equations

Eq III. B. 1. :

$$S = \frac{2 \times m \times g}{\rho \times Cx \times V^2}$$

With S surface of the parachute, m mass of the parachute, g gravity, ρ density of the air, Cx coefficient of friction, V targeted speed limit

Eq III. C. 1. :

$$\text{Pressure} = \frac{\text{Vout}}{\text{Sensibility}} \times \frac{4}{3} \times \text{GainAop}$$

E. Code

Code.III.C.1: It's just a part of the code

```
if (GPS.fix) {
        Serial.print("Location (in degrees,
        works with Google Maps):");
        Serial.print(GPS.latitudeDegrees,4);
        Serial.print(", ");
        Serial.println(GPS.longitudeDegrees,
        4); Serial.print("Angle: ");
        Serial.println(GPS.angle);
        Serial.print("Satellites: ");
        Serial.println((int)GPS.satellites);
        x = GPS.latitudeDegrees;
        y = GPS.longitudeDegrees;
        angle = GPS.angle;
} } }
{ if (millis() - timer > 2000)
        { timer = millis(); // reset the timer
        xdiff=(x0-x)*100;
        ydiff=(y0-y)*100;
        distance=xdiff*xdiff+ydiff*ydiff;
        angle=angle*0.0174533;
        cosdiff=abs(cos(angle)*10000)-
        (xdiff*xdiff+ ydiff*ydiff)/(ydiff*ydiff) ;
        }
}
```

Code.III.C.2: Sending data by Xbee

```
void envoi_donnees(SoftwareSerial xbee,
double x, double y, float pression, int deploy){
//Envoi des données via le Xbee
if (xbee.available()){
        xbee.print("Coordonnées : ");
        xbee.print(x); xbee.print(" , ");
        xbee.println(y);
        if (deploy == 0){
                xbee.print("Pression:");
                xbee.println(pression);
                }
        }
}
```

F. Hardware

Altium
XCTU
Arduino

Conclusion

To this day, every part of the Cansat is able to work independently from the others, but while the architecture is all set, combining all elements is still a hardship we have to overcome. Indeed, all captors works properly, the parachute is able to hold the fall and can correctly deploy its wheels and roll, however, the implementation of the Arduino chip requires an advanced electronical organisation inside the can and to take into accounts all the peculiarities of every component: avoid disturbance in the communication between the GPS and the satellites or between the two Xbees, for example.

While several tests were led, we still weren't able to achieve a satisfactory result given all the restrictions we have to take into account. Also, while it theoretically works, we still have to test our position system in real situation. Therefore, the tasks we hope to accomplish in the coming weeks are the completion of a stable and perfectly functional Cansat and the tests in as close as possible to the real situation of the challenge.

Acknowledgments

We acknowledge partial support of this work by Phelma and we would like to thank our tutors from Phelma Patrice Petitclair and from the Cansat organisation Anthony Bidault for their help.

JawaCan, the CanSat that will explore planet CTU-7219

Christophe MAESTLE, Geoffrey GUYOT, Lucas GOSSET, Killien DALLE, Christelle DUCLOS *(June, 2016)*

The JawaCan project is being run by a group of engineering students from Compiegne's University of Technologies (UTC). Its goal is to simulate the exploration of an Earth-like planet in order to determine if it is adequate for a human settlement.
The project is remarkable for three main aspects. Firstly the general design has been done so that the JawaCan is easy to assemble and modify. The modularity could also allow using the same body for other missions. Then the Can is composed by two parts that will be divided into one base communication module and a mobile rover that will carry out the analysis. Eventually, an interesting ground extracting device has been imagined in order to make a pH test possible inside the small rover.

I. INTRODUCTION

THE JawaCan main mission is to carry out analysis to check the presence of some vital elements for a possible human settlement.
The CanSat is divided into two parts. The rover called Jawa will cover a small distance on the unknown surface and use its sensors to measure some environmental data of the planet.
The Can which will stay on the landing site will be used as a communication relay between the exploration Rover and the team of scientists.

II. CONTEXT OF DEVELOPMENT

A. UTspaCe

Founded in 2011, the UTspaCe association includes 12 members divided into three groups: two are making a mini-rocket and our team which is working for the CanSat project. It is actually the first time that UTspaCe take part to the CanSat competition. All the funds of our organization come from sponsorships and grants from our University and city.

The CanSat team counts 5 members, each one have a role and take part to several aspects of the project.

MAESTLE Christophe, is the JawaCan team leader, he defined the mission, is in charge of the CAD design, support a big part of the electronic and the code for the Can. He also worked on the data processing and the Jawa design.

GUYOT Geoffrey, wrote the specifications, decided the communication protocols. He programs the code and manages the information processing.

GOSSET Lucas, is a very active participant to the mechanical design, electronics and Jawa coding aspects.

DALLE Killien, contribute towards the mechanical design, space optimization and is in charge of the pH analyses system. He is also worked on the communication documents.

DUCLOS Christelle, defined the mission, ask for the funds, make the external communication and buy the equipment.

B. Work plan

TABLE 1. ESTIMATED BUDGET

Category	Component	Budget
Communication	Wi-Fi / Infrared	100€
Body	3D Printings	200€
Battery	Batteries / Charger	80€
Actuators	Motors / Controllers	120€
Sensors	Gas / Temperature / Pressure / pH	80€
	TOTAL	580€

In our university, the academic year is clearly divided into two semesters. For this reason, the project development didn't start formally before February.
The design and research of solution part took a lot of time since we wanted to carry out a lot of missions in such a little space. Our main concerns had been how to extract a piece of ground and analyze it and how to make the rover compact and operational.
We were helped in the prototyping part by our knowledge of the prototyping machines provided by the FabLab UTC organization. Without this place, it would have been much longer to achieve the production of the first version and to proceed to the tests.

III. Definition of the Missions

JawaCan has for scientific mission to analyze the environment of the planet on which it is sent. A large area will be defined to find the ideal zone for a human colonization. This mission can be decomposed into several phases.

A. The drop

JawaCan will have to fall as fast as possible to maximize the available time for the mission on the ground. So the speed chosen of descent will be of 10m/s. We chose a cruciform parachute, according to data given in the document about parachutes [1] supplies by PlaneteScience. For a load of 1kg, we shall need quoted by the square of 17.4cm.
During the fall Jawa will send acceleration data to Can for the user, by infrared. Thus, he will be able to know JawaCan speed during the flight.

B. The break-up

Once on the ground and after a lapse of time to consider, CanSat will break-up in two different elements thanks to the demagnetization of an electromagnet situated inside Can. After an infrared dialogue the rover Jawa can leave and leads its mission of exploration.

C. The analysis

The mission of JawaCan is the acknowledgment of the composition of the air. The Jawa will analyze gases around it, after moving away from landing site to avoid contamination.
During its travel it will analyze several parameters: gases surrounding H2, CO and CH4.
Once on the site of drilling, Jawa will analyze the ground and go back to Can with a soil sample. Then, thanks to a dampening roller process, the carrot of earth gets in contact with the pH-paper that will be analyzed by colorimetry and the acidity of the ground will be measured.

D. Data Transfert & Processing

Having returned in front of Can, the rover will transmit all the information collected by infrared. Then the station of telecommunication will pass on all the information by means of an XBee to the user. Its information will be reshaped by a processing and showed on a graphic platform.

IV. CanSat Architecture

A. Mechanical parts

The mechanical design has been thought to help the user to change quickly every electronic component, and to be able to put up CanSat easily.

1) . The Can

All parts were produced by additive method with a FDM 3D printer; the material used is ABS plastic.
The Can have four mechanical modular parts, the bottom lip who contain the electromagnet and holes to allow the IR communication and a top lip.
The central structure holds the cabling and shelf mechanical pressure. All of components could be plug and unplug quickly in.
The fourth part is an 80mm diameter tube in order to protect electronics of environment. To hold electronic components, flexible parts will be used.

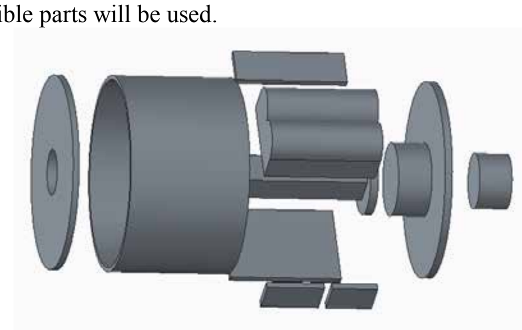


Fig. 1. Can mechanical design.

2) The Jawa

Like the Can, the Jawa rover was designed to be assembled easily. The wheels are hollowed to get more space for sensors. The motors power is transmitted by gears directly on the wheels.

Fig. 2. Wheel and mechanical design of Jawa.

A central structure including the drilling machine, is the skeleton of the rover. The wheels parts are assembled to it with screws. All of sensors are plugged on this structure containing the cabling.

The drilling machine has been made so that the travel length of the drill is maximized. For this reason the pH sensor cannot be in the drill line. We designed a cylinder on which there are water and the pH paper. Then the barrel turns in front of the color sensor and the pH can be define.

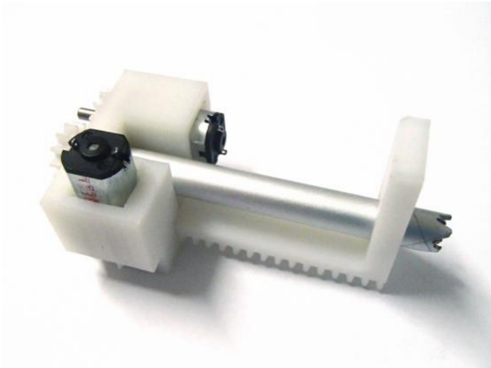


Fig. 3. Prototype of the driller

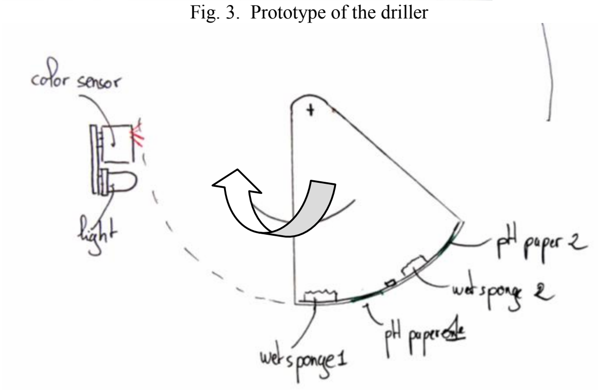


Fig. 3bis. Sketch of the pH analyser principle

B. *Electrical architecture*

To be able to obtain environment data, the CanSat is equipped with many sensors.

1) *The ground station (Can)*

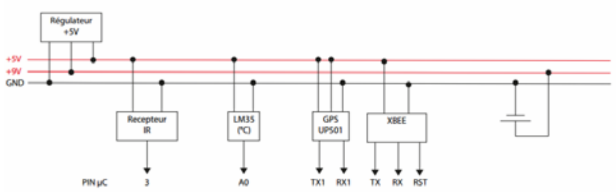
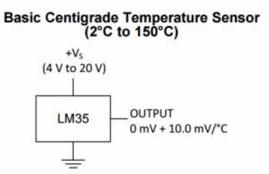


Fig. 4. Picture of the Can electrical architecture.

The Can has a GPS (UP501), it gives an NMEA output. We are interested by the GGA message (Global Positioning System Fix Data) because it contains the latitude and the longitude coordinates.

The Arduino program can separate information to transmit the CanSat position.



To measure the environment temperature, we use an LM35 sensor. It returns an analog value to the Arduino who transforms it in a temperature value.

Fig. 5. Picture LM35 sensor.

The Can is composed by an Arduino which will control the Wi-Fi (XBee), the infrared communication (TSOP4838) and an electromagnet.

The electromagnet trains a magnetic pull of 11.6kg when it is not under voltage and no force when supplied with a 12V current.
The electromagnet can support the deceleration produced by the parachute opening.

Fig. 6. Picture of the electromagnet

2) *The rover (Jawa)*

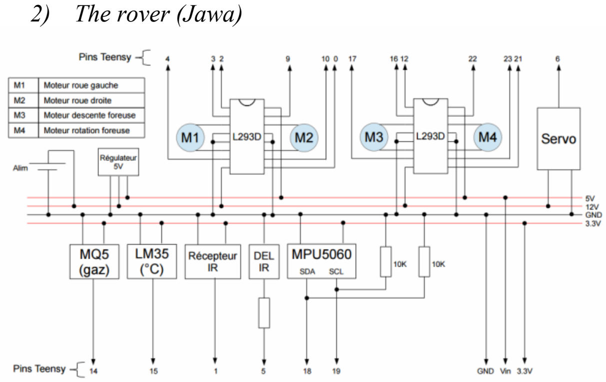


Fig. 7. Picture of the Jawa electrical architecture.

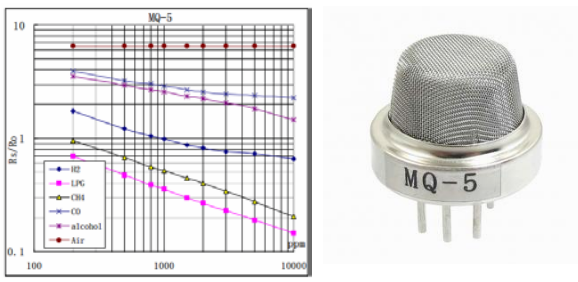


Fig. 8. MQ5 and sensibility characteristics

The Jawa will be equipped with a Teensy LC in order to gather all its functionalities. It will control the motors to move the Jawa, it will collect the data of the embedded sensors and it will control the extraction system to analyze a ground sample.

The gas sensor MQ5 could analyze the ratio of H2, CO, CH4 gas. The sensor output is an analog signal easy to process.
To know the relative position between the Can and the Jawa we use MPU-6050 sensor that contains a MEM accelerometer and a MEM gyro. The sensor uses the I2C-bus to interface with the Teensy LC.

C. Telemetry

C.1 Architecture

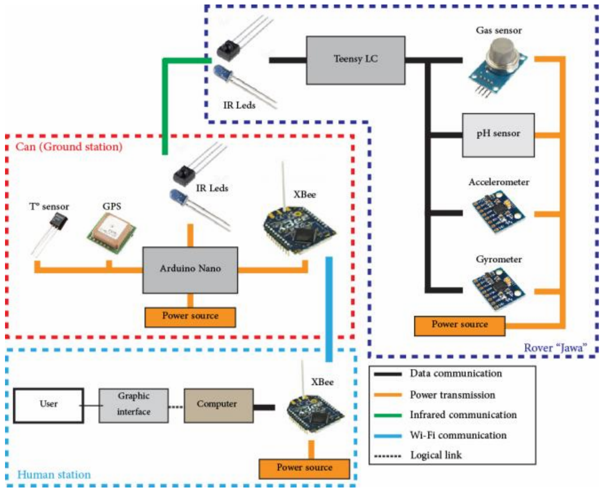


Fig. 9. Picture of the Can telemetry architecture.

The ground station (Can) should communicate directly with the user by a computer and a Wi-Fi communication assured by XBee modules. Therefore, data will be sent immediately to the computer.

For the record, XBee is a commercial solution to communicate via Wi-Fi, Bluetooth or radio waves with another XBee.

The Jawa will collect data from its sensors. After this data collection, the Jawa have to return to the ground station to transmit them by an infrared communication. Both the Can and the Jawa have a couple infrared LEDs/sensor to transmit and receive packets.

The user will be able to analyze data thanks to a graphic interface on his computer linked to an XBee communicating with the Can's XBee.

C.2 Protocol

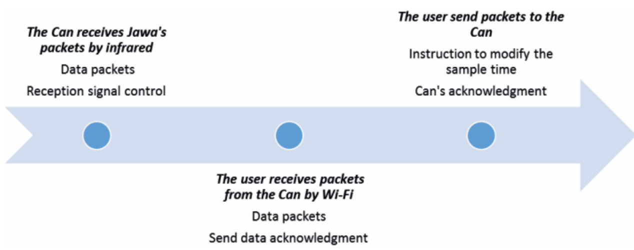


Fig. 10. Communication protocol

The GPS and the temperature sensor which are in the Can will store the corresponding data into the Arduino included in the Can. Furthermore, they will be sent to the computer.

The Jawa includes a Teensy LC in which the data from all sensors can be stored. That is say, data from the inertial measurement unit (accelerometer + gyrometer), from the gas sensor, from the temperature sensor and from the pH sensor.

Data will be collected by both the Can and the Jawa. Yet, the Jawa have to store all of the data in a table structure during the mission. A packet will be sent every 1 second.

Tables are structured as following:

ID	Gas	pH	Accelerometer	Gyrometer	STOP
2 bytes	2 bytes	1 byte	12 bytes	12 bytes	1 byte

Tab. 1. Jawa's data's table structure

Total size: 30 bytes.

Before any packet transmission by the Can, it stores the packet into the Arduino EEPROM

Can data tables are structured as following:

ID	Temperature	Latitude	Longitude	STOP
2 bytes	1 byte	4 byte	4 bytes	1 byte

Tab. 2. Can's data's table structure

Total bytes: 12 bytes

In case of communication failure between the Can and the human station, the Can must store data into the Arduino EEPROM and stop the transmission which cost a lot of energy. Actually, the Can will try to send the last packets not transmitted until it is received by the computer. In the meantime it is storing the new data.

To know if the Can or the Jawa have a communication failure, in each communication, the receiver will transmit an acknowledgement of the packet's sending. That's why communications are bidirectional. The packet send by the receiver is structured with an ID and a binary number which represents the reception or not.

V. Conclusion

Today, many parts have been printed, like the Jawa's wheels and its structure. The Can mechanical and electronic parts have been made and tested, so is the drilling system. The processing data is in development, as the graphic platform. The parachute is in construction.

To finish this project, we need to print all of mechanical and sold the electronic parts of the rover and make some tests of the mission in real conditions.

Acknowledgment

We thank to FabLab UTC, for their help and their tools, and the Société Générale and the FSDIE for their grants.

We thank the military camp of Ger that will welcome us on their military base for the flights demonstration of CanSat in July 2016.

References

[1] *Les parachutes Des fusées expérimentales*, document CNES, Feb. 2002.

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