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CENTRE NATIONAL D'ÉTUDES SPATIALES

Compétition CANSAT-France 2015

DOSSIER DE PRÉSENTATION

20 - 22 JUILLET
sur le site du 1er Régiment de hussards parachutistes, camp militaire de Ger

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Planete Sciences
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CanSat-France
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Compétition CANSAT-France 2015

La compétition CanSat-France se déroule du 20 au 22 juillet sur le site de 1er RHP au camp militaire de Ger.

La compétition CanSat-France se déroule dans le cadre du C'Space, le rendez-vous annuel des étudiants avec l'espace, organisé par le CNES avec l'association Planète Sciences.

Durant cette manifestation, les projets spatiaux des étudiants seront mis en œuvre sur le site pyrénéen du 1er Régiment de hussards parachutistes (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.

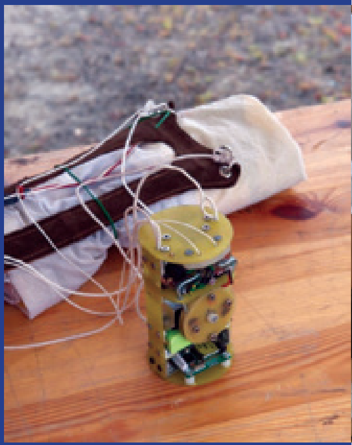
Lâché à 150 m depuis le ballon, il devra réaliser une mission obligatoire : (le déploiement) et au moins une mission libre.

Un jury d'experts du spatial évaluera les projets et récompensera la meilleure équipe selon des critères prédéfinis.

La manifestation accueille cet été 11 équipes dont une équipe autrichienne.

Le meilleur projet se verra récompensé d'un prix décerné par le CNES.

11 équipes engagées dans la compétition



Qu'est-ce qu'un CANSAT ?

Le mot CanSat est la contraction de « canette », et du mot « 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, etc.) y sont contenues.

Cet outil représente donc 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 150m 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 obligatoire.

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 :

- présenter 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 technique, scientifique qu'organisationelle.

Une compétition riche d'expériences

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...

L'idée de la compétition CanSat a vu le jour aux États Unis, en novembre 1998, lors d'un meeting à Hawaï. Cette compétition destinée aux étudiants a eu un fort succès dès son lancement. Depuis, l'évènement 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.

Les missions de la compétition 2015

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.

La mission obligatoire

La mission imposée cette année est la suivante :

- **le déploiement :** lors de sa descente ou de son atterrissage, le CanSat devra effectuer un déploiement hors du volume du CanSat devant répondre à un but clairement établi (similitude avec une sonde, utilité déploiement, originalité du concept). les Cansats de l'édition 2015 devront être originaux et pertinents si les équipes souhaitent remporter cette édition devant un jury de professionnels du domaine.

Quelques 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 exacte 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 :** sur une planète (hormis la Terre), on ne dispose pas de satellites GPS. Si une sonde doit se poser, il faudra qu'elle connaisse sa position pour orienter son antenne vers le sol. La mission consiste à déterminer la position (Latitude, Longitude en WGS84) du CanSat au maximum 5 minutes après l'impact. La position 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. Le choix de la céréale est libre.

- **La prise d'image :** A l'aide d'une caméra miniature ou d'un appareil photo, l'objectif est d'effectuer des prises de vues de l'environnement afin de le situer ou d'analyser le milieu. Ces images peuvent être réalisées soit lors de la phase de la descente, soit lorsque le Cansat a atterri.

Programme

2015	9 h - 13 h		14 h - 18 h
Dimanche 19/07	Accueil des participants		
Lundi 20/07	Installation moyens sol		Tests en vol
Mardi 21/07	Présentation des projets devant le jury		Démonstration en vol
Mercredi 22/07	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 21/07, 14 h - 18 h
- **Remise des prix :** Mercredi 22/07, 12 h 30 - 13 h
- **Bilan de tous les CanSat-France 2015 :** Mercredi 22/07, 18 h

Le Jury 2015

Le jury qui jugera et notera les projets CanSat sera composé des membres suivants :

- CNES : André BORRIEN (sous directeur adjoint technique véhicule architecture et intégration) - Claire Edery-Guirado (chef du service Jeunesse et acteurs de l'Education).
- ESA : Hugo MARÉE (Responsable du Bureau de l'Education et gestion des connaissances)
- Airbus Defense & Space: Thierry DUHAMEL (Directeur recherche et développement)
- Meteo France : Philippe CAILLE (Directeur de la communication).

Les 11 projets CANSAT

Nom du Club	Nom du projet	Email du responsable	Villes	Missions libres	Nom du parrain
Air-ESIEA	Free Fly	behot @et.esiea.fr	Paris	Etudes environnementales (hygromètrie, température, luminosité…), GPS.	Eric KONIECZNY
Sup'Sats	Cerf-Volant	numa-34 @hotmail.fr	Nîmes	Relevé de température, pression et coordonnées GPS.	Frédérique GIARMARCHI
Sup'Sats	Frankensat	numa-34 @hotmail.fr	Nîmes	Relevé de température, pression et coordonnées GPS.	Frédérique GIARMARCHI
Octave	Celesta	hamidou2balde @yahoo.fr	Evry	Affichage sur une station sol de la localisation (position) du CanSat après l'atterrissage.	Benoît HUGUES
NAFM	Tortue NinSat	nicolas.berhault @gmail.com	Paris	Détection, après lâché, d'une altitude fixée au préalable.	
EirSpace	Kirby 2	ludovic.thulliez @hotmail.fr	Bordeaux	Mesures d'altitude au moyen d'un altimètre radar.	
Phelmartien	Viking	gaspard.louvet@ phelma.grenoble-inp.fr	Grenoble	Prises d'images.	Patrice PETITCLAIR
N6K'nSat	TouCansat	alicia.louis @isae.fr	Toulouse	Caméra embarquée et mission come-back : prise et transmission d'images et guidage automatique du Cansat vers une cible lors de sa descente.	Christine ESPINOSA
TU Space Team	CanSat	sasa.meischke-ilic @spaceteam.a	Autriche	Tests GPS	
ENSMA Space Project	SpaceCAN	quentin @open-to-repair.fr	Poitiers	Suivi d'une cible à l'aide d'une caméra. La cible étant définie par ses coordonnées GPS, et son altitude.	Michael RICHARD
SEC	Discovery Stratospheric	francois.rabette @estaca.eu	Paris	Envoi des informations par télémesure. Etude de la température et de la pression durant la descente.	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De l'espace pour la Terre

Compétition 2015

C'Space 2015, Camp de Ger

SCIENTIFIC DESCRIPTION

Cansat projects

FreeFly : a CanSat able to deploy wings

Air-ESIEA third CanSat

BEHOT Valérian, FERNANDEZ Maxime, NGUYEN Richard
ESIEA
Engineering School
Ivry s/ Seine, FRANCE
Air-esiea@et.esiea.fr

Abstract— **Our goal for this contest is to create a CanSat capable of deploying its wings during flight. At the same time, several sensors will study the environment of our probe and its behavior during the different phases of flight.**

Keywords—CanSat, Deployment, Wings.

I. Introduction

For the third year, the French engineering school ESIEA and its aerospace association Air-ESIEA work together to put forward a new CanSat: FREE FLY. Since we don't study mechanics and aerodynamic in details at school, our team had to face a very big challenge: design a fully functional CanSat able to deploy wings to fly. We also wanted to carry our CanSat in a rocket and drop it at peak.

II. Context of Development

A. Club

This project is part of Air-ESIEA, the aerospace association of the French engineering school ESIEA. The association was created in 1986 to create experimental rockets to be launched in the annual CNES/Planète-sciences meeting. We have launched with success around twenty rockets. This year, we decided to take part in the CanSat contest for the third time.

B. Work Plan

We are a team of three students in third year. This project is an annual school project. Based on our school planning, we started this project in November 2014 by making a first draft of our CanSat. As we started the project well before the release of official specifications, it appeared that some requirements were finally not fulfilled. For that reason, we had to redesign an important part.

To get organized, we shared the different tasks according to our interests and knowledge. By early 2015, we had determined the tasks we had to do: electronics, structure, descent system and ground system. The electronics, which regroups the sensors and the deployment system, was managed by V. Behot and R. Nguyen. M. Fernandez worked on the descent system and deployment structure. The development of the ground interface was a common task.

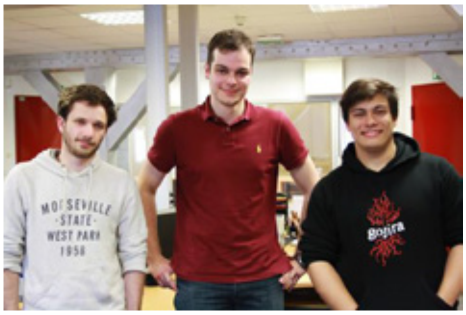


Fig. 1. ESIEA's CanSat Team – ESIEA - 2015

C. Budget

Our project is jointly funded by our school and Air-ESIEA. Air-ESIEA supplies some components and the parachute but we had to buy the structure we designed to fit with the specification. In total, this project represents a financial budget of 350€.

We have also estimated this project in manpower cost. It represents about 800 hours of our time. Some hours were included in our school planning, but we had to work outside this planning. This estimation used the following repartition:

- 50 hours on definition
- 200 hours on electrical design and realization
- 300 hours on mechanical design
- 150 hours on integration testing
- 100 hours on administration (presentation of the project, meetings)

III. Definition of the Mission

As a school project, we decided early which missions our CanSat will have to complete. When the specifications were published, we had already determined the main components to accomplish the following objectives:

A. Scientific mission

During the descent, the CanSat would deploy two wings in order to glide. We want to develop a probe capable of deploying wings, flying over an area and landing. The first step of this ambitious project is to develop the deployment system.

B. Free Mission

We want the CanSat to collect atmospheric data such as pressure, temperature, hygrometry and GPS positioning during the descent phase. We also want to establish a timeline of the drop by collecting the behavior of the probe. The CanSat has to transmit to the ground station all those parameters and also save them on board.

To perform this mission, the CanSat will embed different sensors such as a barometer able to collect the pressure and the temperature, a GPS receiver, and an accelerometer. An analogue humidity sensor will also be installed.

This data will allow us to create an atmospheric model of the environment.

C. Additional Objectives

The Club doesn't only conceive the CanSat, it also worked on experimental rockets. That's why, we have made this CanSat able to be dropped from one of our rockets.

IV. CanSat Architecture

As IT student, we thought long about the mechanical design of the CanSat. However, we found the best design for those missions.

A. Mechanical Architecture

We designed a mechanical structure able to respond in our objectives. It has been then modify to improve its aerodynamics characteristics.

We wanted to make the CanSat capable of flying without propulsion. So we focused our choice on a deployment of two lateral wings. It is from this time that we started to have problems in the implementation of this deployment. The specifications require that the wings must be kept within the module until drop.

To deploy the wings, we use a system inspired by the umbrella. We found that moving a single piece of the umbrella drives the deployment of all other rods. Using motor with a gear and a rack that replace the move of a human hand, which will move all the pieces. We have stretched a piece of spinnaker canvas between two rods. At the beginning of the project, we wanted to have a streamlined wing, but not being a specialist in aerodynamics, we opted for the simplest wing possible.

To make our CanSat, we used 3D modeling software, able to print it in plastic. Our probe can be divided in two separate part, one part, who carry the wings deployment system and the GPS module. The other part, which is only the electronics components (PCB, sensors, batteries …), which are almost isolated from the outside to prevent any damage.

Using a 3D printer, let us have an important weight gain. At the time of writing this document, many components are still missing, but we are able to estimate the total weight of our CanSat as around 500g.

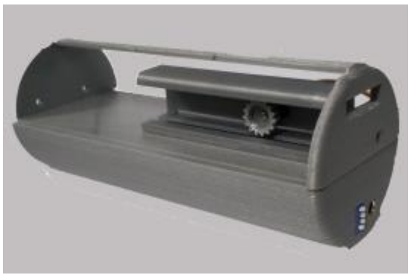


Fig 2 Mechanical Strucure of the CanSats

B. Electrical Architecture

Our CanSat CPU is a board made by ourselves based on an Atmega2560 processor. The microcontroller manages all the components: the sensors required for the free mission, the servo for the deployment and the transmission unit.

To collect all the data needed for the mission, we have programmed the following sensors: Adafruit's BMP180 which gave us the altitude of the probe and the environmental temperature with an accuracy of 0.03 hPa and ± 2°C, Sparkfun's accelerometers MPU6050 which gave us the attitude of the CanSat, Honewell's HIH4000 for humidity (accurate to 2.5%) and the GlobalSat's GPS EM-506 module, which has an accuracy of 2m and a very fast rate (10 Hz).

To log this data, we programed an embedded memory card.

They use different communication protocols such as I2C (MPU6050 and BMP180), UART (GPS, transmission unit) or SPI for the log system. All those protocols are available for the processor we chose.

As all those components don't require the same voltage, several voltage regulators are on board.

C. Telemetry

The CanSat includes a XBEE Pro 868 emitter transmitting at 868 Mhz a power of 10 mW, which permits a communication with the ground station within a 16km range. This range will allow us to embed the CanSat in our rocket for our additional objectives.

Every 10 milliseconds, the CanSat will send data of the flight to the ground station. This transmitted data will contain the data from all the sensors of the CanSat. For example, in our free mission, we want to analyze the attitude of the probe, before and after the wings deployment.

V. Conclusion

At the time of writing this document, many tasks have already been accomplished. We are currently testing all the electrical characteristics of the probe and assembling the different 3D printed parts. We have planned to perform at the beginning of June many tests on the parachute and the wings. During the last week of June, we will make final tests in more realistic conditions.

Acknowledgment

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

- Our academic tutor Eric Konieczny, who oversaw our project;
- Jeremy Cocks for it advice;
- Our school ESIEA, for the support;
- Guillaume Roussel who gave us some advice on the aerodynamics;
- The former Tau'Ri team for its help;
- All the people who organize the C'Space and the CanSat contest, particularly Planète-sciences and the CNES.

PROMETHEE: CanSats to illuminate the unknown planet surfaces

Clara Ferrier, Romane Rey-Vetier, Numa Cavagna

I. INTRODUCTION

According to Albert EINSTEN "two things are infinite: the universe and human stupidity; and I am not sure about the universe"

Indeed, the universe has always been a mystery to us. This is why we developed techniques to get a better understanding of it.

By organising an aero spatial contest, PLANETE SCIENCE allows us to do so. Students of 1st and 2nd year of IUT have been working hard for this competition since September.

Its purpose is to build one or several CANSAT(s) (satellites that have the size of a can) that will be launched to an altitude of 150 meters. The device must respect the specifications, which contain very strict criteria and must be able to accomplish given tasks.

We are so motivated that we already feel like we are proper astronomers even though our mission is not yet accomplished: deploying Cansats from the ground thanks to tripods. Before their landing, one of them would collect temperature and pressure data, meanwhile another would be guided by a directional parachute.

To succeed, the IUT turned into a real industry. In complete collaboration, the « *Génie mécanique* » students are focussing on the deployment system, the « *Génie électrique* » students are taking care of the sensors and the electronics, and finally the « *Génies des Matériaux* » students are choosing what material to use while working on the directional parachute.

II. CONTEXT OF DEVELOPMENT

A. Club

The structure to which the students belong is a student association. Its head office is situated in the IUT of Nîmes. Each member contributes to the project thanks to their specific savoir-faire and knowledge acquired in their personal trainings. SGM, GMP, GEII are all in collaboration.

The Sup'Sats club was created to let the students get involved in the professional sphere where experimentation is central. It is the first time that this club takes part in the « CANSAT » project even though it is already used to this kind of things through other activities like making experimental rockets or mini rockets.

The club is financed by the FSDIE.

As shown on Fig. 1, here is the composition of the team working on the CanSat project.

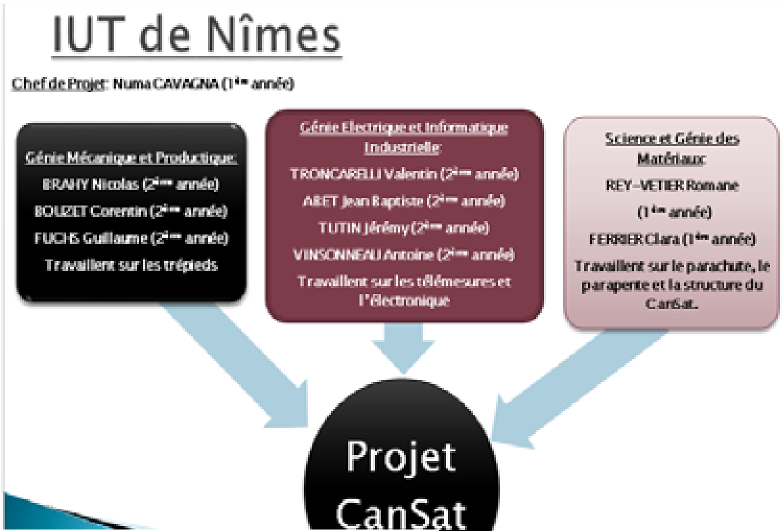


Fig.1 The flowchart of Prométhée's team

B. Work plan

The CanSat project is divided into several steps in order to be a success. First of all, we did some research to get to know the topic better, as well as what we had to do. Then, we started the conception process in order to consider the best technical solutions. At the end of it all, we will enter the testing and making process.

Each student, « specialist » in his own field blends his work with the others in the spirit of collaboration.

The "Science & Génie des Matériaux" students deal with the problems related to the parachute, the materials and, with the other departments, look for the best strategy to incorporate the electronics and mechanics on board. The "Génies Mécanique & Productique" students have worked on the deployment system and its efficient tripod. The "Génie Electrique & Informatique Industrielle" students focussed on the conception of electronic cards that will allow the two devices to measure the different data after its landing. We have been working on the conception of the CanSats since the beginning of the year. From now on (8th, June) we will start building the different elements present in our device. Before that, we will test the materials to make sure they are reliable. Once the assembling is done, we will proceed to the first tests. We cannot yet predict when this phase will take place.

III. DEFINITION OF THE MISSIONS

A. Main Mission

The main mission the CanSats must accomplish is to deploy properly. We must create a reliable system. In order to do so, we chose a system based on a « tripod » which will come out of the bottom of the device during the fall.

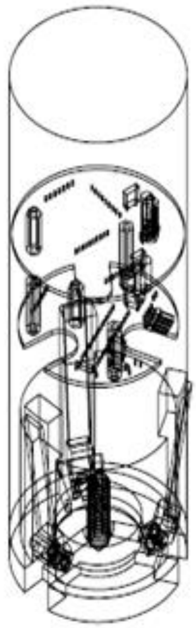
B. Free Mission

We opted for three free missions based on the CanSats. One of them will be equipped of a glider and will be guided by a GPS signal. The other will be equipped of sensors capable of measuring the surrounding environment such as the temperature or the pressure.

IV. CANSAT ARCHITECTURE

We tried to optimise as much as possible the location of each element as well as their number in order to give our device the lightest weight possible.

The electronic components are located in the CanSat's « high » part whereas the deployment system is situated in the "low" part. (Please refer to figures 2,3 and 4)



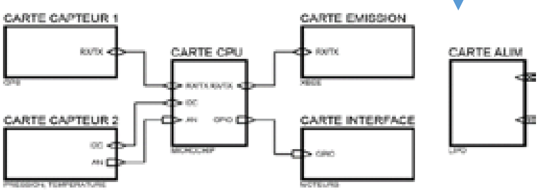
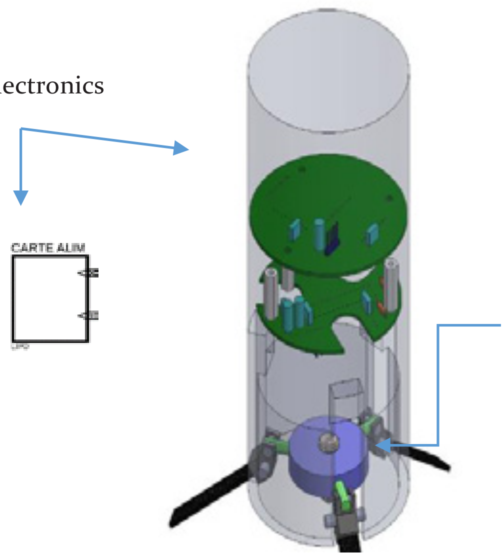


Fig.2 Electrical architecture



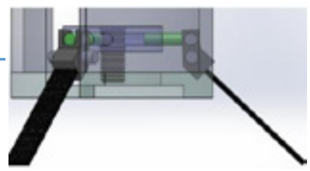


Fig.4 System of deployment

A. Electrical architecture & Telemetry

The electronic runs the whole functioning of the CanSats. The management is taken care of by a CPU-card that uses a 16 MHz processor. Despite the available speed, the program only processes the sensors' data at a lower frequency (100Hz.) The GPS signals are only refreshed every second, but the sensors work faster. The telemetry transmits the data at a frequency of 10Hz but saves 10 times more data. The program is structured by a sequencer which is an algorithm allowing to make sure the program is working properly while running the deployment at the end of the cycle. Mechanical parts

B. The mechanical parts

The parachute will be made of Aramid fiber for its exceptional property of resistance to traction. We have determined the size of the web thanks to the following formula:

$$F = \left(\frac{R.S.C_x.V_0^2}{2}\right)$$

with R being the air density (1,3 g.L-1),
S being the parachute's surface in m^2,
and Cx being the parachute's aerodynamic coefficient.

C. Materials part

As for the CanSats' structure, we are still hesitating between an Aluminium alloy for its resistance/weight ratio and a polycarbonate shell not only for aesthetic matters due to its transparency but also for its viscoelastic properties which make it incredibly shock-resistant.

VI. CONCLUSION

We are currently beginning the system making phase. The modeling is over and the last few flaws have been fixed. We consequently have the final plans for both devices.

ACKNOWLEDGMENT

We thank all the teachers before who supported us in this project, thus putting their knowledge at our disposal, Nîmes IUT who provided a place of work, all students of the association for Sup'Sats efforts continued all throughout the year and finally, World of Science which allowed us to travel to the far reaches of space through this project.

The Viking project: A CanSat to navigate on the ground and in the air.

Maxence Bouvier, Blanche Franceschi, Manon Lazaro, Gaspard Louvet

CanSat :

The name comes from the contraction of "Canette" and "Satellite". This project aims to combine in a 1 liter cylinder equipments similar to those of a space probe. It must have a parachute for the 150m drop. This project is a contest where the CanSat have to achieve a scientific mission, and another mission which the participants are free to choose. The objective is therefore to participate in this competition and to particularly insist on the free mission chosen, which has never been successful yet at Phelma. Consequently this project is a combination of electronics, mechanics and programming.

I. Introduction

This CanSat is part of the line teams Phelma. It is not an upgrade of the previous projects, because of the changes in the contest rules. However it still benefited from knowledge of the materials needed. This year, the instructions for the scientific mission was to deploy something. So, to get out wheels on the extremities was chosen. For the free one it was decided to do the "Come-Back" mission. The purpose is to steer the CanSat to a specific target on the ground, while it drop with a parachute.

II. Context of Development

A. The Team

We are four freshmen of the engineering school Grenoble – INP Phelma, and we worked on the CanSat as a team project for this school. Now it has been six years that it takes part in this contest. The school finances all of our expenses, and every year it replaces damaged materials. The team is composed by Gaspard Louvet, Manon Lazaro and Blanche Franceschi three formers PSI and Maxence Bouvier a former PC from CPGE of all over France.

Fig 1. Picture of the Phelmartien team with their tutor.

B. The Organisation

In accordance with the preferences of every members of the team, the project was divided like this: Gaspard Louvet the leader, in charge of the rover (the body of the CanSat), Maxence Bouvier the responsible for the sailing module, Manon Lazaro in charge of the parachute and Blanche Franceschi the supervisor of the code section.
In all, seven months were accorded to carry out this project. One month was dedicated to mark it out and choose the technical solutions, the rest of the time was split in such a way to fabricate and test the pieces step by step.

III. Definition of the Missions

A. Scientific Mission

To deploy wheels on the rover it was better to choose the simplest solution: use the gravity and a rotation system rather than a translation, which requires a high level of precision. Both wheel assemblies are fixed to an axe made of piano wire. A servo-motor placed on the actuator platform frees and blocks the rotation on the shaft. Said shaft being decentred, with gravity, the wheel assemblies fall and thus are deployed.

B. Free Mission

Viking will also have to head while it has not yet hit the ground. To do this a wing-shaped parachute has been selected then sew because of its ability to handle the changes of direction. The microcontroller of the sailing module has been coded to face the wind and therefore be slightly deviated. It uses a compass to control the direction and a GPS to follow the position. If it is successful on this mission, then the scientific mission will be to turn all over the target.

IV. CanSat Architecture

A. Sailing Module

The sailing module is attached to the parachute. Two servo-motors pull on the breaks of the parachute to steer it. These motors are controlled by an arduino which receives the navigation data from the rover. The parachute module can be separated from the rover after landing.

B. Mechanical Parts of the Rover

The mechanicals parts have already been developed in the section III.A. These are represented in the Fig 2.

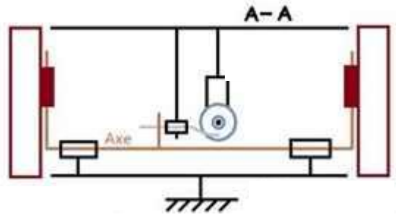


Fig2. Face view of the Rover

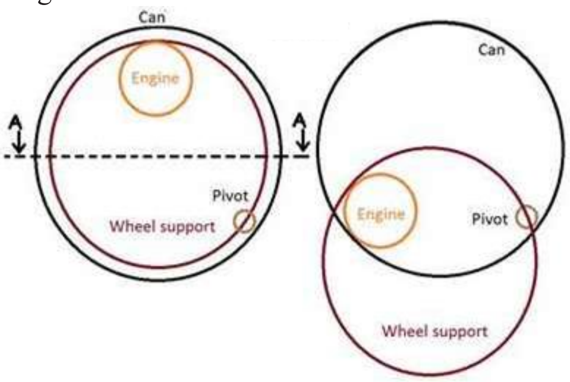


Fig3. Side view of the rover, and wheels dropping system

When landing a servo-motor will release the parachute. Another one will let the wheels go down, then lock them in their ground position (see Fig3). The motors are directly fixed to the wheels, and are controlled by an arduino.

V. Conclusion

The project is not over yet. It is still necessary to assemble all the parts of the CanSat and check that everything works together. The work goes on, and will be assuredly finished for the contest.

Acknowledgment

We would thank all the people who have contributed in some way to this project particularly Patrice PETITCLAIR who helped us realizing the 2015 CanSat at Phelma. Ours thanks also go to Julien TRAVAUX for all the time he awarded to us, his advices were really useful and appreciated. We also thank all the people who were there to assist us: Florence NOEL, Sophie CORNU, Jean-PAUL SAUNIER, Antoine PISA. Finally, we would like to thank Pierre FROMENTIN who helped us to gain a clearer understanding on the way to build a parachute.

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Kirby 2 : a CanSat that knows its altitude

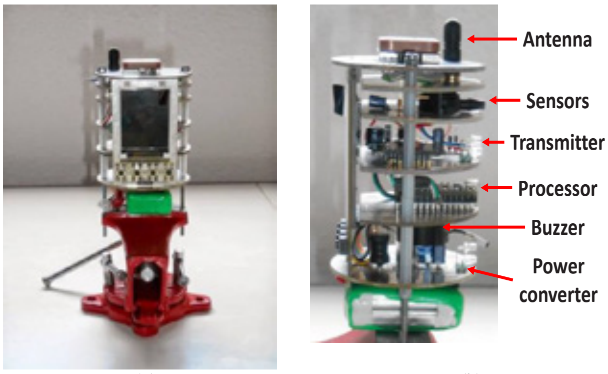
Ryan Thompson, Alexandre Marque, Ludovic Thulliez, Julien Couvidat, Chloé Moreno

***Abstract*—This document presents the proposed design of the Kirby 2 CanSat, presented by the Eirspace student club. Each year, the EirSpace student launches a CanSat during this competition. Three missions are detailed in this article. The main mission, imposed by the organisators, is a deployment. For this session, the deployment proposed by Eirspace is an antenna deployment. The two other missions proposed are a light measurement, and the measurement of the altitude and velocity of the CanSat using a radar system. The radar design consists in a bistatic radar, with one antenna used for the transmission, and another used for the reception.**

The transceiver frequency will be centered at 2.45 GHz, and the signal will be transmitted using a patch antenna. The competition will take place on a controlled area, almost free of Wi-Fi signals. Therefore this frequency can be used for radar operation without interferences.

I. Introduction

This project is realized by EirSpace [1], the airspace student association of the Enseirb-Matmeca engineering school [2]. This project was initially an upgraded version of a CanSat submitted a few years ago (so the chosen name is Kirby 2), but the team operated much modifications, so the name was just kept for sentimental reasons. This CanSat is presented in the pictures below:



(a) *(b)*

Fig. 2. EirSpace international class CanSat launched in august 2014. (a) Front view. (b) Side view.

II. DEFINITION OF THE MISSIONS

The main mission consists in the deployment of an antenna to ensure the telecommunication with the ground station. This antenna will be deployed using an active electromagnet and a spring. The antenna is kept inside the volume of the CanSat until the launch, detected by an Arduino module. After the launch, a current is provided to the electromagnet

by the Arduino, which release the antenna, propulsed outside the volume of the CanSat by the spring.

The second mission proposed for this project is the determination of the spin moment during the fall, using a light measurement with two photodiodes.

The final mission proposed is the determination of the altitude and the speed of the CanSat during its fall using a radar altimeter. The carrier frequency is centered at 2.45 GHz. The global situation of the Cansat during the fall is presented in the Figure 2 below.

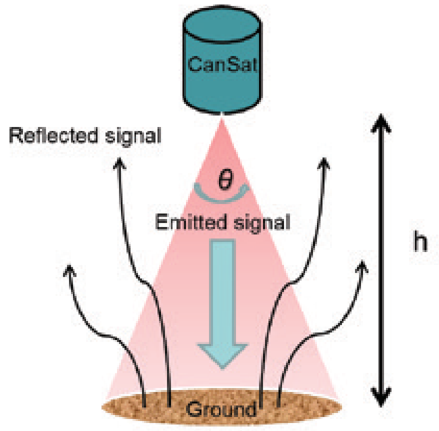


Fig. 2. Situation of a launched CanSat.

The operating principle of a radar altimeter is based on the reflection of a radar emitted signal on a target. The analysis of the reflected signal permits the determination of the distance between the CanSat and the ground. It also allows knowing the CanSat's fall speed, by analyzing the Doppler shift. The Doppler shift is induced by the relative movement between the CanSat and the ground.

The proposed design are detailed in the next part.

.

II. ARCHITECTURE

1) CanSat Architecture

The global architecture of the Kirby 2 project is presented on Fig. 3.

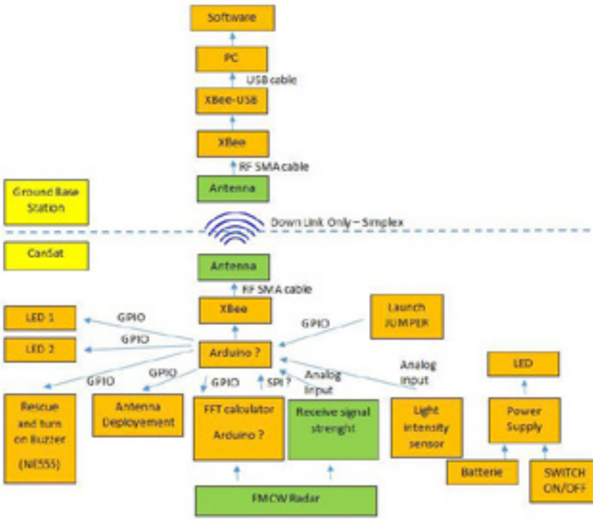


Fig. 3. CanSat Architecture.

2) *Telecommunications*

The CanSat will communicate with the ground station using 2 Arduinos connected, via an XBee shield, to an XBee pro RF module which will be connected to antennas, one for the CanSat and one for the ground station. The XBee module uses ZigBee protocol to communicate to other XBee modules via UART i.e. serial communication.

The ZigBee protocol is a network layer protocol designed to allow low powered mesh, start and peer to peer networks to be created using XBee modules using two networks 802.15.4 and the ZigBee network depending on the module used.

The 802.15.4 is better used for simple peer to peer communication between to modules, however using ZigBee protocol allows for the creation of mesh networks far more easily. Both networks have to be configured differently, the CanSat is configured to work on a ZigBee network.

In order to set up this network each XBee module there has to be configured to have the appropriate firmware and ID which can be done using Digi XCTU software using the following steps:

- Find the serial ID number of each module
- Configure the module in the CanSat to be a coordinator and the module at the ground station to be an end device
- Give each module the same Personal Area Network ID(PAN ID) or else they will not communicate with each other at all
- Make sure the destination address for the coordinator is the same as the serial ID of the end device module

As the module in the CanSat is a coordinator, it can set choose the channel of communication depending on the availability of a channel.

3) *Radar design*

There are several radar architectures with various performances.

The most common radars uses a pulsed signal (emitted during a short period), or a signal whose frequency is constant. However, they have limited performances.

The best compromise to ensure the measurement of the radar range and the fall speed at the same time is to emit a frequency modulated continuous wave (FMCW) signal. Over time, the frequency varies according to a predefined profile. One of the possible profiles is a triangular profile. The frequency emitted starts from its carrier value, and varies over time, as shown in the Fig. 4.

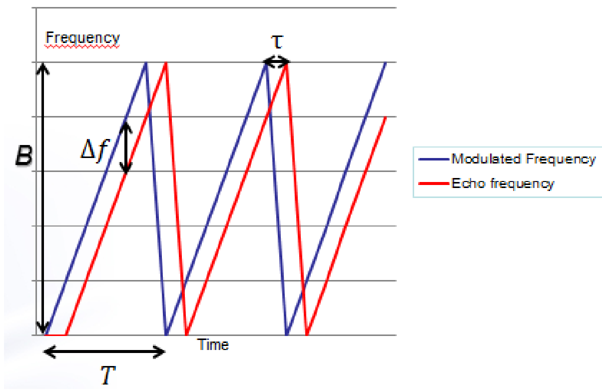


Fig. 4. Triangular frequency modulated profile.

A signal which has such a frequency profile is called FMCW for Frequency Modulated Continuous Wave. The signal is emitted continuously, but its frequency varies over time.

The echo signal is delayed by τ, which is the time required for the emitted signal to reach the target and return to the radar. T is the modulating period, f_d is the Doppler shit frequency and B is the radar bandwidth. The frequency shift Δf (called "beat frequency") can be measured, and analyzed with an appropriate software treatment. The CanSat's height and speed can be determined by analyzing this beat frequency. The French legislation allows the use of a 83.5 MHz bandwidth for the ISM band at 2.45 GHz.

The beat frequency is given by the following formula:

$$\Delta f = f_d - \frac{B\tau}{T} \qquad (1)$$

The choice of a correct modulating frequency is fundamental. A high modulating frequency will increase the beat frequency's value, which reduce the error on the measurement. However, the echo signal must not be shifted over one period of the modulating frequency. (The delay must not be higher than the period T, to maintain the correlation between the transmitted and received signals). This consideration gives a maximal modulating frequency of 1.87 MHz, the chosen one is 100 kHz.

Exploration: a CanSat to explore surfaces of new astres

BALDE Hamidou, KANOUTE Dembo, BALAKISININ Rajmanghan

Abstract - Our CanSat is called CELESTA. It's the first participation to the French CanSat competition for Octave. CELESTA project consists to design and make a space probe miniature. However the size of the probe will not exceed 20 cm in length and must fit in a 8 cm diameter cylinder.

This probe will embed three sensors (BMP085, SHT15 and ADXL 335) and one camera. There is also a mechanical system to dig. A XBee system provide communication between the CanSat and the ground station.

I-INTRODUCTION

Ce document présente le rapport du projet CanSat mené dans le cadre du concours CANSAT FRANCE 2015.

Le projet est mené par l'association OCTAVE, qui utilise les locaux de l'université Evry Val d'Essonne (UEVE) durant toute la période de l'année scolaire.

Nous avons réalisé un CanSat baptisé CELESTA qui a pour mission d'effectuer un sondage atmosphérique, déployer une pelle, puis prendre des photographies et enfin transmettre les informations à la station sol via une communication XBee.

II-CONTEXTE DU DEVELOPPEMENT

A) L'ASSOCIATION OCTAVE

OCTAVE (Organisme de Création Technologique Aérospatiale de la Ville d'Evry) est une association (loi 1901) créé en 2009 par des étudiants de l'Unité de Formation et de Recherche en Science et Technologie (UFRST), qui a pour but de réunir des étudiants du campus évryen, des professionnels ou de simples passionnés du secteur aéronautique ou spatial du bassin d'agglomération d'Evry, pour réaliser des constructions et des expérimentations dans le domaine aérospatial.

Local technique :

Bâtiment UFRST Evry

40 rue du Pelvoux

91080 Courcouronnes

site web : www.associationoctave.fr

C'est la première participation de l'association OCTAVE dans un concours CanSat de France. OCTAVE a pour but de promouvoir les activités aérospatiales dans le bassin de la ville d'Evry à travers la réalisation de fusées expérimentale et de drones. Incubée au sein de l'UFR Sciences et Technologies, l'association travaille en étroite collaboration avec l'UEVE sur le projet PERSEUS. Participant activement depuis sa création à ce projet, elle regroupe des étudiants motivés et soutenus par l'UFRST, leurs enseignants et le CNES. Sa création découle des contraintes imposées par le projet PERSEUS.

Les différents projets de l'association sont financés par les principaux partenaires qui sont entre autres :

- CNES (Centre National d'Etude Spatial) ;
- UEVE (Université d'Evry Val d'Essonne) ;
- La mairie d'Evry, le CROUS de Versaille, le Conseil Général de l'Essonne ;

Notre projet CanSat a été financé principalement par UEVE.

Les membres du projet pour le concours CanSat de France sont au nombre de trois :

- Hamidou BALDE chef de projet deuxième année BTS système électronique au lycée GEORGES BRASSENS.
- Dembo KANOUTE étudiant en deuxième année de BTS systèmes électroniques au lycée GEORGES BRASSENS
- Rajmanghan BALAKISININ étudiant en deuxième de BTS informatiques réseaux pour l'industrie et les services techniques au lycée DOISNEAU.

B) LE PLAN DU TRAVAIL

Le plan du travail est reparti entre les trois membres en fonction de nos spécialités. Dembo et Hamidou s'occupent des parties électroniques et mécaniques du CanSat. Rajmaghan, quant à lui, gère les travaux informatiques, de programmation industrielle principalement.

Pour commencer le projet, nous avons étudié le module Arduino et les différents capteurs choisis par l'équipe. Nous avons réalisé le concept tout en respectant le cahier de charge.

III-LES MISIONS

LA MISSION PRINCIPALE

La mission principale de déploiement consiste à déployer une pelle pour « creuser » (on parlera plutôt de gratter) le sol après atterrissage de la sonde.

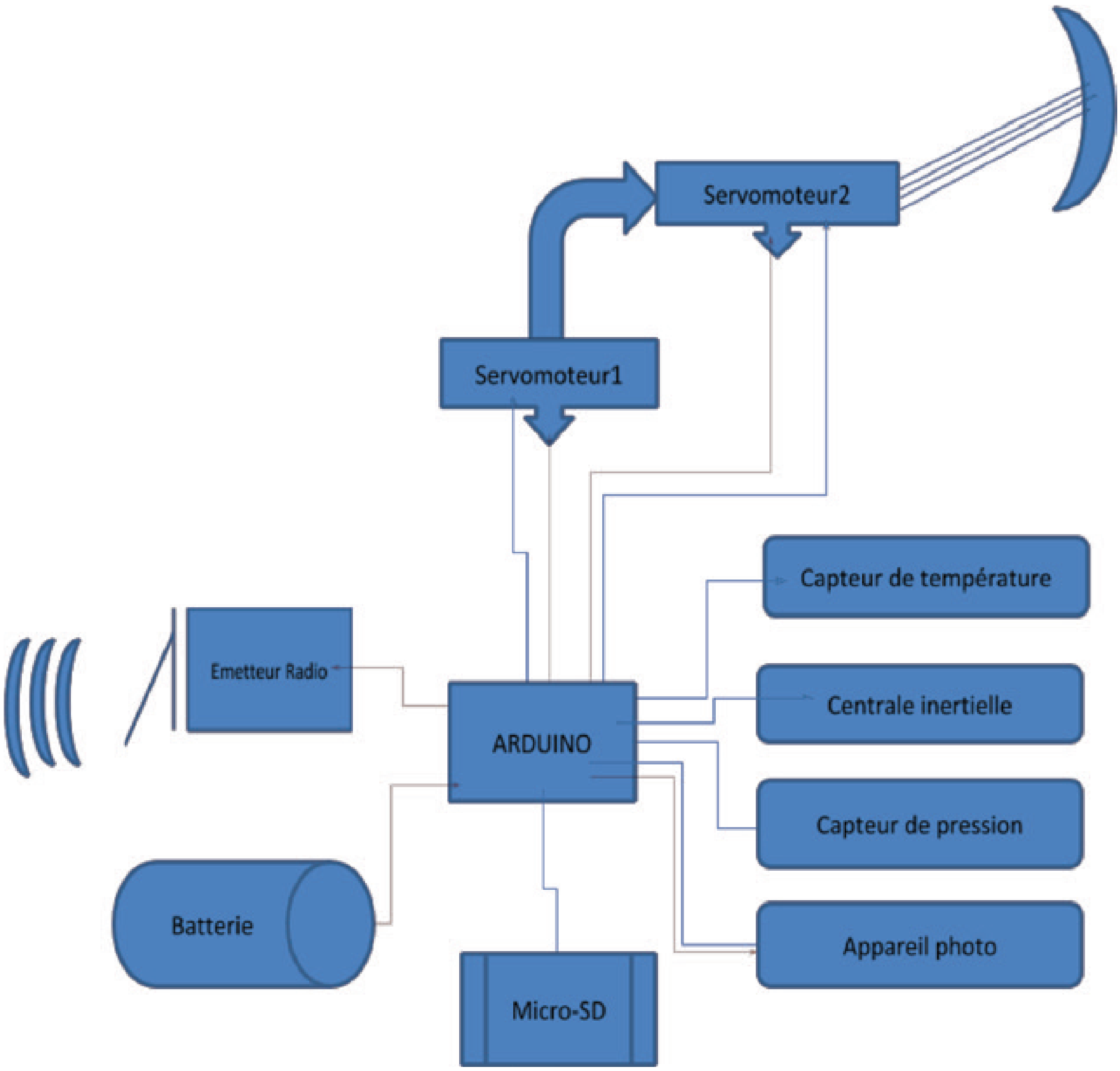
LES MISSIONS LIBRES

Les missions libres nous servent à faire des sondages atmosphériques ; c'est pour cela qu'on utilise les capteurs comme :

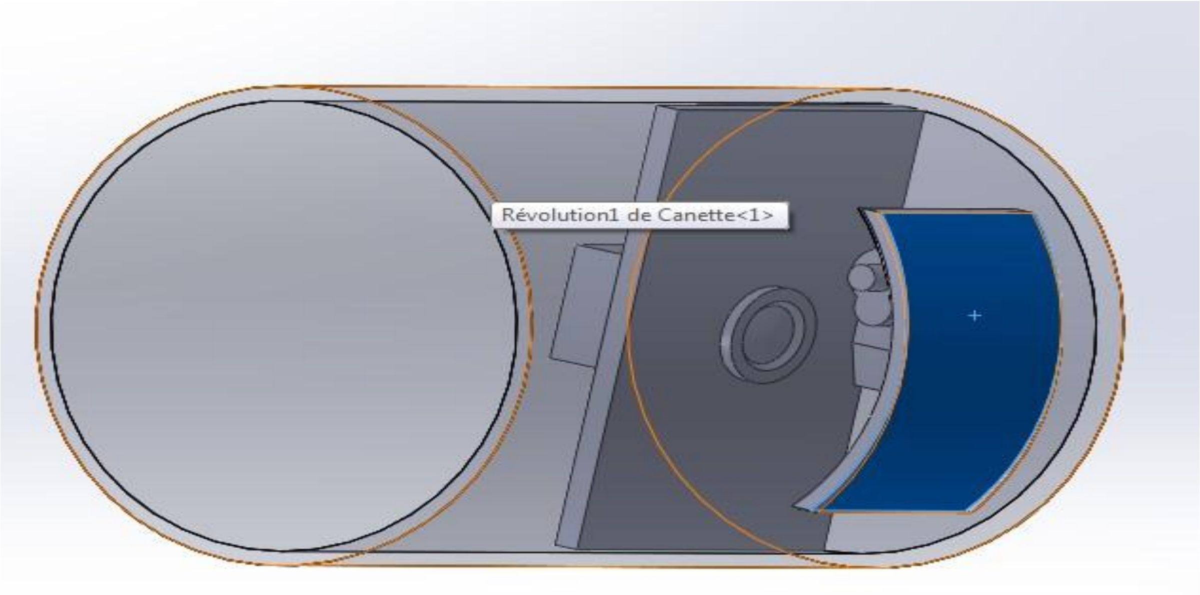
- BMP035 permet de mesurer la pression et en déterminer l'altitude ;
- SHT15 permet de mesurer la température et le taux d'humidité ;
- ADXL335 permet de calculer les accélérations suivants les trois axes (x ;y ;z) ;
- Une caméra pour prendre des images pendant le largage et après le stationnement au sol.

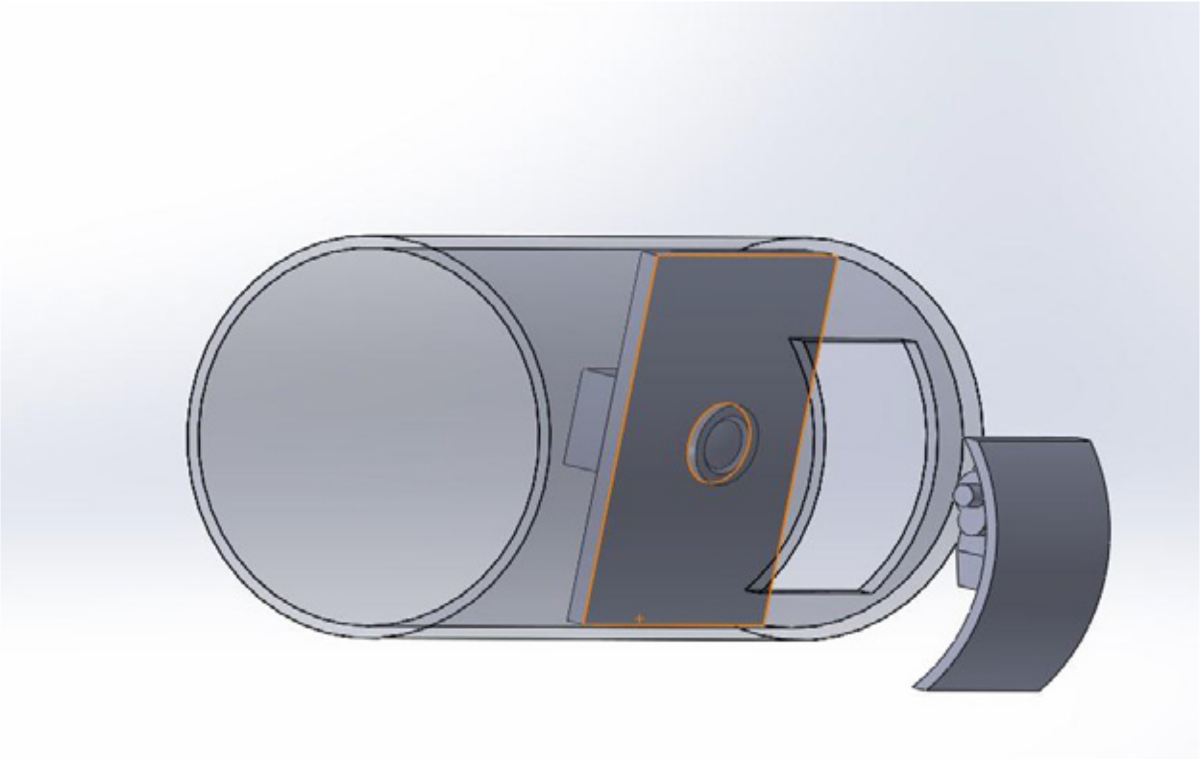
IV-ARCHITECHTURE DU CANSAT

SCHEMA STRUCTUREL DU CANSAT



PARTIE MECANIQUE





Cette partie n'est pas terminée.

LA TELEMETRIE

La transmission et la réception des informations s'effectuent via un réseau Zig Bee à partir des modules XBee Pro S5.

On a choisi ce module car il s'adapte bien au cahier des charges Planète Science, en terme de fréquence a respecter.

Nous utilisons deux modules Xbee pour que le CanSat communique à la station sol, pour récupérer en direct toutes nos données.

Il a une puissance d'émission de 1mW et une fréquence de 868MHz

V-SOURCE DOCUMENT

www.matlog.fr

- Les Capteurs (ici ils sont relativement précis et abordable):
  Nous avons trois capteurs :
  -le 1^{er} est le capteur BMP, c'est un petit capteur qui
  permet de calculer l'altitude à partir de la pression, d'où
  cette formule:
  Altitude = 44330 *[p/p0]^(1/5.255)] en m.

- Il y a aussi le capteur SHT 15, qui un capteur (petit et grande précis) de température allant de -40°C à 85°C et avec un précision de plus ou moins 0.3°C.
  Il mesure l'humidité de 0 à 100 % avec un précision de plus ou moins 2 %.

- Enfin le dernier capteur, qui est le ADXL 335, qui est un accéléromètre qui donne trois valeurs analogiques X, Y et Z. Grâce à cela, nous pouvons connaître la position.

VI-CONCLUSION

Les difficultés de ce projet résident dans le fait que les équipements devraient être embarqués dans un espace réduit. Puis la sonde doit effectuer des mesures tels que la température, l'humidité ainsi que les coordonnées des axes X, Y et Z et effectue le déploiement de la pelle.

Malgré le léger retard de nos travaux à cause des préoccupations de nos projets scolaires, On aura suffisamment le temps pour aboutir et finaliser notre projet CanSat à fin de participer au concours.

SEB&SEC

Stratospheric Experiments Balloon and Stratospheric Experiments CanSat

ESTACA – François Rabette <francois.rabette@estaca.eu>

Abstract – This report is the outcome of our CanSat project done during 2014-2015 school year. As part of ESO club, we first wanted to explore the stratospheric atmosphere.

So, we started our work on a stratospheric balloon. Our main experience objective was the analysis of earth atmosphere, pressure, temperature, humidity, wind…

Then, we had the intention to drop a module from the balloon (SEB). SEC was born!

Its mission is to enrich SEB's exploration. Therefore main experiences are present on both projects.

Summary

Introduction

Since many years, earth atmosphere is the concern of many scientific researches.

This project application is a solution to explore and collect data in atmosphere at many altitudes with almost no outside perturbation. Today, we use stratospheric balloon able to maintain about 2 metric tons [1] for 25 days [2] in flight.

Figure 1 : Stratospheric Balloon (CNES)

This project's report includes all the elements for the implementation of a stratospheric balloon and a CanSat module, it will show you how we have designed these parts and its advantages in flight to serve scientific missions or civil applications.

Balloon and CanSat

This part deals with balloon stratospheric and CanSat history and current application.

Stratospheric Balloon

As same principle of Montgolfier, stratospheric balloon operates with Archimedes thrust. Instead of hot air for hot air balloon, it uses a low density gas as helium or hydrogen. In France, for security issue, the only used gas is helium (density of 0.17 [3]). In other country or for most specific experiments, hydrogen (density of 0.09 [3]) is used.

It is currently used in many aeronautic application and experiment.

The first application is scientific missions. Indeed, balloons are the best way to make soundings in the atmosphere. Thanks to his capacity to stay in air for many weeks, it serves to weather predictions and climate study.

The second application is currently experimented by Google : Loon project [3].The goal of this project is to bring internet in low populated area with a giant network of stratospheric balloon. To move balloon, Google wants to use jet winds.

Figure 2: Loon Project (Google)

The third application is for world record space jump Felix Baumgartner [3] in 2012 of 128K ft and Alan Eustace [4] in 2014 of 135K ft.

In weapon, we can notice fire balloon with FUGO project. The goal of this project was the aerial bombing of the west cost of United State of America by Japanese. This application was also one of the first use of jet winds [3].

CanSat

Since 1957 with the first satellite launched by the Soviet Union: Sputnik 1 [7], satellites have progressed.

Today, satellite, probe and CubeSat have many applications: Space Exploration, civil services (weather, positioning…), earth guard, scientific researches and military recognition.

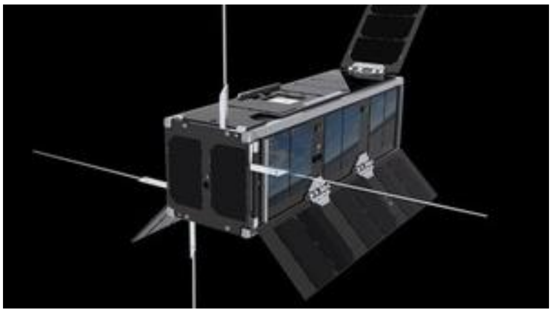


Figure 3 : UKube-1: 2014 - first CubeSat of UK Space Agency

In our case, CanSat symbolize satellite for scientific studies [8].

For the CanSat France contest, CanSats are dropped from a captive balloon at around 150 meter.

Project development

This part concerns our project development context. We will explain to you our club architecture, team composition and place where we work.

ESO

Our club Estaca Space Odyssey was found in 1992. Our objective is to promote space in our school and for public. This year, we have done presentations and conferences for events as "Fête de la science", Rosetta landing or International Congress of Astronautic (IAC). We also build rockets, balloons and CanSat.

Team

The project is developed by volunteers of ESO in 2^{nd} and 3th year. We dispatch the work between the members and regularly have meetings together to explain our choice and tip each other.

Figure 5 : Project team

From left to right: Reece, Vincent, Alexis, Adrien and François.

Workspace

Into our project realization, we have many places to work regarding our task. For engineering and design we have all the softwares we need in school IT room.

After that, to test and calibrate our sensors, we can use school's laboratory. It contains for example acoustic and vibration test benches or numeric oscilloscope.

When school is closed, we have access to another room dedicated to school club's used to do the mechanism assembly.

For carbon fiber manufacturing, we have a partnership with CemCat center. It is a laboratory specialized in composite process development. In their local, we can use some of their equipments: vacuum pump for resin injection and autoclave for coating baking. They also organized a visit to show us their laboratory. It is very interesting to see it because of their new process works (plastic injection in carbon coating for example).

Figure 6 : Carbon fiber in vacuum bag

Work done

This part will explain our work plan, our objectives and those that we really realized. It also explains our experiments and work process.

For the following chapters, SEB design box attached to balloon and SEC the module dropped from SEB.

Specifications

This project is part of CanSat France contest. So, modules have to satisfy to some specifications given by the contest management. The project has also to satisfy civil specification for its stratospheric flight. This one is given by "Direction General de L'aviation Civile" and translated by "Planete Science" in balloon requirement.

The first requirement for our project concern security issues. So, our elements need a minimum and maximum drop and rise speed of respectively [2-15] and [4-∞] $m.s^{-1}$ [9] [10].

The second one is also for security issue. It concerns materials used. They should be safe for environment and people who will find our experiments after flight [9] [11].

The last requirement is about cost. Indeed, this project has a budget of about 300€ for both parts. So we use low-cost items and concentrate to do a maximum of things by ourselves.

Objectives

In our requirement, we have one imposed experiment: unfolding. We chose to deploy three undercarriages. Many possibility exist to do that, servomotor, electromagnet and mechanics. We have chosen a full mechanics with pin and spring for its simplicity and space requirement.

For the other experiment, we chose to stay in the theme of atmosphere analysis, so we study temperature, pressure and humidity regarding altitude for both part of the project.

After regarding some scientific articles, we expect to obtain -55°C and 6330Pa at 20km high (see figure 8).

From stratospheric pod, we want to measure earth roundness. To do that, we put a camera inside the pod. The video made will be used to do some communication events in school about stratosphere and more globally space.

In the dropped module, we have set up a sonar to establish fall speed of SEC. Figure 7 shows performance of this sensor.

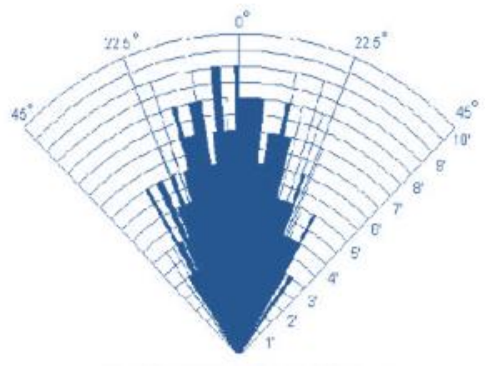


Figure 7 : Ultrasonic angular performance

After flight, result exploitation will be required to conclude on our work. It will be done after data export from embedded cards to computer. We have made calibration of our sensor and establish a law to find parameters we look for.

Realization

We started this project in October 2014. The first steep was the experiments choice. Then, in December, we made the first plan of our project on Catia for mechanism and on ISIS Proteus for electronic hardware.

To protect experiments and electronics from cold temperature of about -40°C [12] in stratosphere, we have chosen a polystyrene foam box.

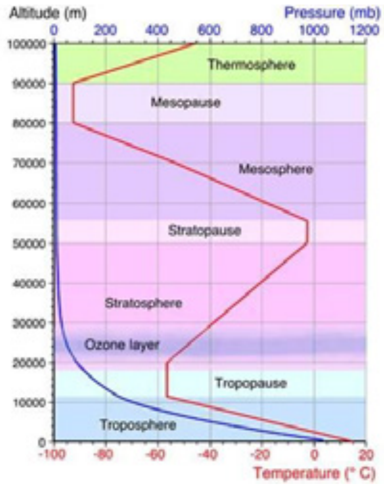


Figure 8 : temperature and pressure regarding altitude

From February to May, once all part of our project bought, we have started the assembling. When modules were designed and built they were tested and integrated in structure to check them all together.

Then, we carried on to program different cards to be self sufficient during our experiments. To allow a high implementation and evolution of software, we have used a real-time API and object oriented programing.

Finally, was left to do: prepare the campaign procedure, plan the spare items and wait for the flight on July 2015.

Preparation for launching campaign

To be more efficient during launch campaign, we have prepared some procedures.

It includes launching, test and assembly / disassembly procedure. Members present on the campaign were informed to all projects procedures and technology used to be able to answer to any failure and controllers questions.

Conclusion

This project allowed us to put in application our school knowledge and even surpass it. It was a fun and ludic project in space domain. During this year, we have learned new skills as budget managing, sponsor search or communication.

It was also the opportunity compare ourselves to other space club in competition of CanSat France.

For the project conclusion, it was the first club CanSat and the second ESO stratospheric balloon. So, it could serve as a base for further projects.

Finally, these, researches gave us the opportunity to search information in our activity domain: Aerospace. It was also a good initiation in scientific reports. Indeed, we find many articles during our preliminary researches that we had never heard about before and yet interesting.

Acknowledgement

This latest part is to thank people and company who supported us into our realization.

Zodiac Aerospace: Parachutes for CanSat is provide by Zodiac.

Radiospare : Supported us by reduction on different component for our project and by free shipping cost.

Cemcat : allowed us to use their composite laboratory. Thank to them, we could experiment and make pre-impregnated coating in safe area and all required equipment's.

Estaca : Our school gave us logistics and financial help. They also advised us for work projects, insurance and bank account.

Cnes : thanks to the national space study center, we have access to a high efficiency module to transmit data from our balloon to the ground antenna : Kiwi Millenium [13]. We didn't have the ability to make our own telemetry module and it was a real benefit for us.

Planete science : Every year, Planete Science and its volunteers help clubs into their realization of rockets, balloon and CanSat. It happens during national and regional campaigns and during meetings (RCE). They also manage campaigns in collaboration with Cnes the C'Space.

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SpaceCAN: Imagery CanSat for new horizons

Quentin CANEL, Antoine BELLANGER, Kevin DESIR, Alexandre GONZALEZ DEL CASTILLO, Gauthier MAQUIN, Edouard SMITH, Pierrick ROUSET, Axel BERNARD

SpaceCAN is a project done by members of the ESP club at ENSMA. It's part of their last school year and will be an important part of the semester validation. Its main purpose is to observe a specific point during the descent and to keep it on the screen all the time.

I. Introduction

SpaceCAN is ENSMA's CanSat project. ENSMA is an engineering school which delivers a master of engineering science degree. During the last year of their studies at ENSMA, students shall complete an engineering design project. Student are entirely autonomous on this project, indeed teachers can help us in case of difficulties.

It is a major part of our ending studies year. Every alumnus shall produce a report that will receive a mark which matters a lot in the semester.

Our team first presents the context of this project, then chosen and imposed missions, and finally the conception of our CanSat.

II. Context of development

A. *ENSMA Space Project Club*

SpaceCAN is one of ESP club project. Indeed ESP hosts all "Space" projects, like CanSat, Rockets and weather balloon. It has also a project for Dassault UAV challenge, and Fahrsat. Finally, ESP takes part in a Robot challenge (French Cup of Robotics).

Members of SpaceCAN project are almost all students on their last year at ENSMA. Two of us, Pierrick and Axel are in their first year of master of engineering science degree (second year at ENSMA), they help us as we don't have much time. Our team was split in three groups: Antoine, Edouard and Kevin have programmed the logics of the controller. Alexandre and Gauthier did the mechanics, and Quentin made the electronic board. Finally, Pierrick and Axel helped us to make the parachute and test it.

We spend at least around 120 hours in the year to work on this project. We also made lots of meetings in order to keep everyone up to date, to manage delivery scheduled and give second-year members all practical details to organize their work.

Fig. 1. Picture of the SpaceCAN team

B. *Work plan*

This project takes place in the last school year at ENSMA. This imposes us a short timeline to develop and build our CanSat. We started the project on mid-October and we had to write a final report for the end of March.

The SpaceCAN team managed to take decisions quickly about missions and design basis. However, at the beginning of December, we received new rules for the CanSat competition. Therefore, everyone has to take them into account as major rules changed, and we had to start again from scratch. And even we had to adapt the missions and changed totally conception basis.

It took us less than a month to react and to decide changes on missions. And we started to make the CAD model in January, and we bought new component to embed. The construction of our CanSat took the rest of the time. We decided to make it the simpler possible, in order to be able to repair it as fast as possible, and also to limit the risks of failures.

At the end of the school year, we had a functional (but not finished) CanSat, and the logic of the controller is almost done. The essential part is still to be done: testing and verification of requirements. As most of members are no longer next to school, we decided to give the CanSat to Quentin, who will test it at home until the C'Space event. He will also make some modifications on the mechanical structure in order to correct problems found at the end of the year, and He will repair the electronic board which wasn't working anymore.

For this CanSat, the funds were given by the school as this is a school project (for most of the part). The remaining portion came from ESP club.

They were no need to find sponsors as the funds were adequate. Moreover, our conception is pretty simple, with basics parts and many materials come from DIY store. A final financial report will be available at the end of the project, before C'Space event.

III. Definition of the missions

A. First chosen mission

At the beginning, we didn't have the new rules yet. We had to decide the mission without being sure that nothing will change this year.

We had decided to build a video tracking system. It has to be able to follow a specific point on the ground, defined before flight by setting GPS coordinates in the CanSat. During descent, the module shall estimate the exact position, and to define the camera angles to give in order to see the selected point.

The camera is on a two-axis mount. As we do not need camera own axis of rotation. We had to choose between embedded storage for the video, or radio transmission. We selected the second option as small cameras exist and there are almost ready-to-fly solutions available for video transmission. This transmission is the only radio connection made with our CanSat. Transmitter is started at launch time, and disconnected a shortly after landing in order to save power.

On ground, we use a receiver and a video capture card on a computer to get and save the video in real-time. We do not need to develop any interface as this is standard software, available freely on Internet.

B. Imposed mission

This year, the imposed mission was "the deployment". When we have got this point, we found that the conception we had already done didn't fill the requirements.

As we didn't have lot of time, we decided to make a simple mission: deploying a lander once landed. This would permit the CanSat to stabilize himself and to perform the video mission.

This lander is composed of four legs that will make the CanSat raise a little from the ground. It will also avoid it to turn. They will be moved using four servomotors driven by the main controller.

IV. CanSat Architecture

A. Electrical architecture

As the CanSat has to be very small, we decided to include all the electronics on one board. This board has to distribute power to every element, and receive power from the battery. We have to power the RF transmitter, the camera, and every 4 servomotors for the lander. The camera and the transmitter imposed us to have a power of at least 10V DC and a current of about 300mA. We decided to use an 11.1V DC, 610mAh Lithium-Polymer battery as they have a good capacity/weight ratio.

On the main board, we needed several components: an IMU (Pololu MinIMU-9), containing a 3-axis accelerometer and gyrometer, and a 3-axis magnetometer, a GPS from Adafruit, an opto-transistor to switch off the transmitter, and a controller. We decided to select a Teensy 3.1 controller as it is very small (35mm x 18mm) and fast (96MHz).

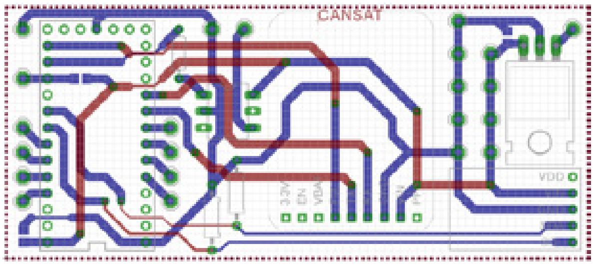

Fig. 2. Main board typon

B. Mechanical structure

The whole mechanical structure of our CanSat was designed on Catia V5 (CAD software). This ensured us, everything fits correctly and therefore, we will not face troubles assembling it.

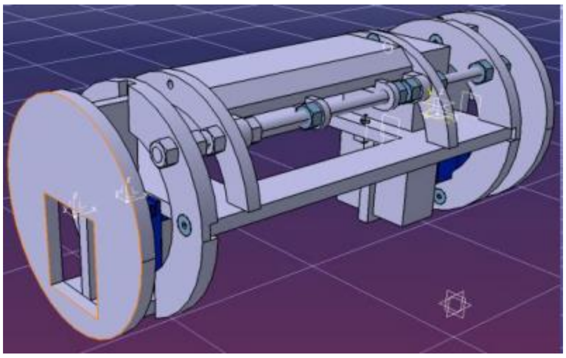

Fig. 3. CAD Model of the CanSat

We wished to be able to re-build our CanSat (after a repair for example) in a short amount of time, so we decided to assemble it only with plywood panel and stud bolt. We have been able to find it easily, and make a first prototype within a day.

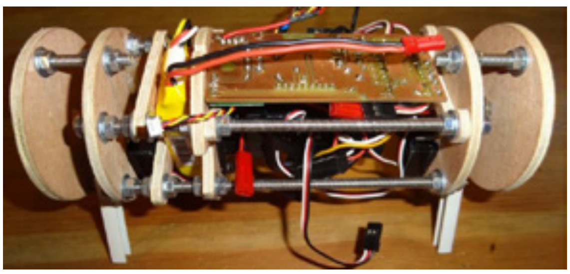

Fig. 4. Final CanSat structure

The CanSat has to be sustained by a parachute during the descent. We had to evaluate the needs and make it.

As many rockets in our ESP club use cross parachutes with good results, we decided to make it like a cross. We used an available excel file with the right computed formula to determine the size adapted to our CanSat weight and maximum vertical speed.

We finally made a speed test to be sure that it was working great. After analysis of a video of this test on a computer, the descent speed calculated is about 5m /s. This is near the low speed allowed (2 m/s), but still within the range (up to 15m/s). And moreover it is needed as we want to film a stationary target. So, it shall not be too fast.

Table 1. Main characteristics of the CanSat

Parameter (Unit)	Value
Weight (g)	400
Length (cm)	19
Diameter (cm)	7.8

C. *Telemetry*

The only telemetry needed is the video stream. There are lots of video transmitter that allows us to connect directly the camera and to transmit it to the ground. These transmitters work in analogue mode, so stream can be obtained on any TV, or computer with a capture card.

Video transmission needs an important bandwidth, the power required is extensive, and otherwise signal will not be strong enough. There are two available frequency for these transmitters: 2.4GHz, or 5.8GHz. We have chosen one on 5.8GHz, with a transmitted power of 200mW. This power is too important for civil use (the French laws limit it to 10mW). Hopefully, one member has an amateur radio certificate, and is allowed to use it. He will be present for C'Space event, and he is responsible for wireless transmission (call sign: F4HIC).

D. *Video tracking*

Video tracking is the most valuable part of our CanSat. It does not use the video stream to compute angles, this needs too much processing and cannot be done on the controller embedded in CanSat. This could have been calculated on the ground, but we are not allowed to communicate commands or orders to our CanSat during the flight.

We decided to use an inertial central with a GPS to determine the position, and with a pre-defined GPS position of the target we are able to calculate the camera position.

A Kalman filter is used to combine accelerometer and gyrometer values, and the GPS is used before flight to have the correct position. A static algorithm is used to determine camera angles to apply at the end of the process.

Here is a 1-D example to explain the filter:

- Accelerometer gives unstable values with noise:

$$a_M = a + b_1$$

- Gyrometer gives values with noise and bias:

$$\omega_M = \omega + b + b_2$$

We can put it in a matrix form:

$$Y = HX + B$$

Where Y is the value from sensors, X the estimated position, B the input noise and H the observation matrix.

Prediction step:

$$\hat{X}_k^+ = A.\hat{X}_k$$

$$P_k^+ = AP_kA^t + Q$$

Correction step:

$$\hat{X}_{k+1} = \hat{X}_k^+ + K_{k+1}(Y_{k+1} - H_{k+1}\hat{X}_k^+)$$

The logic implemented on the CANSAT follow these equations, but on a 3-D basis.

V. Conclusion

Right now, the project is almost finished. Every sensors and actuators are working well, and the structure is fully assembled.

The program has to be fully tested in order to be sure everything is working as expected. This part is certainly significant work to be done, and it is hard to do it as we cannot meet as often as needed.

Finally, we can state: 4 months of work is really short, especially when changes happen. We still need to test and debug the code, and verify that the whole mission is functional.

But this project showed us how to manage our time, and how to organize us in order to work together. This was a really tangible work, and we had to achieve small goal, to complete step after step a working CanSat assuring us that the main mission will be successful.

Acknowledgment

We would like to thank every people that helped us on this project, especially Mr. Richard for his management and knowledge, Ms. Chocinski and the ESP club for the orders.

We also thank Planète Sciences and every voluntary, to organize this competition and give us a chance to make this project real during the C'Space week.

Tortue Ninsat

Nicolas Berhault, Anthony Bidault, Franck Dadie

***Abstract*–Tortue Ninsat is a CanSat developed by NAFM. It has the particularity to be made with a 3D printer. It will try to detect a pre-defined altitude on the purpose to reuse the system for a rocket airbag.**

I. Introduction

TORTUE NINSAT is the first CanSat made by NAFM, an aerospatial club for passionate people. It will accomplish the imposed mission (Flag deployment) as well as 1 free mission: altitude detection. This paper presents the CanSat, the team working on it and the project budget.

II. Context of Development

A. Club

Tortue Ninsat is developed by 3 members of NAFM. The club, constituted by 4 just graduated members, was created in 2014 and its aim is to design and build aerospatial projects such as miniature rockets, experimental rockets or unmanned Aerial Vehicles during free time. It will be the first participation of the club to the C'Space although all members have already attended this competition.

Figure 1: Picture of the Tortue Ninsat team

B. Work plan

Nicolas Berhault is the project leader. He manages the good progress of the project and insures good communication in the team. Despite coming with a mechanical background, Anthony Bidault is the electronic manager. He particularly works on the electronic cards and needs. Finally, Franck Dadié is the mechanical manager. He designs the mechanical structure and the parachute of the CanSat. He is also responsible for material supplies.

C. Budget

Table 1. Tortue Ninsat's budget

Reference	Description	Quantity	Total (€)
Motor	-	1	5
MPXA6115AC6U	Pressure	1	9.65
INA826AIDGKR	Amplifier	1	3.72
XBee Pro	Transmitter	2	80
Arduino Nano	Processor	2	5.50
SD card	Memory	1	5.50
SD card shield	-	1	2.50
9V battery	Battery	1	4.60
Miscellaneous	LED, resistors, wires…	-	6
Spinnaker	Parachute	-	8
PLA	Shell material	-	35
		Total (€)	165.47

NAFM is funded by its members.

III. Definition of the Missions

A. Mandatory Mission

TORTUE NINSAT will deploy a flag once on the ground. The system represented on Figure 2 is inspired from a fries cutter which uses three rotation axes. Thanks to the fixed guides, the rotation is then converted to a translation which drives the flag out.

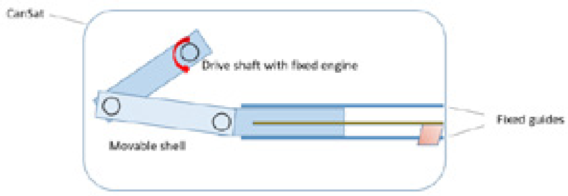

Figure 2: Deployment system scheme

B. Free mission

The CanSat will detect its altitude during the whole flight. To achieve this measure, a pressure sensor (MPXA6115AC6U) will be embedded and the formula (1) will be used to deduce the altitude. The sensors are connected to an Arduino Nano which data will be written on SD card and sent to the ground via an XBEE emitter.

$$z = c \times T \times \log(\frac{P_0}{P}) \quad (1)$$

Where z is the altitude, c is a constant, T is the temperature, P_0 is the pressure at sea level and P the pressure at z. [1]

Thanks to the altitudes collected, Tortue Ninsat will send a signal when a given altitude is detected. By comparing the time of the signal with the theoretical fall trajectory of the CanSat, the precision of the altitude measurement system will then be known. If this system is precise enough, it will be reused for an airbag triggering altitude detection in a future project.

IV. CanSat Architecture

A. Electrical architecture

Tortue Ninsat is composed of several boards:
- -A power board that converts the energy from a 9V battery, to fit the different voltages used by each component
- -An Arduino Nano which will treat all data
- -A board for the pressure sensor and the amplifier
- -A board for the XBEE and the SD card

B. Mechanical parts

1) Shell

Tortue Ninsat's external structure is created with a 3D printer. It is made with polylactic acid (PLA) which offers enough rigidity for low weight. It is designed to respect the required dimensions and to allow an easy assembly and an easy disassembly of the CanSat.

2) Parachute

The Tortue Ninsat parachute is circular and easy to use. It has a 15 cm radius and is composed of spi canvas with 6 lines as the following figure shows.

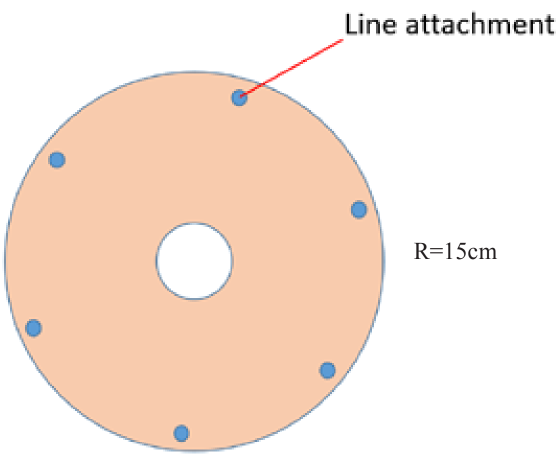

Figure 3 : Parachute design

C. Telemetry

The CanSat will use an XBEE module to send its measurements to the ground. The emission frequency will be 2.4GHz and the power will be between 10 and 60mW. Another XBEE will be used to receive data.

V. Conclusion

At this time, Tortue Ninsat is not completed yet. Almost all components has been bought.

During the two following months, the team will finish the remaining boards and test the whole CanSat in order to be ready for the D-day.

Acknowledgment

We thank Planète Sciences for their technical support and the CNES for their participation in the C'Space organization. We also thank the jury for the time they spend on reading our descriptive document.

References

[1] http://en.wikipedia.org/wiki/Altimeter

ToucanSat 1.0 : Atmosphere probing and opening of solar panels

Alicia Louis, Erwan Lecarpentier, Jordan Da Silva, Quentin Rohan, Médéric Roger, Maxime Efoui

[1]**Abstract - In this paper, the N6K'nSat O.C.T.[2] will present its ToucanSat 1.0 which is a continuation of the 2014 open class CaienSat project. The two main missions of the ToucanSat 1.0 will be atmospheric probing and the opening of solar panels: the latter will rely on data provided by the former (altitude and luminosity). We will run tests under the guidance of the Toulouse DGA[3] in order to validate the different scientific and technical subsystems of our CanSat, including data onboard analysis, opening and transmission.**

I. Introduction

This article focuses on the Cansat called ToucanSat 1.0 which will be released from a CNES[4] balloon during the C'Space 2015, a CanSat competition which will be held in Tarbes from July, 18th to July, 25th. Cansats are mini-satellite replicas released from a rocket or from a balloon which must fulfil some missions according to the rules of the competition.

The first mission required by the C'Space[5] organization this year concerns deployement. Our team chose to focus on the opening of solar panels to simulate a real satellite in space. The second mission we chose concerns atmospheric probing: altitude, luminosity, position sensors. Our Cansat which is called ToucanSat 1.0, will fulfil these missions during the C'Space Challenge, relying on tests run during this year.

Short story: we were inspired to choose this name since the toucan bird is the mascot of ENSICA which will be merging with Supaero on june 30.

II. Context of development

A. Association

The N6K'nSat is an association under the French law 1901. It was created to promote the study of and work on Cansat since over the last few years, more and more students from ISAE-ENSICA[6] have participated in the CanSat project. Indeed, ENSICA students have won prizes at the CanSat France Competition every year since 2009 and in one Spanish contest. In 2013, the two teams won first and third place in the technical category at the C'Space competition, in which the EnsiCansat team was participating for the first time. Last year, one team won the innovation prize and ranked second in the competition.

Fig 1: the N6Kn'Sat logo

Currently, the association is composed of 6 members who are all second year students from ISAE–ENSICA, an aeronautical engineering school located in Toulouse, France. The whole team has dedicated its 2nd year academic project to the development of three Cansats: the ToucanSat 1.0 and the Rox 1 and Rox 2. Rox 1 and Rox 2 will be launched from the 1/25 Soyuz replica built by SSAU[7] students from an altitude of 700 m as part of the Fusex Challenge during the C'Space Competition. The ToucanSat 1.0 is meant to participate in the Open Class Competition at the C'Space and is the topic of this article. The association is assisted by the ENSICA research laboratories and professors from all scientific and technical fields. It is financially supported by the school thanks to Initiative and Research Funds and by the ISAE-Supaero Foundation which truly appreciates the project for its importance and scientific interest.

1 The authors are with the club N6K'nSat, ISAE ENSICA, 159 rue Louis Plana 31500 Toulouse (Team Leader contacts : telephone: +33 6 79 73 17 02, e-mail: alicia.louis@isae.fr)

2 Open Class Team

3 Direction Générale de l'Armement http://www.defense.gouv.fr/dga

4 www.cnes.fr

5 www.cnes-cborg.fr/cspace/2015/fr/

6 Institut Supérieur de l'Aéronautique et de l'Espace formation Ecole Nationale Supérieure d'Ingénieurs en Construction Aéronautique.

7 Samara States Aerospace University http://www.ssau.ru/english/

Fig 2: The team

B. Work schedule

In the 6 member team, everyone works as part of a two person sub-team in their field of interest working on specific technical and engineering issues. Thus the team works as a whole and faces difficulties together thanks to a strong team spirit. We chose to work this way to ensure adequate communication and knowledge in the event of a problem. For example, last year, one member of the team specialised in coding could not participate in the launch as he was sick; because the other members did not understand the code he had written, the launch was aborted. Table 1 displays the different specialties of each team member.

name	main competance	secondary competance
Erwan Lecarpentier	team leader, communication	embedded systems
Alicia Louis	budget, communication	sail
Quentin Rohan	programming, electronics	embedded systems
Jordan Da Silva	structure , telemetry	mechanics
Maxime Efoui	electronics	programming
Médéric Roger	sail, structure	mechanics

TABLE 1: ASSIGNEMENT OF TASKS ON TOUCANSAT 1.0

First, we defined the deployment mission and the atmospheric probing mission during preliminary conception after having discovered the requirements of the CanSat project and assimilated the knowledge collected from the previous projects of Ensica teams. Then came the development phase – which enabled each twosome to design their technical parts – the conception phase and the tests phase. During this year, we have met regularly to check our progress and to define short terms objectives.

The estimated time we spent on each part and the previsions for the remaining work are detailed below:

- 100 hrs. selecting and defining missions
- 100 hrs. structure definition +50 hrs. printing
- 15 hrs. sail making + 5 hrs. deployment and flight tests simulation
- 10 hrs. antenna definition/validation + 5 hrs. tests
- 100 hrs. electronics, composed of: 35 hrs. electronic card design, 10 hrs. electronic integration + 5 hrs. electronic card and components tests, 50 hrs. programming
- 100 hrs. integration tests
- 10 hrs. flight tests operating Cansat
- 70 hrs. administration: fund raising, presentation of the project

We thus obtain a total of 570 hrs.

Concerning the budget, we managed to obtain the help of the DGA for the flight tests and the printing of antennas and some 3D printed structures from ISAE and IUT Toulouse. The remaining expenses went to the purchase of new components including redundancy, the printing of the remaining structure and registration for the C'Space competition for a total amount of about 1500€.

Expenses	Amount
Purchase (new material + components redondancy)	600€
Services (structure)	100€
Register to the C'Space competition	800€
TOTAL	1500€

TABLE 2: GLOBAL BUDGET

III. DEFINITION OF THE MISSIONS

A. Scientific mission: the deployment

The compulsory mission for the 2015 edition of the competiton consists in choosing a deployment system which has to be activated between the dropping and the landing of the satellite. This is why the team chose to implement two solar panels which deploy when light is sufficient. Moreover, in order to prevent problems, the group also integrated a back-up deployment system which initiates the deployment procedure under 300 feet in case the weather is not optimal (fail-safe system).

B. Free mission

The free mission can be split up in 3 parts that are the atmosphere probing, the GPS tracking and the transmission.

1) Atmosphere probing

We have two light measurements: the first one is provided by a classic light sensor and the second one by the analysis and processing of images taken by a camera. We compare these two measures to have reliable information for the opening of the solar panels.

2) GPS Tracking

In order to deal with the fact that there is no “come back system” this year, the team decided to integrate a GPS module able to communicate the position of the satellite on the ground so it can be located after landing. This system permits us to follow the satellite in real time and to anticipate possible drift due to wind.

3) Transmission

The objectives for this mission are atmospheric pressure probes, luminosity and onboard informations. All data measured by these sensors will be sent to the ground station in real-time and stored onboard on a micro SD Card. The purpose is also to supply the next team with tests which have been proved reliable, and to guarantee transmission system efficiency. It will also provide the association with information concerning the CanSat flight and could constitute a starting point for future missions.

IV. Cansat architecture

A. Electronic

The satellite is equipped with a luminosity sensor (Fig. 3) which collects data concerning light, a camera (Raspberry PI Camera board 3g – 5Mpx) which collects pictures and a pressure sensor which collect data concerning altitude. The camera is linked to a Raspberry PI card (model B+ 40 GPIO, 3.5W) – that you can see on the figure 4 – which makes an image processing. Thus we deduce a second luminosity data. In order to determine if there is sufficient luminosity to deply, a Arduino UNO card (Fig. 5) compares the two luminosity data and triggers the deployment if there is enough light. Thus the Arduino is linked to a servomotor (Fig 6) that enables it to free the panels as explained in the next part titled “Mechanical architecture”. If the luminosity data does not match the light required for the deployment, the Arduino triggers anyway the deployment since the altitude is under 300feet.

Indeed, the pressure sensor is linked to the card and gives the altitude data required for this fail-safe plan. The only need of this altimeter is to be calibrated the day of the launch in order to provide the altitude of the place to the satellite.

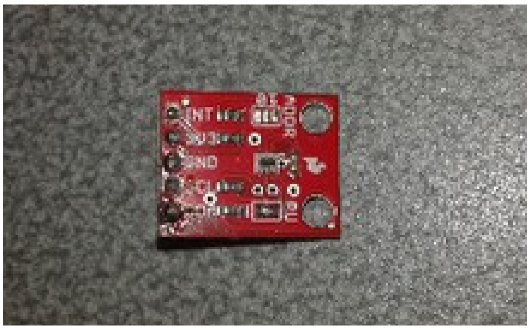

Fig 3: the luminosity sensor

Fig 4: The Raspberry PI

Fig 5: the Arduino UNO

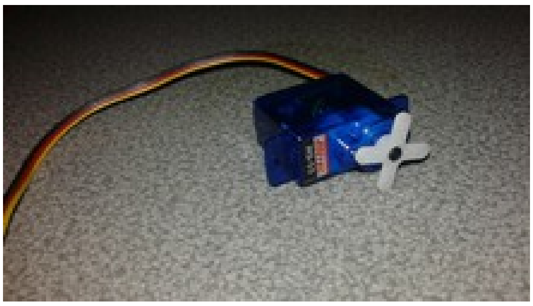

Fig 6: the servomotor

Concerning the GPS tracking, the GPS module (GPS module LS20030: accuracy 2.5m) contains an antenna that receives the coordinates and transmits them to the Arduino card, which centralizes the data and sends it via a square 2.45GHz patch antenna to the emitter system, which we receive on the ground. You can find a picture of the GPS module on the figure 7.

Fig 7: GPS module

B. Mechanical architecture

The main constraints for the design of the structure are the mechanical system of the two solar panels and the space taken up by the Raspberry which is much larger than the Arduino card. We agreed on a 2 stage CanSat as we can see on the figure 8: a first stage for the Raspberry and the servomotor with iron stem for the deployment, and the second stage for the sensors, the Xbee, the batteries, the antenna and the Arduino card. The solar panels are located on the side of the structure. The CanSat’s is 198 mm high and has a diameter of 78 mm.

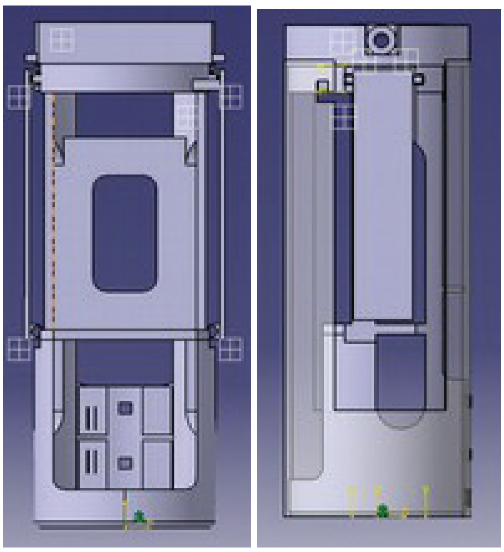

Fig 8: Front and lateral view of the structure

The solution we decided to use for the deployment is a combination of an angular spring and an iron stalk, controlled by a servomotor. Indeed, the aim of the angular spring is to apply a force on the panel to deploy it. However, there is a little hook located on the panel where there is the iron stalk. The aim of the stalk is to prevent the deployment of the panel since it has not been triggered by the Arduino card. Eventually, the servomotor applies a rotation of 8 degrees to the stalk, releasing the hook and allowing the deployment of the panels. On the figure 9 you can see the pivot, one panel on the figure 10 and the emplacement of the servomotor and the iron stem on the figure 11.

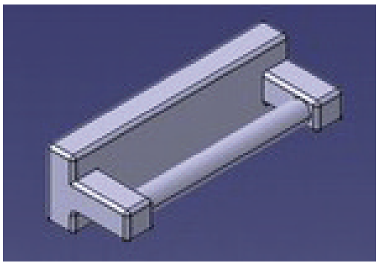

Fig 9: the pivot

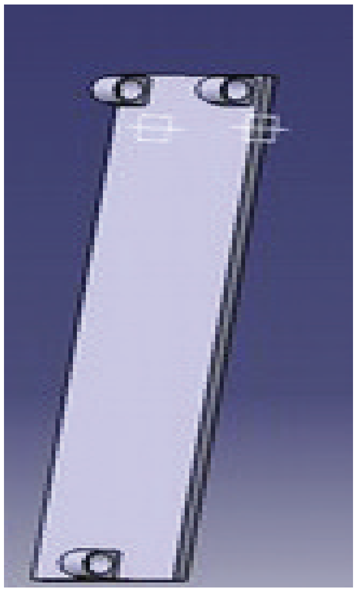

Fig 10: a panel

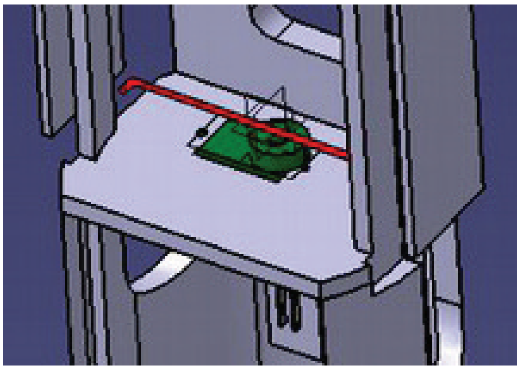

Fig 11: Location of the servomotor and the iron stem

We realized a stress analysis of the structure of the ToucanSat 1.0. The most critical phase of the flight is the sail deployment in terms of constraints. Thus we only studied this step of the fall. On figure 12 you can find the visualisation of the stress. We can see that the highest constraint is located on the lines' ties and reaches a value of 0,145MPa. Since the material's tensile strengh is 37 MPa it proves the resistance of our structure.

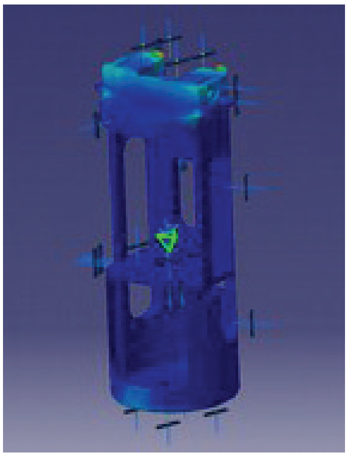

Fig 12: visualisation of the stress over the structure

C. Telemetry

To ensure the communication to the ground, we use an Xbee module emitting at 2.45GHz. A coaxial cable links the Xbee module to a patch antenna. This antenna is very thin. We have sized it to have a resonant frequency of 2.45 GHz. This way the reception power is maximized so we can receive the data more easily. This antenna has the shape of a square, but two angles are cut at 45 degrees. Thanks to this modification, the polarization is circular instead of linear, and the reception is improved in every direction, which is the optimal design for us considering that the CanSat is descending and at the mercy of the wind. On the figure 13 you can see the Xbee module linked to the patch antenna.

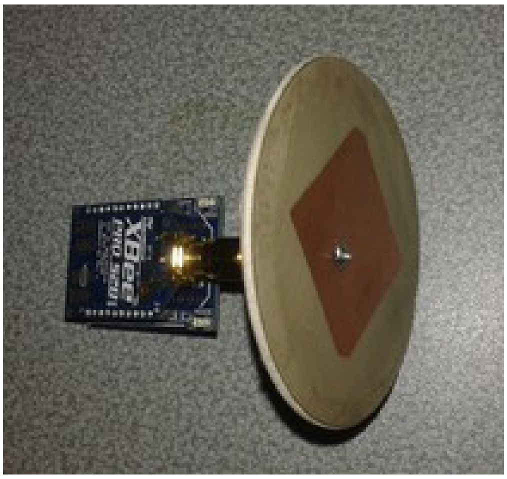

Fig 13: the Xbee module linked to the patch antenna

D. Sail

1) Sail

We chose to use the same sail design as last year's, the NASA Parawing 5. This design presents the advantage of being auto-stable: it opens quickly and effectively with a minimum risk of failure. We had to enlarge the sail because our CanSat is larger and heavier than last year. For the parachute material we are still using spi (spinnaker), which has the advantage of having strong longevity and high resistance [1].

2) Lines

We chose to use Dyneema lines. Our choice was based on comparisons between mechanical and aging properties and relied on the previous studies from ENSICA teams. Their work led to these conclusions:

- Oversizing the parachute suspension lines will prevent line breakage during tests and flights compared to cotton-Kevlar fishing lines.
- Dyneema ages better than Nylon with lower length variations: this will keep the profile of the wing unchanged longer.
- Low elasticity: The fiber's very high lubricity leads to poor knot-holding ability compared to nylon. This will help us to have the most successful deployment rate possible and reduce the risk of failure during parachute inflation.

3) *Flight tests*

The first flight tests of the wing were conducted with a mass of 1kg corresponding to the ToucanSat 1.0 (see Fig. 14). This allowed us to verify the speed of the fall (limited to 15m/s) and the correct length of the suspension lines. Moreover, we became familiar with the wing folding and the deployment procedure without risking breaking a printed structure if the parachute did not inflate properly, preventing us from a loss of time and money. Up to now we conducted 2 launches from each floor of a 5 story tall building, equal to approximately 30 m. We will eventually conduct tests of the finished wing with a prototype of our ToucanSat 1.0 in the DGA facilities of Toulouse. It will enable us to understand the deployment of the parachute and the main movements of the Cansat thanks to frame by frame studies of the flight.

Fig 14: the sail with the mass of 1kg

E. Algorithms

1) Sensors and servo-motor

Most of the sensors are provided with data sheets which makes it easier to connect them to the Arduino card. The algorithms are gathered in some API that Arduino provides to every user[2] and that everybody can obtain from their website. As noted, the code has to be modified between each use because the altitude reference varies from town to town, and the backup deployment system has to be calibrated. Concerning the servomotor, the difficulty has been to find the right PWM signal to control the rotation speed and duration of the bar.

2) Transmission

The first step is to configure the XBee so that each module can recognize the other one(s). Their configuration (done with an USB module and the freeware XCTU) also prevents interferences from another team on D-day. The serial API of Arduino card makes it easier to connect the module and to emit thanks to the function "write".

3) GPS tracking

As for the XBee Module, the GPS module has to be configured. The Arduino card serial API does not permit the direct use of the module with its default frequency. That is why the freeware Realterm was used to change the GPS frequency.

V. Conclusion

This new CanSat built by an ENSICA team is quite different from the previous ones in terms of structure, algorithms and data processing. Indeed the deployment of solar panels is a new accomplishment and the use of several data sources for the automatic opening is a new challenge in terms of coding. The other elements such as the sail, the transmission system, the energy supply are inspired from the previous models and validate their use?. Currently we are working on the integration of what? and have started a few tests, preparing/to prepare for the C'Space competition in July.

VI. Aknowledgments

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- The DGA who is willing to let us perform flight tests in Toulouse;
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VII. References

[1] La maison du cerf-volant, 7 Rue de Prague, 75012 Paris www.lamaisonducerfvolant.com

[2] http://www.arduino.cc/
http://www.sparkfun.com/
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NOTES

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Pour en savoir plus sur la compétition 2015

www.cnes.fr/jeunes

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