Phoutnik : To infinity and beyond

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Abstract - The CanSat project is part of the CanSat contest organized by the CNES (Centre National d'Études Spatiales). The goal of this contest is to realize a can with the basic censors for atmospheric surveying. In order to accomplish this project a team was formed : it counts among its members five first year students and four second year students.

A team last year already took part in the contest, this year team are therefore working on their results. But two special features were added this year. The first one is a micro-camera to allow the can to take shots of the ground beneath it. The other one is the "come-back" option, featuring a compass and a micro-controller to be able to choose the landing spot.

I. Introduction

A CanSat (for CAN SATellite) is an autonomous device in the shape of a soda can designed to act like a basic satellite. This concept was created in 1998 during students projects in Japanese and American universities. Since, it moved into contests and traveled through the Atlantic Ocean to become a competition in Europe.

In fact, since 2009 the CanSat competition is organized by the CNES and Planète-Sciences. This Competition is each year hold in Biscarosse (near Bordeaux in the South-West of France) in a military base during the C'Space, a national event bringing together space clubs, engineering schools and professionals of the CNES and the DGA (Direction Générale de l'Armement). It also brings together students from whole France, and foreign teams from Australia, Austria, Turkey and Russia.

During the French competition, the CanSat will be released from a balloon at 150m and will accomplish 2 or 3 scientific or technological missions chosen from different missions proposed by the Organization. The team chosen missions this year are the following : atmospheric survey as the mandatory feature, Shots taking by the camera as the additional feature , and finally the "come-back" mode as the optional one.

II. Context of development :

A) The team :

The CanSat project is one of the projects that phelma's students have to choose from in order to accomplish an important part of their training during the second semester. And this year two teams decided to be part of this adventure and are therefore financed by the school.

The Phelma's team Phoutnik (the acronym of Phelma and the Russian satellite Sputnik) is composed of two teams from first and second year. In accordance with the chosen missions the sharing of the tasks between team members was made as follows : first year team will be working on the material part of the realization (building the sail and the frame) and on providing the needed power supply, while second year team will take care of the censors and the programming of the micro-controllers.

B) Work plan :

The two teams work in parallel on the parts described earlier.

For first year students three main tasks were shared between the five students :

- The building of a sail.
- The modelling of a robust frame.
- The conception of the power supply structure.

As for second year students the realization of their part was also divided into three part :

- Sensors and actuators functioning.
- Micro-controllers programming.
- The management of the camera.

Once these parts are functional, the can can be assembled and many tests will be performed outdoor to check the reliability of the probe and its good functioning. The team is planning on checking these elements:

- The transmission, by doing transmission trials at 200m between the probe and the ground station (the maximum on the day of the competition)
- Photographs taking and saving: we run the CanSat and check if the memory card has the pictures taken.

- Atmospheric probing: the CanSat is moved to several places and the values it provides for the pressure and the temperature are compared with external measures done with a thermometer and a barometer.
- Robustness of the probe: fall without and with components to see if the Can and the components are damaged.
- Flying tests with the paraglider wing, to check if the probe can fly and be directed with servomotor. In order to follow the progression of the realization of the CanSat, each team proposed a GANTT Diagram in which the estimates of time of each part are specified. The two diagrams are given in appendixes n° 1 and 2.

The budget assigned to the project is :

COMPONENTS	PRICE	QUANTITE ORDERED	QUANTITE first expected
Thread for the sail	15,50 euros	x N	x N
Servomotor : S3114M Futaba	15 euros	x 1	x 2
Batteries Hyperion G3-CX-1S http://www.hyperion-eu.com/products/product/HP-LG325-0130-1S-UM	6,70 euros	x 0	x 2
Power supply system	About 11 euros	X 0	X 2
3 button batteries and supports	23,7	X1	X0
Micro-controllers PIC	5 euros	X2	X2
Temperature and Pressure sensors VTI Technologies, SCP-1000	45,50 euros	X1	X1
SD Card kit	25 euros	X1	X1
Total	129,7 euros		

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III. Definition of the missions :

A) Scientific mission :

For this mission, a sensor to measure the pressure and another one to measure the air temperature were needed. These sensors have to be ranged for atmospheric measures (1015hPa, 20°C) and must be accurate because of the small variations of these values.

A sensor which was able to measure both pressure and temperature was chosen because it permitted to minimize the size: VTI Technologies, SCP-1000.

This sensor communicates with a micro-controller using the I2C protocol, a digital communication standard based on the master-slave principle: the master (micro-controller) sends orders (a request for a temperature value for example) to the slave (sensor), which answers the corresponding value trough the same bus. This functionality is often included in common micro-controllers, which makes it easy to implement.

Measured values are then sent to the ground station in order to be processed. To do so, communications frames are created by the micro-controller: they contain the data, and bits permitting to make the frame unscrambled. Once they are created, frames are provided to a radio-frequency transmitter which modulate the signal and send it through an amplitude modulation made at 868MHz, in accordance with the rules imposed by the Organization.
A common 868MHz transmitter/receiver kit is used: the transmitter for the probe and the receiver for the ground station.

B) Free mission :

The photographs are taken by a mini-camera: *4D Systems, µCam Serial JPEG Camera Module.* This camera is directly connected to the micro-controller which controls it to take pictures when needed.

The photographs are then transferred to a Read/Write SD Card module, which save automatically the pictures on a memory card. This solution allows picking up the photos easily after the landing of the probe. This module is the *4D System uDrive-USD-G1*.

C) Optional mission :

To make the CanSat able to find its way to the target, a sail was made according to the Nasa Parawing 5 plans . In addiction to this, an algorithm was created to act as an autopilot. The aim is to know the position of the CanSat as often as possible, to determine where it has to go to reach the target. The orientation of the CanSat is also useful to make the CanSat following the right direction. Thanks to a digital compass, a vector “orientation” compared with the North and the East is provided and a second vector “direction to follow” is calculated.

The used GPS is the *GlobalSat EM406-.* It communicates through a serial communication and provides NMEA frames, an international specification for GPS coordinates. Thanks to this specification, one ASCII word is enough to send the position to the micro-controller.

For magnetic data, a common 2-axis compass is employed. It uses the I2C protocol too. This specification allows to easily collect the useful data which are the angle compared to the magnetic North and the angle compared to the East.

Finally, the micro-controller controls one servo-motor. The servo is controlled by an electric impulsion which length corresponds to the angle it has to move to. Then the servo acts on a paraglider sail which makes the CanSat go left or right.

IV. CanSat Architecture :

All the components were chosen according the missions and specifications imposed by the Organization. However, the architecture of the system was studied first in order to make a reliable and efficient device, and then to make the conception easier.

The following architecture was adopted :

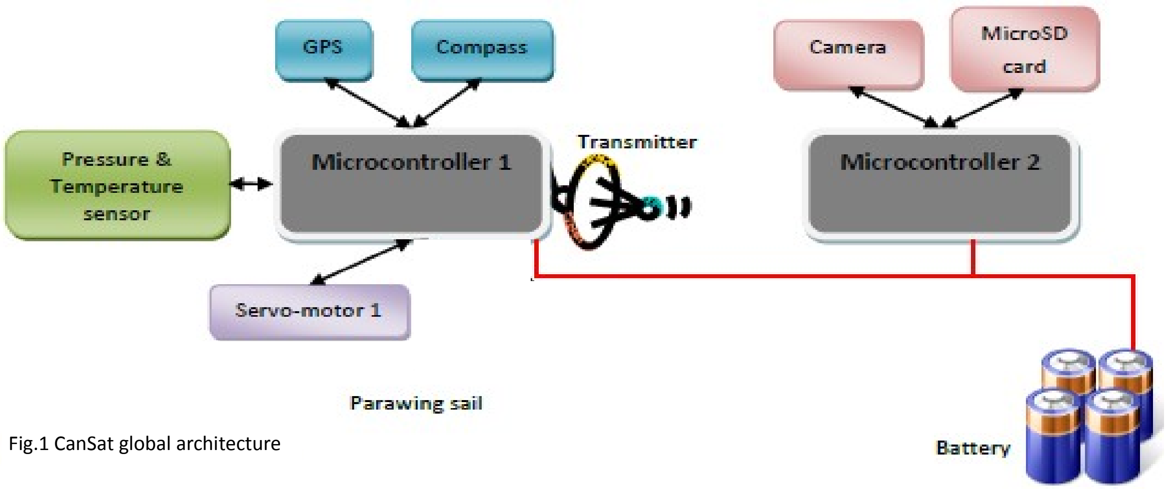
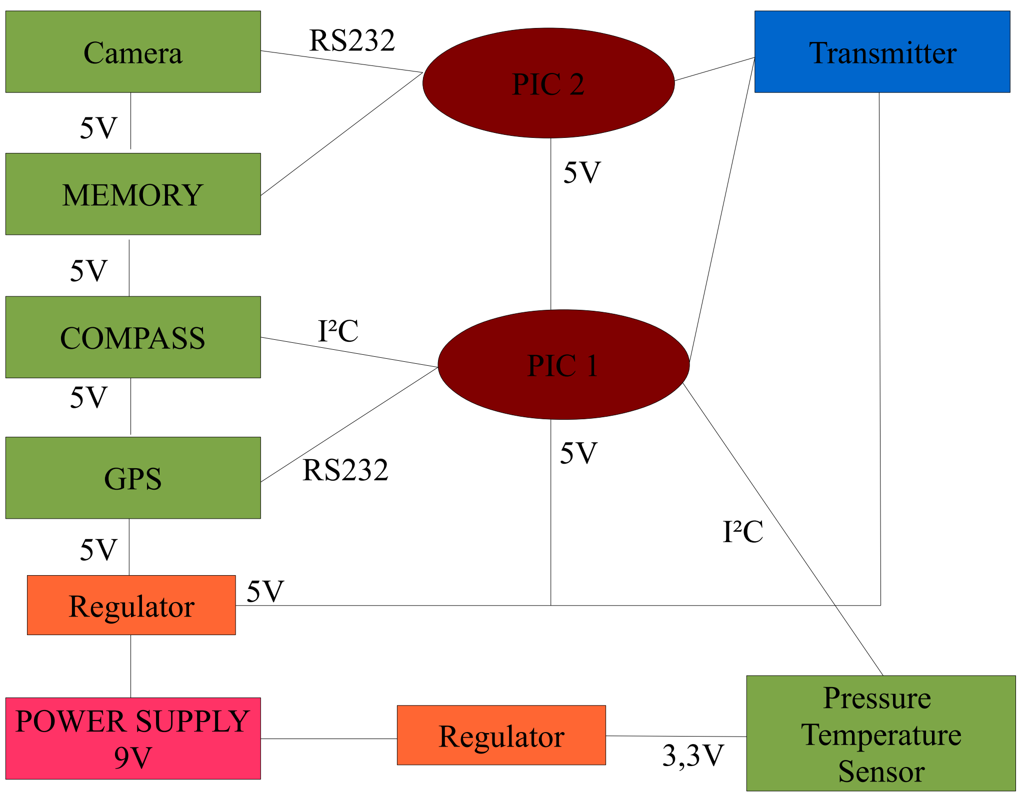


Fig.1 CanSat global architecture

A) Electrical architecture :



B) Mechanical parts :

The body of the CanSat is similar to a soda Can. It is made of ABS plastic, which is strong enough without being too heavy. Besides, it must not interfere with the radio-frequency emission or with any component which have to send or receive data inside the CanSat.

Because it is made of different parts, less than 1mm thick, the can will be realized on a machining platform GI-NOVA in the school Génie Indutriel.

A prototype was made in the platform in order to test the organization of the various patches and the components. (see fig.2)

FIG.2 CanSat prototype in plaster

V. Conclusion :

At this stage, the project is not entirely finalized. Only two missions were implemented. The figure bellow shows the fully implemented parts and the ones that still need to be finalized :

Scientific mission		
	Pressure and temperature measures	✓
	Data transmission	✓
Free mission		
	Photographs taking	✓
	On memory card writing	✓
Come-back mission		
	GPS	✓
	Compass	✗
	Servo-motor	✓
	Paraglider wing	✓

Fig.3 Status of the project

To get ready for the D-day, the team has to find a way to minimize the electromagnetic perturbations which make the data provided by the compass hardly workable. This way the team could run more tests in conditions similar to the ones of the competition.

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