Phoutnik : a CanSat to gather information about the atmosphere

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With the growing risks of global warming and environmental pollution, it becomes more and more important to monitor the evolution of the atmosphere's properties in order to identify risk areas. That's why the Phoutnik team decided to develop a CanSat designed to accomplish these tasks.

I. INTRODUCTION

At the outset, our CanSat project should have been a continuation of the project undertaken previously. However, too many components were since lost or no longer worked. Therefore we can say that our project is a new one.
We've chosen to accomplish various objectives during the can's fall:

- Altitude, pressure and temperature measurements (obligatory)
- Video recording during the fall (additional)
- Bearing measurements (additional)

II. CONTEXT OF DEVELOPMENT

A. Club

This is not the first time that the engineering school Phelma has taken part in the CanSat competition. This year's team, Phoutnik, is representing Phelma alone, although originally the team was composed of students from both Phelma and ENSE3.
We are a team of 5 students in the 1st year of engineering school (see Fig. 1) overseen by our tutor Mr Petitclair. We all study PET (Physics Electronics and Telecommunications) so we don't have as much background knowledge in materials and mechanics as those from the aviation schools but we have tried to transform this into an advantage.
We are participating in the competition as part of our group projects (a compulsory course) but also to represent our school at this event. Thus, our project is totally financed by the school and therefore has a limited budget.

Fig. 1 Picture of the Phoutnik team (lr: Sebastien, Nicolas, Jean-Baptiste, Christophe, Dorian, Mr Petitclair)

B. Work plan

To get organized, we started with a list of rules to follow at all times. Then, according to our desires and our expertise, we appointed various officials as follows:

- Dorian: Project Manager & Hardware Manager
- Nicolas & Sebastien: responsible for the sail
- Christophe: Hardware Manager & responsible for the can's design
- Jean-Baptiste: Software Manager

In order to respect the deadlines, a Gantt diagram was created, each session corresponding to 4h (see Fig. 2)

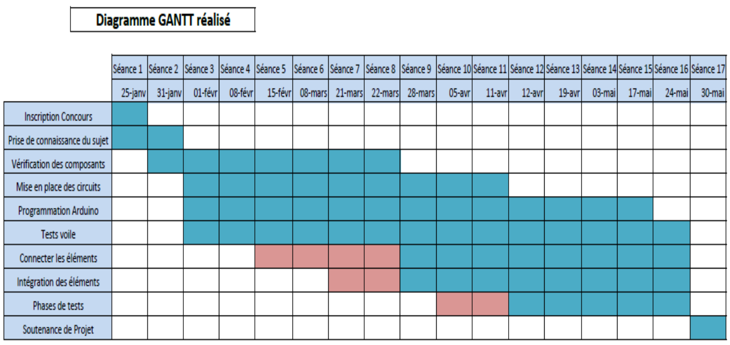

Fig. 2 Gantt diagram (blue: real | red: predictions)

Our initial budget was 0€ but in fact during the course of the project we had to replace some components which came to a total of 90€, all financed by the school. We found this to be a reasonable budget.

III. DEFINITION OF THE OBJECTIVES

A. Scientific Objective

The scientific objective of this project consists of measuring various values during the fall. This year, we've decided to follow the evolution of the pressure, the temperature and the altitude (measurement of humidity wasn't very relevant according to the previous groups).
To carry this out we decided to use a small sensor (see Fig. 3) able to take all of the measurements.

Fig. 3 Picture of the sensor (MPL3115A2)

The sensor is connected to an Arduino module using the I2C protocol which allows us to gather the data stored in different registers. The data is then stored in an external microSD card and is also transmitted to the ground station every second.
Here is an example of an altitude measurement taken in a lift in the school building. (see Fig. 4)

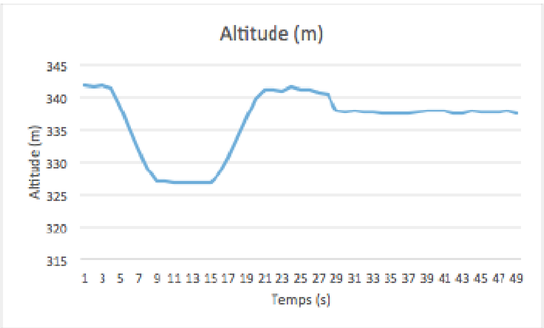

Fig. 4 Altitude measurement using the MPL3115A2

B. Additional Objectives

We have decided to add two additional objectives to the project to deepen its primary goals projects.
The first one consists of recording a video of the ground during the can's decent. That's why we decided to implement a small model aircraft camera "FlyCamOne ECOV2" (see Fig. 5). The video is directly recorded on a 2GB microSD card included in the camera module. So when the can lands, we only have to retrieve the card to watch the video.

Fig. 5 Picture of the FlyCamOne ECOV2

The second objective is to take measurements of the bearings. This is performed with the tilt compensated compass CMPS10 (see Fig. 6) which will be also used for the Comeback mission. We decided for the Comeback mission to maintain a single direction during the fall. To test this, we decided to measure the bearing with the compass and to send all the data to the ground station so that we can verify that the trajectory is almost constant.
Like the sensor, the compass is linked to the Arduino thanks to the I2C protocol which allows us to have access to various other data like acceleration, pitch… which can be useful to counter the influence of the wind for example.
We did not use a GPS because of the price.

Fig. 6 Picture of the CMPS10

IV. CANSAT DESIGN

In this section we are going to explain you how our CanSat has been conceived in terms of electronics and mechanics.

A. Electrical design

All of the electronics involved are organized around the Arduino nano module (as you can see on Fig. 7), a small microcontroller which generates commands for the components, acquires data…
This therefore is the main part of our project.
The Arduino module is powered with a 7V battery and all the other components are powered by the Arduino itself at 0-5V (or 0-3.3V).
We're using different communication ports of the Arduino. For example the sensor and the compass are linked with an I2C protocol, for the microSD

module we use a SPI communication while the Xbee is linked to the serial port.

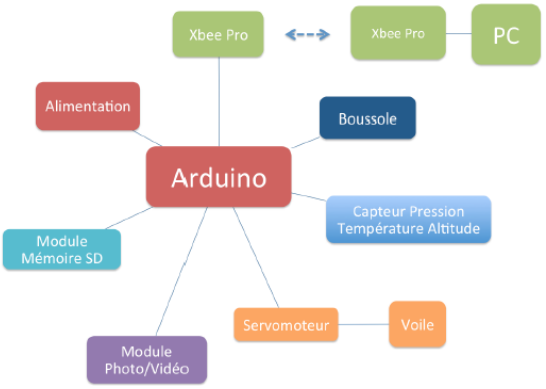

Fig. 7 Interactions diagram

Once all the connections had been chosen, we created a new PCB card with Altium software (see Fig. 8)

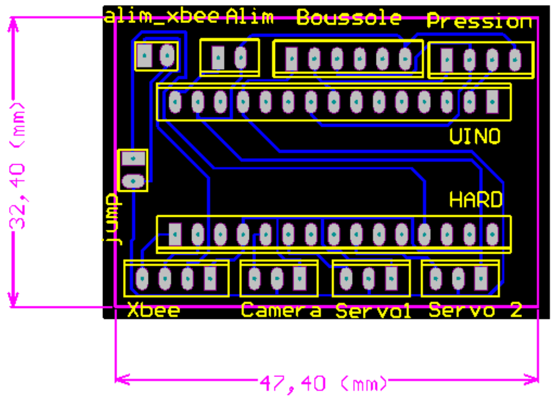

Fig. 8 Picture of the PCB designed in Altium

"Jump" corresponds to a jumper used to detect the start of the fall and which will initiate the Arduino program.
"Alim_Xbee" is the switch used to shutdown the transmission if necessary.
We tried to make the circuit as small as possible in order to optimize the space inside of the can.

B. *Mechanical parts*

There are two main components to the mechanics of our system:

- ➢ The can
- ➢ The sail

As for the first component, at the outset we used the can used by the previous group to work on this project but unfortunately we broke it during a test. During our design process however we decided to implement not one but two servomotors in the can, so in the end designing a new one was necessary anyway.

To do this, we used the software SolidWorks, while to create the can we used a 3D printer built by Mr N Ruty of Phelma.
Figure 9 shows how the new can design is composed of 3 parts, all made from PLA (Polylactic acid). The first one acts as the container for all the electronic components, the second one hosts the two servomotors in the small holes and the last one is just a top to close the can. You can see on Fig. 10 the result when everything is closed.

Fig. 9 The 3 parts of the can realised using 3D printing process

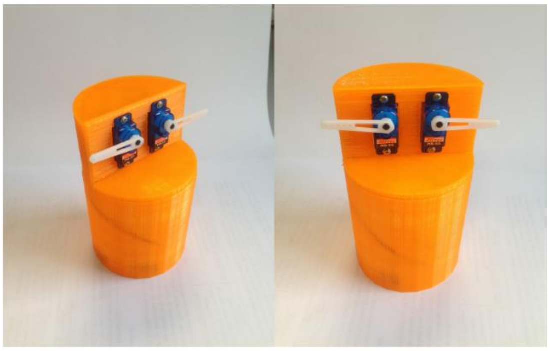

Fig. 10 The assembled can with the two servomotors

The sail is based on the parawing model, built with a power gliding tissue. For the strings we use a special fish line which is very tough and light. We began the flight tests to set the sail by dropping the can from a window on the 3rd floor of our school. However, the aerodynamics near the building are very bad. Before the competition, we will try to drop the can instead from a quadcopter (drone) in order to better simulate the conditions of the competition.

C. *Telemetry*

All the data gathered needs to be sent to a ground station, that's why we've decided to use an Xbee Pro (see Fig. 11).

Fig. 11 Picture of the Xbee Pro transmitter

This is a commercial module which emits at a frequency of 2.4GHz and at a power of 10mW, in order to respect the rules imposed by the French army (DGA).
We receive all the data as a string which has this format:
Altitude (m) , temperature (°C) , pressure (Pa) , bearing (°)   (see Fig. 12).

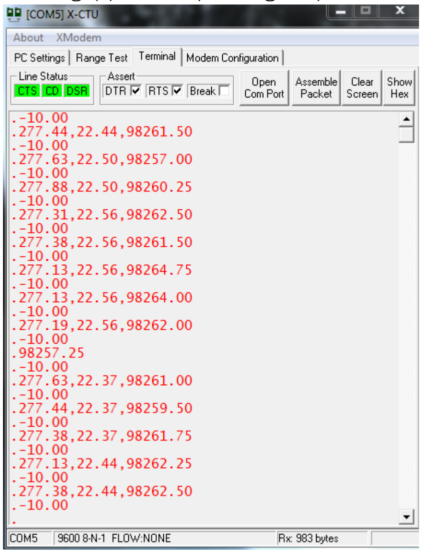

Fig. 12 Example of reception

Then, each variable is extracted thanks to a Labview graphic program, developed by our team, which permits us to follow the evolution instantly like a real ground station.

V. CONCLUSION

For the moment, our CanSat seems in theory to be able to achieve all the objectives (except the Comeback mission). However, we haven't yet tested the autonomy of our CanSat when everything is running. That's why, to be ready for D-Day, we're going to try to carry out some tests in more realistic conditions to see if our CanSat functions well, while also allowing us to perfect the settings to maximise our chances.
We are looking forward to the competition and would like to say good luck to the other participants.

ACKNOWLEDGMENTS

We would like to thank our tutor Mr Petitclair who oversaw our project and registered our school for the CanSat competition. A big thank you also goes to Mr Ruty who printed our can for free.

We also want to thank our school for the financial help.
And finally we want to thank the organizers of the competition without whom nothing would have been possible.