Tau'ri-2: Air-ESIEA second CanSat

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Tau'ri-2 is Air-ESIEA second CanSat, the skeleton is made with homemade circular electronic boards to save space and number of parts. Sensors for atmospheric sounding as pressure, hygrometry and temperature are embedded. Our CanSat is also able to land to take pictures of the land which it flies over. Air-ESIEA is proud to participate to the CanSat competition for the first time.

I. INTRODUCTION

We spent a certain amount of time studying the contest rules and the missions. Then we studied the work accomplished by the previous team, which required a significant time. We have chosen the "atmospheric sounding" proposed mission, and the "image capture". Due to some problems we could meet during the contest, we choose to make the camera completely isolated from the over electronic components.

II. CONTEXT OF DEVELOPMENT

a) A club

The project is part of Air-ESIEA, the aerospace association, of the French engineering school : ESIEA Paris. The association was created in 1986 to make experimental rockets to be launched in the annual CNES/*Planète Sciences* meeting. Recently we choose to focus on the development of a new vehicle: the CanSat. This year we are going to participate to the CanSat Competition France for the second time. We are also developing a low cost and pedagogical UAV: the *Aile Delta* and a versatile platform for rockets. We used to have few sponsors, but the association is mainly financed by the school. Our team is composed of 4 students of 3rd year :

- Maillard Antoine : 3rd, computer programming
- Patrzek Kévin : 3rd, computer programming
- Prévot Christophe : 3rd, embedded programming, electronic, mechanical
- Técher Thomas : 3rd, embedded programming, electronic, mechanical

Fig 1 CanSat building is on progress

b) Work plan

We began to work on the project in February 2013. It consisted in our 3rd year's technical project, named *Projet des Sciences de l'Ingénieur*. Our team was composed of people coming from various other schools, where they learned different fields of engineering sciences. However, none of us came from a computer sciences school, so we had some difficulties for the programming. But we received help from a 4rd year student of our school, and this allows us to well begin the code. Concerning the mechanical parts we had enough knowledge to conceive them without help, the only problem concerned the wing. For this part we had to do some research.

III. DEFINITION OF THE MISSION

a) Scientific mission

The proposed mission we choose is the "atmospheric sounding" mission. During the descent phase, the CanSat shall:

- Acquire hygrometry at least every 5 seconds,
- Acquire altitude at least every 5 seconds,
- Send these data by telemetry to the ground station.

To perform this mission, the CanSat relies on two sensors, a digital pressure and temperature sensor with absolute accuracy of down to 0.01 hPa which allows to calculate altitude with good accuracy, and an analogical humidity sensor with an accuracy of 2,5 %RH. The telemetry is realized with Xbee 2.4 GHz modules.
These components will be detailed later in this article.

b) Free mission

The free mission on Tau'ri 2 is the "Image capture" mission. The objective is to take pictures of the land which is overflies by the CanSat. The module may fly at more than 100 meters. Due to this, we had to take a camera with a pretty good resolution, indeed our goal is to be able to do a map with the picture taken by the CanSat. Another important aspect was the quality of the pictures. Because of the CanSat's moves the pictures could be completely fuzzy. So we had had to take a camera with a FPS[1] enough high.

Fig 2 CanSat's camera: the Smallest Voice Recorder

c) Additional abilities

Due to safety reasons, we chose to have the ability to find the CanSat wherever it is, during and after its fall. For this we had a GPS placed in the top of the module. This component could be combine with the camera, and thanks to this we know where is the place we are watching, and where we have to put it in our map.

To complete the data acquired by the CanSat, we decided to keep the attitude control system, which was present in the previous CanSat, Tau'ri 1. Those components made us able to accomplish another mission if we wanted, the "come back". If so, we have to use this formula to get the distance between the CanSat and our target:

$$d = 2 * \text{asin}\left(sqrt\left(\left(\sin\left(\frac{lat1 - lat2}{2} \right) \right)^2 + \cos(lat1) * \cos(lat2) * \left(\sin\left(\frac{lon1 - lon2}{2} \right) \right)^2 \right) \right)$$

[1]

The course to follow is calculated with this code:

```
if sin(lon2)<0 {
      course=acos((sin(lat2)-sin(lat1)*cos(d))/(sin(d)*cos(lat1)))
} else {
         course=2*Pi*-acos((sin(lat2)-sin(lat1)*cos(d))/(sin(d)*cos(lat1)))
}}
```

[2]

IV. CANSAT ARCHITECTURE

a) Electrical architecture

We decided to make our own PCA, so we can have the functionalities wanted and use also these as the skeleton. This one is more compact than the previous one, so it takes less space and we are also, able to access to the components more quickly and more easily. Indeed this one will be placed vertically, so each side of the PCA

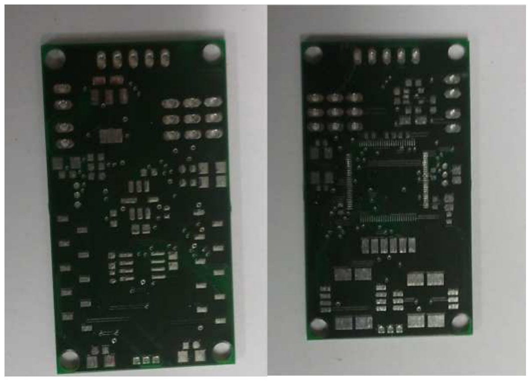

Fig 3 the PCB of the CanSat Tau'ri 2

The main board components:

- A microcontroller, the 40 Mips dsPic33FJ256GP710 from Microchip, this 16 bit chip is used in many projects in our school so we know it well and can perform all the calculations and communications needed.

Fig 4 Microcontroller of the CanSat

- A digital pressure and temperature sensor, the popular BMP085 from Bosch. The resolution of output data are 0.01 hPa and 0.1 °C. It is connected to the microcontroller via the I²C bus.

Then to calculate the altitude, the datasheet gives us these formula and chart:

$$altitude = 44330 * \left(1 - \left(\frac{p}{p0} \right)^{\frac{1}{5.255}} \right)$$

[1] FPS : Frame Per Second (refresh rate)

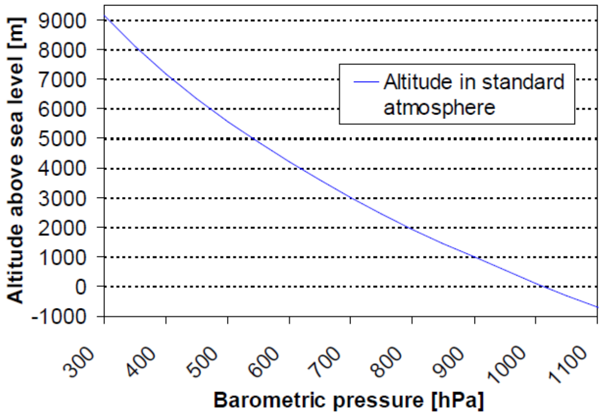

Fig 5 Altitude based on pressure

Fig 6 The Pressure/Temperature sensor

- An analog humidity sensor, the HIH 4000 from Honeywell, with an accuracy of 2.5 %RH. It is connected to a 12 bits ADC input of the microcontroller, which allows a final resolution of 0.02 %RH.

Fig 7 The humidity sensor

Outside the main board, the CanSat carries two more modules for the navigation:

- An AHRS IMU, the Razor from Sparkfun. It gives access to Euler angles, but for the time being we only use the yaw (mag course); and the vertical accelerometer to detect the drop. In the future we may do 3D reconstruction. The Razor is connected to the microcontroller via a serial UART bus.

Fig 8 The attitude control system

- A GPS module, the EM-406A from USGlobalSat. The GPS is connected to the microcontroller via a serial UART bus, and its refresh rate is 1 Hz.

Fig 9 The GPS module

- At last, the CanSat needs of course power. The main board has few voltage regulators; 3V3 and 5V are then available for all the modules. The source is a 2 cells 7.4V 300mah LiPo battery from Losi.

Fig 10 The Battery

b) Mechanical parts

We decided to design our own electronic and non-electronic boards; this allows us to give them the shape we want.

Here obviously the boards are circular, except the GPS support board which is smaller. The diameter is about 60mm, so we have 6mm of margin regarding the maximum diameter allowed.

Two RC servos are installed under the GPS; the paraglide is attached to them, allowing to control it.

Regarding the paraglide, we choose a simple oval shape. The rules say that the descent speed should be between 2m/s and 15m/s, we choose 8m/s. So we need a wing of

We didn't find any formula to dimension a paraglide, however we had one for parachutes:

$$Sp = \frac{2 * m * g}{R * Cx * V^2}$$

It gave us a result of $0.60\ m^2$

Fig 11 The paragliding wing

c) Data transmission

Data collected by the CanSat should be transmitted to ground during flight. We choose to transmit data in real time with the help of two Xbee-Pro Int'l, 2.4Ghz ISM, 10 mW p.i.r.e from Digi. The output power complies with the European and French regulations. These modules allow a range up to 750m in outdoor conditions without obstacles. A Sleep mode is available to save power when the CanSat is waiting the mission.

One is plugged on the main board; the other on ground is connected via USB to a PC. The PC is our ground station and executes our homemade software programed in Java. It has a GUI (Graphic User Interface) showing in real time the data from the CanSat in raw values or/and in curves.

Orders can be sent to the CanSat. In the event of a transmission problem, all the data is saved in an EEPROM located on the main board.

Fig 12 One of the two XBee module

V. CONCLUSION

Actually, the structure, the wing and the electronic are completed. The next step consists in the final program for the module and the human interface. For the tests, we can use the last version of the code if necessary. In June and August, we will focus on the last details for the contest. We will focus first on the code for the computer, to purpose an attractive and easy to use interface.

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REFERENCES

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[2] http://williams.best.vwh.net/avform.htm#Crs