

Altair III: a ComeBack CanSat to make atmospheric measurements

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Abstract—Altair III is the third generation of the long-term CanSat project of the CLES-FACIL, and fifth CanSat generation of the club. Its missions are atmospheric measurements and comeback. Thanks to a parafoil specifically developed for this project by Aerazur, it glides till its target, orientating itself with a GPS and the strings of the parafoil. During the whole descent, it sends location and atmospheric data to the ground station with the onboard radio.

I. INTRODUCTION

SINCE the very beginnings of CanSat programs in France, the CLES-FACIL has always been at the frontline for the development of comeback CanSats. Starting from a first embarked experiment in 2006, the Pole Technique of the association started a long term project in September 2009: Altair. Since then, it has been presented to the Spanish, American, Japanese and French experimental campaigns thanks to its sponsors. Altair won the 2nd prize of the Spanish competition and the CNES prize at the C'Space 2010.



Fig. 1. Picture of Altair II

II. CONTEXT OF DEVELOPMENT

A. Club

The CLES-FACIL is the Space Experiments Association of INSA Lyon, a French engineering university located in Lyon.

Founded in 1967 by Alain Juge, a student passionate by space technology and rockets, it stands now on a worldwide reputation and a large network of old members. Every year since 2007, the team participates to the C'Space campaign with its rocket and CanSat.

The CLES-FACIL also develops stratospheric balloons, water rockets and mini rockets, and holds animations for the younger generations.

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Thanks to the help of our university, INSA Lyon, and our precious sponsors such as Arianespace, Thalès, Aerazur – Zodiac Aerospace and CPE Lyon, the project could finance its development as well as its presentation worldwide.

The team counts four members:

- Rafik Meziani, technician in processes at CPE Lyon: in charge of the mechanical design and communication
- Damien Lieber, student in Mechanical Engineering and Development at INSA Lyon, 3rd year.
- Sebastien Bonnart, student in Telecommunications at INSA Lyon, 5th year.
- Jérémy Carnus, student in Computer Sciences at INSA Lyon, 3rd year.



Fig. 2. Picture of the Altair team.

B. Work plan

Altair 3 only began during March because we had to do some knowledge transfer to the new team members on this project. Starting from this point, we went through the previous flight data of Altair and identified the main points to be improved. We then planned our work in order to achieve these objectives. Next step was prioritizing those tasks relying on interdependency and urgency. This process was done during team brainstorming. Each member works on the current tasks which corresponds to its abilities, thus parallelizing the progresses.

Concretely, we are divided in two teams : mechanical and electrical but in a very tight collaboration as a CanSat needs a very high level of integration. This is why we are having weekly meetings with the full team. On the development level, design of the solutions for Altair 3 is going to take 10 days/men, fabrication/coding will take around 10 other days and testing and adjustments around 25 days/men.

However his fractioned vision is not realistic because the development process is not that much linear. We are using "Extreme programming" methods for the electronic part and mechanical solutions usually begins by some tests.

III. DEFINITION OF THE MISSIONS

A. Scientific Mission

Atmospheric measurements thanks to a pressure and temperature sensor. The measurements are coupled with the altitude's data from the GPS, using a Kalman filter to improve the precision.

B. Free Mission

As it always was, Altair is a comeback CanSat. Therefore the free mission is to land as close as possible from a target which GPS coordinates are known before the launch. This mission has been selected because it is the most challenging and fun one. Moreover we can make the most of Altair's flight heritage in order to be among the bests in this mission. In addition to that, we intend to place a video camera on the CanSat that will record the flight for both imagery purpose and knowledge gathering for future mission debriefing. This camera is not an official imaging mission because we will not transmit any picture during the flight.

IV. CANSAT ARCHITECTURE

A. Electrical architecture

Like the previous versions, Altair 3 is build around an atxmega microcontroller. This microchip provides the processing power needed and has the interfaces required for the sensors during the missions.

The sensors are:

- GPS providing position altitude and direction
- Magnetometer measuring the orientation of the CanSat
- Sensor measuring an external atmospheric property (such as hygrometry, CO₂ concentration, ...)

A video camera is also embedded. It will be self powered and isolated from the rest of the material so that we can decide at the last moment where we will place it for more suitable result.

B. Mechanical parts

Mechanics for the structure will be the same as for Altair II: a robust structure machined in polycarbonate, holding the two servomotors, the GPS, radio and electronics chips as well as the battery.



Fig. 3. Mechanical Structure of Altair.

Following the extraction problem of the main parafoil observed in ARLISS, we developed a new stabilization system based on an induced momentum on the CanSat's nacelle.

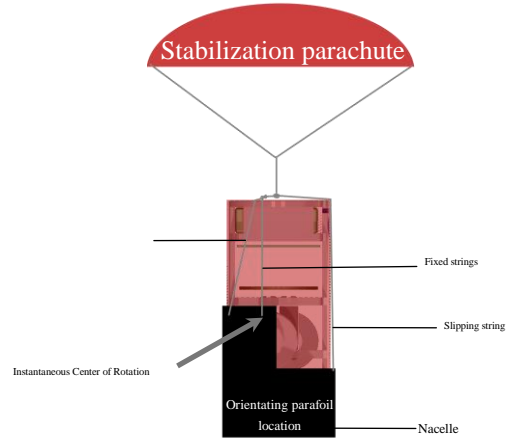


Fig. 4. New system of extraction

The slipping string is held by a hook inside the CanSat, and is released ten seconds after the extraction from the rocket. The string slips through the nodes and makes the nacelle rotate, releasing the main parafoil.

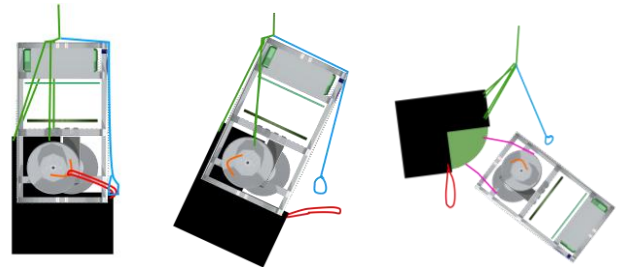


Fig. 5. Steps of the extraction after stabilization

The main development axis in mechanics will be now the parafoil, with more tests conducted and a development in collaboration with Aerazur for better control and performances.

C. Telemetry

The CanSat is embedding a bi-directional commercial radio transmitting 300mW centered on the 869.4 MHz frequency. Even though the module is already using channel coding techniques, we decided to improve its reliability by adding another layer of checksum.

We are currently analyzing the feasibility of using a cell-phone antenna because cell-phones do work at similar frequencies and have unidirectional antennas of very small dimensions.

On the ground, the reception is done using the same radio module, interfaced with a laptop via a USB/RS-232 cable. On the laptop, we run telemetry software providing real time display of data, possibility to command the CanSat (only used for testing situations) and recording of the mission.

D. Flight algorithm

One of the main developments of Altaïr 3 is the flight algorithm. The idea was to start it back from the beginning, using the experience of past CanSats to design the new flight algorithm.

The first step was to build a simulator in C (language used to program the atxmega) that allows to debug and run tests without having to throw the CanSat from a bridge. The simulator allows to easily test the robustness of the flight algorithm in many different configurations even modeling wind from statistical parameters.

The flight algorithm is divided in two functionalities:

- Trajectory planning which decides of an ideal trajectory to land on the target. This is the strategy followed to perform the come-back mission.
- Servitude which makes sure that the CanSat follows the planned trajectory as closely as possible. This is the way the CanSat uses the servo motors to direct itself.

Those are complementary and independent which makes it possible to change the strategy without losing the progresses made on servitude.

Trajectory planning is build from the main observation having been made after the previous flights: « the main vector of trajectory changes is the wind ». Therefore wind is the most important element of our trajectory planning. In order to estimate it, the CanSat uses the measure of speed when it is still hanged to the stabilization parafoil. Moreover, the wind's characteristics are updated during flight by measuring the difference between the magnetometer's data and the GPS direction indicator.

Knowing the wind, the CanSat decides of a trajectory in 3 steps:

- Fly toward the wind plan (defined by a vector representing the wind direction, the vertical axis and containing the landing point)
- Do circles to loose altitude while being driven slightly behind the target by the wind
- Break and land on the target up wind

Those 3 stages define 3 flight attitudes that have to be implemented on the servitude part:

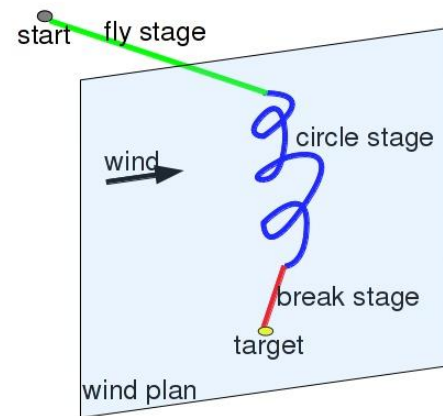
- Fly toward a point
- Do circles
- Break toward a point

The wind and position are constantly updated, in order to continuously update the position where the CanSat has to start circling, till reaching it.

An emergency break function is implemented if the flight algorithm detects that a too strong wind prevents us from reaching the target. This is implemented in order to insure closed landing even in worst conditions.

The servitude algorithm will be based on extensive testing and analysis of videos of previous experience in order to characterize the response of the parafoil and make sure that we

can manage to control and direct the CanSat as precisely as possible. The main phenomenon taken in account is the response time of the system. By knowing this one should be able to direct the CanSat only having to do punctual trajectory adjustments depending on external variations.



V. CONCLUSION

Despite a late beginning, the new Altaïr team is confident that our CanSat will be a success. Altaïr is a long term project and has already given great results. The upcoming developments are foreseen and scheduled. They will put of Altaïr III at the forefront of the current CanSat technology on every aspects : ejection system, on-board electronics/actuators, flight algorithm, telecommunications, ground station etc. thanks to its experience.

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