Neo 3: a Rover in a Can

Louis Perrot-Minot, Mathieu Archen, Antoine Basset, Suk-Kee Courty-Audren

***Abstract*–The main goal of this project is to fit in the volume of a can the elements needed for our CanSat to roll: two wheels, two motors and a GPS based steering system. A 3D-printed structure has made possible the integration of all electronic and mechanical parts. Our CanSat is able to fall without guidance until the floor, and reach the GPS target on its own. It records photos of the landing point and the target, to complete the scientific mission.**

I. INTRODUCTION

THE journeys of rovers on other planets of the solar system are an endlessly source of information. It might be far harder than any other project, but also much more rewarding: it is the only way to analyze deeply the soil of a planet, and the first step before human exploration. Neo tries to reproduce this performance in the CanSat competition. To imitate a real rover mission, the CanSat is launched under a non steered parachute. After landing, the can releases its sail and takes photos of the landing site. Then it tries to reach a GPS target by rolling on the floor, and photographs the ending point. The goal is to realize two panoramic views by putting together the photos. Hence the scientific mission assigned to this CanSat is to take photos of the ground, and the free mission is to reach the GPS target given by the organization for the "come back" mission.

This CanSat is an upgraded version of a last year project. That previously had some technical problem on critical components, so the main task this year is to ensure the realization of the missions, and, of course, tries to improve their precision.

Fig. 1. BudStar logo

II. CONTEXT OF DEVELOPMENT

A. The BudStar team

BudStar was born in 2009 as a university club of the French Institute of Aeronautics and Space (ISAE) in Toulouse. Since 2010, it is an autonomous association led by ISAE students.

French championship 2009 was the team's first CanSat competition – and victory. In 2010, the second version won the International Competition in Madrid.

This year, BudStar is composed by 4 students in 4th and 5th year, specialized in computer sciences, control theory and aerodynamics. It has concluded a partnership with the Institute for design and building, and with the Parachute Flight Test Center (CEVAP) for tests.

Each team member has his field of expertise:

- Louis Perrot-Minot, team leader, and Antoine Basset are programmers;
- Mathieu Archen is responsible for structure and electronics;
- Suk-Kee Courty-Audren is in charge of the design & building of the parachute.

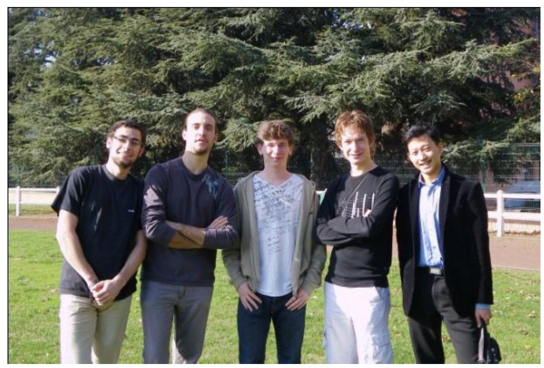


Fig. 2. The 2010 BudStar team.

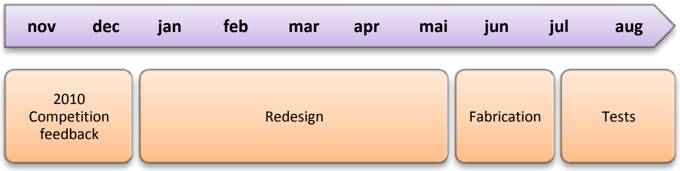
B. Work plan

Since this CanSat already participated to a former competition, and encountered some failures, it was essential to identify its weakness points, and damages due to former crashes. This first step begun just after the last competition and was followed by a redesign stage which is still in progress. The flights made last year proved that the CanSat is able to safely land, release its parachute and roll - at quite low speed - on the ground. The cruxes of the current development are:

- Ensure the fact that the CanSat can be headed to the target on a grassy ground;
- Safeguard the releasing of the parachute, which is the most critical weak point of this can.
- Find a reliable way to command the camera module.

This development will be followed in few weeks by a quite short fabrication stage, since the main of the can is kept unchanged. The aim is to have two full months of tests and adjustments. The team has concluded a partnership with the CEVAP for launching CanSat from a thirty-meter-flight test tour, which allows to quickly set up tests and get nearly live results.

TABLE 1. FORESEEN CALENDAR



The development of this CanSat is also thought to cut the price as much as possible. This leads to a less than €200 autonomous rover in the volume of a can.

TABLE 2. FORESEEN BUDGET

	Quantity	Total
Motor	2	29.72 €
Microcontroller	1	27.17 €
Motor controller	1	23.92 €
GPS module*	1	58.02 €
Camera module	1	10.95 €
Battery*	1	28.38 €
Servomotor	1	18.71 €
structure, screws		0.00 €
Parachute	1	0.00 €
	Total	**196.87 €**

*Shared with Morpheus

III. DEFINITION OF THE MISSIONS

A. *Free Mission: rolling to the target*

After a non-steered fall under a round parachute, the CanSat will be able to roll on the floor and head to the target used for the “come back” mission. A GPS based steering system leads the two-wheeled CanSat to the target.

This mission is the critical point of the project, and requires a transition from the falling to the rolling configuration: the parachute has to be released to free the CanSat and a skid has to be deployed to stabilize the movement.

B. *Scientific Mission: panoramic images of the ground*

As its two big brothers Spirit and Opportunity, the CanSat will record images in order to assemble them in panoramas. Neo 3 will run two recording sessions, just after the landing and once the target is reached.

The embedded camera is protected during the flight by a deployable structure and records images on a µSD memory card. The panorama assembly is hand-made after the flight.

IV. CANSAT ARCHITECTURE

The complexity of the rolling mission was the key point to design this CanSat. The labor was to simplify as much as possible the deployment sequence required to let the can roll on the floor, in order to ensure its reliable realization. This sequence is divided into three main events:

- The CanSat has to release its parachute, in order not to drag it across the floor during the rolling;
- The two wheels are included in the shape of the can, so they are ready to roll, but a skid has to be deployed to stabilize the movement;
- The camera is protected during the flight by a structure which has to be removed to free the field of view.

These three parts are essential for the success of the two missions. The final system is extremely simple since it is only steered by one servomotor. The design of the mechanical parts is closely related to this choice.

A. *Mechanical parts*

The specificity of the free mission leads to a multi-part structure:

- The main frame, on which the internal elements are fixed. It has to bear the landing shock;
- The two wheels, which are visible on Fig. 5: they cover the main part of the surface of the can, in order to improve their efficiency. They are covered with artificial sealskin to give the CanSat the best grip;
- The deployable skid has three functions: during the flight, this structure is closed to protect the camera and lock the parachute; after landing, the skid is deployed and stabilizes the rolling.

This requires a quite complex structure which was realized by 3D-printing. This computer aided method allows complex geometry, which comes to life by depositing thin layers of plastic one by one. This creates a precise structure with a 0.5mm resolution, but the anisotropic way of realization needs to be taken in account, especially for the strength of the main structure.

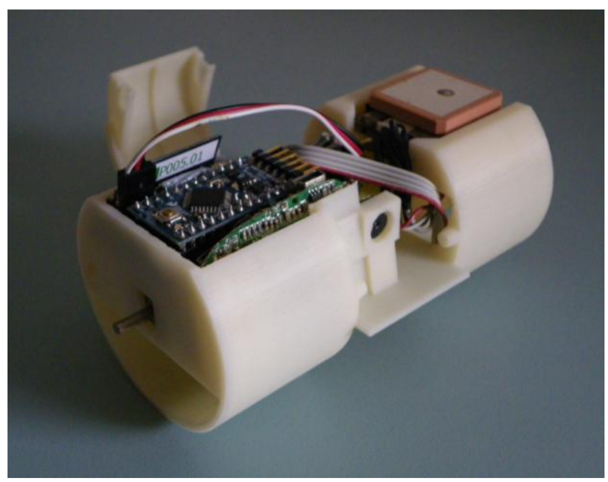


Fig. 3. The 3D printed structure (the main chassis and the skid).

B. *Parachute*

The fastening of the parachute is the far most critical point of the project: it has to be safely locked to the can during the flight, to avoid a disastrous crash. Then it has to be simply and quickly removed, because the rover can absolutely not drag its sail across the floor. A further problem is the fact that the rover leaves the landing point by rolling. Hence it has to be able to roll on the parachute, and not to remain caught on the suspending ropes.

A series of tests was made to validate this stage, and leads to three technical solutions:

- The round parachute was designed as the most simple as possible, in order not to be in the way of the rover;
- The suspending ropes were made with large cloth ribbon, to avoid the risk for the CanSat to be caught on.
- The fastening system consists in two rings locked on two tenons by the skid. The rings are released when the skid opens (see Fig. 3 below).

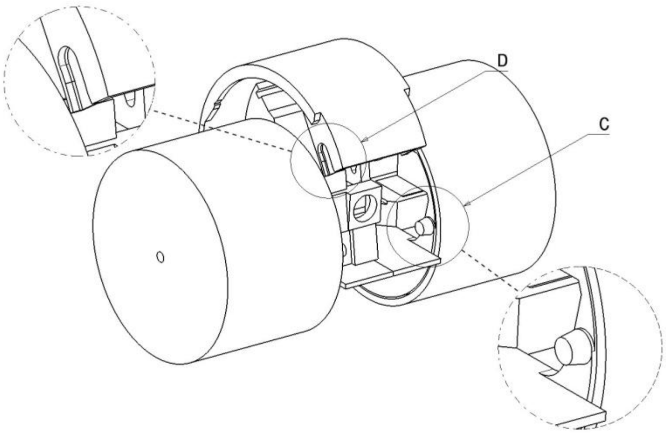


Fig. 4. A sketch of the structure: C and D show the locking system of the parachute. In the middle of the can, the partially opened skid. The rest of the can is covered by the two wheels.

C. Electrical architecture

The electronics inside the CanSat is divided into two parts:

- The command circuit, based on an Arduino microcontroller, links the different parts of the hardware:
  - The camera module which is an off-the-shelf component: this module includes a µSD memory card, and the CanSat sends one simple command to take a photo;
  - The GPS module is used to head the CanSat to the target, by comparing successive GPS coordinates;
  - A servomotor is used to open and close the deployable skid.
- A power circuit is needed to supply the two motors linked to the two wheels and controlled by the command circuit.

In order to reach the target, the CanSat rely on its GPS coordinates, measured every second. It calculates its heading and compares it to the route to follow. The control of the path is made by a different speed command on the two motors.

This CanSat is supplied with a double-cell LiPo battery: it makes the electronic work for more than 1 hour.

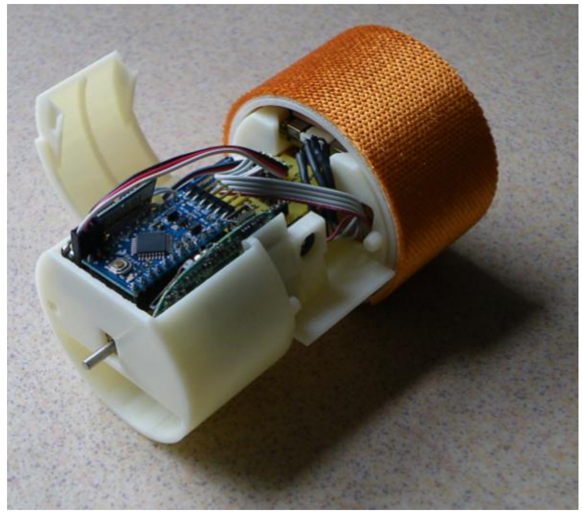


Fig. 5. 2010 integrated Neo (the right wheel is removed)

D. Telemetry

This CanSat has no telemetry: the success of the free mission requires no communication with a ground station, and sending pictures wirelessly needs a large bandwidth, so a quite big RF transmitter. It has been decided not to add this to a already complex system, in order to ensure the fulfillment of the missions and to cut the price of the CanSat.

V. Conclusion

In conclusion, this CanSat will make the most of the experience gained during its former competition to perform on the earth what the most advanced rovers try on other planets: to land and report precious images.

VI. Acknowledgment

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[2] Planète Sciences & CNES, “Proposed Missions for CanSat-France competition 2011”
[3] Various components datasheets and manuals
[4] www.arduino.cc (microcontroller website)