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CANSAT FRANCE : AN INNOVATIVE COMPETITION TO ENCOURAGE WIDE ADOPTION AND PUBLIC AWARENESS.

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ABSTRACT

Since 1962, and with the support of CNES and major aerospace industries, the French non-profit organization Planète Sciences has been providing young amateurs with facilities, tools and programmes to make their dream fly.
Young space conquerors are proposed to get hands on projects ranging from micro-rockets to experimental rockets but also stratospheric balloons and Cansats.

Cansat France is opened to international teams. The pilot Competition was held in 2008 followed by the first edition in 2009. 2010 is the France-Russia year : two teams from Siberia joined the CanSat France and the winning team of the Spanish competition invited to compete.
This paper will discuss how CanSat France offers the integration of the CanSat Spirit with proven design and setup methods developed by Planete Sciences/CNES. It will review the details of the differences with other CanSat competitions.

1-INTRODUCTION

1.1 CNES, the French space agency established in 1961, is a public organization in charge of the development and management of the French space programmes. Its mission is to guarantee access to space capability and its use for all national and European needs. This includes support to space amateurs. Under the control of CNES, Planète Sciences, a non-profit organisation, was formed in 1962 to provide assistance to space clubs for the design, manufacturing and launching of the experimental space rocket projects.

1.2 Planète Sciences is a network of regional associations who promote sciences and technology through practical activities and experimentation to youth from elementary school to university levels [1]. The spectrum of thematics has broadened over the years and now includes space activities, astronomy, robotics, environment, meteorology, energy and archaeology.
Further to nation wide programs and trainings, Planète Sciences organises events or contests such as *Eurobot* and *Eurobot Junior* [2], *First Lego League*, *La nuit des étoiles* (the night of the stars), the national rocket launching campaign (CSpace event).

1.3 Support to amateurs

It originally started with space activities at a time when the space conquest was leading passionate people to build amateur rockets. Several of them lost

their lives while tuning rocket engines made of World War II military ammunition collected from battlefields or by using approximate chemistry formulae.
To prevent further accidents, the French government prohibited any non-professional astronautic activities and assigned CNES to provide assistance to amateurs. The necessity to set specific programs for the youth emerged from the fear that a total prohibition would not eliminate the risk of accidents but on the contrary would promote clandestine usage. CNES, for practical reasons, could not have formal relations with individuals and therefore invited them to gather in clubs thus contributing to the establishment of an association named "Association Nationale des Clubs Spatiaux" (ANCS), now Planète Sciences (Fig. 1).

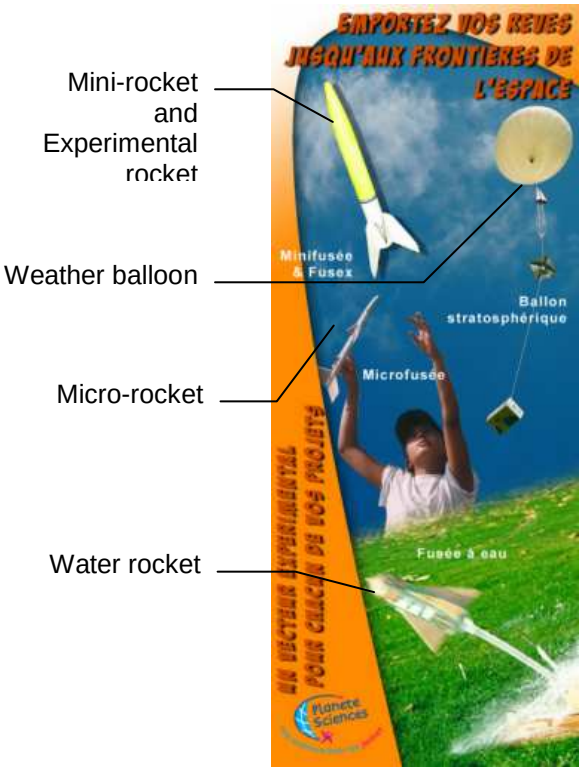


Fig.1: Space activities at Planète Sciences

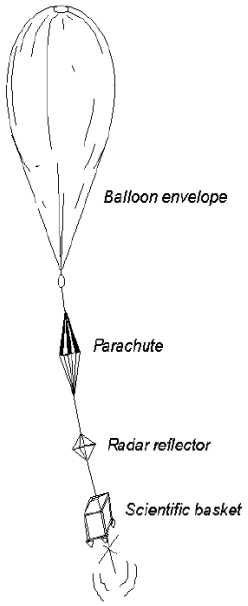
Influenced by the professional background of its creators, who were members of the industrial world, the association developed avant-garde pedagogical methods that are based on concepts such as:

- To introduce youth to science and techniques through practical activities,
- To develop these practices as leisure activities,
- To promote teamwork,
- To offer youth the opportunity to engage in exciting projects such as rockets, where the tuning complexity naturally justifies the necessity to learn,
- To introduce youth to project management and experimental process since, in order to be successful, the capacity to manage a project is as important as the technical knowledge itself.

2- FROM ROCKET TO CANSAT: EVOLUTION

2.1 From Rocket to Weather Balloon

Rockets were the first space vehicles available for youth can experiment in near-space conditions. In the late '80s, with the same will to promote the experimental process, CNES and Planète Sciences have developed a new vehicle for space experimentation: the Weather Balloon [8].



While rockets launched in France can fly a relatively low mass payload (15kg max incl. motor) and reach moderate altitude (1km) over a short time (a few minutes), weather balloon can transport a 2.5kg payload up to 25km and for a duration ranging from 2 to 3 hours. This makes experiments such as atmosphere analysis or remote sensing easy to conduct.

The weather balloon reaches high altitude – closer to space – as seen from this shot from the experiment prepared by high school students in Vesoul (France) in 2009.

The young scientists get their inspiration for weather balloon experiments from various sources, but especially from Earth Observation Satellites. Rockets make youth aware of launchers, Balloons make them aware of satellites.

2.2 From Weather Balloon to CanSat

From the late '90s, space discovery reached new level with robots and probes exploring the surface of distant planets, such as Pathfinder on Mars in 1997, Huygens on Titan in 2005...
Not only these missions raised the interest of general public on extra-terrestrial activities, but revealed the extents of the missions that could be achieved with a rover or a probe.
Planète Sciences has been trying to leverage this trend and started to look for a new vehicle, for youth can develop probe-like experiments, what rockets and weather balloons cannot achieve.

In the mid 2000's CanSat was developing rapidly in the USA and in Japan, and was promoted by ESA in Europe. Japanese space clubs taking part to the French launching Campaign organized by CNES and Planète Sciences [9] demonstrated "quasi-sat" experiments from 2006 [10], with up to 3 modules released from a single rocket. This new vehicle was responding to the expectations from Planète Sciences and was adopted in France, just like in many countries.

CanSat flying back to Earth: the probe is an experiment as itself and gives a new purpose to the rocket.

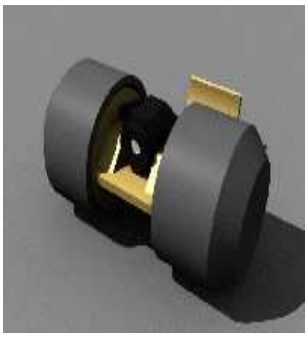
However, it quickly appeared that if CanSat has a large potential to attract teenagers and students to space activities, the constraint of the rocket was hampering its development in France. Indeed: the success of the CanSat mission is linked to the reliability of the rocket and its ejection system and also to the reliability of the CanSat's parachute deployment. Not talking about the recovery of the CanSat itself: when released from a high altitude (up to 1000m), the small module is not easy to locate if not equipped with a dedicated system.

3-CANSAT: A NEW VEHICLE TO REACH NEW FRONTIERS

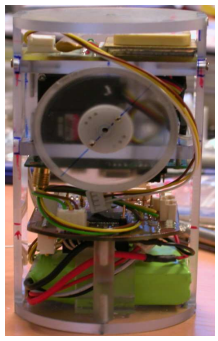
3.1 What's in a word: CanSat?

CanSat is formed from the words (metal) Can and Satellite. CanSat was originally described and proposed by Prof. Twiggs in 1998 at the University Space Systems Symposium [xxx].

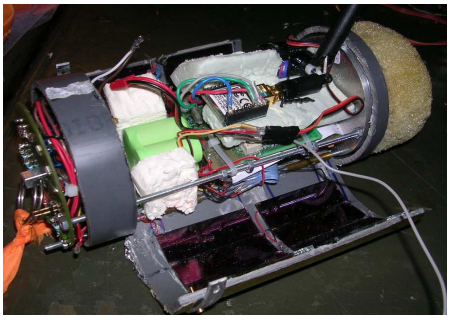
A CanSat is basically an autonomous system capable to complete a scientific mission within a restricted volume. This volume is usually a 330ml metal can. A large variety of missions can be carried out, and several technologies can be embedded in a single CanSat: ground imagery, atmosphere sensing, free fall experiment, target landing, air-bag landing, camera or arm deployment…



Rover CanSat



Target CanSat



Technology CanSat

On top of the CanSat module itself, the mission and its results are presented in two times to a jury composed of University professors or professionals from the space industry. The CanSat and its intended mission are presented before the set-up. Once the mission is completed, the results are processed within a short timeframe and are discussed with the Jury. This latter presentation wears a high interest for the designers as it forces auto-evaluation and enable a fast return on experience.

The CanSat designers learn a lot from the presentation of their results to the Jury.

3.2 CanSat: it contains pedagogy too

CanSat carry the same pedagogic values as Rockets and Weather Balloon:

- Project management
- System design
- Hands on technology (electronics, computer science, aerodynamics)
- Planning management
- Budget Management
- Communication

Beyond these technical aspects, the mission debrief with the jury is especially valuable for the teams' members: they must provide a summary of the results. The content of this summary extends from the technical results (recorded or

transmitted data, achievements) to root cause analysis (why something did fail, what were the communications gaps between the different team members…).
As for example, during the 2010 edition of the French competition, the team "BudStar" simulated in front of the Jury the

observed in-flight behavior of the parachute using a fan.

Mission debrief: "Here's what's gone wrong with the parachute"…explained through simulation with a fan.

This summary phase greatly helps the teams' members to understand the point of failures of their design and to move forward to improve it for a next run.

4-CANSAT FRANCE: A CUSTOMIZED COMPETITION

4.1 A customization of the International model

CanSat France started in 2008 and is following the same principles as the international competitions organized in the USA, in Japan, in Spain, in Norway…

- Presentation of the mission before set-up and mission debrief
- Standard CanSats have a 330ml volume

However, and in order to develop planetary or rover types of missions, the following customizations were made:

- CanSats are released at 150m high from a static balloon.
- An "Open Class" allows larger experiments up to 1 litre
- Teams must develop 2 missions: the first one imposed by the organizers, the second up to their imagination.

This last point aims at increasing the diversity of experiments while maintaining a common framework for all the teams.

4.2 CanSat from a static balloon

The main benefit of this type of release is the null speed at the time of the drop: this strongly limits the mechanical stress on the CanSat. In the CanSat spirit, neither the release nor the recovery of the module are part of the experiment. Indeed, in the case of a CanSat launched from a rocket, the complete project can be annihilated by an ejection failure, by parachute strings tangling or by the lost CanSat due to the high altitude. Therefore CanSat France is offering a release from a static balloon (dirigible type) equipped with a radio controlled release system. CanSats are inserted in a PVC tube closed by a bottom door, before the balloon is lifted up to 150m.

20m^{3}static balloon carrying the remote-controlled release system

When the bottom door opening is remotely triggered, the CanSat drops down according the the laws of gravity.

CanSats are installed in a PVC tube from which they drop when the door is opened

The height of the drop is much shorter compared to a rocket launch. This can reveal to be a limiting factor for missions requiring long flight time such as atmosphere sensing; however this reveals to be a major benefit for the audience attending the competition, as they can enjoy the complete setup and mission deployment. CanSat France 2009 and 2010 took place during C'SPACE [11] held in Biscarrosse (Landes, France). The competition was organized on a football field: the public was comfortably enjoying the event from the benches.

CanSat 2010:
a comfortable seating is key for a wide attendance

Finally, the low altitude preserves the integrity of the CanSat when it lands. Recovered projects are usually ready for another drop after a few minutes only. The teams have the chance to renew their mission several times and gain experience within a short time frame.

CanSat 2010: after the drop…ready to drop again!

4.3 Get the Sat out of the Can: the « open class » category

There are two main reasons for these for this category to exist:

- To remove the small volume restriction for sophisticated experiments
- To open CanSat competition to teams that wouldn't master the required technology to have the mission fitting in the international 330ml CanSat category.

4.4 The missions: either Proposed or Free

As per the rules of CanSat France, each team shall choose, on top of their own mission (called free mission), another one, from a list of four proposals. These four proposed missions are defined by Planète Sciences together with a panel of space industry professional; the missions are primarily inspired from planetary missions and technologies.

The four missions include:

- Atmospheric sounding: during the

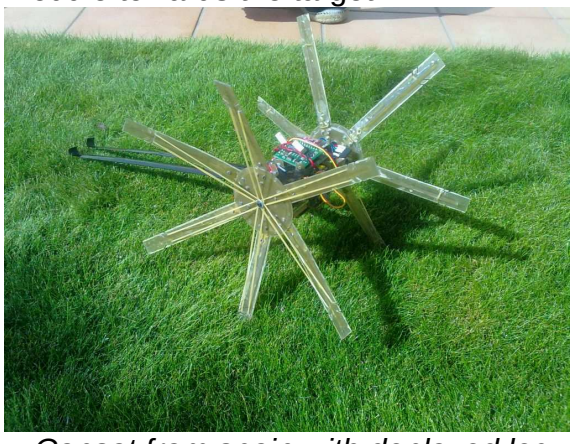
descent phase, the CanSat shall sample air temperature and altitude every 5 seconds and transmit the data to the ground station. This mission is widely present in international contests: it's an easy entry point to CanSat France for foreign teams.

- Deployment of an RF antenna on the ground after landing of the module. This is the first step of a planetary mission in order to initiate communication with the orbiting satellite.
- Photo/Video: a photo or a video of the surrounding area shall be sent through wireless link. In real missions, images give valuable information to the scientists and operators on Earth.
- Localization without GPS: geo-localization is simple from the moment a constellation of satellites orbit around the planet, like Earth, but the situation is different with other planets and asteroids. Therefore this mission is very challenging as well as realistic.

The free mission bears no constraint and allows the team members to develop a mission with the complexity compatible with their technical skills or expectations for the overall project.
Within 3 years, the free missions proved to be original: solar panels deployment, sensing of Co_2 polluting gases, measure of the hardness of the ground, live image processing… However, "comeback" remains the most common free mission: the module shall reach a target defined by the organizers. This is a complex task which involves navigation, aerodynamics and piloting techniques.

CanSat comeback to the ground target is technically challenging

So far, no team managed to complete the mission, although several attempts proved to be convincing with visible steering phases during the descent under parachute. It worth mentioning this mission is the purpose of a project from a Japanese space club launching its rocket every year at C'SPACE since 2006: the rocket deploys a parafoil to fly back to a given landing point [10]. However, despite the treasure of innovations they've implemented year after year, the students didn't manage to fulfill the mission in 4 attempts, and they are still persevering.
Consequently, a couple of CanSat teams rather switched from an fly back to a ground comeback by rolling their module towards the target.



Cansat from spain with deployed leg

5-CANSAT FRANCE: 3 YEARS OF EXPERIENCE

5.1 2008: a rehearsal

CanSat France was trialed in 2008, in order to evaluate the technical constraints of its organization and technical issues experienced by the teams.
Volunteers at Planète Sciences designed a first version of the release system and 3 CanSats were dropped. The teams originated from CanSat Spain and from France under the technical review of Planète Sciences. The Spanish students acknowledged the benefits of the rigor of the organization and the documentation requested from the teams (check-list, chronology) as well as the safety procedures; they are all inherited from nearly 50 years of technical projects with youth. This long experience also serves as an example for other countries.

CanSat France 2008: a rehearsal before the
take off of the competition in 2009

5.2 2009: competition kick-off

CanSat France officially started in 2009, with 4 CanSat from 4 teams, including one from Norway. The international dimension of CanSat France is a clear motivation of the organizers.

From Spain or Norway: CanSat France gathers an international community of passionate students.

The Jury was composed from members of ESA, CNES, Thales Alenia Space and Astrium-Sat. They recognized the value of the event and confirmed their support to the event.

A forum was setup on Planète Sciences Web site to enable exchanges in between the teams.

5.3 2010: take-off

2010 was the French-Russia year: teams from Russia were invited to join CanSat France to which 16 registered with 18 projects. Several teams didn't join the competition since their project was not completed on time. However, two teams joined anyway with an uncompleted project and presented their progress to the Jury. One of these teams was represented by a single member who actually hitched-hike through France from East to West for this sole purpose. CanSat France is definitely a place to be and motivates students to the highest point.

Interview of the Jury of 2010 edition

Cette édition a permis au CNES et à Planète-Sciences de consolider les procédures de mise en oeuvre et de commencer à les optimiser pour mettre en oeuvre tous les cansat en 4 heures.
Cette édition a aussi été l'occasion de commencer à développer la communication sur l'évènement.

Enfin, cette nouvelle année a permis de confirmer la création de deux équipes Cansat en France (BudStar et T'Space). Elle a permis aussi dans, une ambiance conviviale, de consolider tous les liens autour des passionés de Cansat en france et à l'étranger.

6-UNE OPPORTUNITÉ POUR LA COMMUNICATION DES ACTIVITÉS ESPACE DE JEUNES

Le CanSat, vecteur pouvant être mis en oeuvre depuis un ballon captif au dessus d'une surface réduite (type terrain de football), présente l'avantage de ne pas nécessiter de conditions de sécurités pour le publique aussi élevées que pour les fusées expérimentales.

Il devient ainsi possible de réaliser la compétition au coeur d'une ville.

Cette possibilité ouvre ainsi plus facilement des opérations de communications vers le grand publique. Planète Sciences et le CNES réfléchissent actuellement à utiliser cette opportunité pour créer un événement autout du Cansat et avec le thème de l'exploration interplanétaire.

Enfin le principe de la compétition reposant sur une présentation avant et après le largage, permet de communiquer sur les résultats de l'expérience et non pas uniquement sur le vol du Cansat.

7-PERSPECTIVES ET DÉVELOPPEMENT

Le CanSat est un vecteur qui permet de proposer aux étudiants une véritable simulation de mission interplanétaire.

Il reste complémentaires aux vecteurs habituels tels que la fusée et le ballon.

L'approche de Planète Sciences consiste à mettre en oeuvre les Cansat depuis un ballon et non pas depuis une fusée. Certe, l'altitude de séparation est moins élevée, mais cette méthode permet de simplifier la mise en oeuvre et ainsi autoriser plusieurs vols d'essais avant la présentation au jury. Elle permet aussi de faciliter la communication autour de l'évènement.

2011 verra une nouvelle année de compétition visant à confirmer l'évolution du nombre d'équipe et la possibilité de réaliser un événement plus médiatique et probablement plus ouvert vers l'international.

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