DRAGONFLY - DEMOISELLE

Micro Solar Sail Satellite Project
U3P – ‘Green’ Reunion Island

<u>TECHNICAL DEFINITION - PHASE 0</u>

Reference Version

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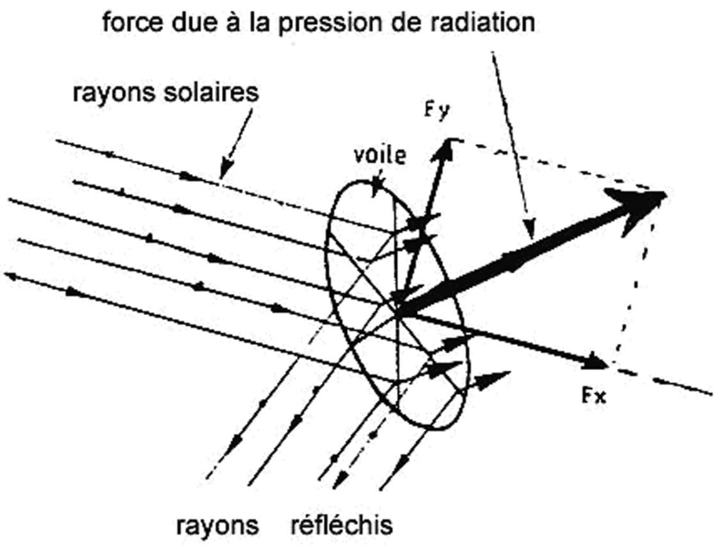
I - MISSION

History and context

Photon propulsion

When a satellite is placed in orbita round the Earth or around the Sun in order to reach a planet, it usually needs to perform a number of manoeuvers in order to remain on its designated orbit or in order to modify its trajectory. The manoeuvers are made by use of thrusters that use reaction mass (gaz or liquid propellants) that have to be sent in orbit together with the payload itself.

The only way known until now not to spend any reaction mass is to use the light from the Sun with a technology called "Photon Propulsion". Sunlight, like any other radiation, exerts some pressure upon the surfaces it hits. On a plane surface that would be perfectly reflecting, that pressure amounts to about 10 micronewtons per square meter, and the resulting force is perpendicular to the surface that receives the light.



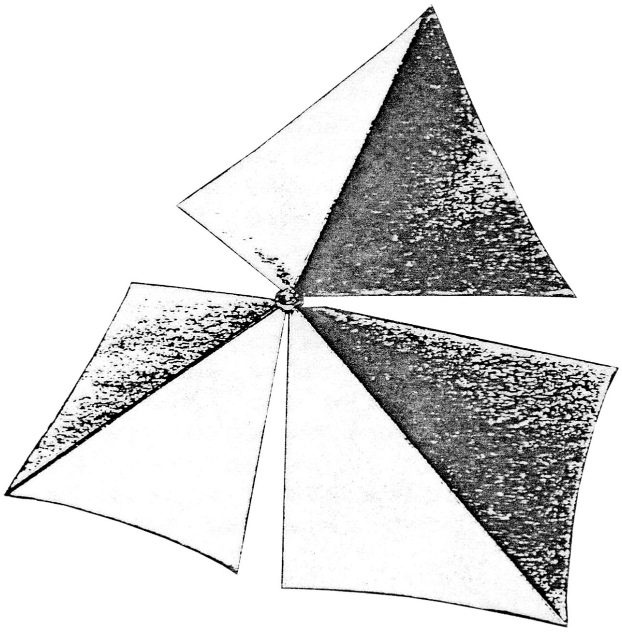
The photon transfers momentum to the reflecting surface

So far, no spacecraft yet sent to outer space from Planet Earth has ever made a systematic use of this available energy to extend its range of action.

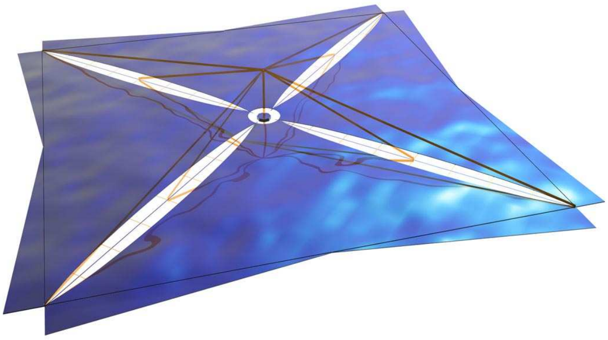
U3P’s former work and experience

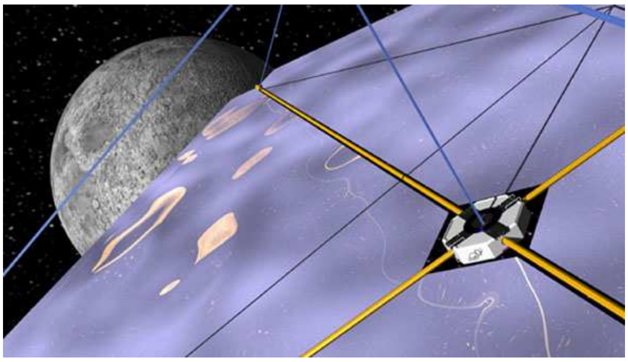
Since the begining of the eighties, U3P conceived and developed over the years several solar sail projects that were taken ever closer and closer to actual realisation.

The current evolution and miniaturisation of technology now allow for the conception of new projects with smaller size and mass that make it much easier to find opportunities for launching.

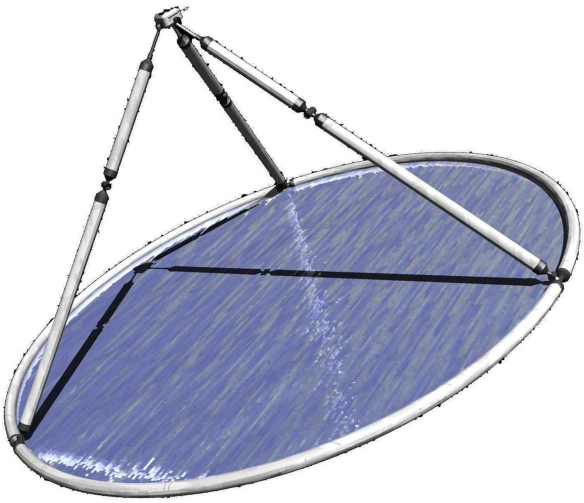


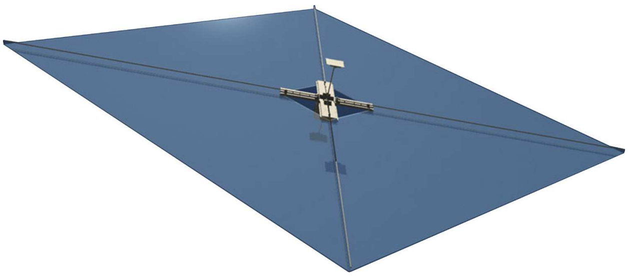
"Butterfly" Sail Project (beginning of the 80's)





"Square" Sail Project (around early 90's)





First "Dragonfly" Sail Project (early 2000 years)

"Circle" Sail Project (early 2000 years)

Reunion Island current Industry context and Space potential : a region’s Ambition

- **Outer Space will be a major issue in the 21st century,** and future studies experts think that by the year 2025 **Space related business,** currently in the order of 50 billion euros considering the whole world, will be multiplied by a factor of 15. **Scientific progress and the subsequent development of many applications in the fields of new materials, nanotechnologies, electronic and optronic components, information and communication technologies, will stimulate the growth of space activities, and later, in return, a number of the technologies developed for space exploration will find new applications for the general public.**

These prospects bring answers to many major needs and they will also considerably help achieving sustainable development. Space activities are of strategic importance for technology development and economic competitivity. Because outer space environment imposes severe constraints for equipment and for energy management, these constraining and hard conditions lead to the development of exceptionnaly reliable systems, they stimulate technological innovation and they generate synergetic effects in many other fields of activity.

- **Europe told firmly, as a part of the strategies decided at the Lisbon Conference, of its political ambition to become number one in the economy of knowledge by the year 2015**.

Reunion Island, an outstanding region of France and Europe in the Indian Ocean, is bound to distinguish itself in the face of the World in this Lisbon’s strategy. The high quality of its infrastructures, the high level of education of its population, especially the youth, which is trained to Europan and international standards, are natural favourable factors towards such goals.

Reunion Island suceeded, within a span of just a few years, to shift from an agriculture-based economy to a modern economy system with an increasing weight of Industry and services and a structure that is similar other regions in France and in Europe. In a global economy system where the center is now anywhere and the periphery nowhere any more, Reunion Island features just as many assets as any other European territory for the development of new future-oriented and employment-prone activities such as biotechnologies, genomics, biocomputing, energy or outer space...

Be partners in the construction of an « initiatory » satellite ?

- Two means of leverage will allow **Reunionnese Industry** to take position as fully qualified actors in a knowledge-based economy : a well designed opening to the international world, and a voluntary technological transition. Reunion Island may commit itself firmly to this technological ambition by becoming the leader of the “Demoiselle” micro-satellite project as proposed by the Reunionnese members of U3P, and building a symbolic regional satellite that will enable the Reunionnese Industry :

- to show the outside world, and to all the Reunionnese, « Green Reunion Island – A land for High Tech and Advanced Knowledge », and thus affirm visibility and attractivity for Reunion Island in all its national, European and global dimentions,

- to enter and become part of international high techology networks, especially in the field of space activities, and thus affirm their credibility and international visibility, because access to space is both a political and an economical bonus, a proof of maturity and an opportunity to obtain advantages,

- to contribute to space activity as technological actors, and no longer simply as collectors or consumers of data coming from outer space, by a concrete and symbolic “hand on” action, through the global temperature sensor on board of the Demoiselle, to work on the problems of climate change and use tools towards a better knowledge of our environment.

Dragonfly-Demoiselle will be both a symbol and a concretisation of the ambition of the Reunionnese Industry and of Reunion Island to definitely project themselves into the 21st Century.

Objectives of mission

The main objective of this “solar sail” programme by U3P is to launch and deploy sails, a critical phase in more ambitious programme to use photon propulsion.

Another objective is to obtain images of the sailcraft and of the Earth, and to perform temperature measurements of the surface of the Earth and transmit them to the ground.

The mission should also allow Industry to invest into the actual making of the spacecraft and thus acquire practical experience into space activities.

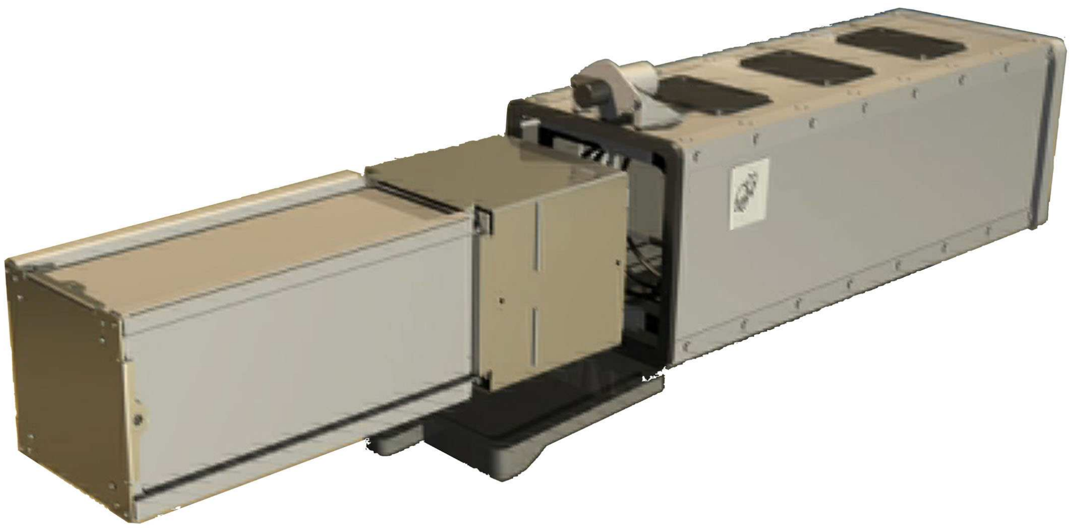
Operations

Launching

Launch will depend on opportunities offered by various operators on board of various launchers (Europe, Russia, USA, India, Japan, etc.). Privileged option will be obtaining launch free of charge.

Flight configuration

The sailcraft with folded sails will be contained in 10 X 10 X 30 cm CubeSat type package to be transported by a standard P-Pod container, as approved by space agencies.

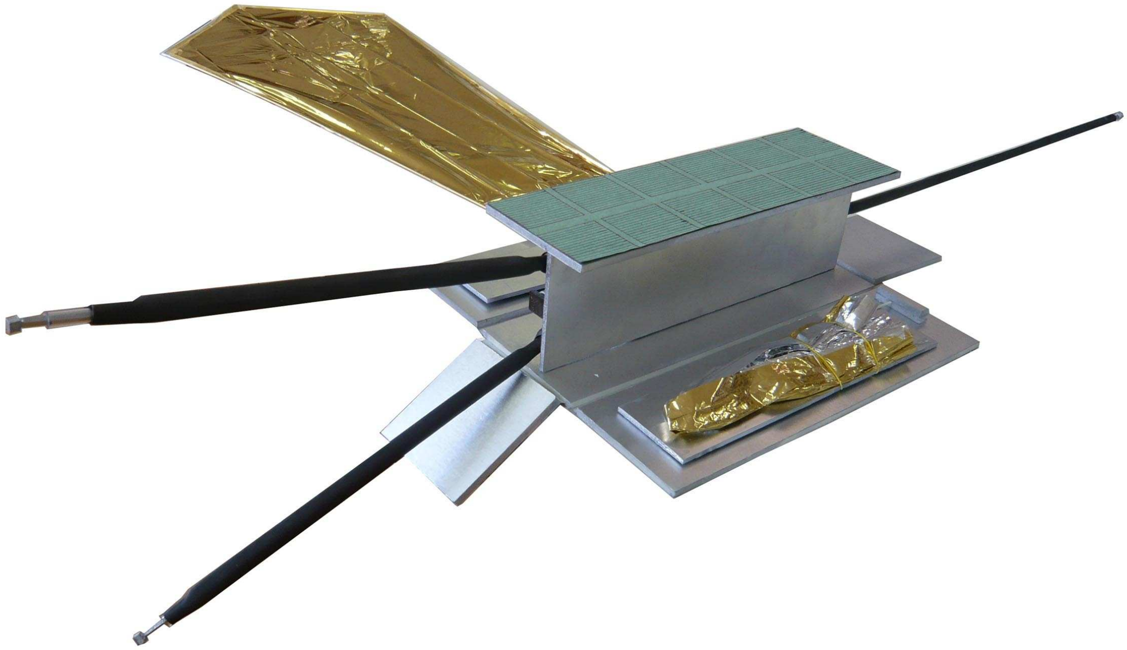


CubeSat (left), being ejected by P-Pod (right)

Deployment

After release of CubeSat all the operation will be automatically programmed :

- activation of electrical system
- activation of on-board computer
- deployment of booms and antennas
- activation of cameras and thermal sensors
- opening of lateral panels
- deployment of folded sails by inflation



Concept presentation model of « Demoiselle » CubeSat,
with one sail in folded configuration and the other one in deployed configuration.

II. SYSTEM

Control

No active control – passive stabilisation by gravity gradient.

Communications

Functions

The communication system should make it possible to send information from spacecraft to the ground to transmit technical information, temperature measurements and images of the sailcraft and of the Earth.

Choice of frequencies

Radio communications are of major importance for the success of the mission. Choice is made to seek cooperation agreement with well-known terrestrial networks that will guarantee the required availability and performance.

The radioamateur frequency band will be used.

Maintaining link

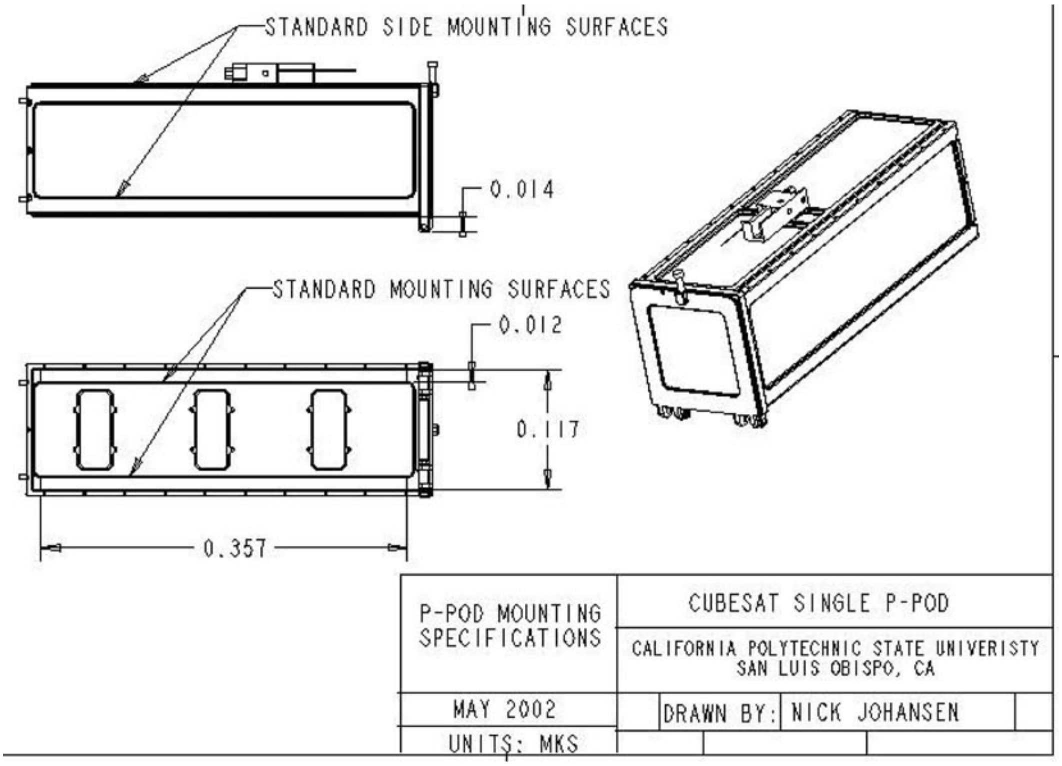
A link may be established only if :

- spacecraft is visible directly from a ground station with an elevation at least 5 degrees above the horizon,
- sail attitude is such that one of the transmitting antennas will see the ground station within a certain zone,
- link budget will be sufficient.

Expression of requirements

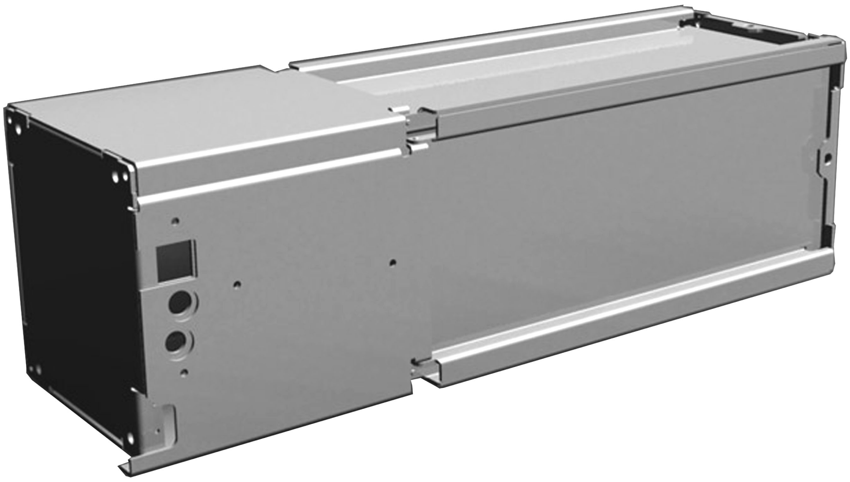
Launch configuration (P-Pod)

The spacecraft's container, that ensures interface with launcher, is standard P-Pod type.



Flight configuration (CubeSat)

Sailcraft is contained in a CubeSat type module that will be ejected by the P-Pod.



Thermal contraints

Thermal regulation must ensure a temperature distribution that enables proper operation of spacecraft. Operating temperatures for electronics are usually ranging between -10 and +50 ℃, storage temperatures range between -25 and +60 ℃. For batteries, temperature ranges are respectively (-5 to +20 ℃) and (-20 to +50 ℃).

Contraints for telemetry

- to transmit technical information (temperatures, battery voltage),
- to transmit measurements from Earth global temperature sensors,
- to transmit images from cameras.

Contraints for system management computer

The system management computer is responsible for :

- scheduling configuration of spacecraft and deployment of sails,
- managing the cameras, the sensors, and the transmitter.

Contraints for energy management

The on-board energy system must provide for the needs of the various equipments, averaged to 2 W . The energy comes exclusively from solar radiation.

On-board storage batteries are a necessity, due to :

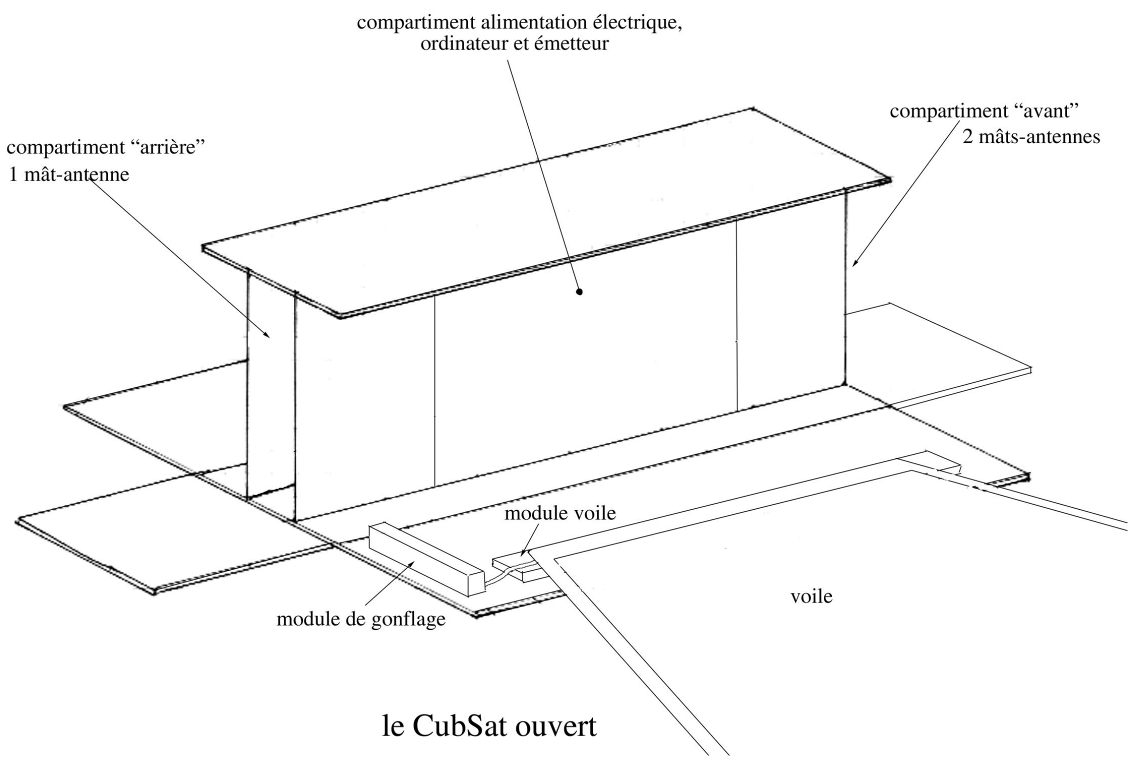
- events that require peaks of consumption
- variable sunlight conditions, from a maximum illumination to total eclipse periods during which a minimum supply of energy is required to maintain operation.

The on-board energy system comprises :

- two solar generators that provide up to 5 W, located on two opposite sides,
- a system of rechargeable batteries,
- a system for energy regulation and distribution to the various equipments.

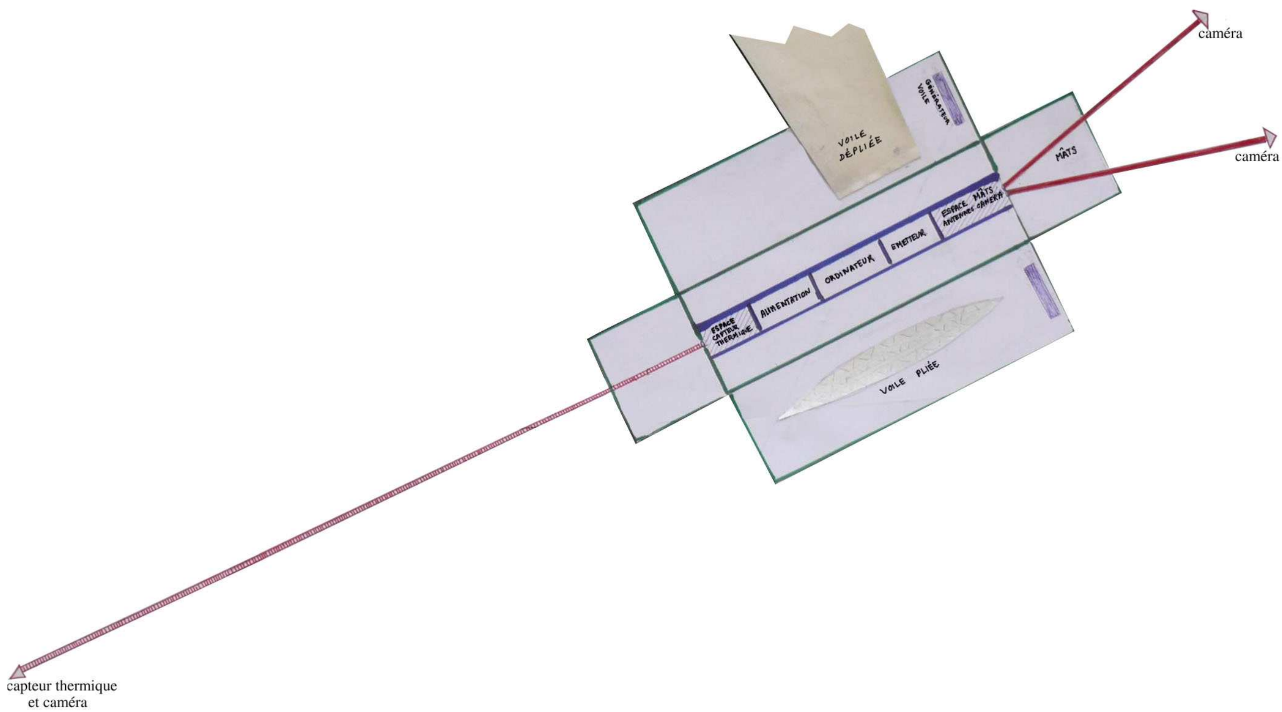
III – SPACECRAFT

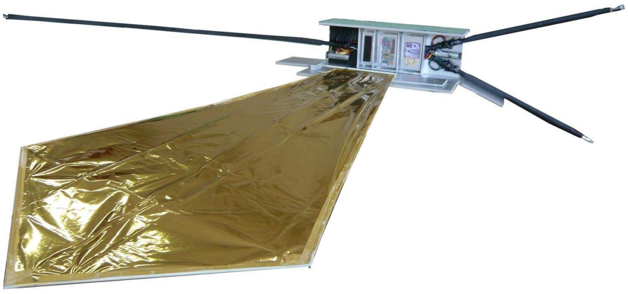
General architecture



le CubSat ouvert

The spacecraft is made of a central « beam » that contains the booms and the antennas, the transmitter, the energy module and the on-board computer, and of two side compartments containing folded sails.





Sub-Systems

Sail

The selected sail material is 8 micrometer Kapton aluminised on both faces, and reinforced by a net of ribons made of the same material in provision for use on future projects.

The choice of Kapton is guided by the following reasons:

- good resistance to ionising radiation (u to 5.10E+9 rads),
- good thermal resistance (250 ℃ for continu ed operation)

Telemetry

The selected solution is use of the radioamateur frequency band.

- the system comprises one transmitter and two whip antennas,
- the transmited power is 10 W.
- the telemetry system should operate in an economy intermitent mode.

Energy

The on-board energy system includes solar panels, storage batteries, regulation and power management electronics, and cabling.

The solar panels are made of solar cells that can provide about 5 W for normal sunlight conditions and about 3 W for incident sunlight at an angle of 70 degrees.

Regulation electronics ensure proper recharging of batteries, and a regulated and progrmmmed power distribution provides energy to the various equipments.

Thermal control

Thermal control is passive. Heat conduction through the structure ensures thermal equilibrium.

IV. <u>GROUND SECTION</u>

Reception and Information Center

A Reception Center will be established, to receive and process the images from the on-board cameras and the data from telemetry.

It may be necessary, when the sailcraft will not be in direct visibility from the main center, to have access and use to auxiliary receiving stations that will relay communication.

V. <u>EXPLOITATION</u>

Beyond observation of deployment, the main points of exploitation will be interpretation of the Earth surface temperature measurement, and the promotion of the Industry and other participants in the project.

This document and sailcraft presentation model were developed by a group of about 10 persons, in 16 hours of time during a week-end seminar organised by U3P as a 4-step project management full exercice.