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BALLOON AND ROCKET AT SCHOOL : COMMON VECTORS FOR AN UNCOMMON SPACE-BASED SCIENTIFIC & EDUCATIONAL APPROACH

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Abstract

The current paper describes two pedagogic programs dedicated to French pupils between 11 and 18 and to their teachers. They consist in providing them everything necessary to assemble either stratospheric balloon probes (Un Ballon Pour l'Ecole, UBPE) or mini-rockets (Une Fusée à l'Ecole, UFAE). The building of baskets of balloons, bodies and payload of rockets is a pretext to an initiation to the sciences, to technology and project management ; it allows young people to discover about space.

Introduction

The "Association Nationale Sciences Techniques Jeunesse" (ANSTJ) is an association which purpose is to promote science and technology to the youth using practical activities. It started handling space activities in 1962, with the help of the French space agency : CNES. That date coincides with the very beginning of space adventure. At that time, youth were enthusiastic about new heroes (Yuri Gagarine, Allan Shepard) and tried to participate at their level to the beginnings of aeronautics by building amateur rockets. Some of them lost their own lives tuning rocket engine made of World War II military ammunition taken from battlefields or by using aproximative chemistry formulae.

To prevent this deplorable situation, government from that time prohibited any non professional explosives or and asked CNES to set an appropriate politic for youth.
The necessity to set specific programs for the youth emerged from the fear that the total prohibition would not suppress the risk of accidents but on the contrary would promote clandestine usage. CNES, for practical reasons, could not have individual contacts and therefore invited them to gather in clubs and thus contributed to the creation of an association named "Association Nationale des Clubs Spatiaux" (ANCS). Influenced by the professional background of its creators, who were part of the industrial world, the association developed avant-garde pedagogic 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 team work.
- To offer the youth the opportunity to work for exciting objects such as rockets, on which the complexity of tuning 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.

When a team of youth wish to start a rocket's project it makes contact with CNES through this association. A moral contract is then proposed to the group. It may be resumed like this :
Being known the tuning of a rocket engine is a very dangerous task for novice people, CNES prohibits this practice but as compensation, it places freely at youth disposal a professional's quality rocket engine. Youth are invited to build their rocket focusing their efforts on the experimental mission and the setting of the payload. The set up of the propeller and the rocket launch is held by a professional pyro-technician from CNES.
Step by step, CNES developed a specific variety of propellers dedicated to experimental rockets for youth. These powder engines offer a high level of security when transported and handled. The average experimental rocket weights about 10 kg and flies 1500 meters high. About twenty rockets are built each year by teams of youth from 15 to 25 coming from all over France.

Taking example on these concepts, the association then expanded to astronomy, environment, robotics, computer science and recently meteorology. This required the name of the association to be changed and thus became ANSTJ in order to best describe its various branch activities. Nowadays, ANSTJ organises many events including the European Space Festival, the national experimental rockets launch campaign supervised by CNES, and Eurobot, a European Robotics competition.

Beside experimental rockets design, in the '80, appeared the necessity to propose engines for smaller rockets, easier and cheaper to achieve, aiming to introduce a wider and younger public to rocketry. That's how another range of rockets named mini-rockets weighing about 3 kg and reaching their higher point around 500m. In the same spirit, new means of transportation were proposed to children as for example stratospheric balloon probes.

In the next part of this paper we are describing more precisely two pedagogic programs based on mini-rockets or balloons proposed to secondary school pupils and their teachers.

Programs description

Programs named UBPE and UFAE are taking place at school either during official learning times or during post-curricular activities that teachers propose to children. Most of time teachers fill in a spontaneous request form describing the educational purpose they want to achieve. Once the application is accepted by ANSTJ (mostly on youth motivation and engagement of teachers), two people are assigned to the project team : a wage-earner from ANSTJ, who co-ordinates programs with CNES and a volunteer from the association, who visits the group regularly during the school year to ensure the best development of the project. Volunteers are mainly students or young adults working in technical fields.

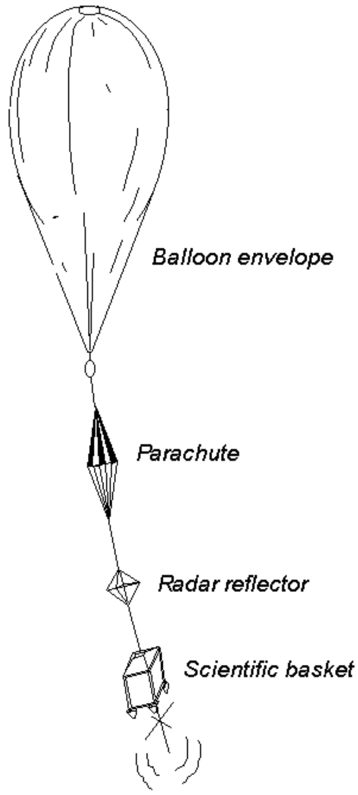
UBPE

UBPE has started in 1992 ; it is proposed to a wide scholar public (from primary school to high school). It is managed by a national responsible at ANSTJ and relayed by local units.
Teachers are aware of this program only with few advertising documents and also thanks to word of mouth. From 30 schools for the first edition, the program is proposed to more than 150 schools each year ; half of these schools are proposed again the program, on purpose.

The program meets the annual scholar cycle. At the beginning of the year, teachers are even invited to a one-day information meeting organised locally by ANSTJ.

Several documents are available to teachers and pupils ; written by volunteers and validated by CNES, they explain the purpose of the program, the way it is managed, and gives all information needed to reassure teachers about this complex-looking project. A reference document called specification book describes technical constraints baskets should apply to be compatible with legislation and the loan of collective equipment. Other documents develop some specific technical aspects : flight mechanism, atmosphere properties, telemetry and methods for project management. These documents are written taking care to be as clear as possible in order to be understood by youth themselves and are regularly upgraded taking account of stated remarks.

Connected to documentation, the following equipment is made available to classroom's by CNES : a balloon probe envelope, a radar reflector, a parachute, an helium cylinder, a suitcase holding lift-off equipment and if requested by the project, a telemetry transmitter. This equipment is regularly used for professional meteorology needs but the transmitter that has been designed on purpose for youth with special care to make it cheap and easy to use. The balloon's volume is about 5 m^3 when lifted off and may carry a 2.5 kg basket up to 25 km ; then it bursts and fall is slowed by the parachute. A typical flight lasts 3 hours. The basket flies with the winds and may land 250 km away from its starting point. The balloon flies high enough to reach troposphere where onboard sensors may record temperature and pressure close to spatial conditions. The balloon activity is fully compatible with aeronautical legislation : the main rules described in the specifications stated by ANSTJ and validated by CNES are based on aeronautical constraints.



At the beginning of the scholar year, youth are invited to question about the environment they live in and to imagine experiments that could help answering those questions. The aim is youth to lead their own analysis thanks to experiments they have imagined without being ordered any proposition by adults. Of course, both teacher and volunteer must lead brainstorms for the chosen experiments are connected to balloon probes and are technically achievable. The most popular studied topics deal with understanding of atmosphere, meteorology, pollution, study of the land and way over-flown by the balloon.

The volunteer is behaving as a technical expert and advises teacher about methodology but never aims to replace him. During his visits, the volunteer works either with the group itself or with the teacher to help him preparing lessons the way the latter wants.

This phase ends with a draft fore-project, written by the team, describing the chosen experiments. Then youth start considering a planning and a task divide-up.

The second phase is dedicated to design, first of all with drawings, of what will take place into the basket. Youth are encouraged to take benefit of all available resources (books, the internet), to get in touch with other groups that already achieved such project, to contact professional and, at last, to build preliminary models. This phase is concluded with another document that gathers all technical information about experiments but also details about tasks divide-up and planning.

Then comes the integration phase : youth are building their experiments, gauge sensors and fix everything in the basket. Now the qualification may begin. This sequence is performed by the responsible for the lift-off ; the team must prove him its basket enforces all the rules described within the specification : weight, security matters, basket identification, operation of experiments. The basket is then delivered the authorisation to fly if everything is OK.

Each of these phases lasts about three months.
We pay a lot of attention to this phase structured work that is nothing else that a simplified version of industrial management methods and especially those from space industry. We wish each phase to end with the visit of the volunteer in the classroom ; however, we're aware such initiation must be adapted to any age, and documents produced by pupils range from few pictures with captions for primary school to well structured files for older pupils.

From a technical point of view, baskets are mostly a few cube decimetres volume made of insulating materials. They hold mechanisms, electrical circuits, batteries, sensors and cameras. The degree of complexity depends of course of the age of the novice researchers. They learn to adapt their wishes to the available time and equipment and favourites boarded experiments intend to measure temperatures, pressure (from which altitude is deducted), up speed, magnetic fields, particles numbering, solar flows, UV sensors etc, etc…

That's how a primary school basket may include, as for example, a thermometer, a low-inflated balloon and an alarm-clock facing a cheap camera. A mechanism triggers the camera at a continuous rate. The basket also holds a letter inviting the discoverer of the basket to send it back to the school. Statistics tells two baskets over three are recovered. The film, once developed allows the children to estimate the height considering to the size of the balloon. It may be connected to temperature and to flight time. Children would have understood the role of the balloon thanks to a demonstration with a vacuum pump.

On the other hand, a high-school team will include electronic sensors connected to a small transmitter, such as the KIWI system developed by CNES. KIWI system is capable of acquiring 8 data channels every 2 seconds, and transmitting them on a range up to 200 km. It takes place on a small electronic board (80 x 60 mm) and weights 50g. It allows children to access transmission principles (analog signals formatting, need for antenna, visibility) and enhance the interpretation of data without the basket to be recovered. The principle is not so far from a spacecraft's.

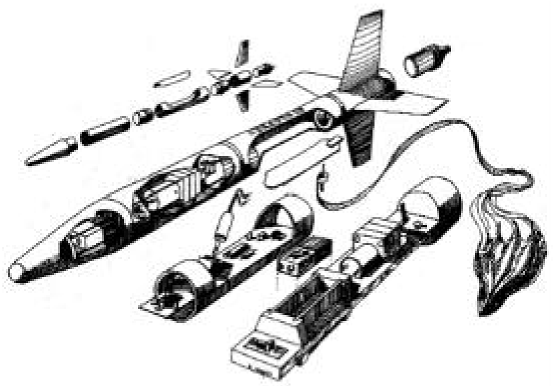
To the ground, signals are received by a small and easy to carry receiver, connected to a GPPCWB (General Purpose Personal Computer With Bugs), which decodes and plots data during the flight. Data are also recorded in a file for further signal processing.

The lift-off takes place in an open area such as football field or playground. Beforehand, an authorisation have been requested to aeronautics administration.
Lift-off is an opportunity to gather the whole school around one event ; the classroom involved in the project is proud to explain the other pupils what its basket consists in. In case if many projects are conducted in the same area, teachers are invited to gather to optimise costs but also to make children meet. Such meetings are welcomed by CNES which sends its pedagogic truck containing fully operational station for data reception but also tools to gauge sensors. Radio data are exploited few days after the lift-off while hikers recover the basket many weeks later. Though experiments are technically simply achieved, due to the lack of experience of youth, about 80% of baskets are holding data that are still readable and usable.

UFAE

UFAE has started in 1999 and is dedicated to the same public as UBPE ; its overall organisation is also similar, carried out by volunteer and managed by wage-earner from ANSTJ. Today, about 30 schools are engaged in this program. The furnished equipment is a mini-rocket propeller as described above. For safety reasons, propellers are exclusively manufactured, handled and ignited by CNES specialists. Youth assisted by such a specialist deploy this equipment.
During the school year, with the same phases and methodology as already described, groups of 5 to 10 youth are working on the achievement of a rocket that before launch weights 1 kg and measures about 50 cm. This kind of rocket reaches 500 m high and a slowing down system must be deployed in order to make it land safely. The climb lasts 20 seconds and fall may last a minute or more. The flight is stabilised thanks to 3 or 4 fins located at the bottom of the rocket. Initial acceleration is about 10 G.
Procedures are also carried out for rockets, according to specifications. Rockets are made of PVC or even cardboard and are designed according aerodynamics constraints. For youth, the main experiment is to imagine and to achieve a way of extracting parachute at the right moment. But rockets may also be fitted with acceleration sensors, sun detection (to deduce the rotation of the rocket)…. Teachers may benefit from the program to develop associated cultural projects : visits of industrial sites or museum, thematic studies connected with history, introduction to new concepts.

The launch is made using a launch pad on a field whose access is restricted during the campaign. For obvious security reasons, public attends the launch gathered a hundred meters away from the rocket. Ignition is electrically triggered.



Training

These programs require a continuous attention from the volunteer assigned to the project, and also good relationship and technical knowledge. Therefore volunteers are given the technical and aerotechnical training during annual dedicated training sessions.

As for the balloon is concerned, there are two distinct trainings, both of them lasting 25 hours over 3 days. The first one intends to give trainees knowledge about the balloon itself : history, security, lift-off techniques. They build baskets with experiments inside but that is not the true purpose of this very training : people are taught how to set up a lift-off, they are explained the rules the basket must enforce in order to apply the validation they perform ; they experience many lift-off for they get familiar with the techniques and become fully autonomous on the field.

The second training is more project and basket oriented : it intends to give trainees as much experience as possible to help youth achieve their project. The experiment question is tackled : “what could be sensed, measured, tested observed inside (or outside) the basket while flying up through the atmosphere ?”. The next two questions are “how to do it easily” and ”is it achievable by kids ?” Trainees then work together and learn how to manage a project with a group, to set milestones and to respect the planning (first visit between October and November, lift-off before the end of June). Pedagogy is also tackled for the project will be well integrated into school programs taking into account the capabilities of children.

The rocket's case is slightly different since only one training is offered to volunteers. They learn how to build a rocket, they are introduced to flight mechanism and are explained the way the rocket is launched. They are given the available documentation and are invited to think about pedagogic methods to set with youth in order to reach education objectives.

Pedagogy

From a pedagogic point of view, the interest of such projects is multiple :
Technically, the building of a basket or a rocket is the opportunity to learn how to measure, to cut, to saw, to nail, to iron…
The youth are becoming aware of spatial environment and space travel, in an experimental way.

Methods are very important and youth get introduced to experimental process, project management and teamwork. They are engaged in a long term activity which needs to be planned, they enjoy teamwork and problems encountered are, most of time, simply and cleverly solved, using daily tools. This whole learning experience, and the way the scholars learn to utilise their newly-gained knowledge motivates them and offers them the opportunity to develop themselves. It appeared it revealed students and in several cases, boosted them in their studies. These projects are much appreciated by both youth and grown-ups.

In the set up of such programs we are of course facing problems ; main ones are :

- Volunteers recruiting and training deficiency : not only it limits the expansion of programs, but considering the budget of our association, volunteers investment for production of documentation is the only viable organisation solution.
- Size of programs : schools are dispersed around the country, volunteers availability needs to set up for a local logistic centralised thanks to the Internet.
- Fear from the teachers : they hesitate to engage such activities for which few of them were trained and none of them had the opportunity to practice ; it is completely opposed to institutional wishes aiming to develop technical activities.

- Low rate of successful launches : we are less experienced in rockets than in balloons at school and we're concentrating our efforts to define the best materials to be used by youth for they overcome launching physical constraints.

Besides the regular growth of involved schools, our efforts are concentrated on strengthening UFAC program, setting up new training tools spread over the Internet for our volunteers and also developing of a forum that could develop connections between schools.

Conclusion

ANSTJ is an association whose ambition is to contribute to the development of scientific and technical cultures towards youth using pedagogic methods based on experimental uses and introduction to project management. To reach its objectives, ANSTJ leads numerous programs, more particularly in the space domain with the help of CNES and local communities. Altogether we propose youth from primary school to high school and also to their teachers, the opportunity to achieve an experimental basket (UBPE) or a rocket (UFAE). These programs are carried out by volunteers with specific training and managed by wage-earners of the association.