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50 YEARS OF SPACE EDUCATION AND OUTREACH IN FRANCE WITH PLANÈTE SCIENCES AND CNES

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ABSTRACT

In 2012, the French association Planète Sciences and CNES are celebrating 50 years of space education and outreach in France. The foundation principle of the association is to bring youth to develop skills that will complete their academic knowledge, and facilitate their integration in the professional world. When youth must deal with the constraints of space-like systems, they experience the management of a multiple-domains project. The evolution of the space outreach activities offered, in France, to younger generations, from primary school to post graduate curriculum is presented in this paper. Starting with Safety as a motivation, the space outreach offer grew step by step with more vectors, with the establishment of international collaborations and the development of new programs to bring space science to a large range of public. CNES promotes the usage of space for the benefits of the planet Earth. Planète Sciences promotes sciences through space-related outreach activities. Together, they raise younger generation's awareness and bring them to eventually embrace a career in programs connected to space.

1-INTRODUCTION:

1.1 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 thematic 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 organizes events or competitions such as *Eurobot* and *Eurobot Junior* [2], *First Lego League*, *La nuit des étoiles* (the night of the stars), *C'SPACE*, the national rocket launching campaign [3]

1.2 CNES, the French Space Agency, was founded in 1961. CNES is the government agency responsible for shaping and implementing France's space policy in Europe. CNES motivations are partly powered by the dream to explore space for scientific discovery and to break the frontiers of knowledge. To maintain and grow this dream, CNES has developed training and knowledge transfer programmes about space and society, targeting youth and their educators. CNES is partnering with organizations, among which Planète Sciences, to implement activities throughout the country (metropole and dependencies).

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 Scientifiques*" (ANCS), today's Planète Sciences.

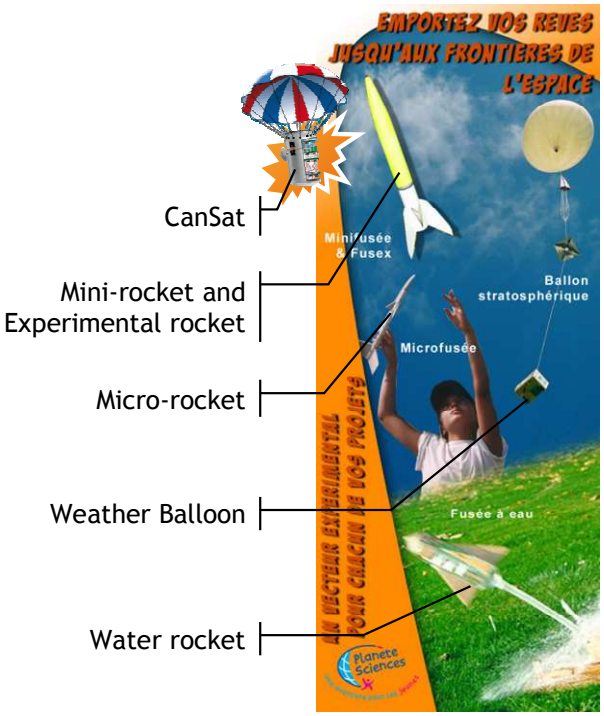

Fig.1: Space activities at Planète Sciences

Influenced by the professional background of its creators, who were members of the industrial world (Matra, now Astrium), 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 team work,
- 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- SAFETY AS A MOTIVATION

Sputnik, the first man-made satellite, orbited around the Earth in 1957: as everywhere in the world, this was a trigger for French scientists and politics to explore new spaces; but not only them: groups of young people formed into aerospace clubs, with the same passion as their peers but with far less means. Especially, they developed their activities beyond the dangers of firing their home-made propellers, less reliable than those developed by professionals, to launch their rockets.

From that stage, supervision from the nascent French Space Agency marks the foundation of ANCS (*Association Nationale des Clubs Scientifiques*) in 1962 which evolved into ANSTJ (*Association National Sciences Techniques Jeunesse*) in 1977 and renamed *Planète Sciences* in 2002.

Planète Sciences holds an accreditation from the French Ministry of Youth and Sport and is the reference contact point in France for space activities with youth.

In this context, as of 2012, CNES is responsible for the set-up, launch and flight safety, including pyrothechnic matters, of amateur experimental rockets.
Planète Sciences is responsible for the set-up of water rockets, micro-rockets, mini-rockets experimental weather balloons, and CanSats.
Documentation is produced by Planète Sciences: it covers the security of the activities and is submitted for validation to CNES that engage its responsibility.

3- VECTORS TO REACH SPACE

Young space explorers are offered to experiment and get hands on projects with vectors ranging from Micro-rocket to Experimental Rocket and also Weather Balloon, CanSat, Parabolic Flight [6] and in rare occasions in CubeSat or Space station. Projects are performed within safety constraints and come along with pedagogic and technical support. Volunteers from Planète Sciences visit the school or club teams to review the project progress several times during its lifetime. Projects involve teamwork and the development of management and experimental processes. They are made available to the widest and most popular range of participants and are the most important space outreach programs in France. Planète Sciences is managing programmes, trainings, workshops, club projects in France and beyond.
Historically, everything started with Experimental rockets.

3.1 Experimental Rocket [4]

When a team is willing to start a rocket project its first step is to make contact with CNES through Planète Sciences. The three parties are bound by a moral contract, which may be summarized as follows: the tuning of a rocket engine is very dangerous for novices and this practice is prohibited by national regulations; alternatively, clubs are invited to design and build a rocket for which CNES provides with both a professional quality powder engine and the launching facilities.
On its side Planète Sciences organizes technical assistance, the launching campaign itself and ensures that the activities fall within the European regulations.
The efforts of the team are thus focused on their mission which is the experimental content of the payload and the mechanical structure of the rocket.
The set up of the propeller and the rocket launch are the responsibility of a professional pyrotechnician from CNES.

Since 1964, when the first launch campaign was organized, size and thrust of propellers have evolved in many ways. Former members of ANCS remember about rockets reaching altitudes of several kilometers. In 2012, a typical experimental rocket measures 2 meters in length, weighs about 10kg and reaches an altitude of about 1500 meters.

Fig.2: Experimental rockets: 1966 - 2011

About twenty rockets of that type are built and launched every year by club members from 14 to 25 years old. They come from regions across France, and also from foreign countries as far as Japan.

3.2 Micro-rocket [4]

Eager to propose space outreach to younger generations, this vector was introduced in France from 1968. ANCS members joined the World Expo in Montreal and discovered the micro-engines: they were imported from the USA and quickly qualified in France and later supplied from Eastern Europe manufacturers. Regular workshops started in 1973.

The Micro-rocket brings youth to make a first step towards space. Micro-Rockets are usually built during workshops; they are well developed in France under strong safety conditions, and are proposed from 7 years old.

Fig.3: it takes a few hours and little material to build a thrilling micro-rocket

Micro-rockets, propelled by A, B or C motors (from 2.5 to 10 N.s), are mainly made of cardboard, measure from ~15 cm to ~40cm and can reach 200m high with a 200km/h lift off speed before falling down under a parachute.

During a couple of hours-long workshop youngsters are brought to design and manufacture their first rocket and to learn the basics of aerodynamics, flight stability, propulsion and safety procedures; they also discover simple building techniques.It is the ideal vector to experiment and understand what makes a rocket stable and fly straight up.

Kids are given the chance to handle tools such as glue gun or drill and raise them with more responsibility. Because safety is Planète Sciences activities' golden rule, micro-rockets motors are not part of any experiment. They are supplied from an approved manufactured, retailed by Planète Sciences and are launched by and certified adult (18 and above). The micro-rocket certificate (*agrément microfusée*) can be obtained from Planète Sciences after successful attendance to a 25 hours training session. The training deals with manufacturing, rocket flight, stability experimentation and evaluation, safety rules, launching campaign organization and pedagogy. Trainees are given a 75 pages reference book gathering knowledge about propulsion and stability, safety, manufacturing techniques (basic rockets, multi-motors or multi-stage rockets, ignition box) and pedagogy (experimental process). Trainees then master the fundamentals to hold workshops and launch rockets in safety conditions with kids. Each year, about 50'000 micro-rockets are launched in France: more than a million since 1980.

3.3 Weather Balloon: experimenting near space

The first ANCS experimental balloons were released in 1968, in Mourmelon: they were made of un-expandable material. In 1975, a dedicated summer camp was organized to design and build experiments for stratospheric balloons. In the end of the 80's, payload spaces were offered by CNES to scientific clubs, onboard the professional scientific basket lifted by open-hydrogen balloons. But it's not before 1992 that the weather balloon became a standard vector offered to a wide public of students and

scientific clubs, with the kick-off of the programne “Un Ballon Pour l’Ecole” (a balloon at school) conducted over a school year [7].
The weather balloon raises 30km above the ground, above the planes ceiling and high enough to observe the round shape of the Earth.

Fig.4: A few hours from ground to capture data in the high atmosphere from the balloon

This vector allows studying the different layers of the atmosphere and its characteristics, to perform remote sensing, land recognition, image processing and other rared-atmosphere experiments. The weather balloon is the ideal vehicle to answer questions such as: “what happens so high in the sky?”, “is it more hot or more cold over there?”, “can birds breath and fly so high?” The youngsters raise assumptions and set up experiments to obtain answers. Experiments are placed onboard a basket hanging from the weather balloon.
A dedicated telemetry transmitter, called KIWI, is provided by CNES for the young space explorers assess their first results.
A reference document called “Cahier des charges” describes the technical constraints baskets should comply with to be compatible with legislation and the loan of collective equipment. Other documents develop several specific technical aspects: flight mechanism, atmosphere properties, telemetry and methods for project management. These documents are written with great care: to be as clear as possible in order to be understood by youth themselves; they are regularly updated taking into account remarks or technology and regulation evolutions. In relation with the documentation, the following equipment is made available by CNES to the teams: a weather balloon envelope, a radar reflector, a parachute, an helium tank, a suitcase containing lift-off equipment and if requested by the project, a KIWI telemetry receiver set.

3.4 Mini-Rocket: the intermediate launcher

Mini-rockets have emerged in the mid 80’s as an intermediate vector in between micro-rockets and experimental rockets. Initially the vector was derived from antihail rockets: the commercial propeller was reused and qualified for the purpose of pedagogic projects. Later, dedicated propellers were developed (named after cervids: *Dick-Dick, Koudou, Cariacou*). The mini-rocket design constraints and controls methodology got inspired from experimental rockets.
The main experiment however is to imagine and to build a way to extract the parachute at flight’s apogee. But mini-rockets can also be fitted with acceleration sensors, sun detection (to deduce the rotation of the rocket)…
Before flight, a typical mini-rocket weights 1 kg and measures about 50 cm, with a 500 m altitude reach; the slowing down system must be deployed in order to make it land safely. The ascent lasts generally 20 seconds and the fall may last a minute or more. The flight is stabilized thanks to 3 or 4 fins located at the bottom of the rocket. Initial acceleration is about 10 G. Mini-rockets are made of PVC or even cardboard and are designed according to aerodynamics constraints [6]

Fig.5: From micro to experimental rocket: the mini-rocket is proposed to clubs as an intermediate step

Mini-rockets are proposed as part of a programme [7] similar to *Un Ballon Pour l'Ecole*, and since 2010 they are involved in the Rocketry Challenge, described in a further section.

3.5 Parabolic Flight: the un-planned Zero-G student flights Development

Guy Pignolet recalls: at a point sometimes in the late 80's, Jean-Pierre Haigneré was invited at the launch campaign in Mourmelon to give a conference about his cosmonaut experience, and also about micro-gravity flights aboard the "Zero-G" Caravelle aircraft for which he was the lead pilot. At the end of his talk, he offered to take two ANSTJ club members to make a Zero-G experiment in November later the same year. It was to be a one-time offer. Two of the club leaders conceived a simple experiment and made their own schedule and travel arrangements, including a briefing day in Toulouse shortly before the fight. A week or so before the meeting they received from CNES a note telling them a paying passenger from a Japanese research lab was to take their place, sorry, but there would be a later occasion, sometimes. The two young experimenters said they already had take a day off and bought train tickets to come to Toulouse, could they attend anyhow, just watch and listen, to gain a little bit of experience in their preparation. That was agreed, the meeting went smoothly, and when the organizers saw they had some time left before lunch, they told the ANSTJ's boys: "You are not going to fly this time, but anyhow, can you briefly describe your experiment?" So they did, and everyone went for lunch. While eating, one of the organizers asked: "Your experiment is simple and small, could you run it while staying in the seats which are used at the back of the aircraft during take-off and landing, so you would not need to use any floor space?" They responded positively, and the next thing they heard was "Then OK, we'll take you on the flight". The student participation in the Zero-G campaign went very well, and as a result ANSTJ was offered to fly experiments in the back seats on every flight!

Fig.6: winning a seat to experiment in micro-gravity: they did it!

A flight campaign is basically a set of 30 parabolae, each of them providing 22 seconds of microgravity.

Initially, Planète Sciences provided assistance to youngsters (from 15 to 30 years) in the preparation of their project while CNES provided assistance during the flight. From 1992 to 2002 about 10 projects have been tested in micro-gravity, and 12 youths have taken part to parabolic flights and enjoyed the

feelings of evolving freely in the plane cabin out of gravity. Experiments mostly dealt with physics, such as:

- Dynamics of a marble,
- Test of a mass measurement device
- Behavior of fishes in aquarium,
- Oil and vinegar separation by centrifugation,
- Movement of soda bubbles
- Heat transfer in a fluid

Later CNES handled the student projects directly, as part of the programme *Parabole*, with the support of Novespace the company responsible of the Airbus A300 ZERO-G plane maintenance and flights campaigns. Every year, CNES offers to 3 university student teams and 3 high school teams, the possibility to fly an experiment onboard the A300 ZERO-G.

3.6 Water Rockets: the most simple but one of the youngest vectors

Water rockets developed in the 90's: they are cheap, easy to build from soda PET bottles and easy to launch. Because it is not under the control of any regulation, Planète Sciences developed documents to ensure safety, but also to highlight the pedagogic interest of this tool. Like other countries in the world, water rocket workshops are proposed by Planète Sciences to bring kids to discover about space, sciences and techniques through the excitement of a simple jet of water propelling their rocket in the air.

3.7 CanSat: the latest and the smallest vector

From the late '90s, space discovery reached a new stage 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 for extra-terrestrial activities, but revealed the extents of the missions that could be achieved with a rover or a probe. Planète Sciences had 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 [8].

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 launch campaign organized by CNES and Planète Sciences [4] demonstrated "quasi-sat" experiments from 2006 [9], with up to 3 modules released from a single rocket.

Fig.7: In France CanSats are dropped from a static balloon

During spring 2008, a small delegation of CNES and Planète Sciences was invited to assist to the International CanSat competition organized by LEEM in Spain. This event was the beginning of the CanSat story In France. The CanSat initiative in France, proposed by CNES and Planète Sciences, has two goals:

- To propose to Youth a project linked to space probe, another vector to explore space, beyond rocket.
- To trigger motivation of Youth, by proposing a competition-based approach.

CanSat France is further developed in section 5 of the present paper.

3.8 Microsatellite

At a time when CubeSat or NanoSat were not as developed as they are now, CNES supported the development of microsatellites that were launched onboard the European launcher Ariane.

The project *Thésée* was prepared by le GAREF Aérospatial and launched in 1980.

The Project SARA (Satellite Amateur Radio-Astronomique) was prepared by the engineer club ESIEESPACE in Noisy-le-Grand and was launched on 17th July 1991 onboard Ariane IV (V44). The 26 kg, 0.34m cubic satellite carried a radio astronomy experiment designed to survey radioelectric emissions from Jupiter at frequencies between 2-15 MHz. These frequencies can not be observed from the Earth, as they are blocked by the ionosphere. These measurements are of great scientific interest, and reflect phenomena occurring deep in Jupiter's magnetosphere.

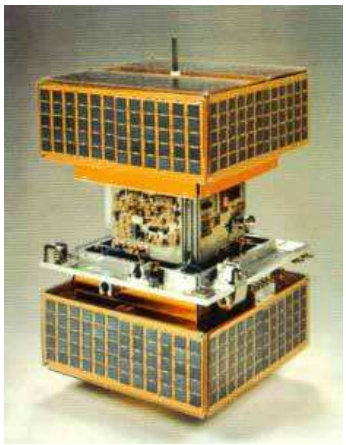

Fig.8: SARA, a student microsatellite well before Cubesats and Nanosats

SARA has been completed with very low funding. The total cost of this project is 3,244 KF (about 0.6 M$) launch included. It has been done thanks to the CNES, Matra (now Astrium), Dassault Aviation, ANVAR (now OSEO). The core team of the project was composed of 4 members, who had 5 years experience with experimental rockets and stratospheric balloons [13].

More recently, CNES provided technical and financial support to the University of Montpellier to develop the nanosatellite ROBUSTA (Radiation On Bipolar University Satellite Test Application) that was successfully launched on VEGA's launcher Maiden flight, on 13th Feb 2012 [14]. During the preparation of the project, students experimented onboard the A300G.

3.10 Space Station

Youth experiments in space stations date back to 1971, with a contest opened to American high school students. Among 4000 proposals, 14 were selected to be tested onboard Skylab in 1973.

In 1988, leveraging Aragatz mission on Mir space station with the French spationaut Jean-Loup Chretien, a set of simple modules has been developed by members of CNES and ANSTJ to visually demonstrate zero gravity in space. Videos shot in the station have been further distributed in schools, as pedagogic material. In 1992, mission Antares, Michel Tognigni performed experiments live at the request of school pupils recorded on video tape. For the mission Cassiopée with Claudie Haigneré in 1998, CNES worked at enhancing meals of the spationauts by inviting a hospitality school to prepare a set of dishes compatible with space station constraints. The French spationaut also manipulated

experiments prepared by high school students.
Watching the video recorded in the space station or space shuttle reveals the spationauts really enjoyed experimenting on behalf of youth. If the experiments may seem very basic, they however form real pedagogic material for schools. As for example, during the mission Altaïr in 1993, high school students proposed Jean-Pierre Haigneré to screw a bolt into a nut…but he could only revolve around them because he had no support to lean on: that was a brilliant and evident demonstration of a simple task in exceptional conditions.

4- INTERNATIONAL EXCHANGES

4.1 From ANCS to Youth & Space

Jean-Claude Guiraudon recalls: in 1969, the year Neil Armstrong first walked on the moon, the mayor of Poitiers (France) decided the theme of the European Christmas that he used to organize for a few year now, would be "space exploration". The idea was to gather two to three young member of each country member of the EU and beyond. *Le Palais de la Découverte* (Science museum in Paris) was contacted to setup a delegation to represent France. ANCS was the main member of the *Federation des Clubs Scientifiques* that was hosted by the museum: soon ANCS formed a delegation composed of Guy Préaux, Lionel Lescouzère and Hervé Moulin.
The idea to form a European association emerged during the gathering in Poitiers and was quickly adopted by the president of ANCS, Pierre Quétard, who convinced partners, le Palais de la Decouverte, CNES –with Michel Bignier, the Ministry of Youth and the CIC ONIG, (an organization affiliated to UNESCO that later became MILSET), to support the initiative. Then started a tour of Europe: ANCS members, supported by Gilles de Boisgelin, the delegate for Space Affairs at the Ministry of Foreign Affairs, visited several Eastern Europe countries to federate members for the future association.
End of February 1972, Hervé Moulin and Hervé Tétu organized a European Congress for Youth and Space. It was held within the facilities of INJEP at Marly-le-Roy near Paris. Representatives from Belgium, Yougoslavia, Netherlands, Germany, Egypt, Canada, Italy, Spain, Romania, Sweden, Denmark, Norway, USA and USSR with the remarked presence of Youri Krounov, the first cosmonaut to transit from a spacecraft to another in 1969 (from Soyouz 4 to Soyouz 5).
Youth & Space (Y&S) was born: the first international association of youth for Space. It was hosted in Paris, under the governance of CIC, with Henri Lips from Netherlands as president.

4.2 Youth & Space: a real association throughout Europe, well before the political treaties

Eric Shmitt recalls: from its birth in February 1972 at Marly-le-Roy, and through the years, the association Youth and Space Association has built a tangible European structure to support and develop bi-lateral and even multi-lateral experimental rocket projects cooperation. Y&S provided assistance, technical reviews and organized regular conferences (Belgrade 73, Madrid 75, Wuppertal 76, Tunis 77, Eindhoven 78, Beaumont 79, Roskilde 81, Autrans 83, Brest 89 and Noordwijk 91) and seminars with themes as various as education, program development, security, launch campaigns, propulsion.
During the Eindhoven conference in 1978, Y&S has established working groups, thus promoting its operation outside the conferences; they dealt with: pyrotechnics, trajectory calculations, on-board experiments, electronics, recovery, test-benches and safety but also new directions for Y&S. The

outcome of the working groups was delivered from 1979 onwards in recommendations and technical booklets. Coordination between local clubs and national associations was also strengthened. For several years, national launch campaigns were regularly organized in several countries.

To celebrate its 10th anniversary, Y&S organised the first European Launch Campaign (ELC) in October 1982 in Valdahon (France) with significant support from CNES [10]. For the first time, 45 members from 7 European countries worked together, with a common language that was not theirs to organize land coordinate the launches of 12 experimental rockets. The event gathered 250 participants.

This campaign was a technical and human success. However, minor incidents without consequence, thanks to safety procedures that were set-up, motivated the working group dedicated to launch campaigns to harmonize safety procedures, to help and bring national associations and clubs to improve the safety level during their launch campaigns ; worst case, they were invited to join foreign launch campaign to enjoy safer launch conditions. The working group monitored 12 campaigns in 5 countries and published control procedures and safety recommendations taking into account the economic and technical realities of the various members of Y&S. To certify the quality of these campaigns, a label based on the main safety rules was implemented in parallel with the preparation of the second ELC in Skillingaryd (Sweden) during July 1986. This campaign didn't require much funding but those from the clubs and associations for their projects. CNES offered the transportation of the material. Most of the spendings were covered by the registration fees and the total budget for the second ELC didn't exceed 8000 Euros.

Publications called "Impulse" (from 1980 to 1984) and "Youth and Space Newsletter" (from 1989 to 1992) accompanied the works and these achievements.

All these activities were entirely conducted by volunteers, in a spirit of openness, cooperation, with extremely rich cultural exchanges: Cophenhaguen's Carnival, Roskilde's festival, visit of the Rijk Museum in Amsterdam, of the Deutches Museum in Munich, of the Palais de la Découverte in Paris, of the BD fair in Charleroi, and also trekking in the Mount Blanc area or in the Pyrenées; not to forget the discovery of regional culinary delicacies, always very much appreciated…

During these years, Y&S was ahead of the construction of Europe. Accommodation was provided by in the members in Eindhoven, Haarlem, Alblasserdam (Netherlands), Sivry, Gosselies, Gilly, Charleroi, Heverlee, Beaumont, Deinze, Boils (Belgium), Udine (Italy), Paris, Strasbourg, Neubois, Sarcelles, Argentière, Toulouse, Ramonville (France), Zagreb (Yougoslavia), Vanløse, København (Denmark), Wuppertal (Germany), Braas (Sweden) when we held our working groups meetings or the Steering Committee meetings. Often coupled with cultural or festive events, these meetings favored conviviality, knowledge sharing and understanding of each others. Sharing our experiences, our working methods, our lifestyles enriched our know-how, our experience about working together, much more beyond the simple technical cooperation and the exchange of data.

During the second ELC, 2 English, 8 Belgian, 13 Danish, 10 French, 15 Dutch, 1 Norwegian, 10 Swedish and 1 Yougoslav nationals worked in entire coordination and safety, in a truly European infrastructure. They

successfully launched 9 experimental rockets from 5 different countries: this successful achievement gave the hope for a serene future.
Leveraging the forward move of Y&S, an ambitious Europrojet was initiated: it was catalyzing the energies and talents of the clubs to reach the limits of space. Summer camps were organized in Spain, Belgium and Greece, data about all available information related to launches in Europe were gathered; researches about more efficient propulsions modes and involving less dangerous manipulations were pursued (propellers based on alternate of fuel and combustive elements, hybrid propellers…)

Fig.9: Youth & Space: team work and conviviality without borders

However, the existence of Y&S could not be maintained despite its formalization in 1987 and multiple attempts to structure it, to fit in the administration standards and to adapt to the policies required to receive European subsidies. It must be said that the interest of Y&S members was more on the field rather than on the promotion of the activities in the administrative organizations. Due to diverging political and economic interests, European agencies could only sporadically support Y&S, pioneer in kind and with an achieved ideal of an international union without borders of languages and cultures.
It remains that this European adventure marked deeply all those who attended. Launch campaigns still take place in Netherlands, in Belgium, and of course in France. An adventure that has forged unalterable relationships and has contributed to make amateur rocket launches more secure; that demonstrated that cooperation around a common objective was profitable to all the participants; and that Europe could exist across the citizens despite the constraints and the competing interests of each of us.

4.3 1992: the International Space Year
Beyond Youth & Space's ELC in Oldebroek (Netherlands), CNES and ANSTJ invited foreign countries to a set of activities, including the French launch campaign, in the frame of International Space Year (ISY). Several educational activities were proposed in and around Mourmelon, in the vicinity of Reims, in July 1992:

- A seminar for educators
- An international Youth Camp, hands-on for youth from several countries. They discovered technical skills and the main aspects of the philosophy developed for decades by ANSTJ in France for space activities: team work, project organization, experimental process…
- a World-Wide Launching Campaign (WWLC) gathering space clubs from France, Canada, Japan, the United Kingdom, Germany, Belgium, Netherlands to launch more than 20 experimental rockets and a few stratospheric balloons.

This program jointly conducted by a European steering committee composed of members from ANSTJ, CNES, ESA and the Hermann Oberth Society (Germany).
The WWLC was organized by CNES and ANSTJ in a manner similar to the usual French campaigns, especially with regards to the safety procedures; in addition, all the roles of the operations ground staff were held by a duo

composed of a skilled and a new (still untrained) participant.
The most remarkable outcome of the WWLC, were durable contacts with Japanese and Canadian teams: they joined the French launch campaign during the following years. The province of Québec, Canada, saw a burgeoning of space clubs far into the 1990s, even allowing some experimental rockets local launches. The Japanese team, originally from YAC-J (Young Astronauts Club Japan), eventually became independent formed several clubs. While no launching solution could be settled according to the Japanese regulations, Japanese clubs have become regular participants to the French campaign since 2005: with 2 to 3 projects launched each year [4], [9].

Fig.10: WWLC, the start of a long series of Japanese rockets in the French campaigns

4.4 The Japanese Odyssey of *Mizu-Rocketto* (Water rockets)

Guy Pignolet recalls: the highlight of the years of the launch campaigns in Mourmelon, was the 1992's WWLC. Kenji Ogimoto, a lead engineer at Kawasaki Space Systems, and a great all-time space educator was leading the Japanese team. We had seven activities in parallel in Mourmelon, including an educator's seminar, conferences, and exhibitions. A British manufacturer, Hinterland, came with a strange gadget-like "water-rocket" called a "Rokit", some 20-cm high, which you would fill half-way with plain water for reaction mass, and put on a small hand-held air-pump with a sealing ring and a lock. After a few strokes to put energy in the rocket, a trigger was pulled and the rocket rose about ten or twenty meters high. It was fun and everyone enjoyed the demonstrations. Kenji Ogimoto took the idea to his space-club in Kakamigahara, near the city of Gifu, and quickly turned it into a powerful educational system. With the contribution of all the chapters of YAC-J, it took only a few year before "mizu-rocketto" (water rockets) became a nation-wide success in Japan, with regional and national meetings gathering hundreds of participants. Eventually the success spread worldwide, including back to France and Planète Sciences. This is how the Mourmelon "toy", after growing and maturing on the rising sun side of the planet, has eventually become the experimental backbone of kid's education to space propulsion all over France.

Leveraging the successful establishment of water rockets as an educational tool in Japan, and as part of the APRASF group, the Space Education Programme Coordinator of UNESCO worked with the excellent educators' material produced by JAXA to propose this activity throughout developing countries in Asia Pacific [12]

4.5 French-Russian space cooperation: youth too

Since the first cooperation agreement decided by General Charles De Gaulle in 1966, France and Russia have combined their space expertise for lunar exploration, human spaceflight and launch vehicles.
In this context, and to celebrate the 50th anniversary of the first flight of Yuri Gagarine, students from the Aerospatial University of Samara have built a miniature replica of Soyouz and successfully launched it during C'SPACE 2011 in Biscarrosse.

4.6 Other international connections

CanSat opened the door to more foreign participation to the activities offered by CNES and Planète Sciences: clubs from Australia, Austria, Iran, Turkey, Russia and Spain, joined CanSat France.

It is also important to note that beyond Europe, North America, Russia and Japan, other countries, especially in Africa, had (and still have) interest and fascination for space. Tunisia joined Youth & Space and also hosted several members of ANSTJ and Planète Sciences to receive trainings and support to launch rockets or weather balloons on its territory. In South Africa, space activities for youth have been continuously proposed, with the support from the French Embassy, at Scifest Africa, the national Science Festival since 2001 [11].

5- NEW PROGRAMS TO REACH OUT A LARGER PUBLIC

Space activities are usually considered to be an elite domain restricted to a few number. At the same time, they are powerful educational tools. For these reasons, CNES and Planète Sciences promote the gathering of youth in clubs to build a projects; they continue to develop programs to reach out a larger public.

5.1 Festiciels and C'SPACE

If safety is the triggering point of the amateur space activities in France, rocket launches must be organized to host participants and potentially visitors. Planète Sciences sets up the launch facilities depending on the needs of the clubs. Regional launch campaigns called *Festiciel* are organized for mini-rocket and weather balloons: a festive event where the public is also invited to enjoy water rockets, micro-rockets and other short outreach activities related to space.

For experimental rockets, the national launch campaign takes place in the heat of summer under the supervision of CNES, and the assistance of the army who provides the facility. The national campaign took several forms over the decades, and is called C'SPACE since 2009 [5]. From the launch pad to the details of accommodation, everything is arranged to host about 30 mini or experimental rockets and more than 300 young amateurs, either club members or volunteers in charge of the organization. C'SPACE is made possible thanks to the involvement of the large number of volunteers (more than 40) and the trust of CNES authorities.

Professional pyrotechnicians and ground safety managers from CNES assist the volunteers. CNES funds the launching campaign and supports the development of student space research programmes, such as PERSEUS for nano-satellite launchers, or CanSat.

Fig 11: Launch campaigns locations through the ages

5.2 CanSat France

CanSat France started with demonstrations in 2008 and turned into a competition in 2009. It follows the same principles as the international competitions organized in the USA, in Japan, in Spain, in Norway…

- Presentation of the mission before setup and mission debrief afterwards.
- Standard CanSats volume is 330ml

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

- CanSats are released at 150m high from a static balloon.
- An "Open Class" category allows larger experiments: up to 1 liter volume.
- 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.

For practical reasons, CanSat France so far took place during C'SPACE.

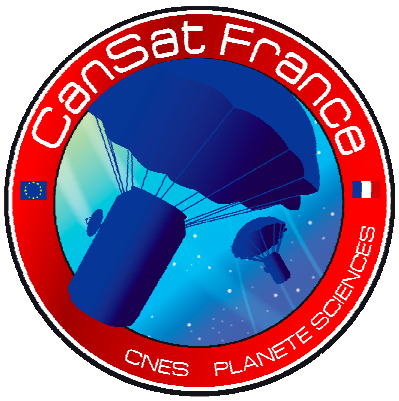

Fig 12: CanSat France hosts competitors as far as Russia or Australia

The competition is opened to university students from France and overseas, Registration is opened from November 1st until December 31st and the competition takes place end of August. A dedicated set of missions is issued each year, where proposed and imposed missions are described.

The specificity of the French competition comes from the fact that CanSats are not released from a Rocket but from a tethered balloon. This for sure reduces the released altitude but offers a bigger chance for the CanSat to survive before starting its mission. In addition, this makes the competition possible within the perimeter of a football field, over a single day.

5.3 *Un Ballon Pour l'Ecole* (UBPE), *Une Fusée A l'Ecole* (UFAE)

These programmes for the development of balloon and rocket at school in project mode started in 1992 and 1999 respectively [7]. Documentation is provided to the school groups to help them conducting the entire project throughout a school year typically. As part of the programmes, 2 to 3 technical reviews are provided by the members of Planète Sciences. Balloons are released from the school grounds or a nearby football-like field. Rockets are launched during ad'hoc campaigns or during *Festiciels*. Yearly, about 100 balloons and 120 rockets in average are released as part of these programmes.

5.4 Summer Camps

Soon after the establishment of ANCS, summer camps revealed to be a convenient frame to work on rocket project: material and resources being available all at the same place, in a friendly and collaborative environment, usually close to the launch field. Quickly other themes were proposed to the participants, such as Geology and Astronomy (1967, first international summer camp). Since then, summer camps are proposed every year by Planète Sciences, during school holidays. Creativity and imagination of youth from 8 to 18 years old are stimulated on the theme of science, together with sports activities and cultural discoveries.

5.5 *Espace dans Ma Ville* (EMV)

The programme called Space in my City [12] has been initiated in 2005 by CNES that was willing to reach youth from underprivileged areas. A pilot has been carried out during the summer months of 2005 within 5 French cities. Having met a wide success, the operation has existed since then; since 2007,from 10 to 20 cities in France host Space in my City during spring, summer and autumn schools holidays (from April to October). 5700 participants were reached during the 2011 edition.

Fig 13: Space in my city: bringing space activities to unprivileged areas

The programme is aimed at youngsters who live in underprivileged areas of large cities, who are usually not exposed to science and technology. The objectives of the initiative are:

- To contribute to help the youngsters from deprived areas to find their place in Society.
- To boost their city and neighborhood's image
- To encourage long-term local initiatives for scientific activities, with a focus on Space topic
- Making science something they can enjoy

Space in my City is a week-long programme of events and workshops dedicated to science and space in underprivileged areas of cities. Lone youngsters or youth groups from social centers are welcomed by leaders under light open tents installed in their area. An indoor wide space, "the Space media center" also welcomes youngsters who want to learn on their own, discover an exhibition, watch DVD or CD-ROM…

Specifically for this programme, Planète Sciences developed new sets of workshops and extended the range of space activities traditionally covered, leveraging other topics developed at Planète Sciences. As a result, more than 15 different activities, short or long, simple or complex, are offered to youth, such as:

- Build a mars rover: build a robot capable of moving and avoiding obstacles.
- Build your satellite: wear clean-room gears in order to assemble your satellite from building blocks: bus, antenna, solar panels, and experiments modules…just like real engineers.
- Space and meteorology: understand what the satellite images of Earth tell us about weather, topography....
- A giant fresco visible from space: "draw" a fresco on the ground from 3x3 meters pieces of cloth - is it visible by Satellites?
- Satellites to save the Earth: to better understand the purpose and role of space-based observation of the Earth
- Train like an astronaut in the pool: get prepared for your next Extra Vehicular Assembly in conditions approaching zero gravity.
- GPS Rally: understand about the principle of satellite localization, about latitude and longitude notions, and how the GPS system works.
- Discover the stars: under the inflatable planetarium, sky watchers learn about stars and constellations
- Build your solar system: discover the specificities of the planets as you build at-scale models of the planets - learn about sizes and distances.

Not to forget Micro-rockets, Water rockets and Weather balloons.
A festive conclusion is organized by the participants, where they present their project and creations. A final presentation is organized in Paris: a delegation of participants promotes their experience and projects to officials at the French Parliament.

5.6 *Espace au Fil du Fleuve* (E2F)

Space along the river, kicked off in 2008, is an informative educational mission aimed at schools in French Guiana, on Space exploration and applications and their contribution to daily life.

Fig 14: Space along the river: space outreach has no limit

The concept of this unique programme takes into account the specific geographic, cultural and linguistic environment of the territory. The activities are specially designed for educating students in schools, and getting them to practice French. Onboard a pirogue for reaching inaccessible areas, facilitators from Planète Sciences propose workshops to pupils and train other facilitators from the Guiana educational authority in order to further the development of local, far-reaching initiatives involving scientific and technical activities, workshops for making scale models of rockets, satellites, exhibitions and initiating students to astronomy. The target public includes children from nursery school to junior high school, including junior high schools and primary schools for a total of 1700 participants in 2012.
If Ariane, Soyouz and Vega are launched from the modern Kourou, space along the river brings the space dream to the population living in rudimentary conditions along the rivers of Guiana: Haut Maroni (2008, 2011), Oyopack (2009, 2012), Bas Maroni (2010).

5.7 Activities in Prison

Reaching out all types of publics is a challenge that Planète Sciences is always ready to address. As for example, the astronomy division imagined a programme dedicated to blind kids. For instance, the space division brought space activities to a prison, to offer a virtual escape to young inmates.
Samüël Kauffmann recalls: In France, school education is mandatory for inmates up to 16 and teachers deliver customized lessons that match the level of the imprisoned pupils. Aside, dedicated educators propose projects to help social a professional integration of the inmates, by the mean of pedagogic activities. In this context, Planète Sciences' branch in Picardie was invited to propose science and technology workshops. Further to a brainstorm, the weather balloon was unexpectedly selected; but because it offers a wide range of experimentation and also because it involves many skills and techniques, it fit well to the expectations. But probably the most convincing argument was the symbol of evasion represented by the balloon escaping the prison with experiments built by the inmates: could it represent their future? Could the expected success of the project be the first of a long series in their life on the other side of the metal doors? Could the balloon, retrieved by unknown people from the outside world

testify of the will from the young prisoners to integrate the society?
Even though the teenagers were not inclined to evolve in a scientific environment in the future, the presence of the science communicators was received as a bubble of oxygen while inmates get quickly bored inside the prison: the project was a good reason for them to exit their cells. They were learning things, gaining confidence in the learning process; they were facing problems to overcome, in group, thus developing more respect for the other members.
Lectures about space exploration and its stakes were given and the Dr. Vladimir Plester from ESA visited the group: discussion revolved around the concept of confinement: in prison, in a space station, in an asylum.
If the experiments prepared were rather basic, the same type as those generally prepared by primary school pupils, the skills of the inmates were better demonstrated with the preparation and decoration of the basket containing the experiments. The challenge was however met: to complete the project, within 2 months, with integration of the balloon project in the lessons from the teachers.
The balloon was released on April 14th 2011, and was still not recovered so far [20]. Young inmates stay for 3 months in average. Since then most of the participants left the prison.
The teenagers seemed to be interesting by the entire programme and as delinquent they can be, they proved to be fascinated by the theme of Space. They showed pride in their achievement.

The passion of Planète Sciences' members for space education, together with their technical knowledge for such project overcame all the gates placed in front of them to make this experience a memorable success, a life experience, and to bring hope and evasion to youth confined in the prison. If this operation was rather unique, it could be reproduced on demand.

5.8 Argonautica
Argonautica is an educational project, aimed to capture interest middle and high school students, with remote sensing data. Moreover this project includes, curriculum-oriented activities to improve environmental and ocean literacy, and get to know the role of ocean observation satellites [16] [17].
Argonautica consists in 3 parts:
- **ArgOcéan**: to track buoys drifting in the major ocean currents (Gulf stream, Antarctic Circumpolar Current. . .), thanks to ARGOS system, and to compare their routes to marine current charts derived from JASON satellite data. It also brings participants to understand the relation in between oceans and climate.
- **ArgoNimaux**: to follow the world's great animal migrations routes (penguins, albatrosses, leatherback turtles. . . which are fitted with ARGOS transmitters) and to study, with the help of scientists, aspects of the animals life, conservation status, food web. . . and connections to ocean processes and remote sensing data (JASON. . .).
- **ArgoTechno**: to design, built and exploit the results of a buoy equipped with a satellite tracking device.

The project involves collaboration with scientists and maritime professionals who release the buoys. Pedagogic support is also provided by the mean of multimedia documentation, maps, and suggestions for studies. At the end of the school year, participants meet in La Rochelle's Aquarium to share their experience and results.

Argonautica was started by CNES in 2000: 2 drifting buoys were built in schools, with the support from ANSTJ's branch in Montpellier. Once hardened

for their journey in ocean, they have been released from oceanographic ships in Northern Atlantic. Since then, 2 to 5 buoys are built and released every year as part of ArgoTechno: in the Pacific ocean, in the Indian ocean, in the sub-arctic ocean, in the Mediterranean sea or in the Gironde's estuary, near Bordeaux.
ArgOcéan was also started in 2000 when skippers competing in the Vendée Globe (round-the-world single-handed yacht race) kindly accepted to release buoys in the main ocean streams.
More recently, ArgOcéan focused on the plastic islands in the Pacific ocean. Buoys will be released in spring 2013 as part of the expedition "7th continent".

ArgoNimaux was initiated in 2001: from raw data shared by CNRS, the French institute for research, students could follow luth turtles laying eggs on the beaches of French Guiana, penguins, sea elephants and albatross in the sub-Antarctic. Collaboration with other institutes brought students to monitor migration of ivory seagulls or polar bears.

Fig 15: Argonautica leverages satellites beacons to track movement of buoys or animals in the oceans

Argonautica is also part of the collaboration with NASA/JPL. It is one of the activities being conducted in support of NASA/CNES ocean surface topography missions education and public outreach.

5.9 Calisph'AIR

CNES is running Calisph'AIR since 2004, based on the international programme GLOBE (Global Learning and Observations to Benefit the Environment) [18]. School groups perform measurements in their near environment, following rigorous protocols. Results are loaded in an Internet database in order to be used for pedagogic, scientific or simply school project purposes. Pupils are invited to measure the characteristics of the surrounding atmosphere: counting dust particles, either from natural source or not thanks to photometers developed by CNES. This raises youth's awareness about pollution and climate change thanks to the correlation of field data with remote sensing data collected by satellites (CALIPSO, PARASOL…) [19].
Data collected by French explorers (Stéphane Levin from 2006 to 2008, Jean-Louis Etienne in 2009) were also made available to school groups.

5.10 Terre Images

Always eager to promote Space to the service of the Earth, CNES has just started a new environment education programme focusing on immersed lands: urban growth, deforestation, floods… It relies on high resolution images captured by the satellite PLEIADES.

5.11 Rocketry Challenge (RC)

The competition is an extra-curricular hands-on project-based learning program, modeled around the aerospace industry's design, fabrication and testing processes.

It was originally proposed in the USA from 2002 and then in UK. France, with Planète Sciences from the support from GIFAS, joined the competition in 2009.
All students participate in a team of 3-10 students to design, build, and fly a rocket. Like aerospace companies work within specific design parameters, every year the challenge requires teams to achieve the same basic mission-oriented goals of hitting a precise altitude, landing within a specific flight time window, and returning a raw egg (”the astronaut”) without cracking. Each year a unique task is also included.

Fig 16: Rocketry challenge: an egg in a rocket – don’t make an omelet!

Planète Sciences organized the international final during the Paris Air Show 2011 with the expertise from CNES, in complete safety conditions in the middle of aircraft demonstrations. 17 French teams have entered RC in 2011 and 20 in 2012. A French team won the international competition held in Farnborough (UK), ahead of the champions from USA where the national event involves more than 3000 students from 48 states. A recognition of the space education know-how accumulated in France by Planète Science since 1962.

5.12 Aquamax

Willing to offer a challenging platform for youth to experiment on water rockets, Planète Sciences established Aquamax in 2009. It’s a rather simple programme starting with a short training session for primary school teachers who are then equipped to build and launch water rockets with their pupils. All along the school year they learn notions, techniques and safety rules while experimenting with this vector. The competition is a festive comment during which rockets are launched to decide the awards for the longest flight duration, the best decoration, the best scientific presentation and the preferred rocket from the contestants.

50 YEARS: ONLY THE BEGINNNING

Space outreach, in France, in Europe, beyond the borders of countries, across the oceans, in disadvantaged areas or in prisons, high or low in the sky, through satellites data or even onboard spaceships…: that’s what Planète Sciences and CNES have offered for 50 years to youth.
These would not exist without the initial passions and collaboration of amateurs willing to walk in the steps of Tsiolkovski, Esnault-Pelterie, Goddard, Von Braun…to reach space with rockets.
The passion was transmitted through generations within ANCS, ANSTJ, Planète Sciences, giving birth to brilliant careers, in the aerospace industry, in the field of education, and also research. Volunteers from Planète Sciences, supported by CNES and industries have initiated and deployed a wide set of science education tools and outreach programmes, by adapting know-how from the industry, with safety constantly in mind.
50 years, already: but it’s only the beginning. Interest for space keeps growing and remains a fantastic support to educate future generations about science and technology. Planète Sciences and CNES will meet the new challenges brought by the development of Space activities for the benefit of the planet.

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