From educational programmes to professional projects: finding flight opportunities

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Abstract
Nowadays, lots of opportunities are offered to students to fly their own experiment on board of rockets or balloons. Thanks to those opportunities, young scientists have a chance to experience hands-on project and even to find a vocation: pursuing experimentations on-board of flight missions. However, it can appear, for these young professionals, that flying on board sounding rockets or stratospheric balloons is hard to access or to afford. Yet the opportunities exist and are waiting for them!

Space educational programmes enable students to learn, in a short period of time, all phases of a scientific project; a unique chance to experience a full project cycle from objectives' definition to the publication of the results. Thus, students define mission requirements, design, manufacture, test and finally launch their own experiment! On REXUS/BEXUS [1] for example, students experience an end-to-end project with all disciplines required by a Space project (science, mechanics, electronics, software, system engineering, management, finances, outreach). The concretisation of all efforts occurs during the launch campaign, organised at SSC Esrange (Sweden). The campaign is always an intense period for the participants: high level of concentration, pressure, stress but a massive work that pays off during the flight and after. Usually, this key event enables ideas and improvements to pop up; a prolific event to define the next step of an experiment, maybe on a future mission!

Many students start their professional career after the campaign. Despite new ideas and the drive to pursue, a common idea of these young professionals is that it is hard to access to flight opportunities on sounding rockets or stratospheric balloons while not being a student anymore: too expensive to finance a campaign? too complex to organise? who to contact? Many questions that it is time to answer. Yes, it is possible! At SSC, we enable access to stratospheric balloons, sounding rockets and drop tests on a cost-efficient entrance level or fully funded through national and international programmes. One of these examples is the EOSTRE mission [2] (Experiment on Outliving Microorganisms under Stratospheric Environment), developed by FH Aachen University of Applied Sciences (Germany) in collaboration with the University of Oulu (Finland); a former BEXUS team that developed its own balloon mission, launched successfully from Esrange in March 2020. Several former students from REXUS/BEXUS have joined professional opportunities, such as the HEMERA [3] programme, with the experiments GRASS from INAF (Istituto Nazionale di Astrofisica) and STRAINS (Sapienza University, Rome) and launched it from Esrange in September 2021. Today, SSC is also offering ride share opportunities on sounding rockets with the programme SubOrbital Express [4]; first successful launch was in June 2019 on board MASER 14 (S1X-1). Opportunities are still open for the next missions in fall 2022 (S1X-3) and in 2023 (S1X-4).

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Acronyms/Abbreviations

AO *Periodic Announcement of Opportunity*

BEXUS *Balloon EXperiment for University Students*

CORA *Continuously Open Research Announcement*

DLR *Deutsche Zentrum für Luft und Raumfahrt*

ESA *European Space Agency*

ESC *Esrange Space Center*

GSTP *General Support Technology Programme*

REXUS *Rocket EXperiment for University Students*

S1X *Suborbital Express*

SciSpacE *Science in Space Environment*

SNSA *Swedish National Space Agency*

SSEA *Symposium on Space Educational Activities*

SSC *Swedish Space Corporation*

1. Introduction

Sounding rockets and stratospheric balloons enable to carry on a wide spectrum of scientific experiments such as atmospheric research, astronomy, astrophysics, biology, material science, physics and of course microgravity research. In addition, both vehicles could be used for technology demonstration. However, as young professional, having your experiment accommodated on such missions seem complex. In this paper, you will find a synthetic description of the existing opportunities in Europe, advises on how to finance your project and contact points to not miss any opportunities.

2. Sounding rocket & Stratospheric balloon missions: the opportunities

2.1. Institutional missions: answering a call for proposals

2.1.1. National missions

To find a mission, the first step is to look at opportunities offered by the national space agencies. For example, in Sweden, the Swedish National Space Agency (SNSA) opens regularly calls for applications; the national programme enables a wide diversity of research such as astronomy, astrophysics, astrobiology, atmospheric sciences, Earth observation, fundamental physics, life and physical sciences, space physics and technology demonstration. A particularity of this programme: all missions are launched from Esrange Space Center (ESC). The national programme enabled missions such as SPIDER (Small Payload for Investigation of Disturbances in Electrojet by Rockets) and SPIDER 2 studying the Farley-Buneman instability in the auroral electrojet; rockets launched respectively in 2016 and in 2020). More recently, a group of scientists have been selected by SNSA: the BROR mission (Barium Release Optical and Radio rocket experiment) will study the dynamics of the ionosphere's electric and magnetic fields. This mission, initiated by IRF (Institutet för Rymdfysik, Institute for Space Physics) in cooperation with EISCAT (European Incoherent Scatter Scientific Association) and SSC (Swedish Space Corporation), will be launched in 2023. The national programme also enables stratospheric balloons missions like PoGO (balloon-borne telescope studying polarisation of gamma-rays from pulsars) [6]. The balloon flew successfully in 2013 during 12 days around the North Pole, from Sweden to Canada. After this successful mission, another collaboration with SSC was initiated by KTH (Kungliga Tekniska Högskolan, Royal Institute of Technology Stockholm) in collaboration with Swedish and Japanese scientific teams, still under the umbrella of the national programme: the PoGO+ mission.

To reach such national mission, scientists are strongly advised to subscribe to the SNSA newsletter [5] to not miss any opportunity! Calls are open regularly and proposals are evaluated by a panel of experts.

2.1.2. International missions

In Europe, scientists should look for calls for announcement from the European Commission and the European Space Agency (ESA).

The European Commission established a programme called Horizon Europe (formerly

Horizon 2020). This programme opened regularly calls for proposals. Unlike the Swedish national programme, Horizon Europe is divided in topics. Thus, an important attention should be brought by the group of scientists to find an appropriate topic for which their experiment can fit in. This is a critical aspect of any proposal to increase the chances of being selected [7].

An example of a mission that was funded by this programme is ESBO (European Stratospheric Balloon Observatory) [8]; a dedicated mission led by a consortium of 5 partners: Institute of Space Systems at University of Stuttgart, Institute for Astronomy and Astrophysics at the University of Tübingen, Max Planck Institute for extra-terrestrial Physics, Institute of Astrophysics of Andalucía and SSC. ESBO was initiated by scientific institutes experts in astronomy, to enable astronomy observation from the stratosphere. The ESBO partners submitted a proposal to the Astronomy call of the Horizon 2020 and was selected. After a successful project, ESBO partners submitted another proposal to Horizon 2020 to pursue the development. It was then another success for the group of researchers that got the funding for a full development of the telescope, the detector, the image stabilisation system and the development of the spin stabilised gondola.

Second main call for international missions is SciSpacE (Science in Space Environment) programme by ESA [9]. SciSpacE offers opportunities on several ground-based platforms such as in Antarctica station, drop tower, parabolic flight and sounding rockets. It is opened to researchers studying human research, biology, astrobiology, planetary sciences and physical sciences. When selected, experiments are accommodated on TEXUS (Technology Experiments in Zero Gravity) (for DLR (Deutsches Zentrum für Luft und Raumfahrt, German Space Agency) and ESA microgravity research programmes) or on the Swedish rocket SubORbital Express / MASER (MAterials Science Experiment Rocket) as well as on TEXUS. Both TEXUS and MASER could carry up to 230kg of experiments to an altitude of 260 km, providing 6 minutes of microgravity. ESA is procuring the flight opportunity and the execution of the launch campaign. As an example of former flights: TEXUS 56 [10] was launched in 2019 embedding experiments from McGill University PERWAVES, Université Libre de Bruxelles, Braunschweig ICAPS, University of Freiburg InSituKris, E4T from Airbus & OHB and AEGIS from Sint Pieters College in Belgium.

Lastly, other calls initiated by consortium of major space actors can be reached. Such as HEMERA, funded by CNES (Centre National d'Etudes Spatiales), SNSA, DLR, ASI (Agenzia Spaziale Italiana), CSA (Canadian Space Agency), ASC (Andøya Space Center), SSC and Airstar. HEMERA [3] was funded by Horizon 2020 to enable scientists to launch experiments on stratospheric balloons making accessible a wide range of mission profiles to fit the largest user community. Two calls for proposals were opened in 2018 and 2019. The next launch campaign is scheduled for September 2022.

2.2. Commercial missions: booking a flight ticket

New opportunities emerged recently: commercial missions for sounding rockets launches. Announcement of flight opportunities are published on the SubOrbital Express website [4] regularly and experimenters can simply book a flight ticket! The first mission was launched in 2019 from ESC on SubOrbital Express 1 / MASER 14 rocket. Currently two missions are under preparation: one is scheduled for a launch in October 2022 and the next one in autumn 2023 (still open for payloads).

SubOrbital Express enables dedicated and rideshare missions (like MASER 14). Each experiment could have a dedicated rocket module or could share the module with other experiment(s). Mass, volume, power supply, communication service and any special requests from the experimenters are discussed with SSC to provide the most suitable solution for the scientists. Price of the flight ticket mainly depends on those parameters.

2.3. Open missions: initiating your own flight

Sometimes, experiments do not fit in any calls for proposal. Thus, another solution for experimenters is to initiate their own mission. If it could seem difficult it is in fact a realistic alternative.

The CRYOFENIX [11] project is an excellent example of a dedicated mission. Initiated by Air Liquide, CRYOFENIX aimed at studying the behaviour of liquid propellant during motor re-start and propelled phases of a launcher. Such results are then used for the European launchers of the Ariane family. If fluidics research under microgravity was already conducted by Air Liquide and CNES on MASER, a dedicated mission was considered to push the study further. Air Liquide initiated the

project: a feasibility study was performed while visiting ESC and securing funding by CNES. Air Liquide worked in close collaboration with SSC to adapt a MASER rocket to Air Liquid needs: the mission became CRYOFENIX: a fully dedicated rocket with a dedicated service module, cryogenic control module and a fully developed thrusters' module for the needs of the mission. A fantastic example of initiated mission that successfully flown in 2015.

EOSTRE (Experiment on Outliving Microorganisms under Stratospheric Environment) [12], is another example of initiated mission on a balloon developed by FH Aachen University of Applied Sciences and University of Oulu (former BEXUS team) that flew from ESC in 2020. It was a dedicated mission initiated by the scientists in collaboration with SSC.

If such dedicated missions offer an "à la carte" experience, the main drawback is the costs. Thus, to make the mission affordable, the solution is the rideshare mission. First option for the experimenters is to contact SSC to describe the mission needs. If other experimenters have contacted SSC with compatible payloads, SSC could then initiate a shared mission. Second option for the experimenters is to reach other groups of experimenters and then contact SSC as a shared payload. Then SSC would organise a mission; this is valid for both rocket and balloon missions. Ridesharing is an interesting solution to share the costs of the launch, the launch campaign, and the use of launch systems. Thus, networking is a key for scientists who want to build a mission. Conferences and workshops are an excellent way to get in contact with space agencies, launching companies and other groups of scientists. As an example, the HEMERA workshop is planned for July 2022 [13].

3. Financing your project

Beginning an academic career often implements the need to find funding sources for the desired work field. Same here. Universities often provide the basic frame for research, the facilities, laboratories, and offices, while the team need funding sources to work on the scientific subject. This is locally very different and depending on the structures of the University. Here it is recommended to look out for innovation budgets, research clusters focussing on certain topics and external research budgets.

Funding can be locked to certain purposes. The budget maybe either used for hardware and direct costs such as travelling only, or it is only covering the labour costs for the project lifetime. Development costs and the flight ticket itself are usually another big problem and are addressed in the following. The public funding programmes provide hence different alternatives. Often, it is necessary to combine different funding options for one dedicated research activity. To receive a certain funding source, it might be even mandatory to guarantee the base funding for labour and facilities by another source.

It must be stated, that publicly funded research projects require the publication and sharing of the scientific data. The team of the principal investigator has the exclusive right to work and publish the results for a limited time before the data is made available to the entire research community.

3.1. National Agencies

3.1.1. Swedish National Space Agency (SNSA)

The Swedish National Space Agency offers on their website [15] (currently only in Swedish) support to research in a broad choice of thematic areas. The calls are distinguished in continuously open calls, annual calls, less frequent open calls, and targeted calls.

The Continuously Open Calls provide support for proposal writing, travel and events in preparation of space research missions and support to international collaborative missions. Annual Calls provide career support and PHD position fundings or long-term international missions.

The Less Frequent and Targeted Calls enable research within the Balloon and Rocket Programme, the National Research Satellite Programme or for Technology Development. Furthermore, SNSA provides in the framework extended fundings for international and ESA Science missions.

3.1.2. German Space Agency (DLR)

DLR follows an approach supporting the entire research project (called "Forschungsvorhaben") over a timeframe of 3 years. The funding includes the costs for personnel, material, the implementation, and flight ticket on the selected platform. The experiment concept or research idea is directed to the DLR Agency and throughout an iterative process the project is discussed, defined, and selected for funding. The Agency acts in a

supporting role to find the best suitable platform and project setup for the science teams [18].

3.2. European Space Agency (ESA)

ESA has opens for researchers from the 15 ESA member states in the *European Programme for Life and Physical Science in Space (ELIPS),* opportunities to apply for the funding the access to research facilities providing space or space related environments. The funding opportunities within the *ESA SciSpacE programme* are described below. Concerning microgravity platforms, ESA [16] provides an exhaustive collection of information about the platform and the accessibility through the application processes of which two are described here briefly.

3.2.1. Periodic Announcements of Opportunity (AO)

The AO are issued on a periodic base with funding options mainly for research on board of the ISS and Sounding Rocket platforms. Often are the AO´s linked to the triennial funding cycles of the ministerial conference of the contributing ESA member states, the AO. Opening dates as well as deadlines for the calls, detailed information to the application processes and the requirements towards the formal proposal are thoroughly described on the ESA Website [14].

3.2.2. Continuous Open Research Announcement (CORA)

The call for the fast track for experiment including Parabolic Flight and Drop Tower experiment proposals is continuously open and can provide support within a shortened application procedure. It applies, if the scientific goal can be anticipated to be reached within a single campaign [14]. Those announcements are then continuously open for a dedicated timeframe.

3.2.3. General Support Technology Programme (GSTP)

While the previously discussed funding options focus on fundamental research, the GSTP provides the fundament for technical developments from the concept to the final application. ESA is following a 3 elements approach. The first Element *Develop* supports to raise the Technology Readiness Level (TRL) level from the concept to a qualification state. The second Element *Make* lifts the technology to marketable products, while the third Element *Fly* enables the in-orbit / in-flight application [17].

3.3. Research fostering European Programmes

3.3.1. Horizon 2020

Horizon 2020 was a research fostering programme by the European Commission and supported research projects and developments over a timeframe from 2014 to 2020. The total budget was almost €80 billon. Today, the programme is closed, but it is succeeded by the Horizon Europe Programme [18].

3.3.2. Horizon Europe

Today, the European Commission has an open call for the Horizon Europe programme, which provides funding for research and innovation projects with a budget of €95.5 billion [19]. It is open from 2021 to 2027 and should facilitate the competitiveness of the EU space sector and enhance the access to space. Furthermore, the programme supports developments with funding for In Orbit Verification (IOV) and In Orbit Deployment (IOD) activities. The calls are open within dedicated research field, in which the applicant can receive funding. These fields are mostly narrowly defined. Horizon Europe is mainly supporting working hours and hardware within a limited budget and for a strict timeframe. Thus, this is common for funded projects to re-submit a proposal some years later to pursue the project development.

4. Conclusion

Experimenters shall be aware of existing launch opportunities in Europe and regularly check the calls for proposals. Subscribing to space agencies newsletters is an easy solution to get notifications for example. In addition, although institutional missions represent major part of the missions, scientists could also consider commercial missions and even initiating their own missions if existing opportunities are not suitable for their experiment. Thus, experimenters shall not limit themselves to existing missions but shall be pro-active and initiate their own missions. For this purpose, experimenters are encouraged to contact the actors of the sounding rockets and stratospheric balloons domain. At SSC, we are open to discuss future missions and will work in close contact with you until the launch from ESC and beyond!

As advises, experimenters are strongly encouraged to select wisely the topics of their calls and not to underestimate the work for preparing a proposal. Support from people that

are experts in this challenging exercise should be sought. In addition, visiting launching facilities (payload preparation halls, launch pads…) is also a good way to meet the operational team and understand how we could build a mission together.

5. Disclaimer

This paper does not claim to provide an exhaustive and exclusive listing of research and funding opportunities. It focusses on a few typical examples for the research utilising sounding rockets and stratospheric balloons as vehicles as being familiar to the authors.

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