Continuously Open Research Announcement

soliciting for proposals for Spaceflight Analogue

Parabolic Flight

ESA-CORA-PF
1 INTRODUCTION

ESA’s “Science in Space Environment” (SciSpacE) programme – which is part of ESA’s overall European Exploration Envelope (E3P) programme – includes scientific activities on research platforms such as ground-based space analogues (e.g. bedrest studies, research on Antarctic stations, radiation facilities, drop tower, sounding rockets, parabolic flights), as well as an ambitious research programme on-board the International Space Station (ISS). The SciSpacE programme activities cover science in the domains of Human Research, Biology (including Astrobiology) and Physical Sciences, with an emphasis on scientific excellence, space research- and exploration-relevance, innovation and timely delivery. Its research results will advance Europe’s knowledge base, support its economy and help prepare future human and robotic space exploration. In addition to gaining fundamental knowledge, the research carried out within ESA’s SciSpacE programme is helping to deliver solutions to problems back on Earth, e.g. developing innovative materials to manufacture products, removing pollutants from water, improving engine efficiency, testing new medical techniques and support equipment for the elderly and disabled. To further enhance and promote ESA’s strong non-ISS research programme, ESA’s Continuously Open Research Announcement scheme has been expanded to offer dedicated opportunities for research on ESA’s non-ISS research platforms. This document provides an overview on the research opportunity offered within this Continuously Open Research Announcement as well as on the sequence of events starting from submission of the research proposal to selection and implementation of successful experiments.

2 OBJECTIVE OF THIS OPPORTUNITY

Parabolic flights are the only sub-orbital carriers allowing scientists to carry out, in person, biological, biomedical and physiological as well as physical and material science experiments under conditions of microgravity or other (reduced) gravity levels as self-standing experiments.

Through this Continuously Open Research Announcement for the Spaceflight Analogue “Parabolic Flight” in Bordeaux, France, ESA provides scientists with an opportunity to conduct research necessary to advance knowledge relevant to the effects of space in the area of Life and Physical Sciences, with the overarching aim of contributing to safe and sustainable space exploration with human crews – an overview of key questions to be addressed with this opportunity can be found in Annex 1. Scientists are strongly invited to address one (or more) of the topics outlined in Annex 1 of this document with their proposed experiments.
3 THE FACILITY TARGETED WITH THIS OPPORTUNITY

The ESA Parabolic Flight Campaigns take place with the Airbus A310 ZERO-G operated out of the Bordeaux-Mérignac airport by the company Novespace. Novespace’s A310 ZERO-G aircraft has been certified for flying parabolas that can provide reduced gravity levels between 0g and 1g (1g being Earth’s gravity).

ESA Parabolic flight campaigns are typically conducted twice per year in Spring and Autumn. Each flight campaign normally consists of three individual flights, each of which has 31 parabolas, i.e. a campaign has 93 parabolas in total. During each parabola, there is a period of increased gravity (1.8g), immediately prior to and following a period of reduced gravity.

Typically ESA Parabolic Flight campaigns focus solely on 0g, of which the Airbus A310 ZERO-G can produce about 20 second per parabola, giving a total of about 10 minutes of microgravity per flight, and 30 minutes per campaign. For other gravity levels in between 0g and 1g, the durations vary. Interested science teams are invited to specify in their proposal which g-level conditions (between 0g and 1g) they require to conduct their experiments, bearing in mind that campaigns focusing on intermediate gravity levels are very infrequent.

Detailed description of the ESA Parabolic Flight and campaign organisation can be found in annex 2.

4 APPLICATION PROCESS

4.1. Who can apply

Scientists from the member states participating to ESA’s SciSpacE programme may apply to the programme. Participating countries are Austria, Belgium, Canada, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Scientists from other ESA member states may participate in proposals as team members.

4.2 Preparing and submitting the proposal

The document "ESA-CORA-PF submission template" shall be used for submission of the proposal. The proposal shall include a clear description of the proposed experiment and the G-level requested to conduct the experiment.

The proposals shall be submitted electronically as one single file to:

cora-pf@esa.int

An acknowledgement of receipt will be sent to the submitting proposer upon receipt and confirmation of completeness of the proposal.
4.3 Evaluation of proposals

ESA will make use of independent experts for the relevance and scientific merit evaluation of proposals. The proposal coordinator will receive information on the outcome of the review, typically within 2 months.

The evaluation criteria that will be applied for evaluation of the proposals are:

- **Research Platform Relevance**: Is this study appropriate to the proposed research platform, *i.e.*, can the objectives and protocol be achieved adequately within the capabilities and constraints of the platform?

- **Scientific Merit**
  - **Significance (30%)**: Does this study address an important problem? If the aims of the application are achieved, how will scientific knowledge or technology be advanced? What will be the effect of these studies on the concepts, methods, or products that drive this field?
  
  - **Approach (25%)**: Are the conceptual framework, design, methods, and analyses adequately developed, well integrated, and appropriate to the aims of the project? Does a flight proposal build upon a successful foundation of ground studies? Is the proposed approach likely to yield the desired results? Does the applicant acknowledge potential problem areas and consider alternative tactics?
  
  - **Innovation (20%)**: Does the project employ novel concepts, approaches, or methods? Are the aims original and innovative? Does the project challenge existing paradigms or develop new methodologies or technologies?
  
  - **Personnel (15%)**: Does the scientific team have the appropriate level of experience, are sufficient & appropriate personnel dedicated to the project. Is there evidence of the science team’s satisfactory productivity?
  
  - **Environment (10%)**: Does the scientific environment in which the work will be performed contribute to the probability of success? Do the proposed experiments take advantage of the scientific environment or employ useful collaborative arrangements? Is there evidence of institutional support?

5 IMPLEMENTATION OF THE SELECTED PROPOSALS

After positive selection of the peer-reviewed proposal, the scientific coordinator of the experiment will be notified and the proposal will be added to the pool awaiting flight. Allocation to any specific campaign may not be immediate, and typically happens at least six months in advance. The scientific coordinator will then be required to confirm the availability of resources, including funding for her/his team’s work in the project.
Please note that through this continuously open research announcement, only the research opportunity on-board the parabolic flight aircraft is provided. Funding of the science team, as well as costs for hardware, software, consumables and travel to/from Bordeaux have to be borne by the science teams themselves. It is recommended that the experimenter requests for funding in parallel to their application in response to this CORA, in order to commence applying for national funding as early as possible or to seek for alternative funding sources if necessary.

Please take note that the acceptance of a proposal is not a guarantee for a flight opportunity. Implementation will be subject to a technical feasibility review carried out by the selected facility after selection.

The gravity levels requested through the selected proposals will feed into the planning and g-level set-up of the individual campaigns.

6 DATA RIGHTS

6.1 General

The general data policies of ESA’s Directorate for Human and Robotic Exploration Programmes will apply to all data resulting from the experiments in the context of this Continuously Open Research Announcement. Final results of the study shall be made available by the scientific teams to the scientific community through publication in appropriate journals or other established channels as soon as practicable and consistent with good scientific practice. In the event such reports or publications are copyrighted, ESA shall have a royalty-free right under the copyright to reproduce, distribute, and use such copyrighted work for their purposes.

6.2 The Erasmus Experiment Archive (EEA)

The EEA covers both physical and life sciences, and can be found at the following URL: http://eea.spaceflight.esa.int. The EEA is an ESA service to the international scientific community. Abstracts, from all ESA microgravity experiments performed to date are collected in this database. Experimenters sponsored by ESA have the obligation to provide these abstracts themselves. Special emphasis is placed on the completeness of the list of references of articles where the experiment results can be found.

Scientists in Europe who have performed experiments, either in orbiting or ground-based facilities are encouraged to either provide an abstract on each of their experiments, or to provide information enabling the updating of their existing abstracts, in particular the list of articles published.

ANNEX 1: SCISPACE ROADMAPS
The Science Department of ESA’s Human Spaceflight and Exploration Directorate recently undertook an extensive exercise to create a new strategy, focusing on a set of newly defined goals to help to positively shape the future research programme of the Directorate and maximize research potential.

**Figure 1. ESA Roadmaps**

Figure 1 gives a graphical overview of ESA’s Science Roadmap questions, the detailed roadmaps can be found at: “https://www.esa.int/Our_Activities/Human_Spaceflight/Research/Research_Announcements” on ESA’s Research Announcement website.

Submitting proposers are strongly invited to address one of the topics outlined above with their research proposal.
ANNEX 2: DETAILED DESCRIPTION OF THE ESA SPACEFLIGHT ANALOGUE “PARABOLIC FLIGHT”

Parabolic flights are the only sub-orbital carriers allowing scientists to carry out, in person, biological, biomedical and physiological experiments under conditions of microgravity or other (reduced) gravity levels as self-standing experiments, in addition to testing instrumentation prior to use in space, to validate operational and experimental procedures, and to train astronauts for future spaceflight.

The ESA Parabolic Flight Campaigns take place with the Airbus A310 ZERO-G operated out of the Bordeaux-Mérignac airport by the company Novespace. The Novespace’s A310 aircraft has been certified for flying parabolas that can provide, in addition to weightlessness, periods of reduced gravity that can vary between 0g and 1g (1g being Earth's gravity).

Campaign organisation
Within ESA’s SciSpacE programme, it is planned to maintain the level of on average two parabolic flight campaigns per year, which experience has shown matches the requirements of the scientific community.

A typical parabolic flight campaign is normally scheduled for two weeks, with the first week dedicated to experiment incoming inspection, followed by installation, test and safety verifications within the aircraft. The second week is devoted to the parabolic flights themselves. At the start of the second week (on a Monday), attendance at a medical and safety briefing is mandatory by all persons planning to fly.

Three flights of 31 parabolas each are nominally scheduled for the Tuesday, Wednesday and Thursday mornings, with a flight duration of approximately three hours. In the case of inclement weather or technical problem with the aircraft, a flight is delayed to the afternoon of the same day or morning of the next day. The Friday of the second week is reserved as a back-up flight day.

Investigators who are foreseen to participate to the parabolic flights will have to pass a medical examination, abide to the "Terms and Conditions for Participation to ESA Parabolic Flight Campaigns" and sign dedicated agreements.

A310 ZERO-G characteristics
The main technical characteristics of the Novespace A310 ZERO-G cabin are:
- The equipment test area measures 20m x 5m x 2.2m (L x W x H);
- All equipment must be loaded through an access door of 1.8m x 1.06m;
- Cabin pressure during flight is 825 +/-5 hPa, with a temperature range of 17 to 20 °C, and relative humidity <15%;
- Electrical power is available: 230 V AC at 50 Hz (single phase);
• A ventline is provided for the purging of gases and liquids from the aircraft during flight;
• There is continuous in-flight lighting;
• Protective white foam padding covers internal surfaces to prevent injury to flight personnel

Detailed information on design guidelines for instruments and/or payloads, the A310 ZERO-G interfaces, and the applicable procedures for parabolic flights, will be provided upon experiment selection. Specific information may be requested prior to proposal submission if necessary.

**Parabolic Flight Manoeuvre**

Starting from a steady horizontal flight, each parabola begins with a “pull up” phase lasting about 20 seconds, during which the aircraft experiences a vertical acceleration of around 1.5-1.8g (i.e.: 1.5-1.8 times normal Earth gravity). Once the aircraft is approximately 50 degrees nose-up, there is a short “injection” phase of 2-3 seconds during which the acceleration reduces to the target level. This is achieved by reducing engine thrust to just compensate for air drag, and adjusting the aerofoil angle-of-attack to produce zero lift.

During a microgravity parabola, the aircraft pitch is controlled to maintain this zero-lift angle-of-attack, and the aircraft therefore follows a free-fall ballistic trajectory. Weightless conditions are achieved within the aircraft for approximately 20 seconds. During partial G-levels parabolas, the flight parameters are adjusted accordingly, to provide reduced gravity.

Target reduced gravity levels are typically achieved within +/- 0.02g, and at least within +/- 0.05g, on all three primary axes. At the end of the reduced gravity period, the aircraft is approximately 42 degrees nose-down and a “pull out” phase begins. This gives rise to another 20 second period of 1.8g, after which the aircraft returns to normal steady flight.

The figure 2 below gives an overview of a typical parabolic flight manoeuvre. The case illustrated refers to a microgravity parabola.
Parabolic manoeuvres are flown repeatedly, with a period of 3 minutes between the start of each two consecutive parabolas. After each group of five parabolas, there is a rest interval of 5 to 8 minutes.

Throughout the flight, all personnel are kept continuously informed of the flight status, including an indication of the upcoming parabola number, and the rest period durations. The entire flight duration is around three hours, from take-off to landing.

**Safety and Health Regulations**

The safety of personnel and equipment are of paramount importance during all ESA campaigns. Parabolic flights are considered as test flights, and therefore particular precautions are taken to ensure that in-flight operations are made safely, and that all participants in the flights are adequately prepared for repeated high and low gravity phases. Prior to an individual campaign, support is provided to researchers in their equipment design and safety aspects. As deemed necessary, experiments may be reviewed by experts during visits to the investigators’ home laboratories. All experiments characteristics and safety processes are assessed by both Novespace and ESA. A safety review is held one month prior to the campaign, where the integration of all equipment is discussed and the overall safety aspects of the campaign is assessed. Finally, a safety inspection is performed in the aircraft prior to the first flight to verify that all equipment complies with the applicable safety rules.

All researchers selected to participate in parabolic flights must pass a medical examination. On-board, researchers must wear special flight suits, provided on loan during the campaign. For experiments proposed to be conducted on human subjects, medical protocols submitted by the researchers shall be reviewed by relevant Medical Boards to ensure that the proposed research is conducted according to established ethical and safety rules. During the flights, specialised personnel supervise and support the in-flight experiment operations. A Flight Surgeon participates to all flights to supervise the medical aspect of in-
flight operations, and to assist flying participants in case of sickness. Due to the association of low and high gravity flight phases, motion sickness may appear among participants to parabolic flights, sometimes hampering them to conduct their tasks. Prior to the flights, anti-motion sickness medication is made available to all participants and is strongly recommended.