ESA Announcement of Opportunity soliciting for proposals for "Electro-Magnetic Levitation Sample Experiments on-board the International Space Station (EML-ISS Batch 4)"

AO-2019-EML

European Space Agency
Agence spatiale européenne

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.
This document provides an overview on the research opportunity offered within this announcement as well as on the sequence of events starting from submission of the research proposal to selection, definition and implementation of successful experiments.

2 OBJECTIVE OF THIS OPPORTUNITY

ESA's SciSpacE activities for the different research disciplines are guided by Science Roadmaps as outlined in Annex 1. This Announcement of Opportunity falls within the domain of advanced material processing, and more in particular addresses the topic of microstructure formation and materials properties.
The objective of this opportunity is the selection of eighteen priority and an appropriate number (typically two or three) of back-up samples to serve as the so-called Batch 4 for the Electro-Magnetic Levitator on-board the International Space Station (EML-ISS). The EML-ISS enables container-less processing of metallic and other liquids excluding the effects of gravity, and can be used for the study of solidification mechanisms (e.g., crystal nucleation and growth, multiphase growth, and glass formation) and the measurement of thermo-physical properties at unprecedented accuracy (e.g., specific heat capacity, surface tension and viscosity) amongst others. Extending scientific knowledge in these areas is of pinnacle importance in further advancing the predictive capabilities of numerical modelling approaches for casting and solidification processes, which in turn are key to the manufacturing of almost all (metallic) industrial and consumer goods on Earth.
Specifics of this Announcement of Opportunity are as follows.

- The proposed samples and experiments are to build on and supplement the alloy systems, chemical compositions and measurements that have been and are being undertaken for the earlier selected sample batches for EML-ISS and as being documented in scientific literature amongst others. New ideas are thus being encouraged, but noting that sample compositions have to be qualified for flight *a priori* by earlier testing in parabolic flight.

- Like for earlier EML-ISS sample batches, collaboration and sharing of samples between research teams and projects is encouraged so as to make optimal use of resources.
- In addition to established research teams and projects (ESA AO and MAP research projects), scientists that have not worked with EML-ISS before are encouraged to apply. Further, first-time Principal Investigators are encouraged to apply so as to foster a new generation of scientists to conduct research with EML-ISS.

3 THE FACILITY TARGETED WITH THIS OPPORTUNITY

EML-ISS is a multi-user facility that provides container-less melting and solidification of electrically conductive, spherical samples under ultra-high vacuum and/or high gas-purity (argon or helium) and continuous microgravity. This ESA/DLR facility is operational on-board the International Space Station since 2015 and has been successfully and reliably utilised in the meantime for the processing of two batches of samples, with a third batch being currently prepared for flight. Meanwhile the facility has been extended with a Sample Coupling Electronics (SCE) unit that enables some further specific property measurements from the inductive feedback of the levitated sample to the heating circuit. Under development still is an Oxygen sensing and Control System (OCS) that is to measure and control oxygen partial pressure within the process chamber in a wide range (likely not available for Batch 4 experiments though). Explored materials to date include a variety of model systems (such as Al-Ni alloys, Cu-Co immiscible alloys, Si-Ge semiconductor materials) as well as commercial alloys (such as nickel-based super alloys, titanium alloys and bulk-metallic glass-forming alloys).
The EML-ISS supports research on meta-stable states and phases and on the measurement of highly accurate thermophysical properties of liquid metallic alloys in the stable and undercooled state. The former field covers for instance investigations into nucleation and solidification kinetics in undercooled melts and the developing microstructure. Thermophysical properties of high-temperature (and highly reactive) melts measured in EML-ISS include surface tension, viscosity, melting range, fraction solid, specific heat, heat of fusion, mass density and thermal expansion, and thermal transport properties such as the total hemispherical emissivity and effective thermal conductivity. In addition, electrical conductivity and – to some extent – magnetic susceptibility are measured. Research on thermophysical properties is oriented to fundamental research but also application where reliable data for high-temperature melts are required for accurate modelling of industrial processes and where these are difficult or impossible to be obtained on ground, in particular for reactive melts. The long-term and multiple access research conditions provided by the ISS allows parametric study of all these phenomena to a degree that has previously not been possible.
Heating and positioning of the sample are achieved by electromagnetic fields generated by a coil system, the maximum processing temperature being about 1,950 °C. With respect to diagnostics, the facility is based largely on digital data acquisition, using a pyrometer for temperature (resolution 0.1 °C >600 °C, 100 Hz) and two cameras (axial; radial high speed ≤190 kHz) for video observation. The operations concept is based on tele-science.
Each sample container fits eighteen samples (typically of 6–8 mm diameter), being called a batch. The sample container is mounted on the process chamber, with each sample being placed in a sample holder to prevent it from escape under microgravity. Sample

holders come in different designs ("cup" or "cage"), their choice being dependent on the diagnostic tools to be used for the individual experiment (visibility) and the evaporation rate of the sample, amongst others. As additional features, a sample holder can contain a trigger needle to trigger nucleation when desired, or a chill-cooling plate that will be moved towards the sample to rapidly cool the sample from the liquid state.
For processing, the sample holders are moved into the coil system. By switching on the coil power, the sample will be lifted and positioned and melted (positioning and heating resonance circuit). Samples are processed one by one (automatic sample exchange) with stimuli diagnostics and largely controlled from the ground. A processing cycle consists of (1) the melting of the sample, (2) the gathering of science data while performing experiments, and (3) the subsequent cooling of the sample. The next cycle starts with the re-melting of the sample. An experiment can consist of numerous cycles to achieve the science objectives. Breaks between the cycles are possible (e.g., to avoid LOS periods or perform preliminary science analysis).

4 APPLICATION PROCESS

4.1. Who can apply

The scientific institution for which the coordinator of a proposal is working must be located in one of the ESA member or associated member states that contribute to the SciSpacE programme: Austria, Belgium, Canada, Czech Republic, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, United Kingdom. Scientists from other ESA Member States that do not contribute to the SciSpacE Programme and scientists from other European countries having a cooperation agreement with ESA are encouraged to enquire with their national space organisation about the conditions for their participation in proposals to ESA. In addition to the previous, submissions from international investigators that are part of the EML agreement are also welcome.

4.2 Preparing and submitting the proposal

The schedule for this Announcement of Opportunity is as follows:

Letter of Intent due:	May 1, 2019
Announcement of Opportunity Workshop:	May 21, 2019
Proposals due:	July 1, 2019

A workshop for this Announcement of Opportunity will be held on May 21, 2019 at Airbus Defence and Space in Friedrichshafen, Germany. Please indicate your interest in participating in this workshop to the below dedicated eMail address, for planning, registration and logistical information distribution purposes, at the latest by May 1, 2019. During the workshop, ESA will provide general information about this opportunity, in addition to information on the characteristics and constraints of implementing experiments on-board the ISS. The workshop will also provide an opportunity for scientists to network and potentially start collaborations. Letters of Intent will serve as preparatory input to the workshop.

To facilitate timely proposal processing (e.g. organisation of peer review), potential submitting proposers are requested to confirm their plans to submit a proposal in response to this Announcement of Opportunity via (non-binding) Letters of Intent. The Letters of Intent will be distributed to the participants of the proposal workshop to facilitate possible cooperations. This should be taken into account when formulating the Letter of Intent, e.g. by avoiding inclusion of unpublished data. The Letters of Intent shall be prepared using the template found on this website and shall be submitted as PDF file to the below dedicated eMail address.

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

ISS-EML@esa.int

An acknowledgement of receipt will be sent to the submitting proposer upon receipt and confirmation of completeness of the proposal.
If funding of the research is not in place yet, ESA strongly advises submitting proposers to contact their national representatives to investigate possible national funding procedures and timelines as well as probability of funding in order to identify alternative funding sources if necessary. As a minimum, it is recommended to submit the proposal to their national bodies in parallel with their application in response to this Announcement of Opportunity, in order to initiate applying for national funding as early as possible.

4.3 Evaluation of proposals

ESA will make use of independent experts for the relevance and scientific merit evaluation of proposals. 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?

After the peer review evaluation, proposals with a relevance and science merit score above the threshold considered for selection will be subject to a detailed technical feasibility review, which will be performed in-house. The objectives of this review are the following:

- Assess the compatibility of the proposed project objectives and requirements with ISS capabilities;
- Assess the hardware technical complexity and the relevant potential costs for development as required to fulfil the project requirements;
- Identify and rank the areas of technical risk or uncertainty;
- Perform the preliminary assessment of resources required for implementation and operation of the proposed project.

It should be noted that there may be cases where proposals which pass the science merit threshold are not selected as they are considered unfeasible from the technical or resource requirement standpoint. In these cases, the rationale for not selecting these proposals will be clearly identified.
The proposed selection, with rationale for threshold will be presented to the appropriate ESA Science Advisory bodies for comment and endorsement. Following approval of the proposed selection, the proposers will be individually informed of the outcome of the review in a confidential letter. This will include the report of the scientific peer review with overall scoring, technical review summary and programmatic assessment.
The results of the selection will be final and not open to appeal.

5 IMPLEMENTATION OF THE SELECTED PROPOSALS

After positive selection of the peer-reviewed proposal, the Proposal Coordinator for the priority and back-up samples will be notified and the proposal will be added to the candidate pool of ISS experiments. The Proposal Coordinator will be required to confirm the availability of resources 6 weeks from notification by ESA, including (but not limited to) funding for the involved work by the science teams for the further specification of the scientific requirements, the provision of ground and flight samples, the experimental campaigns, and post-flight analysis and follow-up as appropriate. It is recommended that the experimenter requests for funding in parallel to their application in response to this announcement, in order to commence applying for national funding as early as possible or to seek for alternative funding sources if necessary.

ESA reserves the right to select only a part of a proposed project if this portion is still of high scientific merit. The applicant will be given the choice to accept or decline such a partial opportunity. If two or more proposals address similar problems and/or adopt similar approaches, it may be requested that the science teams consolidate specific parts of their projects into a single project and work as one team.

It should be noted that the acceptance of a proposal is not a guarantee for a flight opportunity. Implementation will be confirmed after a detailed definition phase, for which science teams will be assigned an ESA Project Scientist to support in defining the experiment-specific scientific, hardware, software, and operational requirements. Once considered feasible and selected for implementation, the science team will continue working with the ESA Project Scientist as well as with ESA functions to prepare the experiment for implementation.

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 Research Announcement. Specifically, ESA shall be the owner of all the Raw and Calibrated Data directly resulting from experiments implemented in the context of this opportunity, ESA shall thus be entitled to use (i.e. disseminate, valorise, preserve) the Raw and Calibrated Data resulting from the Experiments for its own purposes in the field of space research and technology and their space applications. ESA will grant the Investigator an exclusive right of prior access to the raw and calibrated Data. The duration of the exclusive right ("Period of Prior Access") shall be six (6) months from the provision by ESA of the data to the Investigator in a form suitable for analysis. This provision by ESA includes all the agreed science deliverables upon the completion of the science acquisition process, resulting from the execution phase. After this exclusivity period – unless otherwise agreed upon -, data will be made publicly accessible and available.
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.

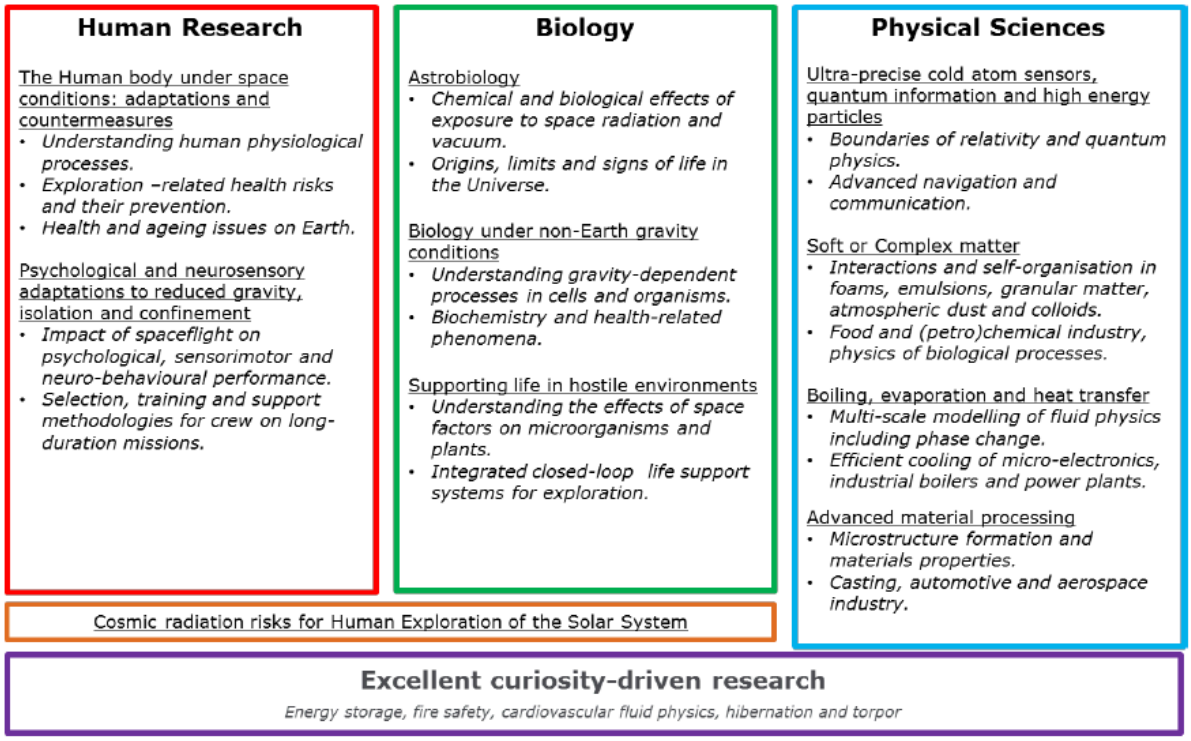

Figure 1. ESA Roadmaps

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 on the Human Research part with their research proposal.