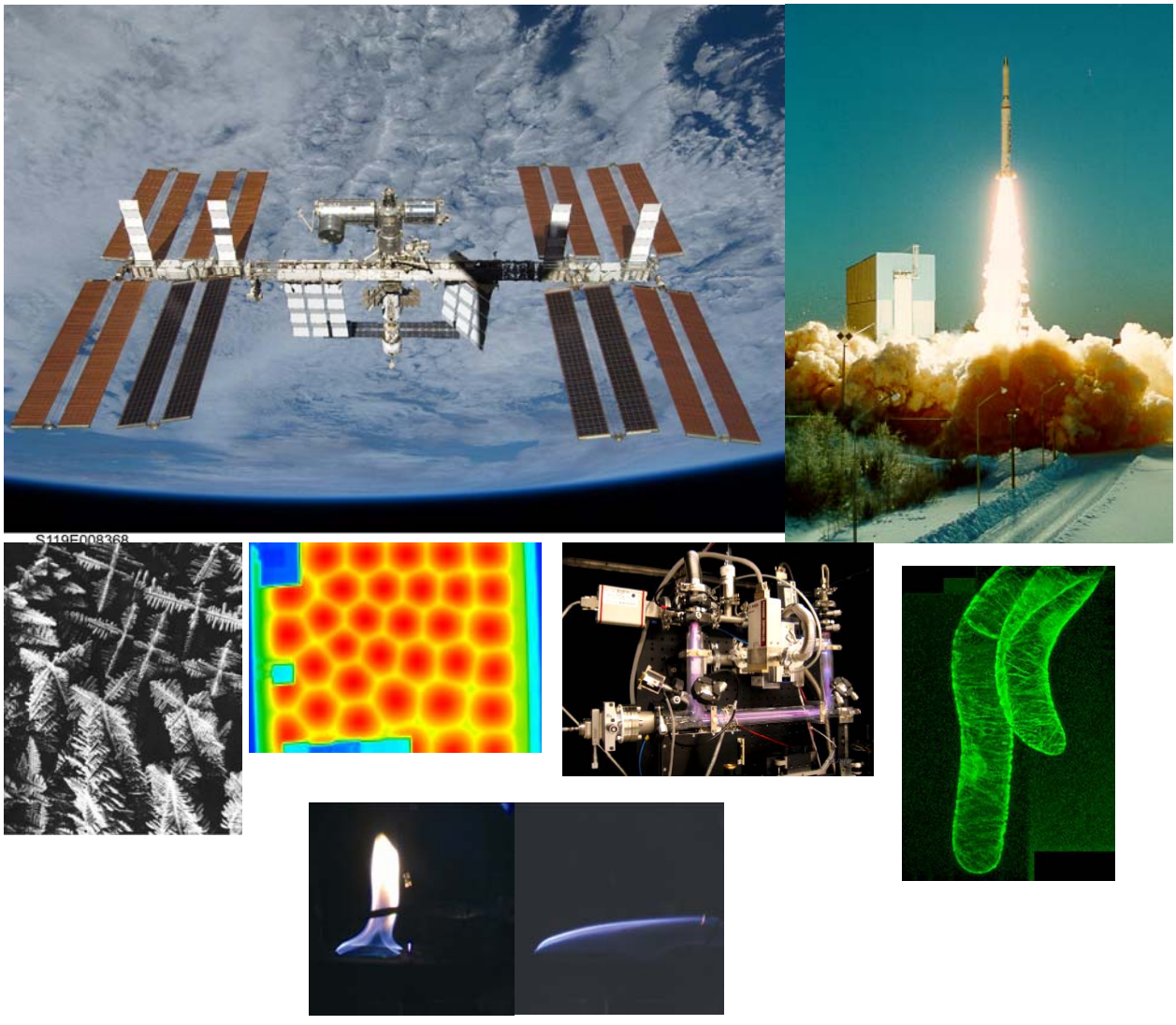
# ANNOUNCEMENT OF OPPORTUNITY
# for
# RESEARCH IN PHYSICAL SCIENCES ON SOUNDING ROCKETS AND THE ISS
# and
# RESEARCH IN LIFE SCIENCES (BIOLOGY) ON SOUNDING ROCKETS



**Letters of Intent due: 15th June 2009**

**Proposal due: 14th September 2009**

**Summary of Submission Details**

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| **'Letter of Intent' due:** | 15 June 2009 |
| **Proposals submission deadline:** | 14 September 2009 |
| **Proposal Workshop and Networking Meeting:** | 22-23 June 2009 at ESTEC, Noordwijk |

**On-line submission**: using the **ESF web sites** as follows

Letters of Intent: http:www.esf.org/loi/phys-biosr

Proposals: http:www.esf.org/phys-biosr

N.B. Full proposals exceeding 8 MB size will not be processed

**For the on-line submission of the Letter of Intent, the following information is required**

- Names, institution, addresses, and telephone numbers of the team coordinator and all team members
- A title descriptive of the proposed research
- A brief summary (20 lines) describing the proposed research project
- Maximum 5 keywords that describe the research area of the pending proposal

**Proposal Contents Checklist**

Your proposal must contain within a single, not password protected electronic file of less than 8 Mb the following material in this order:

- Project scientific and technical description, maximum 15 pages, not including references.
- Work Package Break-Down demonstrating the process of coordination between team members and the corresponding Financial Form for each team member ((PDF)/(MS Word))
- Biographical Sketches (max. 2 pages per team member, including list of relevant publications)
- Description of the dedicated instrument or equipment required by the project
- Page with the signature of all Team Members endorsing the contents of the proposal

**Participant Eligibility**

Generally, participants in the selected proposals will be nationals of those countries that participate in the ELIPS programme (A, B, CDN, CH, CZ, D, DK, E, F, GR, I, IRL, N, NL, S).

Nationals from countries that are ISS partners (Canada, Japan, Russia, USA), should consult with their national space agency on its intention to support their participation in projects submitted to this ESA AO.

Nationals from other European states may participate in proposals as ordinary team members. Such nationals should consult with their own national authorities regarding intentions to support their participation and furthermore, to participate in future phases of ESA's ELIPS utilisation programme.

**Tentative Evaluation Schedule**

- Scientific review by the European Science Foundation until early 2010
- Technical review by ESA of scientifically recommended projects in Spring 2010
- Formal endorsement by Advisory Bodies to ESA and approval by ESA's Programme Board and subsequent notification in Fall 2010

**Contact at ESA**

For any questions regarding this Announcement of Opportunity please send an e-mail with as subject "PHYS-BIO SR", including your contact details to : ELIPS_AO_2009@esa.int

**Table of Contents**

## 1. Introduction; Objectives of the Announcement of Opportunity

In 2008, Europe successfully completed two more major elements of its contribution to the International Space Station project (ISS). The Columbus laboratory was launched by the Shuttle and docked to the existing orbital infrastructure contributed by Russia, the United States and Canada. ESA's Automated Transfer Vehicle, the ISS cargo supply spacecraft, launched by an Ariane 5 rocket, automatically manoeuvred towards and docked with the ISS. A few months later, the Kibo module built in Japan was also docked with the ISS

These events marked the start of a new phase of the utilisation of the ISS by all the International Partners and by ESA in particular. The research facilities launched together with Columbus and Kibo were commissioned and first series of experiments started. Further facilities and series of experiments are already scheduled for flight in the coming years.

In the framework of the Utilisation Programme of ESA, the ELIPS programme (European Life and Physical Sciences in Space) projects that have been selected from previous research announcements are now in their flight implementation phase. Other dedicated instruments that were defined by international teams and developed by the ISS partners will make use of the facilities onboard Columbus, Destiny, Kibo and the Russian Segment as appropriate, mainly between 2009 to 2013 but also beyond these dates.

In parallel, other ESA research activities, independent of the ISS, are still being pursued. These involve the utilisation of Sounding Rockets, the Drop-Tower in Bremen and other ground based facilities that enable the investigation of space relevant problems.

**Please note that Life Sciences projects addressed by this document cover only the use of sounding rockets. Life Sciences projects aimed at using the ISS are addressed in the International Life Science Research Announcement (ILSRA) coordinated between the ISS partners and released in parallel. The application process for these projects can be accessed here.**

The utilisation of ground based facilities, the drop-tower and the parabolic flight campaigns is the subject of a Continuously Open Research Announcement (CORA) by ESA, independent of the present one. Proposals can be submitted to the CORA at any time, this Announcement of Opportunity can be found here.

By the very nature of ESA's ELIPS programme, to which 14 European countries currently contribute, the vast majority of the projects that are implemented have a distinctive European dimension, relating to the scientific teams that have proposed and run them, and the industry that develop the instruments. Beyond this initial European dimension, Canada joined the ELIPS programme in 2004 and coordination initiatives jointly with the other International Partners involved in the ISS project (Russia, the United States and Japan) have led to the development of projects with even larger international perspectives. This approach will enable the ISS partners to avoid the duplication of instruments and to serve a larger scientific and industrial research community. The level of effectiveness that could already be demonstrated with this approach has encouraged the ISS International Partners to promote the further development of international teams to propose projects and coordinate the implementation of selected projects between the ISS partners.

In this context, the present ESA Research Announcements foster the solicitation of proposals by international teams for projects aimed at utilising the space environment and, in particular, the existing facilities onboard the International Space Station. This provides the opportunity for existing projects to consolidate

their scope and team membership and to reach out to a broader community of scientists including those in Russia, Japan and America. It is also the opportunity for international teams that have been preparing new projects in the framework of International Topical Teams to submit these projects.

## 2. Topical Teams

In order to foster teaming up in anticipation of Announcements of Opportunity, ESA is supporting networks of scientists called Topical Teams that have the following objectives:

- To assess the potential long term development of research in their topic;
- To assess the relevance of the space environment as a tool for investigations and determine the specifications of the instruments required for such investigations;
- To identify potential industrial partners that could benefit from the envisaged research and involve them to the definition of the objectives and the strategy of a project including a space element;
- To assess the relevance of the project to the Framework Programmes of the European Commission;
- To submit (where possible in association with their industrial partners) research programme proposals in response to regular ESA Announcements of Opportunity such as the present one.

Several Topical Teams are currently active in Life and Physical Sciences and one of the objectives of this Announcement of Opportunity is to enable them to formulate and submit the research programme proposals that resulted from this incubation phase. It should be noted that Topical Teams are open structures so that interested scientists can contact the team coordinators at any time and seek to join any of the active teams.

New Topical Team proposals can be submitted at any time to ESA. Proposals are reviewed by the Advisory Groups for their space relevance, the competences gathered in the proposing team and the non-duplication of already existing Topical Teams activities and projects. The ESA support covers solely travel and meeting costs, it does not cover actual research work. The list and membership of active Topical Teams in Life and Physical Sciences can be found here.

ESA's Advisory Groups and the ESF have frequently stressed how much Topical Teams have contributed to enhancing the quality and the maturity of the research projects submitted to AOs, as well as the scientific coordination within the ELIPS programme. The Advisory Groups and ESF have therefore strongly recommended that ESA further promotes this preparation phase of projects.

### International Topical Teams

For several years, JAXA and CSA also support networking of scientists in Japan: the JAXA Working Groups and the CSA Discipline Working Groups. When similar topics are addressed, ESA, JAXA and CSA then promote the joining of these groups into International Topical Teams to foster coordination and cooperation at an intercontinental level. Research programme proposals incubated within International Topical Teams are then to be submitted in parallel to ESA AOs and JAXA and CSA Research Announcements. This approach has proved successful and provides the science teams with the possibility of utilising the most appropriate facilities amongst those developed by ESA, JAXA or CSA. Russian and US scientists can also become involved in International Topical Teams, thereby potentially providing the teams with access to even more capabilities for experimentation on

the ISS, enlarging the scope of projects and maximising the scientific return on investments.

In view of this developing trend, the inter-agency coordination group in physical sciences (the International Microgravity Strategic Planning Group or IMSPG), with representatives from CNES, CSA, DLR, ESA, JAXA, NASA and ROSKOSMOS recently signed a joint letter stating the following:

"*The IMSPG recommends a more assertive evolution towards international cooperative efforts in order to maximise the return on investments for hardware development and for the scientists supporting the projects. In view of current experience, the path encompassing International Topical Teams and similar endeavours to organise international networks of scientists, is deemed to be an appropriate strategy to foster scientific collaboration and incubate future space projects… IMSPG proposes to develop an internationally agreed upon and supported long-term scientific research plan*".

## 3. The ELIPS Research Plan for Life and Physical Sciences

The ELIPS Research Plan results from a bottom-up analysis of the research proposals received by ESA. These proposals have been subjected to review by external, independent peers, assessed to be technically feasible and eventually accepted into the ELIPS project pool. The projects have been further subjected to re-assessment on a tri-annual basis by the Advisory Groups to ESA.

On a regular basis, ESA also consulted the European Science Foundation (ESF) to review this research plan in dedicated user consultation meetings. The Research Plan is thus revisited, updated and endorsed via user consultation and independent global review at the start of each phase of the ELIPS programme. A new phase of the programme is then proposed for implementation on the occasion of each ESA Council meeting at Ministerial level (ELIPS-1 in 2001, ELIPS-2 in 2005 and ELIPS-3 in 2008).

The current ELIPS Research Plan focuses on key questions identified by ESA's Advisory Groups in the following generic disciplines:

- General Physics
- Physics of Fluids and Combustion
- Materials Sciences
- Human Adaptation and Performance
- Exobiology
- Biology

The key questions cover areas of research where concerted efforts on an international scale have already produced, or are expected to lead to significant results. The intention is that new proposals will consolidate or complement the currently planned research.

Interdisciplinary research is also emphasized. The ELIPS programme is deemed by ESA's Advisory Groups to represent a unique opportunity for cooperation and synergy between different scientific communities. This is expected to result in significant progress in theoretical, modelling and experimental work of interdisciplinary nature. Some of the key questions are also relevant to the future of human spaceflight and so research is encouraged in these areas so as to assist the development of space exploration support systems.

This Research Plan has been approved by all countries contributing to ELIPS. It aims to:

- Produce harmonisation between the support of ESA and that of other research funding agencies;
- Lead to a better coordinated, more efficient and comprehensive implementation of research efforts.
- Promote the creation of teams of research groups at an international level, thus combining strengths of the different team members, increasing the quality of the research projects, maximising the knowledge generated by the programme and spreading this knowledge to a broader scale.
- Enable the ISS International Partners to optimise available and future research facilities in order to sustain those objectives.

The Tables 1 & 2 in the following list the key questions identified by ESA's Advisory Groups summarising the current ELIPS research plan.

Table 1: Key questions addressed in the different disciplines within the Research Plan of the ELIPS programme developed by ESA's Advisory Groups

| General physics | Materials sciences | Physics of fluids and combustion | Exobiology | Biology | Human adaptation and performance |
|---|---|---|---|---|---|
| Test of fundamental physics theories and measurement of fundamental constants to unprecedented levels of precision. | What are the thermophysical properties of high temperature melts? | What are the dynamics and the properties of interfaces? | Organic compounds and mineral interactions under space conditions | How does gravity alter development and performance of organ systems? | What are the mechanisms orchestrating organ systems interaction and recovery under variable gravitational levels (system homeostasis)? |
| Universal time scales, time transfer, and clock comparison at world scale | What is the influence of convection on the formation of different microstructures in alloys? | What are the key mechanisms of phase separation when coupled to evaporation and heat transfer in particular? | Polymerisation, stability and replication studies under space conditions | What are the molecular mechanisms for sensing and adaptation to variable g-levels by cells (microbial, fungi, plants and animals)? | What factors impair physical and cognitive performance? |
| Dynamics and properties of degenerate quantum gases in microgravity conditions | What is the influence of the processing conditions on the features of crystalline and amorphous phases of biological, organic and inorganic materials? | What is driving the stability of complex fluids? How does coarsening happen? | Response of pre-biotic building blocks to extraterrestrial conditions. | How do different gravitational levels interfere with the formation of multi-cellular structures (cell-cell, cell-extracellular matrix/cellwall interactions)? | How can we assess and monitor health, psychological well-being and interpersonal relationships in conditions of isolation? |
| Matter-wave interferometry from atoms to large molecules | Understand the fundamental link between materials processing, structure and properties of new light-weight structural metallic or intermetallic materials | Measure the chemical physics of bulk homogeneous samples of supercritical fluids | Mechanisms of survival and adaptation of extremophiles to extraterrestrial conditions | How does gravity modify the lifecycle from embryonic development to senescence? | What are the factors governing the inter-individual variability in the response to spaceflight conditions? |
| High performance atomic clocks in space: from the microwave to the optical domain | | Understand the combustion process of dispersed systems | | What are the biological responses to multiple stressors? | What are the human responses to multiple stressors? |
| Test of entanglement over long distances and quantum communication in space | | Understand fundamentals of convection with model fluids systems. Study convective instabilities under conditions not realisable on Earth. | | How do evolution and cross-interactions between organisms occur under space conditions? | Can one identify and validate optimal countermeasure strategies based on physical, pharmacological, nutritional and psychological interventions |

Table 2: Key questions that call for an interdisciplinary approach promoted in the ELIPS programme

| | General physics | Materials sciences | Physics of fluids and combustion | Exobiology | Biology | Human adaptation and performance |
|---|---|---|---|---|---|---|
| **Atmospheric physics** | What is the relation of space-atmosphere interactions with climate change? | | What are the interactions of dust with hydrometeors in the atmosphere? | How do organic compounds (biomolecules and micro-organisms) form in planetary atmospheres, and how are they transported? | | |
| **Soft matter physics** | Measure time and length scales in dust aggregation, phase transitions in colloidal systems and granular materials | What is the influence of gravity on the time and length scales of nucleation and growth? | What are the rheological properties of homogeneous samples of complex fluids? What drives the self-organisation of nanoparticles at surfaces and in liquid films? | | How does fluid dynamics influence biological systems? | |
| **Dealing with radiation** | Model the cosmic radiation environment and its interaction with matter. | What are the possible strategies to adequately shield crew and systems from space radiation? | | What are the effects of UV and cosmic rays on pre-biotic molecules and micro-organisms? | What are the molecular mechanisms of heavy-ion impact on cells? | Quantify the risks to humans of exposure to space radiation (acute and chronic) |
| **Life support systems (Sustaining life)** | | How can one extract and exploit the elements contained in planetary regoliths to support exploration missions? | How do gas exchanges take place in (bio)reactors in space? How to complete waste recycling to 100%? What is the flammability of materials in space? How to best manage heat fluxes and air flows in manned spacecraft? | | Can one develop a sustainable closed loop biological life support systems? | What are the consequences of artificial life support systems (microbial environment, air composition, dust, etc.) on human health and well-being? |

Interested scientists will find on the ESA Human Spaceflight website detailed information on the projects that are currently being implemented, classified by disciplines. When looking for information on specific instruments that could be candidates for the project they intend to propose, they will also find links to the same details of the projects that are already planning to use these instruments. The information provided in the web site are the reports submitted by all projects

in 2007 for the purpose of the tri-annual review of the programme by ESA's Advisory Groups.

## 4. Fundamental and Applied Research

With this Announcement of Opportunity, ESA solicits Research programme proposals encompassing a space experimentation element aiming at a critical advancement of knowledge in various scientific disciplines. Projects are triggered by the fact that space offers a unique environment to realise critical experiments that are very difficult, if not impossible to realise, on the ground, or not at an adequate level of accuracy. However, the scientific approach developed by the projects should be such that no ambiguity remains as to which parameter has influenced the difference in measurements. This calls for a detailed analysis of the environment that prevails in space in comparison with the ground based environment, and its effect on the process or phenomenon under investigation. The end results should enable scientists to challenge, or validate current theories and stimulate further development towards a better understanding of fundamental principles.

It is well known amongst the scientific community interested in research in space that ESA initiated in 1996 a specific programme providing financial incentives to teams that propose applications-oriented research in space in partnership with industry. The overall strategic objective of the Microgravity Applications Programme (MAP) is to promote and accelerate the transfer of knowledge to the development of new industrial products and processes. One element of this strategy consists in capitalising on ELIPS projects to formulate larger scale, industry-defined projects to be submitted to relevant calls of the European Commission. The Integrated Project IMPRESS (**I**ntermetallic **M**aterials **P**rocessing in **R**elation to **E**arth and **S**pace **S**olidification) submitted by ESA to an FP6 call was selected by the European Commission in 2004. This project, which will end in October 2009, has clearly demonstrated how experiments in space can contribute to a strongly industry driven project by providing relevant and unique benchmark data and benchmark samples.

In the framework of the ELIPS-3 programme, ESA will primarily focus on the completion of the first MAP projects supported since 2000 or 2004. However, ESA intends to propose, in parallel, a complementary funding scheme as an incentive to identify industrial partners to participate in any projects of the ELIPS research pool deemed of industrial R&D relevance and furthermore to develop projects towards the FP programmes of the EC.

This new scheme is yet to be approved by ESA's HME Programme Board.

Therefore, whereas this Announcement of Opportunity does **not** specifically solicit new MAP projects proposals nor project proposals with industry partners, proposing teams are strongly encouraged to assess, develop and nurture contacts with industry partners that could become associated to their project in anticipation of the possible implementation of this new scheme.

## 5. Implementation of Projects

In terms of implementation, the information provided in this Announcement of Opportunity on facilities that have been developed or are under development is meant to demonstrate the breadth of research topics that can be addressed and the range of experimentation that can be endeavoured using the different carriers and instruments available to ESA. In some cases, specific details are also provided for what concerns limitations to the preparation, conditioning and post-flight handling of sensitive samples, particularly in biology on sounding rockets.

Proposing teams should therefore define their experiment requirements, at least in a preliminary fashion, to enable ESA to assess the feasibility and most effective way of implementing the experiments called for by the projects if it is positively peer-reviewed. Either one or more existing facilities or equipment that can be adapted may be utilised. If the need occurs, ESA will let new instrumentation be developed by industry under ESA contract in order to fulfil specific sets of requirements.

ESA will also assess, in coordination with the proposing teams in physical sciences, the scientific and technical appropriateness of performing experiments on short-duration carriers (drop-tower, parabolic flights or sounding rockets) to consolidate the experimental concepts and to test critical components and sub-systems. Such precursor experiments may then become part of the development plan of the project. Similarly, proposals for a sounding rocket experiment in life sciences, namely biology, can be submitted to this AO either independently or along with the proposal for a project aiming at long duration experimentation on the ISS submitted in parallel to the ILSRA. Since these will be reviewed by the same peer panel, this correlation should be clearly mentioned in both proposals so that the scientific justification of the overall strategy can be adequately evaluated.

The full cycle of projects from writing the Experiment Scientific Requirements document (ESR) under the guidance of an ESA project scientist to the collection of space data and samples can thus very well span from about 2 years for sounding rocket experiments or ISS projects that aim to use already existing equipment and repeat measurements on different samples, to 6-7 years for projects that require significant adaptation of existing instruments or in some cases the development of new instrumentation and/or series of experiments on different platforms to attain their full research objectives.

As already stressed above, scientists who have no previous experience with the utilisation of the space environment for research and development, and would like to explore new ideas, concepts or research topics can propose at any time to set-up a new Topical Team to thoroughly assess with other experts in their field the relevance and the potential of this new idea or topic. Ground based facilities can then be utilised to perform first tests and demonstrate experiment concepts. The access to these facilities is subject of a continuously open specific Announcement. This approach enables adequate maturation of projects and collecting the data required for a full-fledged project proposal to be submitted in response to the next Announcement of Opportunity.

## 6. Funding of Projects

In terms of funding, there are essentially two facets to all projects: the funding of the team members and the funding of the instruments and flight opportunities.

ESA is responsible for procuring and managing flight opportunities and for organising the funding of the development of instruments under contract with space industry.

Nevertheless, funding of the team members throughout the whole cycle of the project, from the definition phase to the exploitation phase is of utmost importance. For this, the baseline is that all team members need to secure their own funding from either national space authorities or other funding sources, essentially on the basis of the information provided in the proposal to ESA.

Any significant investment by ESA into the different phases of the project will be conditional to the availability of funding commitments for all team members.

As a consequence, all proposals must include a detailed description of the work to be performed by each individual team member for the first phase of three years in

the form of work packages. The teams are invited to utilise the work package description and cost form (PDF)/(MS Word) provided with this Announcement of Opportunity to present how they will structure their work and coordinate the interfaces between the team members and to justify their budget request.

Once the work breakdown structure is finalised and agreed between all members, the corresponding financial information must be consolidated into these cost forms and compiled in the final table that is also provided with the forms.

National space authorities represented in the ELIPS programme will be provided with a copy of the proposals involving scientists from their country, so that the funding needs of these scientists will already be known to them.

## 7. The International Space Station

***The access to ISS facilities designed to support research in the life sciences is subject of a specific parallel announcement coordinated between the International Partners: the International Life Sciences Research Announcement (ILSRA-09) and is therefore out of the scope of this document.***

In terms of pressurised volume, the International Space Station includes two modules provided by Russia, the Destiny module provided by NASA, the Kibo module provided by JAXA and the Columbus module provided by ESA.

For research in physical sciences, the following multi-user facilities are hosted in Columbus. These are the Fluid Science Laboratory (FSL), the European Drawer Rack (EDR) that can accommodate several sub-rack size instruments and the Microgravity Science Glovebox.

Columbus also features external platforms pointing from zenith to nadir that offer a unique environment and resources for a broad range of research instruments.

A very brief description of these facilities and instruments, as well of those that are currently in development for the upcoming phases of the utilisation of the ISS together with the Internet pages presenting the detailed features of these facilities are provided below.

## 8. Sounding Rockets

Sounding Rockets provide experiment payloads with excellent microgravity conditions, real-time data and video downlink and full tele-commanding capabilities. The duration of the flight is determined by the apogee reached by the payload after detaching from the rocket. Since 1982, ESA's Microgravity Programmes make use of Sounding Rockets as a carrier for experiments that can meaningfully be performed within 3 to 12 minutes. All Sounding Rockets missions procured by ESA are launched from the Esrange, near to Kiruna, northern Sweden.

The detailed information on Sounding Rocket flights and examples of experiment module that have been developed for different missions can be found here.

Examples of modules developed for sounding rocket experiments for frequent re-use are briefly presented here for information. These are the BIM module that can support a range of short-term biology investigation, and the XRMON-2 module that enables investigations of the dynamics of microstructure formation in metallic alloys using in-situ X-ray radiography.

## 9. Facilities available for Physical sciences on ISS

### a) Fundamental Physics

- Atomic Clock Ensemble in Space (ACES)

ACES is a payload consisting of two atomic clocks: a primary frequency standard based on laser cooled caesium atoms (PHARAO) and an active hydrogen maser for space applications (SHM). The two clocks are compared on-board the ISS and combined together to generate the ACES clock signal. The on-board time scale is transferred to ground via a microwave link (MWL) and used to perform space-to-ground as well as ground-to-ground clock comparisons. In addition, an optical link complementing MWL is presently under study.
ACES will perform accurate tests of general relativity and develop all a series of applications ranging from relativistic geodesy to atmosphere studies and remote sensing (GNSS radio-occultation and reflectometry).
Beyond the microwave clocks employed for the ACES mission, the next generation of space clocks is already under study. A portable optical clock is currently being developed in the frame of the SOC (Space Optical Clock) project.

- Plasma Kristall Experiment, the instruments PK-3+ and PK-4

PK-3+, sponsored by DLR, has now been very successfully operated in the Russian segment of the ISS for several years. PK-4 under development by ESA significantly differs from the PK-3 series insofar as it utilises DC-plasmas instead of AC-plasmas.
PK instruments are operated cooperatively between the Max Planck institute for Extraterrestrial physics (MPE) in Garching, near Munich, and the Joint Institute for High Temperatures (JIHT) in Moscow. Joint experiments defined by a team of European, Russian and Japanese scientists are currently planned in 2009 and beyond.

### b) Dust particles physics and related science

- ICAPS precursor: IPE

IPE is a micro-gravity experiment that addresses planetary science. Its goal is to understand the formation of planetesimals, or planet precursors, by studying dust particles and their agglomeration in conditions representative of pre-planetary conditions. It will also make it possible to study the light scattering behavior of proto-planetary dust aggregates.

### c) Atmospheric physics and chemistry

- Atmosphere-Space Interactions Monitoring instrument ASIM

The ASIM payload is an external, observatory-type payload for Columbus which will study giant electrical discharges (lightning) in the high-altitude atmosphere above thunderstorms and their role in the Earth's climate. The instrument payload is composed of light detectors, sensitive in the optical range (cameras, photometers) and in the X-ray to Gamma-ray range (imaging spectrometer).

- Miller-Urey Experiment payload MUE

The Miller-Urey experiment aims at the investigation of prebiotic chemical pathways for the synthesis of organic compounds in the protosolar nebula. This environment will be simulated in vials filled with various gas mixtures and solid particles.

### d) Fluid Science

- The Fluid Science Laboratory in Columbus is a multi-user facility for conducting fluid physics research in microgravity conditions and providing a variety of generic optical diagnostics FSL. Several experiment containers (ECs) are already in development as described in the following.

- FSL experiments container For investigations on fluid motions in spherical gaps (project GEOFLOW)

This EC consists of a sphere that is surrounded by an outer spherical shell supporting a gap in between. A temperature difference and an electric field can be established between the inner sphere and the outer shell and both can also rotate with the same, or with different velocities.

- FSL Experiment Container for investigations on emulsions (project FASES)

This EC is designed to characterise droplet-size evolution, and droplet motion as well as their aggregation and coalescence in diluted, transparent emulsions amenable to optical diagnostics as well as in opaque emulsions that are then monitored by Differential Scanning Calorimetry.

- FSL Experiment Container for investigations on convection and interfacial mass exchange (project CIMEX)

The goal of the CIMEX experiment is to quantify mass-transfer processes across interfaces, and their coupling with surface-tension-driven flows and instabilities in a pure liquid and mixture. The results will be used to test theories and numerical models. A tomographic interferometry technique is developed for the spatial reconstruction of the convection pattern in the liquid-phase. Furthermore, micro-thermocouple racks will provide detailed information about the temperature distribution across the gas-liquid interface.

- FSL Experiment Container for investigations on reference multiscale boiling investigation (project RUBI)

The goal of RUBI is to investigate the basics of boiling heat transfer phenomena on a heater surface, in a pool boiling configuration. A multi-scale experimental and analytical approach is adopted including the application of two external forces (electrical field and shear flow). Both pure liquid and mixture are to be studied. Furthermore, with the option of multiple boiling bubble initiation, bubble interaction will be also assessed. The data will be used for the validation of theoretical models and numerical codes.

- FSL Experiment Container for investigations on enhanced methods for heat transfer in a loop heat pipe demonstration (project EMERALD)

The aim of the experiment is to investigate the possibilities of heat transfer enhancement in microgravity in view of meeting the thermal control requirements of next generation space exploration systems. An evaporator/condenser based loop heat pipe model is studied to better understand the involved physical phenomena. Together with theoretical calculations, the qualitative and quantitative results of this experiment should lead to correlations and design rules for microgravity conditions.

- FSL Experiment Container for investigations on in FSL of liquid film evaporation and condensation (project SAFIR)

The experiment focuses on the fundamental aspects of liquid film evaporation and condensation. Concerning evaporation, the interest is to observe surface tension and evaporation driven film flow and eventual instabilities on a non-uniformly heated smooth and structured surfaces. For condensation, the goal is to assess capillary effects on a single fin condenser. This basic knowledge is required to be able to better design energy handling devices (e.g. energy control, conversion, etc.).

- FSL Experiment Container for investigation of foam coarsening (FOAM-C):

This facility will enable investigations of the coarsening process in foams at high liquid fractions that are highly unstable on the ground.

- Self-standing instrument for investigations of foam stability FOAM-S:

This instrument will allow studies of very unstable foams at various liquid fractions and surfactant concentrations far below the Critical Miscellar Concentration, or without surfactant.

- Facility for Adsorption and Surface Tension studies FASTER

The objective of this facility that will be operated in the European Drawer Rack in Columbus is to establish a link between emulsion stability and the physico-chemical characteristics of droplet interfaces. It will employ the oscillating bubble or drop technique to measure adsorption and desorption kinetics of single or double interfaces (liquid membrane). It capitalises on the facility FAST that flew on Shuttle missions and yielded outstanding results.

- Selectable Optical Diagnostics Instrument SODI

The SODI facility for the MSG is a 2-wavelength Mach-Zehnder Interferometer set-up and a thermal conditioner for liquid cells. It is designed to enable measurements of the distribution of indices of refraction in fluid samples that are thermally stimulated. The system also includes a linear motor to mount the cell conditioner on and permit mechanical stimuli to the fluid sample. Finally, a dedicated optical set-up providing for Near Field Scattering measurements will enable investigations of the features of colloid solutions.
The optical and mechanical features of SODI are expected to be well suited to other types of experiments.

- Vibration Induced Phenomena in GRANular media: VIP-GRAN

This set-up will enable scientists to observe the behaviour of a population of metallic spheres in a cell submitted to vibration over a broad frequency range. The aspect ratio of the cell, the level of filling of the cell, the size of the spheres (monodisperse or not), the frequency of the vibration are amongst the parameters to be varied. This development benefits from lessons learnt from two sounding rocket experiments.

- Dispositif pour l'Etude de la Croissance et des Liquides Critiques DECLIC

DECLIC is an apparatus developed by CNES to be accommodated in a NASA Express rack to support the study of material growth and liquids behaviour near their critical point. It provides all subsystems required to operate an experiment dedicated insert installed on an optical bench. ESA is preparing in coordination with CNES the study of an insert enabling investigations on oxidisation in supercritical water (SCWO).

### e) Materials Sciences

- The Materials Sciences Laboratory MSL

The Material Science Laboratory in the Destiny laboratory supports research in the areas of solidification physics, crystal growth and thermo-physical properties of materials. It provides all subsystems required to operate furnace inserts and stimulate and diagnose samples (rotating magnetic field, thermocouples, Seebeck and resistance measurements, ultrasound detection of the solid-liquid interface).
Two MSL furnace inserts were developed in order to cover the range of thermal conditions required by scientists.

- Low Gradient Furnace MSL-LGF

MSL-LGF is designed to support Bridgman-type experiments on semiconductor or metallic alloy samples. The flexibility in designing the experiment specific

cartridges that contain the sample enables scientists to fully exploit the capabilities of the furnace insert.

- Solidification and Quenching Furnace MSL-SQF

MSL-SQF is primarily intended for metallurgical solidification research under steep temperature gradients, with the possibility of quenching the solidifying interface at the end of processing – by quickly displacing the cooling zone.

- The Electro-Magnetic Levitator EML

The EML electromagnetic levitator facility is a joint development of ESA and DLR and is aimed for containerless materials processing in space. The EML will consist of a set of modules accommodated in the European Drawer Rack in the European Columbus Laboratory on the ISS. It will provide for containerless melting and solidification of electrically conductive samples, under ultra-high vacuum and/or high gas purity conditions. The EML will support research in the field of Meta-stable States and Phases and in the field of Measurement of Thermophysical Properties of Liquid Metallic Alloys at high temperature.

- DIRectional SOLidification instrument: DIRSOL

The DIRSOL facility, currently under development under ESA contract, aims to support DIRectional SOLidification experiments with transparent materials using the Bridgman technique, along with direct optical observation.

- Solution Crystallisation Diagnostics Facility SCDF

SCDF is an advanced light scattering instrument that combines state of the art static and dynamic light scattering, ultra low angle scattering and more recent multispeckle techniques based on cameras. In order to allow maximum versatility, SCDF will allow in orbit exchange of experiment specific sample cells.

### ISS Facility overview

| Facility Name | Short | Web location |
|---|---|---|
| **Fundamental Physics** | | |
| Complex plasmas investigations Plasma Crystal Experiments with AC or DC field | PKE3+ & PKE4 | http://www.mpe.mpg.de/pke/index_e.html http://www.esa.int/spaceflight/pk4 |
| Atomic Clock Ensemble in Space and next generation space optical clocks | ACES | http://www.esa.int/spaceflight/aces |
| **Dust particles Physics** | | |
| Interactions in Cosmic and Atmospheric Particle Systems (ICAPS) ICAPS Precursor Experiment | ICAPS-Precursor | http://www.esa.int/spaceflight/ipe |
| **Atmospheric Physics and Chemistry** | | |
| Microgravity Science Glovebox Miller-Urey Experiment Instrument | Miller-Urey | http://www.esa.int/spaceflight/mue |
| Atmosphere-Space Interaction Monitor | ASIM | http://www.esa.int/spaceflight/asim |
| **Fluid and Combustion Physics** | | |
| Fluid Science Laboratory Overview of the FSL facility | FSL | http://www.esa.int/spaceflight/fsl |
| FSL Experiment Container Fluid Motion in Spherical gaps | FSL-EC GEOFLOW | http://www.esa.int/spaceflight/fsl-geoflow |
| FSL Experiment Container Emulsions | FSL-EC FASES | http://www.esa.int/spaceflight/fsl-fases |
| FSL Experiment Container | FSL-EC | http://www.esa.int/spaceflight/fsl-cimex |

| | | |
|---|---|---|
| Convection at interfaces with mass exchange | CIMEX | |
| FSL Experiment Container<br>Boiling Investigation | RUBI | http://www.esa.int/spaceflight/fsl-rubi |
| FSL Experiment Container<br>Enhanced Methods for Heat Transfer | EMERALD | http://www.esa.int/spaceflight/fsl-emerald |
| FSL Experiment Container<br>Liquid film evaporation-condensation | SAFIR | http://www.esa.int/spaceflight/fsl-safir |
| FSL Experiment Container<br>Foam coarsening investigation | FOAM-C | http://www.esa.int/spaceflight/fsl-foam-c |
| Self-standing instrument for foam stability research investigations<br>Foam Stability | FOAM-S | http://www.esa.int/spaceflight/foam-s |
| EDR<br>Facility for Adsorption and Surface Tension studies | FASTER | http://www.esa.int/spaceflight/faster |
| Microgravity Science Glovebox<br>Selectable optical diagnostics instrument | SODI | http://www.esa.int/spaceflight/sodi |
| Vibrational Phenomena in Granular Materials | VIP-GRAN | http://www.esa.int/spaceflight/vipgran |
| CNES Facility DECLIC: EXPRESS Rack in Destiny (Dispositif pour l'Etude de la Croissance et des Liquides Critiques)<br>Supercritical water oxidisation insert | DECLIC | http://smsc.cnes.fr/DECLIC/index.htm<br>http://www.esa.int/spaceflight/scwo |
| **Materials Sciences** | | |
| Material Science Laboratory | MSL | http://www.esa.int/spaceflight/msl |
| Material Science Laboratory<br>Low Gradient Furnace insert | LGF | http://www.esa.int/spaceflight/msl-lgf |
| Material Science Laboratory<br>Solidification and Quenching Furnace insert | SQF | http://www.esa.int/spaceflight/msl-sqf |
| Material Science Laboratory<br>Electro-Magnetic Levitator | MSL-EML | http://www.esa.int/spaceflight/eml |
| Microgravity Science Glovebox<br>Directional Solidification Instrument | DIRSOL | http://www.esa.int/spaceflight/dirsol |
| European Drawer Rack EDR<br>Solution Crystallisation Diagnostics Facility | SCDF | http://www.esa.int/spaceflight/scdf |

## 10. Data Rights

### a) Data Rights

The Agency shall grant the Investigators an exclusive right of prior access to the Raw and Calibrated Data. The duration of the exclusive right (Period of Prior Access) shall be one (1) year from the provision by the Agency of the data to the Investigator in a form suitable for analysis.

The exclusive right of prior access shall be granted to the Investigators under the condition that the Investigators shall:

- undertake to furnish the Agency with an analysis of the results obtained and shall take all reasonable steps to publish such results or, alternatively, shall authorise the Agency to do so (such publication shall include a suitable acknowledgement of the services afforded by the Agency); and

- provide the Agency, free of charge, with an agreed number of copies of the publication and, notwithstanding the provisions of the paragraph above, the Agency shall have the right to reproduce and disseminate results that have already been published.

Any change to the duration of the Period of Prior Access shall take into account, inter alia:

- the extent and nature of the involvement of the Investigator in the development of the Experiment; and
- the type and complexity of the data to be received from the Experiment.

### b) The Erasmus Experiment Archive (EEA)

The EEA is an ESA service to the international scientific community. Abstracts, from all European 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.

The database includes a full-text search capability to retrieve information on experiments in a certain discipline, subject, mission, or by investigator name. The EEA covers both physical and life sciences, and can be found at the following URL:

http://eea.spaceflight.esa.int

This database includes also a large number of pictures, as well as video sequences documenting experiment abstracts.

Scientists in Europe who have performed experiments, be it in orbiting or sub-orbiting facilities (drop-tube, drop-tower, parabolic flights, sounding rockets, orbital robotic capsules, Soyuz, the Space Shuttle or the ISS), are urged 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.

An abstract features the following contents:

Mission Name and Date
Team Members and Affiliations
References
Processing facility
Experiment Objectives
Experiment Procedure and Results
Attachments

Please e-mail your new abstracts (in attachment) or the updated information for already existing abstracts to the EEA Curator.

## 11. Submission – Eligibility

### 11.1. Letter of Intent

To facilitate proposal processing, potential investigators are requested to confirm their plans to submit a proposal in response to this Announcement.

This Letter of Intent should be no more than one page and should contain:

- the names, addresses, and telephone numbers of the team coordinator and all team members
- a title descriptive of the proposed research a brief summary (10 lines maximum) describing the proposed research, indicating clearly the research areas defined in this Announcement that are most relevant to the proposal
- the major participating institutions
- up to 6 keywords that best describe the research area of the pending proposal
- Indication of participation in Proposal Workshop

The information of your LOI will be regarded as open information that can be distributed to other authors of LOIs, unless you specifically identify otherwise.

The Letter of Intent is to be filled on-line of the dedicated website set-up by ESF for LOIs for this AO to support the organisation of the collection and scientific evaluation of proposals.

**The submission deadline for LOIs is 15 June 2009**

Scientists listed up in an LOI with no restriction on distribution will be invited to the AO Wokshop.

### 11.2. AO Workshop

As a means to guide proposers to submit a more complete and well written proposal, in addition to improving the possibilities of scientific teaming and networking, an AO Workshop will be arranged at ESA/ESTEC, Noordwijk, The Netherlands.

The workshop, to which all scientists listed up on Letters of Intent with no restriction on distribution will be invited, will take place on **22-23 June 2009**

It is the intention that this workshop will allow for

- Answering questions related to the AO and review process, and to the various elements that should be addressed in a proposal

- Addressing technical issues related to the platforms or facilities offered
- Clarifying scientific matters
- Identifying potential partners working in the same domain with whom a joint proposal could be prepared.

ESA will to distribute, in advance of the workshop, the information contained in the Letters of Intent received (see paragraph 3.2 above) to the participants in order to identify possible team members.

The first day of the workshop will be dedicated to a presentation of the AO and clarifications in answers to questions from the participants. During the second day, meeting rooms can be made available upon advanced request to ESA to groups of scientists who wish to discuss the preparation of joint projects.

### 11.3. Proposal Submission

All information relevant to the preparation of a Letter of Intent and ultimately to the preparation of a Proposal is to be found on the ESA web site where this Announcement is presented.

The submission process however is a task that is delegated by ESA to ESF. An on-line proposal submission web site has been set-up for that purpose that can be accessed to at:

http:www.esf.org/phys-biosr

**The submission deadline for proposals is 14 September 2009**
**Proposals exceeding 8 MB size will not be processed.**

### 11.4. Participating member states

In general, participants in the selected proposals will be nationals of those countries that participate either in the ELIPS Programme (A, B, CDN, CH, CZ, D, DK, E, F, GR, I, IRL, N, NL, S) or the ISS Exploitation Programme (B, CH, D, DK, E, F, I, N, NL, S).

It is expected that Team Coordinators will be from countries that contributed to the construction of the ISS infrastructure, which are the countries that now participate to the ISS Exploitation Programme of ESA, and Canada.

Nationals from countries that are ISS partners (Canada, Japan, Russia, USA), should consult with their national space agency on its intention to support their participation in projects submitted to this ESA AO.
The Canadian Space Agency requires from Canadian scientists who plan to participate in science teams submitting proposals to this AO to obtain a Letter of Support from the Canadian Space Agency prior to submission of the proposal to ESA. A request for a Letter of Support must be sent with the Letter of Intent to the Canadian Space Agency (see list of national contact points at the end of this documents) at the same time as the Letter of Intent is submitted to ESA via the ESF web site for submission.

Nationals from other European states may participate in proposals as ordinary team members. Such nationals should consult with their own national authorities regarding intentions to support their participation and furthermore, to participate in future phases of ESA's ELIPS utilisation programme.

## 12. Proposal Evaluation

### 12.1. Peer Review by the ESF

The principles applying to the review process, and the related high quality standards, were consolidated by ESA's Advisory Bodies in a reference documents that was approved by the delegates to the responsible ESA Programme Board in 2004 and strictly applied to all reviews organised by ESA.

For this Announcement of Opportunity, the scientific part of the review of the proposals submitted to an ESA AO will be outsourced to the European Science Foundation (ESF) under ESA contract. The principles mentioned above will however still strictly apply and the peer review process will be closely monitored by ESA and representatives of the Advisory Groups.

### 12.2. Selection Criteria and Scoring

The Main Selection Criteria and the means to assess proposals against them are:

- Scientific Merit: assessed by Independent Peer Review;
- Space Relevance: assessed by Independent Peer Review;
- Technical Feasibility: assessed by In-house Assessment (ESA)

In the Independent Peer Review, each proposal will receive for each of these Main Selection Criteria a score between 0 and 100 points. As a result of the scoring the proposals will receive, for each Main Selection Criterion, one of the following marks:

- Outstanding 100 - 91 points
- Excellent 90 - 81 points
- Very Good 80 - 71 points
- Fair to Good 70 - 46 points
- Unacceptable 45 – 0 points

For some of the above Main Selection Criteria the scoring will be weighted according to sub-criteria:

For the Scientific Merit criterion there will be the following 5 sub-criteria with their relative weights:

- Significance 30%
- Approach 25%
- Innovation 20%
- Personnel 15%
- Environment 10%.

For the Space Relevance criterion there are no sub-criteria.

Proposals that score 70 points or lower on any of the Main Selection Criteria will not be selected. Owing to the resources available for the development and also for the implementation of experiments, potentially only the two upper ranges may eventually qualify for selection.

### 12.1.4. Technical Feasibility Assessment

All successful proposals in the Peer Review process are subjected to a Technical End-to-end Feasibility Assessment by ESA, including the mission implementation. The purpose of the assessment will be primarily to establish technical feasibility but also highlight areas of technical incompleteness of the proposal or areas of technical risk.

The technical assessment can be crucial in determining how or, even in some cases, if the proposed experimental programme can be carried out and therefore shall be completed within four months of the Peer review. Proposers may be contacted by ESA technical staff for clarifications, but this shall not imply any intent on the part of ESA to fly any experiment or set of experiments prior to a formal implementation decision.

The marking on technical feasibility shall cover the following sub-criteria:

- Functional Requirements;
- Space Platform Resource Requirements;
- Safety;
- Preparation for Flight Experiment;
- Estimated Cost and Schedule

with the following scoring scheme:

| | Can be implemented immediately | Feasible with minor adaptations | Some issues to be resolved | Major concerns | Not feasible |
|---|---|---|---|---|---|
| Score | A | B | C | D | E |

Those proposals receiving one or more E's or three or more D's in any of the above sub-criteria shall be deemed to be not feasible and shall not be selected.

In the case of successful proposals the proposers shall be informed as to the start of the Definition Phase described below.

### 12.1.5. Endorsement of Review Results and Establishment of Research Pool

After the full scientific and technical aspects have been reviewed following the procedures outlined above, all proposals that successfully passed the criteria are submitted to ESA's Life and Physical Sciences Advisory Groups for endorsement and subsequently to the Support Board of Delegates to ESA's relevant Programme Board for discussion and approval. Proposals thus approved enter the Pool of Research Projects (Research Pool) and will be incorporated into the ESA Research Pool Database that will be published on an annual basis as a working document.
Proposers shall be informed immediately as to the formal outcome of the Review process by a letter from ESA, giving the consensus opinion, the overall marking and any relevant comments of the Peer Board as well as the outcome of the Technical Feasibility Assessment. The results of the Review are final and shall not be open to appeal.

Once a project is included in the Research Pool, ESA will initiate steps for the implementation of that project (see section 11.2). As this inevitably involves investments both financially as well as in terms of manpower, ESA will require assurance that the project is well supported and financed. Therefore, within 3

months after reception of the formal notification for approval by ESA, the coordinator of the project is required to deliver to ESA:

- A Project Agreement and Acceptance Form covering third party funding
- Partnership Agreement detailing the rights and duties of the project team and ESA (will be updated during coming months)

Without the timely submission of these documents, the proposal will be eliminated from the Research Pool.

In this context it is however recognised by ESA that National review procedures may preclude the provision for a full financial commitment for third part funding within 3 months. In such cases, ESA will accept a conditional commitment in the Project Agreement and Acceptance form, if this is accompanied by a defined date when a full commitment can be given. Based on such information, ESA will treat the proposal as being part of the Research Pool. However, the initiation of definition-, phase A or accommodation studies for the proposal, or other activities which will require more significant investments, will be delayed until a full financial commitment is available.

## 13. Project Implementation

After formal inclusion of a project in the Research Pool, the following steps will be initiated by ESA. As soon as possible, and at the latest within 1 year, a nominated ESA Project Scientist will initiate the definition phase. This includes the writing up of a detailed Experiment Scientific Requirements (ESR) document together with the science team of a project that was selected and involving as well an instrument developer and an ISS operations manager. Once approved within ESA and signed by the science team, the ESR will become one of the applicable documents to the contract that ESA will place with industry to study its development and implementation. The ESR may evolve in the course of the project realisation, keeping track of all changes agreed to it and including progressively more details of relevance to the following phase of the project (study-manufacture-testing-launch-in orbit operations-exploitation).

Although it is highly likely that successful proposers will be in contact with ESA on a regular basis as they prepare their experiments for flight, there might be occasions in the case of flight delays where such contact is not so regular. ESA shall strive to inform proposers at least on an annual basis of the status of realisation of the project.

## 14. Review - Reconfirmation - De-selection

Proposers should be aware that all projects that are in the ELIPS research pool are subject of a tri-annual review by the Life and Physical Sciences Advisory Groups. This review based on progress reports submitted by all scientific teams follows also a clearly established and approved procedure that it is not deemed necessary to outline in this document.

The outcome of this procedure can result in one of the three following cases:

- the project is re-confirmed upon recommendation of the relevant Advisory Group;

- the project is recommended for re-evaluation by an ESF peer panel and can then be either re-confirmed or de-selected;
- the project is de-selected upon recommendation of the relevant Advisory Group.

The outcome of this procedure is implemented upon formal approval by the relevant ESA Programme Board.

## 15. Points of Contact - National Funding Authorities

### National Points of Contact for ESA member and associated states

**AUSTRIA**
Mr. Andre Peter
Austrian Research Promotion Agency
FFG-ALR – Aeronautics and Space Agency
Sensengasse 1
A-1090 Vienna
tel. 43-5 7755 3309
fax 43-5 775593309
Mob:43-(0)664 45 25 175
andre.peter@ffg.at

**BELGIUM**
Mr. Pierre Coquay
Services fédéraux des affaires
scientifiques, techniques et culturelles
8, rue de la Science
B-1000 Bruxelles
tel. 32-2 238 35 86
fax 32-2 230 59 12
coqu@belspo.be

**CANADA**
Mr. Perry Johnson-Green
Canadian Space Agency
6767 Route de l'Aéroport
CA - Saint-Hubert (Québec) J3Y-8Y9
tel. 1.450.926.4780
tel. 1.514.866-2833
fax 1.450.926.4766
perry.johnson-green@asc-csa.gc.ca

**CZECH REPUBLIC**
Mr. Jan Kolář,
Czech Space Office
Katerinska, 10
12800 Praha 2
tel. +420-603 319 407
fax +420-224 918 288
jan.kolar@czechspace.cz

**DENMARK**
Mrs. Cecilie Tornøe
Head of Section
Danish Agency for Science Technology
Innovation Policy
Bredgade 40,
DK-1260 Copenhagen K
tel. 45-35 44 63 53
fax 45-35 44 62 01
Mob.45-25 18 66 53
ct@fi.dk

**FINLAND**
Mr. Paul Stigell
TEKES National Technology Agency
FI – 00101 Helsinki
tel. 358-10 65 21 5856
fax 358-10 65 21 5901
Pauli.Stigell@tekes.fi

**FRANCE**
Mr. François Spiero
Centre National d'Etudes Spatiales
2, Place Maurice Quentin
Paris 75039 Cedex 01
tel. 33-1 44 76 74 40
fax 33-1 44 76 78 59
francois.spiero@cnes.fr

**GERMANY**
Mr. Peter Preu
DLR
Königswinterer Strasse 522-524
Postfach 30 03 64
D-53227 Bonn-Oberkassel
tel. 49-228 447 319
fax 49-228 447 735
peter.preu@dlr.de

**GREECE**

Mr. Nikolaos SPYROU
Department of Astronomy
Faculty of Physics
Aristoteleion University of Thessaloniki
541.24 Thessaloniki - Greece

tel. 2310 998181
fax 2310 995384
spyrou@helios.astro.auth.gr

**IRELAND**

Mr. Brian Rodgers
Enterprise Ireland
International Science & Technology Dpt
East Point Business Park
The Plaza – IE-Dublin 3

tel. 353-1 808 2478
fax 353-1 837 0178
bryan.rodgers@enterprise-ireland.com

**ITALY**

Mr. A. Lorenzoni
Agenzia Spaziale Italiana (ASI)
Viale Liegi 26
I-00198 Rome

tel. 39-06 8567 313
fax 39-06 8567 328
andrea.lorenzoni@asi.it

**LUXEMBURG**

Mr. P. Decker
Ministère de la Culture et de la Recherche
18-20 Montée de la Pétrusse
L-2912 Luxembourg

**THE NETHERLANDS**

Mrs. W. van der Meulen
NIVR
Kluyverweg 1
P.O. Box 35
NL-2600 AA Delft

tel. 31-15 27 89 485
fax 31-15 26 23 096
W.vandermeulen@nivr.nl

**NORWAY**

Mrs. Marianne Vinje Tantillo
Norwegian Space Centre
Drammensveien 165
P.O. Box 113 Skoyen
N-0212 Oslo - Norway

tel. 47-22 51 18 00
fax 47-22 51 18 01
Mob.:47-98 88 26 38
marianne@spacecentre.no

**PORTUGAL**

Mr. José Santos-Victor
Instituto de Sistemas e Robótica
Instituto Superior Técnico
PT – 1049-001 Lisboa

tel. 351-218418294
fax 351-21 8418291
jasv@isr.ist.utl.pt

**SPAIN**

Mrs. Andrea Perez-Carro
CDTI
C/Cid, n° 4
ES – 20881 Madrid

tel. 34-91 581 5609
fax 34-91 581 5584
perezcarro_andrea@cdti.es

**SWEDEN**

Mrs. Kristine Dannenberg
Swedish Board for Space Activities
P.O. Box 4006

tel. 46-8 627 64 98
fax 46-8 627 50 14
kristine.dannenberg@snsb.se

SE – 171 04 Solna

**SWITZERLAND**

Mr. Oliver Botta
Scientific and Space Exploration Programmes Manager
Federal Department of Home Affairs FDHA
State Secretariat for Education and Research SER
Swiss Space Office SSO
Hallwylstrasse 4
CH-3003 Berne

tel. 41-31 322 99 67
fax +41-31 322 78 54
mob. 41-(0)79 7753149
Oliver.botta@sbf.admin.ch

**UNITED KINGDOM**

Mr. David Parker
BNSC
Polaris House, North Star Avenue
Swindon, SN2 1SZ, UK

tel. +44 203 300 8787
fax +44 203 300 8842
mob. 44(0) 7901 514 969
David.Parker@bnsc.gsi.gov.uk
David.Parker@stfc.ac.uk

## ISS Partners Points of Contact

**JAPAN**

Mr. Shinichi Yoda
Institute of Space and Astronautical Sciences
Space Biology and Microgravity Sciences Department
Japan Aerospace Exploration Agency
Tsukuba-shi, Ibaraki-ken, Japan 305-8505
Tsukuba Space Center

tel. 81-298-68-3650
yoda.shinichi@jaxa.jp

**RUSSIA**

Mr. George Karabadzhak
TSNIIMASH
4 Pionerskaya
Moscow
Russia 141070

tel. +7-(498)-602-9542
gfk@mcc.rsa.ru

**UNITED STATES**

Mr. Francis Chiaramonte
ISS Research Project -Program Executive
NASA HQ
Washington DC
United States

tel. +1 202 358 0693
Francis.p.chiaramonte@nasa.gov