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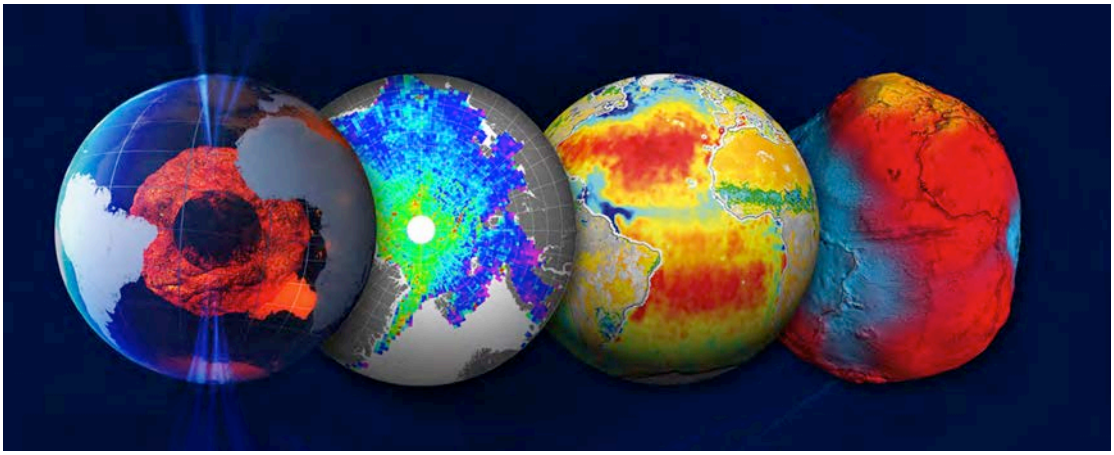
The Earth Observation Envelope Programme



Call for Earth Explorer-10 Mission Ideas

25 September 2017

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1. Introduction

As part of its *Earth Observation Envelope Programme* (EOEP), the European Space Agency (ESA) announces an opportunity for scientists from the Earth Observation (EO) community in ESA Member States, Canada and Slovenia to prepare proposals for ideas to be assessed as potential *Earth Explorer Core Missions*. These missions will be used to conduct research in the field of EO and/or to demonstrate the potential of new innovative EO techniques of relevance to both the scientific and the application-oriented user communities.

The *Earth Observation Envelope Programme* is a rolling programme designed to lead European efforts in EO from space. The Research Mission element of the programme consists of a series of missions addressing critical Earth science issues. In the past, eight Earth Explorer missions have been selected for implementation, namely four *Earth Explorer Core Missions*, GOCE (Gravity field and steady-state Ocean Circulation Explorer), Aeolus (Atmospheric Dynamics Mission), EarthCARE (Clouds, Aerosols and Radiation Explorer), Biomass (forest carbon mission); and four *Earth Explorer Opportunity Missions*[1], CryoSat (polar ice monitoring), SMOS (Soil Moisture and Ocean Salinity), Swarm (Earth's magnetic field and environment), and FLEX (Fluorescence Explorer).

The motivation behind this Call is the Agency's wish to engage the scientific community as far as possible in determining and advancing the content of the *Earth Observation Envelope Programme*. The Agency wants to achieve a clear appreciation of the science community's views on what mission ideas will provide the highest scientific return and the best response and solution to scientific and societal challenges (c.f., Earth Observation Science Strategy for ESA: A New Era for Scientific Advances and Societal Benefits, ESA SP-1329/1 and ESA's Living Planet Programme: Scientific Achievements and Future Challenges – Scientific Context of the Earth Observation Science Strategy for ESA, ESA SP-1329/2, European Space Agency, Noordwijk, the Netherlands, 2015).

Taking into account the experience from previous calls, and in line with the spirit of the programme, the Agency is soliciting ideas for missions to be implemented as ESA-led Earth Explorer Core missions. Mission candidates will be selected from the proposed ideas on the basis of their innovation and scientific excellence. The total cost of the mission should not exceed 400 M€ to ESA (at 2017 economic conditions). However, proposals with more cost-effective solutions are strongly encouraged.

A response to the Call may be made by scientists from ESA Member States, Canada and Slovenia, or teams of scientists, where proposing teams may also include scientists from non-ESA member states.

[1] Nowadays referred to as "Fast-track" missions

Copies of this announcement and key reference documents will be found linked from this call website http://explorercall.esa.int and the Agency's Living Planet website http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme. .

2. Scope and Nature of the Call

Responses to this Call can cover any topic in Earth science relevant to the ESA *Earth Observation Envelope Programme* in accordance with the attached scientific priorities. Information on the scientific context of the *Earth Explorer* element of this programme will be found in the Earth Observation Science Strategy for ESA, which was accompanied by an appraisal of the achievements with respect to the previous scientific challenges for the ESA Living Planet Programme (c.f., Earth Observation Science Strategy for ESA: A New Era for Scientific Advances and Societal Benefits, ESA SP-1329/1 and ESA's Living Planet Programme: Scientific Achievements and Future Challenges – Scientific Context of the Earth Observation Science Strategy for ESA, ESA SP-1329/2, European Space Agency, Noordwijk, the Netherlands, 2015).

The Earth system behaves as a single, highly coupled system comprising physical, chemical and biological components and processes, on which humanity is having significant effects. There are complex interactions and feedbacks between the Earth system components that cut across disciplinary boundaries of the Earth sciences and take place over a wide range of spatial and temporal scales. Even in the absence of external forcing, the Earth system exhibits considerable natural variability, which needs to be understood and distinguished from human-induced trends.

The societal challenges that humankind faces require a strategic, sustained scientific response. The Earth Observation Science Strategy for ESA identifies the following key elements as the foundation for this response:

1. Ground-breaking exploratory missions integrated into flexible observing systems for Earth System science.

2. Sustained observations to understand and attribute trends beyond the expected variability.

3. International cooperation to provide an integrated optimised Earth observing system, which can fill gaps in observational needs and build new capability in a cost-effective way.

4. Translational science to synthesise and adapt the data streams from individual instruments and satellites into knowledge.

5. Wide communication and dialogue with people beyond the scientific sector to help explain the value, opportunities and inspiration provided by EO from space.

These elements are not exclusive, but represent the Agency's view on what are major science strategy related issues to be addressed in this Call. Proposals on other topics must demonstrate novel approaches and new scientific insights, again related to the societal issues as quoted above.

The response to the Call for Ideas for ESA-led Earth Explorer Core missions is intentionally page-limited, as mission ideas do not need to have been defined in full conceptual detail. The selected mission ideas will first be elaborated in an Assessment studies (Phase 0), and then down-selected candidate mission concepts addressed in Phase A feasibility studies. For this Call and in the interest of time, the industrial system activities in Phase 0 and Phase A will be linked under parallel frame contracts, each of them covering the two phases.

Since this Call is seeking new scientific ideas and innovative approaches, the proposers may consider mission ideas that are still at a lower degree of scientific maturity, or "readiness", but nevertheless show potential for the EO scientific and application communities. Evidence for the current Science Readiness Level (SRL) shall be provided in the Proposal indicating the scientific status in the area of the related research, possibly published material in the peer-reviewed literature (with specific reference to the proposed mission idea) and any analysis or simulation software that may be available, in accordance with the SRL Handbook. Regarding technology readiness, a first analysis of the critical technologies and their current Technology Readiness Level (TRL) should be provided in the Proposal

Ideas for potential international co-operative approaches may be proposed. A preliminary commitment by the intended partner is sufficient at this stage.

Addressing innovative approaches as part of this Call, such as small satellite formations and constellations, new methods for end-to-end system integration, or taking advantage of existing and future space infrastructure, e.g. flying in coordinated manner with a long-term operational mission, in order to address new science issues, is encouraged.

It is important to note that the Agency invites proposals that clearly demonstrate **scientific excellence combined with innovative technology**.

It should also be noted that an Earth Explorer 10 (EE-10) mission idea does not necessarily have to comprise a single satellite but could be composed of a constellation of (smaller) satellites, provided they allow to address the science challenges.

In line with the spirit of the EOEP programme, the Agency is soliciting proposals for mission ideas for implementation as EE-10 that should not exceed a 400 M€ budget to ESA at 2017 economic conditions (e.c.), covering the development of the mission up to the end of the commissioning phase once the satellite is in orbit (phase B1 to E1). This implies, for the proposers, that a target of 225 M€, e.c. 2017, has been set for all industrial development costs for the space segment, excluding launch services, operations, ground segment, level 2 processor and ESA internal costs.

A mission compatible with a dedicated Vega-C launch configuration should serve as baseline. For significantly smaller missions that do not require a full Vega-C launcher, partial launcher cost may be assumed.

Any alternative option arising through an international partnership (e.g. launch opportunity, instrument) shall not impact the overall budget. In case of in-kind contributions, the industrial development costs can be increased according to these in-kind contributions as long as the budget ceiling of 400 M€ to ESA is not exceeded.

The Call will result in the selection of **three mission ideas**, without any order of priority, which will undergo Phase-0 studies. At the end of Phase 0 a Mission Definition Review will be performed to assess each mission concept, and the Earth Science Advisory Committee (ESAC) will recommend the two highest ranked concepts to proceed to Phase-A studies. A decision on the full implementation (Phase B/C/D/E1) of one of the two missions will be taken at the end of Phase A, based upon demonstration that the mission respects all the necessary conditions, supported by a public User Consultation Meeting (UCM) and scientific peer-review under the auspices of ESAC.

The mission selected as EE-10 will be implemented in accordance with a tailored approach of the ESA rules and standards for ‘Earth Explorer Core’ Missions, with particular regard to the approaches for project reviews and documentation, applicable standards, industrial organisation with a cost-effective structure.

The Agency foresees a launch of EE-10 in the 2027/28 timeframe.

3. Proposal Submission and Selection Process

Concerning the proposals for Earth Explorer Core mission ideas, submission will be performed according to the following compulsory steps:

Letter of intent and list of core scientific team

A letter of intent and the list of the core scientific team shall be submitted by **15 December 2017, 12:00 noon (Central European Time)**, introducing the proposing team and outlining the mission objectives and characteristics. The detailed requirements on proposal format and on the topics to be addressed in the letter of intent are given in Annex A. In addition, proposers shall list the core scientific team (not exceeding 20) and indicate their involvement and role in their proposed idea, using the Excel spread-sheet which can be downloaded from the Call web site. Listing supporting scientists who are not directly involved or contributing to the proposal is strongly discouraged. The core team shall remain unchanged between LOI and Proposal.

Submission of full proposal

The full proposal shall be submitted by **2 March 2018, 12:00 noon (Central European Time)**. The detailed requirements on proposal format and on the topics to be addressed in the proposal are given in Annex B.

During the evaluation process, individual respondents may be requested to provide clarification of aspects of their Response to the Call.

Selection of candidates to enter Phase 0 and down-selection for Phase A

The full responses to the Call will be reviewed by ESAC, which will recommend **three candidate ideas** to go forward for assessment study, i.e. Phase 0. This evaluation will be supported by scientific peer-review panels on scientific issues as well as the Executive, who will cover technical and programmatic issues. The candidate mission ideas recommended for Phase 0 will be presented by the Executive to the Programme Board for Earth Observation (PB-EO) for approval.

After completion of the evaluation process and the final endorsement of missions for Phase 0 by PB-EO, the **results will be announced by the end of September 2018** and the assessment phase will be initiated.

A Mission Assessment Group (MAG) will be established for each candidate selected for assessment and all contributors to an idea will, in principle, be regarded as candidates for the respective MAG. This MAG will be tasked with presenting the scientific maturity and feasibility of the mission concept at the end of Phase 0 as well as preparing a Mission Requirements Document (MRD), as necessary to start Phase A.

At the end of the Phase 0, a Mission Definition Review will be held. ESAC will review the scientific aspects of each mission concept whilst the Executive will review the technical maturity and programmatic aspects. The three mission concepts will be

ranked by ESAC according to the selection criteria, and a selection recommendation made to PB-EO for the decision on which mission concepts to proceed to Phase A.

Although no strict requirement on SRL and TRL applies for the responses to this Call, evidence should be given in the Proposals that SRL of 5 can be achieved at the end of Phase A and TRL of 5 at the end of phase B1.

Roadmap towards Selection as EE-10

At completion of the Phase A the MAG will be tasked with producing a *Report for Selection* for each candidate mission. The intention is to present the results of the studies to the community in a User Consultation Meeting (UCM), which will contribute to the selection of one mission to be implemented as EE-10.

It should be noted that responses to the Call that do not lead to selection might still be further investigated by the Agency. All commended ideas that are not selected will be reviewed to identify potential new areas where the science or technology aspects remain insufficiently mature to initiate development of a mission and where further scientific or technological development is needed.

Mission selection schedule from Call until start of mission development

Release of the call	25 September 2017
Deadline Letter of Intent (LOI) and list of core scientific team	15 December 2017, 12:00hrs (noon) CET
Proposal submission deadline	2 March 2018, 12:00hrs (noon) CET
Announcement of results – candidate missions to enter Phase 0	End of September 2018

Any response that misses the deadline for submissions will be discarded.

4. Evaluation Criteria

Following PB-EO's acknowledgement of the Earth Observation Science Strategy for ESA – A new Era for Scientific Advances and Societal Benefits (ESA-SP-1329/1) and ESA's Living Planet Programme: Scientific Achievements and Future Challenges – Scientific Context of the Earth Observation Science Strategy for ESA (ESA-SP-1329/2) and discussion at PB-EO level, the applicable seven Earth Explorer selection criteria are as follows:

1. **Relevance to the ESA research objectives for Earth Observation** – for this criterion reference must be made to the general and specific objectives and

scientific challenges set forth in the document Earth Observation Science Strategy for ESA – A New Era for Scientific Advances and Societal Benefits and 'ESA's Living Planet Programme: Scientific Achievements and Future Challenges' – Scientific Context of the Earth Observation Science Strategy for ESA (ESA SP-1329/1+2, 2015). Here account shall be taken of how scientific advances anticipated from the mission contribute to addressing major societal issues.

2. **Need, usefulness and excellence** – this must take account not only of scientific requirements and/or the importance of a mission viewed as a precursor but also the extent to which the requirements, including those of space/time sampling, can be met by the proposed mission.

3. **Uniqueness and complementarity** – this must take account of other (i.e. not space) means of addressing the mission requirements as well as the activities and plans of other national and international bodies for space missions.

4. **Degree of innovation and contribution to the advancement of European Earth Observation capabilities** – this relates to technical/industrial aspects as well as to user interests.

5. **Feasibility and level of maturity** – this encompasses the technical constraints with a particular emphasis on the technology readiness and the scientific readiness, as well as the status of the associated user community within ESA member states and the maturity of its requirements.

6. **Timeliness** – this must take account not only of the timeliness of a mission from the point of view of user needs but also with regard to implementation constraints.

7. **Programmatics** – in addition to the considerations of development schedule, cost, risk, etc., this addresses the implications of possible cooperation with other bodies, including synergies with other national and international developments, and taking account of the planned availability of relevant data from other observing systems.

Annex A – Guidelines for Letter of Intent (LOI) and list of core scientific team

The Letter of Intent shall introduce the concept for the mission idea to be proposed and should not exceed 4 pages. It shall provide a brief overview of the scientific objective of the mission idea and its assessment containing evidence that the concept of the proposed mission idea has been scientifically validated. It shall clearly identify the Lead Proposer and the scientific and technical team. The Letter of Intent format shall be in Adobe Acrobat PDF (unlocked).

The following structure for the Letter of Intent is expected:

- Proposing Team, introducing the members of the team directly involved in preparing the proposal together with their affiliation. The **entire scientific team shall not exceed 20 persons**.
- Executive Summary, summarising the mission idea, its objectives
- Scientific Objectives of the idea, describing the research objectives of the mission together with their relevance to ESA's EO Science Strategy and expected deliverables.
- Characteristics of the mission idea, identifying the main features, together with an indication of the related scientific and application-oriented user demands, together with a brief assessment of its expected feasibility.
- References

In addition, proposers shall list the scientific team (not exceeding 20 people), and indicate their involvement and role in the proposed idea, using the Excel spread-sheet that can be downloaded from the Call web site. Listing supporting scientists who are not directly involved or contributing to the proposal is strongly discouraged. The core team shall remain unchanged between LOI and Proposal.

Lead Proposers shall identify qualified independent candidates for the scientific peer review of their proposals to ESA, in the LOI.

Annex B - Guidelines for proposal preparation

The following guidelines for the proposal shall be followed:

- Proposals shall identify a **Lead Proposer,** who is a national from one of the Agency's Member States, Slovenia or Canada. The proposal shall be prepared by scientists (individually or in cooperation with other individuals and/or scientific institutes), supported by technical experts in industry or other expert entities.

- The scientific team listed on the proposal shall be justified by their respective contribution to the content of the proposal. The **entire scientific team shall not exceed 20 persons**. This number includes any potential support letters from scientists.

- Ideas for potential international co-operative approaches may be proposed. A preliminary commitment by the intended partner is deemed sufficient at this stage.

- The proposal shall be submitted in English language.

- The proposal format shall be in **Adobe Acrobat PDF (unlocked)**, A4 page format, single-line spacing, font to be used: Times New Roman or Times, font size 11. All proposals must be submitted via the Call website.

The proposal shall have the following structure (**not exceeding 28 pages**, excluding references):

Cover Page (1 page) is the title page of the Response to the Call with name and full address and affiliation (plus phone, fax and e-mail) of the Respondent plus list (names and affiliations) of associated scientists. The reference number provided by ESA (following submission of the LOI) shall be entered on the top right corner of the proposal cover page).

Executive Summary (1-2 pages) describing the mission idea in a nutshell.

- A concise resumé describing: the scientific objectives, the science-context and requirements in terms of the geo-biophysical variables or parameters to be retrieved, the targeted accuracy and the relevant spectral, spatial and temporal scales, as well as a broad justification for the realisation of the mission.

- An outline of the envisaged mission implementation concept addressing the required observation concepts and the associated main requirements, together with the main elements of the mission idea.

- The Agency shall be allowed to use the Executive Summary for public distribution. The rest of the proposal will be treated confidentially.

Scientific Objectives, Requirements and Justification (<10 pages) is a description of the mission objectives with justification.

- A description of the objectives of the mission and their rationale, including the status of the scientific knowledge and the identification of the gaps and open issues that the mission intends to respond to.
- The required mission duration and the relation to other planned or existing missions.
- The identification of the geophysical variables and data products required to fulfil the objectives of the mission and the relevant observation requirements (e.g. accuracy, spatial and temporal scales).
- The SRL status in the associated area and the status of potentially available geophysical retrieval algorithms. Supporting peer-reviewed references validating the concept idea shall specifically refer to the details of the proposed concept, and include the methods for achieving the required geophysical measurement in relation to the specific instrumentation and observation technique proposed.
- A Roadmap should be provided outlining the steps and scientific risk reduction measures foreseen to achieve SRL 5 at the end of Phase A.

Technical Concept (<10 pages) is an outline of envisaged technical concept with some indication of its heritage and potential feasibility.

This section of the proposal presents the general characteristics of the mission and the associated measurement requirements, including a justification of how these allow the fulfilment of the scientific objectives of the mission. This section shall include:

- The observation techniques relevant to the mission idea.
- The relevant observation requirements (e.g. observation geometry, required observing conditions, temporal, spatial, spectral and radiometric requirements, spatial and temporal co-registration requirements, measurement accuracy requirements).
- Other general requirements (e.g. synergy with other missions and relevant co-registration requirements)
- A Roadmap should be provided outlining the technical risk reduction measures necessary to achieve TRL 5 by the end of Phase B1.

Relevance to Evaluation Criteria (<5 pages) – response to the selection criteria outlined in Section 4.

References - relevant publications shall be included.