Φ-sat-2 Challenge of ESA
Call for proposals

Introduction
As part of its initiative to promote the development of radically innovative technologies such as Artificial Intelligence (AI) capabilities onboard Earth Observation (EO) missions, the European Space Agency (ESA) announces an opportunity for the EO community to present cubesat-based ideas to be assessed for a potential Φ-sat-2 mission. This opportunity is open to “economic operators” – including, among others, industry, research institutes and academia - from the ESA Member States plus Canada and Slovenia participating in the FutureEO-1 Programme, which is tabled for subscription at ESA Ministerial Conference Space19+.

The Φ-sat-2 mission will be used to demonstrate the AI enabling capability for new useful innovative EO techniques of relevance to EO user communities. The overall objective is to address innovative mission concepts, fostering novel architectures or sensing that enable to meet user-driven science and/or applications by means of onboard processing. The latter will be based on state-of-the-art AI techniques and onboard AI-accelerator processors.

Building upon the experience from the development of Φ-sat-1 experiment, the Agency is soliciting ideas for missions to be implemented according to ECSS (European Cooperation for Space Standardization) standards and requirements tailored for cubesat missions (as per Applicable Documents [AD1][AD2][AD3][AD4][AD5]).

Mission candidates will be selected by the Agency on the basis of their innovation and capability to demonstrate the disruptive potential of onboard AI for EO according to the criteria defined in this Call, as explained hereafter.

Scope and Nature of the Call
This Call is seeking new ideas and innovative approaches to EO exploiting onboard AI. The selected concepts are expected to be implemented and ready for launch within a maximum of 16 months after confirmation as winning candidate.

The overall development will be implemented via a two-phase contract:

- The first phase (Mission Concept Phase), led by instrument and AI innovators, will consolidate the instrument and overall mission concept;
- The second phase (Mission Development Phase), led by a mission integrator, will be dedicated to the design and development of the space and ground segments, launch, in-orbit operations, data exploitation and distribution.

Pending the outcome of Space19+ for the FutureEO-1 programme and the evaluation of the proposals, the Agency will grant a contract whose first phase (Mission Concept Phase) shall cost a maximum of 240 keuro and last maximum four months. At the end of this phase, the Agency expects that the selected consortium will have a representative Breadboard Model (BBM) of the instrument able to demonstrate the overall performance and the AI capabilities, as well as an update of the plans and any other relevant documents for the following phase (Mission Development Phase).

The first phase will end with a Readiness Review, during which the Agency will evaluate the results achieved as well as the updated plans for the Mission Development. Upon successful completion of the Readiness Review, the second phase will be activated. This second phase,
devoted to the Mission Development, shall fit in a maximum overall budget of 2.5 Meuro, including satellite Flight Model (FM), procurement of launch service, in-orbit operations (Launch and Early Orbit Phase, commissioning, nominal operations for one year, provisions for end-of-life disposal), payload data downlink, data processing and data distribution. The schedule for the development of the mission shall last a maximum of 12 months from the start of the Mission Development Phase up to the satellite readiness for delivery to the launch service provider. Nominal operations shall last a minimum of 12 months after satellite commissioning (including payload and AI application) and include data downlink, processing, storage and distribution.

The contractor shall abide to a free and open data policy for the distribution of the data.

**Proposal Submission and Selection Process**

Submission shall be performed according to the following compulsory steps:

A mission idea shall be submitted by the 31st of January 2020, 12:00 noon (Central European Time). Proposing consortia shall be composed of “economic operators” from the ESA Member States plus Canada and Slovenia participating to the FutureEO-1 Programme, which will be tabled for subscription at ESA Ministerial Conference Space19+ at the end of November 2019.

Given the financial envelope, the Agency expects proposals for missions to be implemented using cubesats (cf. Reference Documents [RD1] [RD2]), although this is a guideline and not strictly mandatory if the above financial constraints are respected.

This mission idea shall include:

1. A summary description of the complete mission concept, outlining the main objective targeted by the mission, including science/application, user community, how the objective achievement will be demonstrated.
2. The composition of the consortium and its background and experience including CV’s of key personnel, presenting all the information directly relevant for the proposed activities and showing that all needed elements of expertise are present in the team (list of publications in CV shall be limited to the latest five most relevant items). The resources (including software tools) required to perform the proposed work, making it clear how the rights to use them have been secured.
3. A detailed description of the mission concept demonstrating the disruptive role of onboard AI leading to an innovative EO technique and/or application. The description shall identify the innovative contents of the proposal and explain how these can improve the state of the art in the domain being targeted, including expected impacts and benefits. This shall include a detailed description of the instrument design and of the AI application with a first iteration of technical requirements for the instrument and the AI application.
4. A detailed description of which measurements will be taken and which users could eventually be served and with which derived products, providing a justification and the rationale for the use of AI, an initial roadmap for wide exploitation of the data to be generated and evidence of the interest of potential users. Where relevant, this shall also describe target performance levels to be achieved with quantitative values. The verification approach shall be identified. An analysis shall be included about whether the proposed satellite complements any of the existing European EO missions (e.g. Earth Explorers, Sentinels, meteorological missions, national missions) and whether any joint data use is foreseen.
5. The detailed description of the scientific and technical steps needed to develop the
mission concept and meet the objectives, with a first iteration of the concept and the baseline implementation. The baseline design shall include the system architecture and a functional decomposition, presented in block diagrams providing any internal and external interfaces. This part shall elaborate on the trade-offs that need to be made and show the overall logic of the work proposed, including any key review and decision points.

6. An analysis of the Technology Readiness Level (TRL) of the critical technologies along with the status of the possible application and a detailed assessment of the TRL level of the instrument and of the AI algorithm and related Hardware (HW). A discussion of potential problem areas and key development risks that may be expected during the development in order to reach the target performance levels, with a risk assessment proposing mitigation and preventative actions to reduce likelihood and potential impact of such risks/problems. Credible alternative design or implementation solutions shall be discussed.

7. A description of the required ground segment to operate the space segment and to receive, process and disseminate data. A detailed description of the work logic and work plan for the Mission Concept Phase and of the Mission Development Phase including the development of the instrument BBM and the AI Software (SW) and HW processor as well as the development, launch, mission operations and data exploitation phases.

8. Schedule, review milestone plan and deliverable list shall be included. A detailed design, development and exploitation plan, with corresponding schedule, shall be elaborated. The plan shall include the development of space segment, ground segment, data elaboration and dissemination as well as all foreseen development models (“flatsat” if any, structural models if any etc.). The schedule and the review milestone plan shall reflect the two-phase approach of the contract with a first phase of four months (Mission Concept Phase) ending with a Readiness Review with deliverables as per Annex I. The schedule and review milestone plan for the second phase shall be according to [AD3][AD4][AD5].

9. Detailed costs for all phases, including Mission Concept Phase, space and ground segment design and development, launch service provision, mission operations and data downlink, processing, distribution and exploitation.

The ideas submitted in reply to the Call will be reviewed and ranked by ESA. This evaluation will be supported by ESA EO application, mission, instrument and AI experts, who will assess the ideas considering both technical and programmatic aspects.

The criteria for the ranking of the proposal are:

1. Level of innovation and uniqueness of the proposed mission and technologies involved;
2. Maturity of the EO application as well as the proposed instrument and onboard AI HW/SW;
3. Quality and suitability of the proposed programme of work, adequacy of engineering approach as well as of the design and development plan;
4. Consortium background knowledge and experience in the field of AI and EO instrument development for cubesats;
5. The level of contribution of AI as an enabling factor for new EO technique and/or for new applications;
6. Technology and programmatic feasibility of the mission implementation;
7. Potential for future user uptake and/or integration into a European EO system of systems;
8. Conformity to the budget and schedule of the Call and adequacy of Management, costing and planning for the execution of the work.

Pre-requisite for the participation to evaluation and ranking process is the conformity to the proposal to the allocated maximum budget of 240 keuro for the Mission Concept Phase and 2.5 Meuro for the Mission Development Phase (including space and ground segment development, launch service provision, mission operations and data downlink, elaboration, distribution and exploitation) and to the allocated schedule of 4 months for the Mission Concept phase, 12 months from the start of the Mission Development Phase up to the satellite readiness to be delivered to the Launch Service Provider and a minimum of 12 months of operations, including data downlink, processing, distribution and exploitation.

The Agency will then release a Request for Quotation (RFQ) to the consortium whose proposal has been ranked as the best.

During the first phase the selected consortia shall design, manufacture, assemble, integrate and test a BBM of the instrument including the SW and HW AI processor and verify its performance. In particular it is expected that the BBM, as part of this phase, will undergo the following tests:

1. Functional and performance verification tests, including validation of all operation modes and mode transitions.
2. Tests shall be performed to demonstrate the performances of the instrument for all functions and operation modes. In particular, the Agency expects the selected consortia to demonstrate through the analyses of the results of the performance tests the ability to perform the innovative mission proposed and to be able to demonstrate the disruptive advantages that the onboard AI brings to the mission.

During the first phase the selected consortia will update the plans for the Mission Development phase by updating:

1. The composition of the consortium for the second phase and its background and experience, including CV of key personnel. This shall identify the prime contractor for the second phase, who is expected to have experience in mission implementation, satellite assembly, integration and testing, the innovator partners who will develop the FM of the instrument and exploit the application results, the responsible for the launch service provision, the responsible for operations, ground segment and data processing. Consortia shall be composed of economic operators from the ESA Member States plus Canada and Slovenia participating to the FutureEO-1 Programme, which will be tabled for subscription at ESA Ministerial Conference Space19+.
2. The work logic and work plan for all the phases (development, launch, mission operations and data exploitation).
3. Design, development and exploitation plan. The plan shall include the development of space segment, ground segment, data elaboration and dissemination as well as all foreseen development models (“flatsat” if any, structural models if any etc.).
4. The identification of user needs and the definition of the mission objectives and EO application requirements.
5. Costs for all phases, including space and ground segment design and development, launch service provision, mission operations and data downlink, processing, distribution and exploitation.

This first phase will end with a Readiness Review in which the Agency will verify:

1. The achieved maturity of the instrument and the AI algorithm(s) and associated HW/SW.
2. Achieved results with the BBM. This will include the matching of the tested performance with the mission objectives and requirements for the proposed mission.
3. Confirmation for the second phase Background and experience of the consortium and key personnel.
4. Quality and suitability of the updated proposed programme of work, adequacy of engineering approach as well as of the design and development plan.
5. Verification of the achievement of the objective highlighted in the proposal especially in terms of innovation and contribution of AI as enabling factor for new EO technique and/or for new applications.
6. Technology and programmatic feasibility of the proposed second phase.
7. TRL level reached in the Mission concept phase and the plan to increase it up to the flight as well as TRL levels of all other technologies of the space and ground segment.
8. Adequacy of Management, costing and planning for the execution of the work.

In case of successful achievement of the Readiness Review the second phase of the contract will be activated.

Applicable documents

[AD1] TEC-SY/128/2013/SPD/RW- Tailored ECSS Engineering Standards for In-Orbit Demonstration CubeSat Projects
[AD2] TEC-SY/129/2013/SPD/RW Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Projects
[AD3] TEC-SY/126/2013/LST/RW IOD CubeSat Deliverable Items List
[AD4] TEC-SY/127/2013/DRD/RW IOD CubeSat Deliverable Requirements Definition
[AD5] TEC-SY/78/2016/REV/RW Review Objectives for ESA In-Orbit Demonstration (IOD) CubeSat Projects

Reference Document

[RD1] 6U CubeSat Design Specification Rev. 1.0 California Polytechnic
[RD2] CubeSat Design Specification Rev. 13, California Polytechnic
## ANNEX I

Deliverable list for the Mission Concept phase to be delivered at the Readiness Review

<table>
<thead>
<tr>
<th>Deliverable</th>
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<tbody>
<tr>
<td>Mission Scope Document (MRD)</td>
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<tr>
<td>Instrument Requirements Document (IRD)</td>
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<tr>
<td>Instrument Design Report (IDR)</td>
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<tr>
<td>AI design report</td>
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<tr>
<td>Instrument Interface Control Document</td>
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<tr>
<td>Instrument Development Plan (IDP)</td>
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<tr>
<td>Product Assurance Plan (PAP)</td>
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<tr>
<td>AI network and Training, validation and test data sets</td>
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<tr>
<td>BBM Functional test plan</td>
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<td>BBM Test Reports</td>
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<tr>
<td>Mission Design development plan and exploitation plan (including application requirements as well as requirements for the space and ground segment development and deployment)</td>
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<tr>
<td>Consortium composition and background experience for the second phase</td>
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<tr>
<td>The work logic and work plan for all the phases (development, launch, mission operations and data exploitation)</td>
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<tr>
<td>Schedule, review milestone plan and deliverable list for the second phase according to [AD3][AD4][AD5]</td>
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