ARTES 4.0 Generic Programme Line Business Applications - Space Solutions

“Commercial Applications of Space-Enabled Robotics – Agriculture”

THEMATIC CALL FOR PROPOSALS

Prepared by	ESA
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Table of ACRONYMS

AI	Artificial Intelligence
APQ	Activity Pitch Questionnaire
AoF	Authorisation of Funding
ARTES	Advanced Research in Telecommunications Systems
BASS	Business Applications and Space Solutions
DG	Director General
ESA	European Space Agency
FP	Full Proposal
OP	Outline Proposal
OSIP	Open Space Innovation Platform
SME	Small and Medium sized Enterprise
TIA	Directorate of Telecommunications and Integrated Applications

1. OVERVIEW

This document presents an overview of "Commercial Applications of Space-Enabled Robotics", under the 6th thematic area "Agriculture", thematic call for proposals issued under the ARTES BASS, 5G and 4S programme lines. The call offers the opportunity to companies to bring forward their business propositions, which leverage space and advanced digital technologies for delivering sustainable solutions.

2. BACKGROUND AND RATIONALE

Agriculture is humankind's oldest and most consequential economic activity, providing the necessary sustenance to fuel humanity's survival. With a growing global population, pressure is surmounting on the agricultural sector to satisfy increased demand for produce while preserving environmental and ecological health. Considering limited land, water and labour resources available, it is likely that the necessary advances in agriculture must be oriented around efficiency and productivity gains, to address rising pressures faced. [1]

Agricultural robotics refers to the use of automated machinery and advanced technologies like robots, drones, and AI-driven systems to perform tasks in farming and agriculture. Robotic systems have become a mainstay in the agricultural sector, enabling farmers to achieve levels of output far greater than that plausible with human labour alone. Mechanisation has dramatically enhanced the capabilities of farmers and the amount of land that they can manage in a given period. Traditionally, farmers have used robots for simple, repetitive tasks such as picking and packing fruits and vegetables or planting seed – jobs that are challenging to fill due to the strenuous nature of the work and associated low compensation, and those that robots can solve at cost-effective rates. As advances are made across robotics and AI, such systems are increasingly capable of performing more complex tasks. The repertoire of tasks addressable by robots now span a wide range of functions such as planting, harvesting, weeding, spraying, soil monitoring, tending to livestock, and precision farming, often with greater speed, efficiency, and accuracy than traditional manual labour. As such, the transition towards higher levels of intelligence in exploited robotic systems is underway.

To carry out such functions, various types of agricultural robots are utilised. Articulated robots equipped with advanced sensors and AI are capable of delicate handling of certain fruits and vegetables, enabling automated harvesting. Autonomous tractors affixed with precision GNSS (Global Navigation Satellite System) receivers can navigate fields autonomously, performing tasks such as ploughing, seeding, and tilling with high accuracy. Drones are well-suited to tasks such as aerial crop monitoring and surveying large fields to get a sense of vegetative health, insect issues and more. They can also be used for irrigation management and application of agrochemicals, leveraging satellite positioning for navigation of drones and complementary earth observation data for

[1] Agricultural Robotics & Automation - IEEE Robotics and Automation Society - IEEE Robotics and Automation Society (ieee-ras.org)

mapping and analysis of larger plots of land. A marriage between agricultural robotics and computer vision has enabled such systems to handle weed control for specialty crops, leveraging laser technology to destroy the weeds without compromising the crops. Use of specialised sensors enable robotic systems to derive soil properties such as pH levels, moisture content, and nutrient levels to guide decision-making. [2] Many further applications of robotic systems having arisen in the preceding decades and are expected to arise in those following, the latter in relation to automation of tasks that mimic the more nuanced capabilities of humans.

As such, the global agricultural robotics market is expected to experience substantial growth, rising from $13.4 billion in 2023 to an estimated $86.5 billion by 2033, with a projected compound annual growth rate (CAGR) of 20.5% during the forecast period. This expansion is fuelled by the growing demand for automation in agriculture, increasing labour costs, and the need to address the rising demand for food production. [3]

Satellite technology has also played a prominent role in agriculture. The use of satellite imagery for mapping, monitoring and analysis of agricultural plots of land being amongst the most prominent applications of satellite earth observation data. Satellite technology is critical for several robotics applications, including the navigation of such systems and the geo-referencing and timestamping of acquired field data. GNSS RTK (Real-Time Kinematic) positioning is a key enabler for high precision robotics applications, for example those involving plant-by-plant management and repeat visits of the same sites or plants, particularly where concerns high-value crops. Satellite communications can enable the use of such systems in regions with limited or poor connectivity. Advances in the available stock of satellite imagery, positioning solutions, and novel satellite connectivity services are expected to enable new capabilities in the agricultural sector, with new possibilities for robot-based solutions.

The rationale for this initiative is to cultivate new services that take advantage of parallel advances in both robotic systems and satellite technology, with regards to novel technologies, business models and/or operational environments, for applications in the agriculture sector.

The following application domains, or others duly identified by industry, may be considered:

- Automated, high-throughput, field phenotyping using sensors, satellite technology, drones and robotics, to support researchers and breeders in selecting for desirable crop traits and optimising for crop productivity. [4] Solutions should leverage robotic systems for precise and repeatable assessments of individual plant conditions to enable demarcation of specific traits and environmental parameters leading to particular phenotypic responses.

[2] 15 Agricultural Robots and Farm Robots You Should Know | Built In

[3] Agricultural Robot Market Size, Share | CAGR of 20.5%

[4] The Big Idea – Phenotyping – Envision – College of Agriculture Magazine at Purdue University

- Use of fleets of small robots for precise seed bed preparation and seed placement, to relieve excessive soil compaction from large tractors. This is in view of reducing degradation to soils, costs of reparative actions, and associated downstream environmental impacts (increased waterlogging, surface run-off, and otherwise). [5]
- Robotic weed mapping and treatment, leveraging precise positioning, machine vision, and environmentally-friendly treatment mechanisms (mechanical, laser-based, reduced quantity precision-spraying) to identify and remove unwanted plants without causing damage to crops. [6] [7]
- Selective harvesting of crops, including validation of attained crop quality thresholds, and harvesting of target crops without unintentional damage. This will require robotic systems leveraging computer vision (for recognition, segmentation and spatial localisation), sensors and precise positioning.
- Robotic systems for improved tending of livestock and aquaculture farms to improve animal welfare and environmental sustainability, and enable streamlined compliance with welfare accreditation schemes and eligibility for environmental stewardship schemes. Solutions could focus on autonomous monitoring of livestock themselves and/or identification and reporting of environmental issues such as algal blooms, and onset of disease-prone conditions.
- Robotic systems tailored towards atypical farming terrain, such as heterogeneous and hilly topographies. [8]

3. OBJECTIVES OF THE CALL

This Call for Proposals invites proposals for feasibility studies and demonstration projects for services that combine the use of satellite technologies and robotics for downstream services.

Downstream services here refers to activities involving the utilisation of data and services provided by space assets. This includes satellite communication services, satellite earth observation data, satellite PNT (positioning, navigation, and timing) services, and other applications that leverage space technologies to be used on Earth.

'Robotics' is here defined to include physical robots, autonomous drones, machines and vehicles, and precursory solutions or those that enable these (e.g. connectivity and navigation systems for robotics services, connectivity solutions to enable tele-operated robotics, and beyond).

The main objectives of the Space-Enabled Robotics call are to:

[5] T. Duckett, S. Pearson, S. Blackmore, B. Grieve, "Agricultural Robotics: The Future of Robotic Agriculture. Year" (2018)

[6] The Next Frontier of Weeding Robots | GOFAR (agricultural-robotics.com)

[7] A. Upadhyay et al., "Advances in ground robotic technologies for site-specific weed management: A review," Comput. Electron. Agric., vol. 225, 2024, 109363, https://doi.org/10.1016/j.compag.2024.109363.

[8] T. Duckett, S. Pearson, S. Blackmore, B. Grieve, "Agricultural Robotics: The Future of Robotic Agriculture. Year" (2018)

- Enable and cultivate the study, development, and demonstration of innovative[9] services at the intersection of space-based services and robotic systems, to create an added-value in various industries. This made possible by integrating any of satellite communications, earth observation and/or positioning at the system or service level (i.e., integrated with the robotic system directly, or supporting the overall service).
- Utilise this combination of advanced technologies to improve industrial efficiency, productivity, operational safety, competitiveness, and generally tackle challenges in industry that could not otherwise be addressed without the unique complementarity of these technologies.
- Support the adoption of satellite technology/data into robotic systems in the context of operational services such that the emergent design, development, and implementation constraints are identified, evaluated, and mitigated, to enable more rapid realisation and scaling-up of such services on Earth, into the future.
- Enable the creation of new markets and the establishment of novel business models permitted by this combination of technologies in the chosen sectors.

In accordance with the above, the objectives of this specific subtheme are to:

- Identify the most feasible and attractive commercial opportunities within the agriculture sector for the uptake of robotic systems, that enable positive societal impact.
- Establish the roadmap and associated constraints to operational deployment of services based on such robotic systems.
- Develop and demonstrate such services in pre-operational environments to showcase the perceived value propositions in the intended commercial setting.
- Support the eventual uptake of robotic systems on land, sea or air, in operational settings in which they prove viable and offer significant benefits by way of enhanced safety, sustainability, efficiency, and commercial competitiveness.

4. SPACE ASSETS

Satellite technologies and data have a significant role to play within prospective services:

- **Satellite positioning** can provide coarse to high accuracy positioning information to robots, vehicles, machines, and drones operating in outdoor spaces. This can be used for navigation, geo- and timestamping of collected data, time-synchronisation of networked machines, and/or determination of speed and heading. Augmentation of GNSS can offer higher positioning accuracies for certain use-cases via solutions such as Galileo HAS (High Accuracy Service) or GNSS RTK (Real-Time Kinematic) solutions, with the selection dependent on the service requirements.
- **Satellite communications** provide data, video and voice communications and may add value to applications implemented in the following service provision

[9] Innovation could reflect the business model, technology, operational context, or a combination thereof.

scenarios:
    - Environments that have inadequate, unreliable, compromised, or altogether absent mobile cellular connectivity.
    - Mobile services that operate across regions with varying cellular connectivity quality (good in certain areas, poor in others) and require continuous coverage and availability.
    - Services that have high security, robustness and resilience requirements may benefit from satellite communications for redundancy in compromised or unforeseen circumstances.
- **Satellite Earth Observation -** it is expected that satellite earth observation could support robotic solutions at the service level i.e., providing complementary or enabling datasets to support the activities of the autonomous systems. This could be through situational awareness data to support the navigation of a robot, or use of earth observation data to inform, initiate, or halt deployment of an autonomous system. Satellite earth observation data could refer to air quality measurements, thermal heat signatures, optical, radar, meteorology, or combinations thereof.
- **Spaceflight Technology Spin-Outs –** applications (on Earth) of robotics originally developed for use in space (and other astronomical objects) that also have commercial applications on Earth, i.e. Spaceflight Spin-Outs, are also considered eligible. This could relate to robotics originally developed for, and used in, space, tele-robotic solutions and algorithms (perception, planning, control…) for autonomy of space robotics, or otherwise.

In all cases, the role of space technology and/or data in the service should be justified in comparison to non-space alternatives.

5. SCOPE OF THE CALL

The proposals submitted under this Call for Proposals shall address the agriculture domain with innovative user-driven downstream services which rely on the combination of satellite technology/data (any of those mentioned above) and robotic systems.

The Bidder shall either address the (optional) use cases included in the Annexes (*if* additional use-cases have been supplied, they will be published on the website) or address other use cases and requirements related to agriculture provided by other customers / users directly involved by the Bidder. [10] In the latter case, support of those potential customers shall be evidenced in letters of interest to be attached to the Outline Proposal (the second step in the application process). Proposals under both options will be considered equally.

The service provider shall be identified and be part of the bidding team to ensure the commercial operational roll-out of the proposed service following completion of a demonstration project.

This Call for Proposals covers two types of activities:

[10] Note that if no Annex document has been published, no additional partner-supplied use-cases are foreseen.

1. **Feasibility Studies**, which provide the preparatory framework to identify, analyse and define new potentially sustainable services. The applications and/or services covered by the proposed Feasibility Studies must:
   - Be customer/user driven and present a strong sustainability potential.
   - Propose a service demonstrating the benefits of the utilisation of integrated space assets.
   - Include a viability analysis.
   - Aim to evolve the targeted applications and services to marketability and operational roll-out, potentially through a Demonstration Project after successful completion of the feasibility study.

2. **Demonstration Projects**, dedicated to the implementation and demonstration of pre-operational services. The applications and/or services covered by the proposed Demonstration Projects must:
   - Be customer/user driven (including user involvement and active participation in the project).
   - Propose a service demonstrating the benefits from the utilisation of space assets with clear potential to become commercially sustainable.
   - Provide a measurable socio-economic impact.
   - The Bidder shall involve in the project representatives from user communities, which shall take part in the pilot.

6. PROCUREMENT APPROACH

The proposals submitted in reply to the call shall be implemented in the context of ESA BASS, 5G and 4S programme lines of ARTES in coordination with National Delegations.

The Bidder shall submit first an Activity Pitch Questionnaire, and following evaluation, may be invited to submit the Outline and Full Proposal. The Activity Pitch Questionnaire (APQ) template provided by ESA shall be used. This is considered the entry point for companies to submit their idea, providing a simplified and single point of access to the ESA ARTES framework.

The price of activities carried out in a given State are charged against the contribution of that State in the programme. A letter of Authorisation of Funding (AoF) from the relevant National Delegation is therefore required as part of the Full Proposal. The Bidder is however advised to inform the relevant National Delegation(s) when submitting the Pitch. The contact information of the National Delegates can be found here: National Delegations | ESA Space Solutions

The Agency will admit for evaluation only (Outline and Full) proposals from a bidding team composed of a company and/or organisation - be it as Prime or Subcontractor - residing in any of those states that subscribe to the Programme under which you wish to submit your proposal:

I. **for the ARTES 4.0 BASS Generic Programme Line - Component A**: Business Applications. To date, Austria, Belgium, Czech Republic, Denmark, Estonia,

Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Sweden, Switzerland and the United Kingdom have subscribed.

II. **for the ARTES 4.0 5G Strategic Programme Line**: Austria, Belgium, Finland, Germany, Greece, Hungary, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Romania, Spain, Sweden, Switzerland, the United Kingdom and Canada have subscribed.

III. **for the ARTES 4.0 4S Strategic Programme Line:** Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxemburg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Switzerland, the United Kingdom and Canada have subscribed.

Note that the Netherlands has opted out of this initiative. Thus, companies residing in the Netherlands may not apply.

7. PROCESS AND SCHEDULE

It is planned for the call for proposals to be opened on **28th October 2024** until **15th January 2025**, 13:00 CET.

7.1. Timeline and Procedure

Bidders can respond to this thematic call by submission of a short Activity Pitch Questionnaire within the above timeframe.

The Call is planned to be implemented according to the following stepwise approach:

In **Step 1**, the interested Bidders are requested to submit their proposal(s) based on a short Activity Pitch Questionnaire (APQ) template made available by ESA that can be downloaded from the Thematic Call website. The pitch should provide the initial idea of what the Bidder would like to propose, elaborated on the basis of the thematic areas and either the use cases proposed by ESA's partners or others selected by the Bidder. If the Bidder has the relevant information available to them, they may consider completing the supplementary questions (AP5) in the APQ template as part of the APQ+, which may allow to skip Step 3 below, at ESA's discretion.

The bidder should select 'Thematic Call (under 1-10494)' and 'Commercial Applications of Space-Enabled Robotics' under the drop-down options on the introductory page of the APQ template (also indicating if they intend to address an optional use-case or not) as per figure 1 below. Should the bidder wish to cooperate with any of the listed partners in the annexes, they shall give to the Agency the authorisation to distribute the activity pitch questionnaire to these stakeholders by explicitly stating it in the Activity Pitch Questionnaire. Subject to such authorisation, the Agency will follow up distributing the APQ to the bidder's authorised stakeholder(s) and liaise with them to facilitate interactions with the Bidder.

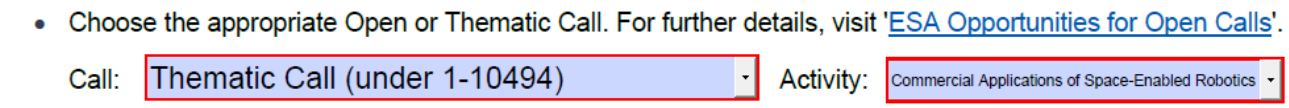


Figure 1 Select 'Thematic Call (under 1-10494)' followed by 'Commercial Applications of Space-Enabled Robotics'

The Bidder shall not contact any of the stakeholders listed in the annexes on the webpage.

The Bidder shall NOT involve any of the stakeholders mentioned in the annexes in the bidding consortium neither as subcontractor nor as external service (including consultancy).

The completed Activity Pitch Questionnaire (APQ) shall be uploaded using the online web submitter, ESA's Open Space Innovation Platform (OSIP) in the channel named "APQ for ARTES Downstream Business Applications"

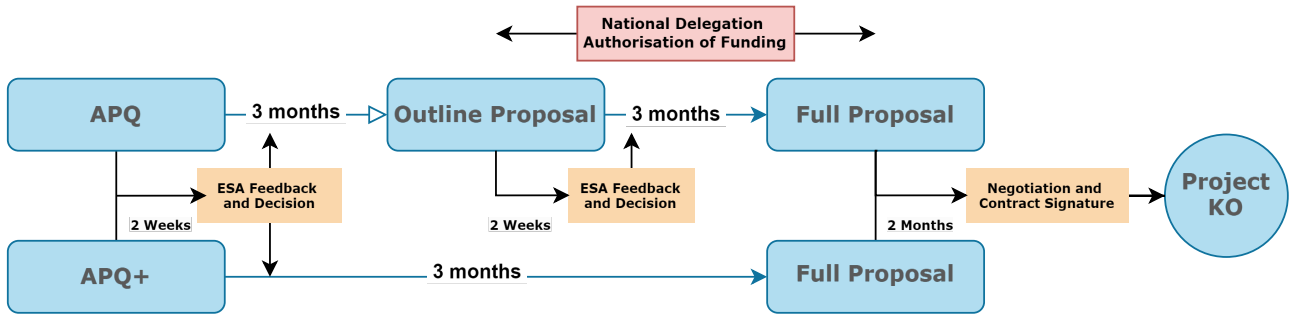
Multiple Pitches can be submitted.

It is strongly recommended that the interested Bidder liaises with the relevant ESA Member States Delegates from the beginning.
In **Step 2**, following an assessment of the Pitch by ESA, ESA will provide feedback to the company, aiming to provide a reply within 10 working days following the deadline for submission of the Pitch.
It is recognised that some interactions with the Bidder may be required and ESA may therefore consult with the Bidder and may offer support in providing further clarifications, aimed at better shaping the subsequent proposal(s) which form the subsequent steps. Dialogue sessions may be organised individually with potential partners prior to Step 3.
ESA might also consult, when necessary, with the relevant National Delegation(s) for orientation and will provide key information (e.g. title, cost, price, subcontractor) to the relevant National Delegation(s).

Subject to a positive evaluation of the Pitch and the Bidder having informed the National Delegation(s), the Bidder will be notified by ESA and invited to submit an Outline Proposal. Note that the APQ+ can act as a substitute for the Outline Proposal, thus if having adequately answered the additional questions included in the APQ+, the Bidder may be able to skip Step 3.
In **Step 3**, the Bidder will submit the Outline Proposal, based on a template provided by ESA, with letter(s) of interest from users/stakeholders. The Outline Proposal expands upon the Pitch with a more extensive level of detail. The Bidder will be allowed 3 months from the APQ submission deadline to submission of their Outline Proposal. The Outline Proposal will be submitted on the OSIP platform under the channel "Outline Proposal for ARTES Downstream Business Applications – Feasibility Studies/Demonstration Projects".
In **Step 4**, subject to a positive assessment from ESA and in-principle support from the National Delegations, the Bidder will be invited to submit a Full Proposal on ESA-STAR in accordance with BASS programme line. The Bidder will be allowed 3 months from submission of their Outline Proposal to submit their Full Proposal on ESA-STAR.
In **Step 5**, the Bidder will submit a Full Proposal with the Authorisation of Funding (AoF) from the relevant National Delegation(s). Following a positive assessment by ESA the

proposed activity will be approved for implementation.

A summary of the process is shown below.



NB: Indicative Timelines are the Maximum Durations

Figure 2 Summary of the Application Process

7.2. Evaluation Criteria

The evaluation process is non-competitive, as each proposal will be assessed individually on its own merits, according to the evaluation criteria applicable for CALL FOR PROPOSALS FOR DOWNSTREAM APPLICATIONS IN ARTES 4.0 (esa star ref.: 1-10494).

More information for the assessment of the APQ and outline proposal stages can be found on the OSIP page "APQ for ARTES Downstream Business Applications".

More information on the evaluation criteria for the final proposals can be found within the document "Appendix 1 to AO/1-10494/20/NL/CLP (Issue 2.2)" which can be found on ESA-STAR at the prior link.

8. GENERAL CONDITIONS

The submissions and all correspondence relating to it shall be in English.
The tender shall not contain any Classified Information, whether in the Pitch, Outline Proposal or in the Full Proposal.
To avoid any confusion with Classified security markings, the unclassified protective marking used by the Tenderer in the proposal shall not contain the terms: "Restricted", "Confidential", or "Secret".

However, should the Tenderer consider necessary to include Classified Information in the tender, the Tenderer shall inform beforehand the ESA Security Officer.
The Tenderers are informed that Classified Information can be shared with ESA only in compliance with the Project Security Instruction (PSI) duly established by the Agency beforehand and subject to the approval by the ESA Member States.

The Agency will treat commercially sensitive or proprietary information confidentially and solely for the purpose of the assessment of the response.
Expenses incurred in the preparation and dispatch of the response to the announcement will not be reimbursed. This includes any expenses connected with a potential dialogue phase.
The announcement does not bind the Agency in any way to place a contract. The Agency reserves the right to issue amendments to the announcement.