European Innovation Council

PATHFINDER CHALLENGE

IN-SPACE SOLAR ENERGY HARVESTING FOR INNOVATIVE SPACE APPLICATIONS CHALLENGE GUIDE

EIC Work Programme reference: HORIZON-EIC-2023-PATHFINDERCHALLENGES-01-05
Call deadline date: 18/10/2023
EIC Programme Manager: Stella Tkatchova

The EIC will hold an Info Session on this Pathfinder Challenge topic on 26th January 2023 at 11:30 AM CET. Participants can access the meeting as guests here. Participation in the meeting, although encouraged, is optional and is not required for the submission of an application. A recording of this Info Session will be made available on the same URL. Notifications of additional dissemination events can be found at EIC Challenges information days (europa.eu).

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1. About this document

The Challenge Guide serves as guidance and background for the common understanding, participation rules and obligations for the EIC beneficiaries that are involved in the Challenge Portfolio. Contractual Obligations are further detailed in the EIC Work Programme 2023

The Challenge Guide is a guidance document accompanying a topic of the Pathfinder Challenge call for proposals to provide further information about how portfolio considerations will be taken into account in the evaluation of proposals for that topic.

The Challenge Guide is prepared by and under the responsibility of the relevant EIC Programme Manager (information about the EIC Programme Managers is available on the EIC Website (https://eic.ec.europa.eu/eic-communities/eic-programme-managers_en). It complements the Scope, Specific Objectives and/or Specific Conditions set out in the EIC Work Programme by a description of the portfolio considerations and how a portfolio will be built. The presentation provided by the Programme Manager during the Info Day gives applicants a further opportunity to understand the background of the call, and to ask questions to the Programme Manager. In no case does the Challenge Guide contradict or supplant the Work Programme text.

Following the selection of a proposals to be funded under the Challenge, the Programme Manager will work together with the consortia of the selected projects to develop a common roadmap with a strategic plan for the Challenge. This roadmap/ strategy plan will integrate the activities and milestones of the individual projects into a shared set of objectives and activities across and beyond the projects. The roadmap serves as a common basis for the project portfolio and may affect the project implementation - including possible adjustments, reorientations or additional support to projects. The roadmap will be updated in light of emerging results or issues during the implementation.

2 Scope and objectives of the Challenge as defined in the Work programme

This section is a copy of the Challenge call in the EIC work programme text. Proposals to this Challenge are expected to explain how they relate to and intend to go beyond the state of the art, and how they interpret and contribute to the objectives of the Challenge.

EIC Pathfinder Challenge: In-space solar energy harvesting for innovative space applications

2.1 Background and scope

Thermonuclear reactions in the Sun are practically an unlimited source of energy, however only tiny fraction of it is so far being exploited. At the same time, increased satellite launches and advancements of Low Earth Orbit (LEO) mega constellations, emergence of in orbit satellite servicing (IOS), and active debris removal (ADR) services demonstrate the need for energy to fuel ever increasing spacecraft in-space mobility. Satellite owners are expected to launch in multiple orbits, service satellites, perform collision avoidance manoeuvres, and move their satellites or space tugs into the desired orbits (e.g., LEO, etc.). Therefore, future spacecraft will need innovative propulsion capabilities in order to achieve long-term reliable, affordable, and scalable solutions for in-space mobility.
The visionary idea to find a way to collect solar energy in space and transmit it, possibly via an appropriate grid of re-translators, to various in-space recipients to be utilised for various in-space applications and novel propulsion approaches will result in emerging breakthrough innovations for renewable and self-sustainable in-space mobility solutions and bring substantial benefits for the European satellite owners.
There is an exponential growth of activities in orbit that will require in-space mobility with game changing novel propulsion methods and energy to be utilised for this propulsion. In-space energy harvesting could offer continuously energy to spacecrafts in orbit for in-space mobility, provided that a proper propulsion system is developed. These could be green propulsion solutions, utilizing the transformed and transmitted energy for orbital manoeuvres. Game changing green propulsion solutions for increased payload capability without impacting launch costs and even reducing them is one of the challenges to be addressed.
In addition, the lack of atmosphere will make possible also the transmission with limited loss of this green energy to the lunar surface for various in-space applications e.g., In Situ Resource Utilisation (ISRU).
Mastering all the necessary technologies for developing innovative in-space applications would support the EU strategic autonomy in the critical field of energy, green propulsion for in-space mobility, and in-space transportation.

2.2 Overall goal and specific objectives

The EIC is looking for breakthroughs in the areas of in-space energy harvesting and transmission, and of novel propulsion concepts that will use such harvested energy.

To achieve such a breakthrough, the scientific and technological challenges to be overcome are enormous, since there are many obstacles and bottlenecks requiring game-changing solutions. The proposals submitted to this Challenge should address at least one of the fields below. In particular, targeted research and development is necessary in order to come up with:

- Scalable solutions (e.g. on-board spacecraft large deployable photovoltaic panels to collect the solar energy, wireless power transmission (WPT) devices, wireless receiver devices that re-convert to usable energy, batteries, etc.) for in-orbit efficient solar energy collection and storage.
- Conversion DC-to-RF of the harvested energy in a form, appropriate for transmission at long distances in empty space.
- Efficient wireless and secure power transmission of the transformed energy between in-space harvesting devices on spacecraft and re-translation stations or other final receivers, including laser and/or microwave-based solutions (e.g. large beam pointing antennas for transmission, rectennas for the final receivers). This may require a grid of re-transmitting stations, which not only amplify the wireless transmission, but also redirect the transmission as necessary.
- Innovative green propulsion solutions for in-space mobility, resulting into low cost or eco-friendly innovative concepts.

2.3 Expected outcomes and impacts

This Challenge aims at developing and as such make related impacts in:

- Design and laboratory validation of new concepts and technologies for energy harvesting in space e.g. in-space utilisation of this energy for transportation and other related research and innovation activities, in particular for cleaning space debris;
- Development and laboratory validation of breakthrough technologies for wireless power transmission of energy, e.g. through power grid, for energy beam pointing and control;
- Development of eco-friendly and innovative green propulsion solutions for in-space applications (e.g. spacecraft orbital corrections, in orbit satellite servicing, active debris removal, end-of-life services, etc.) addressing the barriers to the use of in-space solar energy harvesting for innovative propulsion.
- Development of innovative in-space robotic solutions for in-space manufacturing and assembly of space-based solar units will be considered too.

The development of viable technologies in this area as a basis for space-based energy harvesting will significantly increase the EU strategic autonomy. The direct benefits will be potential fuel cost savings, in-space clean energy solutions and innovative in-space robotic and assembly solutions. This thus will encourage the development of in-space manufacturing and assembly, with a wide range of applications in space (e.g. navigation, satcom, etc.) and are also likely to result into spin-offs into terrestrial markets (e.g. robotics, electronics, etc.)

Moreover, it will allow satellite owners to improve in-space mobility, extend the lifetime of their satellites, decommission their old satellites, and potentially generate fuel cost savings. Offering continuous energy and encouraging innovative green propulsion solutions for in-space applications contribute to European leadership in space clean energy, while increasing competitiveness and autonomy of EU space economy.

2.4 Specific conditions

The submitted proposals must follow interdisciplinary and cross-sectorial approaches, looking for inspiration, ideas, and knowledge in a broad range of disciplines. Space sustainability is of critical importance for Europe and therefore, submitted proposals should incorporate considerations for sustainable space debris management.

The safe and sustainable use of non-critical raw materials is crucial, and the projects should include a full life cycle analysis of the proposed solutions and their impact on Europe's decarbonisation goals.

2.5 References

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3 Portfolio considerations for the evaluation of applications to the Challenge

This section describes how portfolio considerations will be taken into account in the second evaluation step. For more details of the full evaluation process please refer to the EIC Work Programme pages 29-32.

For this Challenge the portfolio-building process will be based on the preliminary mapping by the committee of the proposals to one or both of the following categories:

1. Collection, conversion and transmission (CCT) of in-space solar energy, with the following subcategories:
    a) Innovative approaches, methods, and technologies for increased end-to-end efficiency of in-space solar energy collection, conversion, storage, and for wireless power transmission.
    b) Types of scalable solutions (antenna types, rectennas, solar concentrators, PV cells, coating types, etc.)
2. In-space green propulsion, with the following subcategories:
    a) innovative applications for in-space use of solar energy (e.g., in-space mobility of space tugs, In Orbit Servicing (IOS), End of Life (EoL), Active Debris Removal (ADR), In Space Assembly Manufacturing (ISAM)).

The evaluation committee will aim to compose a balanced and diverse portfolio covering the two aforementioned categories.

Within and among these categories, the evaluation committee will look at shared components or potential complementarities among the projects to identify a clear added value for the development of synergies and collaborations among the projects in the portfolio in order to maximise the overall impact of the portfolio on the expected outcomes and impacts of the Challenge. For instance the output from projects proposing innovative methods or devices for collection, conversion and transmission (CCT) of in-space solar energy can contribute to projects from the innovative green propulsion category. Or, as another example projects proposing modular solar arrays with solar concentrators can be interoperable with new types of modular or lightweight rectennas or grids of in-space re-transmitting stations.

Starting from the highest ranked proposal, a portfolio of proposals will be selected based on shared components/complementarities, while ensuring diversity among the selected proposals and coverage of the two categories. This implies that if the evaluation committee considers that a highly ranked proposal does not have a shared component/complementarity with other proposals, it will not be selected for the portfolio. To ensure diversification, proposals which the evaluation committee considers to be very similar to a proposal already included in the portfolio will not be selected. Consequently, this means that the projects selected for funding after the second step is expected to differ from the ranking list established from the first step (score based ranking after assessment of each proposal separately).

The following table summarises the portfolio building approach.

	Elements for portfolio building	
Categories	**Functions/devices**	**Enabling outcomes**
Collection, conversion and transmission(CCT) of in-space solar energy	**Collection** Scalable solutions for in-space solar energy collection I. On-board spacecraft deployable photovoltaic panels II. on-board batteries III. PV solar cells with efficiencies above 35%, thin-film, solar cells based on CIGS technology, batteries, etc. IV. New types of transmitting antennas and rectennas, (e.g. fully integrated transparent antennas, modular solar concentrators, solar generators and others) V. Advanced solar arrays for solar electric propulsion	I. Innovative concepts and methods for end (E2E) energy efficiency conversion or transmission II. Interoperability III. Lightweight
	Conversion	High efficiency conversion from DC to RF, RF-to-DC or light-to-DC
	Transmission Wireless power transmission (WPT) I. In-space harvesting devices on spacecraft and re-translation stations or other final receivers. II. Grids of re-transmitting stations, which not only amplify the wireless transmission, but also redirect the transmission as necessary.	Wireless power transmission (WPT) I. WPT can involve either laser or microwave approaches.
In-space green propulsion	Solar electric propulsion (SEP) for increased in-space mobility or increased payload capacity in benefit for in orbit satellite servicing (IOS), In space assembly and manufacturing (ISAM), active debris removal (ADR), end of life (EoL) time Solar sail propulsion for in-space mobility	I. In-space propulsion systems for reduced propellant and reduced spacecraft mass and therefore resulting in lower costs

4 Implementation of the Challenge portfolio

Once funded, projects will be expected and obliged to work collectively during the implementation of their projects under the guidance of an EIC Programme Manager. This section summarises some of the key aspects of this pro-active management which applicants should take into account in preparing their proposals.

Proposal preparation and Grant negotiations

Applicants may be requested to make amendments to their proposed project in order to take into enhance the portfolio. Such changes may for instance include: additional tasks to undertake common/ joint activities (workshops, data exchanges, joint research, etc) with other projects in the portfolio.

Based on first experience, it is proposed to foresee in your proposal a dedicated work package for portfolio activities and to allocate at least 10 person-months (see below for the purpose and examples of such activities).

If you fail to do this during proposal time, your proposal will not be scored lower during the evaluation, but in case your proposal is selected for grant agreement preparation, you will be requested to add the portfolio work package to your grant agreement. Please be aware that in that case the maximum grant you receive will not change, and you will need to find the resources for portfolio activities within the foreseen project budget.

Challenge portfolio roadmap/ strategy plan

This Challenge aims at:

1. **Enhancing the development potential of the portfolio individual project, as a result of its active participation in the portfolio activities:** Ensuring that portfolio members, can access a much higher number of relevant partnerships
2. **Enhancing the commercialisation potential of the portfolio individual project, as a result of its active participation in the portfolio activities:** Ensuring that portfolio members, can access the right industry partners to explore key partnerships

In order to accomplish the above the Programme Manager needs to develop and agree on a strategy plan for the 2024 portfolio with the portfolio projects.

Portfolio Strategy Plan

Following the selection of a proposals to be funded under the Challenge, the Programme Manager will work together the consortia of the selected projects to develop a common strategy plan/roadmap for the Challenge. This plan will integrate the activities and milestones of the individual projects into a shared set of specific objectives and activities across and

beyond the projects. The roadmap serves as a common basis for the project implementation - including possible adjustments, reorientations, or additional support to projects. The roadmap will be updated in light of emerging results or issues during the implementation. The objectives can be revised, for instance based on projects' unexpected achievements, new technology trends, external inputs (other projects, new calls…).

In particular, the Challenge roadmap/ strategy plan will include activities on the transition to innovation and commercialisation, and to stimulate business opportunities. These activities may be reinforced during the implementation with additional funding and expertise through pro-active management. Non-exhaustive examples of activities towards the above-mentioned aims are:

Non-exhaustive examples of activities towards the above-mentioned aims are:

- Contributing to understanding better the main barriers to strategic EU autonomy and space technology non-dependence in the domains of solar collection, conversion and transmission (CCT) of in-space solar energy and in-space green propulsion

- Effectively communicate of any key outcome of the research work of the portfolio members collectively and/or an individual project, to early stage private and corporate investors focused on the same field. Such communication might also be addressed to the general public to increase social acceptance for proposed solutions, or to other researchers and stakeholders through common dissemination activities at scientific conferences or trade-fairs.

- Market analysis: Map the stakeholders, identify emerging market trends and identify specific players with which the entire portfolio can establish partnership(s) of much higher impact as opposed to that of the individual project.

- Innovative space applications for in-space use of solar energy (e.g., in-space mobility of space tugs, In Orbit Servicing (IOS), End of Life (EoL), Active Debris Removal (ADR), In Space Assembly Manufacturing (ISAM)).

- Considerations on early stage commercialisation strategies

- Providing access to research lab infrastructure and test facilities (e.g. TVAC, clean rooms, EMC labs, etc.) and others

- Providing access to new non-EU markets and customers

- In-space robotic solutions or devices for in-space manufacturing and assembly of space-based solar units and in-space grid stations, that have achieved flight readiness TRL 5/6 will have fast track access to the IOD/IOV initiative

These tasks require the active participation of portfolio members to a series of meetings called for and steered by the Programme Manager. Portfolio projects will be expected to exchange

information on the proposed research methodologies, experimental tests, techno-economic input data and relevant results achieved, in order to collectively use the available resources. This exchange of data between portfolio members can enhance the potential of individual projects, use of results originating from the analysis of common databases, as well as their chances to establish key partnerships.
The exchange of information for the purpose of EIC portfolio activities will fall under the conditions and non-disclosure obligations as specified in the EIC Work Programme 2023 (Annex 6, section 2).

Tools though which projects can receive additional support

Projects in the portfolio may be offered additional support, either individually or collectively, in order to reinforce portfolio activities or explore the transition to innovation. Such additional support includes:

- Booster grants of up to €50k (see Annex 5 of the EIC Work Programme)
- Access to additional EIC Business Acceleration Services (see https://eic.ec.europa.eu/eic-funding-opportunities/business-acceleration-services_en)
- Access to the Fast Track to the EIC Accelerator, which would follow a project review (see Annex 3 of the EIC Work Programme)
- Access to the EIC Market Place, once operational, to connect with innovators, investors and other selected partners
- Interactions with relevant projects and initiatives outside the portfolio, including other EU funding initiatives as well as those supported by national, regional or other international bodies.