



CHALLENGE GUIDE

PATHFINDER CHALLENGE Strengthening the sustainability and resilience of EU space infrastructure

EIC Work Programme reference: HORIZON-EIC-2024-PATHFINDERCHALLENGES-05

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The EIC will hold an Info Session on this Pathfinder Challenge call on March 20, 2024, between 09:00 and 13:00 CET. Participants can access the meeting as guests at <https://webcast.ec.europa.eu/information-day-eic-work-programme-2024-pathfinder-challenges-2024-03-20>.

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 [https://eic.ec.europa.eu/events/save-date-european-innovation-council-pathfinder-challenges-work-programme-2024-info-day-2024-03-20 en](https://eic.ec.europa.eu/events/save-date-european-innovation-council-pathfinder-challenges-work-programme-2024-info-day-2024-03-20_en).

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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 2024 <https://eic.ec.europa.eu/system/files/2023-12/EIC-workprogramme-2024.pdf>

The Challenge Guide is a guidance document accompanying a Pathfinder Challenge call for proposals to provide further information about how “Portfolio Considerations” will be taken into account in the evaluation of proposals.

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 will give 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 proposal 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. The 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.

2.1 Background and scope

The ever-growing orbital population of satellites and space debris poses increasing challenges to space infrastructure. The density of space objects amplifies the risk of orbital collisions, unexpected fragmentation events and re-entries that may result in the

degradation of space assets, hindering the services they deliver and, thus making Earth orbits unusable.

Debris growth is escalating with more than 2,500 non-operational satellites, 36,500 space debris pieces bigger than 10 cm and 1 million pieces of debris between 1-10 cm in Earth's orbits. Collision avoidance manoeuvres for satellite owners has doubled and is expected to grow. Continuous trajectory changes of spacecraft will result in insufficient fuel for deorbiting, critical end of life spacecraft manoeuvres and any other remediation or in-space mobility activities. In-space recycling of dysfunctional orbital assets will provide an opportunity for space assets re-utilisation and in-space refuelling.

This challenge addresses the long-term emerging need for green, compact and affordable de-orbiting solutions and in-space recycling of space debris.

Space systems and services in the EU are critical infrastructures that need to be better protected. Still, the level of protection of space assets varies across Member States, and there is a need to expand the scope of EU actions.

In this context, the need to protect EU space infrastructure and continue to promote the preservation of a safe and secure space domain is essential.

2.2 Specific objectives

The overall goal of this Challenge is to support the development of innovations that will strengthen the protection of EU space infrastructure.

The specific goals of this challenge are 1) development of technologies for space debris mitigation and active debris removal; 2) concepts for in-space recycling of dysfunctional orbital assets; 3) innovations for protecting EU space infrastructure.

The projects, supported under this challenge are expected to develop break-through concepts in one or more of the following areas:

- Game-changing technologies for controlled space debris mitigation (to reduce their generation) and active debris removal (by managing existing space debris, de-orbiting, relocation, etc.) including ones that prevent spacecraft system damage. This includes among others propellantless propulsion technologies such as space-based lasers, laser pushed lightsails, physical sweeper in orbit, laser electric propulsion, tethers or water propulsion for moving all sized debris.
- In-space Recycling & Re-use of orbital assets- with a focus on recycling and re-using dysfunctional orbital assets. The overall aim is recycling, partial and/ or complete re-use of assets in-space.

- Game- changing innovations and innovative space applications for protecting EU space infrastructure that focus on concepts that enable detection, identification and avoidance of natural and human-made hazards in space.

Breakthrough ideas and concepts proposed under this challenge should be designed and validated in a laboratory environment. They should address “old” debris and active debris removal (ADR) including end-of-life (EoL) disposal. The concepts may also include debris mitigation measures to be integrated into the design of spacecrafts and launchers.

2.3 Expected outcomes and impacts:

The portfolio building approach will select a group of projects in the scope of the above challenge objectives and develop:

- Technologies for space debris mitigation and remediation using very little propellant, that could be self-standing, in combination or in complementarity to other technologies to protect EU Space infrastructure.
- In-space Recycling & Re-use of orbital assets could research techniques or processes to generate basic materials and re-use components for structures and assets, thereby supporting the in-space assembly and manufacturing (ISAM) domain. This may lead to the development of innovative in-space services based on reusing of parts of orbital assets.
- Game- changing innovations and innovative space applications may result in, among others: 1) collision avoidance concepts providing accurate and timeliness detection and tracking of orbiting space objects, 2) innovations for space situational awareness (SSA), 3) development of algorithms and simulation tools for re-entry, close proximity operations, fragmentation and 4) innovative concepts for in-orbit spacecraft recognition and space debris detection.

This topic directly contributes to reinforcing the EU strategic autonomy and EU Space policy, notably regarding the EU Space Strategy for Security and Defence and the EU approach for Space Traffic Management. It will contribute to strengthening the European resilience by promoting a secure, sustainable and safe space domain.

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.

Applicants are encouraged to develop synergies with relevant activities under Horizon Europe Cluster 4 Work Programme 2021 – 2022 and Work Programme 2023 – 2024,

destination Open Strategic Autonomy in Developing, Deploying and Using Global Space-Based Infrastructures, Services Applications and Data.

2.5 References

- 1) [Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space \(unoosa.org\)](https://www.unoosa.org/)
- 2) NASA [otps - cost and benefit analysis of orbital debris remediation - final.pdf \(nasa.gov\)](#)
- 3) ESA's Annual Space Environment Report, [Space Environment Statistics · Space Debris User Portal \(esa.int\)](#)
- 4) NASA Orbital Debris Programme Office [ARES | Orbital Debris Program Office | Debris Mitigation \(nasa.gov\)](#)
- 5) ESA Space Debris Mitigation Compliance Verification Guidelines, [ESA - Mitigating space debris generation](#)
- 6) [ECSS-U-AS-10C Rev.2 DIR1 “Adoption Notice of ISO 24113: Space systems – Space debris mitigation requirements”: Public Review \(14 July – 15 November 2023\) | European Cooperation for Space Standardization](#)
- 7) [WEF Space Industry Debris Mitigation Recommendations 2023.pdf \(weforum.org\)](#)
- 8) IDA report, Global trends in On Orbit Servicing Assembly and Manufacturing (OSAM)
- 9) US ISAM National Strategy, [04-2022-ISAM-National-Strategy-Final.pdf \(whitehouse.gov\)](#)
- 10) Davis, Mayberry, Penn, ON-ORBIT SERVICING: INSPECTION, REPAIR, REFUEL, UPGRADE, AND ASSEMBLY OF SATELLITES IN SPACE
- 11) JAXA CDR 2, [JAXA | Space Debris Removal Project Underway, Taking on the Challenge of Developing Unproven Technologies](#)
- 12) ESA Space Debris Mitigation Requirements, ESSB-ST-U-007 Issue 1, 30/10/2023, [Space debris mitigation \(esa.int\)](#)
- 13) ESA Space Debris Mitigation and Re-entry Safety Framework, ESA Independent Safety Office [ESA%20Space%20Debris%20Mitigation%20and%20Re-entry%20Safety%20Regulatory%20Framework%20-%20Status%20and%20Novelties%20\(2021\)%20-%20Presentation.pdf](#)
- 14) ESA Space Debris Mitigation Compliance Verification Guidelines, ESSB-HB-U-002, issue 2, 14/02/2023, [ESSB-HB-U-002 \(esa.int\)](#)
- 15) ESA Zero Debris approach by 2030, [ESA - ESA's Zero Debris approach](#)
- 16) Viability of a circular economy for space debris, Ryan Leonard, Ian D. Williams, waste Management 155(2023) 19-28
- 17) Triggers and effects of an active debris removal market, Christopher R. May, January 2021

- 18) Viability of a circular economy for space debris, R. Leonard, I.D. Williams, Waste Management 155(2023) 19-28
- 19) Expanding foam application for active space debris removal systems, 62nd IAC, 2010, IAC-11-A6.5.4, P.Pergola, A.Ruggiero, M.Andrenucci, J.Olumpio, L.Summerer

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 stage of the evaluation. For more details of the full evaluation process please refer to the EIC Work Programme.

3.1 Categories

This Challenge addresses the long-term existing need for environmentally friendly, efficient, and affordable space debris mitigation and remediation solutions and in-space recycling. This is relevant for all sizes of space debris (small, medium, large)¹ and all orbits (e.g., LEO, MEO, GEO, etc.).

The portfolio of project, composed as a result of this Challenge should provide direct benefits to satellite owners and operators, comprising reduced propellant use, fuel efficiency, cost-savings from recycling and re-use of in-space assets, augmentation of their satellite capabilities, affordable and timely end-of life services. By space debris mitigation is meant any spacecraft activity that will prevent and reduce the number of new debris that might be generated. Space debris remediation is any action to reduce the risks associated with orbital debris by moving, removing, or reusing it.

The areas of intervention of the projects to be included in the portfolio will represent the main categories to be used in portfolio building:

- **Category I: Space debris mitigation**
- **Category II Space debris remediation**
- **Category III In-space recycling and re-use of orbital assets (ISRROA)**

The following table summarises the categories and their components/values.

¹ According to the ESA 7th Space Debris Environment Report released on the 12/06/2023 there are 36,500 space debris objects greater than 10cm, 1million space debris object greater than 1cm to 10cm and 130 million space debris objects from greater than 1mm to 1cm.

Categories	Components/values
Category I: Space debris mitigation	<ul style="list-style-type: none"> • Controlled Space debris mitigation (e.g., s/c design, shielding, s/c passivation, etc.) • Innovative concepts for in-orbit spacecraft recognition and space debris detection • Innovations for space situational awareness (SSA) • Others
Category II Space debris remediation	<ul style="list-style-type: none"> • Active debris removal (robotic and de-orbiting mechanisms, magnets, nets, harpoons, etc.) • Propellantless debris removal (space-based lasers, laser pushed sails, tethers, solar concentrators, ion beam shepherd methods, etc.) • Others
Category III In-space recycling and re-use of orbital assets (ISRROA)	<ul style="list-style-type: none"> • Design & development of technologies, methods, and processes for recycling (mechanical, space welding and additive manufacturing) • Re-use of parts and components of defunct satellites or upper rocket stages • Others

3.2 Portfolio considerations

Starting from the highest ranked proposal, a portfolio of proposals will be selected by the evaluation committee according to the following principles.

1. A balance of projects between the three categories.
2. Shared component(s) among the projects to be included in the portfolio, in one or more of the categories.

As an example, in the portfolio two or more projects could be selected, which all deal with different aspects of controlled Space debris mitigation (e.g., s/c design, shielding, s/c passivation, etc.) (shared component in Category I).

3. Complementarities among the components in different categories of the projects to be included in the portfolio.

An example of application of this consideration, the portfolio may include a project dealing with innovative concepts for in-orbit spacecraft recognition and space debris detection (Category I), which will be complementary to projects proposing active debris removal technologies (e.g., de-orbiting mechanisms) or propellant less ones (e.g., space-based lasers, tether, solar concentrators) (Category II).

Another example is the complementarity of projects dealing with active debris removal (robotic and de-orbiting mechanisms, magnets, nets, harpoons, etc.) (Category II) with projects, developing technologies, methods, and processes for recycling (mechanical, space welding and additive manufacturing) or for re-use of parts and components of defunct satellites or upper rocket stages (Category III).

The shared components and complementarities must provide 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.

This implies that in case a highly ranked proposal does not have a shared component/complementarity with other proposals, it will not be selected for the portfolio. Also, proposals which are very similar to a proposal already included in the portfolio will not be selected.

Consequently, this means that the set of projects selected for funding after the second step may differ from the set of top proposals in the ranking list, established from the first step (score-based ranking after assessment of each proposal separately).

4 Implementation of the Challenge portfolio

Once selected, 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.

4.1 Proposal preparation and grant negotiations

Applicants may be requested to make amendments to their proposed project 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 advised 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). You may propose concrete activities or remain generic in your description.

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.

4.2 Challenge portfolio strategy plan/roadmap

Following the selection of proposals to be funded under the Challenge, the Programme Manager will work together with 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 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. 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:

Technology:

- Comparing performance of technologies for space debris mitigation, remediation and in-space recycling.
- Contributing to understanding better the main scientific/technological barriers and opportunities to space debris mitigation, remediation, in-space recycling, re-use of orbital assets and game changing innovations.
- Contributing to understanding better the main scientific/technological barriers and opportunities for green, compact and affordable de-orbiting solutions.

Regulatory:

- Portfolio activities that identify gaps and contributing to understand better/improve the current regulatory framework in current regulatory framework Contribute to WG linked to various ECSS flight qualification standards Access to research lab infrastructure and test facilities (e.g., TVAC, clean rooms, EMC labs, etc.) and others.

- In-space robotic solutions or devices for space debris mitigation, remediation or in-space recycling, that have achieved flight readiness TRL 5/6 will have fast track access to the IOD/IOV initiative.

Transition of technology to innovation

- Performance of early cost-benefit analysis of the different concepts for Categories I, II and III.
- Innovative space applications for space debris mitigation, remediation, in-space recycling, re-use of orbital assets and game changing innovations.
- Contributing to understanding better the main market entry barriers and opportunities for green, compact and affordable de-orbiting solutions.
- Market analysis: Map the targeted players in a market and exchange the market research analysis results with other the portfolio projects to identify specific players with which the entire portfolio can establish partnership(s) of much higher impact as opposed to that of the individual project.
- Discussions on commercialisation strategy, IP, licensing and business models.
- Discussions with early stage private and corporate investors focused on relevant fields.
- Providing access to new markets through multipliers like Enterprise Europe Network.

Communication and dissemination:

- 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, 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 2024.

4.3 Tools through 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).

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- 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).
- 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.