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Backing visionary entrepreneurs

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European Innovation Council and SME Agency

EIC Pathfinder

In-space solar energy harvesting for innovative space applications

Introduction

Overview

- WP 2023 Pathfinder
- WP 2023 Budget overview

Deep-dive

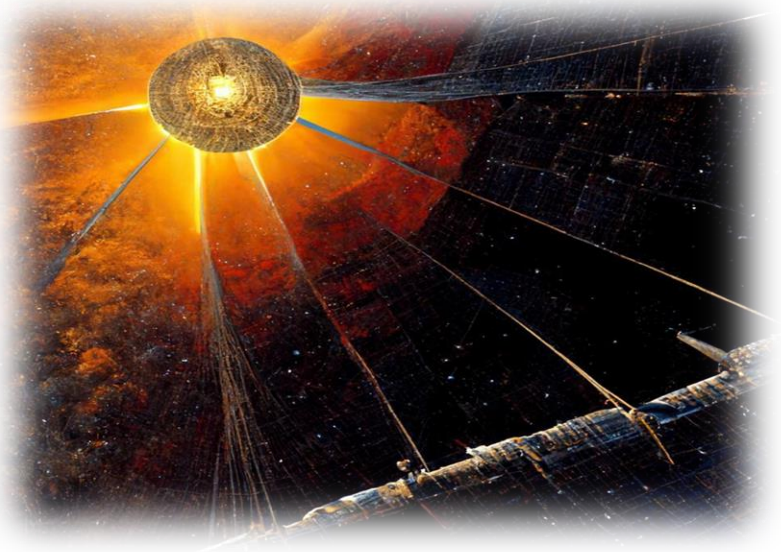
- Background
- Identified GAPs
- In-space solar energy harvesting for innovative space applications
- EIC Space Portfolio Considerations
- Expected outcomes and impacts

Courtesy: Copernicus - Sentinel 3 A ESA image of Europe 2017

WP2023 Space Challenges

- **EIC Pathfinder (TRL 1-4)** - In-space solar energy harvesting for innovative space applications

Preparing for the long term Future



WP 2023 Pathfinder – Part I

The **EIC Pathfinder (TRL 1-4)**

- funds **research** to develop the **scientific basis** to underpin breakthrough technologies
- supports the **earliest stages** of scientific, technological or deep-tech R&D
- aims to build on new, **cutting-edge directions in science and technology** to disrupt a field and a market or create new opportunities
- realises innovative technological solutions to identify, develop and scale up **breakthrough technologies** and **disruptive innovations** in Europe

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WP 2023 Pathfinder – Part II

EIC Pathfinder Open → to support projects in any field of science, technology or application without predefined thematic priorities ('bottom-up')

EIC Pathfinder Challenges → to support coherent portfolios of projects within predefined thematic areas with the aim to achieve specific objectives for each Challenge

WP 2023 Pathfinder – Part IV

- **Single legal entities** established in a Member State or an Associated Country (mid-caps and larger companies will not be permitted)
- **Consortia of two entities** must be two independent legal entities from two different Member States or Associated Countries
- **Consortia of three or more entities** must include as beneficiaries at least three legal entities, independent from each other and each established in a different country as follows:
  - at least one legal entity established in a Member State; and
  - at least two other independent legal entities, each established in different Member States or Associated Countries.
- The legal entities may for example be universities, research organisations, SMEs, start-ups, industrial partners or natural persons.
- RIA - 100% eligible costs up to **€ 4 million** as appropriate (larger amounts possible, if duly justified)

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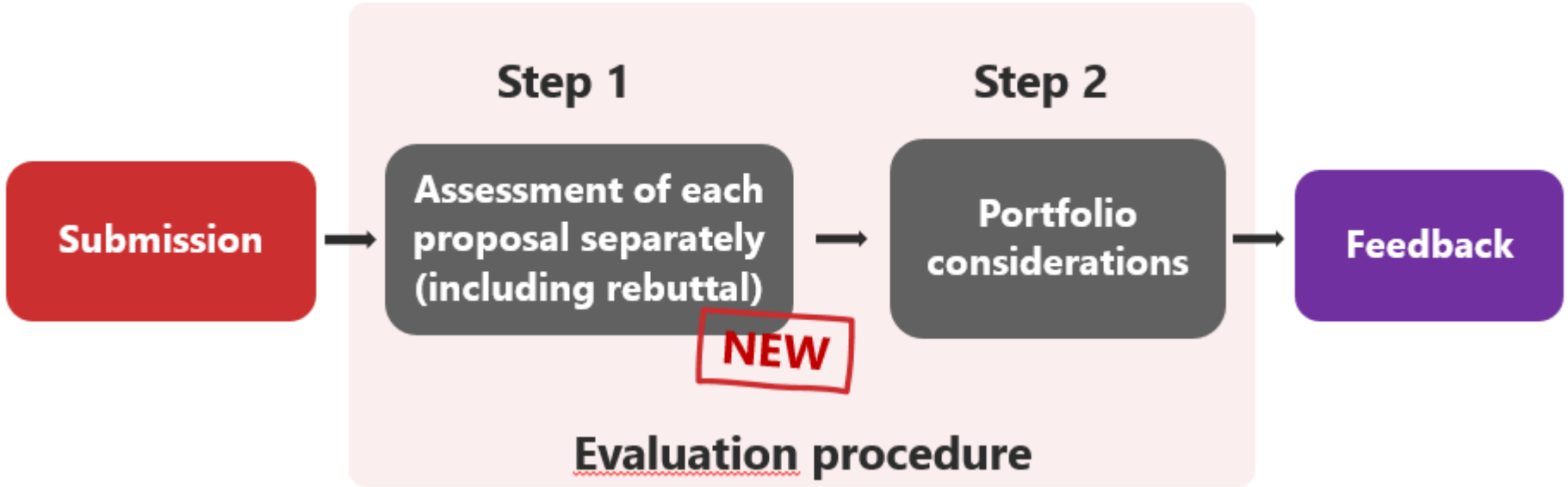
How does the EIC decide if your proposal will be funded?



Pathfinder calls 2023 – Summary table

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	Pathfinder Open	Pathfinder Challenges
Total budget	**€179.5 million**	**€163.5 million**
Proposals (indicative)	Up to €3 million	Up to €4 million
Funding rate	100% of eligible costs	100% of eligible costs
Opening	10 January 2023	20 June 2023
Deadline	**7 March 2023** at 17.00 CET	**18 October 2023** at 17.00 CET
Length of proposal	17-page proposal (part B)	25-page proposal (part B)
Applicants	**Consortia** min. 3 partners from 3 different Memer States /Associated Countries (of which at least 1 partner in a Member State)	**Consortia:** • If 2 partners: from different MS/AC, • Min 3 partners from 3 different MS/AC (of which at least 1 partner in a MS) **Single legal entities** in a MS/AC

Background - Part I

- Japan - JAXA solar farms in space by 2030
- Europe- ESA Solaris
- USA - Northrop Grumman's SSPIDR demo
- China – Space solar power station by 2028

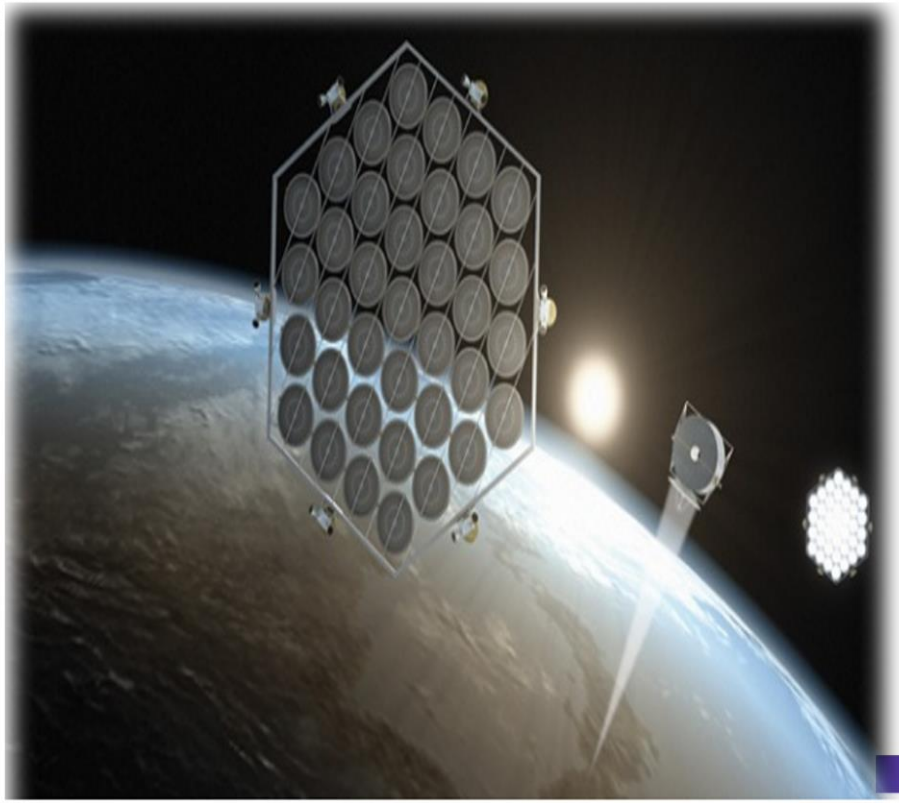
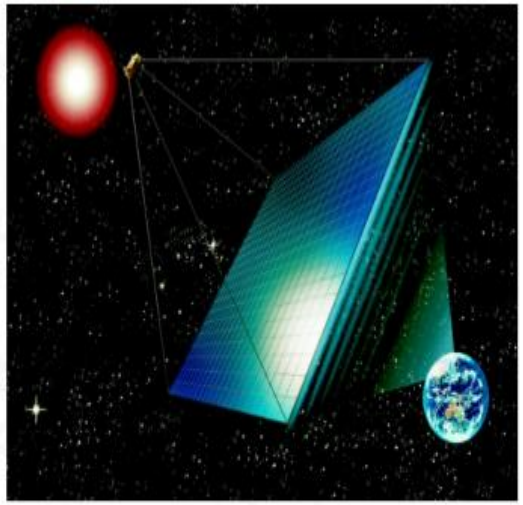


Illustration: John MacNeill (Image Credit: IEEE Spectrum)

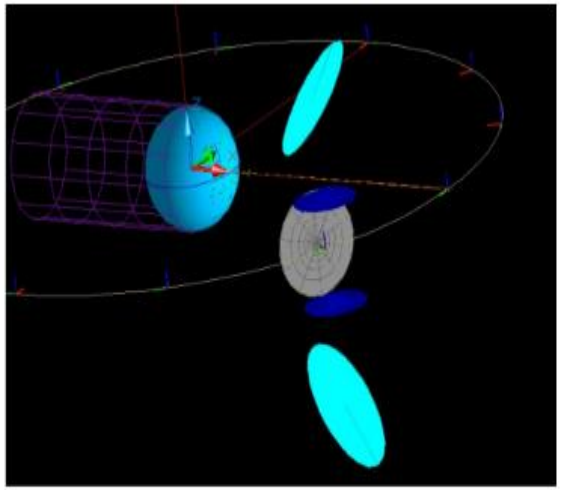
China conducts world's first full-chain, system-wide ground verification for Space Solar Power Station (SSPS) with self-developed OMEGA-SSPS ground test verification system in Xi'an City of northwest China's Shaanxi Province. /Xidian University

Background - Part II

- Solar energy harvesting using small satellites
- Solar energy for powering Smallsats/cubesats
- Various cost-benefit studies and national investments in SBSP



Tethered SPS (Basic Microwave-type Model) (Jspacesystems/METI)



Advanced Microwave-type Model (JAXA/MEXT)

Courtesy: Jspacesystems/METI:Japan Space Systems/ Ministry of Economy, Trade and Industry, JAXA/MEXT:Japan Aerospace Exploration Agency/ Ministry of Education, Culture, Sports, Science and Technology

Background - Part III

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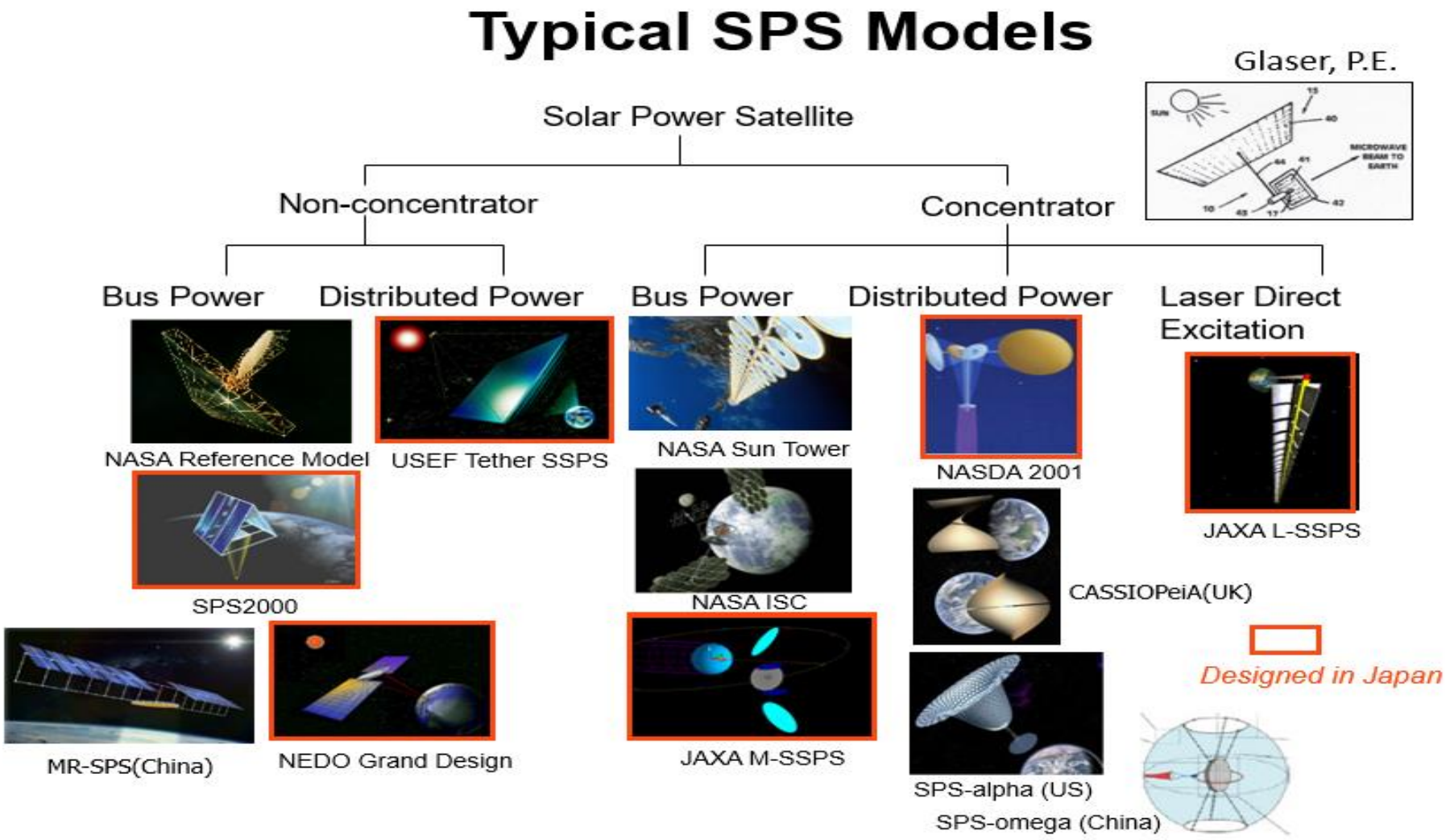

Courtesy: *Koji Tanaka, JAXA, ESA's 1st Space-based Solar Power for Net Zero workshop*

Identified GAPs

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- Urgent need for clean and renewable 24hr energy
- Unobstructed by the Earth atmosphere, the Sun is unlimited non-polluting energy source
- In-space solar harvesting WPT in shorter distances and limited safety concerns
- Innovative in-orbit efficient devices for solar energy collection & storage
- Use in-space energy for innovative in- space applications (e.g. ISRU)
- In-space energy utilisation for in-space mobility for space debris removal or future In Orbit Servicing /Active Debris Removal (ADR) and End of Life (EoL) activities
- Green propulsion for increased payload capability and resulting in potential fuel cost savings for satellite owners
- Urgent need for strategic autonomy for renewable energy resources in space

Source	Clean	Safe	Reliable	Base-load
Fossil Fuel	No	Yes	Decades remaining	Yes
Nuclear	No	Yes	Fuel Limited	Yes
Wind Power	Yes	Yes	Intermittent	No
Ground Solar	Yes	Yes	Intermittent	No
Hydro	Yes	Yes	Drought; Complex Scheduling	
Bio-fuels	Yes	Yes	Limited Qty – Competes w/Food	
Space Solar	Yes	Yes	Yes	Yes

Courtesy: National Security Space Office

In-space solar energy harvesting for innovative space applications - Part I

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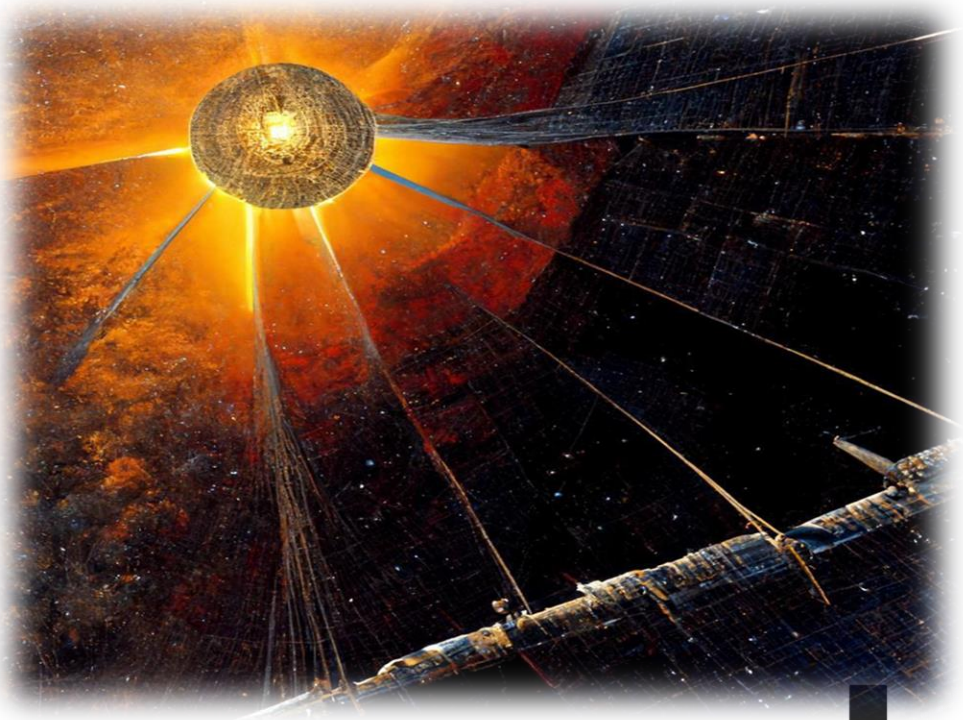
Goal

The development of concepts and technologies required for in-space energy harvesting and transmission, and of novel propulsion technologies that will use such harvested energy.

- Scalable solutions for in-orbit efficient solar energy collection and storage
- Conversion of DC-to – RF of the harvested energy in a form appropriate for transmission at long distances in empty space
- Efficient Wireless Power Transmission (WPT) of the transformed energy between in-space s/c and various stations in orbit
- Innovative green propulsion solutions for in-space mobility, resulting into low cost or eco-friendly innovative concepts



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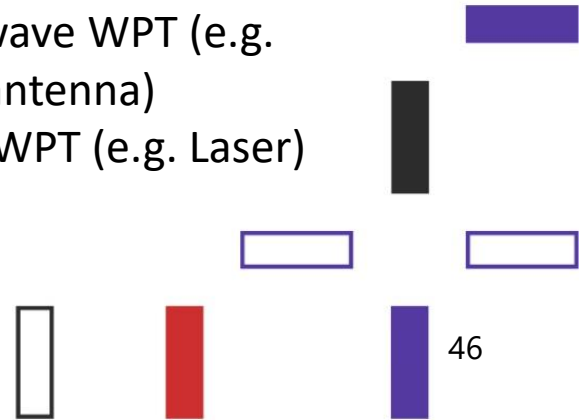
EIC Space Portfolio Considerations

	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

Category I - In-space solar energy harvesting for innovative space applications

- Collection, conversion and transmission (CCT)

Collection	Conversion	Wireless Power Transmission
Antenna's On- board s/c PV panels PV solar cells above 35% Thin-films Solar cells based on CIGS On-board batteries Transparent antennas Modular solar concentrators Advanced solar arrays for SEP	High efficiency conversion from DC to RF, RF to DC or light to DC Rectennas	Microwave WPT (e.g. antenna) Optical WPT (e.g. Laser)



Category I Functions

- Innovative approaches, methods and technologies for increased E2E efficiency on in-space solar energy collection, conversion, storage and WPT
- Scalable solutions (antennas, rectennas, solar concentrators, etc.)
- S/C solar harvesting device or grids of re-transmission stations that not only amplify but also re-direct the beam

Enabling Outcomes

E2E efficiency

Interoperability

Lightweight

Proposals should incorporate considerations for sustainable space debris management

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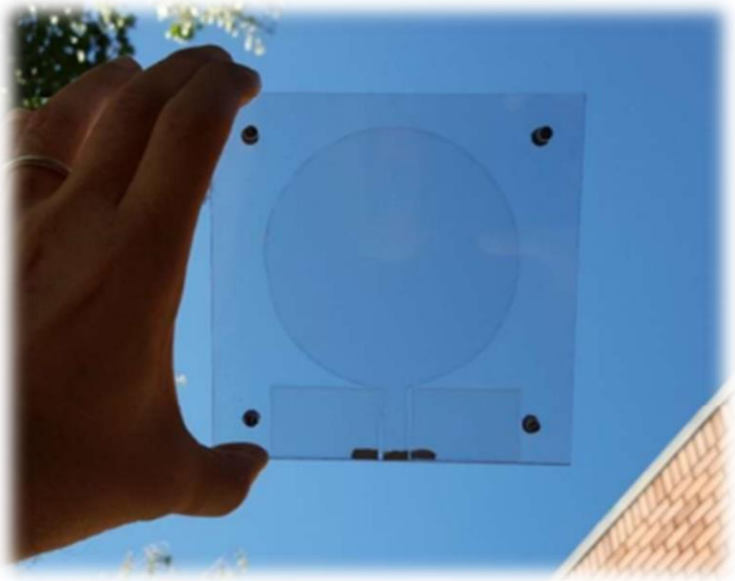
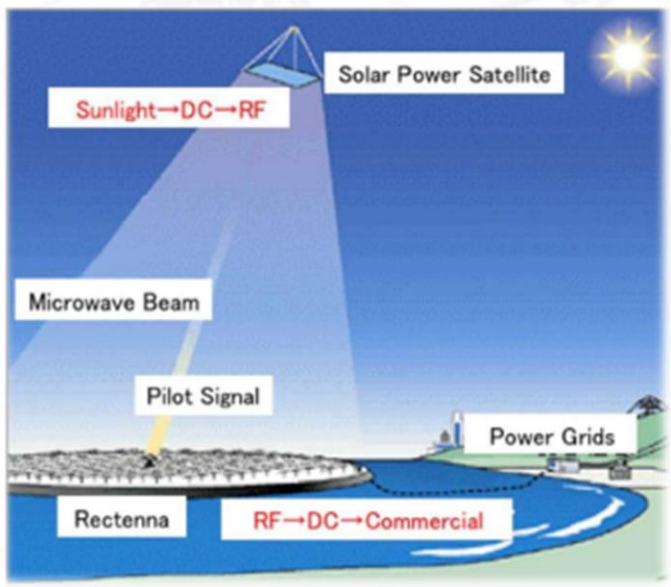
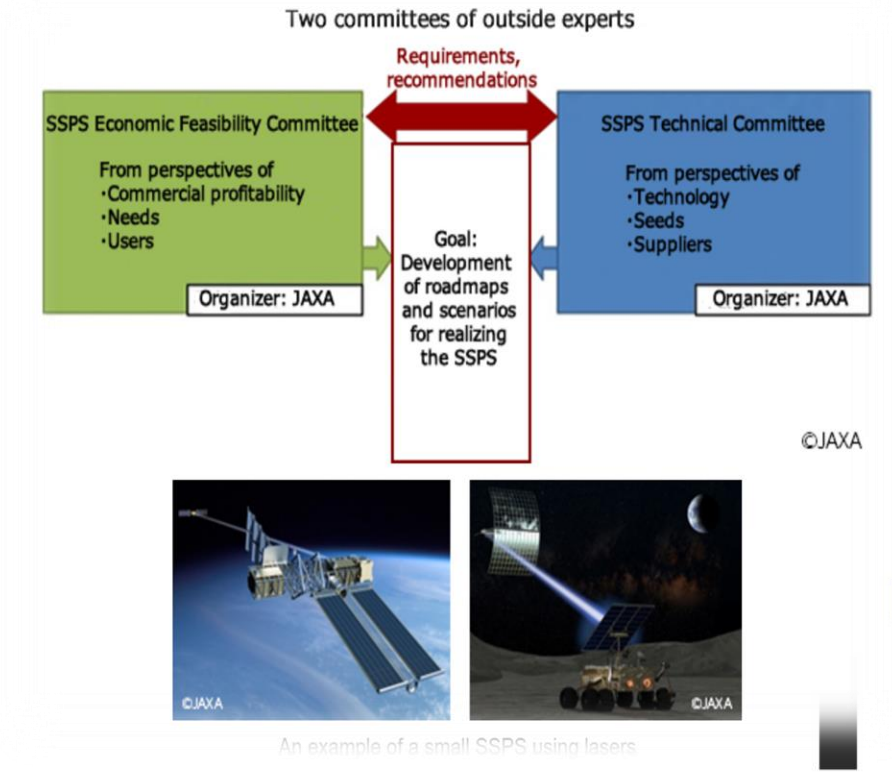
Category I CCT - Some Examples



Courtesy: NanoWeb Transperant Antennas

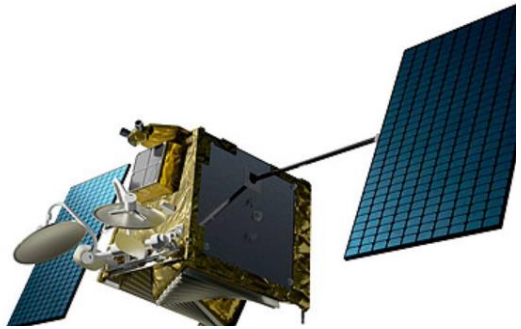


Courtesy: Sasaki, Tanaka, Maki



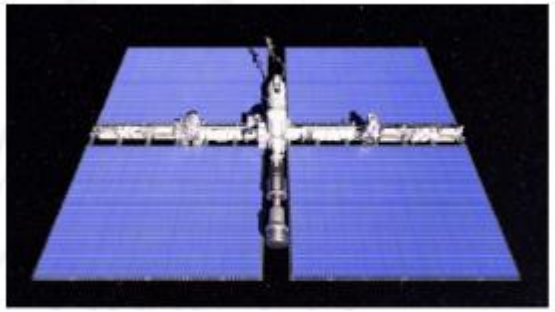
Courtesy: JAXA, inter-orbit energy transfer and planetary exploration mission concepts

Category I CCT - Real Examples



Courtesy: OneWeb

LEO orbit



Courtesy: ASU

Courtesy: Astrobotic WPT for lunar rover

Category II - In-space solar energy harvesting for innovative space applications

- In-space green propulsion for IOS, ISAM, ADR and EoL

In-space green propulsion

Solar Electric Propulsion
Solar sails
Water-based propulsion using electrolysis
Laser propulsion
Microwave propulsion

Reduced propellant → Reduced mass

Courtesy: NASA Pathfinder Technology Demonstrator-1 spacecraft, demonstrating a water-based propulsion system in low-Earth orbit.

EIC Space Portfolio Considerations - In-space solar energy harvesting for innovative space applications

- Category I - Collection, conversion and transmission (CCT)
- Category II - In-space green propulsion for IOS, ISAM, ADR and EoL

SPP1: Collection

SPP2: Conversion

SPP3: Wireless Power Transmission

SPP4: In-space green propulsion

Shared components or potential complementarities among projects

Expected outcomes and impacts

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Expected outcomes

Design, development and laboratory validation of breakthrough concepts

- For energy harvesting in space, e.g., in-space utilisation of this energy for transportation and other related activities, in particular for cleaning space debris;
- Wireless power transmission of energy, e.g., through power grid, for energy beam pointing and control;
- 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.)
- Innovative in-space robotic solutions for in-space manufacturing and assembly of space-based solar power units

Expected impacts

- **Research impacts** - mastering renewable solar energy supply for 365 days per year, developing in-orbit efficient solar power collection, storage, innovative solar power conversion methods, wireless power transmission between in-space harvesting devices and s/c (e.g. autonomous space tugs), innovative "green" solar harvesting antennas, mastering new methods for in-space propulsion of spacecraft e.g. solar electric space tugs or on-board spacecraft photovoltaic cells
- **Innovation impacts** - breakthrough technologies for wireless power transmission of energy, energy beam pointing and control, developing eco-friendly and innovative for space transportation or spacecraft orbital corrections.
- **Strategic impacts**- EU strategic autonomy, potential fuel cost savings, reduce greenhouse gas emissions and leadership in space clean energy solutions. increased competitiveness and autonomy of EU space industry for On Orbit Assembly and Manufacturing (OSAM) and green propulsion

Satellite owners will improve in-space mobility, extend the lifetime of their s/c, decommission their old satellites and potentially generate fuel cost savings

EIC Space Portfolio aspects

In your proposal add a dedicated WP for portfolio activities with at least ***10 person months***

- Barriers to strategic autonomy/technology non-dependence
- Communicate key outcomes of research work
- Market analysis – initial stakeholders mapping
- Innovative space applications for in-space solar energy use (e.g. ISAM, ADR, EoL, etc.)
- Early commercialisation
- Access to research labs/ test facilities
- Access to non-EU markets and customers
- IOD/IOV activities in case of TRL5/6

Conclusions

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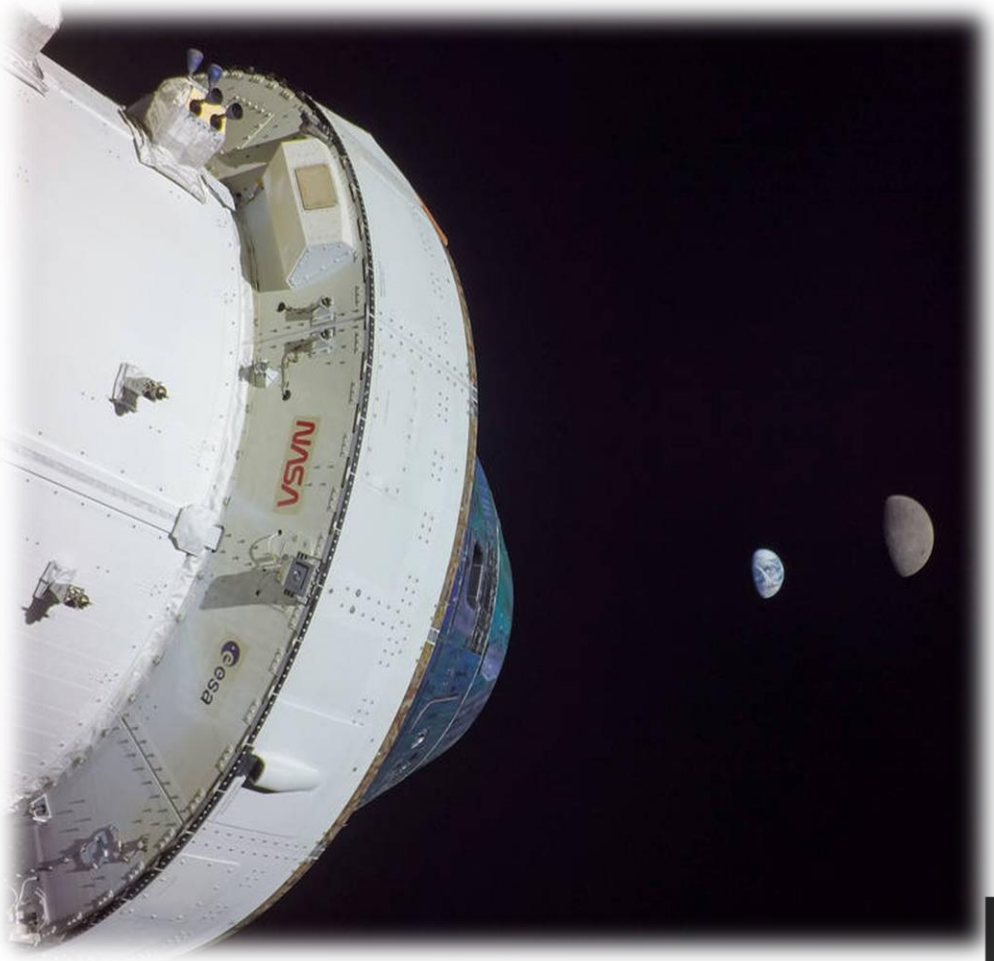
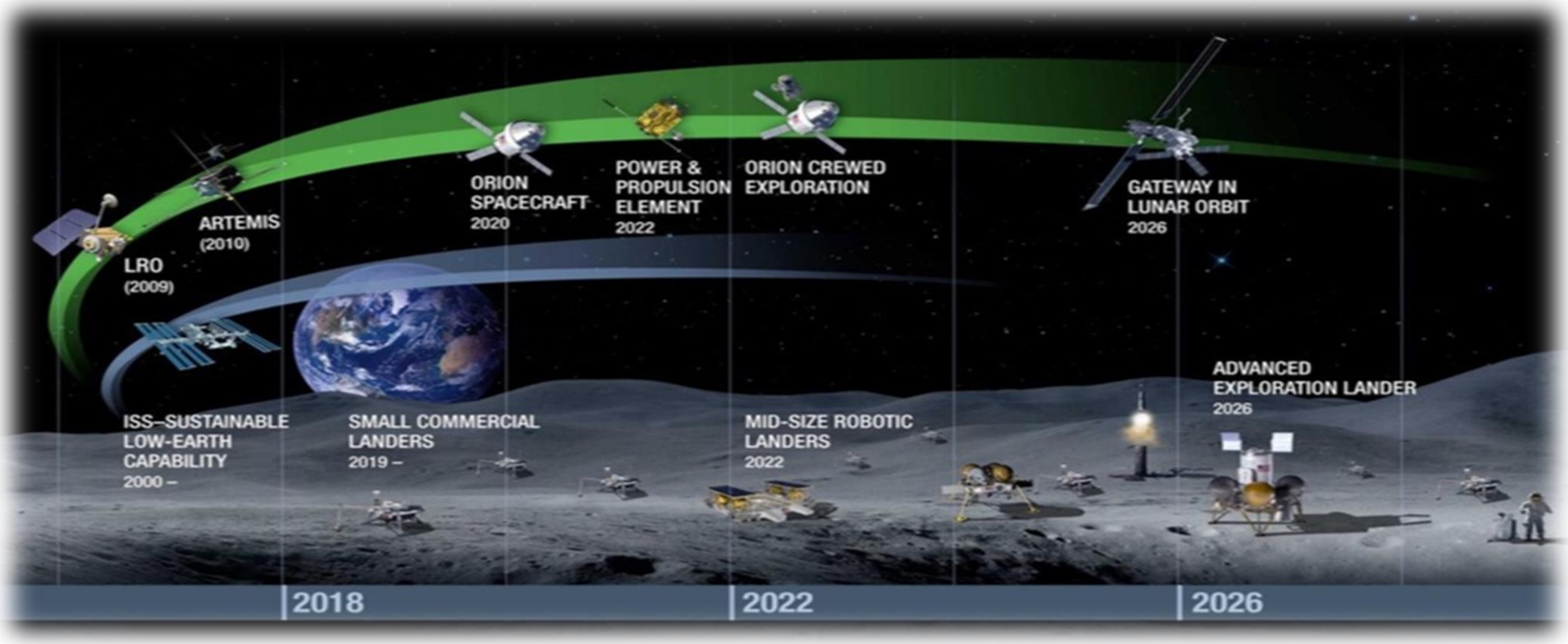
- **WP 2023 -** EIC 2023 work programme (europa.eu)
- **WP2023 Info Day** - European Innovation Council online Info Day - Work Programme 2023 - 13 December 2022 (europa.eu)
- **EIC Horizon scanning** for space signals for future EIC WP - EUSurvey - Survey (europa.eu)
- **EIC challenges information days** - EIC Challenges information days (europa.eu)



Courtesy: NASA Orion image taken the 28/11/2022, imagery of the Earth and Moon together from its distant lunar orbit, including this image on Nov. 28, 2022, taken from camera on one of the spacecraft's solar array wings.

Wrap-up

- Long term future



Courtesy: NASA