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# Integration of orbital environmental impacts within the EU Environmental Footprint framework for space

## Overview of EC-recommended Envrionmental footprint framework

## & potential integration of space debris

05/06/2026

# The Joint Research Centre: common mission for shared values

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## The JRC provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society.

ANTICIPATE

INTEGRATE

IMPACT

**~2700**

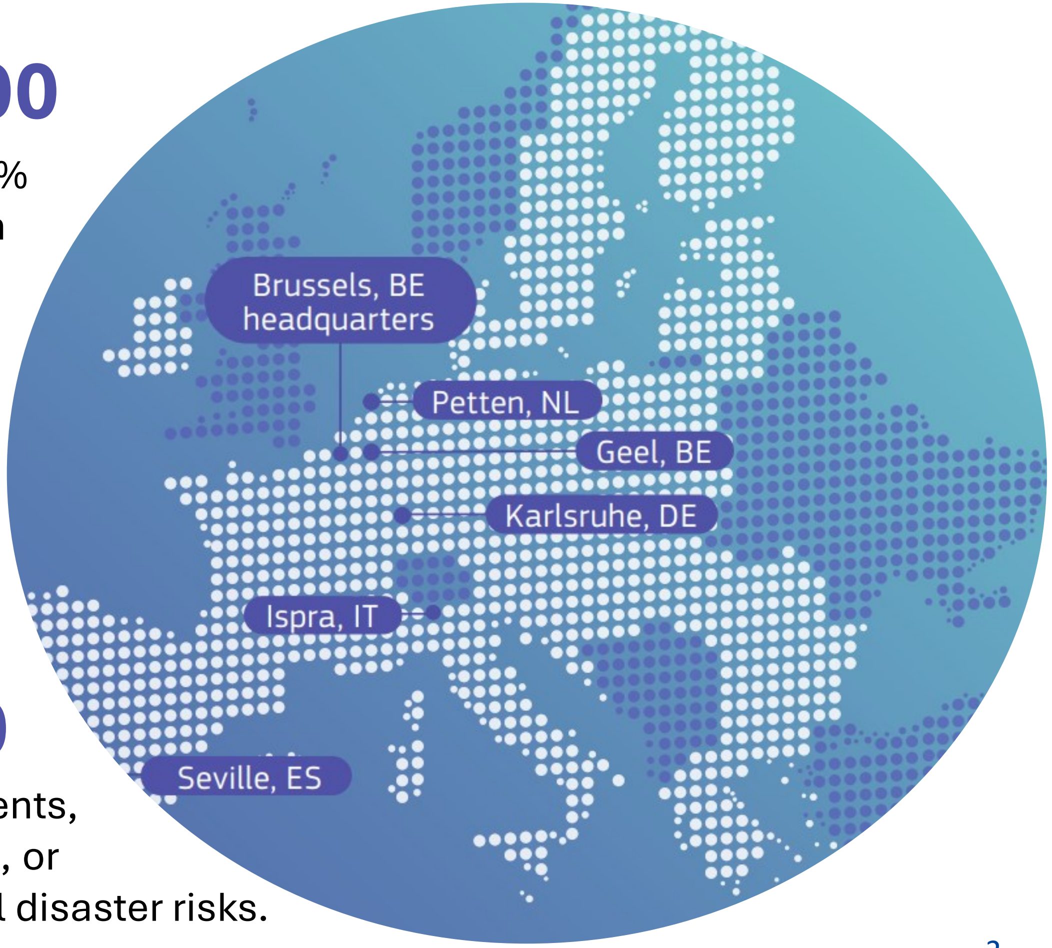
employees, incl. 70% engaged in research

**+3000**

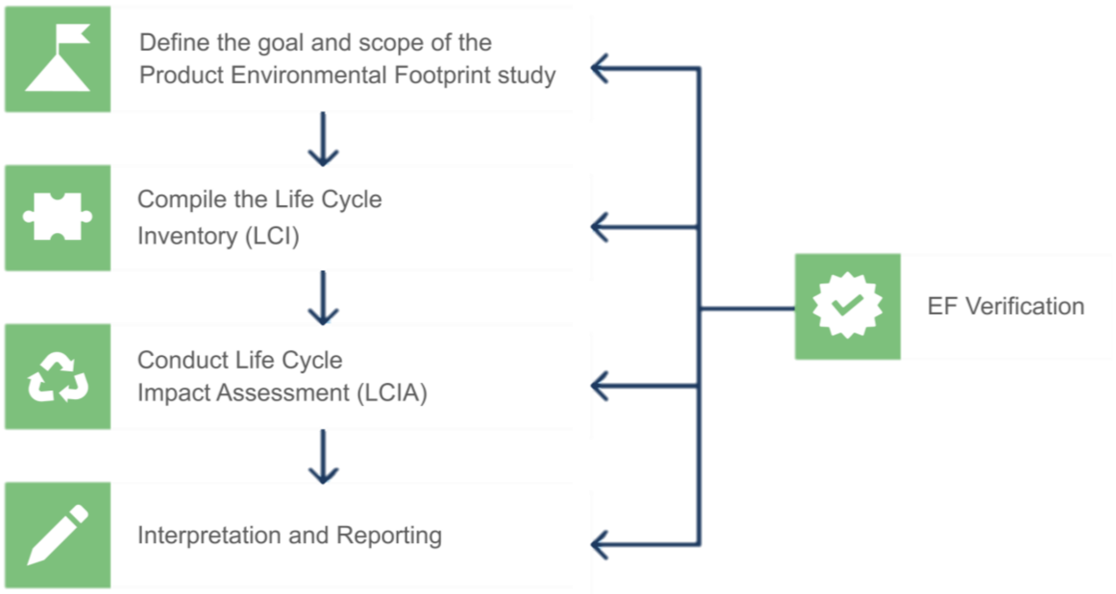
open data sets

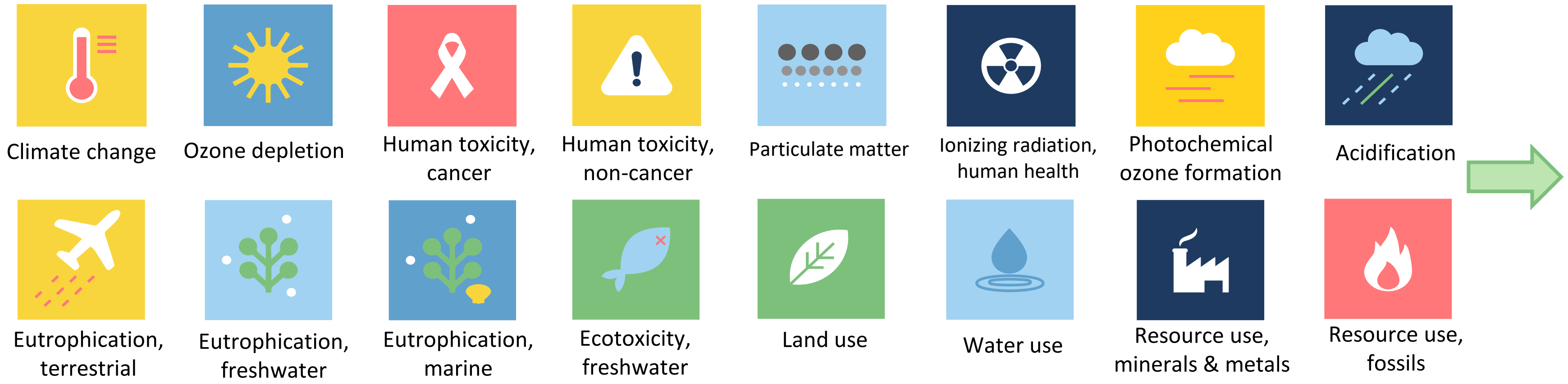
**+100**

models used for impact assessments, monitoring policy implementation, or providing early warnings of natural disaster risks.



# Life Cycle Assessment: multi-phases and multi-criteria approach for mitigating environmental impact


Impacts on

- **human health,**
- **ecosystems quality,**
- **natural resources.**

# Environmental Footprint method
# The EU recommended way of assessing environmental performance

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Environmental Footprint = Product Environmental Footprint (PEF) + Organisation Environmental Footprint (OEF)

**Multi stakeholders initiative**

**Methodological fundation**
Life Cycle Assessment (LCA)

**Based on existing approches**
ISO 14040 series & European ILCD guildelines

**Harmonisation**

**PEFCR (Product Environmental Footprint Category Rules)**

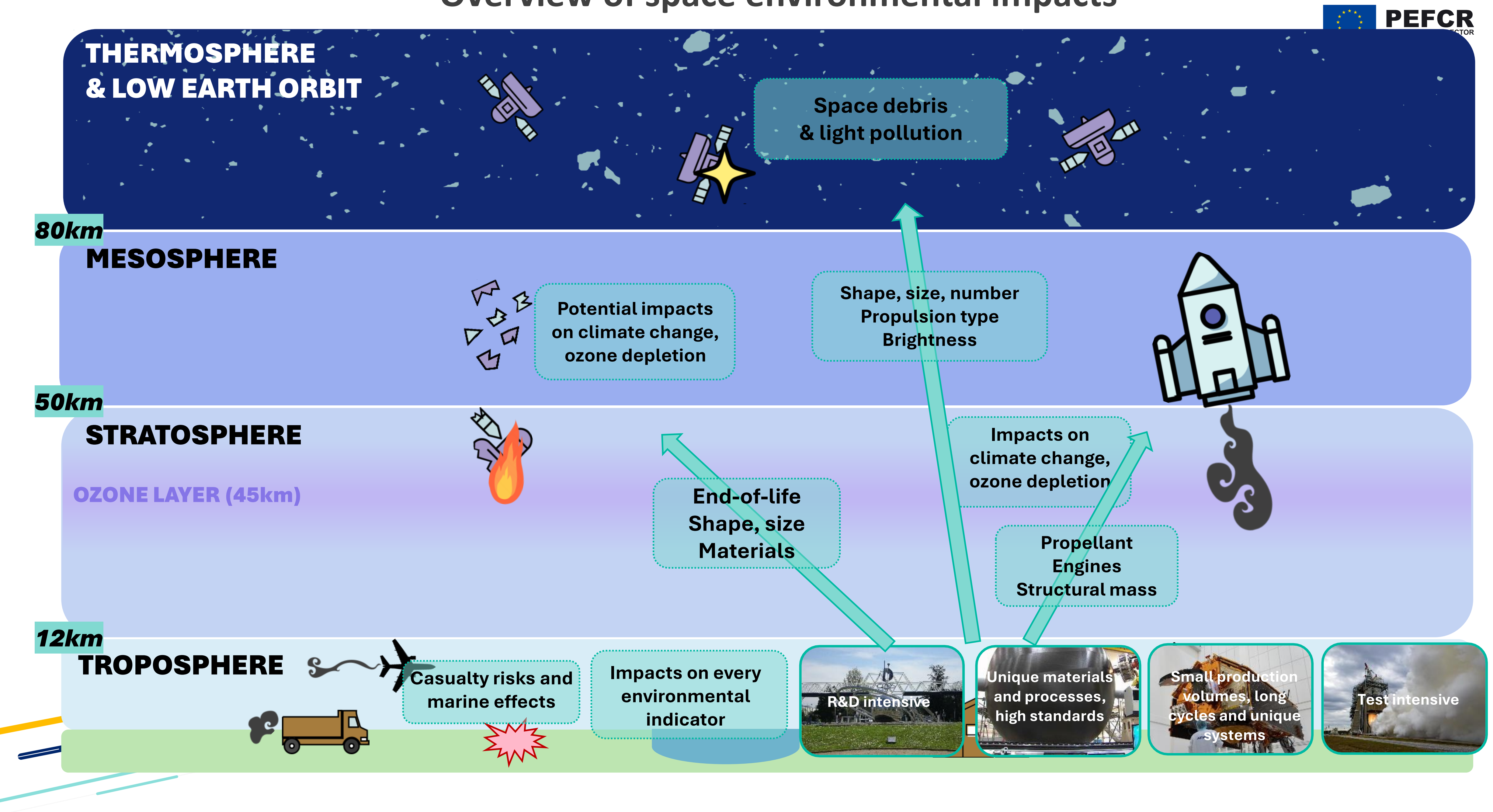
- **Sector-specific** implementation rules
- Ensure studies are robust, consistent, reproductible and **transparent** across the sector
- Required for comparative environmental claims
- Sector-specific **data** provision

**JRC** leads technical and scientific development of the EF methods and defines methodological requirements to be followed to perform EF studies.

Latest recommendations (2021): Commission Recommendation (EU) 2021/2279 on the use of the Environmental Footprint methods

More information: Product Environmental Footprint method

# Overview of space environmental impacts



# Environmental LCA is not new in the space sector. However…

- there's **not a common standard LCA applicable to the space sector full life cycle**
- applying it to overarching EU space systems / programmes may **trigger** the development of **high environmental standards** and **good practices within the EU space market**
- EC **legally recognized schemes** (e.g. PEFCRs) will be more and more required in the frame of the EU sustainability objectives *(eg. **Access to Finance, R&D funding**…)*
- To succeed, there's the need for better **harmonisation of LCA practices** (**allowing comparability**), access to robust inventory data (**reducing costs**) and advanced impact assessment models.

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# ADVANCING SUSTAINABILITY

## Environmental responsibility

The PEFCR4Space project stands for **Product Environmental Footprinting Category Rules for the space sector,** currently under development to provide a specific and standardised method for assessing and reducing environmental impacts.

The PEFCR4Space is **progressing. It is currently running supporting studies** to test how the first draft PEFCR works in practice and devellopming space sector specific datasets.

**Shape with us the future** of environmental standards in the space sector!

#PEFCR4Space #EUSpace

## Key Milestones

**October 2024** Technical Secretariat established & definition of PEFCR4Space scope

**January 2025**
5 Sub-working groups formed

**February 2025**
Set-up of the external review panel

**April - June 2025**
Definition of modelling rules and data collection

**June - Sep 2025**
Call of expression to participate in the supporting studies of the PEFCR4Space

**Oct - Dec 2025**
Open consultation on the first draft of the PEFCR4Space

**Current Phase**

**2026**

- Start the development of EF compliant datasets
- Conduct supporting studies

**2027**

- Open consultation on second draft of the PEFCR4Space
- Release of final PEFCR for the space sector

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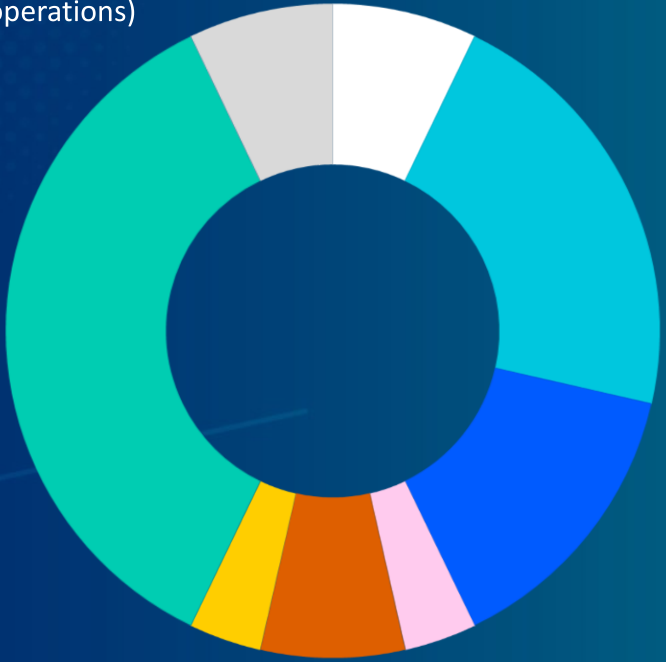
# WHO DEVELOPS PEFCR4Space

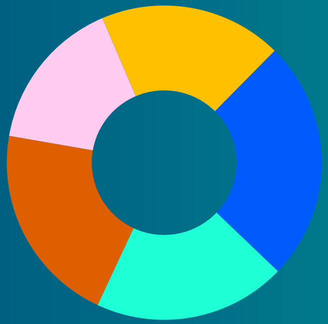
## Composition of Technical Secretariat

**28 organisations**, representing **>56% of the total European market share** (only considering launch, manufacturing, and operations)

- DG DEFIS (chair) **2**
- Experts (co-chairs) **6**
- EC services **4**
- International organisations **1**
- National organisations **2**
- Non-governmental organisations **1**
- Private companies **10**
- Universities **2**



## Five PEFCR4Space Working Groups



- Earth Observation (EO) **21**
- Positioning, Navigation, and Timing (PNT) **16**
- Satellite communication **19**
  (video & connectivity services)
- In Space Transport (IOT) **25**
- Launch services **20**

Assisted by:
Consortium mandated by EC DG DEFIS

vito | PRé | ecoinnovazione spin off ENEA
ecomatters | NOVASPACE | GCU Glasgow Caledonian University

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# First draft PEFCR4Space: Scope

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| | | | | | | |
|---|---|---|---|---|---|---|
| Product category: *(horizontal rules)* | Space-based services delivered to stakeholders in the EU | | | | | |
| Product sub-category: *(vertical rules)* | **Earth Observation Services** | **Positioning, Navigation & Timing Services** | **Sat. Video Services** | **Sat. Connectivity Services** | **In-Space Transport Services** | **Uncrewed Launch Services from Earth to Space** |
| Market average: | No | Yes | Yes | Yes | Yes | Yes, for 4 ΔV |
| Functional Unit *(1st draft)*: | To generate 1 GB of raw Earth Observation data, as prepared for transmission to Earth, relevant to the scope of the mission, with a defined accuracy, resolution and revisit rate. | To send/receive PNT as open service, with a minimum avail. of 90% under clear sky condition, over one yr with a min. horizontal location accuracy of 15m, vertical location accuracy of 7.5m and with a time accuracy of min. 31 Nsec. | To receive 1Mbps of broadcast services over 100km², at a min. availability of 99.7% under clear sky conditions, over one yr. | To exchange 1 Mbps of data at min. availability** of 99.5% under clear sky conditions, over one user terminal over one yr. | To transport 1 kg of cooperative object in space by providing a certain ΔV, with a defined precision. | To transport and release 1 kg of payload in orbit at certain ΔV, for 1 launch, at a defined minimum safety and precision. |

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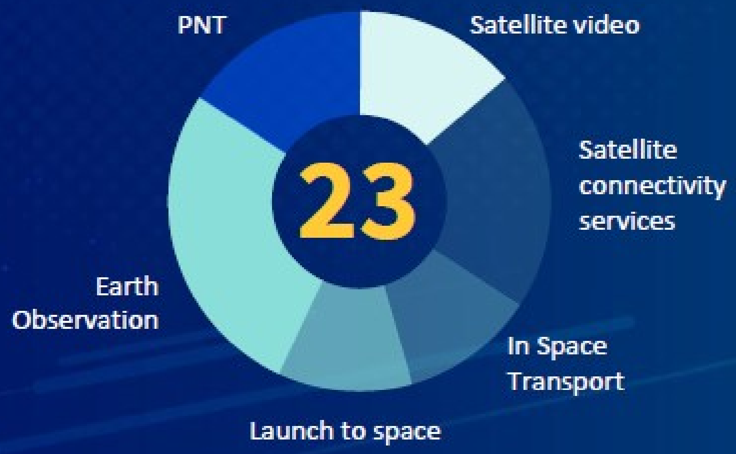
# SUPPORTING STUDIES

## Applications received




## Companies selected

AIRBUS

creotech

hispasat

D-ORBIT

Latitude

U/SPACE

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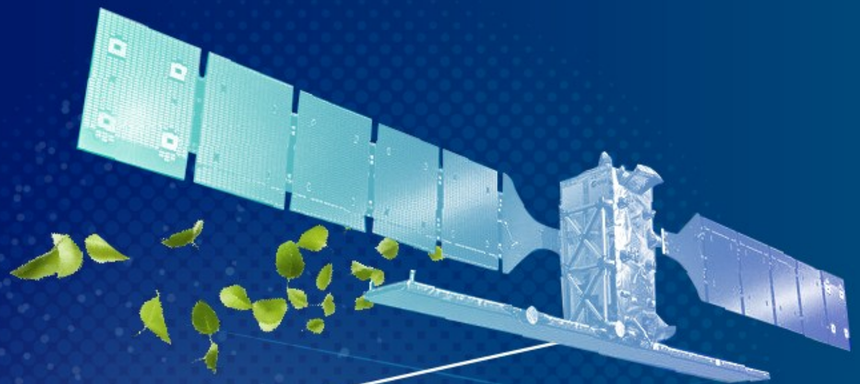
# … and Debris ?



Potential integration within
the PEFCR framework

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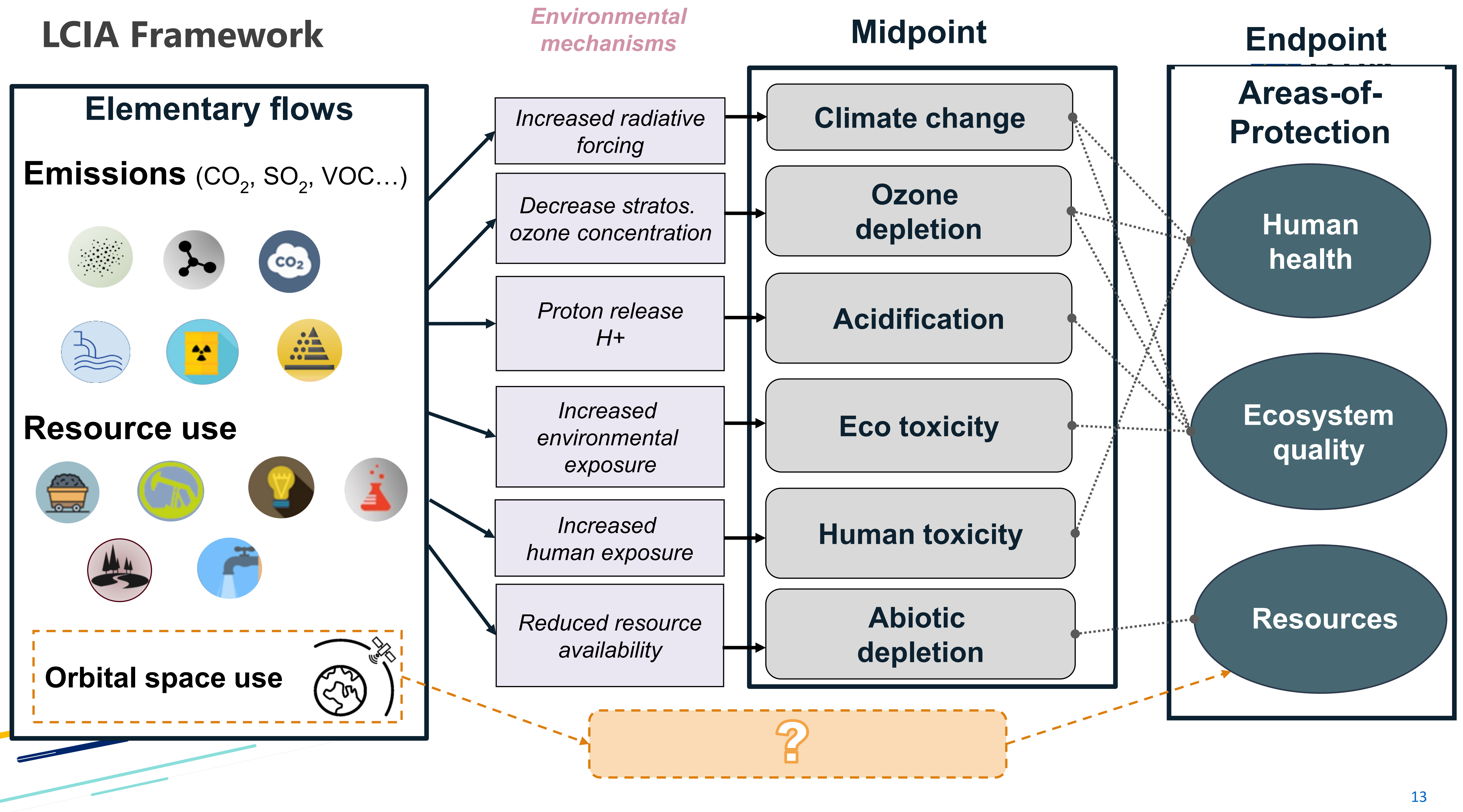
*PEFCR 1° draft report as agreed by the technical secratariat*

## 3.7 Additional environmental information

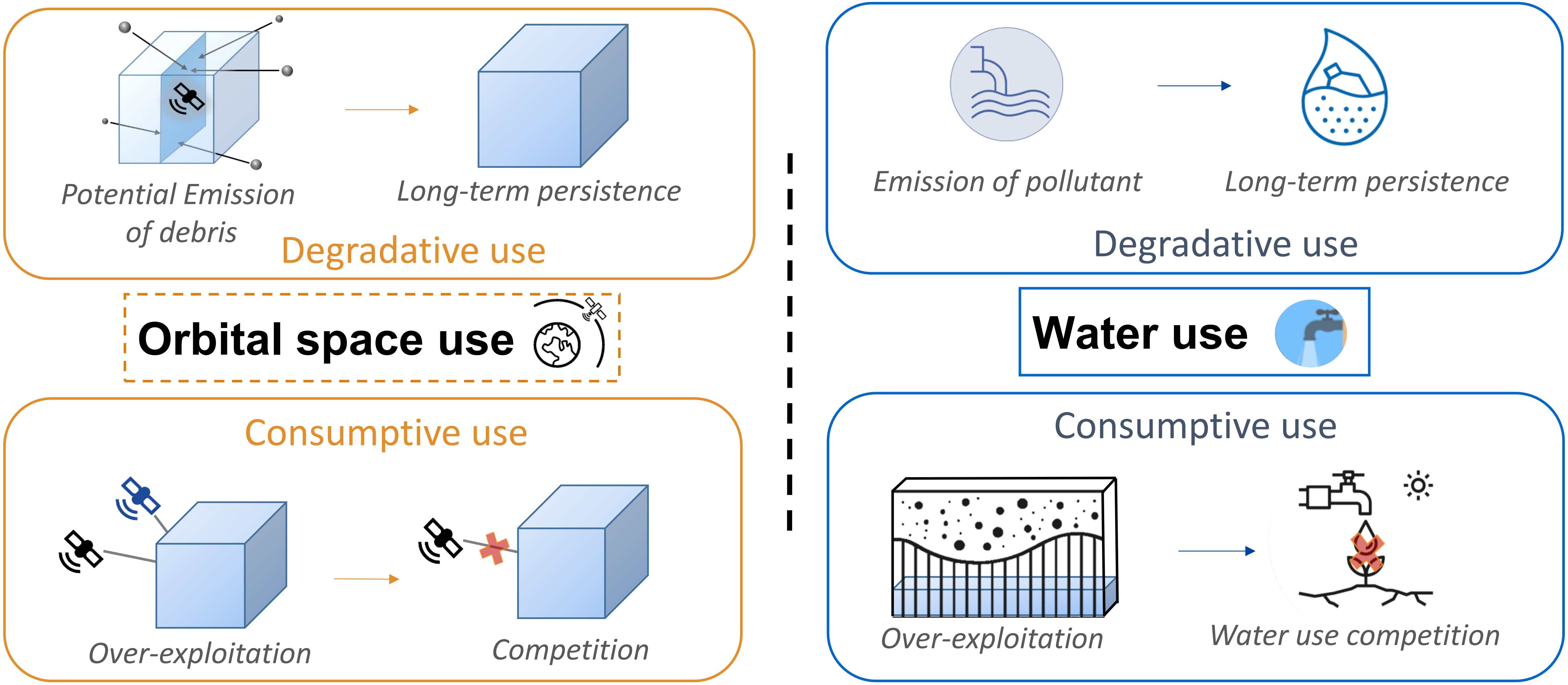
The additional environmental information is used to capture to the extent possible the space-related data gaps in the PEF impact assessment methodology (more details provided in Section 3.8). The following additional env. information shall be reported upon separately, next to the PEF profile:

1. In-orbit related impacts (orbital occupation and potential impact on debris): the amount of space debris left in space at year 5 and year 100 after end of service. This shall be reported upon at 5 year and 100 years as (i) number of objects, (ii) mass left in space per object, (iii) cross-section area of the objects, and (iv) the estimated orbit.


LCIA Framework
Environmental mechanisms
Midpoint
Endpoint
Elementary flows
Emissions (CO2, SO2, VOC…)
CO2
Resource use
Orbital space use
Increased radiative forcing
Decrease stratos. ozone concentration
Proton release H+
Increased environmental exposure
Increased human exposure
Reduced resource availability
Climate change
Ozone depletion
Acidification
Eco toxicity
Human toxicity
Abiotic depletion
Areas-of-Protection
Human health
Ecosystem quality
Resources
?

# ANALOGY WITH WATER AS A RESOURCE IN LCA





# ORBITAL SPACE USE CHARACTERISATION – *Maury et al. 2019*

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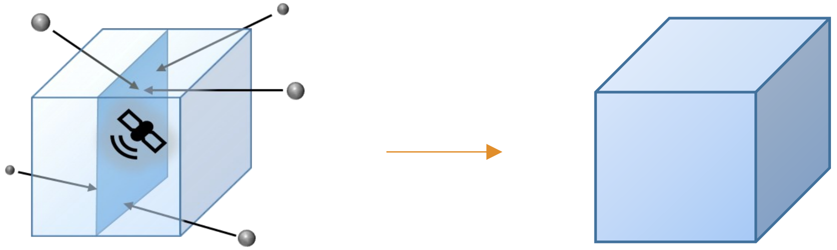


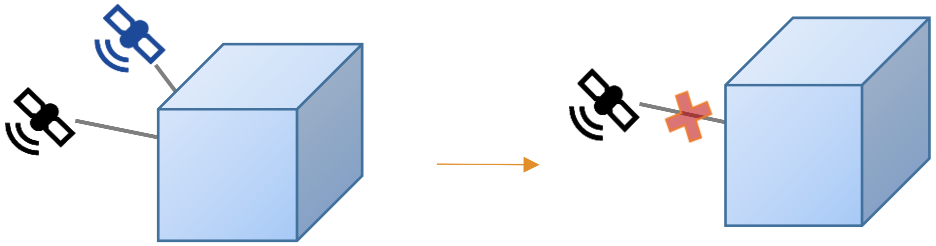
*Potential Emission of debris*

*Long-term persistence*

Degradative use

**Orbital space use**

Consumptive use



*Over-exploitation*

*Competition*

Can be already captured by existing metrics
(required compliance with LCA framework – ISO 14040/44)

➔ Suitable in the context of the PEFCR

**Drivers:** Concentration in the orbital slots, diversity of operators, Atmospheric drag removal / altitude of the slot
balanced with Economic values of the orbital slots

# ALREADY EXISTING LITERATURE


PEFCR FOR THE SPACE SECTOR


ORIGINAL RESEARCH article
Front. Space Technol., 29 November 2022
Sec. Space Debris
Volume 3 - 2022 | https://doi.org/10.3389/frspt.2022.998064


A new impact assessment model to integrate
spa
ba

ELSEVIER


Journal of Space Safety Engineering
Volume 7, Issue 3, September 2020, Pages 198-205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Colombo [c]


ELSEVIER


Science of The Total Environment
Volume 667, 1 June 2019, Pages 780-791


Assessing the impact of space debris on orbital resource in life cycle assessment: A proposed method and case study


Thibaut Maury [a b], Philippe Loubet [c d], Mirko Trisolini [e], Aurélie Gallice [b], Guido Sonnemann [a d], Camilla Colombo [e]


**Validated by LCA peers**

**«Easy to handle» by non-debris experts**

**A limited set of parameters is needed (inventory stage):**

> Cross-section Area
> **Mass of S/C**
> **Targeted LEO mission orbital slots** (simplified with only altitude and inclinaison)
> Post Mission disposal scenarios

# ALREADY EXISTING LITERATURE BUT FACING IMPORTANT LIMITATIONS

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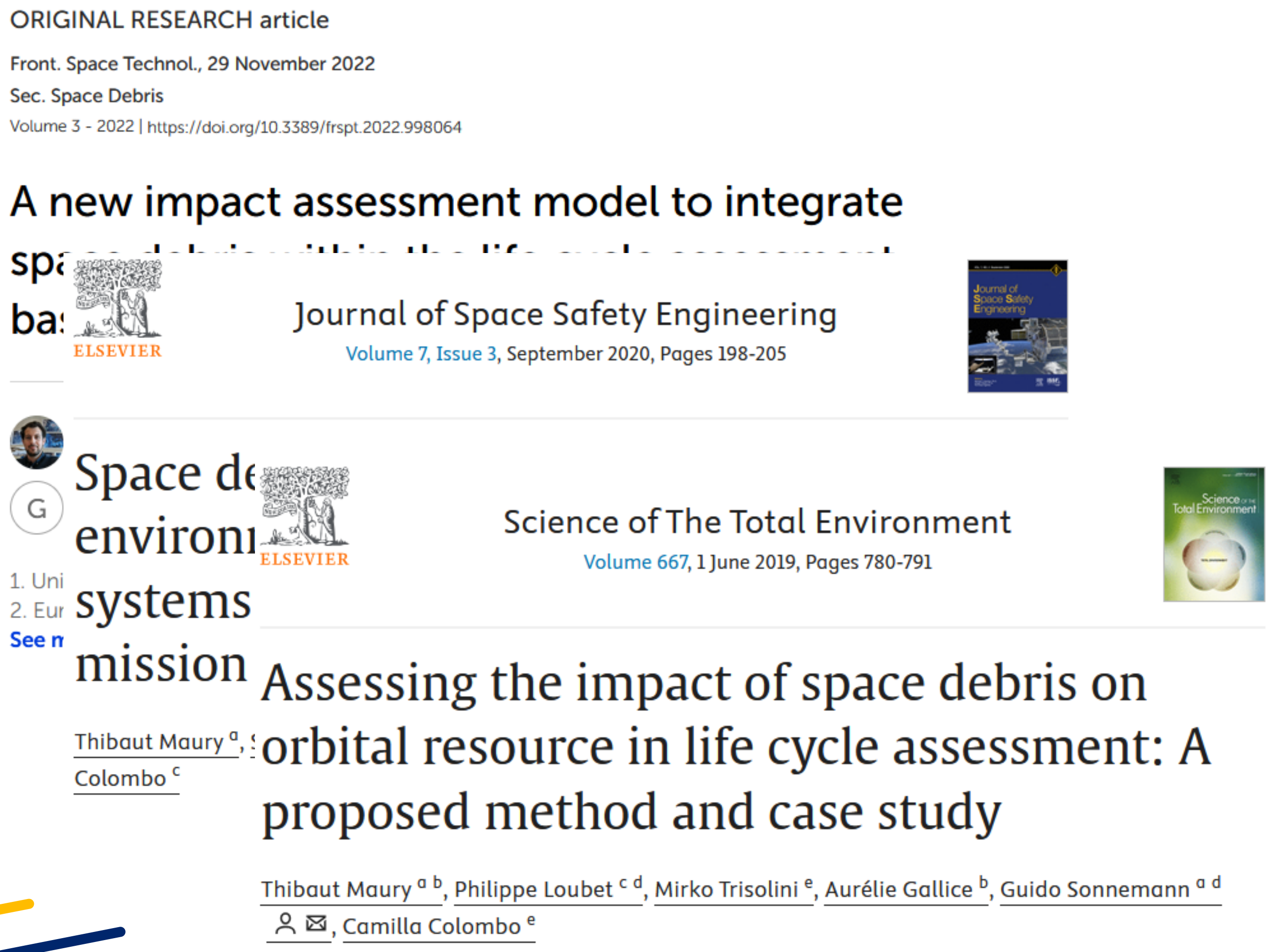
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mission

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## LIMITATIONS (AMONG OTHERS)

> Developped before the Mega-constellations era: Active Satellite population to be updated

> Outdated average flux (MASTER-2009)

> Collision Avoidance Meneuvers? (only considering flux from 1 to 10 cm?)

> Break up Explosion / in-orbit reliability?

> Post Mission Disposal success rate

> Use of carrying capacity is suggested… but not included

# Towards quantification and normalisation…

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**Carrying Capacity (CC)** can be integrated in **characterisation factors** (CF) as normalisation factors complementing **Fate factor (FF), Exposure Factor (EF), Effect Factor (EF)**

$$CF_{x,i,k} = \sum_j \frac{FF_{x,i,k,j} \cdot XF_{x,j} \cdot EF_{x,j}}{CC_j}$$

x → emitted substance / pollutant

i → emission spatial unit

j → receiving spatial unit

k → environmental compartment (air, water, or soil)

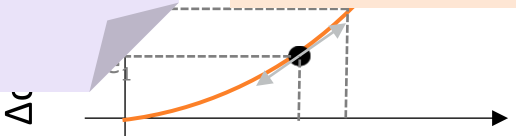
**Parsimony principle:** "as simple as possible and as complex as necessary"

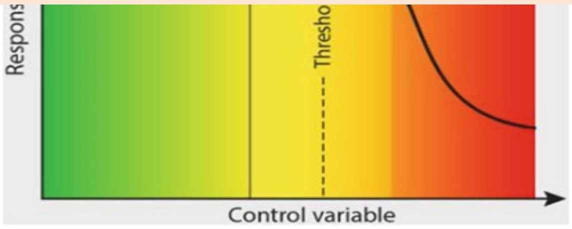
**Evolving LCA modeling** practices (not only marginal linear impact)

(FF)

**Time dimension?** (steady state Characterisation factors?)

**Environmental stressor is not only debris but all objects population**

# Few words of conclusion…



- European Commission is actively supporting the harmonisation of envrionmental footprinting in the space sector via **the Product environmental footprint category rules**

- Orbital occupation and space-related impacts can/could be integrated in the PEFCR framework, as additional information

- Already existing **indicators** should be fine-tuned and updated, potentially **integrating space carryring** capacity (risk-based or units)

- Debris is only on side of **the multi-faceted space sustainability** framework, other dimensions (high altitude impacts, light and radio frequencies pollution) deserves attention

# Thank you

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*«Se vogliamo che tutto rimanga com'è, bisogna che tutto cambi»*
il Gattopardo (1958)

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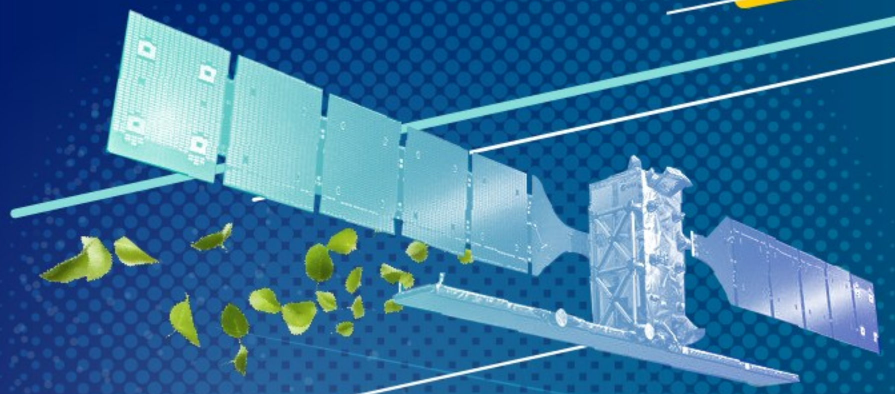

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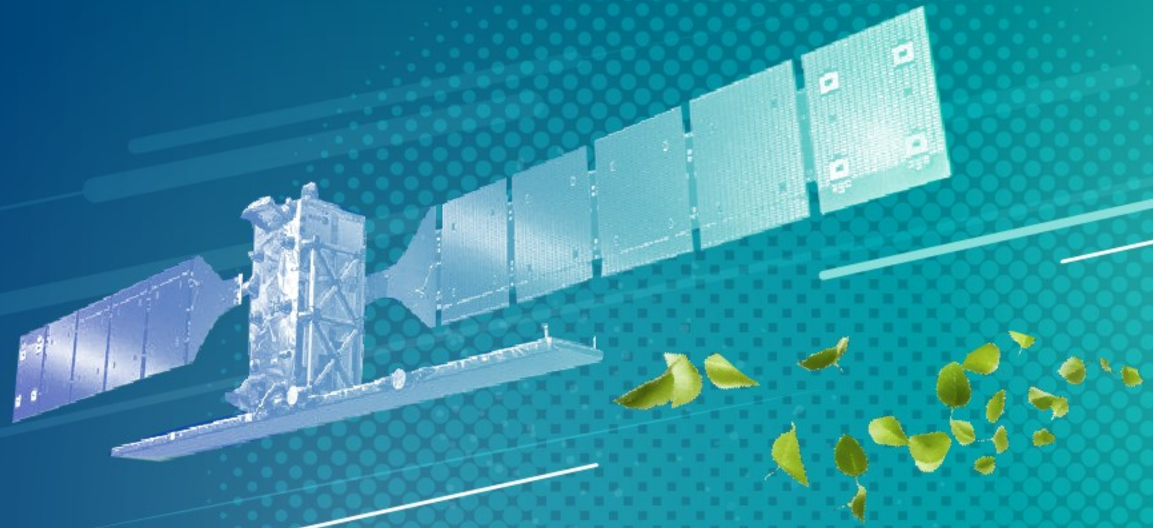

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